

## MEMO ABOUT THE METHODOLOGY FOR THE “STUDY OF DYNAMIC EFFECTS OF THE FBFL WHICH HAS NOT BEEN CONSIDERED IN THE FTC STUDY”

Munich, October 2019

The purpose of this memo is to explain the methodology behind the “Study of dynamic effects of the FBFL which has not been considered in the FTC study”. The study takes as its point of departure the theory of gravitation. This approach is beyond the scope of standard approaches in traffic prognosis like the FTC-study. Consequently, the use of gravitation theory is a way to estimate dynamic effects’ impact on traffic.

### (1) Theory

In physics **gravitation** between two bodies is dependent on

- the masses of the bodies
- the distance between the bodies.

This natural law has been adapted both to

- (1) transport science and
- (2) spatial science/regional sciences

and indeed is common ground for both sciences:

- **interaction** (and thus transport and traffic) **between two regions** is **dependent** on the "weight" of the regions (in terms of population, economic activity) and on the geographical distance or (more general) **the resistance to overcome the space between these regions**.

### (2) Effects the FBFL-project

The FBFL project will, unlike other transport projects which mainly are intended to improve the conditions for traffic and transport, create a more or less **new quality of connection**, generally between Scandinavia and the continent and **especially between the regions of Eastern Denmark/Scania in Scandinavia and Eastern Schleswig-Holstein/Hamburg** in Germany. Given the "physical laws" of transport and spatial sciences this means in consequence that activities and thus transport and traffic will grow due to the new FBFL.

### (3) To what extent have these effects been considered in the FTC-Study?

The FTC-study takes into account how **existing** traffic without FBFL is **redistributed** to the new situation: traffic would shift from other routes (ferry Rödby – Puttgarden, other ferry lines, Great Belt) and other modes of transport to the FBFL.

In addition, to some extent the results of FTC-study include “induced traffic”. Induced traffic is defined as additional or more frequent trips because of time savings with FBFL given the existing structures in the regions. In the FTC-model this effect has been calculated only for existing travellers and without changing the traffic structure in the study area. Consequently, a "gravitation" effect in the sense of (1) has not been calculated<sup>1</sup> as it is beyond the scope of standard approaches in traffic prognosis.

### (4) What has not been considered in the FTC-study?

The results of the FTC-study include some "induced traffic" but the FTC-study did not deal with "**dynamic effects**", which is

- an **intensification of economic and social interaction** between the regions involved (due to increasing gravitation, see (1))
- in consequence an **increase of economic activity and housing** in the regions involved (so called "wider economic effects" of transport projects which are generally accepted in transport economy), these again lead to an increase of traffic.

Therefore, potential new traffic, generated by factors such as Danish citizens taking a job in Lübeck and German citizens buying summer cottages in Lolland following the completion of the FBFL, and even, in goods traffic, new transports due to a strengthening of business relations between enterprises on both sides of Fehmarn Belt are not calculated in the FTC-study.

Thus, the long term demand effects of the FBFL project have been underestimated in the FTC-study. This indeed has been pointed out in the due diligence study of the Danish transport ministry (carried out by COWI).

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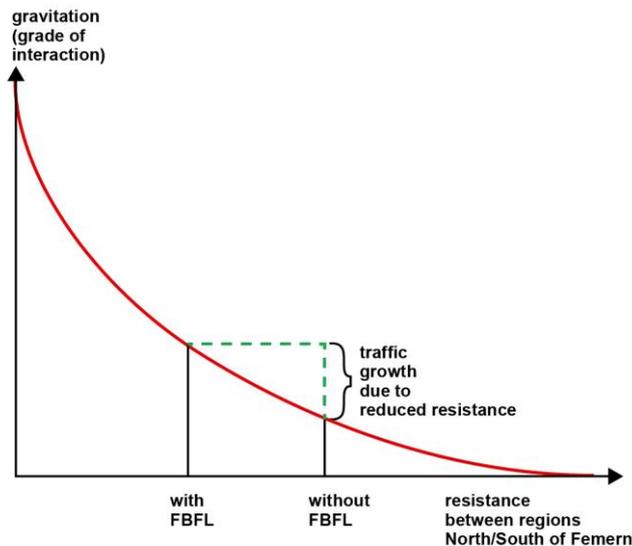
<sup>1</sup> The north-south-traffic has been mapped but not the complete spatial structure of traffic and transport in the wider study area.

