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IMPACT OF NOTAM ON SECURITY AND EFFICIENCY PERFORMANCE OF FLIGHTS (OVERVIEW)

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The purpose of this work is to analyze and assess the impact of NOTAM on the flight safety and efficiency. The main problems associated with NOTAM were considered: number of NOTAMs, the practical use of NOTAM information, technical limitations of the current NOTAM system. Examples of the negative impact of NOTAM on the quality of air navigation support, safety and efficiency of flights are presented. Also, the best practice of solving problems, related to NOTAM in the world, is presented with using: Q-code and flight planning systems (on the example of Lido Flight 4D). The concept of the European AIS Database (EAD), developed on the basis of the Aeronautical Information Exchange Model (AIXM), is presented. The concept of Digital NOTAM, implemented on the basis of AIXM and intended for the exchange, automatic processing and interpretation of the dynamic aeronautical data, is considered. The research studies the new modernized NOTAM system – Federal NOTAM System (FNS – Federal NOTAM System), developed by the Federal Aviation Administration (FAA) of the United States, which allows encoding the Digital NOTAM. ICAO's plans for the transition from the concept of Aeronautical Information Service (AIS) to the Aeronautical Information Management (AIM), applying the principles of the System Wide Information Management (SWIM) concept, were analyzed. As a result of the analysis of the current NOTAM system and the modernized NOTAM system (FNS from FAA), conclusions were drawn that the implementation of Digital NOTAM should solve the technical part of the problems associated with NOTAM, brought about by the use of modern communications (internet) and new data exchange standards (AIXM), which, as a result, will lead to an increase in the level of safety and efficiency of flights. At the same time, problems with NOTAM caused by human factors remain unresolved, due to incorrect use of the NOTAM instrument.

Key words: NOTAM, Digital NOTAM, aeronautical information, AIXM, SWIM, GANP 2016-2030.

INTRODUCTION

Nowadays flight safety and efficiency are impossible without qualitative aeronautical information (AI), as it is necessary to take a large number of crucial factors into consideration. Nevertheless, it is not always possible to analyze the whole AI package given the large amount of information and format of its disclosure. As a result, the important data, which has a direct impact on flight safety, may remain unnoticed by the flight dispatcher (FD) and the flight crew.

ICAO – International Civil Aviation Organization states: "information resulting from the assembly, analysis and formatting of aeronautical data" as a definition of "aeronautical information". Whereas "a representation of aeronautical facts, concepts or instructions in a formalized manner suitable for communication, interpretation or processing" is what is meant by "aeronautical data". AI is provided in a standardized format, including:

- Aeronautical Information Publication (AIP) with amendments (AMDT) and supplements (SUP);
- aeronautical information circulars (AICs);
- notice to airmen (NOTAM) and pre-flight information bulletin (PIB);
- check lists and lists of NOTAMs[1] in operation.

AI is used at all stages of performance of flights. FDs analyze AI, including AIP, SUP, AIC and NOTAM, during flight aeronautical support (AS). Briefing for the upcoming flight, involving PIB and latest NOTAM for it, is a result of the analysis. PIB allows us to reduce flight crew workload in a significant way, as all the NOTAMs in PIB have been singled out by the FD.

[1] Annex 15 – Aeronautical Information Services. (2018). 16th ed. Montreal: ICAO, 60 p.

FDs and the flight crew pay a particular attention to NOTAM analysis, as the main NOTAM task is to inform rapidly all the specialists, involved in performance of flights, about AI (AIP) changes or crucial circumstances, affecting flight performance. According to ICAO Annex 15, NOTAM is defined as "A notice distributed by means of telecommunication containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations" (fig. 1).

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E3144/21 NOTAMR E1852/21
Q) CZUL/QMRLC/IV/NBO/A/000/999/4541N07402W005
A) CYMX B) 2107071147 C) 2108131800
E) RWY 11/29 CLSD DUE NO MAINTENANCE.
CREATED: 07 Jul 2021 11:47:00
SOURCE: CYHQYNYX
```

Fig. 1. Example of NOTAM

According to the example above, NOTAM is a text message in a set format in capital letters. It is customary to abbreviate the NOTAM texts as much as possible, using standard abbreviations according to "Procedures for Air Navigation Services. ICAO Abbreviations and Codes". The following rules arise from NOTAM message size restriction and initially high cost of utilizing Aeronautical Fixed Telecommunications Network (AFTN) communication facilities.

