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## RESILIENCE AND IMPROVEMENT STRATEGIES FOR CRITICAL INFRASTRUCTURE IN PARDUBICE

**Keywords:** *Pardubice, Resilience and improvement strategies, Pardubice Region*

The work focuses on the question of resilience and improvements strategies for critical infrastructure in Pardubice.

### INTRODUCTION

This thesis focuses on the critical infrastructure of the City of Pardubice in the context of the Pardubice Region. The thesis describes selected subsystems of the critical infrastructure. The authors also offer possible solutions for each of the problems.

The authors study at the University of Pardubice, therefore they chose this topic. This topic was chosen by the authors for the Blended Intensive Programme (BIP) in Zagreb, which is part of Erasmus+.

### 1. BASIC INFORMATION

Pardubice is a middle-sized city east of Prague. It is the capital city of the Pardubice Region, with over 90,000 citizens. Pardubice is a university city with more than 10,000 students. The town is situated on the railway corridor line from Prague to Česká Třebová. [1]

#### 1.1. PARDUBICE REGION

In the Pardubice region, more than 550,000 people live. It is situated in the east of Bohemia and covers an area of 4,500 km<sup>2</sup>, surrounded by the Hradec Králové

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Region, Central Bohemia Region, Vysočina Region, South Moravia Region, and Olomouc Region. The region also shares a part of its border with Poland.

The administrative centre is located eccentrically in the western part of the region. In the eastern part of the region, there are regional towns with a population of between 10,000 and 30,000 residents. [1]

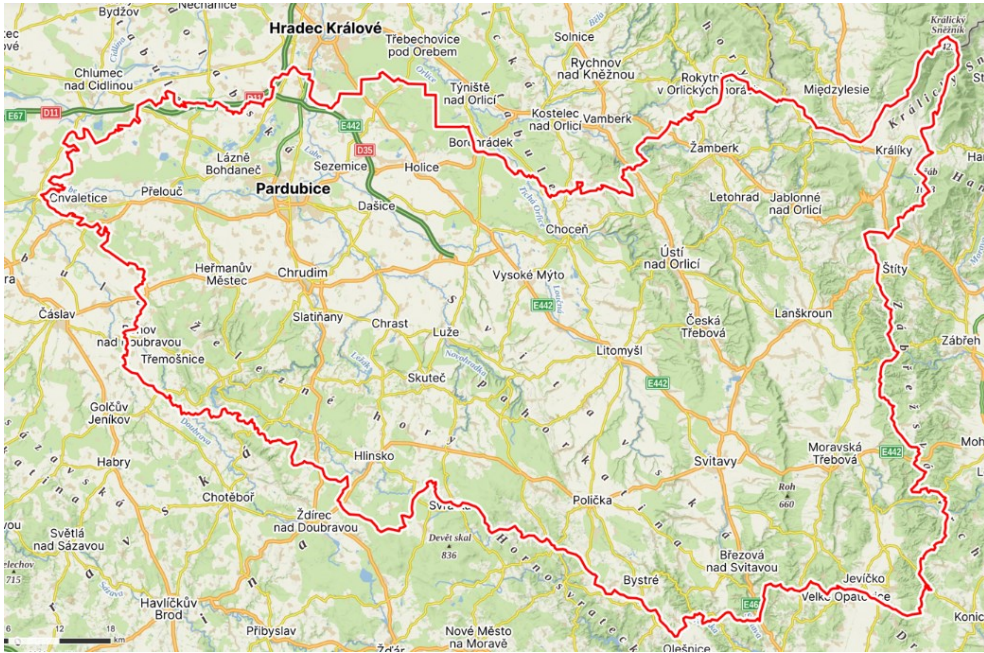


Fig. 1. Map of Pardubice Region [2]

#### 1.1.1. ROAD TRAFFIC

Pardubice Region is suffering from the low density of highway. There is the D11 motorway Prague – Hradec Králové which partly passes through this region. This highway is connected to the D35 highway which provides connectivity to the region.

This motorway is planned to be extended to Olomouc. More than 60 kilometers are planned to be built, or they are already under construction. This extension will increase the accessibility of the geographical centre of the region. Currently, the connection between the central and eastern parts of the region is provided by the I/35 road, which, however, has insufficient capacity. This is mostly caused by passages leading through towns.

