RISK ASSESSMENT – STEP BY STEP IN IMPROVING SAFETY MANNER WITH REGARD TO VOLCANIC ASH CONTAMINATION

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Abstract:*With regard to the volcanic ash in the last 30 years there have been 10 serious accidents which led to engine failure.Dealing with hazards is always challenging to aircraft operation. Like icing conditions, wake turbulence or microburst, volcanic contamination poses operational risks that must be identified and mitigated in order to achieve a safe flight. Aircraft are not specifically designed nor certified for flight in a volcanic ash. Large variation in physical and chemical characteristics of the ash, type and condition of the engine at the time of impact and length of exposure makes it impossible to implement any simple approach to impact assessment. The challenge to all professionals with the argument of flight safety is the creation and establishment of standards for evaluation. Risk analyses and risk assessmentsare significant and fundamental base for identifying the steps needed in order to avoid and mitigatethe risks.*

Keywords: Hazards, volcanic ash, risk analysis, risk management, sources of volcanic ash

1. INTRODUCTION

Volcanic phenomena are common in some areas of the world. Traces of volcanic ash may be found in the atmosphere worldwide. With regard to the volcanic ash in the last 30 years there have been 10 serious accidents which led to engine failure. In all these cases, the crew managed to land the plane safely, but some of the incidents were very serious.

From 1980 to 2004, more than 100 aircraft suffered damage from flying through a cloud of volcanic ash. Repair and maintenance cost over $ 250,000,000 dollars. At least 7 of those 10 cases areclassifiedas engine failure on all engines. These failures were recorded at distances from 150 to 600 nautical miles from the volcano eruption and also damages to the aircraft have been registered and reported up to 1800 miles from the source.

2. APPROACH FOR DEVELOPING CONTINGENCY PLAN FOR ORGANIZATION AND MANAGEMENT OF AIR TRAFFIC IN TERMS OF VOLCANIC POLLUTION AT THE NATIONAL LEVEL

2.1 THE SCOPE

Several lessons learned from Eyjafjallajökull eruption crisis in 2010. First, all national and international regulatory bodies need to make a more serious effort to evaluate the risks to civil aviation of volcanic eruptions. Scenarios should consider eruptive sequences that are longer and more catastrophic than the events of April 2010. They should consider the widest possible range of pollution and also how the various agencies such as (EUROCONTROL, EASA, ANSP's, and Airlines etc.) should act together (Fig.1). Secondly, thresholds for safe flying should be more precisely defined on the basis of evidence-based practice and in close relation to appropriate meteorological and geological remote sensing. Thirdly, international coordination and regulation of European airspace needs to be expanded and more focused on natural hazards.

Fourthly, an integrated plan is needed at European (i.e. pan-national) level for cases in which air travel needs to be substituted by other modes of transportation[1].

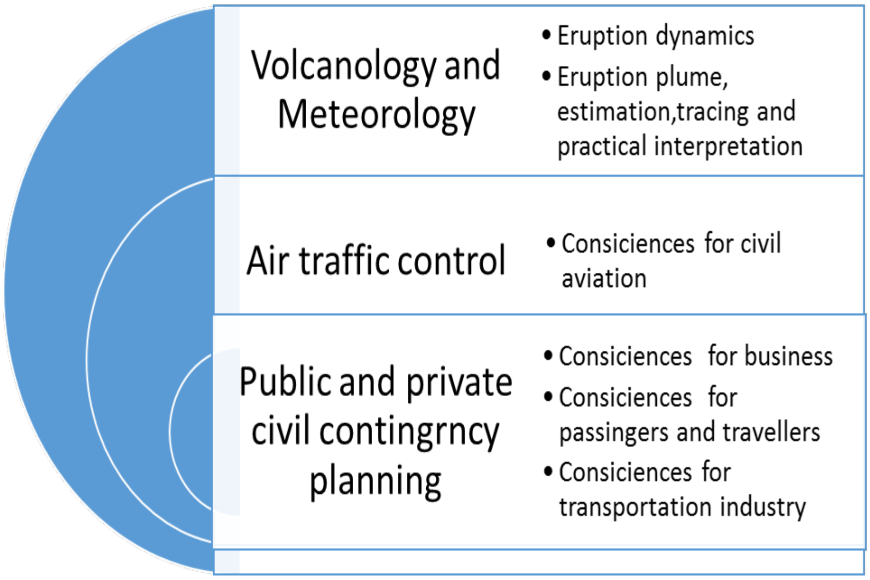

FIG.1. Schematic depiction of different competenciesand responsibilities in managing a volcanic ash emergencyfor civil aviation

Lessons learned from large-scale crisis should be evaluated and based on them to devise a national strategy which to include an action plan in the event of volcanic ash contamination. Apart from aircraft incidents involving volcanic ash, the aviation industry is now facing two newly recognized hazards.