The NOTAM system operation seems to have already been up and running, as the pattern has been being utilized in aviation for more than 74 years, but, unfortunately, the actual situation is different. NOTAM-related challenges remain urgent nowadays. This fact is mostly caused by aviation industry development: growth of the number and size of airports, increase in the number of flights, and also by the negligence of the specialists, responsible for AI (NOTAM publishing, instead of prompt amendments in AIP) and NOTAM utilization for unauthorized purposes.

On July 17, 2014, the plane B777-200ER, performing the flight MH17 Amsterdam – Kuala-Lumpur, was shot down in Donetsk Oblast, as a result 298 people were killed. This accident may serve as an example of NOTAM emergencies. The flight crew, performing the following flight, could see NOTAM A1492/14, Figure 2 among the hundreds of them in flight briefing.

```
A1492/14 NOTAMN
Q) UKDV/QRTCA/IV/BO /W /260/320/4822N03807E095
A) UKDV B) 1407141800 C) 1408142359EST
E) TEMPO RESTRICTED AREA INSTALLED WITHIN FIR
DNIPROPETROVSK BOUNDED BY COORDINATES:
495355N 0380155E 485213N 0372209E 480122N 0370253E
471352N 0365856E 465018N 0374325E 465900N 0382000E
470642N 0381324E THEN ALONG STATE BOUNDARY
UNTIL POINT 495355N 0380155E.
RESTRICTION NOT APPLIED FOR FLIGHTS OF STATE ACFT
OF UKRAINE.
F) FL260 G) FL320)
```

Fig. 2. NOTAM for flight MH17

NOTAM A1492/14 was the one to inform the aircraft flight crew that the flights in temporary restriction area involve the high risk to flight safety, and more than a dozen of The Ukranian Air Force aircraft were shot down in 2014 June-July. Unfortunately, there was no data on the crashed aircraft in

the following NOTAM. The following data could have, probably, raised awareness of the FD and flight crew, whether it was noted in NOTAM, and this plane crash could have been averted.

Thus, NOTAM issues can be divided into three groups:

1. The number of NOTAMs;
2. The practical use of NOTAM information;
3. The technical limitations of the current NOTAM system.

NUMBER OF NOTAMs

ICAO states that in 2020 the number of published NOTAMs exceeded 1.7 million, while as on 2021 November 1st [2] the number of NOTAMs in operation was 35879[3]. European Organization for the Safety of Air Navigation (EUROCONTROL) states that the number of NOTAMs increases by 100000 annually. For 10 years in a row the number of NOTAM has reduced only in 2020 by 5%, on account of decrease in number of flights due to COVID-19 pandemic.

Let us take the charter flight Moscow (SVO/UUEE) – Mumbai (BOM/VABB), on the aircraft An-124-100, as an example in order to realize the scale of the issue. Ahmadabad (Sardara Vallabhai Patela, AMD/VAAH) and Goa (Dabolim, GOI/VOGO) will be used as flight plan alternates, № 1 and № 2 respectively. The route of the flight will pass through 10 flight information regions (FIRs), and 23 airports will be used on the route as alternates.

FDs will have to analyze 1250 NOTAMs (236 pages), 221 NOTAMs (17,7%) are older than 3 months, and 99 NOTAMs (7,9%) are older than 1 year, (tab. 1). It must be noticed, that NOTAM older than 3 months is the Doc 8126, ICAO violation. According to the document, temporary amendments older than 3 months must be published as Supplements (SUP) to AIP. When the amendments are of repetitive nature, the following NOTAM data must be entered in AIP by Amendments to AIP. Consequently, NOTAM older than 3 months should not exist. PIB of relevant NOTAMs will be formed after the FD proceeds the whole NOTAM package. There will be only 170 of 1250 (40 of 236 pages) in the PIB, so that the flight crew significantly saves time.

Table 1

NOTAMs for flight SVO/UUEE – BOM/VABB

Object	NOTAM			PIB
	Number	NOTAM age		
		> 3 months	> 1 year	
Departure airport SVO/UUEE	20	5 (25%)	1 (5.0%)	19
FIR	747	76 (10.2%)	24 (3.2%)	37
Enroute alternates	393	80 (20.4%)	30 (7.6%)	54
Destination airport BOM/VABB	35	20 (57.1%)	6 (17.1%)	22
№ 1 alternate AMD/VAAH	15	4 (26.7%)	3 (20.0%)	8
№ 2 alternate GOI/VOGO	40	36 (90.0%)	35 (87.5%)	30
Total number of NOTAMs	1250	221 (17.7%)	99 (7.9%)	170
Number of pages	236	45 (19.1%)	18 (7.6%)	40

[2] Global campaign on NOTAM improvement (NOTAM2021), ICAO. Available at: https://www.icao.int/airnavigation/information-management/Pages/GlobalNOTAMcampaign.aspx (accessed: 27.08.2021).

