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CASE STUDY

Evaluation of the Critical Infrastructure's Vulnerability in Opposition to Human Threats

Case study: Non-militant international airports

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ABSTRACT: In this research, the quantitative and qualitative of the vulnerability of the nonmilitant airports against human threats is being evaluated based on the principles of passive defense. Airports are known to be one of the symbols of development in order for being capable to transfer high capacity of passengers and goods between long distances in the least required time. Non-militant airports are considered as one of the most valuable sources of finance in any country and the slightest deterioration in its function of damage of any kinds would cause substantial loss to the nation. The pattern of the applied research and the methodology of the current research AHP-FEMA technique has been used to analyze. The results show that most are ill prepared. The results prove that air strikes and bombings bring the most damage to the non-militant airports, according to the 15 specified key assets. Thereupon each of the primary elements of the airport will be analyzed.

Key words: passive defense, non-militant airports, vulnerability, human-made threats, AHP-FEMA technique

RUNNING TITLE: Critical Infrastructure's Vulnerability in Opposition to Human Threats

INTRODUCTION

Infrastructures or vital routes, including physical and immaterial, systems and assets, are considered urgent for any nation, and whatever form of the disorder in their services can have serious impacts on national security, economic welfare, public health and also a combination of the above. (Zhang et al, 2015:7). These infrastructures are used for production and distribution of goods and services in urban areas, and the possibility of living in any city depends on the quantity and quality of the functioning of these areas (Stephen, 2007:5). With a glance to the combats in the last few decades, we can conclude that the enemies always focused on invading the vulnerable infrastructure, in order to defeat the aimed country with the least cost and effort and to deprive the country defending itself, therefore one of the appealing structures for invasion are airports, the strategy will be helpful since it destroys any entrance of third rings , and any kind of damage to the buildings will cause disturbance to the transportation, assistance and support services to the country, as a matter of a fact the country has ill gone through great material and immaterial losses. (Attaei, 1394:35). The diversity and complexity in the structure of the airport, largely threatens the operations within the airport. (Li and Xu, 2015:780). Divisions of the airport, for example, the runway, control tower, terminal cargo, the mechanical and electrical installations, the counselling and control system and the remaining sections of the airport are at high hazard of being attacked through missiles, terrorist act, sabotage, cyber threats, bioterrorism etc. therefore the affected

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of thea affected will be affected, thus resulting in losses. Ting in losses. Therefore, measuring the vulnerability due to human threats becomes necessary. On an everyday basis we witness destructions of national infrastructures of countries due to bombings, this disaster are still going on and will go on. Since the critical infrastructures of each country are programed to be netted and tied in synergy with the continuation and development of the country's economic, societal, political affairs, the importance of each of the infrastructure should be determined (Shahbazi and partners 1390). Hence, we can conclude that, infrastructures such as airports need to be examined and their vulnerability towards human threats need to be assessed, in order to do so, we need to percept the weaknesses of the transportation infrastructures and specify its magnetization for the enemies and aleastst provide a passive defense solution to reduce the vulnerability. Passive defense is considered as a platform for sustainable development and is one of the most effective and most efficient methods of defense against threats and basically, the plans and journeys taken for passive defense, include various areas such as structures and terrestrial infrastructures, for instance, airports (Ghazanfari 11:1392). In the rest of the research, we analyze available resources about the vulnerability of airports and approaching passive defense. In an article entitled "Assessing the vulnerability of aviation infrastructure against terrorist threats," Cioaca explores the possible risks threatening airports, especially passenger terminals, and offers solutions to thwart or mitigate the effects of terrorist threats on the terminal (Cioaca 2013:145). Wood explains the relationship between different uses and the integrated management of the airport against terrorist threats in an article entitled "Airport Design and Operation with System Security Approach." The author has a new approach to the airport by overcoming the traditional view of the airport that limited it to the runway and the terminal. In this new approach, the airport is seen as a complex system of very important equipment, and fundamentals of a region that has the potential for irreversible damages towards terrorism (Wood 2005:14).