Another major road is the I/35, connecting Hradec Králové, Pardubice, Chrudim, and the whole region to the D1 highway. [3]

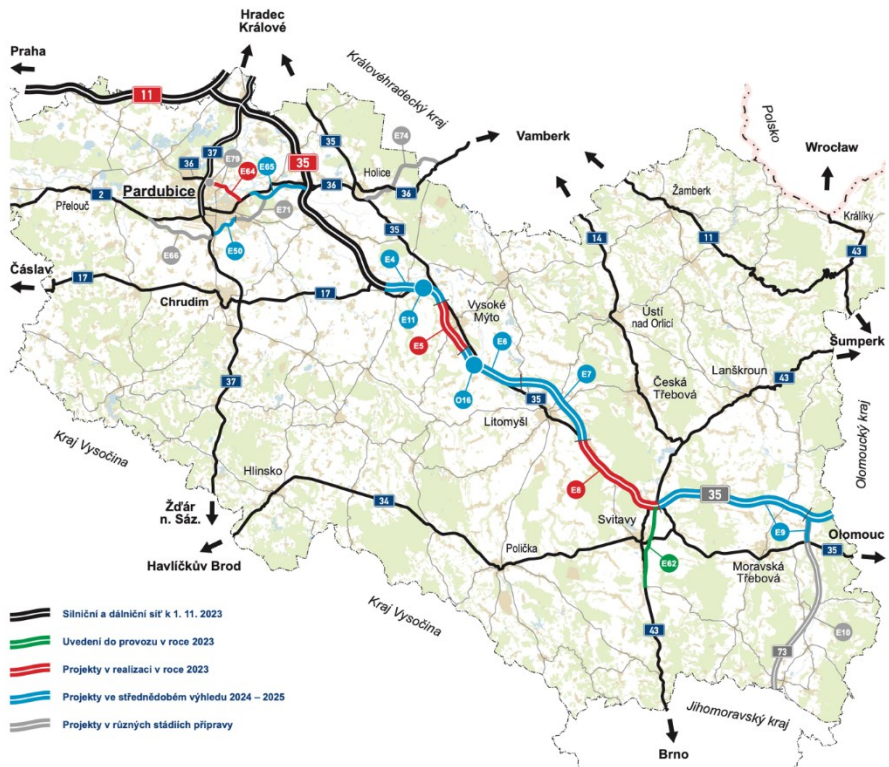


Fig. 2. Map of highway network in Pardubice [3]



Fig. 3. Pardubice junction after the reconstruction [4]

### 1.1.2. RAILWAY TRAFFIC

Railway infrastructure is more important for the Pardubice Region. The largest towns in the Pardubice Region (Pardubice, Přebouč, Chocně, Ústí nad Orlicí, Svitavy) are connected to the railway 001, 010 corridor (1st Czech transit corridor).

This means that, for example, between Prague and Pardubice, you can take a train every 10 minutes during peak times and normally once an hour throughout the day.

Another important railway line is railway number 030, which connects Pardubice with Hradec Králové. This line is experiencing a high increase in the number of passengers thanks to modernization and the deployment of new trains.

Railway number 238 to Chrudim is also a relatively important link. Other lines serve as peripheral connections and are relatively lightly used. This is mainly due to uncompetitive commuting times. [4]

### 1.1.3. CRITICAL INFRASTRUCTURE

The most important are the power plant located in Chvaletice and the power plant for hot water in Opatovice nad Labem. These two power plants supply electricity for the Pardubice Region and the Hradec Králové Region.

Another example of critical infrastructure in the Pardubice Region is Pardubice Hospital. It is the largest hospital in the region. It is necessary to protect the hospital against any cyber-attacks. [1]

## 1.2. THE CITY OF PARDUBICE

The historic centre of Pardubice was built on the left bank of the Labe River near the confluence with the Chrudimka River. Originally, the town developed only on the left bank of the river. However, with the advent of industrialization in the 19th century, Pardubice experienced a high population growth. The right bank of the Labe River, which was not very industrially developed until then, became a natural place for the city to expand.

At that time, only one bridge connected the two banks. In the middle of the 20th century, massive construction caused a great densification of the built-up area. This trend was mainly due to the new prefabricated flats that were built on the periphery of the city.

