SECOND OPINION

on the proposed high speed rail in Sweden

25th May 2016

ARUP

CONTENTS

1

INTRODUCTION

Stockholm is one of the three principle cities on the proposed HSR network

1.1 PURPOSE OF REPORT

Trafikverket has been commissioned by National Negotiation on Housing and Infrastructure to perform a second opinion on the proposed system .

Trafikverket have appointed Arup to undertake a second opinion on the current proposals to develop a high speed rail line linking Stockholm to Göteborg and Malmö. The scheme was originally proposed by Trafikverket and the National Negotiation on Housing and Infrastructure who have input into various aspects of the route and have now requested this second opinion.

Therefore, this report provides a second opinion of the planned "New System" which was presented by the National Negotiation on Housing and Infrastructure on 1st February 2016. The study utilises Arup's international experience on high speed rail around the world and uses examples of best practice to benchmark against the route and the locations of the stations along it. The study undertakes a comparison of international high speed rail and how these operate and compares them to what has been proposed in Sweden.

The report undertakes analysis on the following aspect of the system:

a. The number of stations along the route and the distance between the stations;

b. The criteria and principles for the station; e.g. bypass, central, peripheral or external location;

c. The system and frequency of traffic – currently on hold; and

d. A review of the geometrical restrictions and geometric design against other high speed rail standards.

These four aspects form Task 2 of the study and challenge the thinking of the "New System".

1.2 BACKGROUND

We understand that separate proposals were originally developed for improvements to regional services between Linköping and Stockholm (the Ostlanken) and between Borås and Göteborg. The decision was subsequently made to link these proposals by means of a national High Speed Railway (HSR) connecting Stockholm and Göteborg, and also Stockholm and Malmö, reducing rail journey times and increasing passenger capacity between the cities, and also releasing capacity on existing routes for additional conventional passenger and freight traffic.

An important consideration in the development of the HSR proposals is the balancing of the requirements of long-distance, high-speed traffic with those of the major regional services, thus achieving an appropriate combination of services and avoiding a sub-optimal overall outcome.

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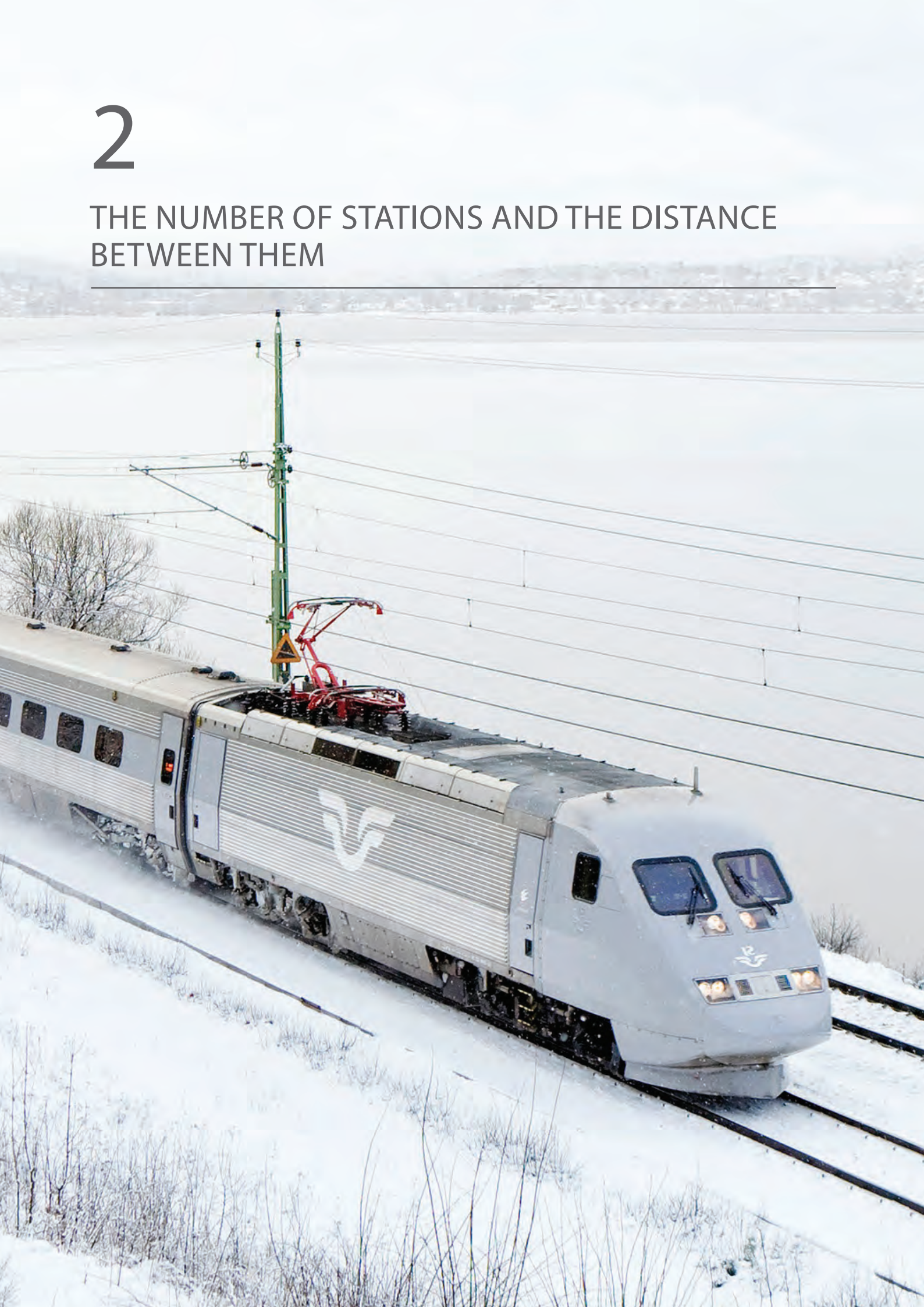
THE NUMBER OF STATIONS AND THE DISTANCE BETWEEN THEM



The new HSR railway will be predominantly at grade

2.1 BACKGROUND: SYSTEM AIMS AND REQUIREMENTS

Overall Aims:

As set out in the 'Decision Document – Choice of Line Sections and Stations', the overall aims of the development and expansion of a High-Speed Rail (HSR) system in Sweden are to:

- Bring the three metropolitan areas (Stockholm, Göteborg and Malmö) closer to each other
- Contribute to the development of the intermediate regions and the rest of Sweden
- Contribute to fewer carbon dioxide emissions for the traffic
- Contribute to increased housing construction

In meeting these objectives, the expansion should:

- Take place quickly
- Maximise socio-economic profitability
- Be cost-effective

In terms of the HSR system to be provided, it should:

- Enable fast, punctual and competitive end-point traffic with trains between Stockholm Central and Göteborg Central and between Stockholm Central and Malmö Central
- Enable fast, punctual and competitive major regional transport by train
- Release capacity on the existing Western and Southern main lines for a combination of more regional traffic, freight and better punctuality

Specific Aims:

Specific, measureable objectives for the system include:

- Stockholm Central – Göteborg Central without intermediate stops in a maximum of 2 hours

- Stockholm Central – Malmö Central without intermediate stops in a maximum of 2 hours 30 minutes

- Interoperable HSR services, able to run through to Arlanda (Stockholm airport, north of the city), Uppsala (north of Arlanda), Kastrup (Copenhagen Airport), Copenhagen and Hamburg (via Jutland and/or Fehmarnbelt

- Population growth outside the metropolitan areas, as evidenced by increased housing construction, among other factors

To meet these objectives, HSR traffic should be sufficiently homogeneous to avoid excessive capacity utilisation and to maintain punctuality (i.e. to avoid the problems experienced by the conventional railway system). To this end,

- The number of stations should be limited to minimise service/traffic heterogeneity and construction costs
- Connections (for through running) with the existing network should be minimised

Criteria for new station location selection willl be developed by the National Negotiation on Housing and Infrastructure, including, in no particular order:

- National interest for a station in a city
- Availability of local/regional co-financing, reflecting potential benefits
- Size and national/regional significance of a city
- Forecast passenger numbers
- Objective of regional public transport authority to procure additional, major regional services.

The specific station location criteria to be met, the first three of which reflect the Swedish Transport Administration's guidelines on 'The Station's Basic Functions and Classification', TDOK 2013:0685 are:

1. The number of residents in the densely-populated/urban areas served by a station should be at least 50,000.
2. Projected passenger flows for a station should comprise at least 3,000 boarding and alighting passengers per annual average day.
3. A station should provide significant transfer opportunities for inter-regional train travel via conventional and high-speed services.
4. The quantity of housing generated in a station catchment by HSR by 2035 should be at least 1,300 new homes.

The Decision Document states that all four criteria must be met to justify the inclusion of a proposed station location on the proposed HSR network. However, on the basis of discussions held at the workshop on 6th April, we understand that just three of the four criteria must in fact be met.

Socio-economic Parameters

In addition to satisfying the above criteria, the station location selection process is influenced by the following parameters:

- Investment cost
- Socio-economic benefits
- Socio-economic calculation (NNK)/CBA
- Travel time between endpoints

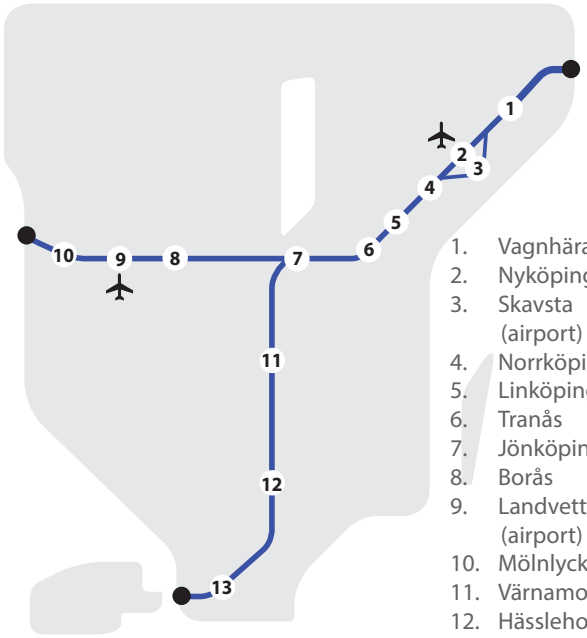
2.2 REVIEW OF QUANTITATIVE STATION SELECTION CRITERIA

The five quantitative criteria for review are as follows:

1. Non-stop end-to-end journey times (Stockholm Central – Göteborg Central within 2 hours; Stockholm Central – Malmö Central within 2 hours 30 minutes)
2. Number of residents in the densely-populated/ urban station catchment areas >= 50,000
3. Projected passenger flows >= 3,000 boarding and alighting passengers per annual average day
4. Station's significance for transfer for inter-regional train travel via conventional and high-speed services
5. Quantity of housing generated by HSR up until 2035 >= 1,300 new homes

These criteria are considered in detail in the following sub-sections of this document.

The following 13 proposed station locations (excluding the three planned termini) are included in the review, based on those listed in the 'Decision Document – Choice of Line Sections and Stations':



1. Vagnhärad
2. Nyköping
3. Skavsta (airport)
4. Norrköping
5. Linköping
6. Tranås
7. Jönköping
8. Borås
9. Landvetter (airport)
10. Mölnlycke
11. Värnamo
12. Hässleholm
13. Lund

Schematic map of proposed HSR network

Numbers of urban residents in proposed station catchments

As noted above, one of the criteria for station selection is that the location in question should have an urban population (i.e. excluding the wider municipal area) of at least 50,000.

Population data for the proposed station locations were extracted from GIS data provided by Trafikverket, and the results are summarised in the table below.

Proposed Station Location	Urban Population	Population >= 50,000?
Vagnhärad	3,324	No
Nyköping	29,891	No
Skavsta (Airport)	N/A	N/A
Norrköping	87,247	Yes
Linköping	104,232	Yes
Tranås	14,197	No
Jönköping	89,396	Yes
Borås	66,273	Yes
Landvetter (Airport)	N/A	N/A
Mölnlycke	15,608	No
Värnamo	18,696	No
Hässleholm	18,500	No
Lund	82,800	Yes

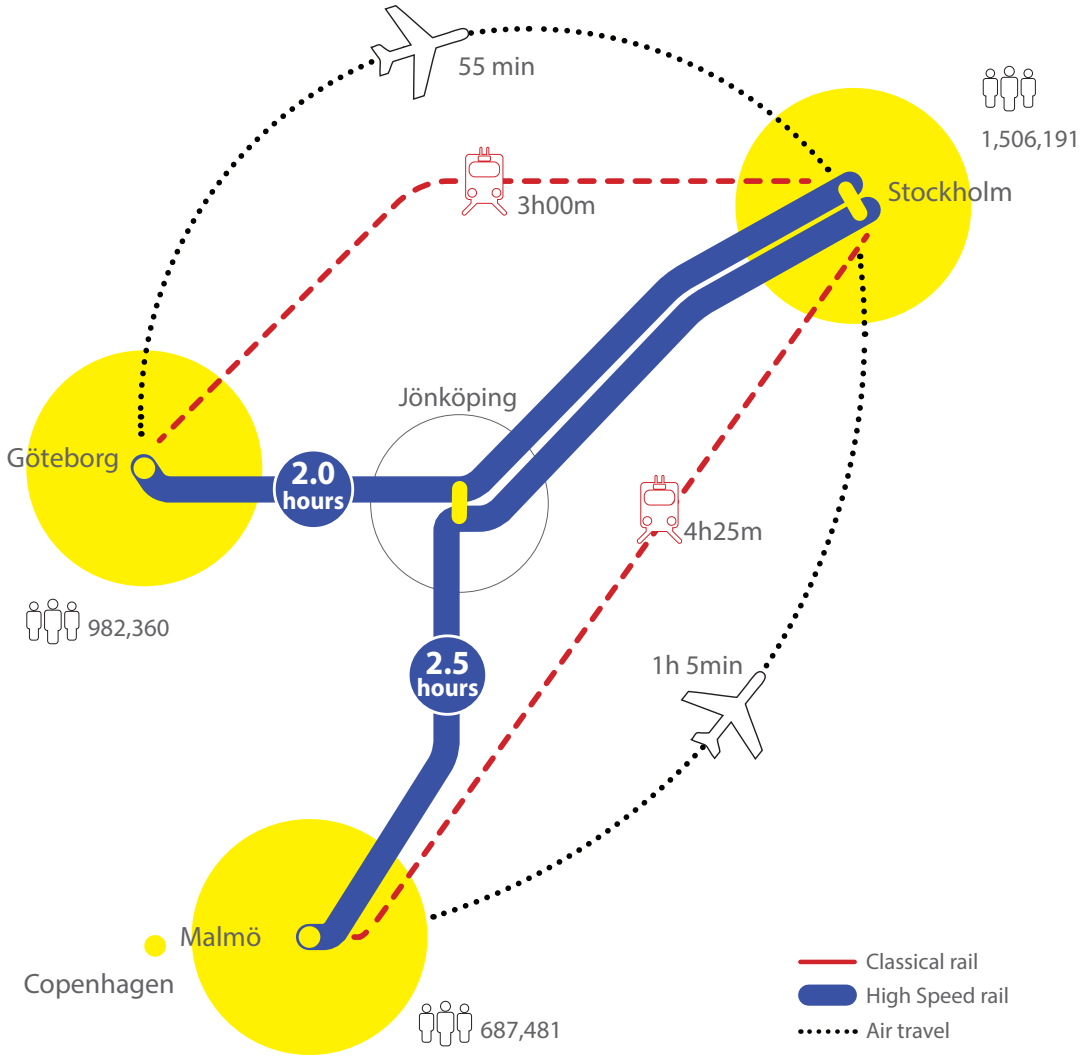
Table showing assessment against city population criteria
Source: GIS dataset - Urban_Population & Municipalties.xlsx

Non-stop end-to-end journey times

Non-stop, end-to-end journey times for Stockholm – Göteborg and Stockholm – Malmö were assessed using Arup's spreadsheet-based 'Routemaster' train journey time calculator. Initial calculations were based on a 320km/h maximum line speed throughout, and estimated distances of 518km (Stockholm – Göteborg) and 653km (Stockholm – Malmö). Since the rolling stock characteristics for the Swedish HSR are as yet unknown, the calculations were based upon existing HSR performance parameters. The initial calculated journey times were 01:40:05 and 02:05:23 respectively, well within the specified maximum journey times.

However, as noted above, these calculations were undertaken in the absence of detailed information on network section lengths and maximum line speeds, and so were subsequently repeated, using RailSys data provided by the client. RailSys model runs, using high-speed rolling stock type 'HHT350' and reflecting line speed restrictions along the routes produced journey times of 01:43:43 for Stockholm – Göteborg (total distance 464.951km) and 02:11:19 for Stockholm – Malmö (total distance 583.589km).

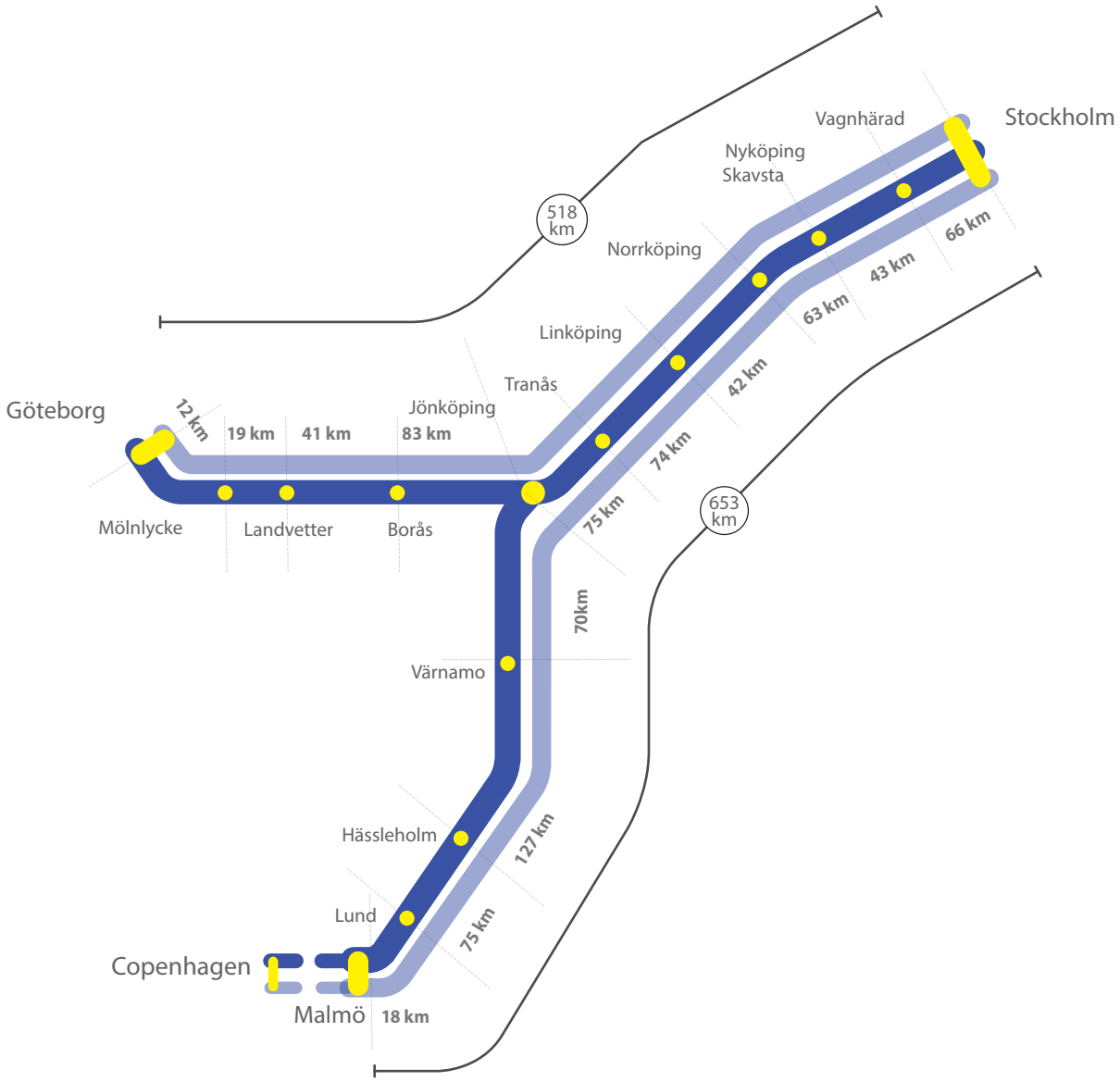
The route lengths are approximately 10% less than those previously estimated, but the journey times are nonetheless slightly longer than the initial estimates, reflecting the line speed restrictions along the route. The results provide reassurance that the desired maximum non-stop journey times of 2 hours (Stockholm Central – Göteborg Central) and 2 hours 30 minutes (Stockholm Central – Malmö Central) can be achieved.



Schematic showing comparative travel times between HSR, current classic rail travel time and air

Projected annual average daily passenger flows for proposed stations

Forecast annual boarding and alighting passenger numbers for the proposed (and most of the rejected) stations locations along the HSR route were provided by Trafikverket. These were converted into daily average totals for comparison with the criterion quoted above that stations should have at least 3,000 boarding and alighting passengers in total per annual average day. No standard conversion factors were available to convert the annual values to average daily equivalents, so the annual values were divided by (52 x 6), i.e. the average daily flow for a weekday was assumed to be less than one-fifth of the total weekly flow, but greater than one-seventh. The results are shown in the table below , first for the included station locations, and then for the rejected station locations:



schematic of HSR network showing approximate distances
Source: Approximate distances from Google maps

Proposed Station Location	Average Weekday Boarding & Alighting Numbers	greater than 3000?
Vagnhärad	1,018	No
Nyköping C	6,140	Yes
Skavsta (Airport)	489	No
Norrköping C	11,428	Yes
Linköping	15,305	Yes
Tranås	2,385	No
Jönköping S	14,045	Yes
Borås C	20,949	Yes
Landvetter (Airport)	784	No
Mölnlycke	5,050	Yes
Värnamo	3,447	Yes
Hässleholm	21,161	Yes
Lund	43,664	Yes

Rejected Station Location	Average Weekday Boarding & Alighting Numbers	greater than 3000?
Ulricehamn	3,226	Yes
Bollebygd	2,083	No
Molndal	No data	Unknown
Nassjo	No data	Unknown
Skillingaryd	2,198	No
Vaggeryd	No data	Unknown
Alvesta	5,089	Yes
Vaxjo (C)	6,100	Yes
Ljungby	2,354	No
Markaryd	No data	Unknown
Almhult	2,607	No
Helsingborg (total)	24,988	Yes
Kristianstad	No data	Unknown

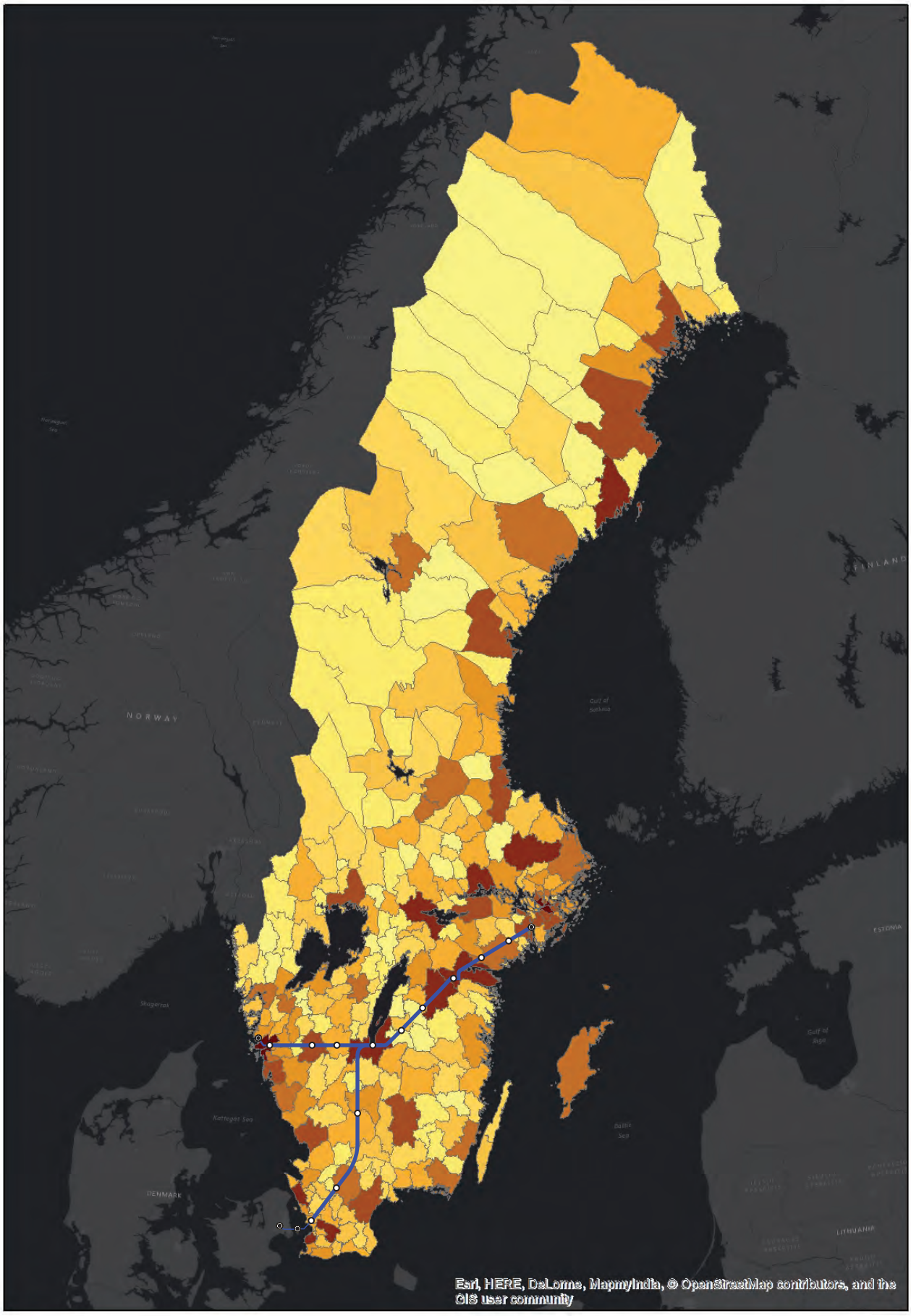
Table showing daily demand against NNHI demand criteria

Source: Trafikverket Demand data 2015-06-24.xlsx from Roger Trafikverket

Of the proposed station locations, it can be seen that all except the two airport stations (special cases), Vagnhärad and Tranås meet the boarding and alighting numbers criterion.

Of the rejected locations, no boarding and alighting data were available for Molndal, Nassjo, Vaggeryd, Markaryd or Kristianstad. Of the rejected locations for which data were available, it can be seen that the following meet the boarding/alighting criterion: Ulricehamn, Alvesta, Vaxjo and Helsingborg.

Of these, Ulricehamn provides no connection to the existing railway network, while Helsingborg does not lie on a direct route between Malmo and Jonkoping (see also below); Alvesta and Vaxjo also lie on a relatively indirect route between Malmo and Jonkoping. The remaining rejected stations fail to meet the boarding/alighting criterion, and their exclusion is therefore not contentious.



schematic map showing population densities in Sweden
Source: Wikipedia

Projected housing generation at proposed station locations

Detailed data for this criterion are not available; it is assumed that, if agreement is reached to provide a high-speed station at a given municipality, an undertaking will be given to develop at least 1,300 new homes within the new station catchment area.

Proposed airport stations at Skavsta and Landwetter

None of the five quantitative criteria listed above applies to the two proposed airport stations, and a review of the UK Passenger Demand Forecast Handbook (PDFH) and the academic literature indicates that there are no standard metrics (in terms of annual airport passenger numbers, for example) for the provision of high-speed (or conventional) rail connections to airports.

A 2004 study [High-Speed line Airport Connections in Europe – Lopez-Pita and Robuste] found that annual passenger numbers at European airports served by HSR varied between approximately 48m (Paris Charles de Gaulle, Frankfurt Main) and 5m (Lyon St Exupery, Cologne-Bonn). Of the two airports under consideration here, Landvetter (6.2m passengers in 2015), falls within this range, while Skavsta (~1.8m passengers in 2015) does not.