[3] NOTAMeter, ICAO. Available at: https://www.icao.int/airnavigation/information-management/Pages/NOTAMeter.aspx (accessed: 27.08.2021).

ICAO has developed the information system NOTAMeter together with The Notam Team (fixingnotams.org), founded by Mark Zee, to estimate the quality of NOTAMs in operation. The given system allows us to estimate the quality of NOTAM judging by NOTAM age criteria, dividing all the NOTAMs into 3 groups (data as of November 1st, 2021):

1. Current, published less than 3 months ago – 35879 (83.2%);
2. Old, published more than 3 months ago, but from less than 1 year ago – 3796 (10.6%);
3. Very old, published more than a year ago – 2222 (6.2%).

The number of old and very old NOTAMs directly depends on the region of the world. The example of SVO-BOM flight, mentioned above, may serve as a proof, as:

- 17.7% of NOTAMs is published more than 3 months ago (10.6% on average worldwide);
- 7.9% of NOTAMs are published more than 1 year ago (6.2% on average worldwide).

There are NOTAMs about animals on runway, grass mowing in progress, flight charge and politics. The way the FDs and the flight crew should react to the data on possible emergence of animals on runway, is not quite clear. It may absolutely exactly be said that NOTAMs serve as means of shifting responsibility from the airport administration to FD and crew. As a result, the airfield authorities publish the warning NOTAM – instead of solving the problem or closing the runway, taxiway and/or ramp.

NOTAMs about politics are particularly dangerous, as there is often data on Air-Traffic Management (ATM) in such NOTAM, namely instructions of which Air-Traffic Control (ATC) agency the flight crew should follow. Meanwhile there may be two contradictory political NOTAMs in the PIB for the flight crew.

The bright examples of such situations may be:

1. The conflict between Greece and Turkey;
2. The conflict between Russia and Ukraine.

Meanwhile those who publish such NOTAMs, do not realize how harmful it is for flight safety. Most of them would tell you, that there is no such thing as an excessive information, but the following position does not meet the main NOTAM data requirement. There should only be the crucial information in the NOTAM. The thing is that, the more NOTAMs is there in PIB, the higher is the probability of missing the really important one by the flight crew.

PRACTICAL USE OF NOTAM INFORMATION

It is a challenge to analyze a large number of NOTAM in a qualitative way, considering particularly, that most of them are about obstacles and restricted areas, which have a lot of parameters to analyze (validity period, coordinates, expiry or the upper/lower limit of operation) (tab. 2). It is necessary to map the NOTAM data on the flight route in order to estimate their effect. Only after that one can make conclusions about the way the NOTAM data are crucial for the given flight route.

Sometimes it is also difficult to estimate if the NOTAM is crucial due to its size. There frequently are NOTAMs containing two or more parts, while the really important information may be in the middle or in the end of NOTAM text. In general, FDs and the flight crew have to analyze NOTAMs quickly due to its large number and lack of time. That is why there is such a high probability of missing the really important data, hidden in the big NOTAM text.

The "E" field, which is for summary of the information in free form, is one of the most important parts of NOTAM. In spite of the fact that its format is strictly governed by ICAO regulations. The free form of presenting the data allows for creativity, so that there are issues with interpreting the following text [1]. Furthermore, using of the abbreviations significantly reduces the NOTAM informativeness and speed of its reading, exacerbating the situation.

Table 2

Examples of NOTAM

Characteristics	NOTAM	
	Obstacles	Restricted areas
NOTAM	A0608/21 NOTAMR A0593/21 Q) VABF/QOBCE/IV/M/AE/000/008/ A) VABB B) 2105170801 C) 2108162359 EST E) TEMPO OBST CRANE ERECTED AT LCA 185944.1N 0724915.0E RADIUS OF CRANE OPS 30M. CRANE MARKED AND LGT F) GND G) 220M AMSL CREATED: 17 May 2021 08:05:00 SOURCE: VABBYNYX	K7375/21 NOTAMN Q) UUWV/QRRCA/IV/BO/W/040/240/5017N03954E025 A) UUWV B) 2107190500 C) 2107232359 D) 19-23 0500-2359 E) RESTRICTED AREA ACT: UUR213. F) 1200M AMSL G) FL240 CREATED: 12 Jul 2021 17:27:00 SOURCE: UUUUYNYX
The number of NOTAM parameters	6	6

THE CURRENT NOTAM SYSTEM TECHNICAL RESTRICTIONS

AFTN is one of the key elements of the current NOTAM system. Sending out the NOTAM notifications, flight plans (FPL), communications between the aircraft operators and aviation authorities are made by means of AFTN. Sending out the NOTAM notifications by means of AFTN originated in 1947. International Telegraph Alphabet 2 (ITA-2), implemented in 1924, is a 5-bit character set used as a language.

