Terrorist attack at Köhlbrand Bridge and its impact on the transportation chain on metropolitan Hamburg using simulation

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ABSTRACT

This paper presents a scenario analysis to determine the impact of a terrorist attack at Köhlbrand bridge across the river Elbe on the transportation chains on metropolitan Hamburg. It is of special interest to decide how to redirect trucks for the time of impossible traveling across the bridge as a consequence of the terrorist attack. This analysis is done by investigating transportation chains from the container terminals to post-sea transport, storage and distribution. This paper also show the development of the scenario analysis, experiments evaluating the impact on post-sea transportation, analysis of simulation results and conclusions

KEYWORDS

Terrorist attack, scenario analysis, redirect trucks, transportation impact

INTRODUCTION

The term terrorism comes from the Latin terrere, which can be seen in the context of frighten, and from the etymology point of view the term terrorism is related with the French word terrorisme, which is often associated with regime de la terreur - the reign of terror - of the revolutionary government in France from 1793 to 1794. A leader of the French revolution, Robespierre, proclaimed in 1794, "Terror is nothing other than justice, prompt, severe, inflexible; it is therefore an emanation of virtue; it is not so much a special principle as it is a consequence of the general principle of democracy applied to our country's most urgent needs."

The English word "terrorism" was first recorded in English dictionaries in 1798 as meaning "systematic use of terror as a policy." (see Douglas Harper, "Terrorism," Dictionary.com Online Etymology Dictionary).

In general terrorism is the systematic use of terror. Most definitions of terrorism include only those acts which are intended to create fear (terror), and/or are perpetrated for an ideological goal (as opposed to a lone attack) and deliberately target or disregard the safety of non-combatants. Some definitions also include acts of unlawful violence and war (see http://en.wikipedia.org/wiki/Terrorism#cite_note-1).

Terrorism is also a form of unconventional warfare and psychological warfare. The word is politically and emotionally charged, and this greatly compounds the difficulty of providing a precise definition. A 1988 study by the US Army found that over 100 definitions of the word "terrorism" have been used (see Dr. Jeffrey Record, Bounding the Global War on Terrorism). Hence, finally a person who practices terrorism, is a terrorist.

Terrorism has been used by a broad array of political organizations in furthering their objectives; both right-wing and left-wing political parties, nationalistic, and religious groups, revolutionaries and ruling governments. The presence of non-state actors in widespread armed conflict has created controversy regarding the application of the laws of war (see http://en.wikipedia.org/wiki/Terrorism#cite_note-1).

While acts of terrorism are criminal acts as per the United Nations Security Council Resolution 1373 and domestic jurisprudence of almost all countries in the world, terrorism refers to a phenomenon including the actual acts, the perpetrators of acts of terrorism themselves and their motives. There is disagreement on definitions of terrorism. However, there is an intellectual consensus, that acts of terrorism should not be accepted under any circumstances. This is reflected in all important conventions including the United Nations counter terrorism strategy, the decisions of the Madrid Conference on terrorism, the Strategic Foresight Group and ALDE Round Tables at the European Parliament (ALDE: Alliance of Liberals and Democrats for Europe (see http://en.wikipedia.org/wiki/Terrorism#cite_note-1).

KÖHLBRAND BRIDGE IN HAMBURG

To analyze the impact of a terrorist attack at Köhlbrand bridge on the transportation chain on metropolitan Hamburg, the most important facts of the Köhlbrand bridge must be known and have to be taken into account such as:

- Current use of road traffic
- Crossing of Köhlbrand canal, part of river Elbe branching
- Construction: cable-stayed bridge
- Overall length: 3618 m
- Height: 53 m
- Building outlay: 80 Mio €
- Start of construction: 1970
- Completion: 1974
- Second largest viaduct in Germany
- One of the town's landmarks
- Four lanes (two in each direction)
- Basically commuter traffic and transportation of cargo of the container terminals
- Port traffic between freeways A1 and A 7
- Morning and afternoon high commuter traffic
- Commuter traffic prevail
- Balanced truck traffic
- 37,000 vehicles per day
- Congestion at 17 days of 22 work days
- Prognoses of increase of traffic via the Köhlbrand bridge within the next few years based on the fact of today's traffic:
    - 45,000 vehicles/day in 2015
    - 84,000 vehicles/day in 2025

SCENARIO FOR TERRORIST ATTACK

Based on the previous discussion on terrorism a terrorist attack is an act which is intended to create fear. This can be done as lone attack and/or as a perpetrated one for an ideological goal. In both cases with the target of deliberately or disregard the safety and/or economy of non-combatants.

In this simulation case study the impact of a terrorist attack at the Köhlbrand bridge – connection to bridge the container terminals with the freeway system – on the transportation chains of the metropolitan region of Hamburg will be investigated by simulation, embedding a multi criteria analysis, based on the assumption that $A \neq 0$ is a set of alternatives of the decision problem.

Assuming the attack will result in several bottlenecks that are in relation to primary and secondary delays due to the shortage of infrastructure resources. Primary delays result from the necessary detour, and secondary delays are those who result from traffic jams due to the increase of vehicles due to a lesser extent of road infrastructure. Therefore the simulation analysis has to define the several scenario postulates:

Scenario Postulate Part I:
As a result of a terrorist attack at the Köhlbrand bridge the bridge is completely destroyed.

Scenario Postulate Part II:
Available by-passes

- South of river Elbe
  From freeway A7 exit Moorburg, via Kattwyk Bridge, Neuhöfer Dam, Ross-Dam or Hohe-Schar-Street to entrance freeway A1 (Length approx. 10 km)
- North of river Elbe
  From freeway A7 exit Bahrenfeld, via B431, B4, Versmann-Street, Veddeler Dam, Ross Dam to entrance freeway A1 (Length approx. 16 km)

Scenario Postulate Part III:
Possible new constructions:

- Re-erect Köhlbrand Bridge
  Sounds not to be a good idea, because re-erection didn't change anything prospective in the sense of congestion, which has not yet been solved
  From expert opinion it is well known that the rest life cycle of the bridge is only 20 years before she fall into disrepair over time
  Probably the height of the bridge will be too little for the next generation of container ships
- Port link road
  Port freeway between freeways A1 und A7
  Several traffic routings possible:
  Bridge parallel with old Köhlbrand Bridge
  With tunnel on level with Kattwyk Bridge

Scenario Postulate Part IV:
Advantage of port link road:

- Substitution of Köhlbrand Bridge
- Bridge the gap between freeways A1 and A7
- Improving hinterland cargo transportation
- Unburden inner-city east-west traffic

Disadvantage of port link road:

- Respect onto the city development (carving the district of Wilhelmsburg)
- East-west freeway will guide the whole east-west traffic through Hamburg which will hamper the city and port traffic
- Building outlay: approx.. 1 Billion €
- Idea: Toll collection for private transit traffic

SCENARIO SIMULATION

To simulate the terrorist attack scenarios a traffic network model was developed, based on a slight modification of VITS (Virtual Intermodal Transportation System), that explicitly supports multi-model traffic and provides a reasonable tradeoff between (macroscopic) computational efficiency and (microscopic/agent-oriented) accuracy which would require data nearly impossible to obtain for real world applications.

The traffic network, interpreted as graph, consisting of nodes (e.g. freeway junctions and exits, plants and ports) and links (road, ship, or waterway segments each of which connect two nodes). Road, rail, and waterway mode are supported.