The growth of the built-up area also meant the absorption of the surrounding villages, which were subsequently properly integrated into the perimeter of the city. Due to the not always natural integration of the surrounding villages within one administrative unit, the built-up area of Pardubice is not very compact. The built-up area is often separated by narrow corridors of green spaces that follow the original boundaries of natural settlements. [5]

### 1.2.1. ROAD TRAFFIC

Public urban transport in Pardubice is operated by the company "Dopravní podnik města Pardubice". It's owned by the city. The company operates bus and trolleybus transport in the city, with 74 buses and 56 trolleybuses. [6]

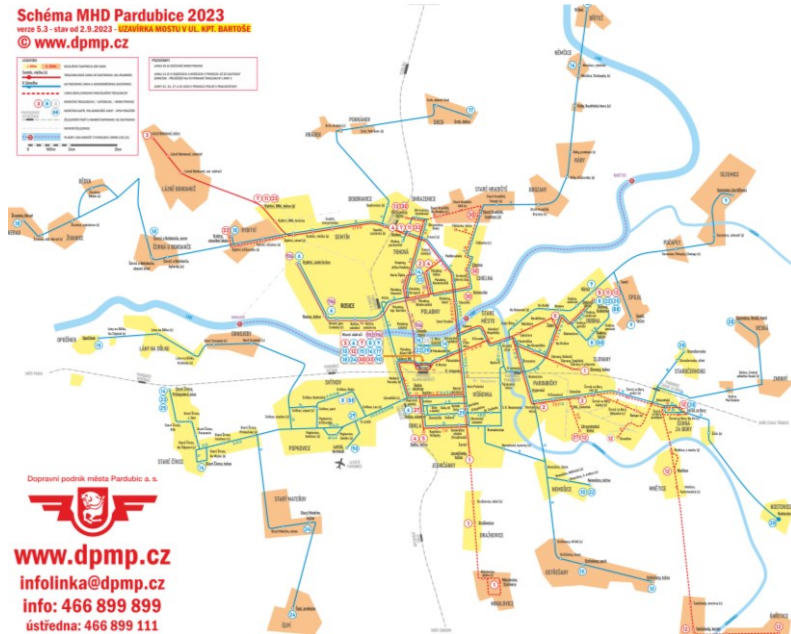


Fig. 4. Scheme of Pardubice urban public transport [7]

The A36 road runs through Pardubice. This road connects Pardubice with Sezemice and Borohrádek. It's highly used by lorries and cars. As Pardubice does not have a functional bypass, traffic jams often occur in the centre of the city. [3]

### 1.3. CRITICAL INFRASTRUCTURE

As was mentioned previously, one of the most critical infrastructures in Pardubice is the hospital. The hospital is located in the southern part of Pardubice. Hospitals are one of the key institutions in our society. [5]

Another example could be the bridges in Pardubice. Although the Labe River flows through Pardubice, there are only three bridges, one of which is in a state of disrepair.

In the next chapter, the authors would like to introduce each of the critical infrastructures and describe them. [3]

## 2. BRIDGES IN PARDUBICE

A significant part of the population lives in the area north of the Labe River. For these inhabitants, there was a need to ensure adequate connections with the rest of the city, so the river has been spanned by several bridges over the years.



## 2.1. PAVEL WONKA BRIDGE

The Pavla Wonka Bridge (in picture 5 - yellow) is located in the central part of the city, connecting Masaryk Square - one of the transport hubs for public transport - with Polabiny or Stavařov, a residential area. The bridge is primarily used for road traffic, as it carries the road II/324. The trolleybus line runs above the roadway in each direction. Additionally, there is a mixed pedestrian and cycling path on both sides of the road. Until the construction of the bridge on the A37 road in the western part of the city, this bridge was the only capacity link for transit car traffic. [3]



Fig. 5. Map of Pardubice's bridges [8]

The protection of the bridge from physical influences was already addressed during construction. In addition to the river itself, the bridge crosses an inundation area, thus ensuring protection not only against periodic flooding but also against flooding from thawing and intense rainfall. According to the flood plan of the city of Pardubice, the bridge should be secured against 100-year water. The technical condition of the bridge is also monitored. The bridge deck consists of a field of prestressed concrete. This type of structure is susceptible to degradation, mainly due to possible corrosion of the steel cables. Hence, a visual inspection of the steel cables is periodically conducted. Non-invasive methods, such as resonance scanning, are also used for inspecting the bridge. The bridge underwent repairs in 1965, 1983, 1987, 2003, 2006, and 2022. [9] [10]