Alcaraz and Zeadally in the article "Protecting Sensitive Infrastructure: Requirements and Challenges of the 21st Century" believe that critical infrastructure plays important roles in supporting the modern company. Reliability, performance, service continuity, safety, maintenance, and infrastructure protection are among the national priorities for countries around the world. Researchers have addressed the vulnerabilities and threats faced by the sensitive modern infrastructures with an emphasis on industrial control systems and their protection strategies, and also pointed to a number of challenges in this area, such as security management (Alcaraz and Zeadally, 2015:58). In another article "Analysis of the vulnerability of vital infrastructures against defensive attacks and planning" Brown & partners outline the human threats and according to the threats, solutions are presented to reduce the vulnerability. Terrorist threats and bombings are known to be the center of hazards, as a solution for intelligent locating technology was given (Brown and partners 2005:127). Li and Xu in the article "Analysis of the Airport Network Vulnerability Based on Phase Logic: From a Structural and Functional Perspective" express that the recently reliability and vulnerability of the infrastructures were highly attended to. In air traffic systems, vulnerability analysis for airport networks can be applied to direct air traffic organizations and, most significantly, in airport maintenance, as considerably as to avoid unnecessary disruptions in flight scheduling programs. In this article, in the first stage, the importance of airports assessing indicators from both topological and functional points of persuasion will be acquainted. In the second stage, an integrated assessment method based on the phase one theory for the identification of the important airports, according to the first phase airports were presented and in the third stage, in society to assess the accuracy of the selected methods, China's and the United States airports compared and the geographic differences and similarities were discussed (Li and Xu, 2015:781). Most of the researches on this topic have paid attention to comprehensively look at the general characteristics of the airports, and at higher levels assessing the vulnerability was

on top of their agenda. But in this research, each of the components of the airports was examined and the vulnerability of each to human threats were extracted.

MATERIALS AND METHODS

The present study seeks to investigate the existing conditions and extract the vulnerability of the components of the civilian airports against human threats. Accordingly, the chosen research methodology is a descriptive method. In order to collect and analyze data in a research, quantitative and qualitative approaches can be used (Hafez Nia, 1389:52). Which in this research a combination of the quantitative and qualitative method was employed. In order to extract the inconveniences caused by their occurrence and ways to reduce vulnerability with the interview method (qualitative) and also for assessing the vulnerability the number of damages w extracted with the questionnaire method (quantitative) by the techniques given through the Federal Agency for Crises Management of the United States. The statistical community is a group of almost 150 experts in this study who have worked in fields of passive defense and airport designing together and are experienced in these areas. Accordingly, around 100 experts complete the expert community, which out of them 48 experts selected the Cochran's sample method.

Analysis method

In this research, the AHP-FEMA methods were used for analyzing the data. After distributing the questionnaire and evaluating the vulnerability of the non-militant airports, and fulfilling it with the research community, the average result given by the experts is based on the Likert spectrum that is known as the FEMA method. But the provided results through this method is not effective enough for assessing the threats of civilian airports since the weight of the indicators not specified. Therefore, by considering the weight of each of the indicators, we can obtain an appropriate level of assessing the vulnerability of the civilian airports, which can be done using the AHP method.

Theory

Assuming that the dimensions of the occurrence of the threats in areas were studied, and results of the possible damages were attained, we can introduce, define and develop the levels and types of coping with each of the inconveniences. Therefore, it seems that pathologic studies are second most integral part of the defense study (inactive and passive) (Hosseini 1389:32). The vulnerability is not static phenomena, but it is a dynamic process, and that affects the damages it might cause. The researchers insist on two types of vulnerability. Firstly, the vulnerability of people in return of the disaster, and to what extent they might be at risk and overcome them. And secondly, the vulnerability of organizations and systems such as water equipment, emergency networks, hospitals, against disasters (Bull-Kamanga et al, 2003: 194). The vulnerability is an analytical tool in urban safety studies. Vulnerability analysis and evaluations provide a new foundation for urban planning (Chunliang et al, 2011:278).

The vulnerability consists of two parts: Capacity and Resilience.

The extent to which the community, people or organizations have the capacity to get damaged in front of the crises that threaten them. Capacitance can be analyzed from two positive and negative views, from the negative point of view its proximity to the planer fracture and the positive point of view its easy access to a geographic region (Snaider, 2004:10). Resilience is the level to which the society, organizations, and groups can adapt to the threats caused by the crisis in bearing the damage, repair, recovery and exit the emergency.

