METHODOLOGY OF USE OF POSITION DATA INTERNET APPLICATIONS

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Summary—this article describes the internet applications displaying position data in real time and their use in operational control of air operator. Next, the air carrier operational control is described along with legislative requirements. Furthermore, the author draws his attention to position data sources that are used by the internet applications. Consequently, these are described and to conclude, their practical use methodology proposal is introduced.

K e y w o r d s- Operational control, flight watch, position data, internet applications, flight dispatcher

1. INTRODUCTION

Civil aviation is an important part of local and global economics. Therefore its steady growth is important. In a current situation the air traffic is controlled primarily on a radar basis which is a relatively old technology. Though it underwent some changes and upgrades throughout the years the operating principle is still the same.

The airspace system, when maintaining its level of safety, has its finite capacity which cannot be further increased. In order to accommodate increased air traffic demand, Europe and USA created programs called SESAR and NEXTGEN. These programs bring technological and procedural changes into the air traffic control system. This will be accomplished by move to the ADS-B technology that is satellite based rather than radar based.

ADS-B derives its position from satellites and automatically broadcasts it omnidirectionally. Position information is available not only for the air traffic controllers but also for other airplanes and generally everyone who has adequate equipment to receive this transmission. Equipment needed to receive this transmission is not expensive at all and is commonly available. High speed internet access along with availability and affordability of ADS-B receiving equipment led to birth of the internet applications displaying position data in real time that were no longer dependent solely on position information from official sources. These applications are not targeting air operators but broad mass of ordinary people among who these applications have gained huge popularity throughout the last few years.

2. Operational control of air operator

In ensuring safety, efficiency and seamless operation, operational control holds a crucial role. An operator exercises the authority over the initiation, continuation, diversion or termination of a flight in the interest of the flight safety and flight regularity and efficiency. [3] It consists of several sections which communicate and collaborate between each other and each has its specific role. This article describes selected sections of operational control relevant to the matter.

Flight planning - The primary task and simultaneously output of the flight planning section is the production and calculation of the operational flight plan which is based on information available before commencing the flight. The calculation can be done either manually or using software application. [2]

Flight supervision -Purpose of this section is an inflight assistance to the flight crew during all phases of the flight including monitoring of the flight. ICAO differentiates between three levels. [3]

Flight following – flight dispatcher records arrival and departure messages in real time and ensures that a flight is operating normally and has arrived at the destination.

Flight monitoring – in addition to the flight following requirements, it includes monitoring throughout all phases of a flight, communication of all relevant safety information between flight dispatcher and the flight crew and provision of an inflight assistance to the flight crew.

Flight watch – in addition to requirements for flight following and flight monitoring, it includes active tracking of a flight throughout all its phases to ensure that the flight is following its prescribed route without deviation, diversion or delay.

Operation control - This section is responsible for flight operations. It emphasizes safety and efficiency of operation and optimizes operating costs. Operation control also resolves any non-standard situations or irregularities in operation such as technical problems, diversions, delays or cancellations of flights and helps minimize or eliminate their impact on flight operations. [2]

3. Position information

- Primary surveillance radar

Operating principle of a primary surveillance radar is transmitting pulse modulated signal that is reflected from an object and received as an echo by an antenna and subsequently evaluated. The same antenna is used for transmitting and receiving pulses. The output of the received signal is only position information. It does not provide any additional information such as identification of aircraft nor its altitude.

- Secondary surveillance radar

Use of a secondary surveillance radar solves some deficiencies of a primary surveillance radar. It interrogates the aircraft on frequency 1030 MHz and receives replies from the onboard transponder on 1090 MHz. It is ergo an active system which can, apart from position information, receive additional information depending on a mode of interrogator and transponder, such as identification of an object, altitude and other information. It can only detect aircraft with a functioning transponder.

- ADS-B

Abbreviation for Automatic Dependent Surveillance Broadcast. This satellite based system operates on a different principal. Unlike radar, which computes location of an object on the ground from the received information, ADS-B calculates its position onboard the aircraft or vehicle rather than on the ground. It automatically broadcast its state vector, course, speed, identification and other information irrespective of whether others can receive this information or not.