However, there are considerable potential synergies between HSR and airports, and potential benefits beyond simple passenger numbers, particularly in cases, as with the Swedish proposals, where an airport is located on a proposed HSR route, avoiding the need for a branch line or route diversion.

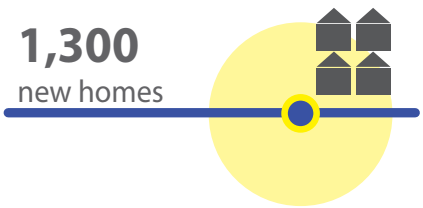
In addition to the environmental impacts of aviation itself, road-based airport traffic can generate considerable air pollution, particularly in cases where road traffic is congested. HSR can help to reduce congestion and pollution, while also reducing journey times between airports and adjacent areas, and, in addition, increasing an airport's catchment area. HSR can also replace short-haul flights along parallel routes, thus reducing air traffic congestion and pollution, and/or releasing airport slots for more valuable longer-haul flights.

The proposed Swedish HSR could thus replace at least some of the flights currently operating between Stockholm Arlanda airport and Landvetter, Malmö and Kastrup (Copenhagen), and between Kastrup and Stavska. Conversely, the HSR connection to Stavska could facilitate the provision of new air services, boosting its role as Stockholm's second airport, and providing convenient air travel opportunities for those in southern Stockholm and its hinterland.

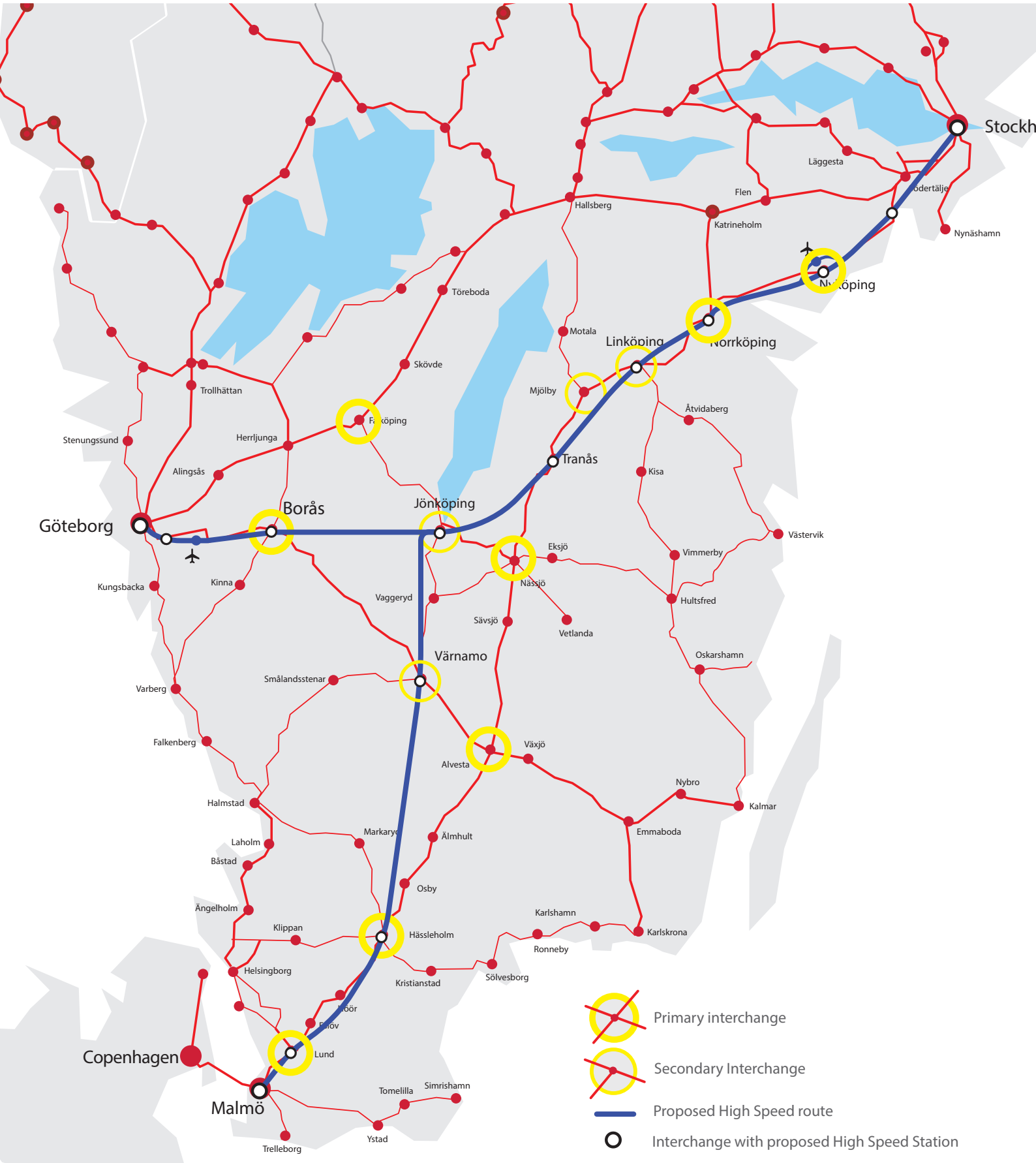
More generally, the provision of a HSR airport station, particularly when these are well-connected with a high-speed road network, provides the conditions to enable the development of a 'high-speed transport hub', facilitating local growth and the development of industry and technology. This could also provide the opportunity for transhipment of low-volume, high-value freight between air and HSR, of particular relevance to Landvetter, which we understand already handles significant quantities of air freight.

THE NATIONAL NEGOTIATION ON HOUSING AND INFRASTRUCTURE:

"The aim is for the high-speed railways to be completed around 2035 and that at least 100,000 new homes are constructed throughout the country."



(average holdhold = 2,0)
1,300 homes = 2,600



Map showing existing significant rail interchange stations

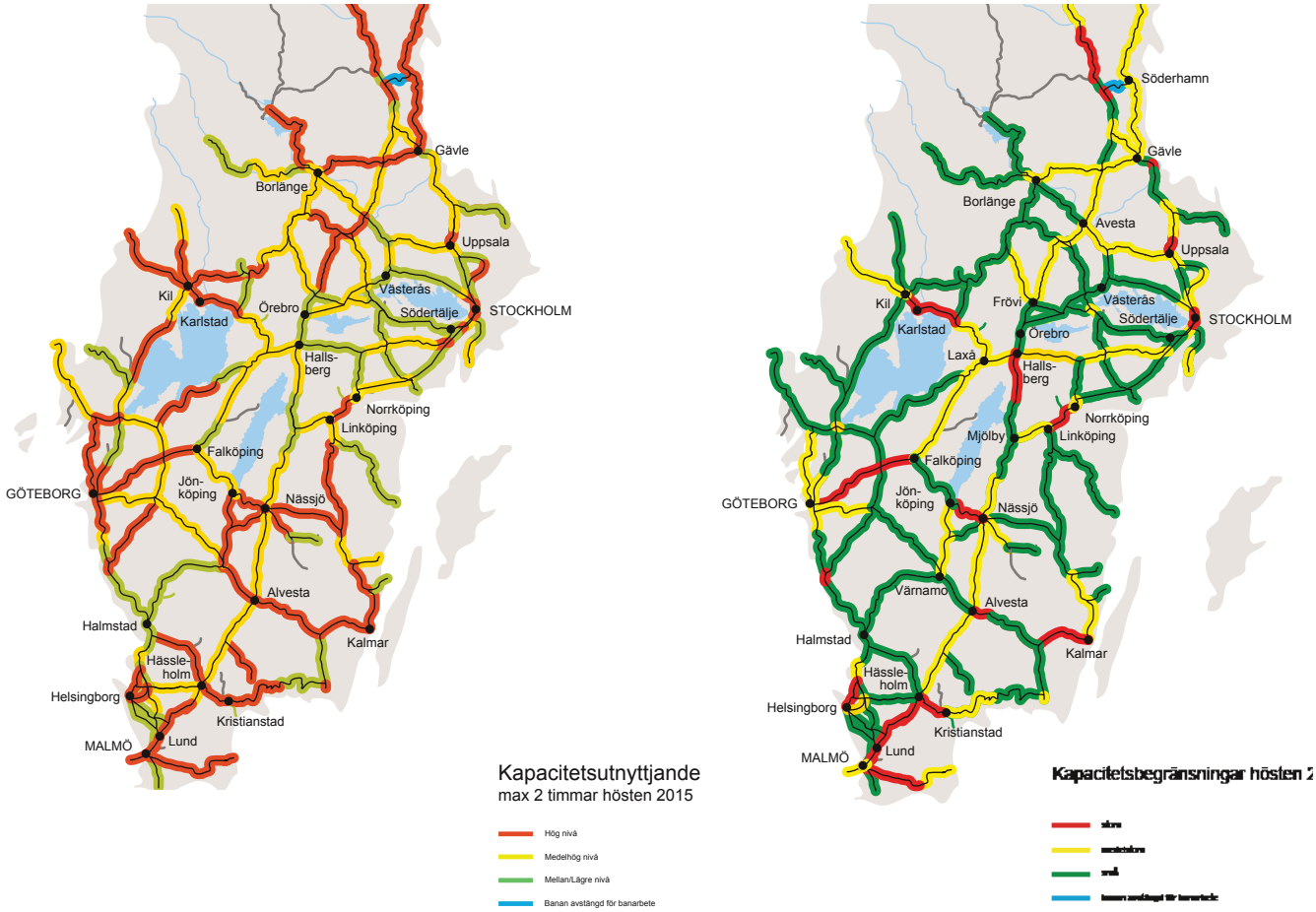
2.3 STATION'S SIGNIFICANCE FOR TRANSFER FOR INTER-REGIONAL TRAIN TRAVEL

Potential for inter-regional train travel via interchange at proposed stations

Ideally, the interchange potential of the various station options would be assessed by means of a detailed demand modelling exercise; however, such an exercise is beyond the scope of the current review. This element of the review is therefore based upon an initial high-level qualitative review of the comparative interchange opportunities presented by the proposed and rejected station options, followed by some supporting quantitative analysis.

With the exceptions of the main lines between Stockholm and Gothenburg and between Stockholm and Malmo, the majority of the lines providing connections with the proposed HSR network are single-track, and thus provide broadly similar potential levels of connecting service, subject to the details of passing loop provision, etc. It is assumed that, to maximise the interchange potential with the HSR network, services on the conventional network would be scheduled to maximise interchange opportunities, as far as is consistent with the maintenance of commercially attractive services on the conventional lines. Such a strategy is set out in the 'Integrated Connectivity Approach' developed by Network Rail as one of the options for integrating the High Speed 2 HSR with Britain's conventional railway network.

The rejected station location options are all to the south or west of Jonkoping. In the following paragraphs, the connectivity of the proposed station locations are compared with the rejected alternatives and with each other, first working north from Hassleholm on the Malmo route, and then working east from Molnlycke on the Gothenburg route. The connectivity of the proposed stations between Jonkoping and Stockholm is then considered.



Source: REPORT "Janrvangens kapacitet 2015_Trafikverket 2016038"

Diagram showing existing rail capacity

Hässleholm vs. Helsingborg/Kristianstad
Hässleholm is located on the existing Malmö – Stockholm main line. It also forms a junction with a line to the east, to Kristianstad and Karlskrona, and with lines to the west, to Helsingborg, and to the north-west, to Halmstad; in total, it is connected to five 'arcs' of the conventional network. It is thus better-connected than either Helsingborg or Kristianstad, the rejected options at similar latitude, as well as being on a significantly more direct alignment between Lund and Jönköping. Its location on the existing main line provides good opportunities for HSR interchange with existing stations between Lund and Alvesta.

Hässleholm vs. Markaryd/Almhult
To the north of Hässleholm, Markaryd and Almhult were also considered, but rejected. Markaryd is on the line between Hässleholm and Halmstad, while Almhult is on the main Malmö – Stockholm line between Hässleholm and Alvesta; each is thus connected to two arcs of the network, providing lower levels of connectivity than either Hässleholm or Värnamo, the proposed HSR station location to the north of Markaryd and Almhult.

Värnamo vs. Alvesta/Vaxjo/Ljungby
Värnamo is located on the existing coast-to-coast railway, and on lines to the north, to Vaggeryd (and thus Jönköping and Nassjo), and to the south-west, to Halmstad. It is thus connected to four arcs of the existing network. This is also true of the rejected option of Alvesta, at the junction of the coast-to-coast and main Malmö – Stockholm lines, whereas Vaxjo is on the coast-to-coast line only, connected to two arcs, and Ljungby has no connection with the existing passenger network. Routeing the HSR through Värnamo provides a slightly more direct route between Hässleholm and Jönköping than the Alvesta option. It also avoids duplicating the alignment of the existing main Malmö – Stockholm line; connectivity via Värnamo could be maximised by coordinating conventional train services with HSR train arrivals and departures, as advocated above, possibly including selective through running from and to the existing main line and/ or providing seamless connections between Alvesta and Värnamo.

Värnamo/Jönköping vs. Skillingaryd/Vaggeryd
Skillingaryd is on the existing railway line between Värnamo and Vaggeryd, and is thus connected to two arcs of the existing network, while Vaggeryd forms the junction between the Värnamo – Jönköping line and a line to Nassjo, and is therefore connected to three arcs, the same number as Jönköping. Skillingaryd and Vaggeryd are both considerably closer to Jönköping than is Värnamo, and the choice of either in place of Värnamo would result in a less even station spacing between Hässleholm and Jönköping, as well as reduced connectivity. Jönköping is connected to three arcs of the existing network, like Vaggeryd, but two of those links connect it with the existing Göteborg – Stockholm and Malmö – Stockholm main lines, at Falkoping and Nassjo respectively.

Jönköping vs. Nassjo
As noted above, Jönköping is connected to three arcs of the railway network, whereas Nassjo is connected to six, being located on the Malmö – Stockholm main line, and forming a junction with the lines to Jönköping, Värnamo and Halmstad, Vetlanda and Eksjo. Nassjo therefore appears to offer greater interchange opportunities than Jönköping. However, as noted previously, locating a HSR station on the existing main line duplicates the existing alignment, and Jönköping is closer than Nassjo to the Göteborg – Stockholm main line. Nassjo's high level of connectivity can perhaps best be exploited by providing high-quality, seamless connections between it and HSR arrivals at and departures from Jönköping.

Mölnlycke/Göteborg vs. Molndal
Molndal, immediately south of Göteborg on the line is connected to two Varberg, Helsingborg and Lund, is connected to two arcs of the railway network, as is Mölnlycke, on the coast-to-coast line between Göteborg and Borås. Mölnlycke enables a slightly more direct route between Gotherburg and Landwetter, and is sufficiently close to Molndal to provide easy access to HSR services from both locations, and the wider area to the south and east of Göteborg.

Landwetter/Borås vs. Bollebygd
Bollebygd is located on the coast-to-coast line between Göteborg and Borås, and is this connected to two arcs of the existing network, whereas Borås is connected to four, with links to the north and south. Landwetter is not connected to the existing railway network, but, as an airport station, is a 'special case'. As well as providing more connection opportunities, Borås is more equidistant than Bollebygd between Göteborg and Jönköping, providing a better overall station distribution and spacing.

Borås/Jönköping vs. Ulricehamn
Ulricehamn is not on the existing railway network, and thus provides no interchange opportunities with HSR, in contrast to both Borås and Jönköping.

Jönköping - Stockholm
As noted above, none of the rejected station options is between Jonkoping and Stockholm, and the proposed stations are all located on existing routes. Of these, Linkoping and Norrkoping are junctions, both connected to three arcs of the existing network, while Tranas, Nykoping and Vagnharad are connected to just two each. However, all the stations allow interconnection with conventional services to and from intermediate stations, and routeing the HSR via Nykoping and Vagnharad provides an alternative high-speed route between Norrkoping and Stockholm to the existing one via Katrineholm, thus improving overall connectivity within the comparatively densely-settled part of Sweden between Linkoping and Stockholm.
The foregoing analysis indicates that the proposed HSR station locations generally maximise the opportunities for interchange with the conventional network and thus for inter-regional train travel. The one significant possible exception to this, in terms of direct connection opportunities, is the choice of Jonkoping over Nassjo, although this can be mitigated by scheduling and routeing conventional services between the two to maximise the interchange opportunities with HSR at Jonkoping.

2.4 BENCHMARKING OF SWEDISH HSR PROPOSALS AGAINST OTHER HSR SYSTEMS

In 'The High-Speed Rail Revolution: History and Prospects', part of the contextual documentation for Britain's High Speed 2 (HS2) HSR between London, the Midlands and the North, four fundamental types of HSR are identified:

- Complete separation from other railway services (e.g. Japan's Shinkansen)
- Mixed high-speed systems, where high-speed trains run beyond the high-speed network on upgraded conventional routes and termini approaches (e.g. France's TGVs)
- Mixed conventional system, where the high-speed network is used by both high-speed trains and (upgraded) conventional services, which operate beyond the high-speed network (e.g. Spain's AVE and ALVIA services, and high Speed 1 (HS1) in Britain, used by international Eurostar services and domestic high-speed services, which run beyond HS1 to serve the conventional network)
- Fully mixed system, where both high-speed and conventional infrastructure are used by both high-speed and conventional (including freight, in Germany) train services (e.g. Germany's ICE and other services and services on the Rome – Florence route in Italy)

These variants are summarised in the diagram below:

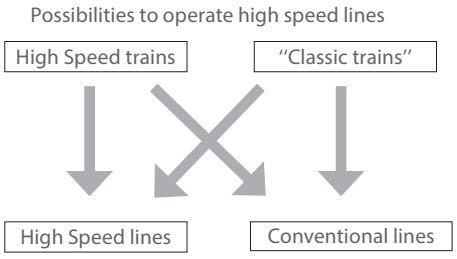


Diagram source: http://www.uic.org/highspeed

The Swedish HSR proposals most closely resemble the mixed high-speed system, as used in France, with all trains apparently running through to existing termini on upgraded conventional infrastructure, and with apparent 'passive provision' for high-speed services to run beyond the high-speed network to Arlanda and Uppsala to the north, and to Kastrup, Copenhagen and Hamburg to the south and west.

The provision of an 'almost-closed', mixed high-speed system, as proposed, best meets the overall objectives for Swedish high-speed rail, in that it enables fast and punctual long-distance and regional passenger rail transport (by meeting the objective of limiting connections to the conventional network, the potential to 'import delay' from beyond the high-speed network is limited). It also releases capacity on the conventional network more effectively than a mixed conventional or fully mixed system, either of which would continue to make extensive use of the conventional network. Finally, the use of a mixed high-speed system also meets the objective of enabling high-speed trains to serve Arlanda and Uppsala to the north, and to provide international services to Kastrup, Copenhagen and Hamburg to the south and west of Sweden.

The length of the proposed Swedish HSR system (Stockholm – Göteborg approximately 520 km, Stockholm – Malmö approximately 650 km) is similar to those of Japan's Tokaido line between Tokyo and Osaka (515 km), the original TGV line between Paris and Lyon (425 km) and Spain's AVE lines between Madrid and Seville (472 km), Malaga (512 km) and Barcelona (621 km).

The Y-shaped configuration of the proposed HSR resembles that of the Spanish AVE lines between Madrid and Seville/ Malaga, which split south of Cordoba, and France's LGV Nord, which splits at Lille to link Paris with the Channel Tunnel and London, and with Brussels and beyond. It also resembles the proposals for Britain's HS2 network, which splits in the West Midlands to link London with the North-West and the North-East of England (strictly, the HS2 network forms an 'X', with an additional short leg to Birmingham).

Station numbers and average spacings on the proposed Swedish HSR are summarised in the first four rows of the table below. Since the Stockholm – Jönköping section is common to both the Malmö and Göteborg routes, station numbers and average spacings are presented separately for it and for the Jönköping – Malmö and Jönköping – Malmö sections. The effects of Arup's suggested revisions on station numbers and spacings between Stockholm and Jönköping are also shown. The subsequent rows in the table provide some international comparisons.

Route	Length (km)	No. of Intermediate	Average Spacing (km)	Notes
Stockholm – Jönköping (Trafikverket proposal)	363	5	61	Nykoping and Skavsta treated as single station for this analysis
Stockholm – Jönköping (Arup proposal)	363	3	91	Vagnharad, Nykoping, and Tranas stations removed removed
Jönköping – Göteborg	155	3	39	
Jönköping – Malmö	290	3	73	
Tokyo - Osaka	515	15	32	Regional - Very densely-populated termini and corridor
Paris - Lyon	425	2	142	High Speed
Madrid - Seville	472	3	118	High Speed
Cordoba - Malaga	155	2	52	Branch of the Madrid – Seville line
Madrid - Barcelona	621	5	104	Regional - 3 stations served by long-distances, high-speed services; plans in place for an additional station at Barcelona El Prat airport for an additional station at Barcelona El Prat
High-Speed 1 (Domestic)	100	3	33	Distance between London and Ashford (regional)
High-Speed 2 (Phase 1)	160	0	160	Distance between London and Birmingham boundary (2 Stations each in London and Birmingham)

It can be seen that the Jonkoping – Gothenburg section of the proposed route has the smallest average station spacing, but that this is similar to those for the (much more densely-populated) Tokaido Shinkansen between Tokyo and Osaka, and, perhaps of more relevance, Britain's High Speed 1 domestic services.

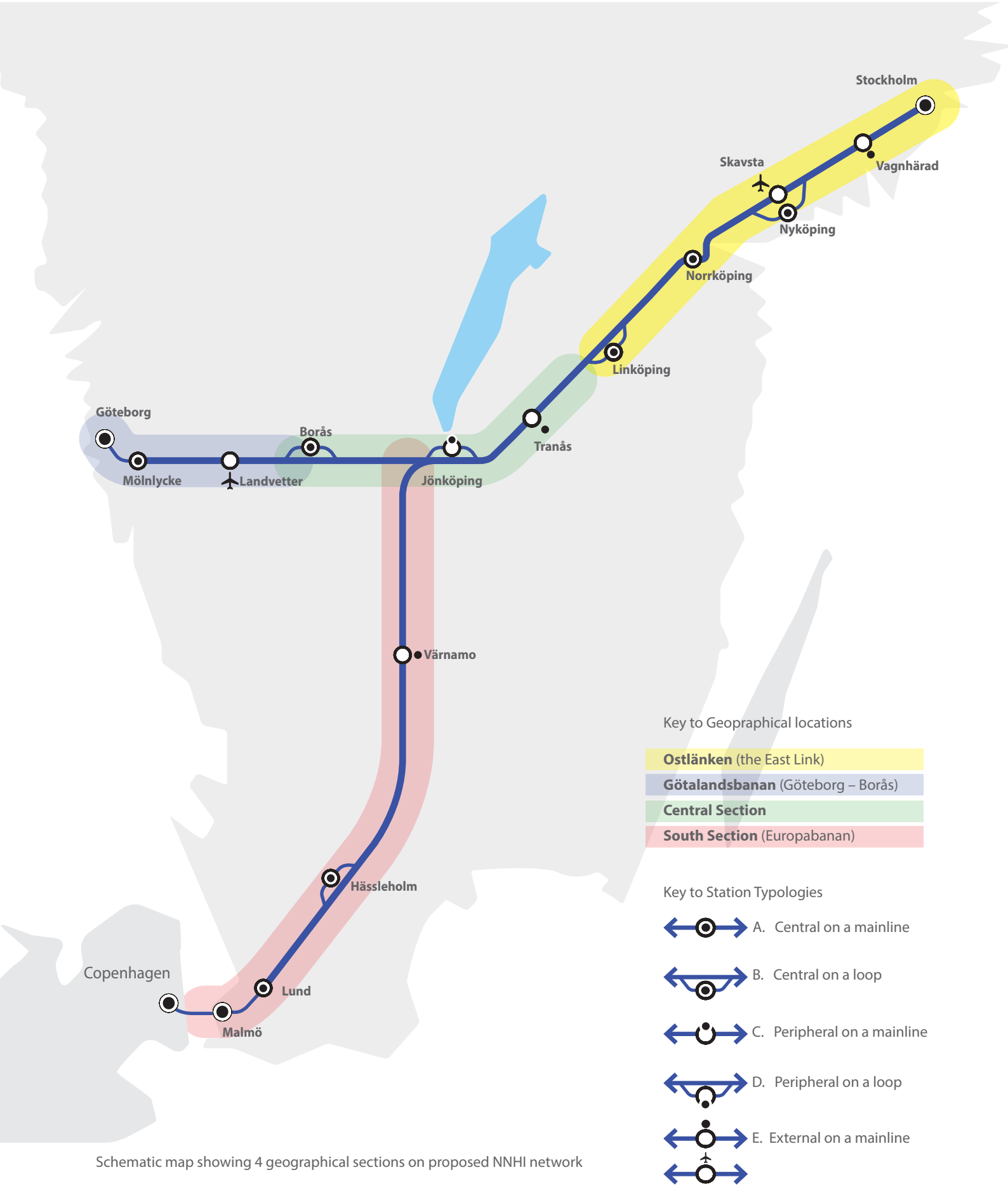
It can also be seen that the average station spacings for Stockholm – Jonkoping (for both the original proposal and the Arup revisions) and for Jonkoping – Malmo fall within the range shown by international comparators, being greater than the spacings for Cordoba – Malaga in Spain, and less than those for, Madrid – Barcelona, Madrid – Seville, London – Birmingham (Phase 1 of Britain's planned High Speed 2) and Paris – Lyon.

AVE High Speed train crossing bridge Saragosa, Spain

High Speed Rail Shinkansen line, Tokyo, Japan

3

STATION LOCATIONS - METHODOLOGY



Schematic map showing 4 geographical sections on proposed NNHI network

3.1 GENERAL

This section of the review will look at the specific station locations proposed by NNHI. These will be reviewed against the established NNHI criteria discussed in section 2 and also station specific criteria identified by Arup and discussed with the Client at earlier meetings. In the first part of the review we will;

- Define the assessment criteria
- Define the station location typologies
- Discuss emerging station characteristics

The proposed 'Y' network comprises four geographic sections and a total of thirteen new high speed railway stations;

Ostlänken (the East Link)
Originally conceived as an intercity high speed service, the Ostlänken (East Link) will follow a more direct route than the existing rail with 150 km of new line. Five stations are planned at Vagnhärad, Nyköping, Skavsta airport, Norrköping and Linköping.

Göteborg – Borås
Project Göteborg – Borås also planned as a stand-alone intercity high speed service has three stations at Mölnlycke, Landvetter Airport and Borås.

Central Section
The central section between Linköping and Borås has two planned stations at Tranås and Jönköping.

South Section
+The southern section of the 'Y' network has a further three stations planned at Värnamo, Hässleholm and Lund.

For each station assessment we will undertake the following steps;

1. Summarise characteristics of city
2. Identify existing relevant infrastructure (roads and rail)
3. Superimpose proposed HSR infrastructure onto existing infrastructure
4. Compare the NHII proposed locations with 2 alternatives
5. Assess against defined criteria, raising considerations and making preliminary recommendations

3.2 TYPOLOGIES

Taking account of the station location typologies identified by NNHI, Arup have selected 5 principle typologies for the second opinion. Essentially there are 3 geographical types relating to location relative to the city; central, peripheral and external. These combine with 2 network types; mainline and loop to give the following typologies;

A. Central on mainline
B. Central on loop
C. Peripheral on mainline
D. Peripheral on loop
E. External on mainline

In brief the characteristics of these are as follows;

Central Station

We have defined a Central Station as one which combines or interchanges with an existing city centre railway station and other transport modes. Typically this station will attract higher levels of patronage due to its accessibility to the city population directly and to a wider catchment through intermodal interchange.

Inherent constraints of this typology however arise from its centrality; an appropriate surface rail alignment may not exist, adequate land may not be available for the station or associated development and the HSR station and railway may impact negatively on urban areas.

Peripheral Station
We have defined a Peripheral Station as one which is within a short (10 minute) travel distance from the city centre using public transport. This equates to approximately 10km although this will clearly depend on the PT technology used and the number of stops on the route.

