Methodology for assessing the risk of an act unlawful interference on transport systems

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Abstract. The study was designed to develop methodology for assessing the risk of an act unlawful interference on transport systems. This methodology be of particular significance for transportation systems, like metros and railroads. For instance, where there is information that in the coming days an act of unlawful interference may occur along a metro line, employing this methodology can enable the experts to promptly determine the stations which are the likeliest to be attacked. The need to develop said methodology has been substantiated by statistics whereby of all acts unlawful interference committed around the world in the period 1970–2019 over 8,000 were aimed at the various facilities of the transportation system, including airports and aircraft and metro and railway stations and trains. The methodology for assessing the risk of an act unlawful interference on transport systems could be employed in training police and secret service officers whose duties include the anti-terrorist protection of the transportation sector.

1. Introduction
A modern transport system is a network of potential vulnerabilities [1-2]. An analysis of data from a set of sources [3] indicates that of all acts of unlawful interference (Act of unlawful interference (AUI) – “unlawful action (inaction), including a terrorist attack, threatening the transportation safety and security, resulting in harm to life and health of people, material damage or threatening the onset of such consequences”) committed around the world in the period 1970–2019 over 8,000 were aimed at the various facilities of the transportation system, i.e. those associated with water, air, rail, and road transportation (Table 1).

Table 1 Transportation targets attacked by terrorists, 1970–2019.

| Type of transportation | Distribution across the types of transportation, % |
|------------------------|---------------------------------------------------|
| Auto                   | 48.1                                              |
| Rail                   | 27.5                                              |
| Metro                  | 0.5                                               |
| Water                  | 3.7                                               |
| Air                    | 19.3                                              |
Typical examples of an act unlawful interference on transportation facilities include the following:

- March 11, 2004 Madrid (Spain): explosive devices (ED) stuffed with mails exploded practically simultaneously in 4 suburban trains arriving at the Madrid railway station "Atocha" during the morning rush hour (Figure 1), 192 people killed, 1856 people injured [4];

![Figure 1. Acts unlawful interference (Madrid) [5].](image1)

- September 11, 2001 New York (USA). The attacks of September 11, 2001 are a series of four coordinated suicide attacks (Figure 2). In addition to 19 terrorists, as a result of attacks killed 2977 people, another 24 were missing.

![Figure 2. Acts unlawful interference (New York) [5].](image2)
The threat of new acts unlawful interference is urgently requiring the development of a set of scientifically substantiated measures aimed at boosting the transportation security. A possible measure of this kind is a methodology for assessing the risk of an act unlawful interference on transport systems.

Researchers have employed various methodologies for assessing the risk of act unlawful interferences, including those described in the following research works:

1. The study [6] compares, across a set of indicators, some of the more common methods for determining the vulnerability of networks.

2. Theoretical model for cascading effects analyses. The model aims at developing cascading effects scenarios at different level of detail, depending on the availability of inventory/exposure data for the different categories of elements at risk and hazard/impact models for the various hazard sources [7].

3. Leveraging Network Theory and Stress Tests to Assess Interdependencies in Critical Infrastructures: The study is providing interesting insights into aspects such as fragility and robustness of different network layouts against various types of threats, despite the difficulties arising in the modeling of the associated processes and entity relationships [8].

A detailed investigation of the above methodologies indicates that carrying the techniques offered as part thereof into effect may be rather time-consuming, which may well matter when it comes to assessing the risk of acts unlawful interference on transport systems.

2. Methods
As part of this study, the have developed a methodology for assessing the risk of an act unlawful interference on transport systems.

The developed methodology, which consists of four major stages, is illustrated in Figure 3.
Figure 3. Methodology for assessing the risk of an act unlawful interference on transport systems.

The methodology implies employing an expert assessment and requires forming a group of at least five experts with professional proficiency in transportation safety and security.

The risk of an act unlawful interference on transportation facilities can be computed via the following formula:

\[ R_{\text{aui}} = P_{\text{attempt}} \times \left( \frac{P_{\text{detection}} + P_{\text{prevention}}}{2} \right) \]  (1)

Where:
- \( R_{\text{aui}} \) is the risk of an act unlawful interference on a transportation facility (0>1);
- \( P_{\text{attempt}} \) is the likelihood of an attempt to carry out an act unlawful interference on a transportation facility (0>1);
- \( P_{\text{detection}} \) is the likelihood of a terrorist getting detected at the facility (0>1);
- \( P_{\text{prevention}} \) is the likelihood of an act unlawful interference getting prevented (0>1).

