Cost Overruns in Large Infrastructure Projects – An Overview of International and Croatian Experiences

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Abstract

Large infrastructure projects, privately or public funded, have always been under public review in order to determine the cause of the costs overruns or failure to achieve the intended projects benefits. Once when the project implementation is finished, it is often revealed that the costs of the project exceeded the planned budget. However, with all these large traffic infrastructure projects complications arise involving the aforementioned anticipated costs exceeding the initial predictions and shortfalls in project benefits. The latest researches, except for usual technical risk analysis, go in the direction of the nature of the behavioral defects in project planning. This paper gives an overview of recent international experiences and researches in this field compare to latest Croatian experience with an implementation of the national traffic strategy.

Keywords: large infrastructure project; cost overrun; time delay; optimism bias

1. Introduction

Construction projects, both funded privately or public, have always been under public criticism and professional review in order to determine the cause of the costs overruns or failure to achieve the intended project benefits. The history of large transport infrastructure project reveals that it is common that costs are underestimated in the early phases, and after commissioning it was revealed that the cost of the project exceeded the planned budget.

Let us remind to some of Europe's major construction projects from the recent history: the project of building the 50 kilometers long tunnel link between France and Britain beneath the English Channel, 17 km long suspension bridge "Vasco da Gama" in Lisbon, 57 km long Gotthard railway tunnel in the Swiss Alps, submerged tunnels in Denmark or the vast investments of German government in road connections after the unification. In practice, many large scale projects bordering megalomaniac like competition to build the tallest buildings in the world where the buildings heights already exceeds 800 meters, construction of stadiums for big

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 sporting events and the Olympics. In terms of the Olympic motto, in construction is a long time ago not important only to take a part. To build faster, higher and more, is the essence how to obey the need of the world economy for constant growth.

In Croatia, after implementation of a part of the national traffic strategy - program of road traffic connection with a network of modern motorways led public debate and media campaign, according to media reports, the excessive cost of implementation of these projects. There is still an ongoing controversy about the economic viability and the total costs for construction of road links all over the state, such as building a fixed link between the mainland and the peninsula of Peljesac, or intention to connect the far south with the modern motorway or just to upgrade the state road. These public debates on doubts are not new, if we recall the debates in time before making a decision on the road connecting the north and south of Croatian land, which begins at the end of the sixties of the 20th centuries, until 2001, when the government brought the decision that the project of motorway linking Zagreb and Split, has to start without delay and to finish in a certain period of three years.

But with all these massive construction projects come complications that include cost overruns in compare to early cost estimations and shortfalls in the project benefits. There is a name for this phenomenon found in literature, so called "megaprojects paradox” and "performance paradox" (Flyvbjerg, 2003).

2. Examples of the International Large Infrastructure Projects

2.1. Eurotunnel „Channel“ (France/Great Britain)

Estimations of total investment cost (prices in 1985), amounted to 2.6 billion £. After completion in 1994, actual cost amounted to 4.65 billion £, or 80% more than the forecasted amount. The costs exceeded partly due to the increased traffic security and environmental protection requirements. Financing costs turned out to be 140% higher than forecast (Flyvbjerg et al.: Megaprojects and Risks - An Anatomy of Ambition, 2003).

The total traffic volume of passenger traffic in peak was 18.4 million in 1998, and then fell to 14.9 million in the 2003. Since then traffic volume rise again to 17.0 million in the 2010. At the time of the decision to build the tunnel, projected number of passengers for the Eurostar trains were 15.9 million passengers in the year of the opening of the tunnel to traffic. In 1995, first full year after the commissioning, actual number of passengers amounted to slightly more than 2.9 million, with an increase to 7.1 million in 2000.

2.2. Great Belt Fixed Link (Denmark)

Great Belt fixed link connects eastern Denmark with a rest of continental Europe and consists of longest European suspension bridge with the second longest railway immersed tunnel. Great Belt opened for rail traffic in 1997 and for road traffic in 1998. At a time when in 1987 the law on Great Belt was ratified in the Danish parliament, the total investment cost was estimated at 13.9 billion DKK. When construction finished in 1999, costs have increased by 54% to 21.4 billion DKK. Also, in 1987 forecasts for daily traffic were 19,700 rail passengers and 9,800 vehicles. After the opening in 1997, daily traffic in the first year was 19,300 rail passengers and 16,990 vehicles, which was better than expected (Flyvbjerg et al., 2003).
2.3. Øresund Fixed Link (Denmark/Sweden)

Øresund fixed link between Sweden and Denmark was opened to traffic in 2000. When the Danish parliament ratified the law in 1991, the total investment costs were estimated at 11.7 billion DKK for the marine part and at 3.2 billion DKK for access from Denmark. When the access to the Danish side was completed in 1998, the actual cost amounted to 5.4 billion DKK or 68% more. When the sea area is opened in 2000, the costs for this part raise by 26% to 14.8 billion DKK. The traffic is forecasted in 1991 with 10,000 vehicles per day and 16,500-19,000 rail passengers. The actual traffic in 2001 amounted to 8,100 cars and 13,400 rail passengers, which was below the forecasts (Flyvbjerg et al., 2003).

2.4. Stuttgart 21 Metro Station (Germany)

Construction of the metro station in Stuttgart, Germany, named Project Stuttgart 21 has proven to be significantly more expensive than previously thought. In December 2012 owners presented data on the total construction cost in amount of 5.6 billion €, an increase of 1.1 billion € compared with the previous calculations. There are other risks worth 1.2 billion €. When the framework agreement on the project was signed in 1995, Stuttgart 21 was supposed to cost 5 billion DM, or about 2.6 billion € (Flyvbjerg, Bruzelius & Rothengatter, 2003).