## 2.2. BRIDGE OF THE I/37 ROAD

The Nádražní Street Bridge (in the picture 5 – blue) is the highest capacity road link. It is located on the I/37 road, which leads from Trutnov through Pardubice to Velké Bíteš, where it is used as a feeder to the D1 motorway. The bridge consists of

two separate bridge decks with 2+2 lanes, which are connected to a part of the road classified as a motor vehicle road. In 2022, trolley poles were installed on the bridge deck, which increased the robustness of the public transport system.

Given the relatively low age of the bridge and the recent reconstruction that took place in 2017, the bridge is in reasonably good condition. The bridge is routed completely outside the flood plain. Monitoring of the condition of the structure is carried out periodically. [11]

### 2.3. KAPITÁN BARTOŠ BRIDGE

The Kapitán Bartoš Bridge (in the picture 5 – red) connects the eastern part of Polabiny with the Green Suburb. The bridge is of regional importance. Currently, due to its poor condition, vehicle passage is restricted. The trolleybus track that runs over the bridge is presently unused because of the excessive weight of trolleybuses. A proposal for constructing a new bridge is currently being discussed.



Fig. 6. New look of Kapitán Bartoš bridge [12]

### 2.4. RAILWAY BRIDGE OF TRACK 031

The railway bridge over the Labe lies on the line 031, which connects Hradec Králové with Pardubice. This line is one of the busiest in the region. At present, the

original bridge deck has been removed and replaced by a completely new construction. [4]

## 2.5. POTENTIAL SOLUTIONS

The construction of the north-eastern bypass of Pardubice will contribute significantly to reducing the vulnerability of the road network. This bypass will reduce the intensity of transit traffic in the west-east direction, which currently leads through the city's inner ring road. In emergency situations it can also serve as an alternative connection. Construction began in December 2022. Completion is scheduled for 2025.

## 3. PARDUBICE'S HOSPITAL

Hospitals are a very important part of the Czech Republic. The Czech Republic has more than 150 hospitals. It's necessary to keep all of them safe.

### 3.1. CYBERSECURITY

In 2019, Russian hackers attacked one of the regional hospitals in the Czech Republic using ransomware. The Hospital in Benešov was paralyzed for more than 20 days. The attack caused damages exceeding 59 million CZK. The hospital lost some data, and its software was also damaged.

It was one of the biggest attacks in the history of the Czech Republic. After that, all the state-owned hospitals renew their server security systems to be safer. [13]

### 3.2. COVERAGE OF THE AREA BY THE RESCUE CORPS

The key thing is to be on the scene of the emergency in time. In the picture, you can see the rescue service base (Hradec Králové, Jihlava, Olomouc, Brno). Air emergency services are not provided in Pardubice. Therefore, this service is outsourced by other regions.

Another problem is the availability of emergency services via road in Pardubice. The hospital is located beyond the railway track. There is only one bridge that crosses the railway, which is potentially problematic for the availability of emergency services. In 2022, this bridge was under construction, and it was difficult for emergency services to reach the location on time. [14]





Fig. 7. Availability of emergency services in the Pardubice Region [14]

### 3.3. POTENTIAL SOLUTIONS

There are few things to change to keep the hospital safe and to keep citizens safe as well.

- Keep protect from hackers,
- relocate the rescue service base.