For the road mode trucks are modeled individually, i.e. attributes including current location, speed, and destination are assigned. Trucks stochastically appear at any node (interarrival time is exponentially distributed) and traverse fixed routes, i.e. a sequence of road links, eventually reaching their destination. Each truck's speed on link *i* currently traversed is sampled from a normal distribution with the mean set such that the expected link travel time ˆ*ti* amounts to

$$\hat{t}_i = t_i \left[1 + \alpha \left(\frac{x_i}{C_i} \right)^{\beta} \right]$$

subject to free flow travel time *ti* (depending on speed limit), link capacity *Ci*, and flow during the last period *xi*. Parameters α and β are set to 0.45 and 7.5, respectively. Flow *xi* and link capacity *Ci* are measured in terms of passenger cars, using an equivalence factor of 2.5 passenger cars per truck. The non-freight passenger car traffic is not modelled explicitly; the flow *xi* is chosen such that trucks account for 25% of the overall traffic. All trucks' speeds are updated every 7.5 minutes.

In contrast to road traffic, rail, and water modes abstract from traffic density influencing travel times; trains and ships always traverse links on their route at desired (maximum) speed, i.e. rail tracks' and rivers' capacities are assumed to suffice for any rail and barge traffic offered.

The application area the traffic simulator was developed for (but not limited to) is the metropolitan area of Hamburg, providing a tool for evaluating terrorist scenarios and its impact onto its transportation chains. Hamburg, location of the world's eighth largest ports handling 135 million tons of sea cargo a year of which two thirds are containers (2006) expects sea-borne freight doubling until 2015, driven particularly be the growth of the restructured economies of Central and Eastern Europe as well as the fast developing foreign markets of Middle and Far East. It is of importance to mention the special situation that the port's container terminals are located in the centre of the city, interweaving freight and individual traffic flows. Besides, Hamburg faces significant freight traffic passing through the city, e.g. from Scandinavia to Western and Central Europe; note river Elbe tunnel (carrying Interstate Highway A7 that links the Danish border to Germany) provides the westernmost crossing.

The simulator provides the ability to investigate such terrorist scenarios onto the planned future network configurations and expected load. Evaluation typically includes performance measures like vehicle travel times, link speeds, or throughput, yielding a valuable decision support tool by offering judgment whether intended solutions as part of the scenario analyzed are sufficient with respect to given target performance measures for further enhancement are necessary.

Figure 1 depicts a Hamburg scenario simulation network, consisting of 16 nodes (of which seven are network boundaries) and 18 links. Most of the nodes denote freeway junctions or exits; in this coarse topology (that does not claim to reflect a level of detail sufficient to produce valid results), the port is represented by the respective container terminals.

For the simulation of the postulated scenarios some assumptions are necessary to be specified:

- Model data have been matched in such a way that the number of vehicles traverse the Köhlbrand bridge are adopted to be 5,000 trucks/ day
- Simulation analysis will be done based on the two case study routes from
  - CTA to Lübeck
  - Heide to Berlin

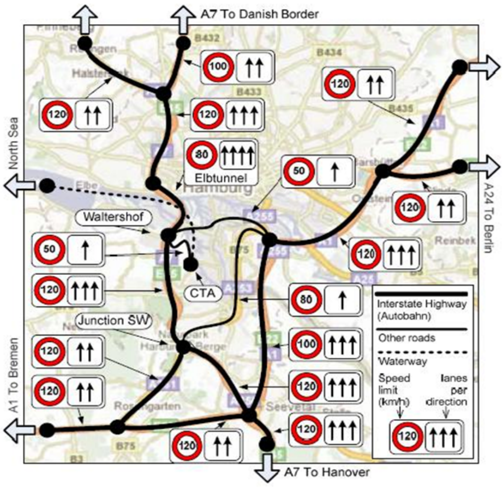

Fig.: 1 Hamburg Network

Table 1. Experiment results: Topology from Figure 1, with traffic traverse the Köhlbrand bridge. Default lanes and speed and freeway entrance to Lübeck and Berlin, respectively.

