

Game Theory - Crisis Management Tool for Creation Security Policies

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Abstract— Issue of terrorism and national, regional or private company security policies are becoming still more important part of security strategies and crisis management worldwide. Czech Republic is state that would not be actually threatened by international terrorism, but prevailing security situation poses number of challenges and especially Czech domestic extremism and terrorism should be considered as significant security threat. Problem of extremist and terrorist activities is increasingly studied using Game Theory, which seems to be proper instrument of crisis management in case when it is not possible to examine various conflict participants, without consideration of their reaction and interaction. This work deals with the Czech extremist and terrorist scene as a potential threat for the Czech state. In this article is analysis of Czech terrorist scene, on the basis of which is designed the direction in which it is possible to proceed in the case of using Game Theory. Solutions for private and mainly public sector are therefore based on available information obtained by analysing domestic extremism and terrorism, and description of Czech public administration. It can be assumed that the framework related to Czech conditions would be possible to use in larger or smaller modifications in other states of European Union.

Keywords—crisis, extremism, Game Theory, region, management, public administration, terrorism

I. INTRODUCTION

Most definitions of terrorism coincide in saying that this phenomenon is described as act of violence used to reach aims by intimidation and fear. Terrorism seems to influence the public opinion equally as the academic world, while the image of an irrationally thinking and acting terrorist has been shifting towards a more thorough research of the conflict reasons and motivation of terrorist acts and their modelling. *“Game Theory plays more important role in the defence economy study. It also plays a role in the study of conflict, negotiation, keeping peace, competition, armament and weapons trade.”* [13] Game Theory (GT) is mathematical

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discipline that deals with conflict situations contingent upon predetermined input parameters and it is applied in private and also public sector as a decision-making tool. *“In decision-making phase there are a number of alternatives; this problem includes economic and technical viewpoints.”* [10] Firstly, we can say that there are many games in which determining the appropriate kind of game is an essential foundation for achieving successful outcome. Secondly, necessary step is determining which players should be part of the game and subsequent definition of their rationality. As discussed further rationality or non-rationality of one or more players is the key prerequisite for the use of correct game. In this paper we will propose the foundations for a game between two players. For the purposes of this paper, the first player shall be the terrorist (terrorist group), and the second player shall be Czech state. In this paper will be outlined options of creation security scenarios and choosing correct part of GT as a supportive tool for crisis decision making. It will be pointed out the rationality of both players and outputs associated with it. Together with scenarios is in paper also introduced a proposal for a State Security Advisory System with its security levels.

II. GAME THEORY AND TERRORISM

GT seems to be suitable tool to study and fight against terrorism, because it reflects interaction between attacked subject and a terrorist while individual steps are mutually depending. Attacked subjects and terrorists should act with the aim to gain a strategic advantage. Several more reasons according to literature to using GT in case of rationality of both players, but as discussed below, it does not need always be.

- a) GT describes terrorist and government actions as mutually dependent.
- b) Governments and terrorists are rational actors who react to counterparty's actions.
- c) Governments and terrorists act in a way to gain a strategic advantage.
- d) Governments and terrorists act to maximize their profit (aircraft hijacking - see above).
- e) Governments and terrorists make decisions in the situation of incomplete information. [14]

Worldwide there are many kinds of terrorism, as shown in the Fig. 1 below. Typical features of contemporary Czech terrorism will be discussed later.

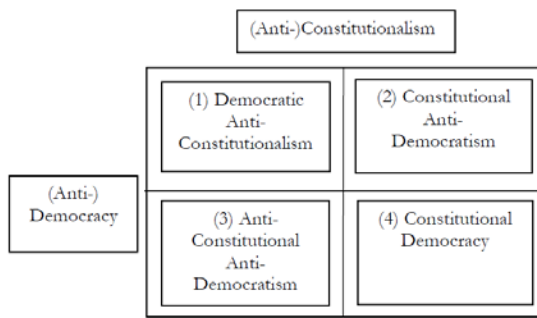


Fig. 1 Forms of Terrorism [1]

A. Key Features of Game Theory

Conflict situation may occur in numerous cases. “The notion of a game in modern Game Theory has a very general meaning that involves both the drawing-room games such as chess or poker, but in principle, any conflicting situation among individuals, enterprises, armies, states, political parties and species”. [4] Game objective is strategy based on the analysis of an aggregate of decision-making unit. “The one who takes an attempt in strategic behaviour should be clear about several aspects, the first one being the objective to approach.” [9] The objective is to choose optimized strategy at respecting assumed strategy or steps to be taken by other player or players. Player can be an individual, a pair or a group. Decision-making of individual players are based on different strategies.