A peripheral station should be located where there is adequate land availability both for the station and potential development. It will require investment in further PT provision to provide accessibility to the city centre and a wider passenger catchment.

External Station
We have defined an External Station as one which lies outside the city boundary although potentially within the Municipal boundary. It is likely to be beyond the range of regular PT provision with the exception of dedicated bus/coach services.

The station may experience lower levels of patronage and will be predominantly car-based in the case of a Parkway station. In the case of airport stations demand will be driven almost exclusively by interchange with air travel although this may be supplemented by work trips where there is airport related development.

Station on a Mainline
A mainline station will be highly constrained and will result in significant potential impact if within an urban area. Speeds will be restricted and costs will be high for acoustic mitigation and particularly high where there is a need to place the rail at a subsurface level. A peripheral station will be less constrained and an external mainline even less.

Station on a Loop
A station on a loop (also referred to in communications as a 'bypass') will be able to accommodate slower trains without compromising the city to city non-stop service and these could potentially cater for the shorter 200m stopping service regional trains.

However there can be a significant duplication of costs involved where a new high speed rail corridor is required for the loop. The extent that existing rail corridors can be utilised for these loops will therefore be key to their viability.

Swedish railway and landscape

3.3 ASSESSMENT CRITERIA

For the purposes of this review, five high level station related criteria, agreed during the course of the review, have been used to assess the characteristics of the proposed stations. These criteria are intended to compliment the broad objectives set out by NNHI and as described in Section 2.1 of this report. At this early stage this is not intended as a definitive evaluation but as an indicator of whether the station proposed is likely to meet the general objectives. The 5 criteria are;

1. Connectivity
2. Urban integration
3. Development potential
4. Environmental impacts
5. Delivery / cost

Connectivity
For a high speed rail station to have a transformational effect on its host city it must be well connected to a wider transport network so that the maximum number of customers can have access to its offer of longer distance connectivity. Depending on the size of the city and the maturity of its public transport network, interchange would ideally be with metro or light rail, buses, taxis, private cars, cycle networks and pedestrian networks.

Clearly connectivity can be achieved most effectively by combining with already established transportation hubs such as normally exist to some degree at central city stations. So as a general rule one would expect central HSR stations to achieve higher levels of connectivity and more peripheral stations to achieve less and probably require supplementary PT provision.

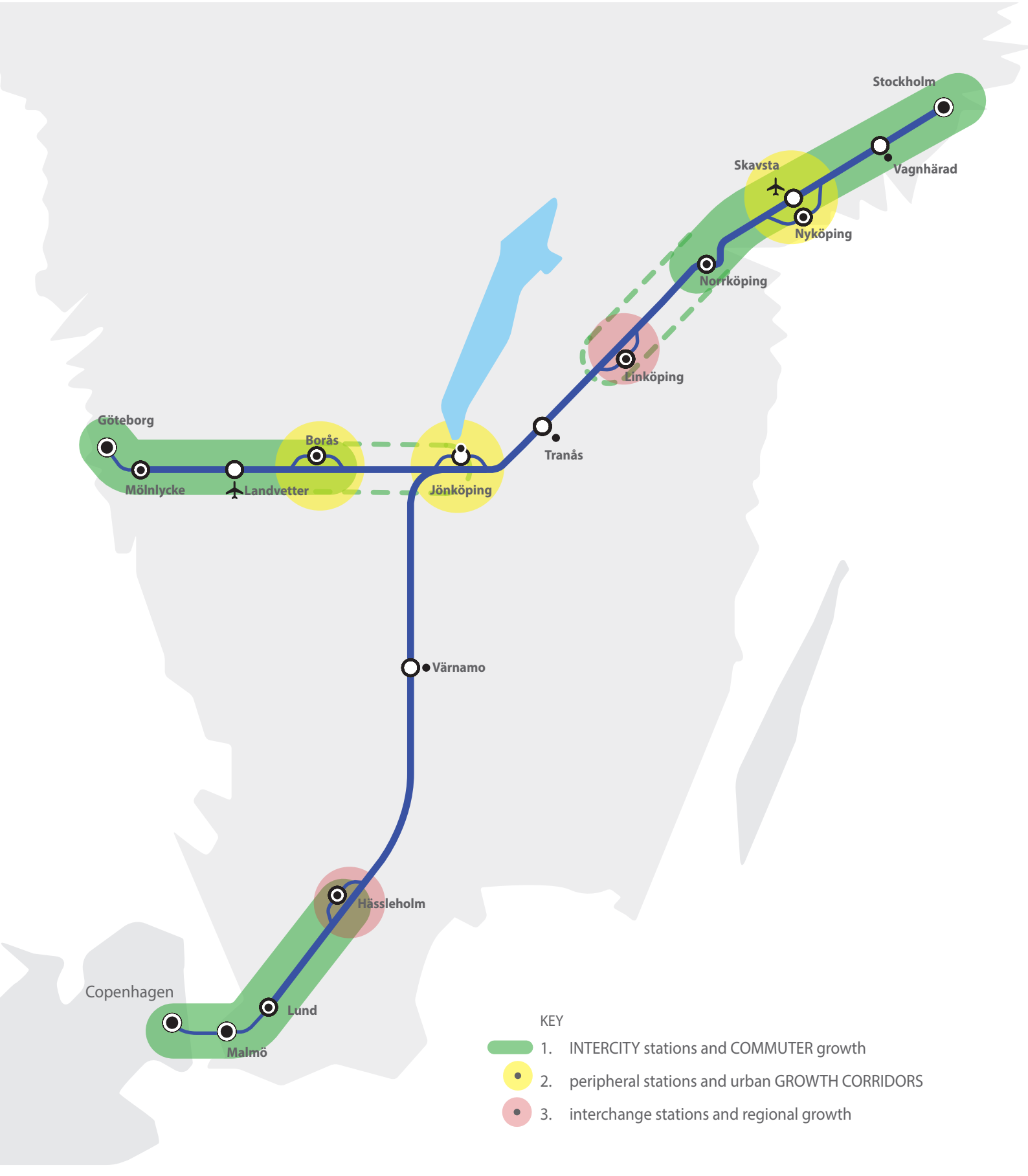
An external or Parkway station will be limited in its connectivity to public transport so would need to be well connected to the highway network and provide ample parking provision for a park & ride service.

Urban Integration
High speed rail stations can both contribute and compromise integration with its host cities' urban environment. As with all urban rail, a railway corridor can create a severance within a city and a barrier to free movement. This can be even more so with HSR due to the high speeds involved and the acoustic mitigation often required, particularly with non-stopping services and high-speed trains running at 320 km/h.
In the worst case scenario, up to 4.5 m high noise barriers may need to be built on long stretches through urban areas. To implement these while also fulfilling aesthetic expectations and urban integration can be a major challenge.
However HSR stations can also provide the catalyst and focus for inner city and city edge regeneration whereby the station becomes the inclusive heart of a new city district helping to bring people together and integrating the urban environment. There are many examples of how this has been effectively achieved throughout Europe.

Development Potential
As discussed above high speed rail stations can catalyse regeneration and create significant value which if managed well and within the context of a comprehensive masterplan can be captured to part fund the overall regeneration project. If well connected as they should be, the HSR station becomes a multi-modal transport hub which can support high densities of development in a sustainable non-car dependent way. Development potential is however also reliant on the availability of land and city centre locations may well be constrained in this respect. City edge locations on the other hand may contain areas of brown field land or lower value industrial sites, thereby offering greater development potential.
External HSR stations will have limited development potential except where there are specific strategic drivers for development, such as at an airport where there is a demand for airport-city types of development.

Environmental Impacts
At this stage we are only able to review based on the information available so commentary on environmental issues will be limited to issues such as likely noise impacts in urban areas or proximity to significant natural heritage where this is known.

Delivery / Cost
Again without more developed costs and programmes we will limit our comments to a high level commentary where for example there are likely to be high costs arising from a central station on a mainline or where there is an opportunity to omit significant elements of infrastructure.



Schematic map showing station location characteristics

3.4 EMERGING THEMES

During the course of the review a number of themes have emerged regarding the characteristics of stations and types of growth that they may stimulate. We believe that the stations reviewed will fall to a greater or lesser extent into one or more of these three categories;

Intercity Stations and Commuter Demand

Whilst it is understood that it may not be a specific objective of the proposed HSR system, accessibility to the 3 principle cities from their surrounding hinterlands along the HSR corridor will be greatly enhanced. A likely effect of this is that inter-city commuting patterns will be stimulated creating a demand which will need to be met.

As well as the mixed system of long distance non-stopping and regional stopping services arising from this demand, there may also be land use planning consequences. In particular, housing which is more affordable than in say Stockholm, could be developed within a redefined commuting distance.

Stations which address this demand will have attributes that are potentially distinct from non-commuter stations. For example they may tend to have a more tidal passenger flow related to the morning and afternoon peak travel hours. There will probably be a demand for more frequent but lower capacity trains as is the case for the high speed commuting service provided on HS1 in the UK.

Peripheral Stations and Urban Growth Corridors

This describes a potential growth strategy that can be implemented at peripheral stations where there is no direct interchange with an existing city centre station. Within the context of a masterplan, a Public Transport corridor could be planned connecting the city centre with the peripheral HSR station.

Initially this could be provided by relatively low cost bus priority or Bus Rapid Transit systems but potentially be upgraded to a higher capacity system later. High density development including housing, could be focussed, particularly at stops, providing a growth corridor generating a significant population using public transport as their primary means of travel.

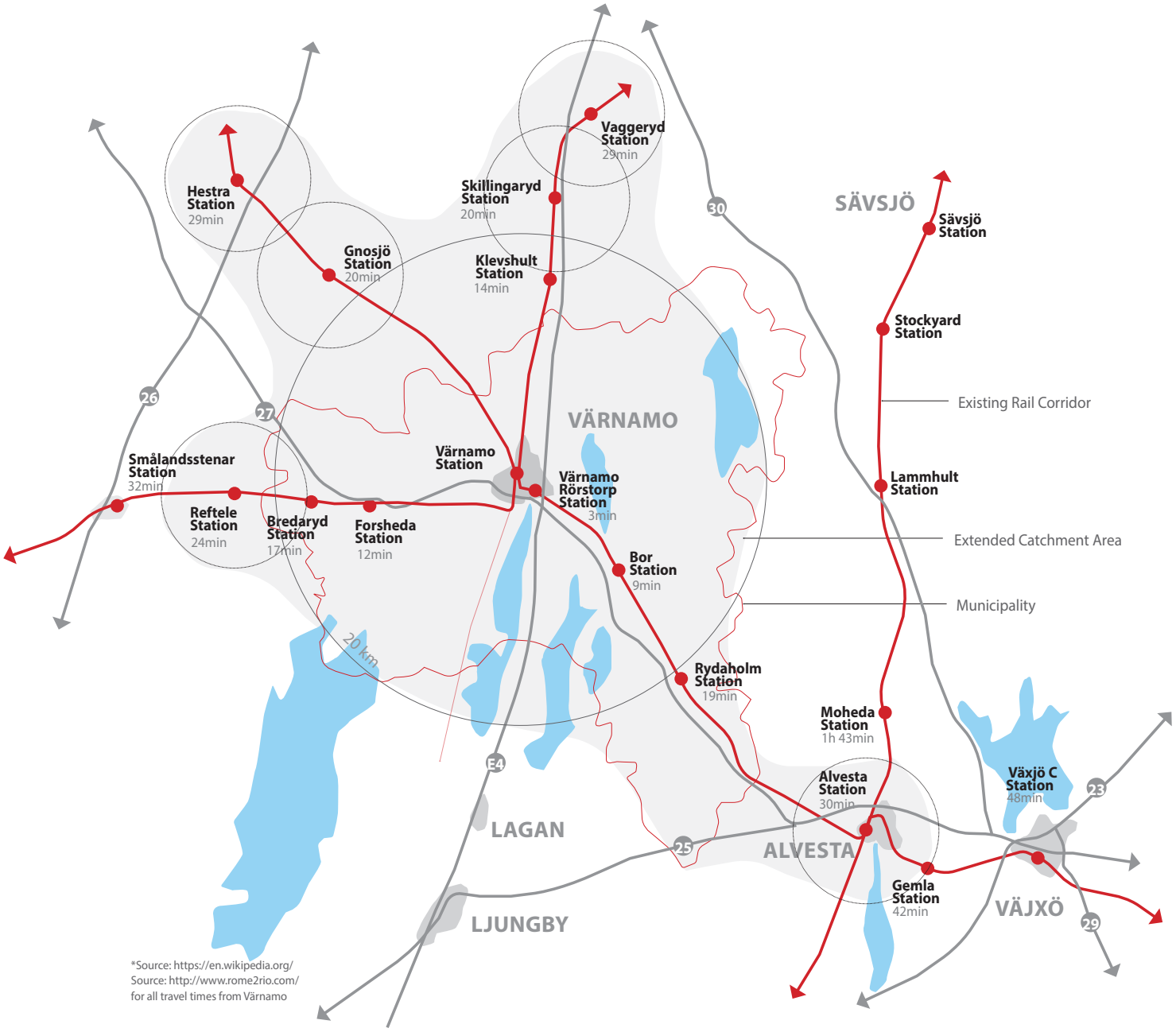
The approach to strategic urban growth corridors in cities around the world is well documented. Curitiba in Brazil is renowned for its pioneering BRT system and the way it has structured urban growth. Melbourne in Australia has plans for four growth corridors, each making provision for population and employment capacity structured around the strategic transport infrastructure. There are many other examples that could be drawn upon to support this strategy.

Interchange Stations and Regional Growth

Improved accessibility to the wider regions can be served by those stations with strong potential for interchange between HSR and the existing regional services. These stations may not serve large city populations but through road and rail access will be able to reach out to larger catchment areas.

A brief study was undertaken of the potential catchment enhancement at an HSR station at Värnamo assuming a city centre station with interchange to 2 existing classic rail lines. As shown on the schematic plan effective rail interchange can compensate for a low city population.

However whilst a city centre location may offer better rail to rail interchange, the lower costs associated with an external location and the availability of large sites for car parking with good highway access suggest a Parkway solution may offer a more viable way of achieving regional connectivity.



*Source: https://en.wikipedia.org/
Source: http://www.rome2rio.com/
for all travel times from Värnamo

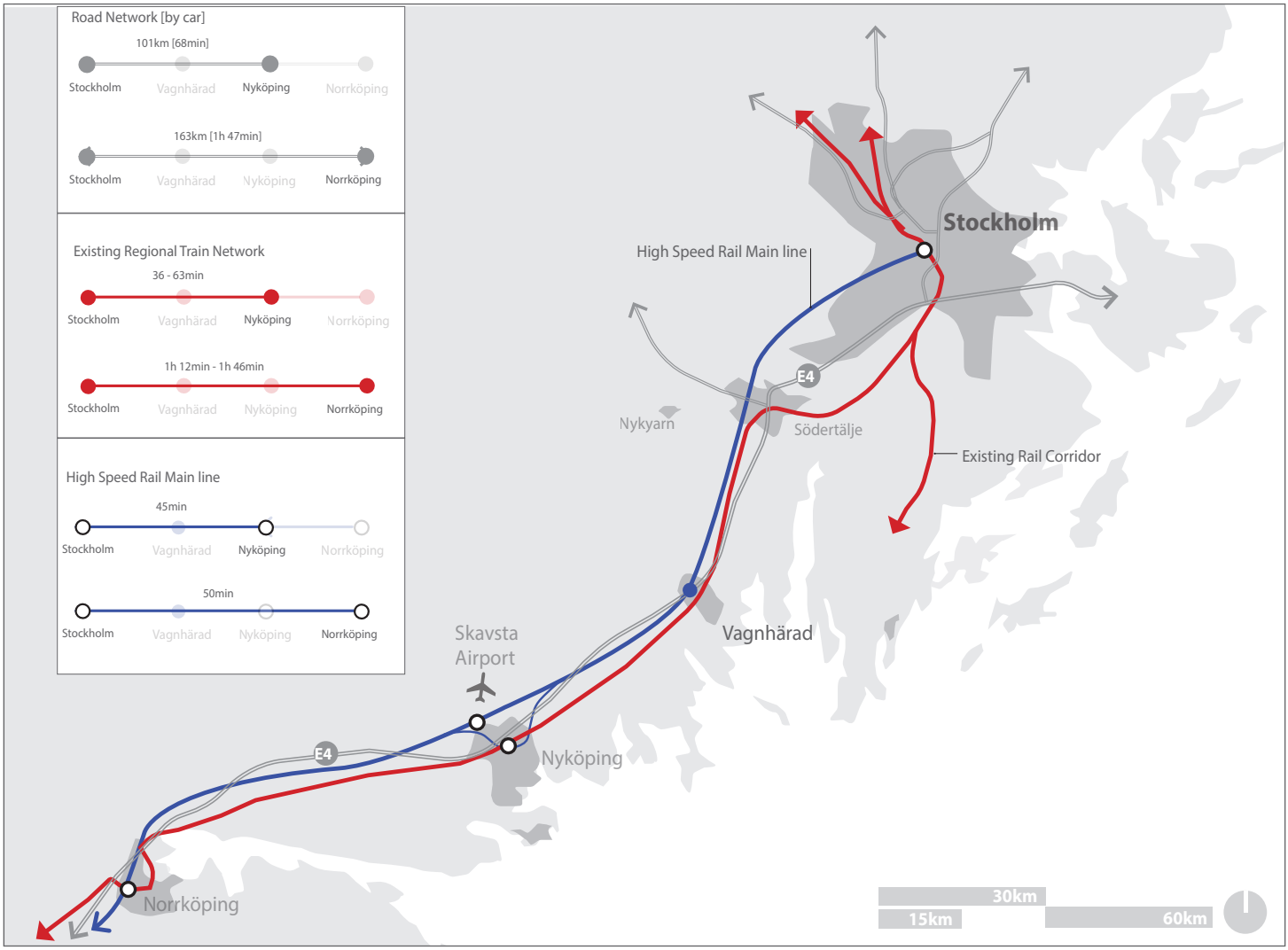
33,473 Municipality residents

24,000*
Additional urban population within the 30min catchment area

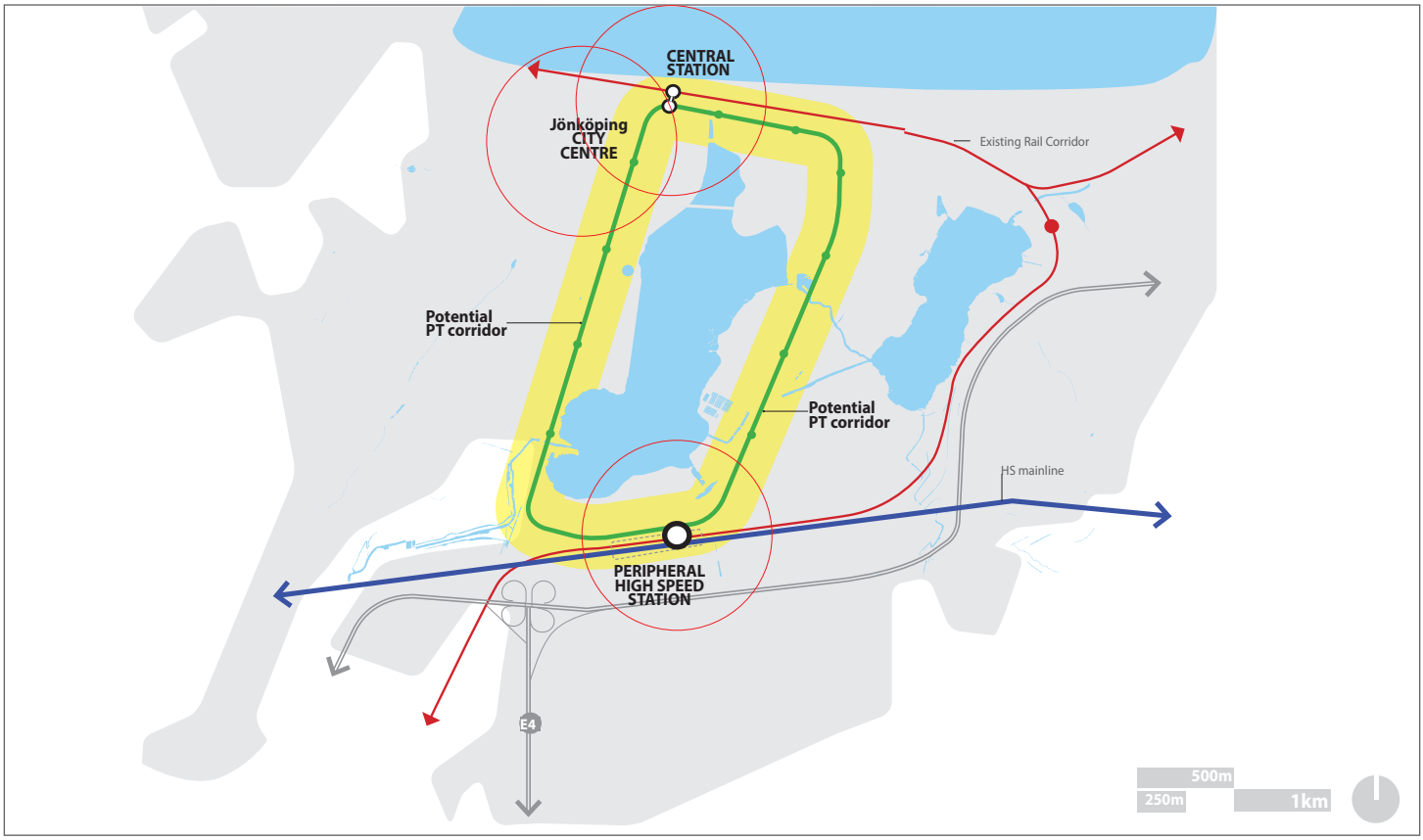
TOTAL: 57,473 Total population

10km
1km
20km

Schematic map showing potential for expanded catchment arising from regional interchange



Schematic map showing comparative commuter travel times between HSR, road and classic rail



Schematic map showing urban growth corridor zone along PT route

4

STATION LOCATIONS – NNHI PROPOSALS AND ALTERNATIVES

View of Vagnhärad

© Erik Jacobsson

Vagnhärad station

© wikipedia Raphael Saulus

4.1 VAGNHÄRAD

LOCATION CHARACTERISTICS

Vagnhärad is a small town situated in Trosa Municipality, Södermanland County, Sweden. It is located close to the highway European route E4 and the railway leading to Stockholm.

Vagnhärad station building

3,324
City population

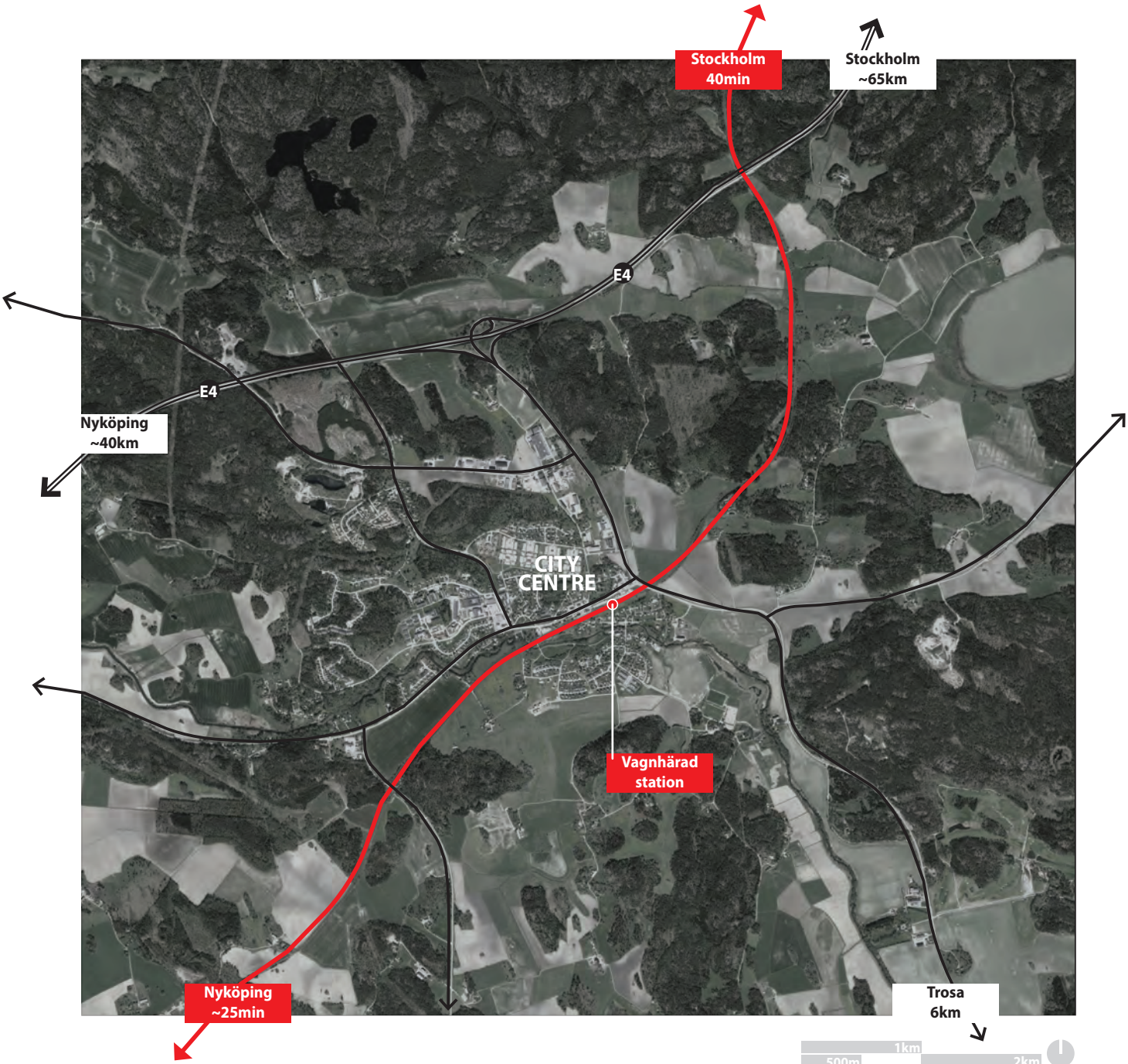
12,078
Municipality population

1,144/km2
Density

2.91 km2
Area

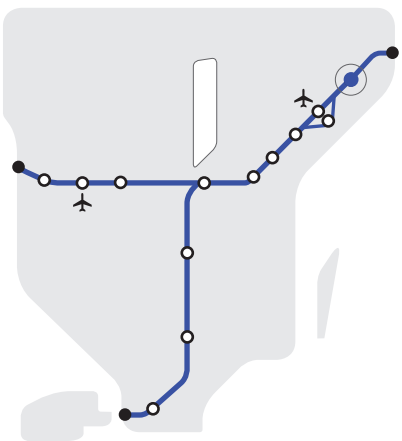
Source: Wikipedia

4.1.2 EXISTING AND PROPOSED INFRASTRUCTURE



Aerial photo showing existing Infrastructure

KEY HIGH SPEED NETWORK KEY DIAGRAM

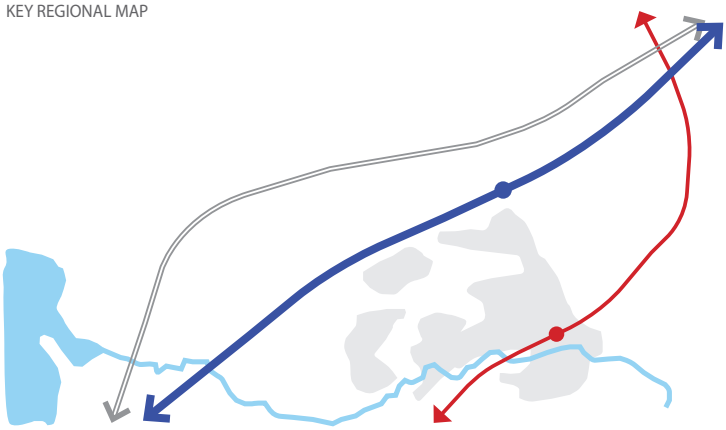


Schematic map showing proposed high speed rail / station

KEY

- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



NNHI proposal: External on Mainline

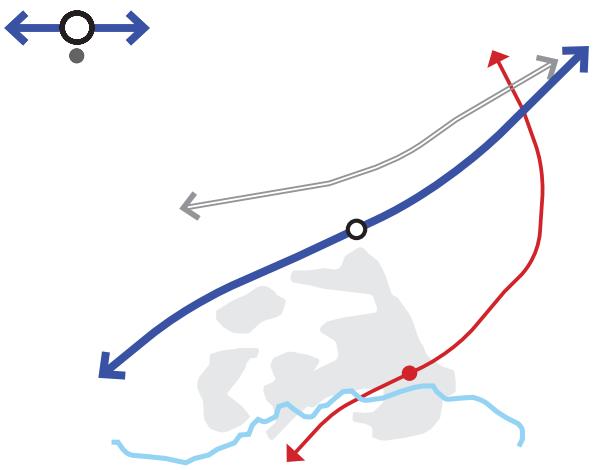
rail - poor
road - good
walk - poor

regeneration - poor
severance - neutral

land availability - good
viability – poor

no major issues identified at this stage

no major issues identified at this stage



Alternative 1: External on Mainline

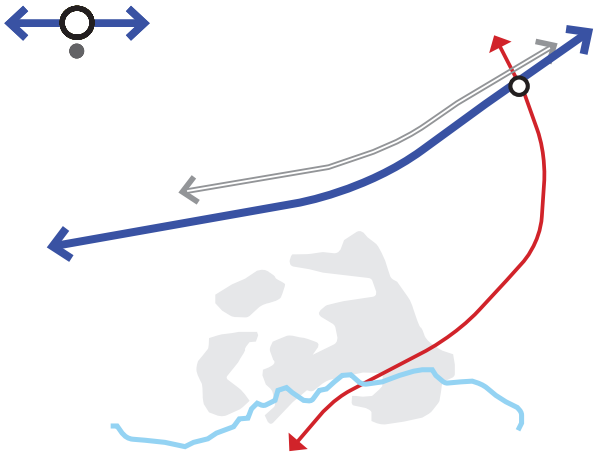
rail - good
road - good
walk - poor

as NNHI

as NNHI

as NNHI

as NNHI



Alternative 2: Central on Mainline

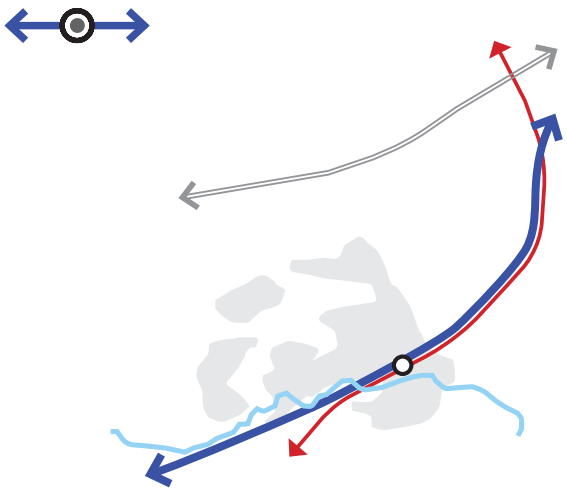
rail - good
road - good
walk - good

regeneration - good
severance - poor

land availability - good
viability – poor

noise in built up area

cost of longer alignment



KEY Connectivity Development Potential Delivery
Urban Integration Environmental Impact

NNHI proposal: External on Mainline

NNHI proposal – External on Mainline
It is understood that the following NNHI text describing the station location forms the basis of negotiation with the relevant Municipality;

Vagnhärad comprises a new railway station outside Vagnhärad's built-up (urban) area, and within the corridor permitted for the new double-track high-speed railway link between Järna - Linköping, which is itself part of the link between Järna - Almedalen and / or that between Järna - Lund. The station will be designed for regional train traffic, with platform lengths according to Trafikverket's regulations.