2.5. Berlin Brandenburg Airport (Germany)

The new airport Berlin-Brandenburg (BER) supposed to be opened in June 2012. However, four weeks before the opening date shareholders suddenly decide not to be generous for this project. Once again announced opening date for flights could not be met. Now is the taking over of the airport planned for October 2013. However, the new opening date is far from certain. And there is also a problem with a lack of funds: In September 2012 shareholders provided around 1.2 billion €, and the costs have increased to 4.3 billion €. The money is not paid yet, and they still negotiating a further 200 million €. At the beginning of construction in the 2006 the calculations were at 2 billion € for works. The project is a public-funded where province of Berlin and Brandenburg hold 37% of the company, and the rest is owned by the federal government (www.focus.de).

2.6. Concert Hall of Elb Philharmonic in Hamburg (Germany)

Delays of works and the large cost overruns for Concert Hall in the port of Hamburg is a constant theme in the German public. In December 2012 the contractor promised to finish the building of Elbe Philharmonic for 575 million €. This is an increase of 200 million € compared with the previous plans. The city of Hamburg threatened to the contractor with termination of contract. According to the contractor’s promises, the building, which besides the concert hall includes a five-star hotel, restaurants and a parking garage, is to be completed by the summer of 2016. This is again a delay for the completion of the prestigious project for another year.

Originally Elbe Philharmonic, whose construction began in 2007, should be finished in 2010. Again and again, the owner and the contractor arguing about additional project requirements, incorrect specifications and input data. At first, it was said that the project will cost 77 million €, and now it is 575 million € - seven times more (www.focus.de).
Table 1 Examples of cost overruns for large infrastructure projects (Flyvbjerg et al.: Megaprojects and Risks - An Anatomy of Ambition, 2003)

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>COST OVERRUN (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airport in Denver, SAD</td>
<td>100</td>
</tr>
<tr>
<td>Tunnel „Channel“ under La Manche, France/UK</td>
<td>80</td>
</tr>
<tr>
<td>Boston Central Artery Tunnel-„Big Dig“, USA</td>
<td>190</td>
</tr>
<tr>
<td>Humber Bridge, UK</td>
<td>150</td>
</tr>
<tr>
<td>Railway Boston-Washington-New York, USA</td>
<td>130</td>
</tr>
<tr>
<td>Great Belt Rail Tunnel, Denmark</td>
<td>110</td>
</tr>
<tr>
<td>Motorway A6 Chapel en le Firth/Whaley, UK</td>
<td>100</td>
</tr>
<tr>
<td>Shinkansen - Joetsu Railway Line, Japan</td>
<td>100</td>
</tr>
<tr>
<td>Metro in Washington, D.C., USA</td>
<td>85</td>
</tr>
<tr>
<td>Light Railway Karlsruhe-Bretten, Germany</td>
<td>80</td>
</tr>
<tr>
<td>Øresund Access Link, Denmark</td>
<td>70</td>
</tr>
<tr>
<td>Metro Line, Mexico City, Mexico</td>
<td>60</td>
</tr>
<tr>
<td>Railway Paris-Auber-Nanterre, France</td>
<td>60</td>
</tr>
<tr>
<td>Metro Tyne and Wear, UK</td>
<td>55</td>
</tr>
<tr>
<td>Great Belt Sea Link, Denmark</td>
<td>54</td>
</tr>
<tr>
<td>Øresund Coast-to-Coast Link, Denmark</td>
<td>26</td>
</tr>
</tbody>
</table>

3. Researches of Cost Overruns

Generally speaking, construction projects are expensive and under the public criticisms have acquired a bad reputation due to the cost overruns and delays in completion. It can be stated that the fault for this phenomenon is divided between direct participants in the construction process: employers, designers, contractors, but the reason should also be sought in the wider project environment due to political and other influences that cause a wide scope of changes.

According to the conventional methodology, inaccuracy in cost estimation is calculated as the size of the cost overruns. Excessive cost is measured as the ratio of actual costs net of estimated costs as a percentage compared to the estimated costs. Actual costs are defined as the real construction costs that are determined at the time of project completion. Estimated costs are defined as planned or anticipated construction costs determined at the time of deciding on the project implementation. Cost estimates become more accurate through the different phases of the project life cycle. (Thompson and Perry, 1992)
Fig. 1 Accuracy of cost estimates in compare with phases of the project (Thompson and Perry, 1992)

The cost is one of the most important criteria, and it is a crucial factor for evaluation of the project feasibility and performance. However, many studies indicate that only a part of projects ending within the predicted time and budget. The World Bank Annual Review of Project Performance Results from the 1990 highlights the average cost overrun of 40% to 63% of the 1,778 construction projects in the past 15 years, and an average 70% of the time delays on 88% of the 1,627 projects (World Bank, 1990).

The phenomenon of increasing costs and delay in the construction of major infrastructure projects is not new, nor is it geographically or politically restricted.

More extensive studies of this phenomenon were carried within the last 30 years, based on the available database of the implemented projects. Some researchers suggested that the average overrun of infrastructure projects amounted to slightly more than 50%. In their review papers, researchers Morris and Hough (1987) covered about 3,500 projects and found that cost overruns are standard, generally in the range between 40% and 200% (Cantarelli, 2011).