Basic prerequisites for a GT application are following.

- a) At least one player is rational.
- b) All the players know the rules which are unchanged during one game.
- c) Players are familiar with the values in the game and know the loss and profit amounts. [11]

One of the essential terms in GT is general model – game in standard form that is understood as a triplet of aggregates.

$$((1,2,...,n),(S_1,...,S_n),(Z_1,...,Z_n))$$

(1,2,...,n) – sum of players

(S₁,...,S_n) – sum of strategies

(Z₁,...,Z_n) - sum of players payoff functions

Players are numbered with natural numbers. Important condition of this model is to differentiate individual players and to know their number, which is at least two. Each ith player has its strategy - S_i. Strategies can be understood as a description of a player’s procedure through the game, or its sequence of steps selected during the game. If it is standard game, then players choose strategy xi∈S_i. All strategies selected by all players in one game then determine the value of payoff function Z_i (x₁,...,x_n) for an ith player. Individual games can be differed by:

- a) number of players,
- b) rationality of players,
- c) strategies,

- d) cooperation,
- e) and the fact if player is intelligent or non-intelligent.

Intelligence or non- intelligence of players is point that is for this paper important. Intelligent player is a rationally thinking subject who understands strategies and has a defined objective. Non-intelligent player, often so called nature, is presented as dependent on natural phenomena, such as weather, earthquake, etc. It can be the player who acts without a plan, say randomly.

B. Game Theory Use in Case of Anti – terrorist Strategies

Sandler and Arce [14] modelled situation where government faces the decision whether and when they should accept terrorist requirements. Authors complement this strategy by conditions stemming from the GT application. The first one reflects the attitude of the government that is required to be persistent at any circumstances. The second condition is incomplete information on the terrorist side about the governmental anti-terrorist measures. Another example of the GT utilization is “competition” in security measures in different countries. Sander and Arce use the GT [14] call it “intimidation race”.

Typical example and probably the most discussed example of the GT use in safety science is the so called prisoner’s dilemma.

Prisoner’s dilemma can be used in decision-making processes in performing contracts about armament or company restraint trade agreements. Sandler and Arce [14] apply prisoner’s dilemma on a situation when governments choose between active and reactive anti-terrorist policies. Active policy focuses on an open and active fight against terrorism, consisting of:

- a) search for and liquidation of terrorists,
- b) destruction of resources and terrorist infrastructure,
- c) active monitoring of terrorist activities,
- d) prevention from terrorists and their sponsors.

If the active anti-terrorist policy of one country is successful and a terrorist unit is liquidated, then other states tend to rely on active measures of other states. In such case the “black passenger” effect occurs and the risk and cost relating to an active fight against terrorism are borne by one state, while the other only profit from the prospective benefits. Reactive policy is typical mainly in the solution of terrorist attack consequences. The black passenger effect is demonstrated by means of the prisoner’s dilemma in the following matrix:

		EU	
		active	non - active
active		2,2	-2,4
USA			
non - active		4,-2	0,0

Fig. 2 Application of prisoner’s dilemma [author]

There are two players: the USA and the EU. Both the states together face a potential threat of a terrorist attack and they are obligated to agree upon applying an active anti-terrorist policy. A necessary prerequisite is an active policy benefit amounting at 4 and costs of 6 for the country that pursues the active policy. If the USA are to apply active policy and the EU is the state that only makes use of the relating benefits (the black passenger), then the EU gains the profit of 4. USA gain -2 (4-6). The costs amounting at 6 will be deducted from the gained profit 4. In the opposite event, if the black passenger is the USA, the profit will be the opposite. If both the countries apply active policy, then each of them gains an advantage of 2 ($6 - 2 \times 4$). The result is a prisoner's dilemma – type - game in which none of the countries intends to apply active anti-terrorist policy.

On the above examples, it can be seen that GT can be applied to various cases in area of counter-terrorism policies. It is true that the use of this tool in case of Czech Republic brings its own specifics arising from the nature of the Czech domestic terrorism and Czech conditions. For the purpose of this paper, there will be two players. The first player is Czech terrorist, and the second is Czech Republic. Rationality, as important condition for the successful application of GT, will be in case of the first player discussed further. In case of Czech Republic, respectively its security measures, let's say, that its rationality do not need to be proven. In chapter dealing with the second player, the Czech Republic will be described from an institutional standpoint, with an emphasis on public security forces.

