

CRITICAL TRANSPORT INFRASTRUCTURE

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***Summary:** Critical infrastructure is a generally accepted term that describes the infrastructure necessary to provide for the basic needs of the state, economy and society. Transport infrastructure is a generally complex creation that includes various disciplines and components, and is exposed to different impacts during its lifetime. In general, the most important traffic connections in the country have always been characterized as critical infrastructure. However, for managers and local communities, almost all road and rail routes are critical because their loss would impede free movement and potentially lead to the isolation of communities. The aim of this paper is to define and explain the concept of critical infrastructure in transport, especially in the context of providing resources and taking management actions to protect it.*

***Key words:** critical infrastructure, transport, management, assessment, protection*

1. INTRODUCTION

Today's security picture of the world scene follows the pattern present throughout the entire existence of civilization. The desire of some to establish domination, impose ideology, conquer territories and resources inevitably leads to opposition from those to whom it is directed. In such a condition, conflicts are an unavoidable factor that needs to be counted on and accordingly steps for the development and protection of the state, society and economy have to be planned. Conflict zones in themselves represent an area where the quality of life is completely degraded and as such have a clear determinant of constant danger. Another problem is the tendency of spreading the conflict to areas that have nothing to do with the original conflict. The most common types are terrorist attacks, sabotage and arson, but in such targeted areas of danger, they still cannot be characterized as a constant armed conflict. The idea of occasional action aims to make demilitarized zones unsafe for life, which due to temporal and spatial inequality can create a huge psychological pressure on the population, the functioning of the economy and the work of the state apparatus.

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In addition to the mentioned problems caused by armed conflicts and/or individual attacks, the infrastructure is also exposed to the impacts of various types of climate and natural hazards that can endanger life, level of service, maintenance budget, functioning of the economy, etc. With the evident climate change, the problems are increasing:

- more problems in already affected areas;
- new problems at locations that were not previously affected;
- less predictable events, different from previous experience;
- less time to recover between events.

Awareness of the threat to all aspects of life and work of the state and society in such circumstances has conditioned the need to define critical infrastructure and actions that should be taken to protect it. Critical infrastructure is infrastructure that is important to a country and whose damage leads to problems or cessation of the provision of a particular service, whether it is directly related to a specific infrastructure or services and activities provided through the infrastructure. Incidents, terrorist attacks, catastrophic events, accidents or deliberate disruptions to the normal functioning of infrastructure can impede or prevent the operation of infrastructure and leave serious consequences for the economy. There are a number of reasons why infrastructure must be protected and secured. The breakdown in the provision of basic infrastructure and public and social services could be devastating for the entire population, especially in the rural areas and areas affected with low economic capacity.

Traffic, as one of the most important logistic activities, the driver of the development of space and economy, occupies the initial and final place in the production process, and at the same time brings high costs with it. The quality of transport service depends on the basic elements of transport (the means of transport that provide the service and the transport infrastructure that enables movement), and it affects the quality of life and economic growth due to the ability to provide access to people, services and resources. Therefore, transport infrastructure belongs to the domain of critical infrastructure.

Transport infrastructure and each of its individual critical elements represent assets of great value to the country in which it is located and can often play a crucial role in international relations. The entire transport sector can easily suffer from weak and unsuitable institutional and maintenance policies that could cause grave deterioration in transport infrastructure, which is a key enabler of development.

Critical infrastructure management should be an integral part of development programs. Categories such as safety and risk prevention from attacks, disasters and catastrophes must be integrated into all relevant documents of infrastructure managers, state institutions and governments. Security of critical infrastructure is a key issue of modern national security; as critical infrastructure is the basis for community survival.

2. CRITICAL INFRASTRUCTURE

Criteria that would serve to determine which infrastructure should be considered critical must be formulated unambiguously at the level of the country and the region, and must be harmonized with the criteria of the European Union (EU) [1].

In order to establish a single definition of critical infrastructure, the Organization for Security and Co-operation in Europe (OSCE) defines the terms “critical” and “infrastructure” [2]. The term “critical” refers to infrastructure that provides key support

for economic and social security, public safety, and the functioning of key government responsibilities. Disruption or destruction of critical infrastructure leads to great consequences and damage for the state, and especially for society and individuals. The term “infrastructure” refers to physical infrastructure and intangible investments through production or through communication networks.