ADS-B may be implemented as a part of several technologies, transmission protocols respectively. These are Universal Access Transceiver, VHL Data Link Mode 4 and 1090MHz Mode S Extended Squitter. The last mentioned protocol is globally accepted for civil aviation.

Compared to short squitter, Extended Squitter contains an additional 56 bits of information which are used for ADS-B messages. These contain among other information values of quality parameters which indicate integrity or accuracy of the transmitted position.

ADS-B normally derives its position from Global Positioning System (GPS) but under certain conditions position can be derived from Inertial Navigation System (INS), which does not provide any information regarding accuracy or integrity. Hence the transmitted values are zero (the lowest value). Position information derived from INS is not as accurate as from GPS and degrades in time therefore position inaccuracy can be significant during long-haul flights. If the values of transmitted quality indicators are under certain value, Air Traffic Control (ATC) system does not accept them.

- Multilateration

Position of a target is determined using a method called Time Difference Of Arrival (TDOA). Signal that is transmitted from aircraft propagates through space with a constant speed and is received at different times at the different ground stations.

System employs minimum of three (usually more) ground stations which are connected by a processing unit which computes position of a target. Time Difference Of Arrival of signals at two different stations defines quadric (hyperboloid) with foci at the receiving stations (antennas). “N receivers” defines N-1 hyperboloids. For an unambiguous determination ≥ 3 hyperboloids, or N $\geq$4 stations are needed.

Two techniques can be used for determining TDOA. Received signals can be either cross-correlated or Time Of Arrival (TOA) of the signal at every station is measured and the differences between these times can be mathematically calculated to produce TDOA.

- Position determination for an air operator

Air operator has several options how to monitor movements, or position of its fleet. Basic option, which is mainly used by small carriers, is voice report via cellphone or company radio. In this case, only arrival and departure times are reported by a flight crew. Another option is to use software applications. An air operator can either create its own application or can use external solution from one of the established companies which in practice prevails. Importance of solutions such as Cospas Sarsat [4]or another Doppler shift navigation system surfaced after MH370 flight accident.

These applications can be divided into two types. First type is based on mathematical calculation from the pre-specified parameters. Inputs to the application are operational flight plan, aircraft performance, en-route weather etc. Output of the application is a timeline which shows progress of a flight according to operational flight plan. If the flight proceeds according to the operational flight plan, the application and its times are rather accurate. Input parameters are not updated during the flight and the application does not receive any surveillance data so if external conditions change, the application has no means to learn about it and therefore inaccuracy exists.

Extension to this application can be a graphical depiction of an expected position of the en-route aircraft. In case of diversion or delay the application will still display the aircraft on its prescribed route.

Another type of applications is based on real time data from various sources. These applications provide updated position of aircraft in real time and integrate various data links providing operational and meteorological information which can be displayed along with position of aircraft giving a flight dispatcher an option to assess current aircraft position with meteorological conditions or to find out expected arrival delay at the intended destination.

3.1 Importance of real time position information for an air operator and its use

Knowledge of position information is not important only for air traffic controllers but also for flight dispatchers, operation managers and ground service providers. Thanks to this knowledge a flight dispatcher can flexibly react to current non-standard situation (e.g. diversion, in-flight support, arrival delay at the destination) and minimize safety and economic impact for an air operator. This applies especially for long haul-flights where the risk of deviations is much greater compared with short flights.

In a model situation during a long-haul flight arrival, capacity at the destination is reduced due to weather conditions. A flight crew usually does not receive this information immediately so it is up to a flight dispatcher who has access to the latest weather forecast and current position of aircraft to assess the situation and propose a solution. Depending on weather conditions he may either propose circumnavigating of the flight to the intended destination with some extra miles or divert the flight directly to the destination alternate which can save fuel.

4. Internet applications displaying position in real time

The first internet applications displaying position in real time were based solely on FAA ASDI (Aircraft Situation Display to Industry) feed which was initially intended for air operators, but later it was made available for third party organizations as well. Data were initially provided in real time, but later were delayed due to security reasons.