Several Departments of Transportation in the United States analyzed the cost overruns of transportation projects during the 1990s and recorded an increase in the levels of around 4% to 12%. U.S. Office of Accounting proved that 77% of motorways projects in the United States experienced increased costs. The U.S. Federal Department of Transportation has analyzed the capital costs for 10 U.S. transit rail total cost of 15.5 billion USD. The total increase in the cost of these projects was 61%, ranging from -10% to +106% for individual projects.

Research on costs overruns in the construction of roads was carried out at the Norwegian University of Science and Technology in Trondheim. (Odeck, 2004) They analyzed the statistical relationship between actual and estimated costs for the construction of roads using a data from the Norwegian road construction in the period from 1992 to 1995. The findings reveal...
a gap between the estimated and actual costs, with a mean cost overrun of about 8% (ranging from -59% to +183%).

In Sweden, the study was conducted on 15 road and rail projects. Average construction cost overrun in eight road projects accounted for 86%, ranging from 2% to 182%. For 7 railway projects cost overrun was 17%, ranging from -14% to +74% (Flyvbjerg et al., 2003).

Study of Flyvbjerg et al. for the British Ministry of Finance (Her Majesty Treasury) in the 2003, indicates that 86% of cost overruns in infrastructure projects are in range of about 28% in average.

In an effort to determine the causes of this phenomenon, many of the aforementioned analysis have been made. Systematic exploration of the reasons of increasing costs in large infrastructure projects carried out in the UK in 2003 at the initiative of the Ministry of Finance. Ministry of Finance of the UK hired the consulting firm Mott MacDonald, a study of the outcome of major projects contracted through public procurement in the UK over the last 20 years.

The goal of this study was to provide guidance for the public sector, and to assess impact on the reduction of optimism bias in the estimates of the project costs. The study results have shown the existence of high levels of optimism in project estimates resulting from underestimating the project costs and duration or overestimating the project benefits (Mott MacDonald, 2002).

In response to such activities of the Ministry of Finance, UK Ministry of Transport hired consulting company COWI and B. Flyvbjerg in 2004 and gave them a task of preparing the survey titled: "Procedures for dealing with optimistic forecasts in the transport planning." This study is a historical overview and a categorization of certain factors that increase the costs that have been identified through literature. Categorization of 18 primary factors that affect the price of all types of construction projects was confirmed in interviews with more than 20 agencies that operate state highways. These factors are documented causes of the problem of increasing costs.

The study sought to prove that when engineers taking these factors for cost overruns into account during cost estimations and are trying to mitigate the impact of these factors on the project cost, will improve the accuracy of their cost estimates.

Table 2 Overview of the researches on causes and explanations of cost overruns (Cantarelli, Chantal, C. 2011)

<table>
<thead>
<tr>
<th>EXPLANATIONS</th>
<th>CAUSES</th>
<th>RESEARCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>TECHNICAL</td>
<td>Forecasting errors including price rises, poor project design, and incompleteness of estimations, Scope changes</td>
<td>Morris, Nijkamp and Ubbels, Lee, Fouracre, Mansfield et al., Kaliba et al., Mackie and Preston Nijkamp, Wachs, Lee, Fouracre et al., Kaliba Hall, Kaliba et al. Hall, Mansfield et al., Kaliba et al. Bruzelius et al., Pickrell</td>
</tr>
<tr>
<td></td>
<td>Uncertainty Inappropriate organizational structure Inadequate decision-making process Inadequate planning process</td>
<td></td>
</tr>
<tr>
<td>ECONOMIC</td>
<td>Deliberate underestimation due to: lack of incentives, lack of resources,</td>
<td>Pickrell, Wachs Odeck, Mansfield et al.</td>
</tr>
</tbody>
</table>
Cost Overruns in Large Infrastructure Projects
by Goran Legac, Mladen Radujković, and Marko Šimac

Technical explanations are usually discussed in the literature on project cost overruns. The costs rise when the project was poorly planned, and incomplete assessment all see as the cause of cost overruns. The increase in costs is difficult to predict in the future, poor project documentation and implementation of the project may be due to lack of experience, and incomplete assessment indicates inadequate data. These are considered variables that affect the cost overruns, but this does not explain the reasons for the cost overruns. The scope of change, uncertainty, inadequate organizational structure, inadequate decision-making processes, and inadequate planning processes represent technical explanations for cost overruns each for their own. All these reasons are mainly related to the difficulty of predicting the future and are considered to be “honest” mistakes. Scope changes indicate changes in project documentation were not previously anticipated, which consequently involves additional costs. Inadequate organizational structure, inadequate decision-making and planning indicate inefficiencies, resulting in higher costs than expected. All of these factors points to a lack of ability for fast adaptation to a changing conditions in project environment, lack of accountability and control and poor planning.

Economic explanations such as a lack of incentives and resources, commitment to the process of securing funding and inefficient planning of public effects are considered economic causes because they influence the extent of increase in costs, for themselves, and cannot provide an explanation of the phenomenon. Planners often lack incentives to provide accurate estimates and consequently underestimate forecasts because it is in their own interest to do so. Due to lack of resources, decision-makers must choose between projects and this leads to competition which is why promoters deliberately underestimate the cost of projects to look more attractive and thus were more likely to fight for their project is selected. Commitment to financial resources securing for the project resulting in cost overruns because the project costs are deliberately underestimated in order to increase the odds of getting a portion of the funds.

According to the abovementioned, the underestimation of costs increases the chances for launching the project.