(ref. TSS: Technical Specification for high-speed trains).

This option is located outside the town on the mainline but is not coincident with the existing classic rail line so would not benefit from interchange. However there are some indications that this section of the rail line may be dedicated in the future to freight only.

The station would be a Parkway station requiring parking provision and good access to the highway network for park & ride passengers.

Alternative 1 - External on Mainline

This option locates the station externally on the mainline but further to the west and at a point which is coincident with regional rail allowing for the opportunity to interchange.
The station would be a Parkway station with parking provision and good access to the highway network for park & ride passengers.

Alternative 2 - Central on Mainline

This option locates the station centrally within the town on an upgraded and realigned railway corridor accommodating the HSR mainline. It is assumed that the alignment would be predominantly at grade through the centre and would therefore require significant acoustic mitigation which would significantly exasperate the existing rail severance, compromising effective urban integration.
Speed restrictions would also be required through the built up urban area to mitigate the environmental impact and this will result in time penalties to the overall end to end journey times.

CONSIDERATIONS

This station fails to meet any of the criteria set by NNHI, although the contribution to housing provision is not known but could be presumed to be less than the 1,300 homes threshold. So on this basis alone it should not be included as a station on the network.

Using the additional set of Arup criteria it also fails to make a significant case for inclusion. The proposed location does not coincide with the regional rail for potential interchange and is not close to the modestly populated town centre. There is not adequate critical mass to justify investment in supplementary transport infrastructure to improve the connectivity. The peripheral station is unlikely to stimulate town regeneration without significant strategic intervention and investment.

To summarise, the indications are that there is little demand for a station at this location and it would make little contribution to the objectives set out by NHII. It is not clear why the station will have been selected but it is understood that it may have been inherited from the earlier stand-alone high speed regional concept where the national objectives had yet to be identified.

So in the absence of justification against the set criteria or alternatively an over-riding strategic plan Arup would not recommend the inclusion of Vagnhärad Station.

Vagnhärad is not recommended as a station on the HSR system

Nyköping Skavsta airport

© Stockholm Skavsta Airport

View to Nyköping port

© Gunta Podina

Nyköping central station platforms

© Markus Tellerup

4.2 NYKÖPING & SKAVSTA AIRPORT

LOCATION CHARACTERISTICS

Nyköping literally translates as Newmarket into English. The city is located near the open Baltic Sea coast, and is also the home of Stockholm Skavsta Airport, a low cost airport located less than 10 kilometres from the city centre.

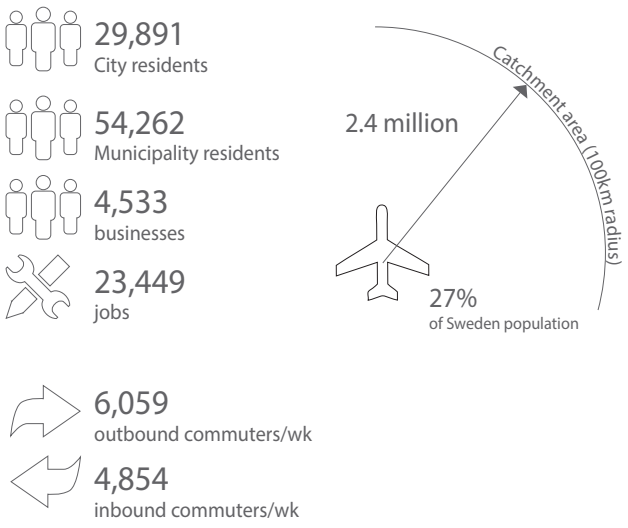
Nyköping is the mouth of a small river, Nyköpingsån, which runs through the city centre, dividing the city into a natural eastern and western part. The narrow river is bridged by seven crossings including one for the E4 highway to Stockholm.

The airport provides for low cost airlines and has 2.4 million passengers per year but has access to a catchment area which contains over 25% of the Swedish population so it could be considered to be of strategic significance.
This is the only situation where 2 stations have been identified at the same general location, so Arup have reviewed them together so as to take account of potential synergies.

Nyköping central station building

Source: Wikipedia

SWEDEN HIGH SPEED RAIL

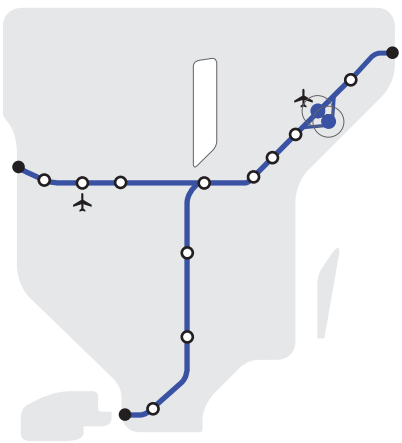


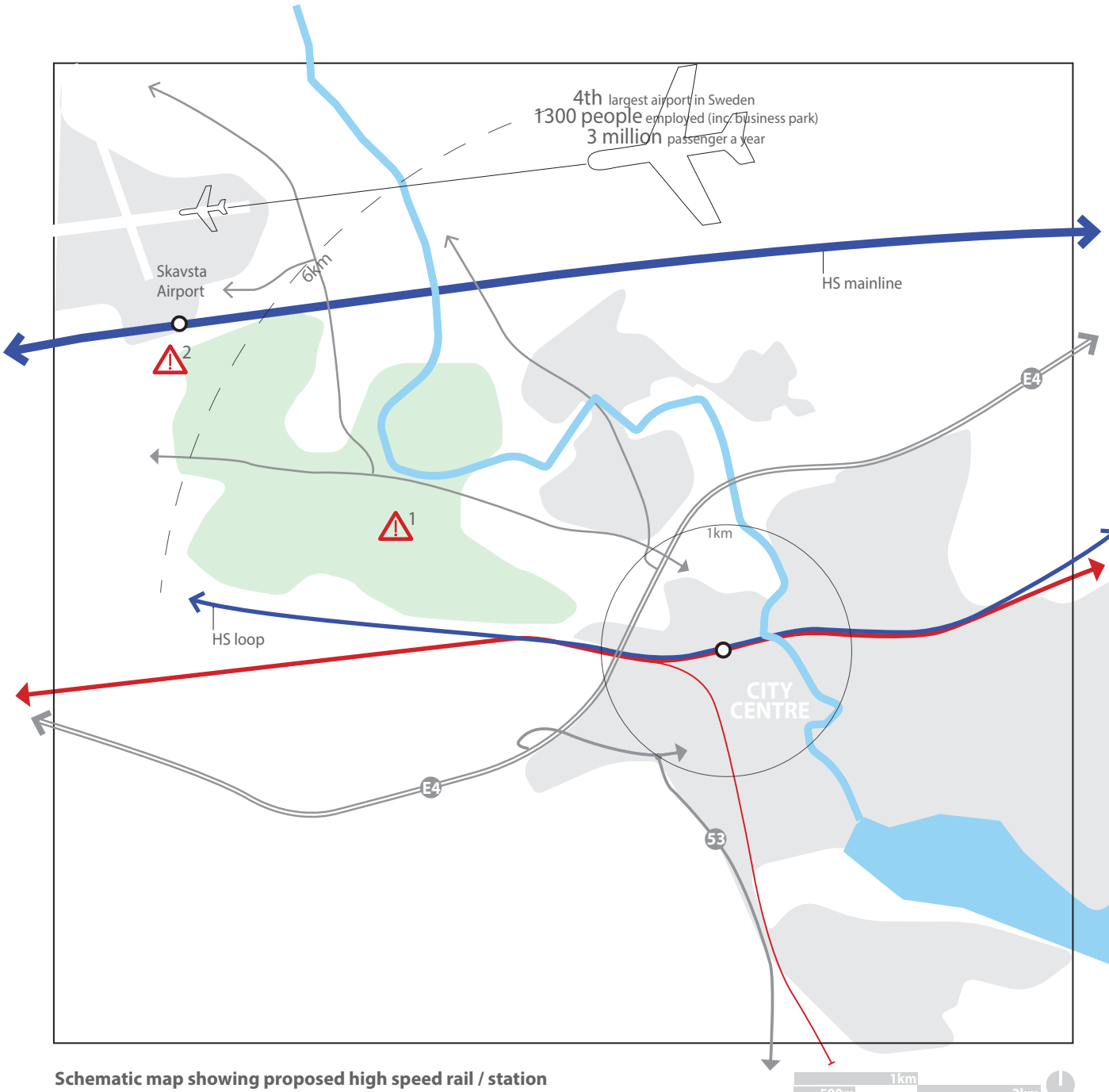
Source: Wikipedia
http://Nyköping.se/
http://www.stationsinfo.se/station/Nyköpingcentral/

EXISTING AND PROPOSED INFRASTRUCTURE

Aerial photo showing existing Infrastructure

KEY HIGH SPEED NETWORK KEY DIAGRAM



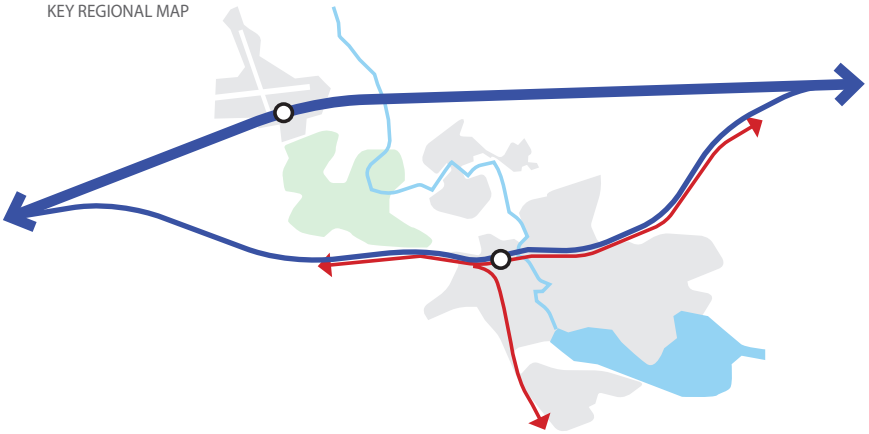


Schematic map showing proposed high speed rail / station

KEY

- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



NNHI proposal: Central on Loop / External on Mainline

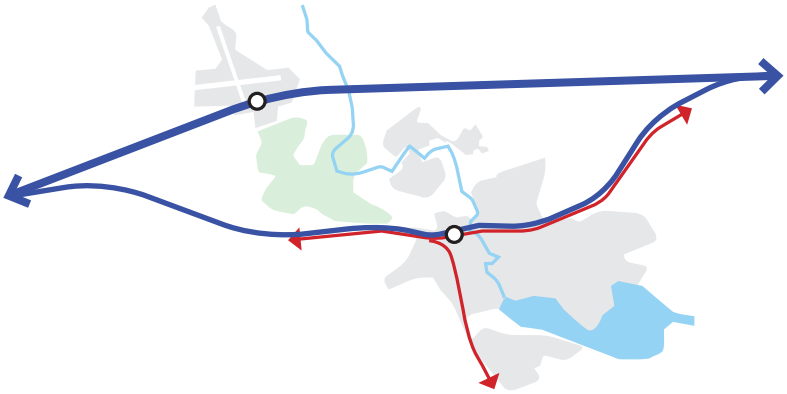
rail - good
road - good
walk - good

regeneration - good
severance - negative

land availability - good
viability – poor

noise in built up area

major duplication of line and station cost



Alternative 1: Central on Loop

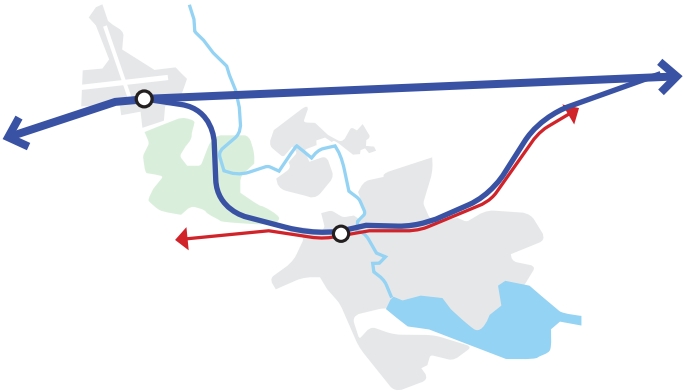
rail - good
road - good
walk - good

as NNHI

as NNHI

incursion on natural heritage / noise

as NNHI



Alternative 2: Peripheral on Mainline

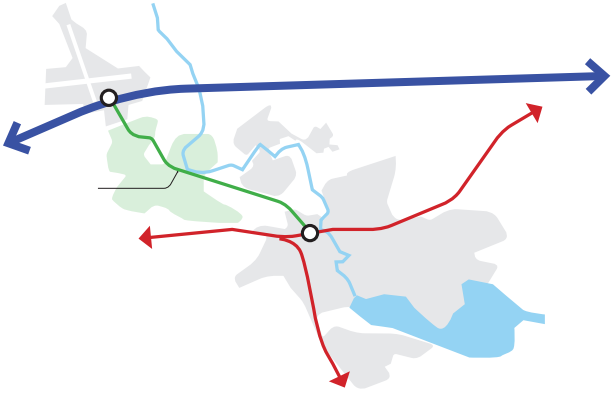
rail - indirect
road - good
walk - indirect

regeneration - good
severance - neutral

land availability - good
viability – good on growth corridor

no major issues identified at this stage

cost efficient



KEY

Connectivity

Urban Integration

Development Potential

Environmental Impact

Delivery

NNHI proposal – Central on Loop / External on Mainline

It is understood that the following NNHI text describing the station location forms the basis of negotiation with the relevant Municipality;

Nyköping comprises a station located at a branch line within the corridor permitted for the new double-track high-speed railway link between Järna - Linköping, which is itself part of the link between Järna - Almedalen and / or that between Järna - Lund. The station will be designed for regional train traffic, with platform lengths according to Trafikverket's regulations (ref. TSS: Technical Specification for high-speed trains).

Skavsta comprises a new railway station at Skavsta airport, located within the corridor permitted for the new double-track high-speed railway link between Järna - Linköping, which is itself part of the link between Järna - Almedalen and / or tha between Järna - Lund. The station will be designed for regional train traffic, with platform lengths according to Trafikverket's regulations (ref. TSS: Technical Specification for high-speed trains).

There are two stations in the NHII proposal; one Peripheral on the Mainline at the airport and the other Central on a Loop at the existing regional station location. It is assumed that the alignment would remain predominantly at grade through the centre and even with reduced speed trains would require acoustic mitigation potentially compromising effective urban integration.

Alternative 1 - Central on Loop

This option proposes a similar solution but with the loop connection relocated to the east of Skavsta Airport to allow city centre to airport access by HSR.

Alternative 2 - Peripheral on Mainline

Alternative 2 proposes only one station, a combined peripheral station on the mainline station at the airport with the city centre connected to this station by supplementary PT such as BRT (Bus Rapid Transit). The new transit route could provide the development framework for a city growth corridor as described in the earlier section.
There appears to be adequate land availability for the station to be a Parkway station with ample parking provision and good access to the highway network for park & ride passengers.

CONSIDERATIONS

Nyköping does not pass 3 of the 4 NHII criteria so could be excluded on this basis. The contribution to housing is not known and the city population is borderline. The NHII criteria do not apply to airport stations.

Using the Arup criteria there is also not an overwhelming benefit to connectivity and urban regeneration which would in our opinion justify 2 stations so close together.

For these reasons we would provisionally recommend consideration of Alternative 2 – Peripheral on Mainline, a combined city and airport station with generous parkway facilities and a fast public transport link in to the centre along a growth corridor. Significant cost benefits would arise from the omission of a station and a the HSR loop.

Skavsta/Nyköping are recommended as a joint station on the mainline of the HSR system.

Norrköping

© www.liu.se

Norrköping city centre

© www.eurovicitiesnetwork.com

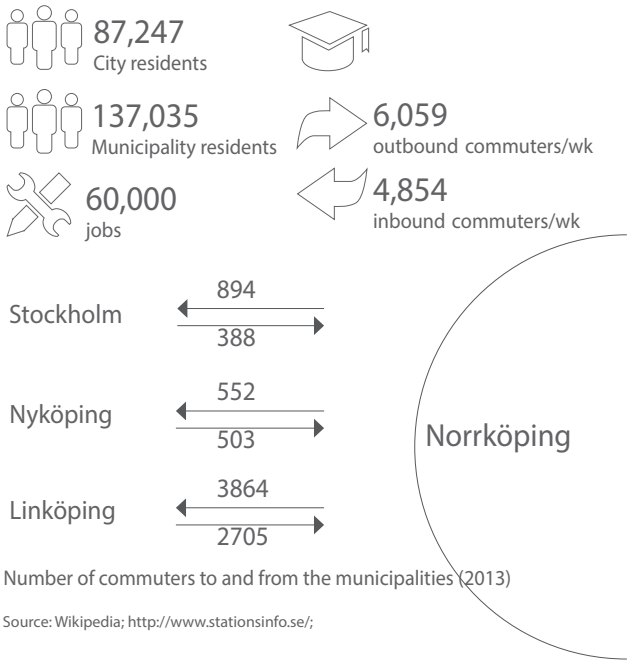
4.3 NORRKÖPING

LOCATION CHARACTERISTICS

Situated by the mouth of the river Motala ström, at Bråviken, an inlet of the Baltic Sea, the city is the tenth largest city in Sweden and eighth largest municipality.

Water power from the Motala ström and the good harbour were factors that facilitated the rapid growth of this once industrial city, known for its textile industry and consequently nicknamed "Sweden's Manchester".

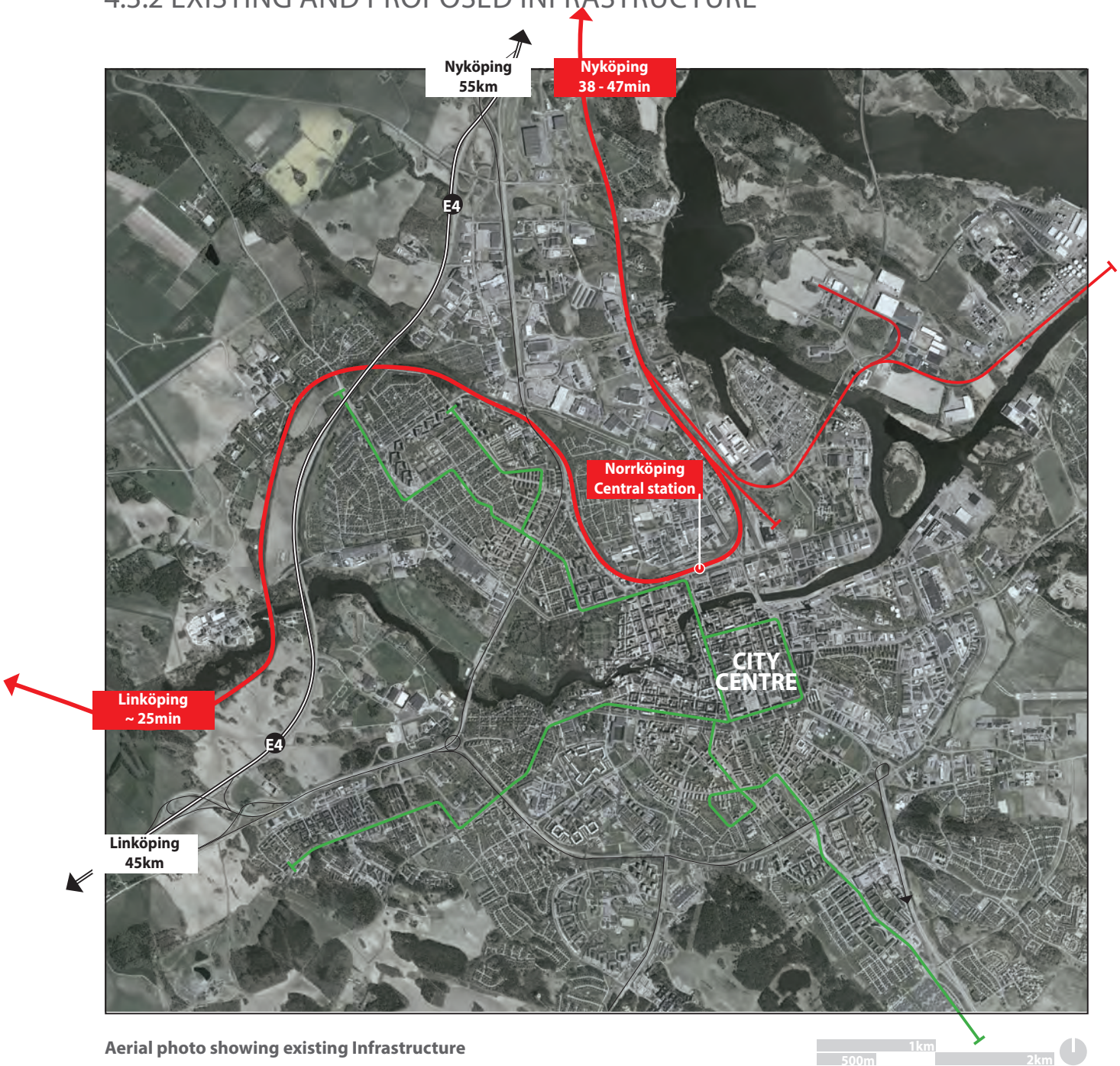
Norrköping station building



Number of commuters to and from the municipalities (2013)

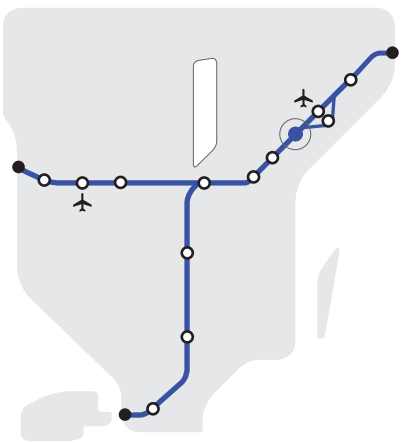
Source: Wikipedia; http://www.stationsinfo.se/;

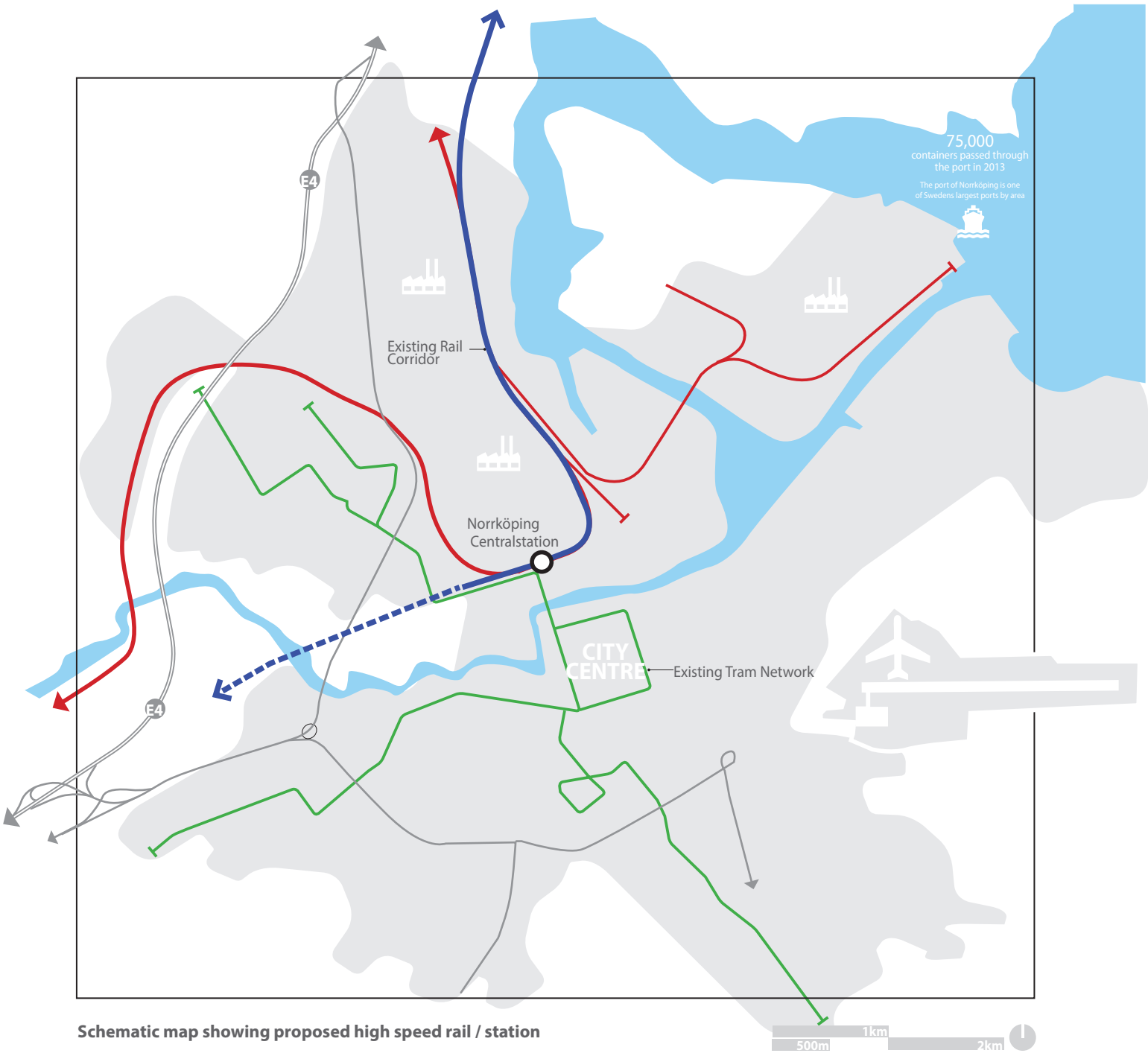
4.3.2 EXISTING AND PROPOSED INFRASTRUCTURE