III. CZECH REPUBLIC AND TERRORISM

At present, Czech extremist and terrorist scene is represented especially by extreme - right and extreme – left wing political radicals. While the low ability of right-wing violent part of scene to work organized causes attenuation of its activity, the successor Workers' Party of Social Justice became the most prominent representative of the current right - wing groups in the Czech Republic. This party has ambitions to work in the Czech political system, and use its program to populist issues (unemployment, criticism of the European Union, migration, anti - Roma attitude) is trying to get sympathizers and voters. This party operate successfully in economically weak regions where organized (and still organize) demonstrations and public gatherings.

Active extreme left presented mainly anarchists reacted critically to the development situation in European Union and Czech Republic and dealing with extreme environmental attitudes. Environmental topics are discussed social problem. [2] In case of extreme approach to this area, it may take violent forms. Significant part is involved in the fight against the extreme right - wing. Marxist - Leninist communist and neo-Bolshevik part of the scene did not show any significant activity in past. Both the Communist fractions are focused on criticism of Czech government and marginally on the issue of right-wing extremism.

According to Reports on Extremism and Racism and Xenophobia in the Czech Republic [3] as these points appear to be basic on the left-wing extremism.

- a) The scene is still fragmented on different ideological currents and directions.
- b) The rate of informal links with foreign left - wing parties increases, which is especially evident within the anarchist spectrum, including militant organizations.
- c) Criminal activity is generally quite specific, its detection is problematic.
- d) Extreme left - wing scene obvious attempts to import platforms civic activism inspired by foreign entities. In particular, the activities of the "15M/True Democracy Now or Occupation" movement, or citizens' initiative within the anti-fascist movement.

Partial conclusions resulting from the analysis of Czech terrorist scene are these.

- a) Extremist parties in The Czech Republic operate across the political spectrum (extreme right – wing, extreme left - wing).
- b) Extremist and terrorist scene in the Czech Republic is characterized by extreme right - wing, whose "serious" part tends to operate within official policy and to gain support also uses some of the tools of political marketing.
- c) Open right-wing groups and the extreme left are taking more direct, often use violent actions, but without sophisticated planning.

A. *Czech Terrorist as the First Player*

The aim of analyzing Czech extremist and terrorist scene was to find out if Czech terrorists could be considered as a rationally thinking player. Authors, who use GT in the case of international terrorism, working primarily with the concept of religious terrorism, when can be particularly said.

- a) Terrorist attacks are carefully planned.
- b) Terrorists respond to changes in government anti – terrorism policies.
- c) Terrorist organizations have specific structure.
- d) In most cases it is clearly identifiable groups which can be unambiguously described.
- e) Terrorists apply violent methods in achieving.

Czech extremist and terrorist scene in comparison with international cannot be taken as similar. Czech terrorists, namely those who are willing and are able to use violent action, do not plan, violent acts often have the character of spontaneous strikes, which have so far only in few cases character of attack on industrial objects. Groups that could be considered in the Czech Republic as terrorist, show only a limited rate of organization. Structure and organization can be identified with extremist parties that operate in the Czech political scene, such as Workers' Party of Social Justice. These parties will, due to their activities towards participation on the

Czech political scene, provide violent terrorist methods with very small probability. Another sticking point is inhomogeneous structure of the Czech terrorism, which basically makes it impossible to identify and work with the term "terrorist" or "terrorist group" as with general term. Based on these conclusions it can be said that Czech terrorist cannot be considered as rational player.

Thus, we propose terrorist or terrorist group is the first player (P1), who triggers critical event and who can be considered as non-rational. Possible sets of such events that may occur after the terrorist attacks, let be the strategy of the first player. If S_1 is marked as a set of strategies of the first player, then:

Def. 1

P1 ... terrorist - non-rational player

$S_1 = (t_1, t_2, t_3, \dots, t_N)$ where N is natural number

t_i ... strategy of the first player

B. Czech Republic as the Second Player

As stated at the end of Chapter 2.2, in the case of this paper, it is assumption of two players. The first player - terrorist, has been described, in this Chapter it will be presented the second player - Czech Republic. After 1989 Czechoslovak Republic went through transformation, just like most of the other countries in the so-called Eastern Bloc. The fall of communism enabled the organisation and implementation of parliamentary elections. The Czech and Slovak Federal Republic (ČSFR) was established in 1990, whereas the growing pressure from Slovakia for increasing autonomy lead to end of the federation in 1992, enabling the formation of the Czech Republic. *"The proposal was unacceptable for the Czech side, which accepted only two alternatives - a functional federation, or two independent states."* [6] The Czech Republic was founded on 1. January 1993 and it adopted all of the commitments and laws effective at the time of the end of the federation. New borders of the Czech Republic were determined according to historical foundations. The Constitution of the Czech Republic from 1992 included the definition of structure of public sector, fundamental rights and liberty of its citizens, and divided power into legislative, executive, and judicial branches.

Public administration can be divided into the state government and regional self-government. State government is represented primarily by the central state administration (government, ministries), regional state administration (employment offices, financial offices). In terms of self-regulated authorities, Czech Republic is divided into 14 regions and 6,253 municipalities. Self-governed organisations also include professional chambers, as well as universities.

Security system is part of the Czech public administration which also deals with problem of extremism and terrorism. Important part of Czech security reality is its membership in European Union and NATO. The frame of Czech security lies in Security Strategies of the Czech Republic which define security policies. The aim is particularly protecting the state and its citizens. At the central level are security policies implemented by The Government, and mainly by Ministry of

Interior of the Czech Republic. Another important office is National Security Council which is specialised authority for dealing with security issues. It coordinates policy and cooperate with regional offices in order to solve crisis situations. At the regional level, regions and municipalities have its crisis management offices and authorities. Czech professional Army emphasises securing defence measures, covering risks, participates in international operations, securing air space and also help in cases of selected non-military operations. Another important player in the Czech security environment is Czech Police which can be divided into State Police and Municipal Police. State Police is under the direct leadership of The Ministry of Interior of the Czech Republic, and its priority is nationwide protection of social of citizens and property. Founder of the Municipal Police is municipality and it depends on each town how if Municipal Police will be established and how it will be organized.

The Czech Republic and its authorities becomes the second player (P2) who use possible security scenarios and security measures. Security scenarios are then the second player's strategies. Let S_2 be the set of strategies of the second player, then:

Def. 2

$S_2 = (c_1, c_2, c_3, \dots, c_N)$ where N is natural number

c_i ... strategy of the second player

P2 tries to maximize its profit, and the reward is presented as to minimize the damage. P1 is indifferent player who causes damage for P2, while P2 wants to stop either or minimize it.

IV. USING GAME THEORY IN CZECH CONDITIONS

Application of GT in the Czech Republic has numerous of specifics. It is beyond the scope of this paper to analyze whole Czech security environment. For the purpose of this article it is sufficient to state these conclusions. First, Czech Republic or its authorities can be considered as rationally thinking player with the ability to use different strategies. Second, it is difficult to define Czech terrorist as rational player. As it was mentioned, Czech extremists or terrorists groups has its specific features.

Functioning security system of the state must be able to highlight the crisis and advises authorities how to respond appropriately to involved situation. In this work, the proposed theoretical framework uses several scenarios and security rules, whose main purpose is to inform and to advise how to rationally react right after the terrorist attack. Proposed model use different scenarios which a tool of first response reaction. From above chapters come several significant facts that have influenced the direction of next steps.

- a) Part of Czech terrorists, that are those who are able and willing to use violence, mostly do not plan their actions thoroughly. Violent actions have often the character of spontaneous attacks without planning or and clearly defined aims.
- b) Czech terrorist groups show only a limited level of organization.

- c) Czech extremist and terrorist scene is diverse and there are many opinions and approaches from those with tendencies to operate in Czech political system, to armed groups that are theoretically able to carry out violent terrorist attack. The lack of homogeneity in principle makes it impossible to determine terrorist or terrorist group as a generalized term for further use.
- d) Attacks on entities that meet the definition of terrorist attack, has been carried in the past an valuation of such attack that triggers was quantified as damages to property and the environment, and other related costs. Quantification of the loss of human lives is generally considered to be problematic.

A. Security Scenarios and State Security Advisory System

“Right after response ” could be difficult in terms of lack of information and time constraints, while respecting the hierarchy:

- to prevent human life,
- to prevent environmental damage,
- to prevent damage to property.

Scenarios and safety rules were designed to authorities to have a tool that will support “right after response” in a crisis situation that must be primarily:

- quick,
- the most accurate in view of the nature of emergency,
- adequate to deploy resources.