Psychological explanations are based on the concepts of planning fallacy and human preferences toward overoptimistic assessments. They include human cognitive bias and cautious attitude to risk when making decisions. In making decisions in risky projects, people have tendency to risk aversion, they are approximately proportional to the attitude towards risk (the relative risk aversion) and have a very narrow margin for problems decision-making. In explanation, people tend to consider decisions of the problems one by one, often isolated from other current problem decisions that may be in progress, as well as future opportunities for
similar decisions. Cognitive biases lead to optimistic forecasts, which in turn results in cost overruns (Cantarelli, 2011).

Political explanations are cited in literature as the main explanation for the project cost overrun. Costs are deliberately underestimated in order to increase the chances for acceptance of the project. Literature also describes various causes of cost overruns due to strategic misrepresentation of data, including lessons learned of the project, lack of coordination, lack of long-term debt, lack of discipline, organization and political pressure and asymmetric information (Cantarelli, 2011).

4. General Findings of Conducted Researches

A group of authors from the University of Aalborg, Denmark led by Bent Flyvbjerg investigated the reasons for costs overruns of transportation projects on the basis of a sample of 258 projects for the construction of railways, bridges, tunnels and roads worth a total of 90 billion U.S. dollars. On the basis of this research, the authors have observed a strong correlation between the increases in the cost of the analyzed projects with the duration of the implementation phase. The consequences of such a conclusion on the decision-makers and planners clearly indicates that the delay and the long duration of the implementation phase of projects pose risks that can result in significant cost increases. Another conclusion of the study is that the projects have grown over the time of implementation. Large construction projects of bridges and tunnels have a higher percentage of increase in costs.

Finally, by comparing the increase in costs for the three types of project owners - private, state-owned enterprises and other forms of public ownership, it turned out that the common claim that public ownership is problematic and private ownership effective in suppressing the increase in costs is too simplify view on the issue. Based on all considerations, the authors concluded that the type of liability significantly more contribute to cost increase, then the kind of ownership.

Results of the research (Flyvbjerg et al. 2004) can be briefly summarized as follows:

- 90% of transport infrastructure projects suffered significant increase in cost (on a sample of n = 258)
- Railway has the average rate of increase in costs of 45% (n = 58, SD = 38)
- Fixed links (bridges and tunnels) had the average rate of cost overruns 34% (n = 33, SD = 62)
- Roads had the average rate of cost overruns 20% (n = 167, SD = 30)
- Cost overruns happened in over 20 countries and on five continents, so it seems that is a global phenomenon (n = 258)
- Cost overruns appears to be more pronounced in developing countries than in North America and Europe (n = 58, data for railway projects)
- Cost overruns have not decreased over the past 70 years. It does not seem to be learned from the lessons (n = 111/246)

Flyvbjerg et al. have shown that an increase in construction costs large transport infrastructure projects is common for different types of projects, different continents and different historical periods.
Optimism bias can be defined as the tendency to underestimate the project costs and duration and/or over-estimate of project performance. It is expressed as a percentage of the difference between the estimate and the actual realization of the project.

\[
\text{Optimism Bias} = 100 \times \frac{\text{Actual} - \text{Estimated}}{\text{Estimated}}
\]

Fig. 2 Relationship between cost of risk mitigation and cost of managing residual optimism bias

Table 3 Applicable optimism bias by types of projects (Flyvbjerg & COWI, 2004)

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TYPE OF PROJECT</th>
<th>APPLICABLE OPTIMISM BIAS UPLIFTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PROBABILITY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50% percentile</td>
</tr>
<tr>
<td>ROADS</td>
<td>Motorways</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Trunk roads</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local roads</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bicycle facilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pedestrian facilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Park and ride</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bus lane schemes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guided bus on wheels</td>
<td></td>
</tr>
<tr>
<td>RAILWAYS</td>
<td>Metro</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>Light rail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guided buses on tracks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conventional rail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High speed rail</td>
<td></td>
</tr>
<tr>
<td>FIXED LINKS</td>
<td>Bridges</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Tunnels</td>
<td></td>
</tr>
<tr>
<td>BUILDINGS</td>
<td>Stations</td>
<td>4% - 51%</td>
</tr>
<tr>
<td></td>
<td>Terminal buildings</td>
<td></td>
</tr>
<tr>
<td>IT PROJECTS</td>
<td>IT system development</td>
<td>10% - 200%</td>
</tr>
<tr>
<td>CIVIL ENGINEERING</td>
<td>Included for reference purposes only</td>
<td>3% - 44%</td>
</tr>
<tr>
<td>(Standard)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIVIL ENGINEERING</td>
<td>Included for reference purposes only</td>
<td>6% - 66%</td>
</tr>
<tr>
<td>(Non-standard)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Despite all professional endeavors, predicting costs, project scope and other effects, project planning has remained inaccurate for decades. For transport infrastructure projects, inaccuracy in costs estimation has an average of 44.7% for rail, 33.8% for bridges and tunnels, and 20.4% for roads (see table 4).