Resiliency can be considered as an indicator for measuring the speed of a system in its recovery from crises. The greater the resilience, the less damage, and the easier to recover, and the easier to return to its initial state. For example, carrying out various activities, such as building rehabilitation, first aid education, firefighting and insurance installation, all increase the resilience of the community (Bakel, 2000:262). According to the above definitions of the vulnerability analysis is

determined by the extent of the ability of a community, individual or organization to damage from the probabilistic hazard and its resistance against the crises that it encounters. The degree of vulnerability can be calculated by multiplying the capacity into resilience (Handmer,2002:49). The procedure that tries to hide the threats from the vulnerability is passive defense. Passive defense reduces the destructive effects in development paths by reducing vulnerability (Shamsaei, 1390).

The points that are considered to reduce vulnerability are (Jalali, 1390):

- ✓ Reducing the risk and danger degree
- ✓ Reducing threats and attacks
- ✓ Reducing loss to places and installations
- ✓ Reducing human loss
- ✓ Reducing equipment loss

As a consequence of reducing vulnerabilities, is fixing the designing weaknesses, using, and operating the assets in order to shorten the loss of assets. One of the vital assets of each country is its airport. Airports are divided into military and civilian based on their type of employment. The purpose of the civilian airports is the spatial-space based services, that serves civilians in order to establish air connections between different parts of the earth.

Nowadays, the relevant airports and communication networks must have the ability to continue their activity at the time of crisis, and this should not be as an option but an undeniable necessity which needs to be pursued and consisted upon (Alexander and Young 2004). The existence of valuable assets and large investments in facilities, construction, communication equipment, telecommunication and navigation, passenger aircraft and expertly trained personnel at the airports of the country have made the continuity of airport activities at times of peace and crisis one of the main concerns of the authorities. Achieving this goal will not be possible except by applying passive defense principles.

The application of passive defense in the vital infrastructures makes crisis management easier to apply and with reducing the risk of attacks to the airports will have negative consequences for the enemies, and in case of possible attacks, the enemies will suffer a great loss before they reach their goals (Abazarloo 1359:54). Furthermore, since the air transportation infrastructures such as airports, is a prerequisite for a balanced development in other sectors and provides the foundation of economical, political, cultural and social development and increase in country's national security, it is necessary to consider the requirements and considerations of passive defense at all levels of its implementation. (Cioaca, 2013)

Analysis

Main components of non-militant airports

These airports are usually divided into the air and land use (Safarzadeh and Masoumi 1383:83). The aerial part separates the land, space, facilities, and equipment that are directly in connection with boarding and take off services from the ground with the security control stations (Graham, 2008:102). The land part refers to a set of building, facilities, and equipment that are blocked by physical borders or security control stations which are separated from associated levels by the aircraft. The land section is responsible for providing services to its clients from the city and aircraft from the apron (Kazda and Cave, ,2007:56).

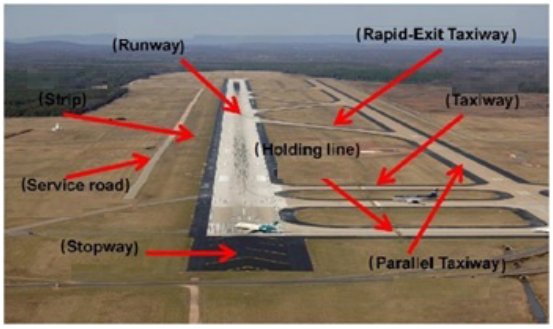

Fig 2: Parts of Airport Runway

A- **Runway**
The boarding and take-off area of the airplane is known as the runway, which can be made of asphalt or concrete. The runways are identified by 2 digit numbers (Vali, 1392)

B- **Aircraft-stand (Apron)**
This area is located in a suitable area near the airport terminal for a temporary stay of the airplanes and also used for loading operations, getting in and out of the plane to the passengers, park, repair and refueling the airplane (Alexander and Young, 2004).

C- **Flight route control unit**
This unit includes the navigation assistance system for guiding planes and detecting the radars. Figure-2 shows a view of the flight control unit and its related equipment (Alexander and Young, 2004).

D- **Flight control unit**
At airports with higher flight rates and also areas in which air traffic volume is high due to several airports being in one region, in order to coordinate the flight route control unit and the flight control unit, and for higher security the route control unit and the control unit guide the air traffic (Alexander and Young, 2004).