The use of AFTN technology in 2021, which is essentially a telegraph network, cannot be explained except as a tradition. The AFTN technology restricts the opportunities of the current NOTAM system, as one can send only text messages of the limited size by means of telegraph system, and it firmly restricts the NOTAM format and makes the processes of NOTAM proceeding and accounting more difficult. The consequence of ITA-2 application is a binding nature of using the capital letters, which significantly reduces the text readability and makes it impossible to separate out the crucial information.

THE MODERN WAYS OF SOLVING THE NOTAM PROBLEMS

There were plans of automatizing the NOTAM processing and accounting by entering the "Q" field with data, called Q-code, and encoded by the certain principle, into the NOTAM format. There is a NOTAM with Q-code, which is highlighted in grey, in Figure 3.

```
K7375/21 NOTAMN
Q) UUWV/QRRCA/IV/BO/W/040/240/5017N03954E025
A) UUWV B) 2107190500 C) 2107232359
D) 19-23 0500-2359
E) RESTRICTED AREA ACT: UUR213.
F) 1200M AMSL G) FL240
CREATED: 12 Jul 2021 17:27:00
SOURCE: UUUUYNYX
```

Fig. 3. Example of NOTAM with Q-code

Q-code allows Information Systems (IS) to analyze the NOTAM on an automatic basis and estimate the way it effects the flight route, judging by the: coordinates, radius and upper/lower limit of operation of the following NOTAM (tab. 3).

Table 3

Decoding of Q-code NOTAM

Field №	Qualifier	Example	Interpretation
1	FIR – Flight Information Region	UUWV	Moscow FIR
2	NOTAM code, according to Doc 8126, ICAO	QRRCA	Q – Q-code. RR – restricted area. CA – activated
3	Type of traffic – the aircraft flight rules (IFR/VFR)	IV	I – Instrument Flight Rules (IFR). V – Visual Flight Rules (VFR)
4	Purpose – purpose of NOTAM publication	BO	B – include information into PIB. O – data has a crucial operating value
5	Scope	W	W – navigation warning
6	Lower airspace limit (in hundreds of ft.)	040	4000 ft.
7	Upper airspace limit (in hundreds of ft.)	240	24000 ft.
8	Coordinates, radius (in nautical miles)	5017N03954 E025	50° 17 min. N. 039° 54 min. E. 25 nautical miles

Q-code implementation has allowed to reduce load on FDs and aircraft flight crew, but it has not completely solved all the NOTAM problems. Research by Mark Zee showed us, that the basic issue of using the NOTAM with Q-code is – an overly large number of variants while encoding the Q-code, namely 179 topics (60 AGA, 47 ATM, 40 CNS (communication, navigation, surveillance), 27 Nav Warnings (navigation warnings), 5 Other (other information)) and 77 points (16 of availability, 26 of danger, 19 of restriction). The number of probable combinations of 5-character Q-code equals to 13783 in total. And even such a large number of Q-code variants does not solve the given problems, as analysis of all the published NOTAM in 2020 showed us, that 47% of NOTAMs about airfields and 25% of them, about FIRs, use the "XX" or "XXXX" codes. The "XX" or "XXXX" is used only if the operator does not know, which code has to be used to describe the event while creating the NOTAM. As a result, the whole automation of the NOTAM processing and accounting by means of Q-code becomes impossible [2].

The NOTAM problems can be partly solved by means of flight planning systems, particularly, Lido Flight 4D by Lufthansa Systems company. Lido Flight 4D – is flight planning systems, which allows us to plot an optimal flight route judging by the aircraft characteristics, flight rules of the countries, terrain and weather conditions. Lido Flight 4D takes AIP, AMDT, SUP, AIC and NOTAM into consideration, due to its own AI database. Every worldwide published NOTAM is proceeded appropriately by Lufthansa Systems officers, and the extracted information is entered into the database, therefore it is still relevant.