State Security Advisory System

GT is tool that captures the interactions, allows to model situations and make rationally decisions in crisis situations. Due to the model there is also need to define rules corresponding to the various level of risk, allowing, among other things, mutual cooperation security elements. It could be called State Security Advisory System (SSAS). In this paper, we say that there will be four levels of threat and four levels of security rules (SSAS1, SSAS2, SSAS3 and SSAS4). These rules will be together with safety scenarios the basis of proposed model. Creation of specific rules is beyond the scope of this paper, but it may be the objective for further research that would more specify this model.

Security Scenarios

There should be identified number of different security scenarios depends on each state but the key thing is that those scenarios capture first respond reaction after terrorist attack and coordinate decision making. According to demonstrating needs there is necessary simplifying, the first scenario is for Fire (EM1), second is Explosion (EM2) and the third is Leakage of poison to air (EM3).

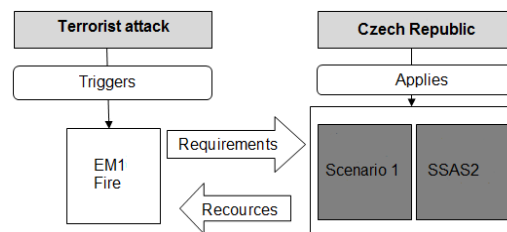


Fig. 3 Fire, Scenario1 and SSAS2 [author]

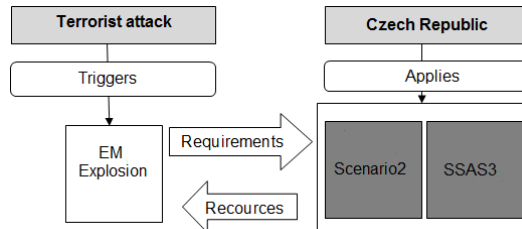


Fig. 4 Fire, Scenario2 and SSAS3 [author]

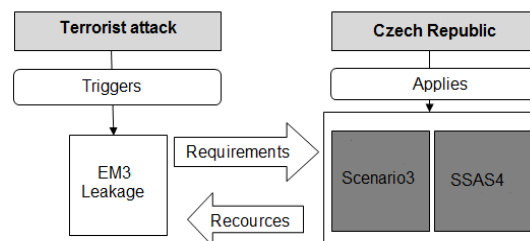


Fig. 5 Fire, Scenario3 and SSAS4 [author]

Individual combinations of scenarios and security rules can be analysed using GT where P1 is represented by terrorist and P2 is Czech Republic based on this assumptions.

- Terrorists are not rational and without ability of long – term planning.
- To generalize the definition of terrorists and to use it when building the model is misleading in Czech conditions.
- Games prisoner's dilemma - type or non – cooperative zero-sum games, which are used, in research on international terrorism are not appropriate to create models in this work.

If the situation should be analysed using Game Theory, it is necessary to determine appropriate area of this framework. For this will serve the above conclusions. In general there are two types of games in GT.

- Games of intelligent players
- Games of non-intelligent players

If Czech terrorist cannot be considered a rationally player, it is the optimal choice for the so-called game against nature. In this case, non-intelligent player, often referred as nature, as that term expresses a large proportion of chance and irrationality in his behaviour, but also results from the application of GT in predictions of natural phenomena (weather, earthquakes, etc.).

B. Games against Non-intelligent Players

If we are using GT to analyze situation where we stand against non-intelligent players whose strategies denote \mathbf{Y} , it is necessary to ask whether we know the probability distribution \mathbf{Y} , as described, for example, the distribution function $F(\mathbf{y})$. If so it is a decision making under risk. If we do not know such probability distribution, we are talking about decision making under uncertainty [5]. In literature it can be found a description of situation when we are talking about decision making under uncertainty. In this case, we do not know exactly the set of strategies \mathbf{Y} . Information about the set of strategies \mathbf{Y} is specified using fuzzy sets. The degree of affiliation of strategies \mathbf{y} to set \mathbf{Y} is given using function μ . Values of function are in interval $\langle 0; 1 \rangle$, and if $\mu(\mathbf{y}) \doteq 1$ we say \mathbf{y} is almost certainly unintelligent player strategy and if $\mu(\mathbf{y}) \doteq 0$ we say that strategy \mathbf{y} is not almost certainly strategy of unintelligent player. [7]

In the following text, attention will be paid to further determine the optimal strategy for intelligent player for the first two described situations and therefore decision making under risk and decision making under uncertainty.