E- **Flight control tower**
The flight control tower is responsible for guiding their traffic in a cylindrical form (flight funnels) around the airport within a specified height (Vali, 1392)

F- **Service and repair unit**
This place is designed for providing the airplanes maintenance and repair services, and this area holds various aircraft in the air-space of the airport (Vali, 1392)

G- **Ground and fire safety**
This unit operates full-time and insures the safety of the airport with the airplane, machinery, a piloting system, and other sensitive and advanced systems (Alexander and Young, 2004).

H- **Terminal**
The terminal connects the ground access system with the air components. This space includes facilities and equipment for processing the passenger's entrance and exit and transiting passengers and cargo into and out of the airplanes. And also, a part of the administrative and operational task is done in the terminal (Vali, 1392)

I- **Airport facility**
Airports usually include a batch of facilities and buildings that provide basic facilities such as water and wastewater network, power stations, gas supply networks, telecommunication system, lighting system, heating and cooling system, and primary platform for activities in the airport (Alexander and Young, 2004).

J- **Fueling unit**
This unit is responsible for providing, carrying, storing and transferring the needed fuel for the airplanes to the airport (Safarzadeh and Mousavi, 1383:690)

K- **Weather forecasting unit**
In order to control air traffic, verified information on the weather forecast is needed, so any inconvenience in the weather can be detected and informed to the pilots at the least time (Safarzadeh and Mousavi, 1383,691).

L- **Security and police**
In order to control and monitor different parts of the airport, the security guard and airport police are responsible to centrally interact and cooperate with each other to prevent any disruption in airports security and pattern (Vali, 1392).

RESULTS AND DISCUSSION

Vulnerability indicators and criteria
In this research, field analysis and qualitative analysis of information have been used to extract the damages to the main components of civilian airports. Obviously, in order to extract the vulnerability in an infrastructure, we need the criteria to measure the vulnerability, which will be elaborated in this research. On a note, the indicators are divided into 5 categories of very high to very low, and the highest and lowest scores are marked 10 and 1 respectively. In the following, each of the components of the

airport in relation with vulnerability indicators extracted using the Delphi method.

♦ **Encountering the weakness**

It is used in terms of strength or weakness, facing the vital assets. The force of confronting depends on inherent factors are environment such as (Jalali,1391:130):

a) Inherent factors: being small, wide, hard, costly
b) Environmental factors: regional integration, defense requirements

♦ **Accessibility**

Access to assets depends on the availability of assets in the event of an attack. In this paragraph, we mean the location of the assets and the obstacles in front of the enemy. So that the proximity or being far from the source of the threat, and presence or absence of the obstacles, will result in either increase or decrease in vulnerability. The goal will be achievable if they enemy can reach and carry out the mission properly with sufficient manpower and equipment. Generally, ease of access or difficulty of moving and approaching the target means available (Jalali 1391:132). The basic steps in recognizing accessibility are:

a) Penetration and infiltration from the source to the target area and movement from the point of entry to the target area
b) The movement towards the vital parts of the targeted area, and exiting and escaping the target area

♦ **The ability to discover and identify**

The ability to identify depends on the use of camouflage, closure and coverage principles. So if any of these factors are considered more and more, the probability of the vulnerability will be reduced. This parameter, depends on the material of the threat, the size of the target and even the weather conditions. The ability to detect and identify the target depends on the extent of detection through the sources, the equipment, and identifying system and intruding information in different situations. The weather condition has a significant role in visibility; rain, snow, fog & etc. makes visibility harder. Other factors such as distance, light, and seasons also affect the identification process (Jalali, 1391:133).

The qquantitative, analyzing the vulnerability of the components of nonmilitant airports

In order to validate the results of the vulnerability assessment, vulnerability analyzes indicators should be measured. This is because the impact of each indicator is as high as its weight in assessing the vulnerability of the threat posed to the components of civilian airports. This is because not all indicators are equal. In order to determine the weight of each of the indicators, after setting the questionnaire, the results were extracted using the AHP method in the EXPERT CHOICE software.