The use of Lido Flight 4D allows us to reduce the load on the FDs and the flight crew in a significant way, due to automatic processing of the majority of the NOTAMs, as the considerable part of the NOTAM is about restricted areas and obstacles. The comparative analysis of the Defense Internet Notam Service (DINS) system with open access and Lido Flight 4D (tab. 4), may serve as a proof. According to Table 4, the use of Lido Flight 4D allowed to reduce the number of NOTAMs from 1250 to 229 (by 82%) and the number of NOTAM pages from 236 to 50 (by 78%). At the same time, the FDs and the flight crew will have to analyze 229 NOTAMs (50 pages) and PIBs, made of 170 NOTAMs (40 pages) respectively, even while using Lido Flight 4D. Such a large number of

NOTAMs, remaining after Lido Flight 4D processing, stems from the complicity of NOTAM automatic processing and accounting, because of its format [3]. It is confirmed by Robert Bobrow research, which showed us, that it is impossible to create a fully automatic system of NOTAM processing and accounting in its current format [4].

Table 4

NOTAM for flight SVO/UUEE – BOM/VABB

Object	NOTAM		PIB
	DINS	Lido Flight 4D	
Departure airport SVO/UUEE	20	23	19
FIR	747	63	37
Enroute alternates	393	75	54
Destination airport BOM/VABB	35	23	22
Flight plan alternate № 1 AMD/VAAH	15	12	8
Flight plan alternate № 2 GOI/VOGO	40	33	30
The total number of NOTAMs	1250	229	170
The number of pages	236	50	40

AIXM AND DIGITAL NOTAM

EUROCONTROL development by European AIS Database (EAD) in 2003 has become the crucial step to digitalization of sources of information. EAD – is the largest centralized aeronautical information database in the world, providing us with guaranteed quality of statistical data management, aeronautical documentation (AIP, AMDT, SUP, AIC, and aeronautical schemes) [5] maintenance and publishing. Kazakhstan, Kyrgyzstan, The Philippines, and many other countries of the world use EAD along with Europe.

The use of Aeronautical Information Conceptual Model (AICM) and Aeronautical Information Exchange Model (AIXM 3.3) initially underlaid in EAD work. Whereby AICM was a logical model and was utilized as the aeronautical database basis/structure. At the same time, AIXM was for electronical data communication between the other users (was used as a standard of electronical information exchange)[4]. AIXM was a set of data, encoded by Extensible Markup Language (XML), its functionality permitted to encode statistic aeronautical data[5], such as AIP, but not providing with an opportunity of encoding the dynamic aeronautical data[5], such as NOTAM, in a qualitative way.

In 2003 EUROCONTROL started working at AIXM model upgrading together with the US Federal Aviation Administration (FAA). Change Control Board (CCB) was founded later, to allow the states and companies to participate in AIXM development. That were the results of CCB work:

- AIXM 4.5 release in 2005 as an update for AIXM 3.3;
- AIXM 5.0 release in 2008, since then AIXM consists of 3 basic components:
  1) data model in Unified Modelling Language (UML);
  2) XML scheme, compatible with Geography Markup Language (GML);
  3) the temporality concept, which allows to encode both statistic[5] (AIP) and dynamic[5] aeronautical data (Digital NOTAM).

[4] AIM AICM and AIXM Introduction. AIXM 5. (2006). Second Design Review. Madrid, Spain, 26 p.
[5] Euro Doc 010. (2003) 2nd ed., Montreal: ICAO, 68 p.

- release of AIXM 5.1 with Digital NOTAM Specification in 2010 (version 1.0) – specifications of different NOTAM events encoding (closing of the runway, etc.);
- AIXM 5.1.1 release in 2019[6].

AIXM 5.1 data exchange model with Digital NOTAM encoding opportunity has introduced the standard of aeronautical data digital publishing and exchange (fig. 4) to aviation. ICAO considers AIXM to be the best practice of aeronautical data digital formatting and exchange[7]. It should be noted, that XML, GML or another type of program code is what is meant by "digital" format, but not images in .jpg in .pdf [5] at all.

AIP: 26 MAR 2020 or AIRAC 26 MAR 2020

AIXM: <gml:beginPosition>2020-03-26T12:00:00Z</gml:beginPosition>

Fig. 4. Example of data in AIXM format

It is planned to release an updated Digital NOTAM Specification (version 2.0) in 2021, and an updated AIXM 5.2 in the first quarter of 2022.