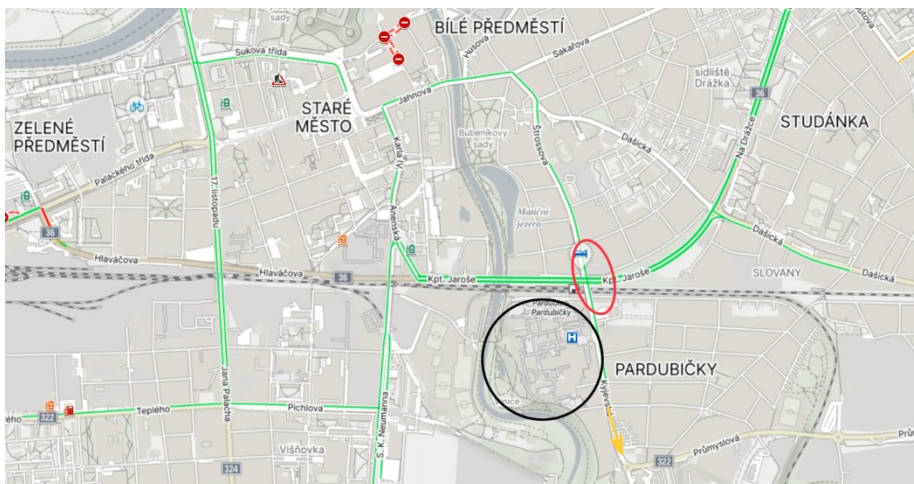


Fig. 8. Map of location of Pardubice's hospital [8]

The first thing is already being done. Pardubice's hospital has its own IT team for keeping software updated and safe. The second thing is much more complicated. As you can see in picture 6, the hospital is shown in a black circle. The problematic bridge is shown in red. It is a problem to choose another route other than this one (via the bridge). The only possible way is to take a longer route to the south (yellow arrow).

#### 4. POWER PLANT

Every city needs electricity. For Pardubice, Chvaletice's power plant has been operating for over 40 years. Today, it is normal for the transmission system to be interconnected, but in the past, Chvaletice was the main power plant for part of the Middle Bohemia Region and Pardubice Region. The other power plant is located between Pardubice and Hradec Králové and is called Opatovice. [15]

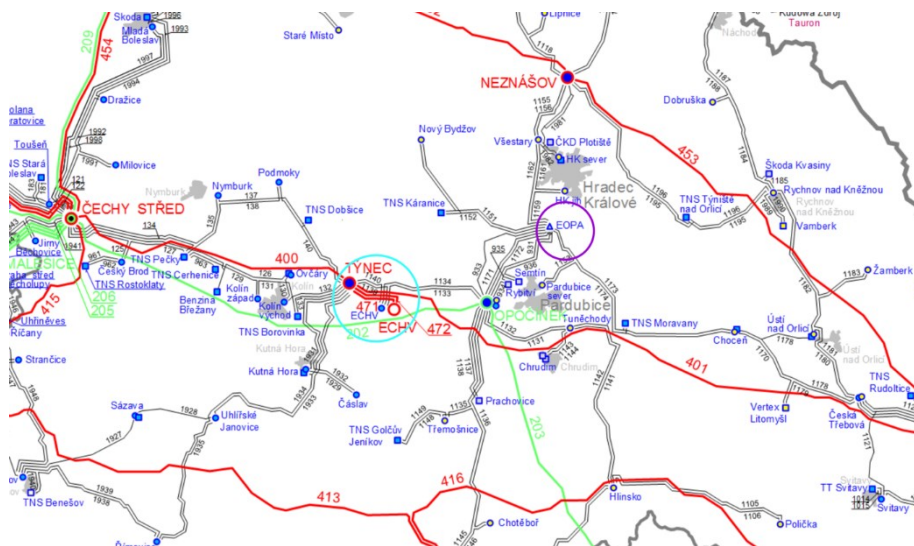


Fig. 9. Scheme of transmission system [16]

##### 4.1. OPATOVICE NAD LABEM

What is still very important for Pardubice and Hradec Králové? The power plant in Opatovice nad Labem produces electricity and hot water for both towns, as well as Chrudim, Lázně Bohdaneč, and other smaller cities nearby. The total length of the pipes is 319 kilometers.

The power plant burns coal, which is not environmentally friendly. Another problem is that if there are any issues with coal logistics, more than 300,000 people will be left without hot water.[17]

#### 4.2. CHVALETICE

Chvaletice's power plant is not producing hot water; instead, it is much more powerful (820 MW). It is owned by the private company Seven Energy. Like Opatovice's power plant, it burns coal to produce electricity. This power plant compensates for fluctuations in the grid and serves as a potential backup. [15]

#### 4.3. POTENTIAL SOLUTION

The best option would be to develop a new sustainable power plant for supplying energy and hot water. It is also important to protect these two power plants as without them, the region will be without electricity and hot water.

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