Preference	Vulnerability analyzing indicator	weight
1	Accessibility	630/0
2	Encountering the weakness	242/0
3	Protection and defense weakness	092/0
4	Detecting and identifying the ability	036/0

Tab 1: prioritizing the indicators of the analyzed threats affecting the civilian airports.

After distributing the questionnaire for assessing the vulnerability of components of civilian airports and completing it by the community of research experts, raw scoring and scoring by the weighting of the indicators are presented in Tables 2 and 3. As you can see, the Likert scale has been taken into account, which is common in the FEMA risk assessment methodology. Table 2 assesses the vulnerability of all components of civilian airports against harsh, medium, soft and special threats.

row	Indicators threats		Indicator's measure	Encountering the weakness	Protection and defense weakness	Accessibility	Detection &	Total score
			242/0	092/0	630/0	036/0		
Flight runway, Taxiway, Apron	Hard	Air, missiles, sea, and land strikes	42/2	10 736/0	8 78/3	6 324/0	9	26/7
	Medium	Electromagnetic and graphite bombs	242/0	1 184/0	2 15/3	5 288/0	8	864/3
	Soft	Human Influence - Chaos, Confusion of Technical Sabotage - Economic Sanctions	484/0	2 276/0	3 41/4	7 288/0	8	458/5
	Special	Bombings - suicide attacks and explosives - hostage-taking, special operations	726/0	3 460/0	5 04/5	8 288/0	8	514/6
Navigation equipment (radars)	Hard	Air, missiles, sea and land strikes	178/2	9 736/0	8 67/5	9 252/0	7	836/8
	Medium	Electromagnetic and graphite bombing	42/2	10 736/0	8 67/5	9 288/0	8	114/9
	Soft	Human influence and technical inconvenience	726/0	3 276/0	3 15/3	5 216/0	6	368/4
	Special	Cyber terrorism	936/1	8 46/0	5 78/3	6 252/0	7	428/6
Flight control unit and tower	Hard	Air and missile strike	694/1	7 644/0	7 78/3	6 144/0	4	262/6
	Medium	Electromagnetic and graphite bombing	936/1	8 644/0	7 78/3	6 18/0	5	54/6
	Soft	Human Influence - Chaos, Confusion of Technical Sabotage - Economic Sanctions	452/1	6 644/0	7 04/5	8 288/0	8	424/7
	Special	Bombings - suicide attacks and explosives - hostage-taking, special operations	178/2	9 736/0	8 67/5	9 288/0	8	872/8

Special equipment storage	Hard	Air and missile strike 694/1	7 552/0	6 04/5	8 288/0	8	574/7
	Medium	Electromagnetic and graphite bombing 452/1	6 552/0	6 26/1	2 216/0	6	48/3
	Soft	Human influence, theft, and chaos 726/0	3 276/0	3 52/2	4 216/0	6	738/3
	Special	Biological threats - bombings - suicide attacks and explosive shipments 936/1	8 552/0	6 78/3	6 252/0	7	52/6
Power plant and electrical installations	Hard	Air and missile strike 694/1	7 736/0	8 52/2	4 216/0	6	166/5
	Medium	Electromagnetic and graphite bombing 936/1	8 552/0	6 67/5	9 288/0	8	446/8
	Soft	Human influence and technical sabotage 726/0	3 368/0	4 89/1	3 216/0	6	2/3
	Special	Cyber terrorism and bombing 178/2	9 736/0	8 78/3	6 252/0	7	946/6
Flight control tower	Hard	Air and missile strike 936/1	8 552/0	6 04/5	8 324/0	9	852/7
	Medium	Electromagnetic and graphite bombing 484/0	2 184/0	2 26/1	2 288/0	8	216/2
	Soft	Human Influence - Chaos, Confusion of Technical Sabotage - Economic Sanctions 726/0	3 184/0	2 26/1	2 216/0	6	386/2
	Special	Cyber-terrorism - Threats to bombings and acts of terrorism - Suicide and bombing attacks 178/2	9 644/0	7 78/3	6 288/0	8	89/6