Unlike the current NOTAM format, Digital NOTAM is for automatic data processing and interpretation. The information may be presented both in text and graphically, with the help of Information Systems for data decoding. Graphical display of closed taxiways (TWYs) and runways (RWYs) in the airfield scheme, with the help of digital NOTAM, will allow to increase the aircraft taxing operational safety in a significant way [6, 7]. Meanwhile the relevant data of the Digital NOTAM will be displayed on flight crew Electronic Flight Bag (EFB) screens automatically [8, 9]. There are the examples of Digital NOTAM with closed taxiways, both textual and graphical, in Figures 5 and 6.

NOTAM		START DATE	FINISH DATE
Ⓐ 07/389	TWY WL BTN TWY WA AND TWY WB CLSD	JUL 30, 2021	AUG 31, 2021
Ⓑ 07/386	TWY WG BTN RWY 15L/33R AND TWY WA CLSD	JUL 30, 2021	AUG 31, 2021 EST
Ⓒ 07/365	TWY NC BTN TWY NC SPOT 9 AND TWY NG CLSD TO ACFT WINGSPAN MORE THAN 130 FT	JUL 31, 2021	DEC 31, 2021
Ⓕ 07/388	TWY WB BTN TWY WK AND 755FT NORTH TWY WM CLSD	JUL 30, 2021	AUG 31, 2021
Ⓟ 02/044	TWY WD BTN TWY NR AND TWY WB CLSD TO ACFT WINGSPAN MORE THAN 171FT	FEB 6, 2021	PERM
Ⓠ 08/031	TWY WB BTN TWY WD AND TWY WE CLSD TO ACFT WINGSPAN MORE THAN 118FT	AUG 4, 2021	OCT 4, 2021
Ⓡ 08/032	TWY NR BTN TWY WD AND TWY WB CLSD TO ACFT WINGSPAN MORE THAN 118FT	AUG 4, 2021	OCT 4, 2021

Fig. 5. Digital NOTAM, in textual display

Digital NOTAM creation may also lead to automatic actions, for instance, the procedures, developed by means of the navigational aids, will be unavailable in case of their closing. Digital NOTAM will allow us to increase the accuracy of the information in a significant way while describing the NOTAM area of operation. The transfer of Digital NOTAM, in AIXM format, will be provided by means of the Internet, without use of AFTN, which will optimize the process of data exchange in a significant way.

The efficiency of using Digital NOTAM together with the up-to-date software and channels of communication was proved by Jeppesen, Luftfartsverket (LFV) and EUROCONTROL while researching and the following flight testing. The published NOTAM about closing the taxiway was accepted, processed, and displayed on the flight crew EFB screen [10] in real-time mode while flight testing.

[6] AIXM. AIXM Versions. Available at: https://www.aixm.aero/page/versions/ (accessed: 27.08.2021).
[7] Doc 8126: Aeronautical Information Service. Manual. (2021). 7th ed., ICAO, 660 p.

Fig. 6. Digital NOTAM, in graphical display

FAA is currently in process of shifting from the old U. S. NOTAM System (USNS) to a new updated Federal NOTAM System (FNS). Development of an updated NOTAM system resulted from the need to digitalize the processes of NOTAM gathering, distribution and storage. The purpose of FNS is in, creation of the integrated trustworthy source for NOTAM entering and distribution[8] in order to increase the NOTAM efficiency, safety, and quality of its information [11].

FNS consists of the complex of services and applications, allowing to create and distribute Digital NOTAM.

Digital NOTAM is created by means of:

- NOTAM Manager – web-application, allowing to create and manage Digital NOTAM;
- NOTAM Origination Service – web-application, allowing the third parties, for instance, companies, providing ATC services on airfield control towers, to create and manage Digital NOTAM;
- eNOTAM II – application for creating and non-digital NOTAM management.

Digital NOTAM distribution is provided by means of:

- NOTAM Search – web-application for Digital NOTAM searching, filtration and sorting. Digital NOTAM are presented in two textual formats: in standard one (only in capital letters) and

[8] Digital – AIM, Federal NOTAM System. The Federal NOTAM System Concept of Operations Description Available at: https://notams.aim.faa.gov/#Applications (accessed: 27.08.2021).

in a form of a common text (in capital and lowercase letters). There is also a opportunity of visualizing the Digital NOTAM information in aeronautical schemes, (fig. 6);

- FNS NOTAM Distribution Service – the intersystem interface, allowing the finite sets to get the Digital NOTAM from FNS.