ASDI feed covers mainly USA, so applications could only provide position over this area. Coverage over other areas was enabled by ADS-B. It is an unofficial source of position information made possible by people at different locations sharing and uploading their own data to servers. To increase coverage, providers offer ADS-B receivers for free for those in poorly covered areas.

Another position source that can be implemented into these applications is a multilateration. It usually provides coverage for altitudes above 10 000 feet. These applications are in their basic version provided for free and in paid version cost several euros per month.

In the thesis two typical applications are mentioned. One based mainly on ADS-B technology and the other on FAA ASDI feed implementing several data links.

Flightradar24

Application established in 2006 in Sweden. During a few years this application gained huge popularity all over the world and especially in Europe. Sources of position information are:

- ADS-B
- FAA ASDI feed
- Multilateration

Primary source of position information is ADS-B. Flightradar24 currently has about 3000 ADS-B receivers deployed all over the world at its disposal. Europe is covered from 99%. USA, Canada, Brazil, Middle East, India, Japan, Thailand, Malaysia, Indonesia, Australia and New Zealand are also covered. In other areas of the world coverage varies greatly and is unreliable. [17]

FAA ASDI feed is also used as a source of position information, but Flightradar24 as a third party organization has access only for delayed feed. To differentiate between delayed and real time positions of airplanes different coloring is used.

Application does not implement any data link services and provides only unofficial data.

It provides origin and final destination of a flight, scheduled time of departure, actual time of departure, scheduled time of arrival, estimated time of arrival and other information such as aircraft type, registration, altitude, vertical speed, speed, track, latitude, longitude and squawk. Arrival and departure times are compiled from third party providers so its reliability and accuracy cannot be ensured.

Flightaware

Established in 2005 with offices in Houston and New York. Flightaware provides data services for airlines and airport operators and other aviation organizations. Apart from displaying private and commercial flights in real time it also provides information such as airport delays, meteorological information, fuel prices etc. [21]

Application integrates several data links such as ARINC, ARINC Direct, GARMIN, SATCOM Direct, Honeywell Global Data Center (GDC), SITA, Spidertracks, Universal Weather and Aviation UV data link.

Sources of position data are FAA ASDI feed, ADS-B and multilateration. Main source is FAA ASDI feed which has only limited coverage. Due to that application divided its service into primary service area and secondary service area.

Application provides its Application Programming Interface (API) called FlightXML for third parties so they can integrate data (flight status, flight tracking and aviation data) from Flightaware into their own application. This service is paid according to complexity of requests and their number. Push notifications allows a user to be notified when a certain flight event occurs (e.g. departures, arrivals, cancellations, diversions, schedule changes, flight plan)

Errors and reliability

During the last few years market with internet applications displaying position information in real time has become pretty competitive environment. Developers therefore protect their know-how and do not provide detailed information about functioning of their applications. Due to that reason one cannot say with certainty what causes errors. We can only presume.

It is important for a flight dispatcher to know limitations and characteristic errors of a particular application or position source. For example flight tracking using multilateration is usually available above certain altitude. When aircraft descends below that altitude, it disappears from an application. Or if time or location of a receiving station (PC) is set inaccurately it affects TDOA and therefore calculated position is inaccurate.

Errors in depicted position may occur at several levels. Incorrect data can transmit aircraft´s transponder, receiver, or data may be incorrectly processed by the application itself. Usually position information from the internet applications is very accurate. Under certain conditions displayed trajectories show substantial fluctuations. A possible explanation besides software errors may be that the applications accept all ADS-B data and do not filter them according to the values of quality parameters. Application receiving correct data from ADS-B suddenly receives data with low/zero value of quality parameters with incorrect position information which the application is trying to display. In poorly covered areas incorrect position may also be displayed.

5. Methodology proposal of use of internet applications

In the thesis author created a flowchart is designed mainly from the perspective of European companies which do not possess with means for direct communication under all circumstances. Flowchart is divided into three parts according to phases of flight.

- Departure

To begin with monitoring of the flight, a flight dispatcher must receive information about its status at the first place. Action begins when the flight is scheduled to departure. About that time the flight dispatcher expects a report about movement of the aircraft that can be obtained from several sources.