Land security unit	Hard	Air and missile strike 936/1	8 460/0	5 41/4	7 252/0	7	058/7
	Medium	Electromagnetic and graphite bombing 484/0	2 184/0	2 26/1	2 216/0	6	144/2
	Soft	Human influence - technical sabotage and economic sanctions 726/0	3 184/0	2 630/0	1 216/0	6	756/1
	Special	Threats to bombings and their acts - suicide attacks and explosive shipments 178/2	9 736/0	8 15/3	5 252/0	7	316/6
Passenger terminal and car parking	Hard	Air and missile strike 42/2	10 736/0	8 41/4	7 324/0	9	058/7
	Medium	Sound bombs 484/0	2 184/0	2 26/1	2 252/0	7	144/2
	Soft	Rebellious parade, chaos, confusion, physiological parade 21/1	5 184/0	2 15/3	5 252/0	7	756/1
	Special	Biological threats (bioterrorism, contaminated materials and commodities, outbreaks, etc.) - Threats to bombing - Suicide and bombing attacks - Hijacking, kidnapping, murder, assassination 936/1	8 644/0	7 67/5	9 324/0	9	316/6
Flight installation canal	Hard	Air and missile attacks 726/0	3 184/0	2 26/1	2 072/0	2	242/2
	Medium	Electromagnetic and graphite bombing 242/0	1 184/0	2 630/0	1 072/0	2	128/1
	Soft	Human influence and technical inconvenience 936/1	8 368/0	4 78/3	6 18/0	5	264/6
	Special	Bombing – explosive cargo 968/0	4 552/0	6 52/2	4 144/0	4	184/4

Administration building	Hard	Air and missile attacks 968/0	4 184/0	2 26/1	2 144/0	4	556/2
	Medium	Electromagnetic and graphite bombing 484/0	2 184/0	2 26/1	2 18/0	5	108/2
	Soft	Spy and Human Penetration - Technical Sabotage 936/1	8 552/0	6 04/5	8 252/0	7	78/7
	Special	Cyber terrorism - Biological threats - Bombing ٤٢/٢	10 736/0	8 78/3	6 216/0	6	152/7
Repair unit	Hard	Air and missile attacks 936/1	8 644/0	7 04/5	8 36/0	10	98/7
	Medium	Electromagnetic and graphite bombing 452/1	6 460/0	5 26/1	2 216/0	6	388/3
	Soft	Human Influence - Technical Sabotage - Economic Sanctions 968/0	4 460/0	5 89/1	3 216/0	6	534/3
	Special	Threats to bombing - suicide attacks and explosive shipments 42/2	10 736/0	8 15/3	5 324/0	9	63/6
Fueling area	Hard	Air and missile attacks 178/2	9 736/0	8 78/3	6 324/0	9	018/7
	Medium	Electromagnetic bombing 242/0	1 092/0	1 630/0	1 144/0	4	108/1
	Soft	Human influence- technical influence 484/0	2 184/0	2 26/1	2 144/0	4	072/2
	Special	Threats to bombing - suicide attacks and explosive shipments 42/2	10 736/0	8 04/5	8 288/0	8	484/8
Service pavilions	Hard	Air and missile attacks 42/2	10 736/0	8 15/3	5 252/0	7	558/6
	Medium	Sound bombing 968/0	4 092/0	1 630/0	1 144/0	4	834/1
	Soft	Spying and human penetration 484/0	2 184/0	2 26/1	2 252/0	7	18/2
	Special	Bombing-suicide attacks and explosives-hostage-taking, kidnapping, terror 936/1	8 460/0	5 04/5	8 288/0	8	724/7

Security and police unit	Hard	Air and missile attacks 42/2	10 736/0	8 78/3	6 252/0	7	188/7
	Medium	Sound bombing 968/0	4 184/0	2 26/1	2 108/0	3	52/2
	Soft	Spying and human penetration 484/0	2 184/0	2 26/1	2 144/0	4	072/2
	Special	Threats to bombing - suicide attacks and explosive shipments	8 368/0	4 04/5	8 288/0	8	632/7
Water tanks and refinery	Hard	Air and missile attacks 178/2	9 736/0	8 78/3	6 288/0	8	982/6
	Medium	Sound bombing 936/1	8 552/0	6 89/1	3 252/0	7	63/4
	Soft	Spying and human penetration 21/1	5 276/0	3 89/1	3 18/0	5	556/3
	Special	Threats to bombing - suicide attacks and explosive shipments 42/2	10 552/0	6 04/5	8 288/0	8	3/8

Tab 2: Analyzing the vulnerability against threats by using indicator weights

Furthermore, the basic damage to each of the nonmilitant airport parts against threats is cited and shown in table 3.