An 84% of all rail projects and 50% of road projects have error in passengers forecast greater than ± 20%. Based on data from a 30-year period of use, accuracy in forecasts of passengers of the railway and the road has not improved (Flyvbjerg et al., 2004)

Table 4 Inaccuracy of transportation project cost estimates by type of project -in constant prices (Flyvbjerg, 2005)

<table>
<thead>
<tr>
<th>TYPE OF PROJECT</th>
<th>No. OF CASES (N)</th>
<th>AVG. INNACURACY (%)</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAIL</td>
<td>58</td>
<td>44.7</td>
<td>38.4</td>
</tr>
<tr>
<td>BRIDGES&amp;TUNNELS</td>
<td>33</td>
<td>33.8</td>
<td>62.4</td>
</tr>
<tr>
<td>ROADS</td>
<td>167</td>
<td>20.4</td>
<td>29.9</td>
</tr>
</tbody>
</table>

5. Reasons of Cost Overruns and Time Delays

Transport infrastructure projects often suffer from significant changes in the project scope during the implementation. Changes may depend on the uncertainty in the early stages of the project in terms of project ambitious, establishing corridors, specification of technical standards, in common with other project in the environment, geotechnical soil conditions, demands on environmental protection, etc.

Consulting company Mott MacDonald based on the results of the research for the UK Ministry of Finance defined the areas of project risks that will most likely cause overruns if not used some of the strategies to mitigate risk. In descending order are listed first eleven project risks which are recorded according to the maximum average percentage of contributions by type of project.

1. Inaccuracy of business case (58%)
2. Environmental Impact (19%)
3. Disputes and Claims (16%)
4. Economic (13%)
5. Late contractor involvement in design (12%)
6. Complexity of the contract structure (11%)
7. Legislation (7%)
8. Degree of innovation (7%)
9. Poor contractor capabilities (6%)
10. Project management team (4%)
11. Poor project intelligence (4%)

According to Mott MacDonald, all other areas of project risks contribute less than 3% to the measured optimism bias. Based on their experience from projects outside this study, the following areas of project risk preferences also contribute to excessive optimism for the project success:

1. Design complexity
Optimism bias in project assessment is not a phenomenon specific to a particular sector, because similar levels of optimism bias are recorded in projects of different sectors. Some types of projects, which recorded a high level of optimism bias, are more risky than others for themselves.

Table 5 Overview of project risks by their holders

<table>
<thead>
<tr>
<th>SOURCES OF RISKS</th>
<th>1. EMPLOYER</th>
<th>2. CONTRACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice of contract award to lowest bidder</td>
<td>Poor construction management</td>
<td></td>
</tr>
<tr>
<td>Underestimated costs and time</td>
<td>Cash flow and financial difficulties</td>
<td></td>
</tr>
<tr>
<td>Change in project scope</td>
<td>Inaccurate cost &amp; time planning</td>
<td></td>
</tr>
<tr>
<td>Changes in designs</td>
<td>Lack of contractor's experience</td>
<td></td>
</tr>
<tr>
<td>Incompetent project team</td>
<td>Changes in designs</td>
<td></td>
</tr>
<tr>
<td>Geomechanical investigations</td>
<td>Unforeseen subsurface ground conditions</td>
<td></td>
</tr>
<tr>
<td>Lack of communications amongst partners</td>
<td>Lack of resources at site</td>
<td></td>
</tr>
<tr>
<td>Poor site supervision</td>
<td>Materials price change</td>
<td></td>
</tr>
<tr>
<td>Slow decision making process</td>
<td>Lack of communications amongst partners</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delay in material procurement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slow decision making process</td>
<td></td>
</tr>
</tbody>
</table>

6. Croatian Perspective

The greatest development in the infrastructure, Croatia got from building the motorway network through the whole territory with the intention of uniform traffic, economic and demographic development of all regions and cities. Before 2000, there were several motorways which were built in the half profile (A6 Rijeka-Zagreb) or not completed all of the sections on the corridor (A3 Zagreb-Lipovac). Until 2001, 309 km of motorways was completed, and in the period from 2001 to 2009 constructed and opened to traffic was total 615 km of motorways (HUKA, 2011).

Construction of motorways in Croatia realized through public companies (Hrvatske autoceste d.o.o. and the Autocesta Rijeka-Zagreb d.d.), fully owned by the state, and financed (the majority of) by credit loans from commercial banks with state guarantees. With interventions in the annual plans and medium-term programs, the public authority has changed objectives, scope, schedule and budgets for transport infrastructure projects.
6.1. The National Motorway Program

The first program of motorways construction was brought in 2000 for a period from 2001 to 2004 in which government has invested 15.13 billion HRK (Program 2001 - 2004).

At a time when the Croatian government has brought second program for motorway construction in period 2005-2008, for this purpose the parliament approved 11.23 billion HRK. After the start of implementation and recalculation of the budget, with the annual revisions of plans requested was total of 14.69 billion HRK or 30.1% more than originally planned (Program 2009 - 2012).

Table 6 Overview of investments in motorway construction (just for Hrvatske autoceste d.o.o.)