Radioactive materials and toxic chemicals released into the atmosphere following industrial accidentshave the similar behavior as volcanic ash in terms of spreading. The accident at the Chernobyl nuclear power plant in 1986 and Japan's Fukushima nuclear plant in 2011 where a cloud of radioactive debris spread across international borders caused difficulties for aircraft operations and brought attention to the potential risk for en-route aircraft to destinations which are in the path of such radioactive clouds.

The actions that need to be taken from the control and interested / affected parties must follow the mandatory SARS of ICAO Annexes and documents related to the safety.

The establishment of the Volcanic Crisis Plan (VCP) on the national level for organization and management of aviation industryare needed as a strategic platform for future actions. In addition, there are economic costs associated not only with the rerouting of aircraft and delays in the air traffic system, but also with physical damage to the aircraft and its equipment.

The scope of the action plan applied to aviation should be directed to the aviation players at strategic and tactical levels with clearly defined duties and responsibilities.

Identification of the parties at the national level in terms of responsibility and actions in case of volcanic pollution in the Republic of Bulgaria are shown (fig.2):

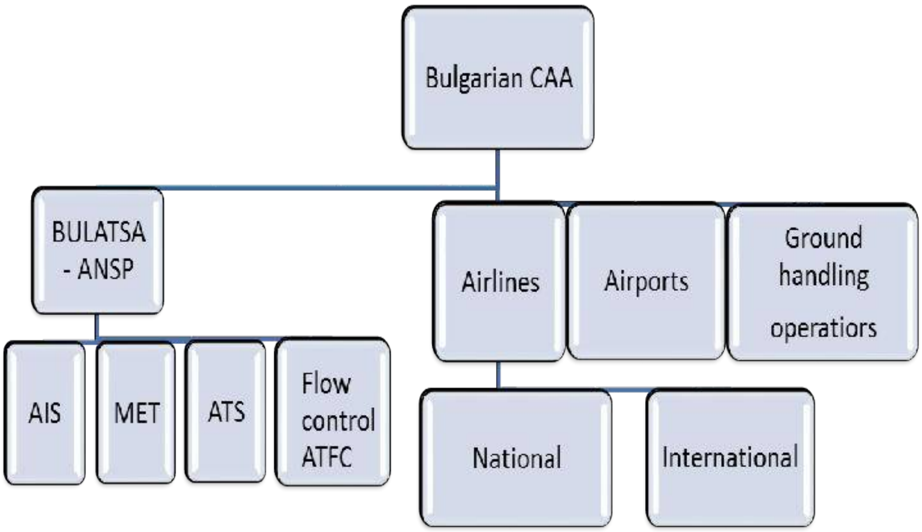

FIG. 2.Organogram of theinvolved parties in case of volcanic ashwith regard to Bulgarian law

2.2 THE METHODOLOGY

The methodology must be based on implementation of principles of Operational Risk management (ORM) as a well-based platform for development of VCP. Risk management must be a fully integrated part of planning and executing any operation, routinely applied by management. Determination of risks, with analysis and control of the hazards create adequate reaction and real actions in case of appearance of some adverse conditions in aviation system in general [2].

The VCP should be based on somepre-developed assessments and analysis in terms of presence of volcanic ash.The complexanalysis and research should be based on pre-assessment of behavior of natural disasters as identification of sources of volcanic ash, detailed analysis of every source as a probability of volcanic eruption, probability of volcanic eruption with fixed VEI and etc.

As a scientific approach is considered global assessment of disaster risk (GAR) reduction. The assessment includes the results of probabilistic risk assessments across a range of hazards including volcano eruption.