Row	Vital parts of the airport	Basic vulnerability against threats
1	Flight runway, Taxiway, and apron	Air, missiles, sea, and land strikes
2	(Navigation equipment (radar	Electromagnetic and graphite bombing
3	Flight control unit and tower	Bombings - suicide attacks and explosives - hostage-taking, special operations
4	Special equipment storage	Air and missile strike
5	Power plant and electrical installation	Electromagnetic and graphite bombing
6	Flight control tower	Air and missile strike
7	Land and fire security unit	Air and missile strike
8	Passenger terminal and car parking	Air and missile strike
9	Installation canal	Human penetration and technical inconvenience
10	Administration building	Spying Human penetration and technical inconvenience
11	Maintenance and repair building	Air and missile strike
12	Fueling area	Bombing - suicide attacks and explosive shipments
13	Service pavilions	Bombing - suicide bomber and explosives, hostage-taking, kidnapping and assassination
14	Police and security unit	Bombing - suicide attacks and explosive shipments
15	Water tanks and refinery	Bombing - suicide attacks and explosive shipments

Tab 3: Basic vulnerability to each of non-militant airport parts

Qualitative analyzing the vulnerability of the components of nonmilitant airports

Based on the results of quantitative analysis in the previous section, primarily, based on these threats, the current status of each asset against the main threats of the same component is analyzed qualitatively and their weaknesses are extracted. In Table 4, vulnerabilities are expressed in terms of assets.

Row	Critical parts of airports	Effective threats	Vulnerability
1	Flight runway, Taxiway, and apron	Air and missile strike	Creating explosive hollows in the runway - Exposed to the waves and the abandonment of parked airplanes in the apron - discontinue flying operations
2	Navigation equipment ((radar	Electromagnetic bomb	Termination of telecommunication systems, radio navigation
		Air and missile strike	Destruction of navigation equipment and radars
		Spying and technical inconvenience	The temporary shutdown of navigation equipment and radar
3	Flight control unit and tower	Technical incon-venience	The temporary shutdown of flight attendants console
		attacks Cyber	Observation of flights and disturbance in airport operation
		Electro magnetic bombing	Termination of flight control tower
4	special equipment storage	Air and missile strike	Structural destruction and destruction of warehouse equipment
		Explosives	The destruction of equipment and causing a fire
5	Power plant and electrical installation	Electromagnetic and graphite bombing	Termination of power plant systems and the interrup-tion of the airport's power grid
		Cyber attacks	Disturbing electricity by hacking
		Air and missile strike	The physical destruction of the power plant and the failure of the power plant and the stopping of the airport operation
		Terror bombing	Partial degradation of a part of the power plant and temporary terminating electric power

6	Flight control tower	Air and missile strike	Death and injury of human employees control tower – physical damage to control tower – the failure of a few types of equipment – discontinuation of flight operation
		Terror bombing	Minor physical damage to the control tower- short time flight operation parking
7	Land and fire security unit	Air and missile strike	Physical destruction of structures and destruction of the equipment and fire fighting machinery- death and injury of specialists – discontinuation if flight operation
		Terror bombing	
		Electromagnetic and graphite bombing	The failure of monitoring systems and the flight path lighting system
8	Passenger terminal and car parking	Biological threats	Causing disease and human loss and fast transfers of the disease – Expanding the threat outside the airport- shutting down of the airport
		Terror bombing	Physical Damage to Terminal Structures and Killed or Wounded Individuals - Creating Chaos at the Exit of Terminal by Individuals- discontinuation of flights
		Air and missile strike	
		Electromagnetic bomb	Failure of control systems in the terminal and interruptions in flight operations
9	Installation canal	Technical inconvenience	Causing damage to the communication lines of the facility and interrupting or destroying them - short-term disruption to flight operations
		Terror bombing	Destruction of a part of the flight facilities channel - Short-period disruption in flight operations
10	Administration building	Spying and human penetration	Obtain confidential information at the airport and transfer to a stranger
		Terror bombing	Physical damage to the building, dead and injured individuals - airport disruption
		Electromagnetic bomb	Failure of computer systems in the building and disturbance in airport operation
11	Service pavilions Police and security unit	Air and missile strike	Complete or partial destruction of a part of the structure - The destruction of equipment inside the area - General or partial damage to the aircraft inside the parking - The termination of operation of the airport
		Terror bombing	
		Electromagnetic bomb	Failure of existing computer systems and equipment in the garage and disturbance in flight operations