<table>
<thead>
<tr>
<th>No.</th>
<th>MOTORWAY</th>
<th>MOTORWAY CONSTRUCTION INVESTMENTS (HAC) (in .000 HRK)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Program</td>
</tr>
<tr>
<td>A1</td>
<td>Zagreb - Split</td>
<td>12.770.401</td>
</tr>
<tr>
<td></td>
<td>Split - Ploče</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Ploče-Dubrovnik</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A1-tunnel Sv. Ilija-Baška Voda</td>
<td>-</td>
</tr>
<tr>
<td>A2</td>
<td>*Zagreb - Macelj</td>
<td>127.740</td>
</tr>
<tr>
<td>A3</td>
<td>Bregana - Zagreb - Lipovac</td>
<td>592.865</td>
</tr>
<tr>
<td>A4</td>
<td>Zagreb - Goričan</td>
<td>1.217.335</td>
</tr>
<tr>
<td>A5</td>
<td>Beli Manastir - BiH border</td>
<td>27.557</td>
</tr>
<tr>
<td>A7</td>
<td>Rupa - Rijeka</td>
<td>313.260</td>
</tr>
<tr>
<td>A8, A9</td>
<td>*Istarski Y</td>
<td>60.904</td>
</tr>
</tbody>
</table>
During all period of the Program, from the decision making in 2000, up to 2005 and putting the A1 motorway Zagreb-Split into traffic, existed the so called "Accelerated construction of motorways" which even included a special committee for the coordination of accelerated road construction. This attitude wasn’t suspended even after the election of a new government in 2004, and this accelerated construction retained until 2009 and global financial crisis when central government and public companies suffered from problems with further credit loans and guarantees. After 2009 and the appearance of the global financial crisis, there was a significant decline of investment in road construction, and schedules are considerably delayed. Croatian motorway construction program for the period 2009 to 2012 was at level of 40% from the previous, pre-crisis program.

6.1.1. A1 Motorway Section Ravča - Ploče

As an example of uncertainty and changes in transportation projects in terms of objectives, scope, deadlines, and cost can be distinctly shown on Ravča-Ploče section of the motorway A1 Zagreb-Split-Dubrovnik.

Originally, the Program 2005-2009 predicted for Ravča-Ploče 19.3 km long alignment without a certain point of intersection and with a time for completion up to the end of 2008. In this area the A1 motorway corridor on the Adriatic-Ionian route merges with the Trans-European transportation corridor Vc and the port of Ploče as the last point of the corridor Vc. The contract for construction of Ravča-Ploče is awarded for the amount of 1.75 billion HRK in 2005. The bases for calculations of costs for Ravča-Ploče were preliminary designs on the one route of several variants of motorway from Split to Dubrovnik. Afterwards the two neighboring countries defined the interstate contact between Croatia and Bosnia and Hercegovina on the transportation corridor Vc. After this Croatia has defined the alignment of the motorway to Dubrovnik, and consequently, complete alignment moved north to the border with Bosnia and shifts the intersection of two motorway routes A1 and A10.

Such changes in design extended the alignment and now the length was 25.5 km. Amendment to the original construction contract used the same unit prices of the original contract, again on the basis of preliminary designs, now for a total amount of 2.18 billion HRK (24.6% more). Neither this amount is not final and the whole project is not completed within this amount, since many circumstances were not known at the time of concluding the contract as they are defined after
the completion of the entire design documentation (position and size of the interchanges and connecting roads, the size and number of structures, viaducts and tunnels, electricity power supply, traffic equipment, etc.). In addition to main motorway alignment, the construction of the connection road from the motorway to the port of Ploče has been provided for a total amount of 927 million HRK. The government again decided to set this project within a budget of Hrvatske autoceste (HAC), not the state roads authority. The early price estimation for connection road Ploče - Port of Ploče amounted to about 811 million HRK were made on the basis of the conceptual design. That means for the project closure, HAC had to invest 14.3% more than early estimated costs.

Fig 4 The two variants of the motorway A1 section Ravča-Ploče alignments

6.1.3. A11 Motorway Zagreb - Sisak

For this project, the contract was awarded in 1998, but the project was abandoned due to giving priority to the construction of the Adriatic motorway from Zagreb to Split. After completion of A1 Zagreb-Split the project was restarted in 2005, but has suffered a lot of time delays and cost overruns.

The main problem in the construction of the A11 motorway Zagreb to Sisak is associated with the adoption of amendments to the urban planning of Zagreb County, which was delayed for 12 months. Urban plan was a prerequisite for obtaining the necessary permits for construction, which led to a delay in building activities Jakuševac - Velika Gorica and Velika Gorica - Lekenik.

Early estimates for the project budget were made without the designs. Sponsors of the project believed that they will provide embankment gravel material found locally from maintenance of Sava riverbed, which at one time was possible, but over the time was terminated. Subsequently,
the contractors had to bring up the fill material instead of gravel from local borrow in Sava riverbed from up to 100 km away. Another important source of risk for the cost of the project was uncertainty of time, the scope of the project and the scope of work required from the cities of Zagreb and Velika Gorica. In the process of obtaining approval for a building permit, town of Velika Gorica asked for the construction of additional local roads, sewers, lighting, pedestrian and bicycle ways along the motorway. Along the motorway section of 8.2 km, another 11 km of local roads and associated utility equipment has been built. During the land acquisition for the project works came to a halt and extensions of time due to the impossibility of solving property matters on the alignment. Disputes were with the status of land owned by private owners who asked for more compensation than they were offered for expropriation.

Implementation of the project has slowed down considerably due to the difficulties in funding caused by lack of interests of international financial institutions. Last issue related to this project is that it will finish before Sisak, while the completion of the motorway in the town of Sisak again waits for some other, better times.

![Fig 5 Motorway A11 Zagreb – Sisak alignment](image)

**7. Reasons of Cost Overruns - Croatia**

There are more explanations for the costs overruns in motorway projects, but more or less, every major reason comes to a change of project scope.