To describe the decision-making situation it can be used the game in normal form

$$\{Q = \{1,2\}; X, Y; M(x, y)\},$$

when one player acts as an intelligent player and the second player acts as unintelligent player. X is strategy of intelligent player and Y is strategy of unintelligent player. $M(x, y)$ is intelligent player payroll function.

Decision making under risk

Decision making under risk is based on the principle of maximizing the average value of winning, therefore, the strategy \bar{x} is the optimal strategy for the risk described by distribution function if

$$\bar{x} = \arg \max_{x \in X} \int M(x, y) dF(y).$$

The shortcomings of this principle already warned about in 1738 D. Bernoulli [12]. To overcome this, it suffices that the function $M(x, y)$ is expressed in units of utility.

Decision making under uncertainty

Common feature of all decision situations under uncertainty is the lack of information about the probability distribution strategies of unintelligent player. In this case, we seek optimal strategy of intelligent player in accordance with the selected decision-making principle [8]. Some basic principles of decision will be listed below.

Laplace principle

Based on the principle that we do not know if the probabilities with which strategies are chosen from \mathbf{Y} , we consider all strategies to be equivalent. Assuming finiteness of set \mathbf{Y} , each strategy \mathbf{y} chosen with a probability $|\mathbf{Y}|^{-1}$ where $|\mathbf{Y}|$ represents the number of elements of set \mathbf{Y} . By this

procedure it was obtained knowledge of probability distribution, and the decision may be made as in case of decision making under risk.

Wald principle

This principle is also often called minimax principle. It assumes that unintelligent player chooses strategy \mathbf{y} from the set \mathbf{Y} that it leads to the worst possible result for intelligent player. Optimal strategy \bar{x} is strategy for which the following applies:

$$\bar{x} = \arg \max_{x \in X} \left(\min_{y \in Y} M(x, y) \right).$$

Using this rule leads to overly cautious decisions. It often chooses assessors with risk aversion.

Savage principle

Sometimes this principle is called minimax of lose. Optimal decision is the choice of strategy that minimizes the difference in payout when choosing this strategy and payout in choosing strategy \mathbf{y} in case of knowledge strategy unintelligent player. Function of loss is defined as

$$Z(x, y) = M(x, y) - \max_{x \in X} M(x, y).$$

Hurwicz principle

Minimax principle is decision principle of evaluators with risk aversion. At the other extreme side would be principle which would have assumed that unintelligent player chooses a strategy from set \mathbf{Y} so that he maximizes the win $M(x, y)$. Hurwicz principle based on the choice of parameter $\alpha \in \langle 0; 1 \rangle$, combining these two extreme approaches. The parameter α is called parameter of risk aversion and optimal strategy \bar{x} is in such case defined as

$$\bar{x} = \arg \max_{x \in X} \left(\alpha \cdot \min_{y \in Y} M(x, y) - (1 - \alpha) \cdot \max_{y \in Y} M(x, y) \right).$$

If the value of parameter α would be equal to 1, it becomes Hurwicz principle of minimax.

As it is clear from the above principles for games with non-intelligent players, there are number of ways using appropriate Game Theory principles to analyze modeled situations. The challenge for future research is therefore the use of these principles in case of specific or model data.

V. CONCLUSION

Changing security reality requires new approaches to research possible threats and also effective management of crisis situations needs to examine extremism and terrorism using new methods. It is true that Game Theory has been used in the field of terrorism for decades, however, importance has dramatically increased, after the 9/11 and of course with today's security challenges. For this reasons, relations between terrorists and governments, private sector, citizens and other actors is recently increasingly studied by Game Theory. This tool becomes not only matter to study this issue, but also

effective crisis management tool helping to create counter - terrorism strategy, policy and mitigation actions. This paper presents possibilities of using Game Theory in case of two players' game. One of them is Czech terrorist and other Czech state. There are also presented three scenarios of crises that may be caused by terrorist attack. For subsequent testing of these scenarios, using Game Theory, it was chosen appropriate part of games - games against non-intelligent players. Opportunity to present previously difficult measurable data with the numeric values with subsequent analysis and model creation opens a new space of research not only in management of crisis situations and government policy making but also in security science research. Logical extension and also challenge is the use of proposed scenarios and testing using Game Theory in case of real or model data.

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