Internal sources: Status of the flight can be reported by the flight crew or obtained automatically via data link. In a logical order internal sources are in the firt place because it is official information obtained immediatelly. If internal sources are not available, a flight dispatcher can use external sources.

External sources: Movement reports from these sources can be delayed or may not be obtained at all times. It includes sources from a handling agent, station manager, FAA, or Eurocontrol.

ASD: Use of an Aircraft Situation Display ASD (internet applications) is considered in the thesis as a last option given that it is an unofficial data source.

It can serve as a visual confirmation of a movement of aircraft. Some internet applications use mapping system which also displays taxiway and runway system of an airport. Under standard conditions the position output of these applications is quite accurate and thus the movement of aircraft during taxiing, takeoff and landing can be tracked. Flight dispatcher can thus visually verify whether the aircraft is already up in the air or just taxiing. If the flight is not shown at all, it means that aircraft´s transponder is switched off and it has not moved from a gate yet.

If the ASD displays movement of aircraft on the taxiway, it can be assumed that it will take off in next few minutes (in special cases max. tens of minutes) and it is therefore not necessary to urge handling agent or the station manager to send a movement message.

Flight dispatcher should treat ASD data with some level of uncertainty, but if a flight dispatcher receives a movement message containing only off block time and ASD displays the flight up in the air, he can assume that the information is correct. For positive confirmation he should wait for the official source anyway. Once the aircraft takes off, another phase begins.

- En-route

If the reduced contingency fuel procedure is applied, a flight dispatcher expects a possibility of diversion from the decision point to the alternate destination.

If it is not possible or desirable to communicate with a flight crew during the flight, a flight dispatcher can use ASD and thanks to the information provided, such as position in real time, flight level, course and vertical speed, he can observe action of a flight crew at the decision point whether the aircraft is descending to the alternate airport or maintaining flight level and proceeding to the original intended destination. Knowledge of whether the flight diverts or not gives a flight dispatcher an opportunity to take action in advance and arrange related activities such as notifying flight crew at the original destination about the delay, provision of ground transportation etc.

Given that ASD provides current position information in real time, it can serve as a tool for better awareness of a progress of a flight. If operation control requires position reports, ASD can be used in case when position report is not available or is delayed. However, these reports cannot be fully replaced throughout the flight.

- Arrival

Around the time of a scheduled arrival, a flight dispatcher can use the same procedures when determining the status of a flight described for departure phase. A different location can change availability of services.

6. Operational use of internet applications

In the USA or Canada flight watch responsibility is shared between a flight crew and a flight dispatcher and regulations consider this matter. Canadian authorities for example require certain position reports to be available for a flight dispatcher. Air operator can use Aircraft Situation Display System (internet application displaying position data in real time) for this purpose. So logically, some requirements exist for this software.

Czech Civil Aviation Authority requirements for operation control are very brief. In the legislation there is no mention about establishing or methods of flight following, flight monitoring, flight watch or shared responsibilities between a flight dispatchers and a flight crew. There are not even requirements for flight watch software. Method of supervision of a flight and choice of application, if any, is therefore solely up to the air operator.

7. Conclusion

The main advantage and also a disadvantage of the internet applications displaying position in real time is a fact that they do not rely strictly on official sources of information, but they also use unofficial sources. This allows them to offer a greater range of services, extend their coverage and further expand their scope in the market.

Unofficial position information is derived primarily from ADS-B, coverage of which is constantly increasing and this trend will most likely continue in the future.

Even though position data come from an unofficial source they are rather accurate. The main problem is the fact that they are burdened with a certain level of uncertainty that depends on several circumstances and cannot be reliably estimated. So a flight dispatcher should treat them as such. A flight dispatcher therefore cannot fully rely on them which decreases its importance in the decision making process of a flight dispatcher and its level of usability.

As a primary tool for a flight watch these applications cannot be thus far recommended. On the other hand, in combination with other tools for a flight watch, they represent a supplement for existing systems enabling a flight dispatcher getting a better situational awareness of the flight operations. From the legislative point of view, nothing stands in a way of using these applications in an operational control of an air operator.

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