FAA has implemented the FNS system in more than 339 US airports. Meanwhile it is planned to accomplish the full shift to FNS in August 2023. Consequently, the FNS system is currently warning the users that the NOTAM Search system cannot be used as the only source of information. At the same time European ATM Information Management Service (EAIMS), which will substitute EAD, is planning to provide the opportunity of encoding Digital NOTAM after 2022. Meanwhile it should be noted, that most countries are currently providing only statistic aeronautical data (AIP)[9] in digital form (AIXM), and the dynamic aeronautical data (Digital NOTAM)[9] is provided only by the US.

In order to update the current aeronautical information system, ICAO has decided that it was necessary to shift from the Aeronautical Information Service (AIS) concept to Aeronautical Information Management (AIM) [5]. The dynamic, integrated management of aeronautical information through the provision and exchange of quality-assured digital aeronautical data in collaboration with all parties.

The main purpose of the following shift is the digitalization of aeronautical information gathering and exchange between the sources and users of the data, by means of System Wide Information Management [12] (SWIM) concept principles. SWIM concept is intended for aeronautical, weather, flight and other information exchange harmonization between all the users, (fig. 7)[10]. The origination of the aviation intranet, based on the use of standard data models and internet protocols, in order to provide the supreme interoperability[10], is the main SWIM challenge. SWIM interoperability should be able to work at the large number of levels: legal, administrative, semantic and technical [13].

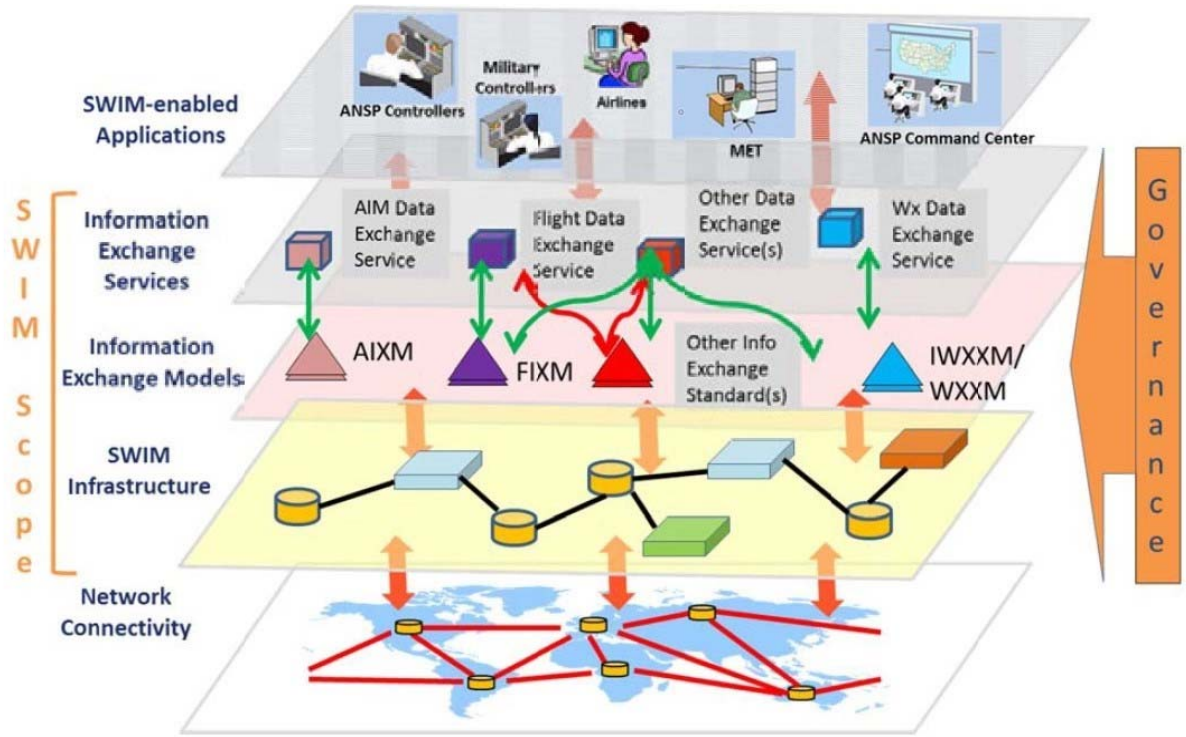

Fig. 7. SWIM concept

[9] Euro Doc 010. (2003) 2nd ed., Montreal: ICAO, 68 p.
[10] Manual on System Wide Information Management (SWIM) Concept. (2015). ICAO, 88 p.