It is very clear from the development of national motorway program that through the years more and more motorways were inserted in the Program (Table 6). For example, motorways A12 and A13 were not intended to be the motorways but state roads. They were upgraded to motorways on the request of local political parties who won the elections in 2007 for the parliament.
At the request of local authorities, also on the recommendation of transportation experts, motorways were upgraded with a construction of more new interchanges in order to connect the new motorways with near settlements. After the beginning of motorways construction, port authorities initiated their projects and stimulate the construction of connection roads to the ports of Rijeka, Zadar and Ploče. The state took over the implementation of the connection roads and tunnel “Sveti Ilija” after termination of the concession agreement with the private concessionaire who did not fulfill the obligations. Because of increased summer traffic, fire protection and traffic security, another tube for longest tunnels (Mala Kapela and Sveti Rok) were added. An important reason for rising costs is that during the public procurement process for the works employers achieved higher prices than foreseen in the early estimates due to the increased demand for infrastructure works. Increased market demands increased prices for raw materials in the global and local markets. Due to suddenly increased market demands, there was a lack of fill stone materials for lowlands motorway alignments and inability to delivery it from the local sources in time, which resulted in higher purchase and transportation costs.

In addition, during the process of obtaining the construction permits for motorways, special conditions required larger traffic equipment in the urban areas, the construction of the power supply and reconstruction of electrical network because the electrical operators were unable to follow the accelerated motorway construction schedule.

Accelerated construction up to 2009 caused the excessively shortened time for project preparations while maintaining the final deadline for project completion and commissioning. Procurement of works and services are for this reason often carried out without an adequate preparation of design documentation at a sufficient level to create a budgetary cost of the project with a reasonable accuracy. This issue is observed in the Report of the state audit of the operations in the Croatian Motorways for 2007, where the National Audit Office expressed the opinion that in tender documents and cost estimate, it is necessary to use the documentation on the base of final designs, not conceptual designs. In addition to these recommendations in the findings of the state audit, it is known that in the process of obtaining building permits define all the terms and agreements relevant to determining the scope, type and specification of works, so that the possibility of change in prices of construction in relation to the assessment of the preliminary design is higher.

Without a detailed and comprehensive analysis of the results and the circumstances in which the project is implemented, it is difficult to accurately determine and rank all the causes of increase in the cost of large infrastructure projects. Despite many aforementioned international analysis and studies on this topic, such analyses in Croatia are not officially requested, even though it is evident from the report on implementation of the road construction program that the cost overruns occurred. In Croatia has been conducted a number of studies of risks in project management, and some of them for the large infrastructure projects, in the framework of scientific topics of Faculty of Civil Engineering-Department of Construction Management under guidance of prof. Radujković.

If we compare aforementioned international experience and researches on this topic, by analogy leads to the conclusion that the Croatian experience fit into the global practice and that such phenomenon cannot be prevented, but the risk of impact on costs can only be reduced.
Based on experiences in the neighboring European environment in the implementation of transport infrastructure projects, in compare to Croatia we can recognize a certain pattern of behavior. Estimates for budget in the early phases of the project are optimistic and often underestimated, and once the project starts, in the later phases of project costs rising due to pressure of (more or less all) project stakeholders to increase the scope and requirements of the project.

Contracting authorities can hardly achieve any significant impact on the prices achieved because the market demand for works and supply define the market price of construction in a given moment. At the time of increasing demand for work came to market concentration, so the market prices went higher.

8. Cost Comparison for Motorway Projects in EU and Croatia

A comprehensive analysis comparing the cost of construction for motorways in the Czech Republic and Europe (IBR Consulting, 2007) conducted by the Czech consulting company IBR Consulting in cooperation with eight European motorway operators: RSD CR (Czech Republic), DARS (Slovenia), Croatian Motorways (Croatia), NIF (Hungary), Vejdirektoratet (Denmark), DEGES (Germany), ASFINAG (Austria) and the Narodna dialnična spoločnost (Slovakia). International organizations dealing with roads (TEM, TEN-T, CEDR, PIARC) do not collect a database for the costs of motorways construction, and the study authors made an analysis on the basis of data obtained directly from investors in motorway construction.

All analyzes were performed based on projects that are procured through a public bidding and contained only the cost of building, without the cost of design documentation, investigations, land acquisition, supervision and other expenses. Cost comparison was done for the motorway sections of the same type, which pass through the same type of landscape, and for major bridges and tunnels.

The report of the study stated that the construction of motorways in Austria, costing an average of 12.87 million €/km. The next most expensive country is Hungary with 11.21 million €/km, followed by Slovakia with 9.56 million €/km and then the Czech Republic with 8.86 million €/km. At the lower end of the scale, the cost of building highways in Denmark were only 5.89 million €/km, Croatia 6.68 million €/km, Slovenia 7.29 million €/km and in Germany 8.24 million €/km.
Ground configuration have a significant impact on the increase in construction costs, and the motorways on the mostly mountain terrain are most expensive in Germany with 25.99 million €/km, followed by Austria with 24.97 €/km, and, in descending order, the Czech Republic, Slovenia and Croatia.

Construction of motorway tunnels is the most expensive in the Czech Republic, then in Germany, and Hungary.

Fig 7 Comparison of construction costs for large motorway bridges
In the Eurostat/OECD program of purchasing power parity (PPP), a survey on the level of prices in 33 European countries is conducted, including Croatia. Countries that participated in the study evaluated three different types of construction:

- Residential buildings,
- Office buildings,
- Civil engineering.

Civil engineering works include transport infrastructure, pipelines, facilities for telecommunications and power supply, and other civil works. The research of the construction costs was carried out in June 2005.