Aerial photo showing existing Infrastructure

KEY HIGH SPEED NETWORK KEY DIAGRAM



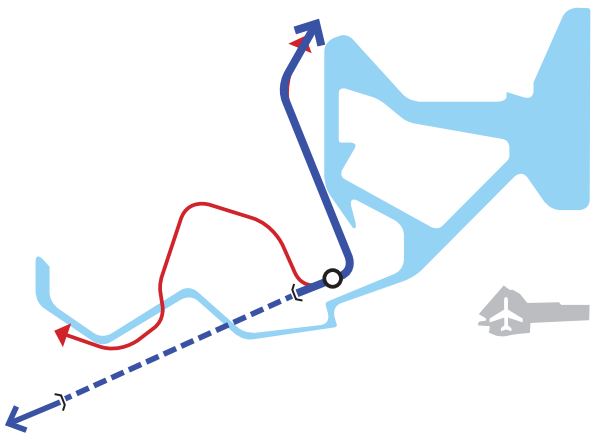


Schematic map showing proposed high speed rail / station

KEY

- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



NNHI proposal: Central on Mainline

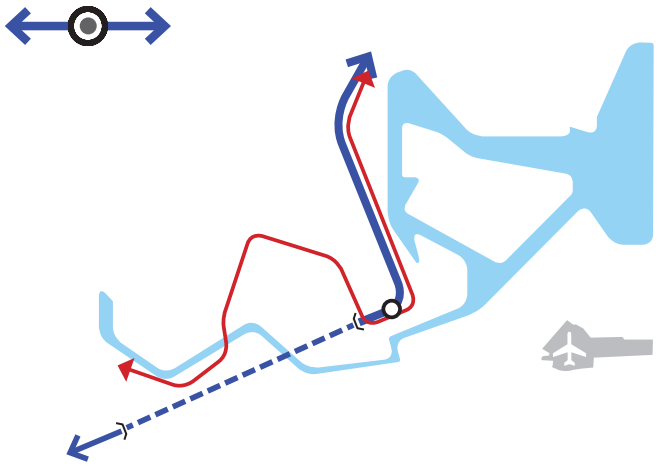
rail - good
road - good
walk - good

regeneration - good
severance - negative

land availability - limited
viability – good

noise in built up area

major cost associated with centrality / tunnel



Alternative 1: Central on Mainline

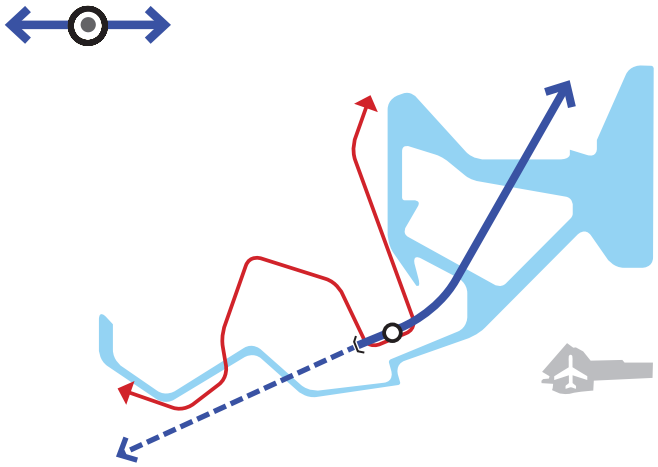
as NNHI

as NNHI

as NNHI

as NNHI

as NNHI



Alternative 2: Peripheral on Mainline

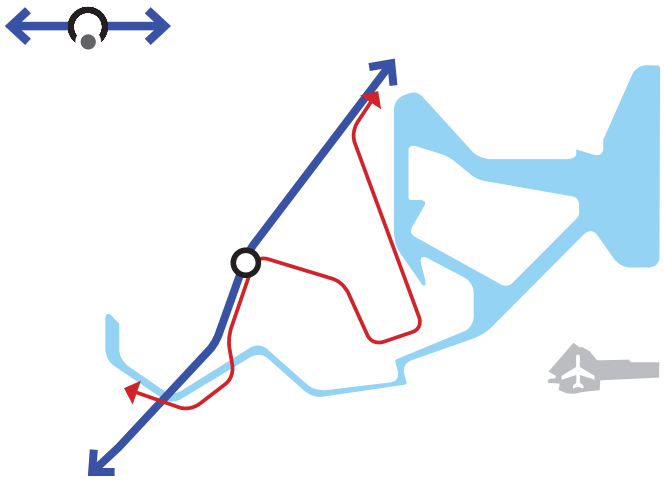
rail - good
road - good
walk - indirect

regeneration - good
severance - neutral

land availability - good
viability – good on growth corridor

no major issues identified at this stage

cost efficient



KEY Connectivity Development Potential Delivery
Urban Integration Environmental Impact

NNHI proposal – Central on Mainline

It is understood that the following NNHI text describing the station location forms the basis of negotiation with the relevant Municipality;

Norrköping comprises a railway station in Norrköping located within the corridor permitted for the new double-track high-speed railway link between Järna - Linköping, which is itself part of the link between Järna - Almedalen and / or that between Järna - Lund. The station will be designed for high speed train traffic, with platform lengths according to Trafikverket's regulations (ref. TSS: Technical Specification for high-speed trains).

This option locates the station centrally within the town on an upgraded and realigned railway corridor accommodating the HSR mainline. It is assumed that the alignment would be predominantly at grade sharing the classic rail corridor as it approaches from the north but understand that the southern route is placed in tunnel. This would have significant cost implications which along with acoustic mitigation on the northern approach may impact on the viability of this solution. The introduction of the HSR mainline would significantly exasperate the existing rail severance within the city, compromising effective urban integration.

Speed restrictions would also be required through the built up urban area to mitigate the environmental impact and this will result in time penalties to the overall end to end journey times.

Alternative 1 - Central on Mainline

This option locates the station centrally within the town on a realigned HSR mainline approaching from the island to the north east of the centre. The station characteristics and other issues will remain as above but the alternative approach alignment may offer advantages and therefore may merit further study.

Alternative 2 – Peripheral on Mainline

This option locates the station on the city edge on the mainline on an alignment which is assumed to be optimal and at a point which is coincident with regional rail allowing for the opportunity to interchange.

There appears to be adequate land availability for the station to be a Parkway station with ample parking provision and good access to the highway network for park & ride passengers. In addition the station could be located so as to connect directly with the existing tramway network allowing a transfer of 18 minutes to the Central Station and good connectivity to areas further to the south.

Whilst this tramway passes through a well-established residential area there would still be significant opportunities for densification and creation of a growth corridor in what is currently a low density part of the city.

CONSIDERATIONS

Norrköping passes 3 of the 4 NHII criteria with contribution to increased housing construction not identified. So on this basis alone it should be included as a station on the network. Using the additional set of Arup criteria it also makes a strong case for inclusion, with good connectivity to existing rail and tram networks and potential contribution to city growth and regeneration.

However the proposed NNHI solution, understood to be inherited from the earlier East Link proposals, is likely to incur substantially higher infrastructure costs than a peripheral station as well as imposing a potentially significant time penalty on end to end travel times. It will also raise significant challenges to urban integration and the mitigation of rail corridor severance and the acoustic impact of arising from a centrally located mainline.

For these reasons we would provisionally recommend consideration of Alternative 2 – Peripheral on Mainline. This station location would also be well connected with good interchange to regional rail, access to the city centre by tram but with the additional benefit of viable Parkway park & ride provision. Costs and end to end travel times could be significantly reduced thereby contributing to the overall viability of the project.

Norrköping is recommended as a peripheral station on the mainline with strong public transport links to the city centre.

View of Linköping with Cathedral

Linköping city centre

Linköping church

4.4 LINKÖPING

LOCATION CHARACTERISTICS

Closely linked to Norrköping roughly 40 kilometres away to the east near the sea Linköping is well known for its cathedral which dominates the city's skyline.

Nowadays Linköping is also known for its university and its high-technology industry. The city has ambitions to become an exemplar of sustainability and a carbon neutral community by 2025.

Central square in Linköping

126,072
City residents

152,966
Municipality residents

70,000
jobs

10,000
Businessess

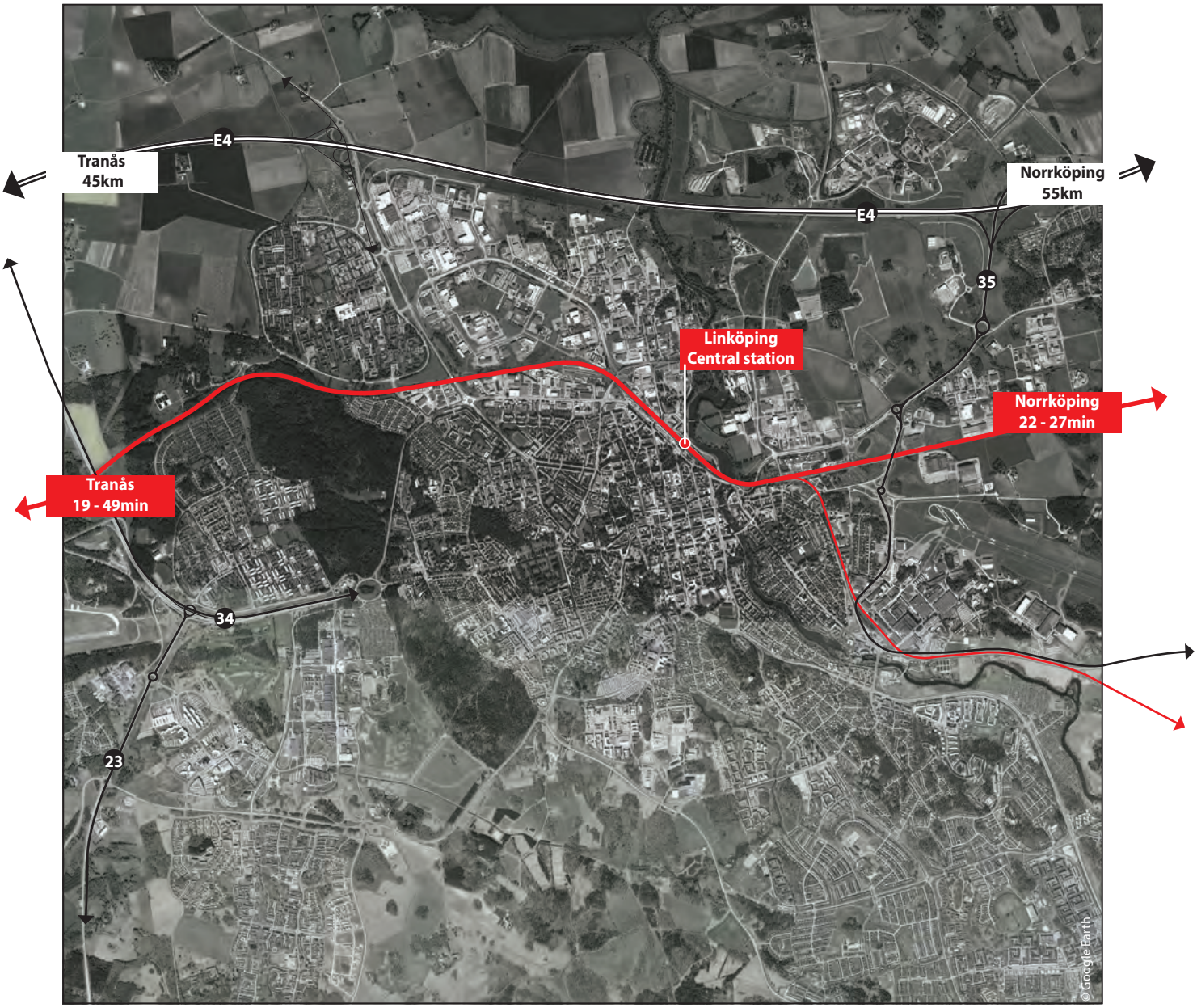
5th
largest city in Sweden

20,000
inbound commuters / day

One of Sweden's biggest universities
27,000 students and
3,800 employees

Source: Wikipedia

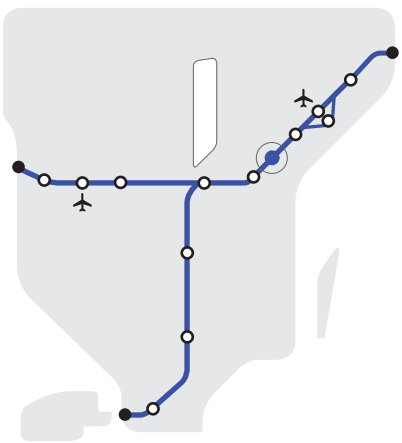
EXISTING AND PROPOSED INFRASTRUCTURE

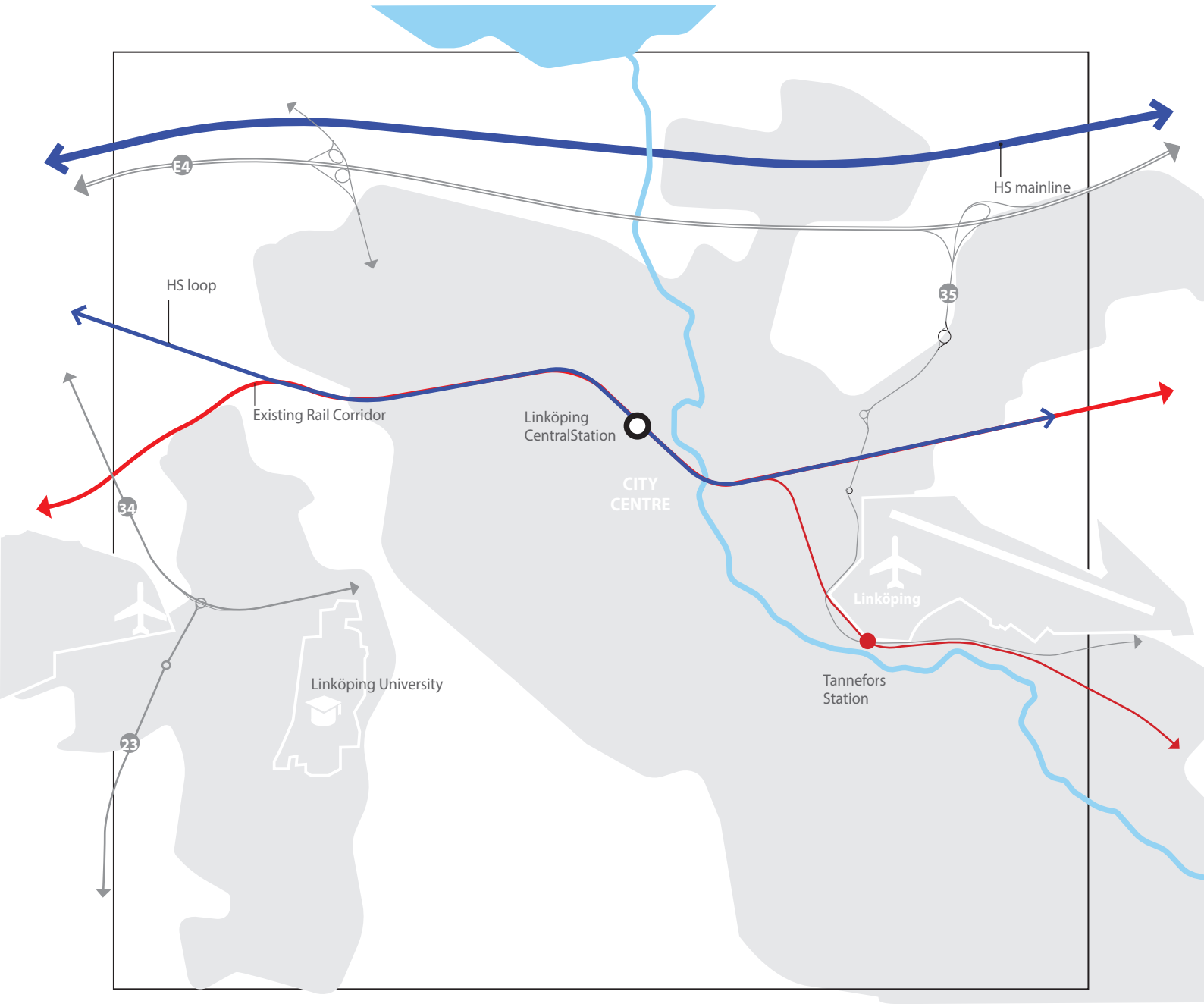


Aerial photo showing existing Infrastructure

1km
500m
2km

KEY HIGH SPEED NETWORK KEY DIAGRAM



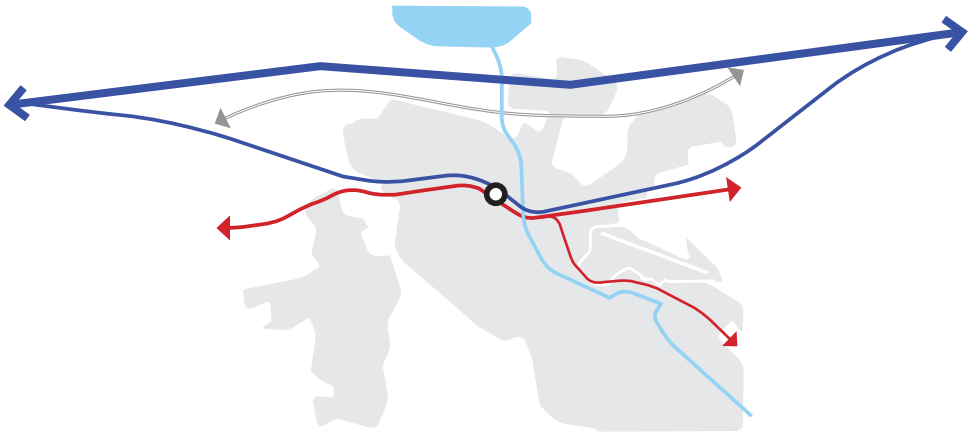


Schematic map showing proposed high speed rail / station

KEY

- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



NNHI proposal: Central on Loop

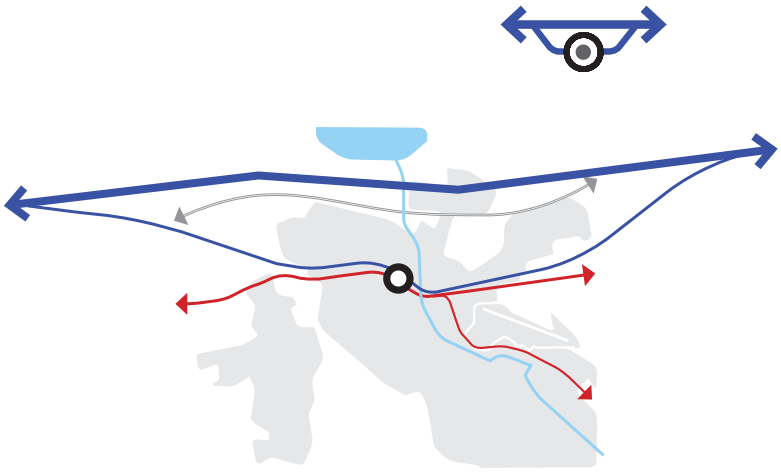
rail - good
road - good
walk - good

regeneration - limited
severance - negative

land availability - limited
viability – good

noise in built up area

major cost associated with centrality



Alternative 1: Central on Loop

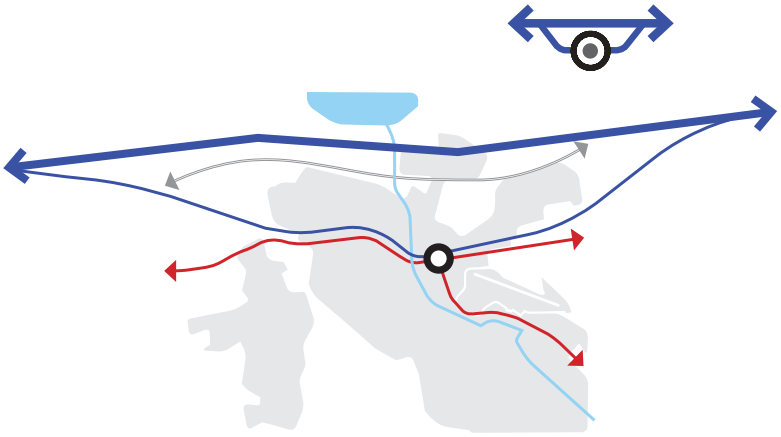
as NNHI

regeneration - good
severance - negative

land availability - good
viability – good

as NNHI

as NNHI



Alternative 2: External on Mainline

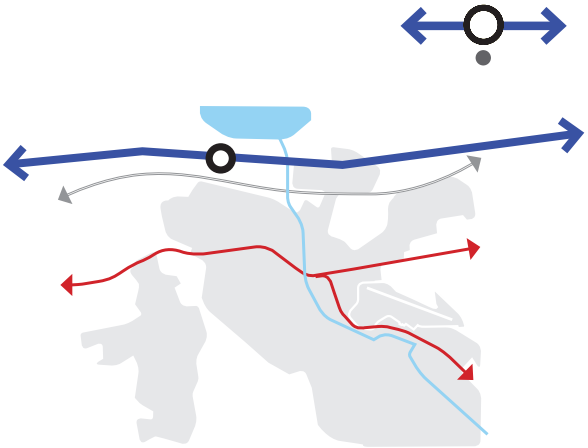
rail - poor
road - good
walk - poor

regeneration - poor
severance - neutral

land availability - good
viability – poor

no major issues identified at this stage

cost efficient



KEY

Connectivity
Urban Integration
Development Potential
Environmental Impact
Delivery

NNHI proposal – Central on Loop

It is understood that the following NNHI text describing the station location forms the basis of negotiation with the relevant Municipality;

Item Linköping comprises a railway station in Linköping located near the existing station. The station is located at a branch line which connects into a bypass track. The bypass track is primarily intended for high-speed through trains. The station will be designed for high speed train traffic, with platform lengths according to Trafikverket's regulations (ref. TSS: Technical Specification for high-speed trains).

This option locates the station centrally on an upgraded railway corridor accommodating the HSR loop. Integration with the existing Central Station would provide good interchange with regional rail and there would be some if limited opportunity for regeneration around the station. It is assumed that the alignment would remain predominantly at grade through the centre and, even with reduced speed trains, would require acoustic mitigation.

Alternative 1 - Central on Loop

This option also locates the station centrally on an upgraded railway corridor accommodating the HSR loop but positions a rebuilt central station further to the east across the river. This is a location similar to the one proposed by the Municipality in studies and supports plans for regeneration and significant development in this part of the city.

The building of an entirely new combined regional and HSR interchange in a new location whilst the existing station continued to operate may have distinct advantages and be more cost effective.

Alternative 2 - External on Mainline

This option locates the station externally on the mainline further to the north on an alignment which is assumed to be optimal. The station would be a Parkway station with parking provision and good access to the highway network for park & ride passengers.

Significant cost savings would be possible by omitting the loop, however overall connectivity will be poor as it is not possible to interchange with regional rail and the benefit to the city will be limited.

CONSIDERATIONS

Linköping passes 3 of the 4 NHII criteria with contribution to increased housing construction not identified. So on this basis alone it should be included as a station on the network.

Using the additional set of Arup criteria it also makes a strong case for inclusion, with good connectivity to existing rail and potential contribution to city growth.

The potential for regeneration and the development of a new city district to the east of the river as identified in Alternative 1, could provide significant added value and is therefore recommended for further consideration.

Linköping is recommended as a central station on a loop but as part of a new-build transport hub east of the river and part of a major new city development.