Therefore, there will be a shift from the outdated communication channels (AFTN, SITA, etc.) and data formats to the SWIM aviation intranet with new digital standards of information exchange, which will allow to connect all the sources and users of information in one whole communication profile [14]. The SWIM concept, developed by EUROCONTROL together with FAA, was approved by ICAO and has become the inalienable part of the Global Air Navigation Plan (GANP) 2016-2030. It is planned to realize the SWIM concept by 2030[11].

CONCLUSIONS

Nowadays the NOTAM issues, are still an urgent topic in aviation, as NOTAM directly effects the flight safety and efficiency. These issues are a consequence of not only a human factor (incapacity or incomprehension of the NOTAM instrument), but also of the current NOTAM system technical restrictions: means of communication (AFTN) and NOTAM format. As a result, the up-to-date flight planning system allows us to solve the NOTAM problems only partly, as it is impossible to fully automate the NOTAM processing and accounting.

ICAO shift to AIM concept with use of SWIM is a crucial step to solving the NOTAM issues, as it will allow to increase the quality, promptness and availability of static and dynamic aeronautical data[5] in a significant way. AIM will also allow us to reduce the charges on developing and supporting the information systems, involved in performing the flights.

Digital NOTAM implementation should solve the technical part of the NOTAM issues, due to use of up-to-date means of communication (Internet) and new standards of information exchange (AIXM), which will have the increase in flight safety and efficiency as a consequence. Meanwhile the NOTAM issues, caused by the human factor, can be solved only if the NOTAM instrument is used correctly:

- Publishing of NOTAM only in case of real necessity, not for shifting responsibility from the airport administration or the aviation authorities to the aircraft operators;
- Making amendments in AIP or publishing SUP, AIC in good time, instead of publishing the NOTAM with a validity period of more than three months.

Solving the NOTAM problem, for its global and systemic nature, is possible only in case directly ICAO and the aviation authorities worldwide take part in it, in order to strengthen the control over NOTAM. As a result, it will become possible to reduce the number of NOTAMs, drawing the attention of the FDs and the aircraft flight crew to the crucial NOTAM.

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ВЛИЯНИЕ NOTAM НА БЕЗОПАСНОСТЬ И ЭФФЕКТИВНОСТЬ ВЫПОЛНЕНИЯ ПОЛЕТОВ (ОБЗОР)

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Целью данной работы является анализ и оценка влияния NOTAM на безопасность и эффективность выполнения полетов. Рассмотрены основные проблемы, связанные с NOTAM: количество NOTAM, практическое применение информации из NOTAM, технические ограничения текущей системы NOTAM. Приведены примеры негативного воздействия NOTAM на качество аэронавигационного обеспечения, безопасность и эффективность выполнения полетов. Также представлена практика решения проблем, связанных с NOTAM, в мире с помощью Q-code и систем планирования полетов (на примере

Lido Flight 4D). Представлена концепция Европейской аэронавигационной базы данных (EAD – European AIS Database), разработанная на основе Аэронавигационной модели обмена информацией (AIXM – Aeronautical Information Exchange Model). Рассмотрена концепция Digital NOTAM (цифровой NOTAM), реализованная на базе AIXM и предназначенная для обмена, автоматической обработки и интерпретации динамических аэронавигационных данных. Разобрана новая модернизированная система NOTAM – Федеральная система NOTAM (FNS – Federal NOTAM System), разработанная Федеральным управлением гражданской авиации (FAA – Federal Aviation Administration) США, позволяющая кодировать Digital NOTAM. Проанализированы планы ICAO по переходу от концепции Обеспечения аэронавигационной информацией (AIS – Aeronautical Information Service) к Управлению аэронавигационной информацией (AIM – Aeronautical Information Management) с применением принципов концепции Общесистемного управления информацией (SWIM – System Wide Information Management). В результате проведенного анализа текущей системы NOTAM и модернизированной системы NOTAM (FNS от FAA) были сделаны выводы о том, что внедрение Digital NOTAM должно решить техническую составляющую проблем, связанных с NOTAM, благодаря использованию современных средств связи (интернет) и новых стандартов обмена данными (AIXM), что приведет к повышению уровня безопасности и эффективности выполнения полетов. При этом проблемы с NOTAM, вызванные человеческим фактором, остаются неразрешенными по причине некорректного использования инструмента NOTAM.

Ключевые слова: NOTAM, Digital NOTAM, аэронавигационная информация, AIXM, SWIM, GANP 2016-2030.

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