New Main Lines

Cost Benchmarking Comparison

February 2021

1. Introduction

Trafikverket has been tasked by the Swedish Government to develop new rail infrastructure connecting Stockholm with Gothenburg and Malmö via dedicated high-speed rail lines. A key element of the 'Nya Stambanor' (New Main Lines) programme involves producing cost estimates on an aggregated level for the planning, design and construction of the scheme.

The baseline design estimate was provided by Trafikverket in 2020 at SEK 295 billion (+/- SEK 50 billion, 2017-02 prices). For this system, sections of the route are designed for a maximum speed of 320 km/h with slab track construction while other sections are designed for 250 km/h with ballast track construction. The scheme length of the New Main Lines is approx. 690km and includes 13 new or redeveloped stations.

To support cost planning and identify a suitable range of cost estimates for the New Main Lines route sections, Trafikverket commissioned Jacobs to carry out an analysis to compare construction costs at the overall project level. These types of analyses are frequently carried out at the early planning phase – the current stage of the majority of New Main Lines route sections - to provide a 'sense check' on the overall cost estimate.

While no two infrastructure schemes have the same specifications and economic conditions, it is possible to minimise the differences by selecting and comparing schemes that have similar characteristics to the reference system and normalising their cost data points by conversion to a route-kilometre metric to allow a consistent comparison to be made between schemes of varying route length.

2. Approach

The methodological approach of the comparison analysis has been developed by Jacobs, in collaboration with Trafikverket, to meet the objective set out by Trafikverket. The objective is to compare Trafikverket's estimated cost per kilometre for New Main Lines to the total cost per kilometre for similar international high-speed schemes.

An effective high-level benchmark comparison requires the differences to be minimised by selecting schemes that have similar characteristics to the reference scheme, for example geographic region and country income level. The following benchmark selection criteria were agreed with Trafikverket for this study:

1) Schemes with operating speed ≥250 km/h - defined as high speed rail;
2) Schemes completed in the last 20 years or schemes which are currently under construction;
3) Schemes in high-income countries with a cost of living in a similar range to Sweden.

Benchmark data already available to Jacobs from previous cost benchmark studies were supplemented by a data collection process which involved sourcing published information, studies and technical documents collected from a variety of public and private sources, including information available from schemes for which Jacobs is currently or previously involved in.

The sample of international benchmark schemes vary in technical specification, number of stations and route length, ranging from ABS Leipzig/Halle - Berlin in Germany - a substantial high-speed upgrade scheme at the low end of the cost per km range (2 stations, 187 km), to the UK High Speed 2 scheme (Phase 1) which is a new 214 km high-speed line designed for 330 km/h operation with 4 new stations.

Construction costs were converted to Swedish Krona (SEK) in 2017 prices using the Eurostat construction cost index[1] and the most recent exchange rates[2]. For non-euro area countries, the IMF

[1] Construction producer price and construction cost indices overview, Eurostat: https://ec.europa.eu/eurostat/statistics-explained/index.php/Construction_producer_price_and_construction_cost_indices_overview

[2] Exchange rates. OECD: https://data.oecd.org/conversion/exchange-rates.htm

GDP deflator[3] was used to convert to 2017 prices. A summary of the technical and construction cost information for the benchmark HSR schemes selected based on these criteria is presented in Table 2.

3. Comparison of Trafikverket estimates with International High-Speed Rail benchmarks

Trafikverket's cost estimate for the planning, design and construction of the New Main Lines network produced in 2020 was provided at the 2017-02 price level and is presented on a per kilometre basis as shown in Table 1.

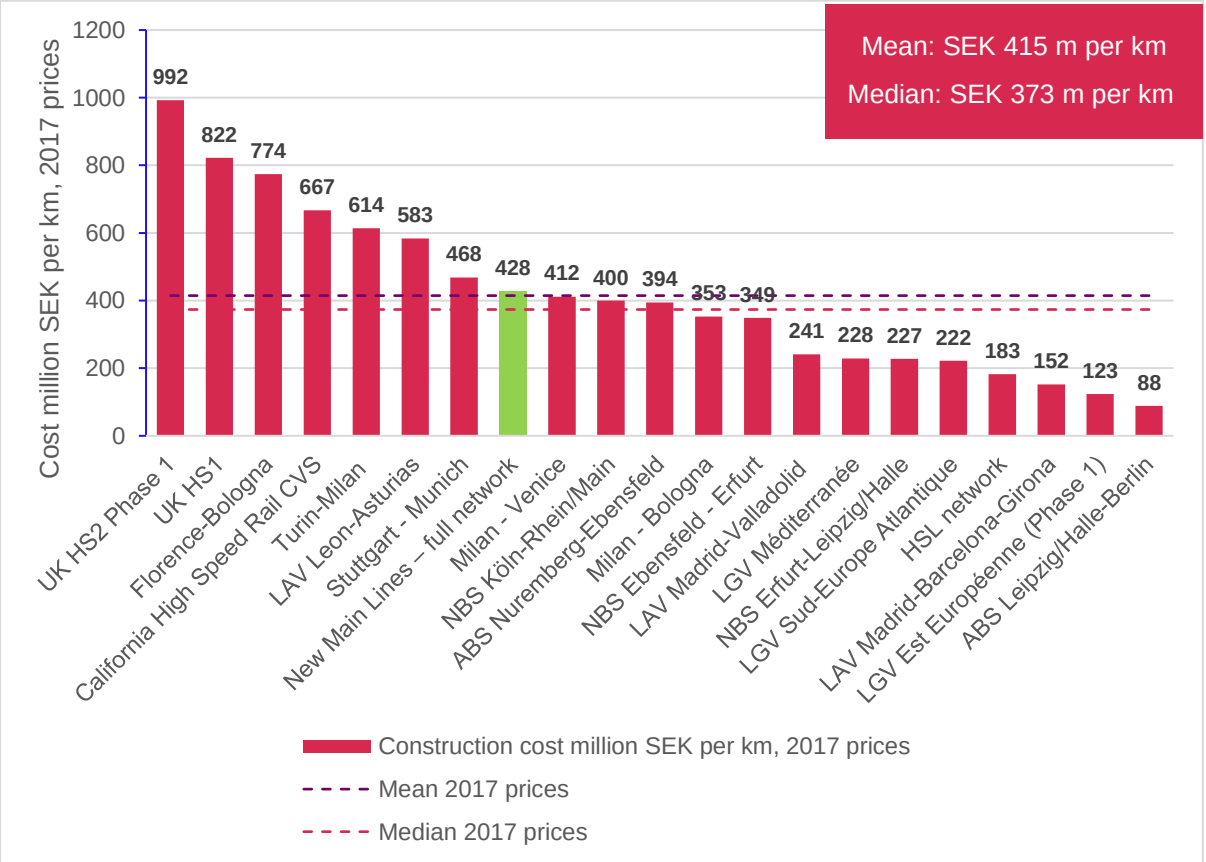
Table 1 Trafikverket cost estimate per kilometre for the New Main Lines network (2020), 2017 prices