Table 1. Definitions of critical infrastructure in different countries [2, 3, 4]

Country	Definition
The Netherlands	Critical infrastructure includes products, services and supporting processes that, in the event of downtime or failure, can cause major social unrest. Interruption of work would lead to a large number of victims and great economic damage.
United Kingdom (UK)	National critical infrastructure consists of resources, services and systems that support economic, political and social life in the UK whose importance is such that failure can cause great loss of life, have a serious impact on the national economy and other severe social consequences for the community.
Canada	Critical infrastructure means a system of all physical and information technologies, facilities, networks, services and goods that, if destroyed or disabled, can have a serious impact on the health, safety and well-being of Canadians and the effective functioning of the Canadian authorities.
Germany	Critical infrastructure encompasses organizations and institutions of great importance to the community whose failure or damage can cause permanent shortages of supplies, major disturbances in public order, and other dramatic consequences.
United States of America (USA)	Critical infrastructure and basic resources is a term that refers to the wide range of different resources and assets that are necessary for the daily functioning of social, economic, political and cultural systems in the USA. Any disruption in critical infrastructure elements poses a serious threat to the proper functioning of these systems and can lead to property damage, human casualties and significant economic losses.
Australia	Critical infrastructure is those physical facilities, supply chains, information technology and communications networks that, if destroyed, or disabled for long periods, could significantly affect a nation's social or economic well-being, or affect Australia's ability to sustain national defense and ensure national security.
EU	Critical infrastructure is property, system or part of it located in the territory of a member state and which is necessary for the maintenance of key social functions, health, security, safety, economic or social well-being, and whose disruption or destruction would have a significant impact on the member state. European critical infrastructure means critical infrastructure located on the territory of a member state, the disruption or destruction of which would have a significant impact on at least two member states. The significance of disturbances in the functioning of critical infrastructure elements should be assessed on the basis of interdependence criteria. This implies effects resulting from cross-sectoral dependence on other types of infrastructure.
Serbia	Critical infrastructure are systems, networks, facilities or their parts, the interruption of which or interruption of delivery of goods or services can have serious consequences on national security, human health and life, property, environment, security of citizens, economic stability, or jeopardize the functioning of the Republic of Serbia.

However, countries define critical infrastructure in their own way (Table 1), having certain similar attitudes, but also differences depending on the general level of development, the level of development and the general condition of infrastructure, budgetary possibilities, etc. Each country has its own priorities, and attitudes based on experience in the functioning of its basic systems, as well as on the existence of previous damage to the same, and available, most often confidential information on potential attacks on critical infrastructure.

Critical infrastructure is, therefore, a set of critical elements on which the activities of modern societies are based, but this notion came to the fore only after the beginning of endangering it. For example, it can be said that the protection of critical infrastructure became relevant in Europe after the terrorist attacks in Madrid and London in the middle of the first decade of this century, and the EU launched many initiatives and strategies aimed at protecting critical infrastructure. Following European trends, but also drawing on its own experiences with major floods and landslides, Serbia received the Law on Critical Infrastructure in 2018 [4].

Due to the wide range of infrastructure uptake, there is no generally accepted classification but series of different groups and subgroups. The sectors for which critical infrastructure is most often identified and determined are: energy, transport, water and food supply, public health, finance, telecommunications and information technologies, environmental protection and the functioning of state authorities.

When looking at infrastructure ownership, critical infrastructure can be in public (state, local or regional government) or private (natural or legal persons) ownership. In general, there are no rules. In some countries, the infrastructure is privately owned, and in others it is publicly owned. There are also mixed forms when infrastructure segments are under private or public authority together. In relation to private ownership, since the owner of the infrastructure can be easily changed, it means that the owner does not have to be the one who built that infrastructure.

Depending on the time during which protection needs to be implemented, there may be permanent, temporary or potentially critical infrastructure [2]. Constantly critical infrastructure must be in focus at all times and include the most important infrastructural elements for a country. It is prescribed by law; i.e. its components are determined by regulations with the force of law. Infrastructure servicing short and often important events can be included in a temporary critical infrastructure (e.g. infrastructure to support some political or sporting events). Permanent and temporary critical infrastructure are important at certain time of the year or during certain events. Potentially critical infrastructure can be important in certain situations that are not planned in advance, but is not primarily in focus.

Although primarily considered within individual countries, critical infrastructure can still have regional and global significance. Therefore, it is possible to talk about national, regional and global critical infrastructure. When analyzing the importance within a country, the critical infrastructure at the local, regional (geographical, economic or cultural regions in the country), state (national) and international level is singled out.