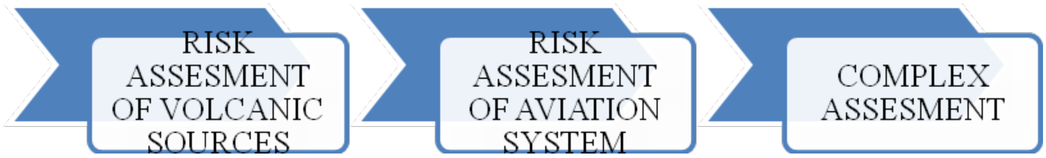

FIG. 2. Flow chart diagram for developing of risk assessment processwith respectto volcanic ash

The methodology for development of Volcanic Crisis Plan is the establishment of dynamic conceptual model for assessment of how to volcanic ash is affecting the aviation industry

The major elements of the model are:

- BUSINESS CASE, containing an assessment of the business environment, the possible scenarios and their economic dimensions in case of presence of volcanic ash;
- SAFETY CASE - a safety organization and management of flights in all aspect - from the maintenance of aircraftto the flights;
- HUMAN FACTOR CASE - contains an assessment of the human factor in process and impact on human from health aspects to the passenger's satisfaction in case of volcanic ash;
- ENVIRONMENT CASE - assessing the impact of volcanic ash on the environment in the large scale limits-from nature of disaster to environment aspect of behavior of impacted population in case of presence of volcanic ash.

The general model provides on fig.2 is a framework for analyzing systems and determining the relationships between the elements that work together to perform the tasks.

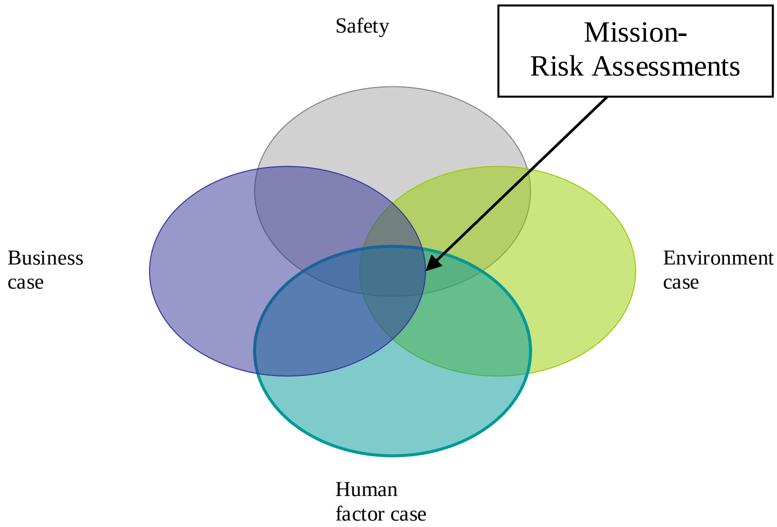

FIG.3. Collaboration between cases

The results of the interactions of four cases form the "Mission" as real operations environment that should be applied for Risk management [3].

3. RISK ASSESSMENT – IN CASE OF VOLCANIC ASH CONTAMINATION

3.1 DATA ANALYSIS

Risk identification is the process of finding, recognition and recording risk. Risk analyses consist of determining the consequences and their probabilities for identified risk events. The consequences and their probabilities are combined to determine a level of risk. The main tasks include identifying of causes and sources of risk [4].

Based on statistical data base of Smithsonian Institute, USGS, USA sources of volcanic ash for Europe are defined as 37 active volcanoes.

Measuring the size or strength of natural events has always been a challenge for natural scientists.Volcanic eruptions produce different types of products, have different durations and develop in different ways. The primary eruption characteristic used to determine the volcanic explosivity index is the volume of pyroclastic material ejected by the volcano. The height of the eruption column and the duration of the eruption are also considered in assigning a VEI level to an eruption. The VEI scale begins at 0 for eruptions that produce less than 0.0001 cubic kilometer of ejecta. Eruptions rated at VEI 1 produce between 0.0001 and 0.001 cubic kilometers of ejecta. Above VEI 1, the scale becomes logarithmic, meaning that each step in the scale represents a 10X increase in the amount of material ejected. VEI 2 eruptions produce between 0.001 and 0.01 cubic kilometers of ejecta. VEI 3 eruptions produce between 0.01 and 0.1 cubic kilometers of ejecta.