Results show that Republic of Croatia is therefore classified between 40% and 60% of the EU average. The costs in civil engineering in this study were at 53% of the average price in the EU.
9. Recommendations for Improvement

Study of Mott MacDonald for the UK Ministry of Finance (2002) have shown that the tendency to optimism in the preparation of cost estimates and the duration of the project are caused by the unsuccessful identification and ineffective management of project risks. Lack of consideration and active management of identified causes can result in increased costs, schedule extensions and reduced benefits of the project in relation to those that can be achieved if one identifies causes and they are actively managed. However, taking into account the risks involved in defining the nature and scope of the project, and then develop a strategy for effective risk management, it is possible to reduce the tendency to increase the level of optimism and confidence in the project evaluation. Therefore, the extent to which there is evidence that the project risks are identified and that they will be managed, must be assessed during the early phases of the project to minimize the prospect of increased cost and time overruns, and lack of benefits once the project is delivered to the client.

The risk of changes in the scope of the project and a proactive change management should be considered during the cost estimation phase.

Fig 10 The appraisal and evaluation cycle - ROAMEF (Green Book, HM Treasury, 2003)

Following the publication of the study results, the UK Ministry of Finance issued a recommendation to the other subjects of public procurement to make corrections in procurement budgets in accordance with the data on completed projects and other similar projects that are implemented in other countries, and to adapt to the specific characteristics of the estimated project. These recommendations resulted with Her Majesty Treasury document named: “The Green Book-Appraisal and Evaluation in Central Government” (2003), guidance to other public sector bodies on how project proposals should be appraised, before allocation of funds. The main aim of this guidance is to provide best practice guidance for reducing optimism in project estimates for current and future projects from the lessons learned.
American Planning Association (APA) has during 2005 officially supported “Reference class forecasting”, a new forecasting method and gave a strong recommendation that the planners should never rely only on the usual techniques of planning. This method is based on the theories of decision making in uncertainty for which a psychologist at Princeton University in the United States won the Nobel Prize for economics in the year 2002.

Reference class forecasting promises greater accuracy in the forecasts through so called "Look from the outside", while in the conventional forecasting the problem is viewed from the inside. View on the project from the outside is based on knowledge of the actual performance of the reference class of comparable projects (Flyvbjerg, 2007).

These recent international experiences and guidance arisen from scientific researches should be considered for implementation in Croatian public procurement strategies after adoption to local legislative in order to improve viability of large infrastructure projects.

The research of the risk register development and implementation for construction projects as a methodology for development of the risk register system for construction projects in Croatia,
with its integration into the risk management process should be continued in order to achieve requirements for increasement of the project management successfulness (Burcar Dunović, Radujković, Vukomanović, 2013). Establishment of such a register can also be a helpful base in further researches of construction project achievements.

Fig 11 Risk Register and Implementation in Construction Projects (Burcar-Dunović, Radujković, Vukomanović, 2013)

10. Conclusion

Optimism bias in project planning and development of the previous cost estimates of major infrastructure projects can be, and in most cases really is an important and common cause of the project cost overruns. Optimism bias originates from the great desire of the project promoters (sponsors), contractors and consultants to push projects toward the realization without an adequate preparation. In doing so, we here refer primarily to the over-optimistic forecasts of the project benefits and neglecting the risks in the estimation of overall investment costs. On the other hand, caution in estimation is encouraged by the stakeholders who should provide financial resources and that will pay the project at the end of a day. These are banks, investment funds, government and end-users: residents, tourists etc. In recent times, when the economy is in an economic depression, the term "prevailing public interest" has been re-introduced as the main criteria for approving investments and removing administrative barriers to the project. Prevailing public interest is primarily measured in the number of new jobs and the impact on GDP growth.

There are also risks in procurement and contract management. Although contractors commit themselves with provisions of contract that they will complete the project within the agreed time and price, both contractual provisions may be modified if the two parties agree so. Such modifications are regulated by amendments to the basic contract and the Law on Public Procurement of the Republic of Croatia (Narodne novine No. 90/2011, Article 26.) allows to increase total contract amount at most 25% more than in the original contract. In the European Union that maximum amount is even bigger.
(Directive 2004/18/EC, Article 31.) the employer is allowed to award without prior publication to the same contractor up to 50% over the amount agreed in basic contract.

No one can claim that all of the increased project costs are unfavorable and harmful. Additional costs may give added value to projects through the delivery of better and more quality products. Cost overruns may result in added value of the project when the additional work is made, for example building a better carriageway for road users or through the addition of new interchanges on the motorway for a direct connection to the inhabited area or to increase traffic safety through the installation of high quality transport equipment. Cost overruns can also add value to the project when additional costs include works that were mistakenly omitted from physical planning or incomplete designs. The contractor is obligated (under the Law of Obligations) to prevent endangering the safety and health and immediate perform additional works, such as erosion control on slopes and protection of structures from the harmful effects of high water levels.

However, certain excess cannot add value to the project, cannot be justified and represent damage through loss of money if these costs do not result in better deliveries. For example, additional costs do not represent added value when the contractor pave the carriageway, and then remove and replace it because of the revised design specifications. This is more matter of a poor project management and lack of coordination between the design, procurement and construction processes causing claims for additional and unforeseen works.

Cost overruns and an extension of time may be avoided or is simply unavoidable. Cost overruns that occur due to poor project management, incorrect planning or errors in design are harmful problems that could have been avoided because they are supposed to predict and try to reasonably prevent. However, some cost overruns are inevitable, because they cannot be prevented, such as increased costs due to unforeseen events.
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