Title	Mean	Min	Max
Vehicle travel time Hamburg_CTA_1-BAB_nach_Lübeck_11 (Truck)	1.1723	0.55842	1.57811
Vehicle travel time BAB_nach_Lübeck_11-Hamburg_CTA_1 (Truck)	0.62427	0.55833	0.94482
Vehicle travel time BAB_nach_Heide_9-BAB_nach_Berlin_12 (Truck)	0.6955	0.64583	0.94968
Vehicle travel time BAB_nach_Berlin_12-BAB_nach_Heide_9 (Truck)	0.67143	0.64582	0.85414
Speed on Road BAB_Kr_Süd_5-BAB_AS_Waltershof_2	49.71607	47.93145	50.0
Speed on Road BAB_AS_Waltershof_2-BAB_Kr_Süd_5	48.01694	0.30399	50.0

Table 2. Experiment results: Topology from Figure 1, without traffic traverse the Köhlbrand bridge. Default lanes,speed and freeway entrance to Lübeck and Berlin, respectively.

Title	Mean	Min	Max
Vehicle travel time Hamburg_CTA_1-BAB_nach_Lübeck_11 (Truck)	2.492	0.74819	3.72388
Vehicle travel time BAB_nach_Lübeck_11-Hamburg_CTA_1 (Truck)	3.87672	0.70687	9.97377
Vehicle travel time BAB_nach_Heide_9-BAB_nach_Berlin_12 (Truck)	0.99672	0.84167	1.48694
Vehicle travel time BAB_nach_Berlin_12-BAB_nach_Heide_9 (Truck)	0.97901	0.84165	1.36855
Speed on Side Road BAB_Kr_Süd_5-BAB_AS_Bahrenfeld_17	26.88017	0.53132	30.0
Speed on Side Road BAB_AS_Bahrenfeld_17-BAB_Kr_Süd_5	26.34515	0.829	30.0

Impact on transportation:

Mean additional time expenditure from CTA to Lübeck approx.80 min, and from Lübeck to CTA approx. 180 min.

Mean additional time expenditure from Heide to Berlin approx.17 min, and from Berlin to Heide approx. 19 min

Table 3. Experiment results: Topology from Figure 1, without traffic traverse the Köhlbrand bridge but with port link road

Title	Mean	Min	Max
Vehicle travel time Hamburg_CTA_1-BAB_nach_Lübeck_11 (Truck)	1.08528	0.49862	1.64137
Vehicle travel time BAB_nach_Lübeck_11-Hamburg_CTA_1 (Truck)	0.56175	0.49833	0.77697
Vehicle travel time BAB_nach_Heide_9-BAB_nach_Berlin_12 (Truck)	0.62281	0.58583	0.82072
Vehicle travel time BAB_nach_Berlin_12-BAB_nach_Heide_9 (Truck)	0.61384	0.58582	0.71265
Speed on Interstate Highway BAB_Kr_Süd_5-BAB_AS_Waltershof_2	99.4789	99.98639	100.0
Speed on Interstate Highway BAB_AS_Waltershof_2-BAB_Kr_Süd_5	99.46475	98.10442	100.0

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CONCLUSIONS

In summary the following conclusions are made:

- From the simulation results it can be seen that a terrorist attack at the Köhlbrand bridge has a huge impact onto the transportation chain of the metropolitan region of Hamburg, which is equal a disaster
- Based on the several scenarios different simulation runs can be done in order to analyze the possible options to minimize the transportation disaster
- Comparing the traversing traffic of the Köhlbrand bridge with the hypothetic traversing traffic via the so called port link road by simulation it can be seen that the traffic flow will be better optimized via the port link road than via the Köhlbrand bridge
- Moreover simulating the hypothetic port link road can give answers for another big problem which lie in the existing overhead clearance height of the Köhlbrand bridge which is a real barrier for the passage of the modern super container ships with their larger superstructure height
- Moreover it can be seen what huge amount of money is necessary to overcome the consequences of a terrorist attack

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