Tranås

©http://www.modernat.se/Tranås

Tranås town hall

© wikipedia - Harri Blomberg

Tranås

© Gamla Tingshuset

4.5 TRANÅS

LOCATION CHARACTERISTICS

Tranås is a small town close to the lake Sommen in the north of Småland. Employers in the town include Strömsholmen, Stiga, Pastejköket, OEM, EFG (European Furniture Group) and IVT

Central street in Tranås

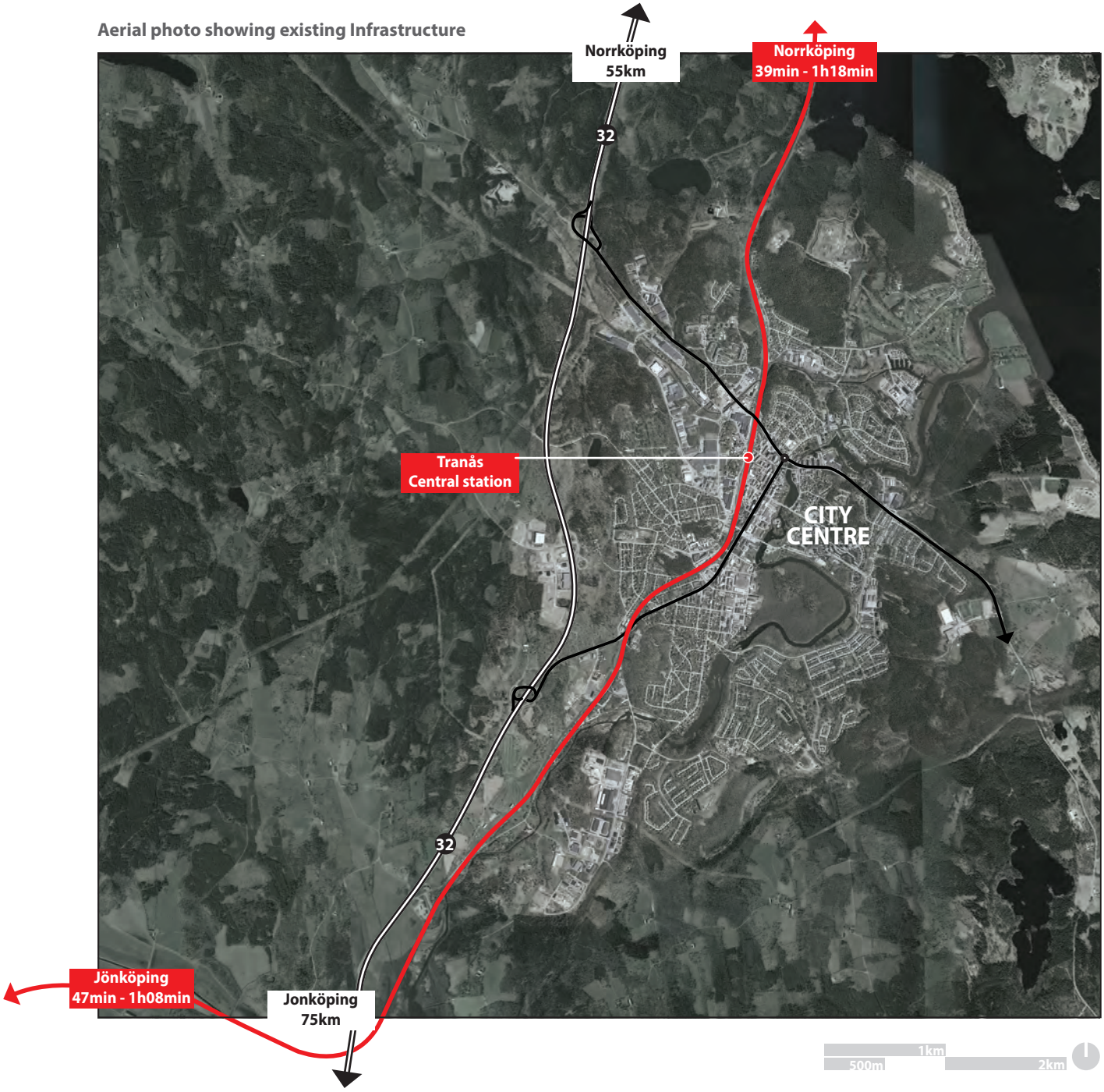
14,197
City residents

18,546
Municipality residents

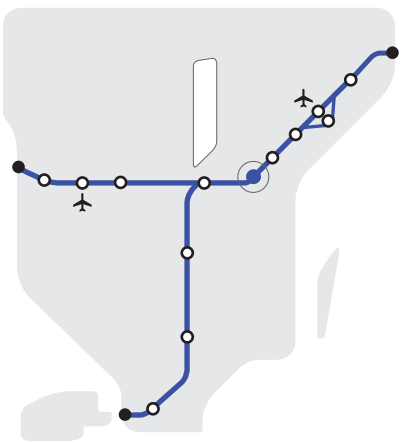
Source: Wikipedia

EXISTING AND PROPOSED INFRASTRUCTURE

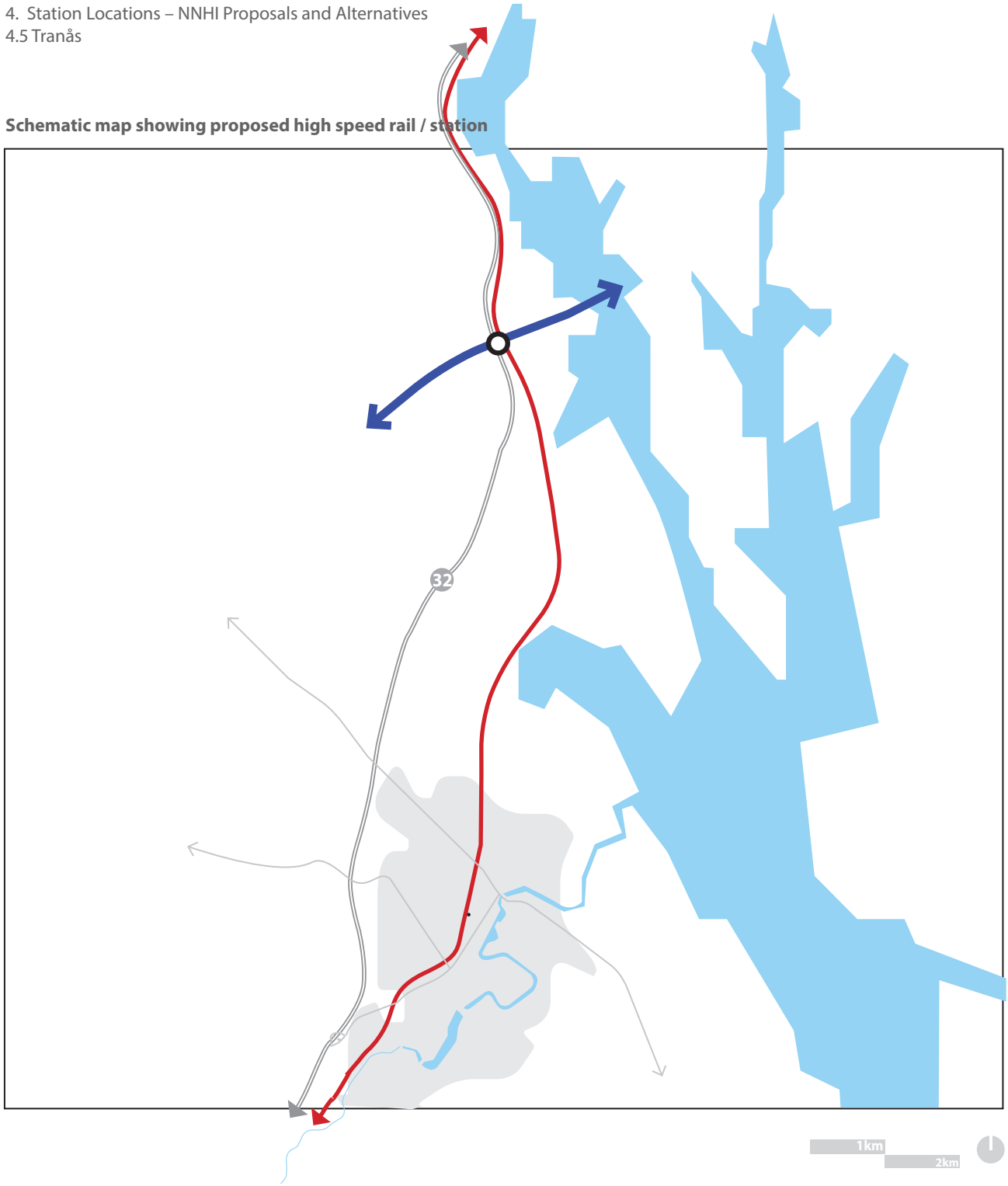
Aerial photo showing existing Infrastructure



KEY HIGH SPEED NETWORK KEY DIAGRAM



Schematic map showing proposed high speed rail / station



KEY

- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road

NNHI proposal: External on Mainline

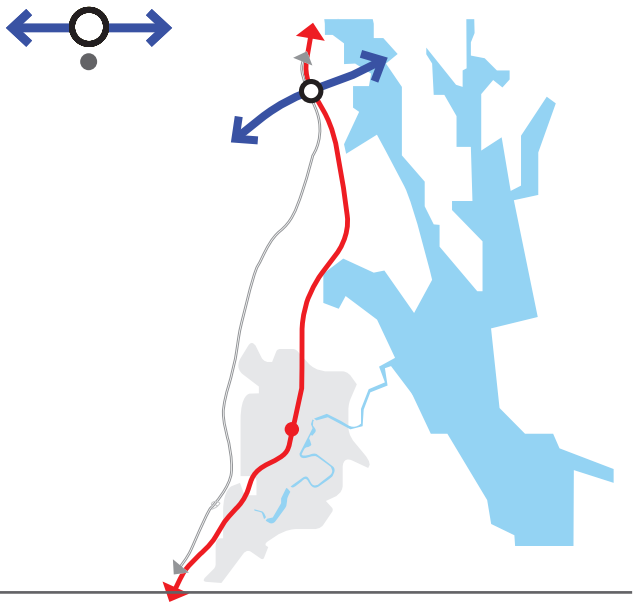
rail - good
road - good
walk - poor

regeneration - poor
severance - neutral

land availability - good
viability - poor

no major issues identified at this stage

cost efficient



Alternative 1: External on Mainline

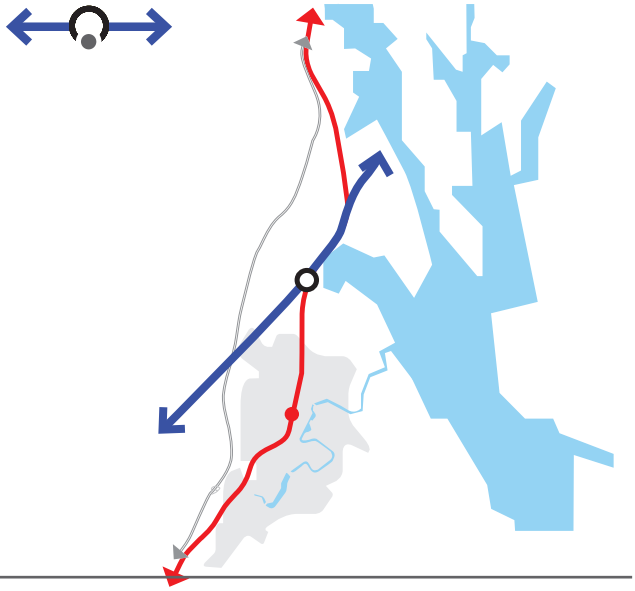
rail - good
road - good
walk - indirect

as NNHI

as NNHI

as NNHI

as NNHI



Alternative 2: Central on Mainline

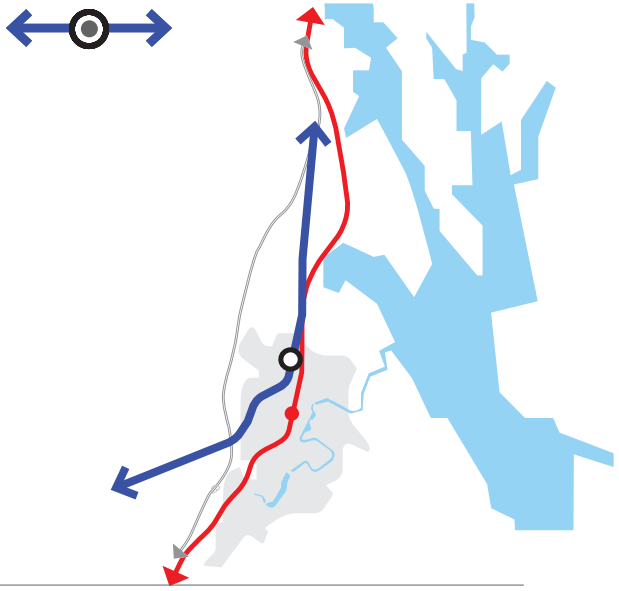
rail - good
road - good
walk - good

regeneration - good
severance - negative

land availability - limited
viability – moderate

noise in built up area

costs associated with centrality and extended alignment



KEY

Connectivity

Development Potential

Delivery

Urban Integration

Environmental Impact

NNHI proposal – External on Mainline

It is understood that the following NNHI text describing the station location forms the basis of negotiation with the relevant Municipality;

Tranås comprises a railway station located externally along the new double-track high-speed railway link between Järna - Almedalen and / or that between Järna - Lund. The station will be designed for regional train traffic, with platform lengths according to Trafikverket's regulations (ref. TSS: Technical Specification for high-speed trains).

The location is over 8km from the town at a point where existing rail and road converge. The mainline alignment is assumed to be the optimal and the location selected for potential connectivity with road and regional rail.

The station would be a Parkway station with parking provision and good access to the highway network for park & ride passengers.

Alternative 1 – External on Mainline

This option locates the station further to the south on a realigned mainline on the edge of the town and at a point coinciding with the existing railway. Here it will benefit from improved connectivity to the town and improved regeneration and development potential but may result in a sub-optimal rail alignment.

Alternative 2 - Central on Mainline

This option locates the station centrally within the town on an upgraded and realigned railway corridor accommodating the HSR mainline. It is assumed that the alignment would be predominantly at grade through the centre and would therefore require significant acoustic mitigation which would significantly exasperate the existing rail severance, compromising effective urban integration.

Speed restrictions would also be required through the built up urban area to mitigate the environmental impact and this will result in time penalties to the overall end to end journey times.

CONSIDERATIONS

This station fails to meet three of the four quantifiable criteria set by NNHI, with exception being the contribution to housing provision reported as 1,500 homes, a little above the threshold. So on this basis alone it should not be included as a station on the network.

Using the additional set of Arup criteria it also fails to make a significant case for inclusion. The proposed location is not close to the modestly populated town centre. There is not adequate critical mass to justify investment in supplementary transport infrastructure to improve the connectivity. The peripheral station is unlikely to stimulate town regeneration without significant strategic intervention and investment. There is potential for interchange with regional rail but this will also be possible at Jönköping and Linköping.

To summarise, the indications are that there is little demand for a station at this location and it would make little contribution to the objectives set out by NHII. So in the absence of justification against the set criteria or alternatively an over-riding strategic plan Arup would not recommend the inclusion of Tranås Station.

Tranås is not recommended as a station on the HSR system

View of Jönköping to lake Munksjon

Jönköping centre and University

Jönköping church

4.6 JÖNKÖPING

LOCATION CHARACTERISTICS

The geographical location of the city has lead it to be a key trading centre throughout its history but also in recent times. Although off the rail network Jönköping is well connected to the road network and consequently has an important strategic significance.

Jönköping was known for its matchstick industry and today is an important Nordic logistical centre, with many companies' central warehouses (such as Elkjøp, IKEA, Electrolux and Husqvarna) situated there.

Bridge in Jönköping

89,396
Municipality residents

133,310
Municipality residents

70,000
jobs

12,593 Businessess - among others IKEA, SAAB-koncernen, Arla Foods Husqvrna AB

12,200
commuting to Jönköping

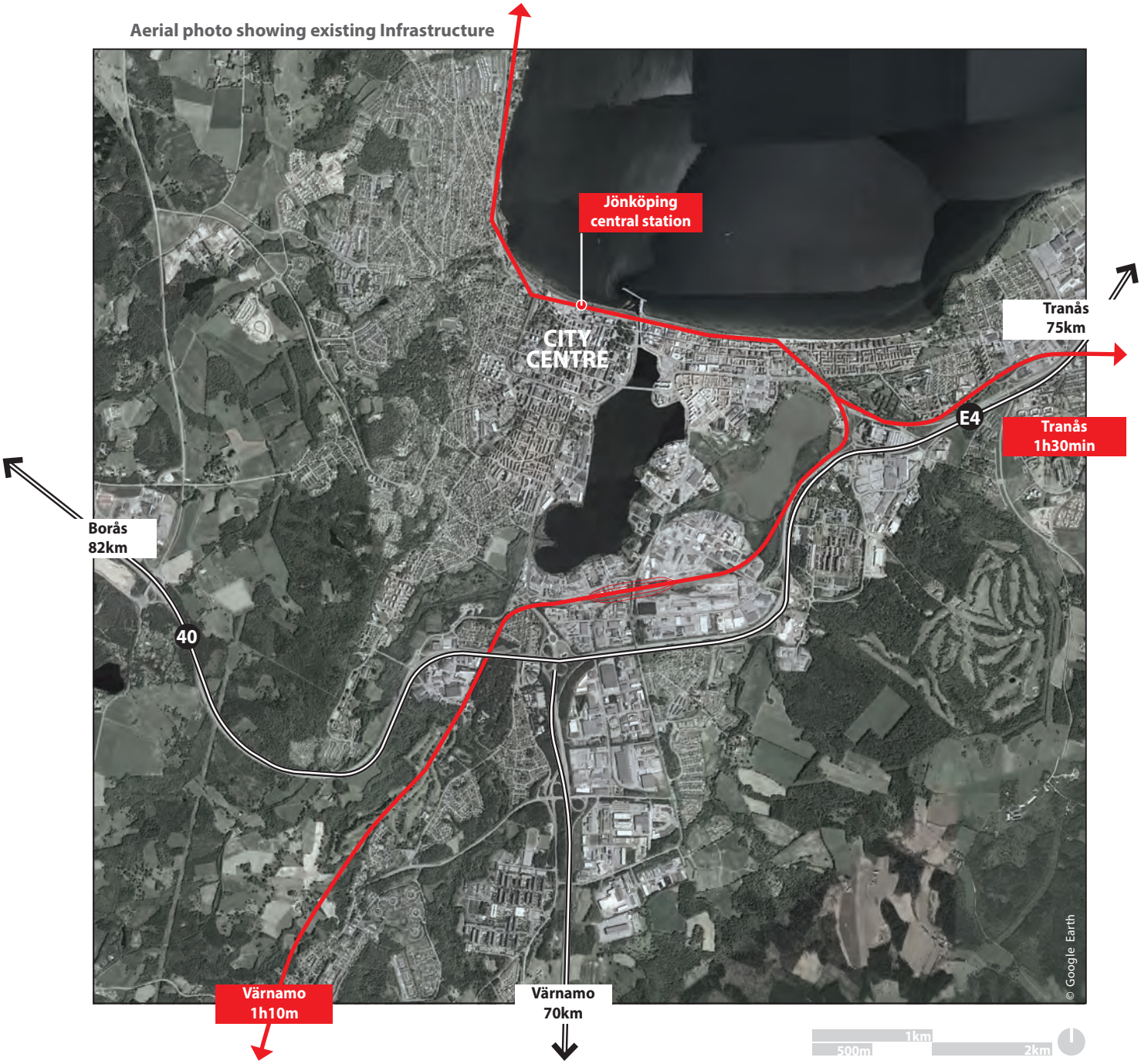
8,200
commuting from Jönköping

A university with 4 schools

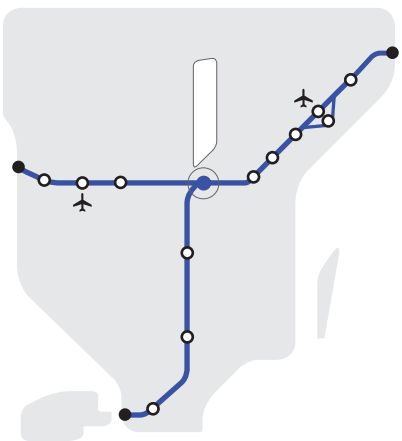
Source: Wikipedia

EXISTING AND PROPOSED INFRASTRUCTURE

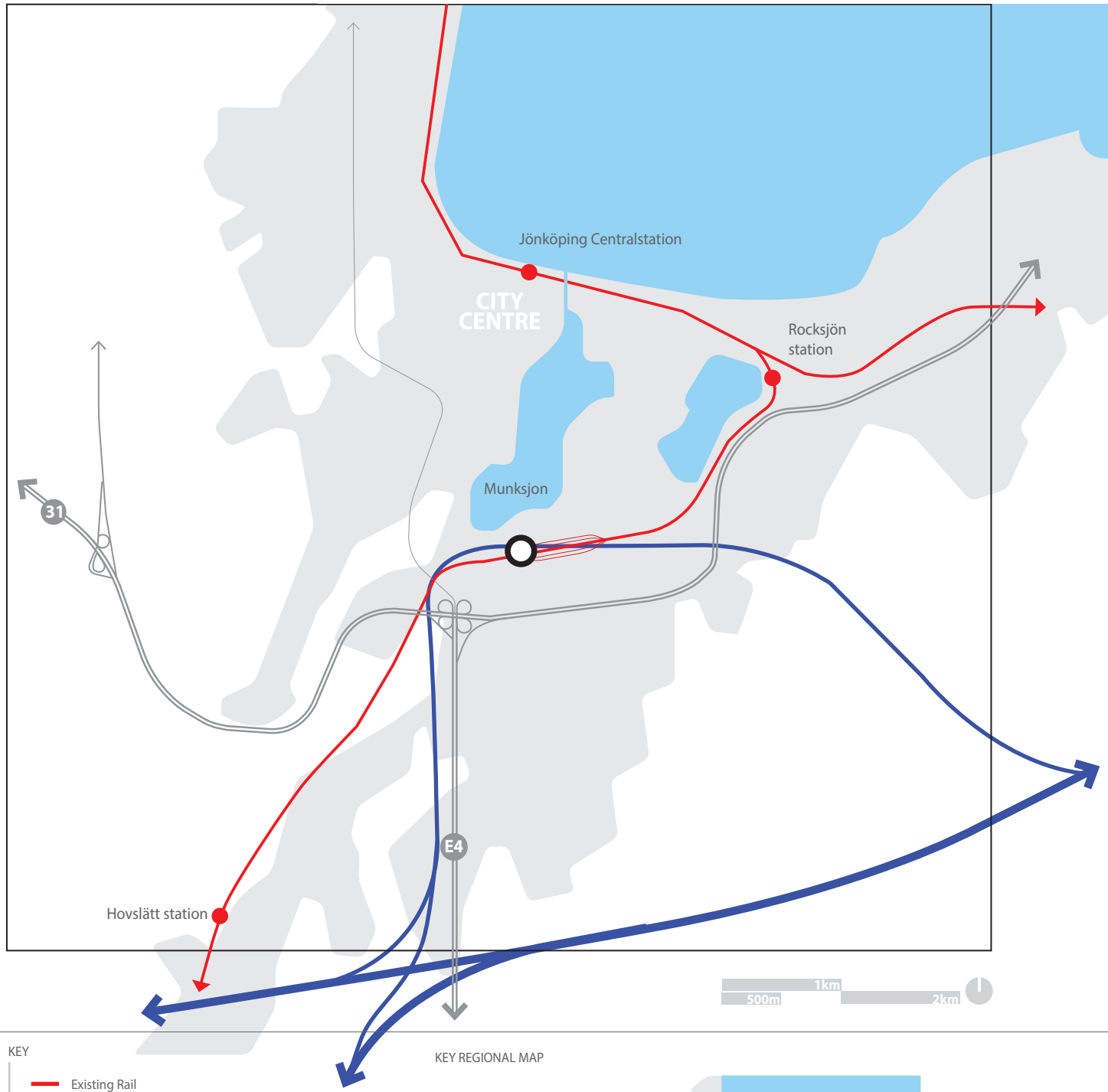
Aerial photo showing existing Infrastructure



KEY HIGH SPEED NETWORK KEY DIAGRAM



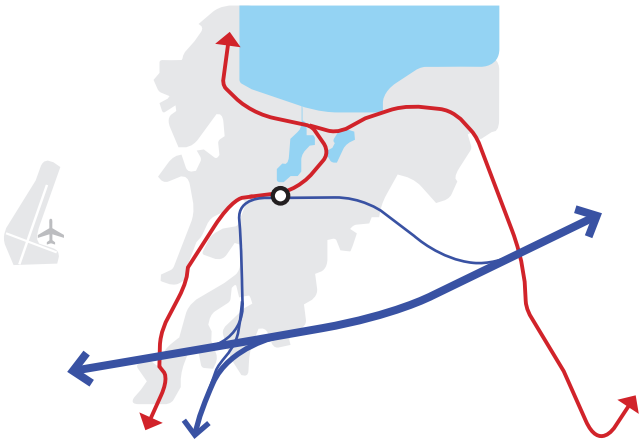
Schematic map showing proposed high speed rail / station



KEY

- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



NNHI proposal: Peripheral on Loop

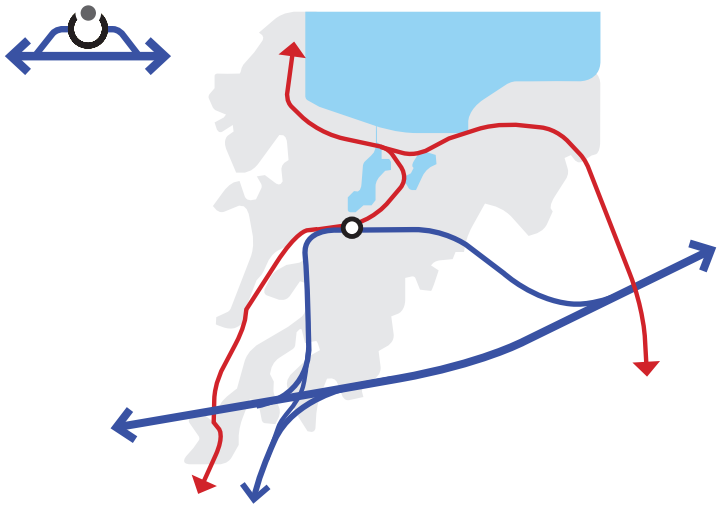
rail - indirect
road - good
walk - indirect

regeneration - good
severance - neutral

land availability - good
viability - good

no major issues identified at this stage

costs associated with line duplication



Alternative 1 - Peripheral on Mainline

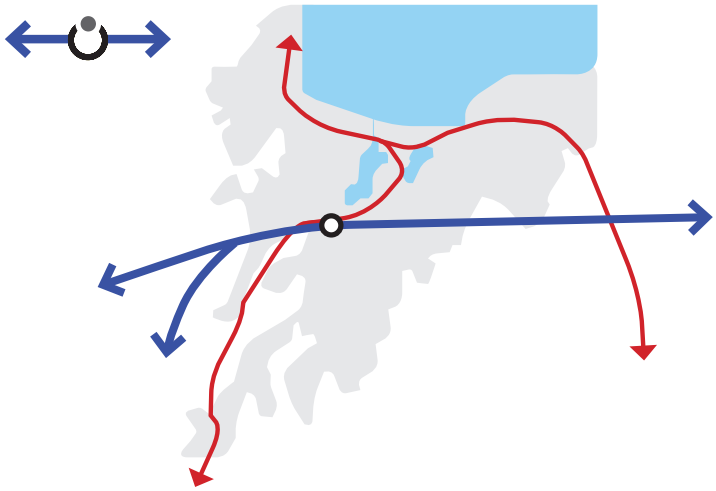
as NNHI

as NNHI

as NNHI

as NNHI

some sub-optimal alignment costs



Alternative 2 - External on Mainline

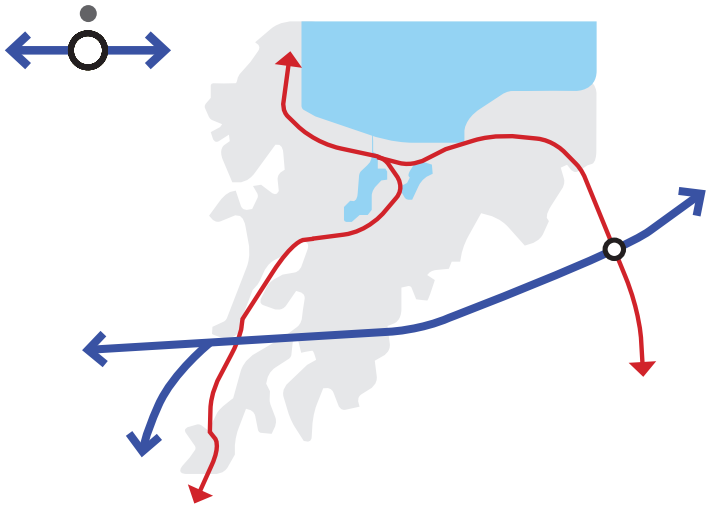
rail - poor
road - good
walk - poor

regeneration - poor
severance - neutral

land availability - good
viability – poor

no major issues identified at this stage

costs efficient



KEY

Connectivity

Development Potential

Delivery

Urban Integration

Environmental Impact

NNHI proposal – Peripheral on Loop

It is understood that the following NNHI text describing the station location forms the basis of negotiation with the relevant Municipality;

Jönköping comprises a railway station located within the development area of Southern Munksjön. The station is located at a branch line which connects into a bypass track. The bypass track is primarily intended for high-speed through trains. The station will be designed for high speed train traffic, with platform lengths according to Trafikverket's regulations (ref. TSS: Technical Specification for high-speed trains).

This location places the station on the edge of the city but in an industrial area already incorporated into city plans and with considerable potential for regeneration. Convenient connections to the centre by public transport would be possible in and interchange with existing regional rail may also be possible although not with a principle line.

The HSR loop alignment would be predominantly in a new rail corridor leading to significant duplication of costs with the mainline. It is also noted that the Municipality may have reservations regarding the location of the station off the mainline and therefore being less likely to benefit from inclusion at some point into a non-stopping service.

Alternative 1 - Peripheral on Mainline

This option locates the station on the edge of the city as above but on the mainline rather than a loop. This would have all the benefits of the NNHI proposal but offer the possibility, if not initially, at some point in the future, of including Jönköping as a stop on an express service between the major cities. Arup consider Jönköping to be a strategically significant station on the network due to its location supporting the case for incorporation on the mainline.

It is expected that by avoiding the duplication of the loop there may be some reduction in costs with this solution.

Alternative 2 - External on Mainline

This option locates the station on the mainline further to the south east and outside the city at a location selected for potential connectivity with regional rail. The mainline alignment is assumed to be the optimal and therefore lowest cost.

The station would be a Parkway station with parking provision and access, although not direct, to the highway network for park & ride passengers.

CONSIDERATIONS

Jönköping passes 3 of the 4 NHII criteria. So on this basis alone it should be included as a station on the network.
Using the additional set of Arup criteria it also makes a strong case for inclusion, with connectivity provided by supplementary public transport potentially in the form of a Bus Rapid Transit system which could form the backbone of a strategic growth corridor around the lake.

A station in this location could make a major contribution to city growth. However the potential for regeneration and the development of a new city district to the south of Munksjon would we believe be greater if the station was located on the mainline as identified in Alternative 1. This could provide significant added value and is therefore recommended for further consideration.