### (5) Basic approach to modelize the dynamic effects of the FBFL project

If the gravitation theory can be applied successfully for the FBFL project, these "dynamic effects" (see (4)) can be quantified for the FTC-context: gravitation between the regions north and south of Femern Belt without the FBFL in comparison to the gravitation in the case with FBFL. If gravitation can be

- a) measured itself
- b) transferred into traffic and transport multipliers

the demand effects of the FBFL in terms of additional traffic ("dynamic effects") can be modeled (see figure below).



### (6) Measuring "resistance" and "masses"

In physics the variables for the gravitation law are just (physical) distance (unit: meters resp. a multiple of it) and (physical) mass (unit: kilogram resp. a multiple of it). For transport and spatial sciences these variables are less explicit. Generally, and this has been applied here, the "masses" of the regions are defined as **population** for passenger traffic (unit: inhabitants of the regions) and economic activity for freight traffic (unit: **regional GDP**, here in Euro). The variable "distance", literally, is even not very precise to describe "resistance" between the regions. More appropriate is travel/transport time. However, the FBFL will be tolled. That means next to time there is another

kind of resistance. In transport science there is a way to **combine travel time and travel costs** in a unit called **Generalized (transport) Costs** (time is transferred into costs using the value of time (VoT) as conversion factor). A matrix of Generalized Transport Costs between all regions of the study area is available from the FTC study. Population and GDP data for each region north of Femern are even available.

### **(7) Measuring correlation between gravitation and traffic/transport intensity**

In the physical law of gravitation, gravitation rises or decreases inversely proportional to the distance. This single and clear correlation does not exist in transport science. Therefore a gravitation model can only be applied, if the correlation between gravitation and traffic/transport intensity can be measured correctly and with a sufficient empirical foundation:

In the context of the German Bundesverkehrswegeplanung (BVWP) widely empirical matrices of traffic and transport flows have been collected and extrapolated between European regions (completely covered: Central Europe and neighbouring countries in Northern, Western, Southern and Eastern Europe). Combining these data (traffic/transport flows between regions = dependent variables) with regional population/GDP and the Generalized Transport Costs (= independent variables) well founded gravitation coefficients could be derived from regression analyses (regression coefficients up to 0.97).

The important thing is: The traffic and transport flows are based on observation and thus represent real traffic and transport interaction between regions. Correlated with socio-economic data of the regions and the Generalized Transport Costs the long term dependency of traffic and transport between the regions in term of travel time/travel costs resp. Generalized Transport Costs can be measured and transferred to projects like the FBFL.

### **(8) Application of the model for the FBFL**

Because the methodical background of the FTC-model in the transport model which has been developed and used for the BVWP, it was possible to apply the findings of the regression analyses based on the BVWP traffic and transport flow data to the FBFL-context. Due to the fact, that the FBFL will serve a border crossing, the gravitation coefficients valid for international traffic and transport have been applied.

To consider the individual situation of the study area the function as shown in the figure above has been used in a factorial way:

traffic due to gravitation in the case with FBFL

divided by

traffic due to gravitation in the case without FBFL.

This factor has been applied to the traffic according to the FTC-study, in passenger traffic minus "induced traffic" from the FTC-study to eliminate double counts.

## (9) Findings

Additionally to the demand effects, which have been calculated for the FBFL in the FTC-study, there is a large potential for additional effects caused by "gravitation" representing "dynamic effects" of the FBFL next to the redistribution of existing traffic from other routes and modes to the FBFL. These additional effects would increase the FBFL traffic in terms of vehicles (cars, buses and lorries) by another 18 % or 2.200 additional vehicles per day (related to 2030, see table below). Differently from route- and mode-shifts these effects would develop gradually. We would expect a number of around 2.500 vehicles per day ten years after opening of the FBFL caused by dynamic effects.

	Passengers/vehicles in FTC study (in 1000)	Additional passengers/vehicles in the study of dynamic effects (in 1000)	Additional passengers/vehicles in % of the FTC- study
Rail passengers	1.083	309	28,5
Bus passengers	1.352	85	6,3
Car passengers	9.573	1.226	12,8
Total passengers	12.009	1.620	13,5
Rail tons	9.464	41	0,4
Cars	3.767	772	20,5
Buses	36,5	3	8,2
Lorries	634	35	5,5
Total vehicles	4.437	810	18,3

Tab.: Dynamic effects of the FBFL (yearly figures related to 2030)

These results show even that the FBFL opens big chances to develop the axis Öresund Region - Femern – Hamburg to a nucleus of growth on the interface between Northern and Central Europe.