Finally, a distinction should be made between the way infrastructure is managed, which can largely determine the type and timing of reaction when infrastructure is compromised. Infrastructure managers can be from the public sector (mainly services, directorates,

agencies founded by the state or local government) and the private sector (legal or natural persons who manage public or private assets).

3. CRITICAL TRANSPORT INFRASTRUCTURE

Road/rail closures and traffic congestion, shortening of infrastructure life due to faster deterioration, loss of alternative routes and inability to evacuate, inability to supply energy, loss of communication, restrictions on movement of people, goods and supplies and similar consequences have a detrimental social and economic impact on countries.

Critical transport infrastructure includes physical elements, services, supply chains, information technology (networks and infrastructure) that play a key role in transporting people and goods, ensuring the health of the population, security of the nation, efficient functioning of the state, society and economy.

Within the country, critical transport infrastructure is represented by the subsystems of the main system. Roads and highways, railways with stations and junctions, ports and docks, urban roads, public transport, airports, logistics centers, multimodal and intermodal capacities, etc., are all subsystems of the entire transport system of the country or region. After all, all these individual elements, depending on the level, ensure the functioning of the international transport of people and goods, as well as the infrastructure systems of other sectors. Disruption of some element of critical transport infrastructure has a negative impact on the functioning of the entire transport system. The consequences that can be caused by disruptions of critical transport infrastructure are complex and much more difficult to eliminate [5]. Therefore, in order for the main system to be able to function smoothly and safely, it is necessary to ensure the safety of critical elements and provide backup solutions between subsystems.

Each subsystem consists of specific elements that enable the functioning of the whole. Potential critical elements of transport infrastructure are defined as e.g. interchanges on highways, bus and train stations, bridges and tunnels. Landslides, heavy rains and floods are identified as consequences of extreme weather conditions that can affect the functionality of transport infrastructure [6, 7]. For example, an accident or fire in a tunnel will prevent the operation of an entire section of road or railway for an extended period of time, so tunnels are considered potential elements of critical infrastructure due to possible disruption of traffic within the country or on international corridors, as well as due to the potentially large number of fatal accidents. Disabling public transport stations affects the local mobility of the population due to the fact that the operation of stations and public transport is very important in the urban area and allows the movement of a large number of people during the day. When the bridge is damaged or demolished, the entire section of the road/rail is impassable and alternative sections must be provided. The cessation of the functioning of intersections on city streets or roads affects the local efficiency of traffic, but, fortunately, non-functioning elements can be renewed in a relatively short time or bypass roads can be used [8].

According to EU Council Directive 2008/114 / EC [9], critical infrastructure facilities in the transport sector are considered within the following subsectors: road, rail, air, inland waterway transport, ocean and sea transport. The affiliation of a sector to critical infrastructure does not automatically imply that its complete structure is included in this definition. In order for certain elements (facilities) or entire sections of the transport

network to be classified as potential elements of critical infrastructure, they must meet the conditions defined by the relevant European directives and national legislation. In the process of classifying transport infrastructure components as potential elements of critical infrastructure, it is necessary to take into account their role in regional, national and international transport flows and services. The task of state institutions dealing with security, but also managers of individual sectors or subsectors, is to identify those segments that are crucial for functioning and can represent a potential target/problem. These should certainly be places whose outages lose their functionality or cause a complete standstill, both in one sector and in the state as a whole.

The general assessment methodology presented below can be used to assess the criticality of transport infrastructure elements [8]. The primary goal of the methodology is the identification of critical infrastructure, as well as the need for managers to raise awareness of the importance of transport infrastructure security for the functioning of the state, society and economy. Also, through the methodological framework, the responsibility of the manager for the safe functioning of the transport infrastructure is determined.