Jonköping is recommended as a peripheral station on mainline as part of a major new city development.

Borås city centre

A view from Krokshall square onto Caroli church with Viskan in front - the city's oldest building

Borås station building

4.7 BORÅS

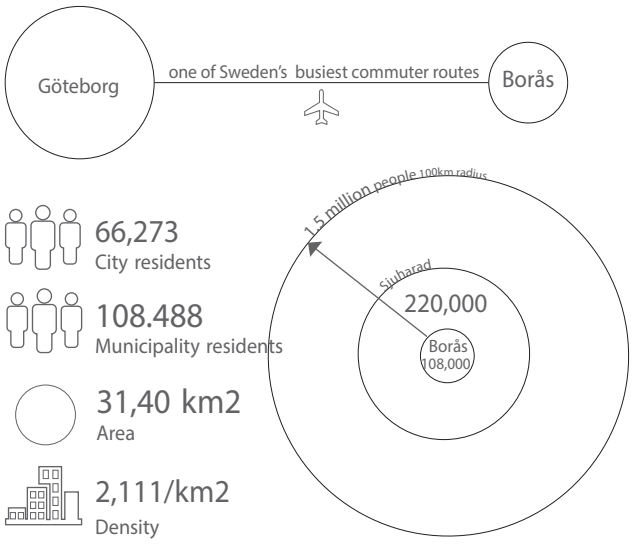
LOCATION CHARACTERISTICS

Borås is well connected to the Swedish rail network and its Central Station is adjacent to a busy bus interchange. There are high volumes of people commuting both into Göteborg and out from Göteborg to Borås including to its University. However it appears that the majority of travel is by bus and not rail.

Borås has a significant manufacturing industry including Swedac and Ericsson, and worldwide clothing retailer H&M who have their worldwide Online office based in the city. Outside the city there are many companies specializing in logistics.

Industries in Borås have close collaboration with the University College of Borås as well as the SP Technical Research Institute of Sweden, the largest technical research institute of Sweden, both located in Borås.

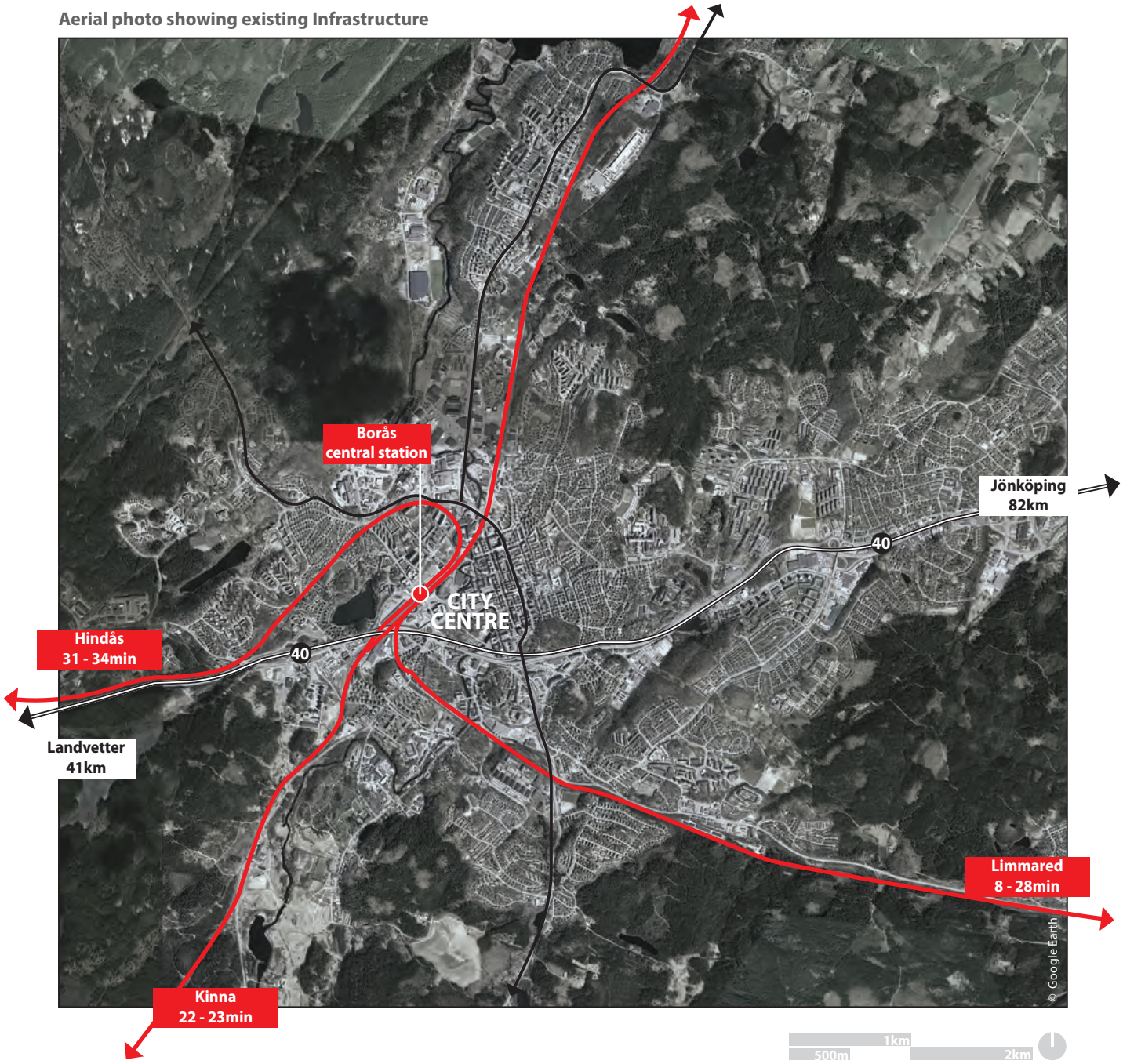
Borås station building - view from the platforms



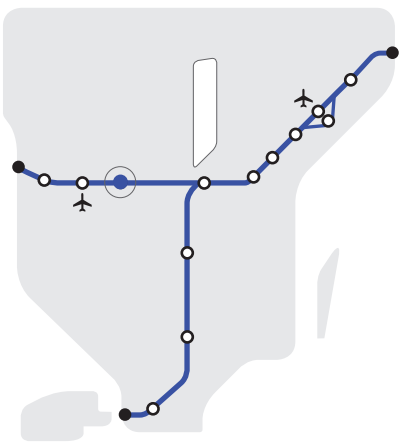
Source: Wikipedia

EXISTING AND PROPOSED INFRASTRUCTURE

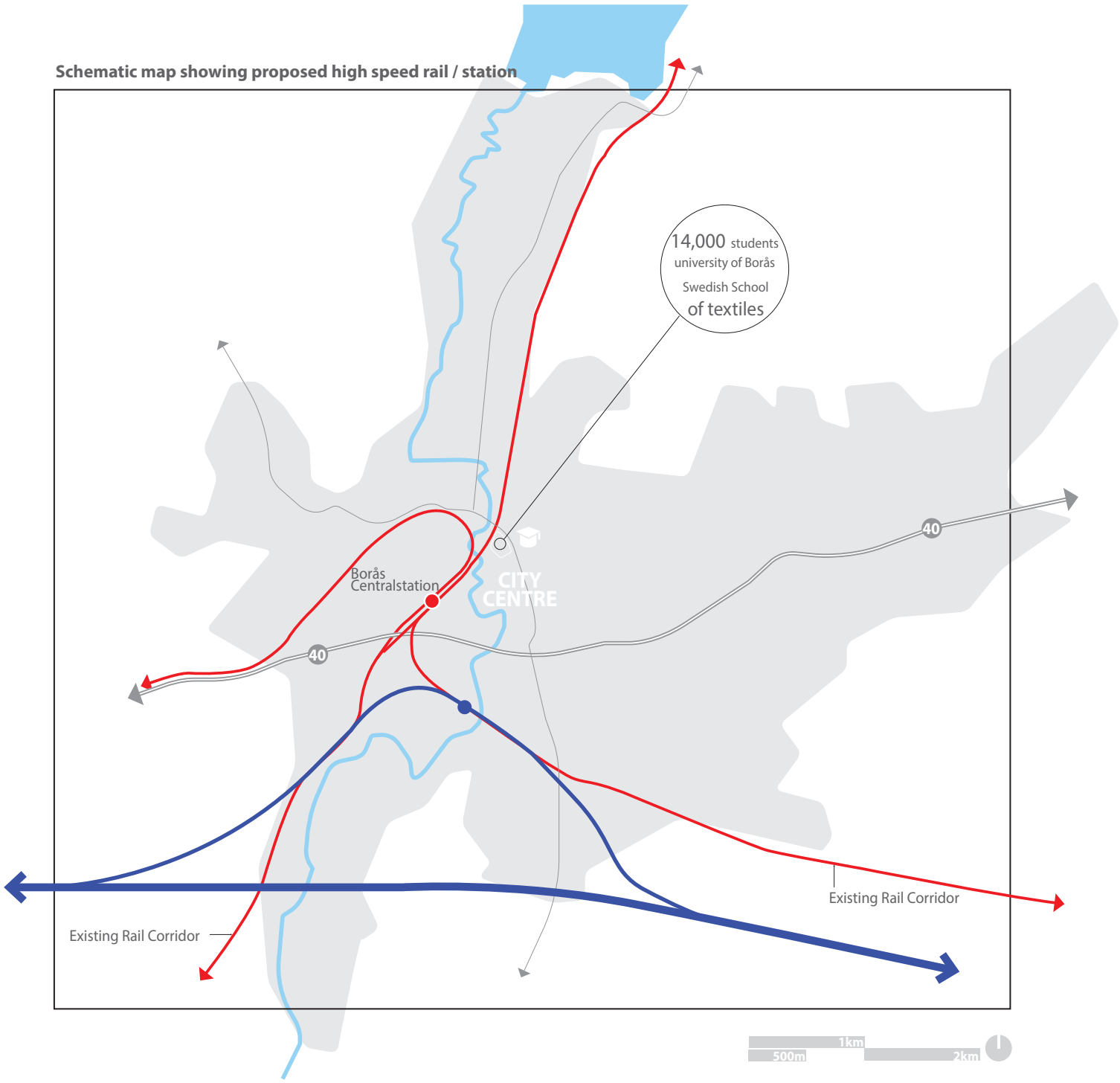
Aerial photo showing existing Infrastructure



KEY HIGH SPEED NETWORK KEY DIAGRAM



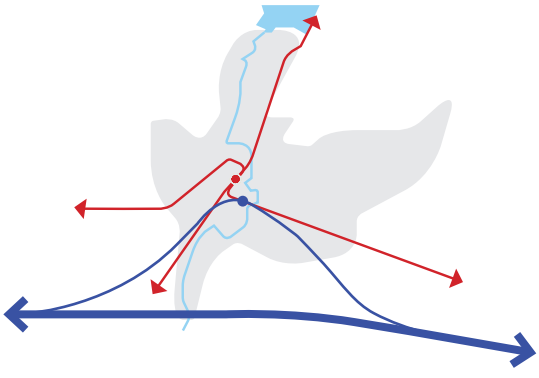
Schematic map showing proposed high speed rail / station



KEY

- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



NNHI proposal: Peripheral on Loop

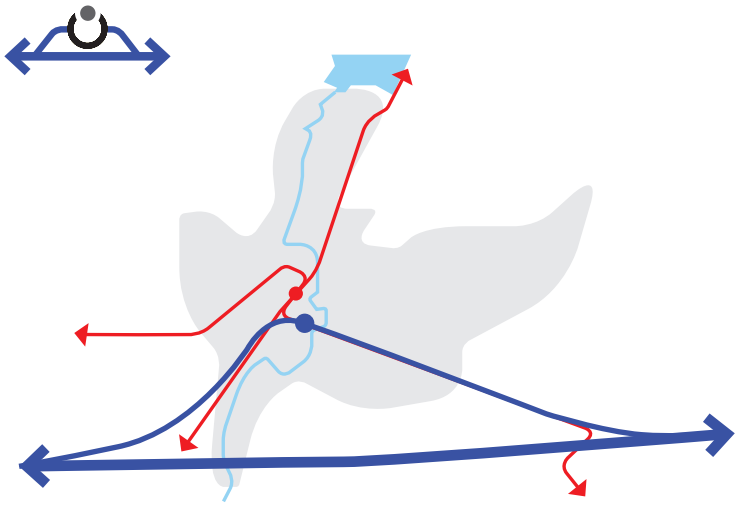
rail - indirect
road - good
walk - indirect

regeneration - limited
severance - neutral

land availability - good
viability - moderate

no major issues identified at this stage

costs associated with line duplication



Alternative 1 - Central on Loop

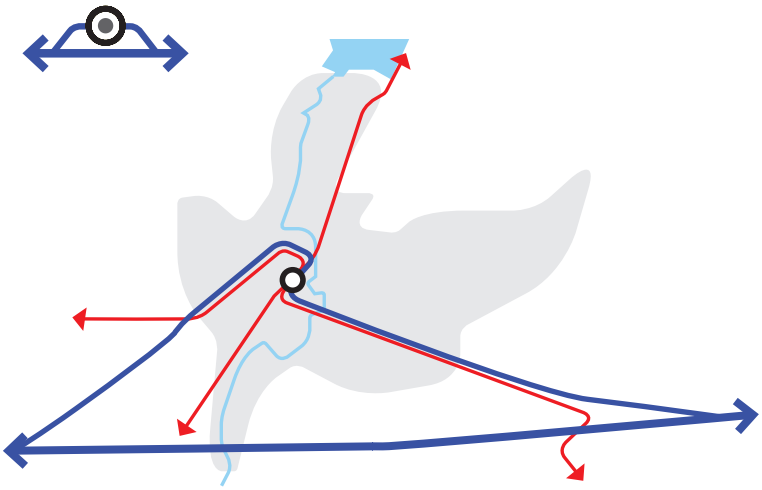
rail - good
road - good
walk - good

regeneration - good
severance - neutral

land availability - good
viability - good

as NNHI

costs associated with north alignment



Alternative 2 - External on Mainline

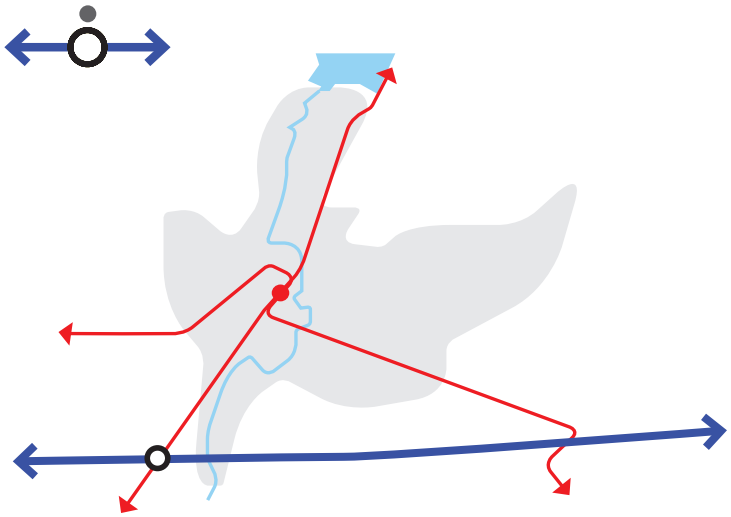
rail - poor
road - good
walk - poor

regeneration - poor
severance - neutral

land availability - good
viability – poor

as NNHI

costs efficient



KEY

Connectivity
Development Potential
Delivery
Urban Integration
Environmental Impact

NNHI proposal – Peripheral on Loop

It is understood that the following NNHI text describing the station location forms the basis of negotiation with the relevant Municipality;

Borås comprises a railway station located at a branch line which connects into a bypass (main) track. The bypass track is primarily intended for high-speed through trains.
The station will be designed for high speed trains with platform lengths according to Trafikverket's regulations (ref. TSS: Technical Specification for high-speed trains).

The location proposed lies to the south of the city centre and would be termed peripheral according to earlier typology definitions. It is understood that a more central location close to the existing Central Station has been studied and is indeed preferred by the Municipality largely due to the potential for interchange and accessibility to the city centre. However approaching Central Station from the south would require an expensive tunnel exiting through the city to the north and this is assumed to be the reason for the exclusion of that option. The proposed NNHI location is consequently accessed from a loop such that the station is located on the edge to the south of the city centre, a significant distance from the city centre.

Alternative 1 - Central on Loop

This option locates the station centrally on a loop off the mainline but the proposed loop approaches from the north utilising the existing rail corridor so that alignment can continue south again joining an existing rail corridor to re-join the mainline. The existing rail corridor to the north has a tight radius but this may not be an issue if the loop is exclusively for the smaller regional trains.

This alternative alignment, if confirmed to be a viable option, would allow the station to be located adjacent to the Central Station and the existing bus interchange and only a short walk to the city centre.

Alternative 2 - External on Mainline

This option locates the station externally on the mainline further to the south on an alignment which is assumed to be optimal and at a point which is coincident with regional rail allowing for the opportunity to interchange.

The station would be a Parkway station with parking provision and good access to the highway network for park & ride passengers.

CONSIDERATIONS

Borås passes all 4 of the NHII criteria and on this basis should be included within the HSR network.

Against the additional Arup criteria the NNHI proposed location is a pragmatic solution with some merit but critically fails to optimise on the interchange potential. It is located too far from the Central Station and bus interchange to capitalise on the high levels of commuter demand between Borås and Göteborg.

Taking this important opportunity into account Arup would recommend the consideration of alternative loop alignments which would allow for a Central on Loop solution to capture the high levels of commuter demand.

Borås is recommended as a central station on a loop with an alternative alignment that allows direct interchange with the Central Station.

Landvetter Airport

Landvetter Airport

4.8 LANDVETTER

LOCATION CHARACTERISTICS

Göteborg Landvetter Airport is an international airport serving the Göteborg region in Sweden with 6.2 million passengers in 2015. It is Sweden's second-largest airport after Stockholm-Arlanda and is also an important freight airport.

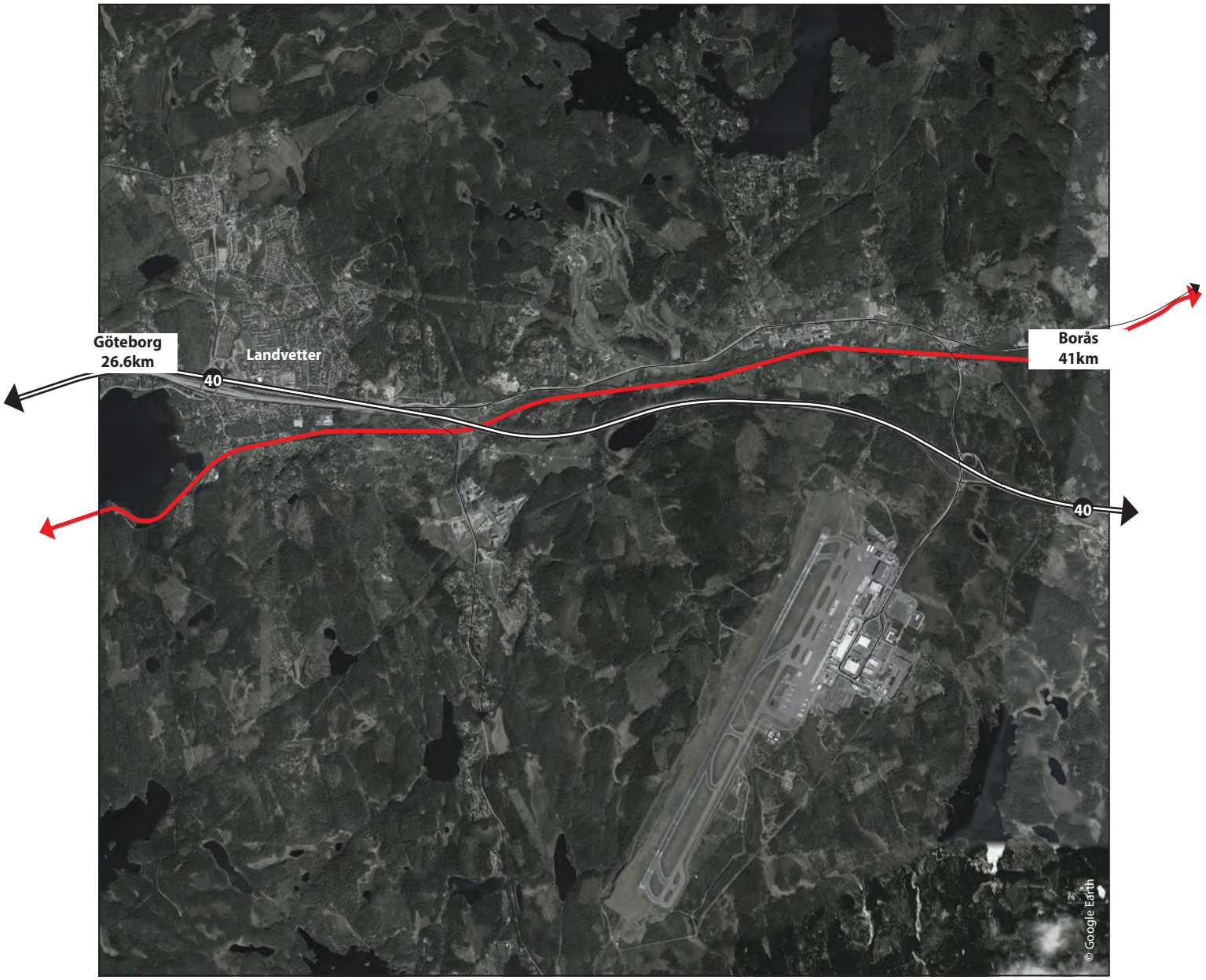
A major Airport City development project is planned at the airport incorporating a logistics park with 250,000 square metres of development of new facilities in warehousing, logistics and operations, including offices.

Göteborg Landvetter Airport

STATISTICS (2015)	
Passengers total	6,162,456
International passengers	4,731,417
Domestic passengers	1,431,039
Landings total	30,332

(Source: Swedish AIP)
https://en.wikipedia.org/wiki/G%C3%B6teborg_Landvetter_Airport
http://www.swedavia.com/properties/projects/airport-city-goteborg/#contentarea2

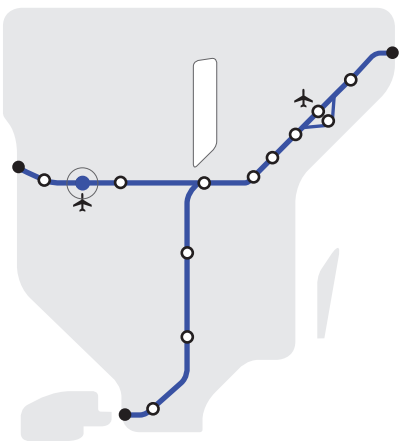
EXISTING AND PROPOSED INFRASTRUCTURE

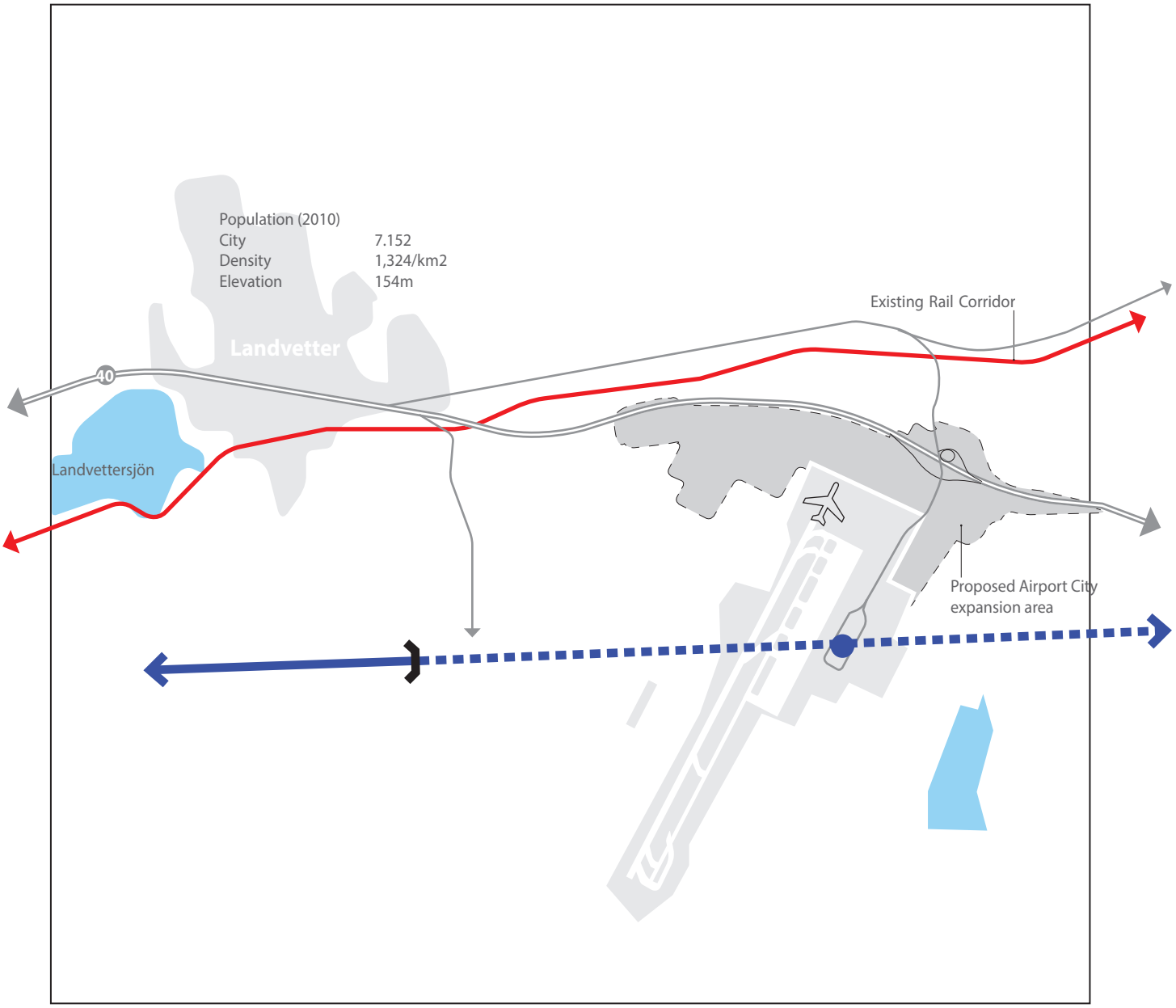


Aerial photo showing existing Infrastructure

1km
500m
2km

KEY HIGH SPEED NETWORK KEY DIAGRAM



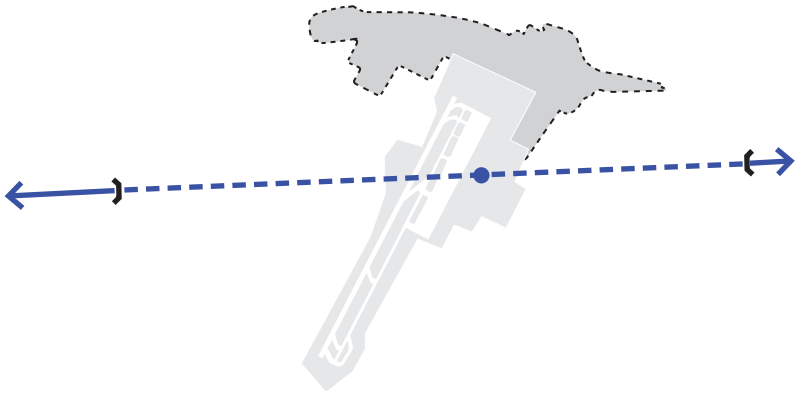


Schematic map showing proposed high speed rail / station

1km
500m
2km

KEY

- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road



NNHI proposal: External on Mainline

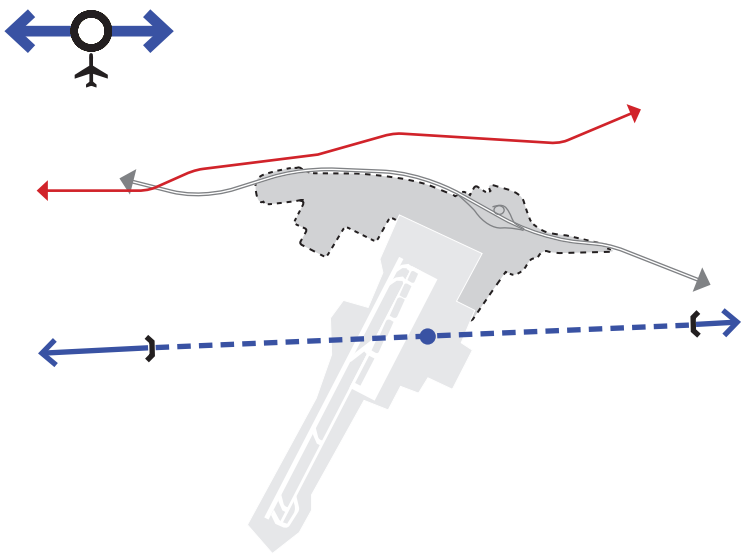
rail - poor
road - good
walk - airport

N/A

land availability - good
viability - good

no major issues identified at this stage

major costs associated with tunnels



Alternative 1: External on Mainline

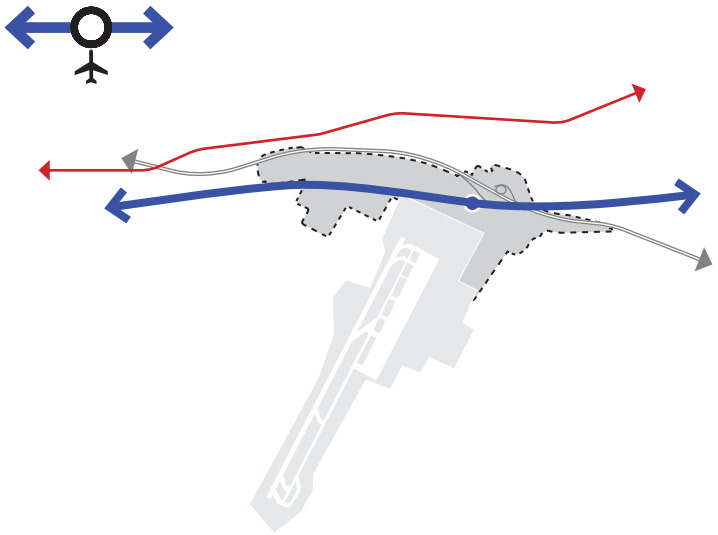
as NNHI

as NNHI

as NNHI

as NNHI

cost efficient



Alternative 2: External on Mainline

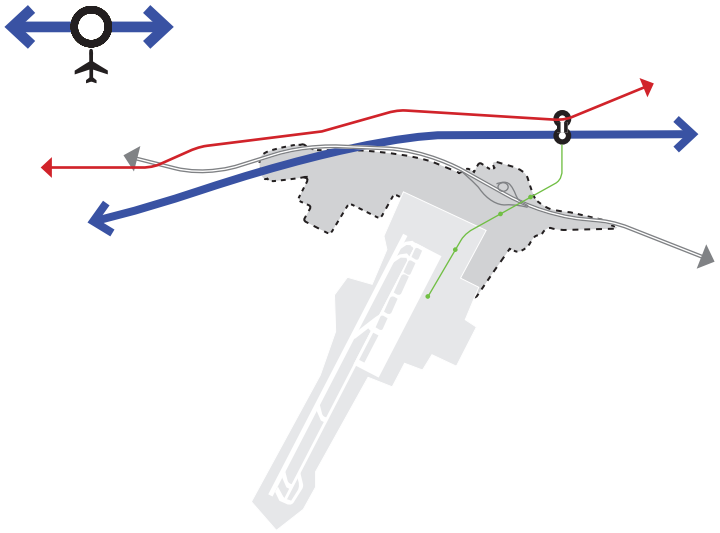
rail - good
road - good
walk - indirect to airport

as NNHI

land availability - good
viability – poor

as NNHI

costs efficient



KEY

Connectivity

Development Potential

Delivery

Urban Integration

Environmental Impact

NNHI proposal – External on Mainline

It is understood that the following NNHI text describing the station location forms the basis of negotiation with the relevant Municipality;