Project	Route length, km	Construction cost. million SEK per km, 2017 prices
New main lines	690	428/km

A sample of international benchmark high-speed rail schemes was collected by Jacobs and presented on a comparable basis in Swedish Krona (SEK) in 2017 prices for the purpose of comparison with the Trafikverket cost estimate for the full New Main Lines network. The average (mean) construction cost of this benchmark sample is 415 million SEK per km and the median value is 373 million SEK per km.

As can be observed in Figure 1, the existing Trafikverket cost estimate for the full New Main Lines network on a per kilometre basis (highlighted in green) lies slightly above the average level of the benchmark sample of international schemes.

Figure 1 International High-Speed Rail Schemes: Construction cost per km, million SEK, 2017 prices



[3] International Monetary Fund, World Economic Outlook Database, October 2019: https://www.imf.org/en/Publications/WEO/weo-database/2019/October ; Eurostat Construction Producer Price Index, August 2020

The benchmark comparison illustrates that the previously published Trafikverket cost estimates for the full network lie close to the average level for comparable international high-speed rail schemes.

No firm conclusions can be made from this comparison as the construction cost of each scheme is driven by its design characteristics including the scale of tunnels and earthworks along with the number and location of stations in the network. A list of key factors and a description of their influence on construction cost of new high-speed rail lines is presented in Table 3.

4. Supplementary Tables

Table 2 Comparison sample of international HSR schemes (sorted high to low construction cost per km)

Country	Project	Scheme status	Year of operation	Route length, km	Construction cost million SEK per km, 2017 prices
UK	UK HS2 Phase 1	Under Construction	2026	214	992
UK	UK HS1	Operational	2007	109	822
Italy	Florence-Bologna	Operational	2009	79	774
USA	California High Speed Rail CVS	Under Construction	2029	192	667
Italy	Turin-Milan	Operational	2009	125	614
Spain	LAV Leon-Asturias	Under Construction	2021	50	583
Germany	Stuttgart - Munich	Under Construction	2022	267	468
Italy	Milan - Venice	Under Construction	2027	273	412
Germany	NBS Köln-Rhein/Main	Operational	2002	177	400
Germany	ABS Nuremberg-Ebensfeld	Operational	2011	83	394
Italy	Milan - Bologna	Operational	2008	182	353
Germany	NBS Ebensfeld - Erfurt	Operational	2017	107	349
Spain	LAV Madrid-Valladolid	Operational	2007	180	241
France	LGV Méditerranée	Operational	2001	244	228
Germany	NBS Erfurt-Leipzig/Halle	Operational	2015	123	227
France	LGV Sud-Europe Atlantique	Operational	2018	340	222
Belgium	HSL network	Operational	2007	314	183
Spain	LAV Madrid-Barcelona-Girona	Operational	2013	804	152
France	LGV Est Européenne (Phase 1)	Operational	2007	300	123
Germany	ABS Leipzig/Halle-Berlin	Operational	2006	187	88
UK	UK HS2 Phase 1	Under Construction	2026	214	992
Total - route km					**4,350**
Average construction cost SEK million per km, 2017 prices					**415**
Median construction cost SEK million per km, 2017 prices					**373**
Standard deviation construction cost SEK million per km, 2017 prices					**254**

Table 3 Key factors influencing high speed rail construction cost

Key factors influencing high speed rail construction cost	Description of influence on construction cost
Scheme specification & design requirements	Higher technical specification driven by operating speed requirement and capacity can lead to higher construction costs in several areas e.g. slab track construction, traction power supply, station platform capacity etc.
Route topography / geography	Greater variation in vertical distance along the route alignment can drive higher excavation volume of earthworks, longer tunnel sections and greater number of structures
Number and scale of stations	A greater number of stations in the scheme specification directly drives cost, and also influences costs in other areas e.g. civils, systems, connections to existing network
Station location	The requirement for central urban locations can drive costs in several ways - urban tunnels & structures are substantially higher cost than non-urban locations, land acquisition and compensation in city centres is normally far higher than peripheral urban locations
Contracting and procurement model	Some procurement models can lead to compounded risk, overheads and profit within the supply chain driving higher overall scheme costs
Cost of construction (price level)	The national price level drives labour and materials costs which are key elements of overall construction cost.
Land and property costs	The cost of land, level of compensation for compulsory purchase and cost of environmental/ noise / visual mitigation can vary, with route alignments through lower density areas typically resulting in lower costs