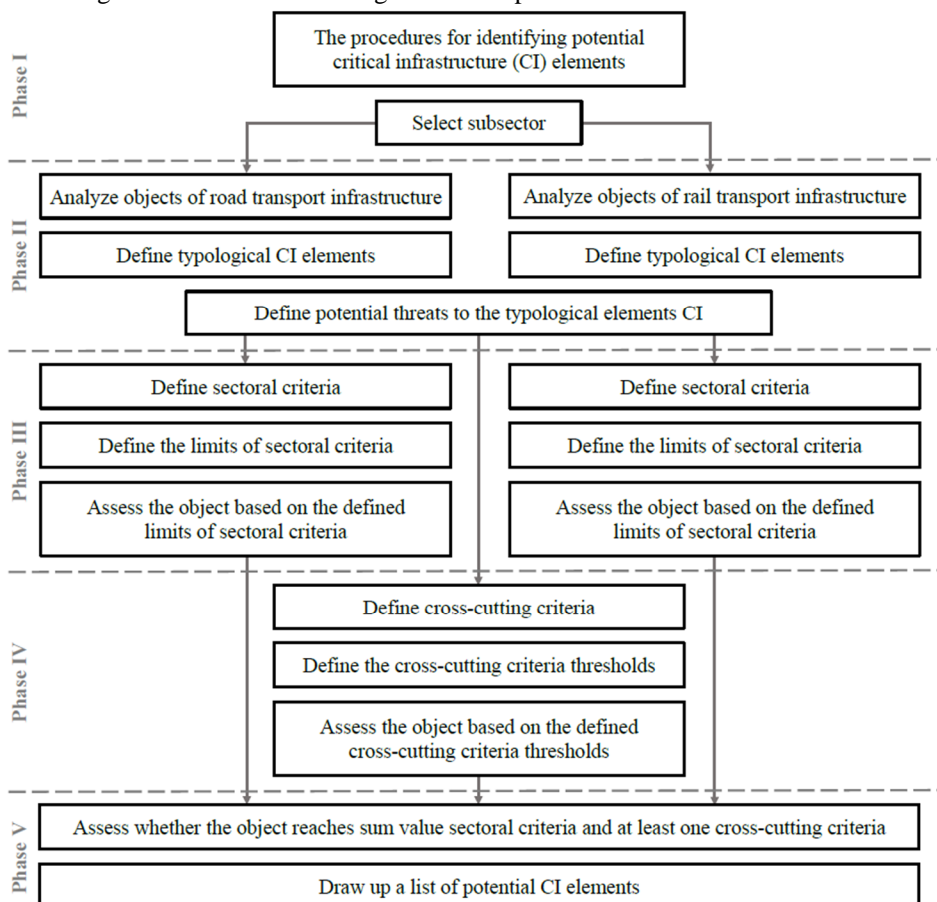


Figure 1. Methodology for identification of critical infrastructure elements for road/rail transport infrastructure [8]

The procedure of identification and assessment of elements of critical transport infrastructure for e.g. road or rail traffic consists of the following five phases (Figure 1):

- Phase I: Determining the most important elements of critical infrastructure for classification into sectors;
- Phase II: Analysis of the elements in order to determine whether they have a unique/specific position in the traffic network; typological elements of traffic infrastructure are identified;
- Phase III: Detailed categorization through division into subsectors. Multi-criteria evaluation of alternatives over the limit values of the criteria is used; describes the reality during the election;
- Phase IV: Setting threshold values for cross-criteria. Cross-cutting criteria specify the conditions under which individual infrastructure elements are identified as critical infrastructure elements. Determining appropriate threshold values is crucial for the quantitative calculation of a set of critical infrastructure elements;
- Phase V: Determining the final list of individual elements of critical infrastructure.

4. CRITICAL INFRASTRUCTURE PROTECTION

Any disruption in the elements of critical infrastructure poses a serious threat to the proper functioning of the transport system and can lead to human casualties, property damage and significant economic losses [3]. Infrastructure should enable the smooth functioning of modern society; therefore, good protection must be provided.

Analysis of the importance of the country's critical infrastructure indicates the importance of insuring these facilities from various risks. Critical infrastructure protection is a set of activities and measures aimed at ensuring the functioning of critical infrastructure in the event of disruption or destruction, or protection in the event of threats and prevention of the consequences of disruption or destruction [4].

In Serbian regulations, the term critical infrastructure also appears in the Strategy for the Development of the Information Society in the Republic of Serbia until 2020 [10]. One of the priorities of this strategy is the protection of critical infrastructure within information security. Protection against attacks by information technology on critical infrastructure systems is important, but an attack using information systems can endanger other types of critical infrastructure, primarily those that are managed by the application of information technologies. In this sense, transport infrastructure is particularly sensitive as information technology enables it to be managed and operated in an efficient and effective way, especially for high-level infrastructure (e.g. high-speed railways, highways, airports and air traffic control, urban transport systems, etc.).

Given the importance of critical infrastructure, its protection is crucial to functioning, and represents a complex system of security equipment, people and procedures that must be followed to keep security at the highest possible level. In the implementation of critical infrastructure protection measures it is necessary to:

- identify critical infrastructure;

- map critical infrastructure;
- exchange information with relevant entities;
- train staff (managers, labor and special services) engaged in jobs and tasks in the critical infrastructure system;
- improve the system of protection of critical infrastructure (automated monitoring of condition and damage, video surveillance, access control, notification of damage and fire, evacuation system) or recovery in case of emergency;
- implement physical requirements on the transport network which improve its flexibility (construction of infrastructure of the same or similar rank in critical zones, and enabling a “backup” option in the case of bridges and tunnels) and improves the condition of facilities and their resilience to potential negative impacts.