The likelihood of the security team preventing an act unlawful interference will depend on their level of preparation for taking action in a critical situation (e.g., in detecting a terrorist carrying an ED). The likelihood of detecting a terrorist at the facility depends on how well the facility is equipped with proper technical security systems [9] (Figure 4.) and on the preparation level of personnel concerned with the operation of those systems.

The numerical values of \( P_{\text{detection}} \) and \( P_{\text{prevention}} \) are to be determined by the experts.

Using the proposed formula, the experts can assess the risk of an act unlawful interference on a transportation facility.

For instance, if \( P_{\text{attempt}} = 0.5 \), \( P_{\text{detection}} = 0.428 \), and \( P_{\text{prevention}} = 0.642 \) (Table 2), performing the calculations via Formula 1 will produce the following result: \( R_{\text{aui}} = 0.267 \).

Table 2. Expert assessment the risk of an act unlawful interference on a transportation facility.

| Factors     | Expert №1 | Expert №2 | Expert №3 | Expert №4 | Expert №5 | Expert №6 | Expert №7 |
|-------------|------------|-----------|-----------|-----------|-----------|-----------|-----------|
| \( L_{\text{attempt}} \) | 0.6        | 0.5       | 0.6       | 0.4       | 0.5       | 0.6       | 0.6       |
| \( L_{\text{detection}} \) | 0.7        | 0.4       | 0.5       | 0.3       | 0.4       | 0.3       | 0.4       |
| \( L_{\text{prevention}} \) | 0.8        | 0.6       | 0.7       | 0.5       | 0.6       | 0.5       | 0.8       |
To classify the transportation facilities by level of risk of an act unlawful interference, you will need to create a system for transforming your quantitative assessments risk into qualitative ones (Figure 5.).

| Quantitative assessment | Qualitative assessment | Danger level |
|-------------------------|------------------------|--------------|
| 0-0.1                   | Low risk               | Green        |
| 0.1-0.25                | Medium risk            | Yellow       |
| 0.25>                   | High risk              | Red          |

**Figure 5.** Transforming quantitative assessments into qualitative ones.

3. **Results**

The results from assessment of the risk of a act unlawful interference can be represented in the form of a transportation system matrix (Figure 6), in which each of the system’s facilities is assigned a specific level of danger (green – low risk of a act unlawful interference, yellow – medium risk, and red – high risk).
Denotations:
X is the name of the transportation system;
X1 is the name of the first station (facility) within the transportation system;
X2 is the name of the second station (facility) within the transportation system, etc.

**Figure 6.** A matrix of the risk of an act unlawful interference on the facilities of the transportation system X: a) matrix template; b) filled matrix.

### 4. Discussion

The findings from a set of experimental calculations conducted using the authors’ developed methodology indicate that assessing the risk of an act unlawful interference in a transportation system comprised of 100 items will take five to seven hours. By contrast, with existing methodologies (see the Introduction section and [10-14]) it may require as long as 24 to 168 hours.

The example of the acts unlawful interference on the metros of Brussels and Saint Petersburg indicates that the promptness of decision-making aimed at protecting the facilities may well be of deciding significance to the successful prevention of the attack.

For instance, it may be worth mentioning the emergency measures taken at the Saint Petersburg metro after the first act unlawful interference on the stretch of the track between the ‘Sennaya Ploshchad’ and ‘Tekhnologichesky Institut’ stations on April 3, 2017. To be specific, the authorities engaged a group of transportation security experts, who helped identify which additional stations could be attacked within hours, enabling the authorities to promptly beef up security at those stations.

This helped find a second explosive device (at the ‘Ploshchad Vosstaniya’ station) (Figure 7) and prevent the next attack. The explosive device found was a fire-extinguisher containing five kilograms of TNT and numerous metal pellets (MP). A device of this kind exploding in the metro’s closed space would have produced the so-called “bunker effect” (with the blast effect amplifying five to six times due to reflection off the walls) and, given the metro’s increased rush-hour ridership (up to nine people per m² [15]), could have left 30 to 60 dead and 100 to 200 injured.
5. Conclusion
The study was designed to develop methodology for assessing the risk of an act unlawful interference on transport systems.

The methodology described herein could be employed in training police and secret service officers [16] whose duties include the anti-terrorist protection of the transportation sector.

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Figure 7. Explosive device found at the ‘Ploshchad Vosstaniya’ station on April 3, 2017 (Saint Petersburg, Russian Federation). Source: https://www.ntv.ru/novosti/1791692/. Accessed 15 May 2019.