3.2 CLASSIFICATION OF SOURCES OF VOLCANIC ASH FOR BULGARIAN AIRSPACE

For detailed assessment of volcanic sources for Europe are usedthe Smithsonian Institution's Global Volcanism Program (GPV) catalogue of Holocene USGS, USA.The GVP reports on current eruptions from active volcanoes around the world and maintains a database repository on historical eruptions over the past 10,000 years.

The analyses of all possible sources of volcanic ash, which may impact to Bulgarian airspace, are recognized 37 sources. In fact, for 25 of them there arefully recorded records. For scope of this researchare used all records from A.D. to 2013. The number of all eruption in Europe for this period is 533. As the feeble explosive eruptions are classified417 as well the intense are 59 eruptions. The results include only classified examples with VEI 1 to VEI 7, despite existing 21 examples with VEI 0.Accordingthe most important characteristic of volcanoes - volcanic explosive index (VEI) and frequency of eruption, the most significant volcanoes in the region of interest (Bulgarian airspace) are selected in table 1. In respect of volcanic ash and spread of volcanic clouds forming in atmosphere, the major sources for Bulgarian air space are:

Table.1 Major sources of volcanic ash for Bulgarian air space

Volcano	Volcanic explosive index**VEI**	Frequency of eruptions
Etna, Italy	1,2,3	167
Stromboli, Italy	2,3,4	11
Vesuvius, Italy	1,2,3,4,5	54
Bardarbunga, Island	1,2,4,6	31
Grimsvotn, Island	1,2,4	46
Eyjafjallajokull, Island	2,3,4	4
Santorini, Greece	2,3,4	10
Furnas, Portugal	3	6

Regarding VEI the volcanic eruption may divide in two groups.

- Feeble explosive volcanic eruption –
  VEI 1to VEI 3
- Intense explosive volcanic eruption - VEI 4 to VEI 7

The identified sources are grouped in two zones with respect of distance to the region of interest:

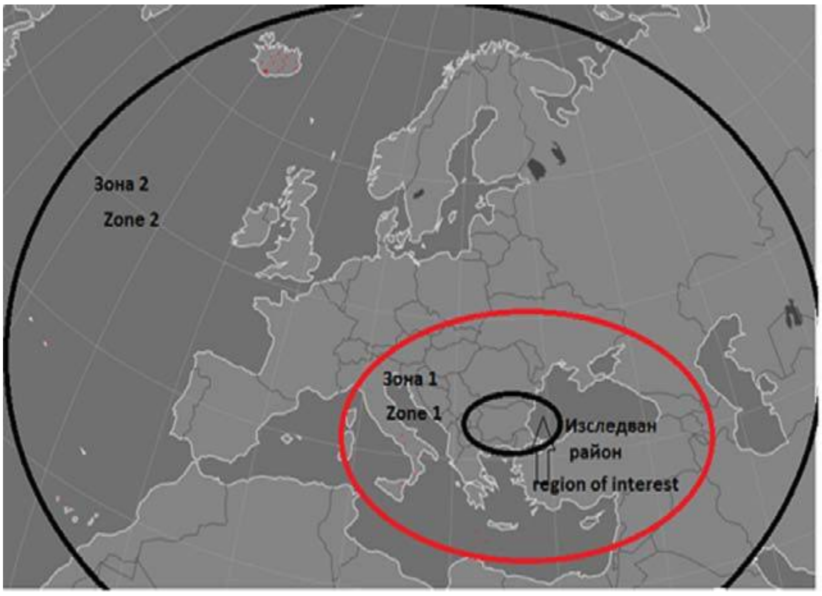

FIG.4. Scheme of potential sources of volcanic ashand region of interest

In fact, the distance is one of the major parameter that provides information and defines the necessity of prospective measures in applying VCP contingency plan.

The lessons learned after Eyjafjallajökull eruption in 2010 are shown that despite of the significant distance from the source of volcanic ash to the region of interest, the impact on aviation might be devastating.

4. CONCLUSIONS

The risk assessment of sources of volcanic ash and identifying of different scenarios in case of presence of volcanic ash is one of the most important tasks for aviation community.The risk assessment must include clearly definable scenarios, and must result in recommendations to all aviation personal dealing with the risk, on real actions, training and other forms of mitigations.

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