12	Fueling area	Terror bombing	Discontinuance of fueling airplanes - Large fires - Possibility of the explosion of fuel tanks - Extreme physical damage within the radius of the explosion – Human loss –termination of flights
		Air and missile strike	
		Electromagnetic bombing	Failure of control systems and electronic equipment in the fueling sector
13	Service pavilions	Terror	Death and injury of individuals
		Suicide attack	Physical damage and human loss and injury
14	Police and security unit	Terror bombing	Complete or partial physical destruction of the structure and - death and injury of the specialist - termination of the flight operation
		Air and missile strike	
15	Water tanks and refinery	Biological threats	Contaminating drinking water –Rapid expansion of disease which can cause death - Possibility of pollution, expansion outside the airport- Time-consuming and complex identification - Indeterminate treatment
		Terror bombing	Physical damage – death and injury of fellow workers- Cutting of airports water supply
		Electromagnetic bomb	Failure of control systems at the refinery and electronic and computer equipment

Table 4: expressed vulnerabilities, in terms of assets

CONCLUSION

Civilian airports, as one of the most accessible spaces in the metropolitan areas of the country, need to be developed in the fields of passive defense, due to the attractiveness and probability of being targeted by the enemies, in order to minimize their vulnerability. The purpose of this study was to identify the quantitative and qualitative vulnerabilities of civilian airports and prioritize them in each of the main components as one of the important steps in passive defense studies. Based on the results of this research, and based on the FEMA technique, the basis for this research is to identify the vulnerabilities of key components of civilian airports. For each of the major components, the severity of the vulnerability of the identified threats is calculated. (Table 2). After applying the weight of each of the vulnerability assessment indicators, the rate of damage from aerial and missile attacks, bombings and explosive shipments has been the highest. Further, the quality of the vulnerability of each component of civilian airports has been gathered (Table 4). Table 5 presents vulnerability reduction solutions.

Row	Vulnerability	Vulnerability is increased factors	Solution to decrease the vulnerability
1	The Building and architecture unit	Striking of the airport's vital parts	Functional paralleling - Multi-functional assets, miniaturization-dispersion
2		Identifying, tracking and easy access and mobility	Increasing security gates and providing privacy
3		The inappropriate appearance of the building	Use of spherical and conical forms
4		Inappropriate materials	Use of materials compatible with passive defense
5		The inappropriate distance between the entrance and exit	Increase the number of entrance and exit and creating distances proportional to population flux
6		Inappropriate privacy of the buildings	Providing an appropriate privacy and the airport
7		Lack of explosion wave and quiver	Depletion of explosion and quiver
8		Inappropriate arrangement (incompatible neighbors) of elements together	Locating the vital assets of the airport and establishing distance from the risk centers
9		Inappropriate smoke evacuation	Improvement of the ventilation system and air-conditioning channels
10		Low velocity of directing and evacuation of the population	Observing accelerated foundations at emergency exits
11	Mechanical and electronic unit & Electrical equipment	Weak physical protection in the assortment	Enhance physical protection by creating more posts and monitoring systems directly from control cameras
12		Lack of shielding in vital electronic systems	Identification of key electronic systems throughout the airport and establishing magnetic protective cover
13		Unique control systems and lack of alternative	Parallelizing and minimizing
14		The late and inappropriate response of security forces	Vigilance and quick reaction of security forces and security guards
15		Lack of attention to the security considerations of control systems	Conducting training courses and using committed human forces
16	Biological unit	Slow detection, identification, and remedy	Use of rapid diagnostic kits
17		Low quarantine speed, population control, and evacuation	Increasing the equipment of transmission of patients in the quarantined environment
18		Lack of special equipment towards biological threats	Establishing and equipping airport emergency
19		Fast expansion of diseases in and out of the airport	Establishing a quarantine environment and controlling the spread of disease

Tab 5: The Relationship between Vulnerability increasing factors and the Criteria of Responding to Vulnerabilities

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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