Also, in the field of infrastructure management, the Law on Critical Infrastructure [4] in Serbia defines the obligation to develop an operator’s safety plan for risk management. This document, which is based on the assessment of threat/security of infrastructure and risk analysis (as an integral part of the plan), identifies risk mitigation measures, defines responsibilities and duties, and establishes a framework for action to eliminate or reduce the consequences of security threats defined in the risk analysis. With the defined obligation to develop this plan, the first step was taken towards ensuring the security of transport infrastructure by its manager.

The fact that is often neglected or implied should also be emphasized. Individual infrastructure managers, and their engaged contractors, can usually deal with minor incidents, but for larger events it is necessary to establish cooperation between several different infrastructure managers (roads, railways, gas pipeline, heating pipeline, etc.) or several organizations (e.g. agencies for waters, civil protection, police, ministry of agriculture and forestry, trucking association, etc.). In today’s setting of relations, problem solving is most often approached so that it is only the concern of one side, but joint action can achieve significantly better effects and greater benefits.

5. CONCLUSION

Facilities that ensure the functioning of social systems or some part of it in terms of administration, health, security, economy, energy sector, traffic, communications, are elements that are extremely suitable for terrorist action, and at the same time exposed to catastrophic events in nature. As such, these elements denote the notion of critical infrastructure. Since these subsystems are usually dependent on each other, disruption of any of the levers causes a delay or blockage in the operation of the others.

Critical elements of transport infrastructure are constantly exposed to natural and human impacts that can lead to undesirable situations with negative consequences for the assets of critical infrastructure and the functioning of the economy, society and the state. The effects of these negative factors can be reduced by positive factors - physical interventions to improve infrastructure and management actions. The performance of critical

infrastructure in transport is affected by both negative and positive factors that absorb disturbances.

Disruption of the critical infrastructure of one country is increasingly affecting the critical infrastructure of the same type in other countries. The effects of major breakdowns and infrastructure failures in one state can be transferred to other neighboring states, especially when it comes to transport. Practically every day, individual elements of the system or the system as a whole can be disrupted. In order to reduce the negative impacts, as well as interruptions in their work, a system of protection and rescue is being created, which would have to adequately respond to the threat to critical national resources, which includes transport infrastructure. Critical infrastructure protection is not limited to providing an immediate and effective response in the event of a failure or destruction. On the contrary, through certain phases in the cycle of critical infrastructure protection, prevention procedures and appropriate treatments at facilities are combined.

In order for the transport system to function smoothly, large investments are needed in the maintenance and protection of roads, railways, bridges, tunnels, navigation systems, transport centers, etc., as well as in modernizing the sector to meet demand, follow up with modern technologies and ensure system sustainability. A major problem, everywhere in the world, is the fact that maintenance and modernization costs are growing significantly faster than gross domestic product, and the economy and national budgets cannot keep up with financing. Without making large investments, the transport system faces inevitable breakdown and decay, and thus becomes even more sensitive to terrorist acts and catastrophic events in nature.

The financial and transport operations consequences, and especially the consequences for the lives of people directly related to the transport infrastructure, require an urgent process of improving the existing protection measures, and mandatory risk assessment and management practice in all future steps of transport network and services design and management.

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КРИТИЧНА ИНФРАСТРУКТУРА У САОБРАЋАЈУ

Резиме: *Критична инфраструктура је општеприхваћен појам који описује инфраструктуру неопходну за обезбеђење основних потреба државе, привреде и друштва. Саобраћајна инфраструктура је генерално комплексна творевина која укључује различите дисциплине и компоненте, и током свог животног века бива изложена различитим утицајима. Генерално посматрајући, најважније саобраћајне везе у држави су увек карактерисане као критична инфраструктура. Међутим, за управљаче и локалне заједнице су критични готово сви путни и железнички правци јер би њихов губитак онемогућио слободно кретање и потенцијално довео до изолације заједница. Циљ рада је да се дефинише и објасни појам критичне инфраструктуре у саобраћају, посебно у контексту обезбеђења ресурса и предузимања управљачких акција ради заштите исте.*

Кључне речи: *критична инфраструктура, саобраћај, управљање, процена, заштита*