Landvetter comprises a railway station at Landvetter airport, located along the new double-track high-speed railway link between Järna and Almedal. The station will be designed for regional train traffic, with platform lengths according to Trafikverket's regulations (ref. TSS: Technical Specification for high-speed trains).

Classified as an external station, the proposed solution is located on the mainline under the airport. We understand the station to be within deep tunnels; 2 outside running tunnels and a central tunnel for an island platform. At this depth the length of the tunnel will be significant, in the order of 30 km, and expensive.

Alternative 1 - External on Mainline

This option locates the station externally on the mainline further to the north and directly serving the new Airport City development but within a short transfer distance to the terminal building.

The station could be either at grade or elevated depending on the interface with the development and road network.

Alternative 2 - External on Mainline

This option locates the station externally on the mainline even further to the north with access to the airport by an automatic people mover system.

The station could be either at grade or elevated depending on the interface with the road network.

CONSIDERATIONS

The station cannot be justified by the 4 NHII criteria which are applicable to a city station and should therefore be considered on the basis of potential strategic significance. On the basis of the strategic justifications for HSR stations at airports discussed in Section 2 we believe there is a case for the incorporation of a station at Landvetter Airport but not at any cost.

Arup would therefore recommend that further study is carried out on location options for this station taking into account possible lower cost at grade or elevated alignments and the interface with the Airport City development to the north as represented by Alternative 1.

Landvetter is recommended as an external station on the north edge of the airport at grade or viaduct.

Aerial view of Mölnlycke

View of Mölnlycke

4.9 MÖLNLYCKE

LOCATION CHARACTERISTICS

The town of Mölnlycke is located at a height of some 90 meters above sea level and is only about 10 km from Göteborg, the second largest city in Sweden. The short distance to Göteborg is probably one of the factors for the rapid expansion of the city during the 20th century when people started commuting to Göteborg.

Mölnlycke station

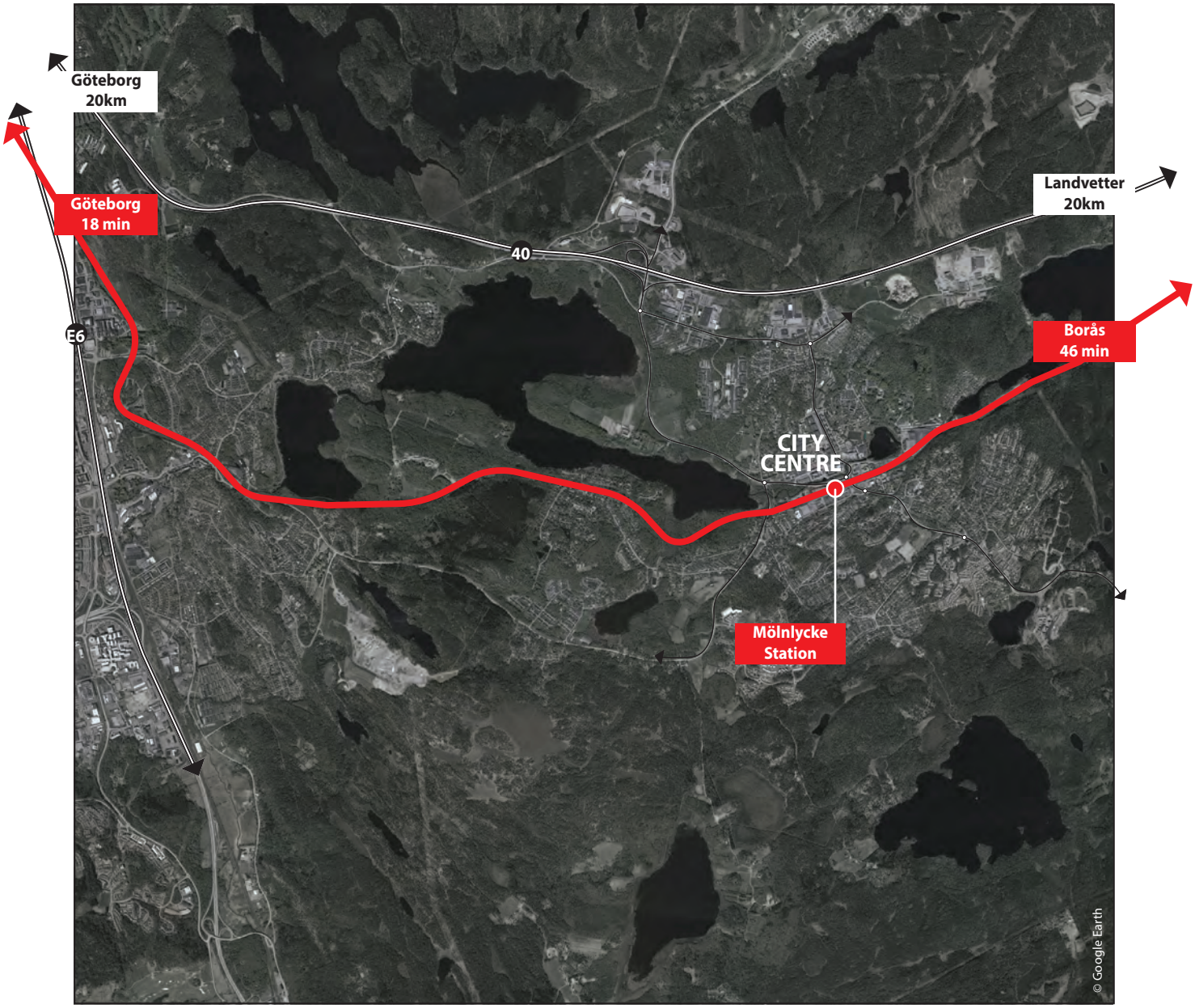
15,608
City residents

36,651
Municipality residents

8,10 km2
Area

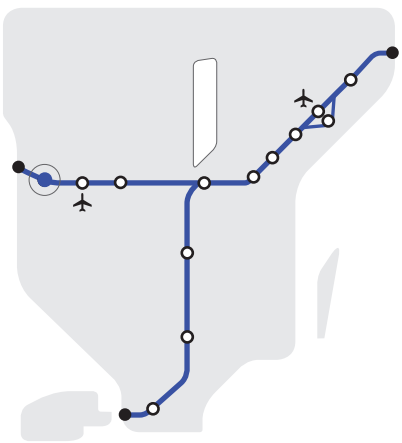
Source: Wikipedia
http://www.Mölnlycke.co.uk/about-us/

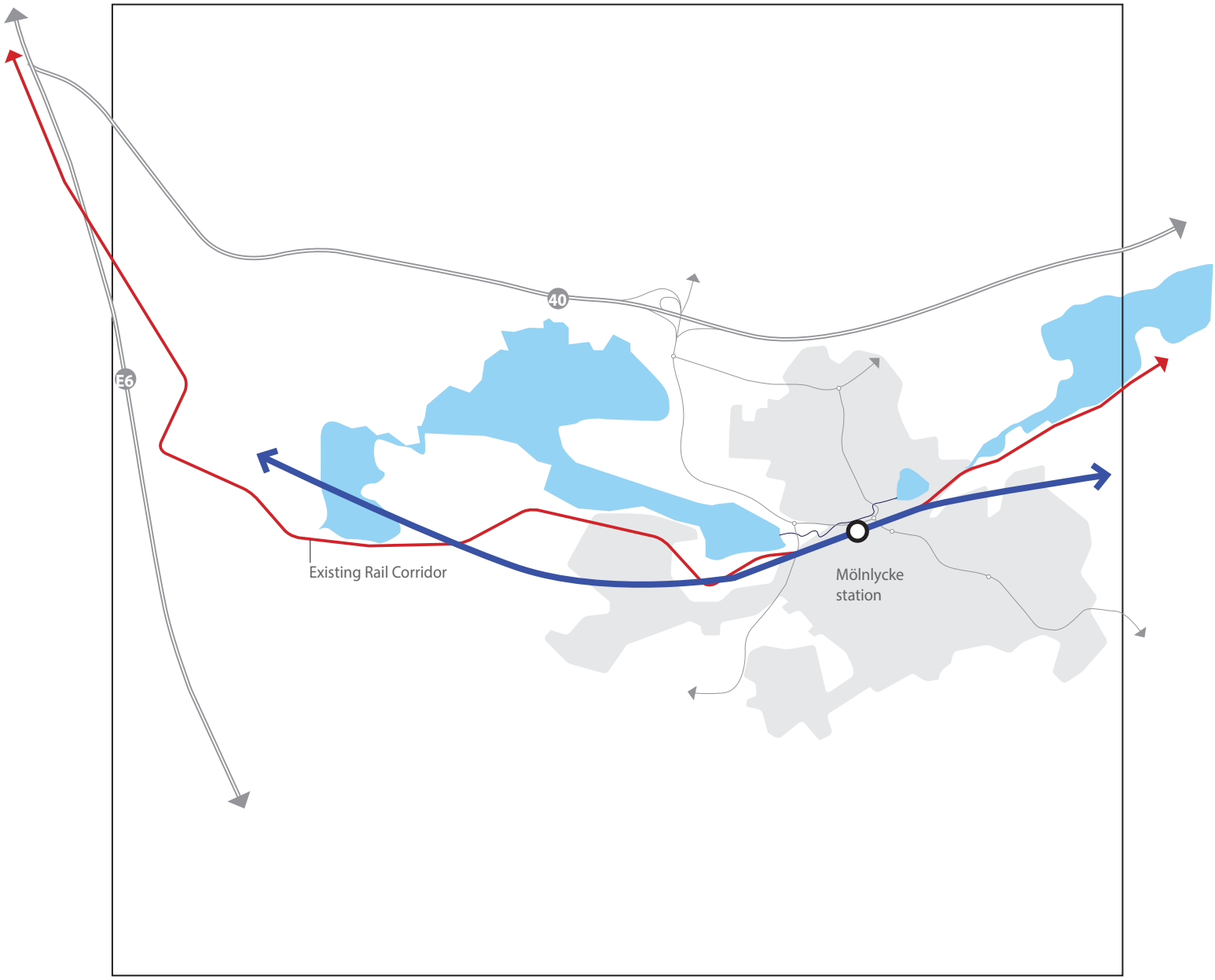
EXISTING AND PROPOSED INFRASTRUCTURE



Aerial photo showing existing Infrastructure

KEY HIGH SPEED NETWORK KEY DIAGRAM





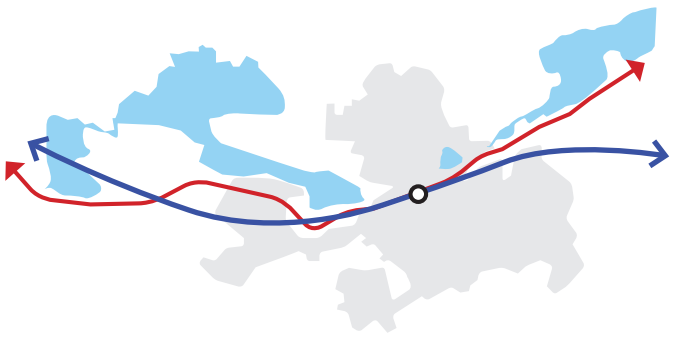
Schematic map showing proposed high speed rail / station

1km
500m
2km

KEY

- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



NNHI proposal – Central on Mainline

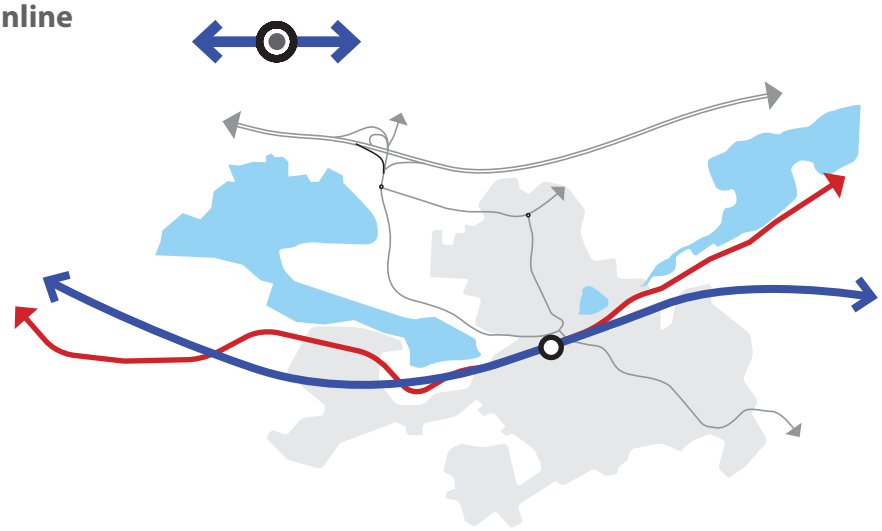
rail - poor
road - good
walk - good

regeneration - limited
severance - negative

land availability - limited
viability - moderate

noise in built up area

costs associated with centrality



Alternative 1 - External on Mainline

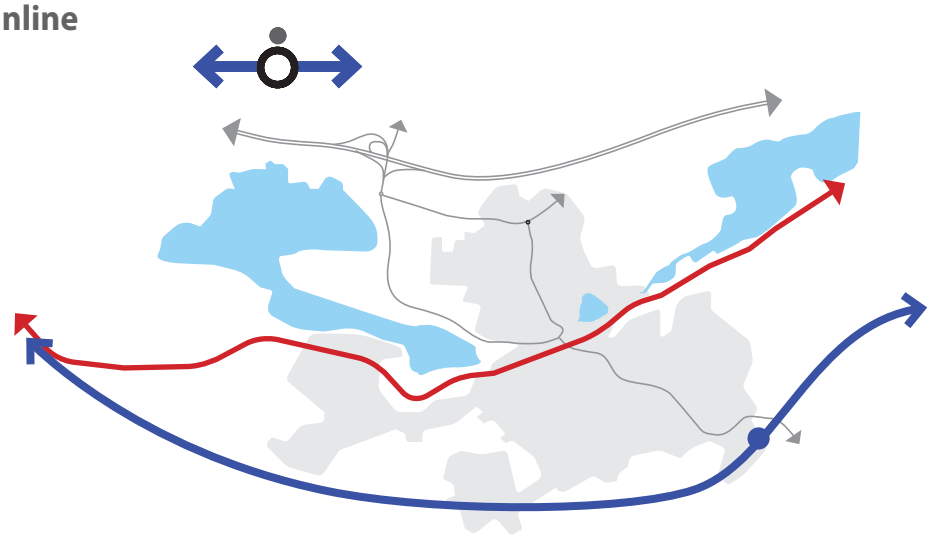
rail - poor
road - good
walk - poor

regeneration - poor
severance - neutral

as NNHI

as NNHI

cost efficient



Alternative 2 - Central on Loop

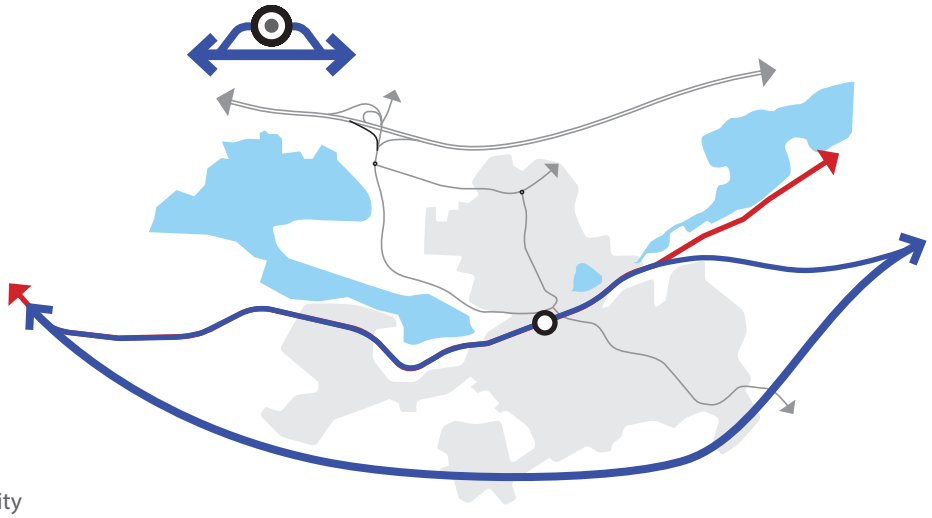
rail - good
road - good
walk - good

as NNHI

as NNHI

as NNHI

costs associated with line duplication / centrality



KEY Connectivity Development Potential Delivery
Urban Integration Environmental Impact

NNHI proposal – Central on Mainline

It is understood that the following NNHI text describing the station location forms the basis of negotiation with the relevant Municipality;

Mölnlycke comprises a railway station in Mölnlycke, located along the new double-track high-speed railway link between Järna and Almedal. The station will be designed for regional train traffic, with platform lengths according to Trafikverket's regulations (ref. TSS: Technical Specification for high-speed trains).

This option locates the station centrally within the town on an upgraded and realigned railway corridor accommodating the HSR mainline. It is assumed that the alignment would be predominantly at grade through the centre and would therefore require significant acoustic mitigation which would significantly exasperate the existing rail severance, compromising effective urban integration.

Speed restrictions would also be required through the built up urban area to mitigate the environmental impact and this will result in time penalties to the overall end to end journey times. Development potential will be limited in the established central area although there will be scope to densify existing low density development over time.

Although indicated as a fairly direct alignment the issues discussed above will lead to additional costs and it is considered that there may be a more cost effective alignment further to the south outside the town.

Alternative 1 - External on Mainline

This option locates the station on the mainline further to the south on an optimal alignment at a Parkway station which may be more cost effective. The station would be a Parkway station providing a regional stopping service principally for park & ride passengers commuting between Mölnlycke and Göteborg.

As such the station could be relatively simple and cost effective catering for 200m regional trains only.

Alternative 2 - Central on Loop

This option locates the station centrally on a loop off of an optimised mainline. The mainline could be located on an optimal route further to the south and the loop could utilise as much of the existing rail corridor as is possible as this wouldn't be required for full speed HSR.

CONSIDERATIONS

This station fails to meet three of the four quantifiable criteria set by NNHI, specifically on city population and significance for regional transfer. So on this basis alone it should not be included as a station on the network.

It should also be noted that demand forecasts provided indicate a high demand of over 5,000 passengers boarding and alighting per day which appears to be high and possibly over optimistic for a city population of only 15,000 with little apparent potential for regional rail to HSR interchange.

Using the additional set of Arup criteria it also fails to make a significant case for inclusion. It is not well connected to other regional rail and the potential for growth in the town will be constrained by the already established nature of the town and the severance effect of the high speed line on the city centre options. A key factor worth further review would relate to the identification of a potentially more cost effective alignment to the south and the potential inclusion of a Parkway station.

To summarise, the indications are that there is little demand for a station at this location and it would make little contribution to the objectives set out by NHII. So in the absence of justification against the set criteria or alternatively an over-riding strategic plan Arup would not recommend the inclusion of this station.

Mölnlycke is not recommended as a station on the HSR system.

Värnamo

© wikipedia - Fjodor

Värnamo

© Värnamo

4.10 VÄRNAMO

LOCATION CHARACTERISTICS

For a long time a small town of little national significance, Värnamo has grown with the expansion of Sweden's railway network and the industrialisation it has brought.

The Church Square, view to Värnamo station

18,696
City residents (2010)

33,473
Municipality residents

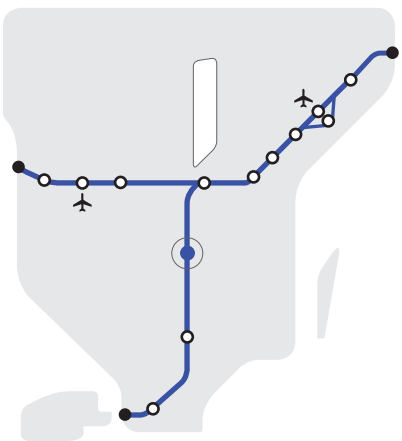
11.89 km2
Area

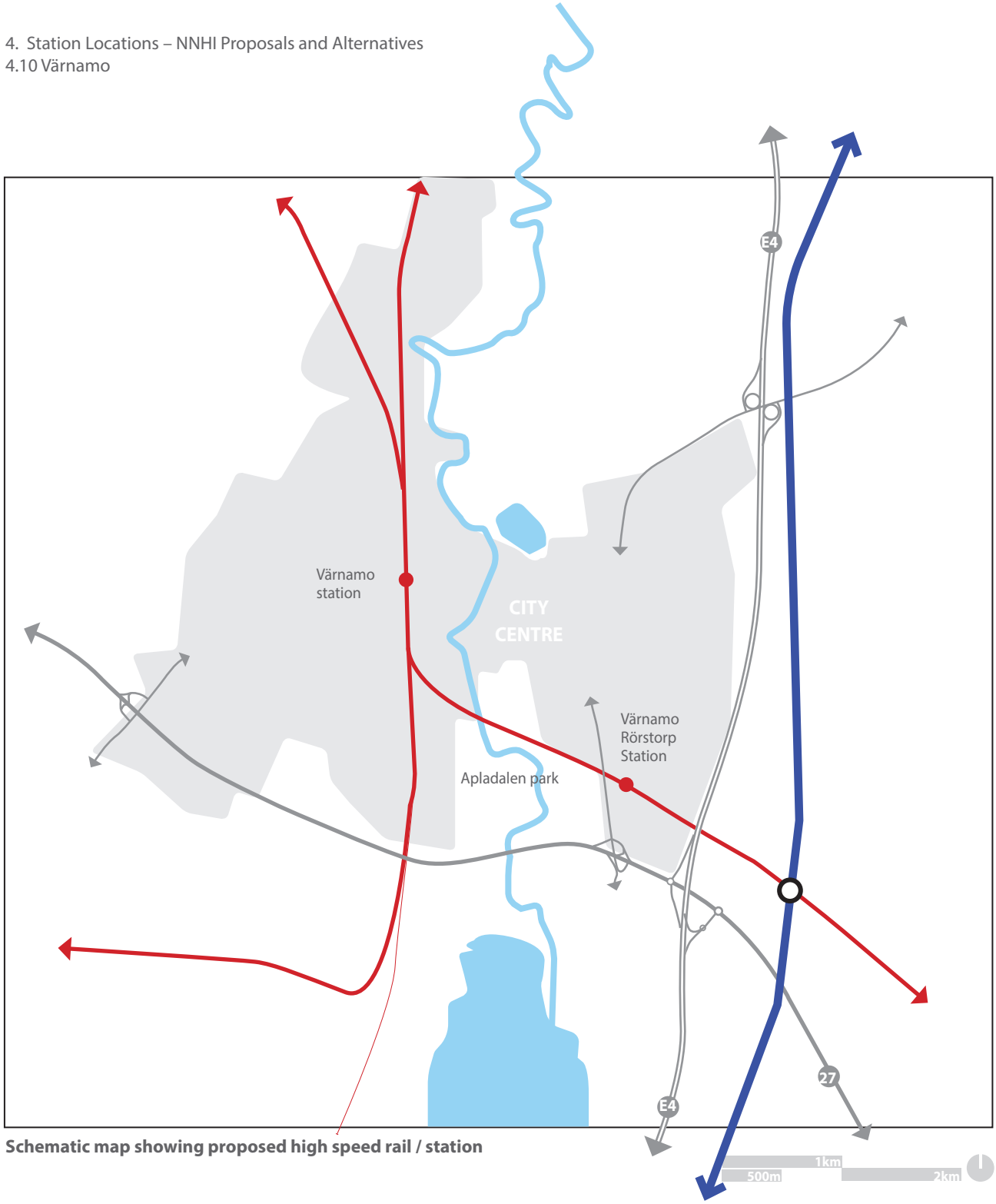
Source: Wikipedia
http://www.stationsinfo.se/station/Värnamostation/
http://www.Värnamo.se/snabblankar/english.4.18ff2710e077ef56080002927.html
http://www.Värnamo.se/Kommunen.html
http://www.Värnamo.se/Snabblankar/English.html

EXISTING AND PROPOSED INFRASTRUCTURE

Aerial photo showing existing Infrastructure

KEY HIGH SPEED NETWORK KEY DIAGRAM



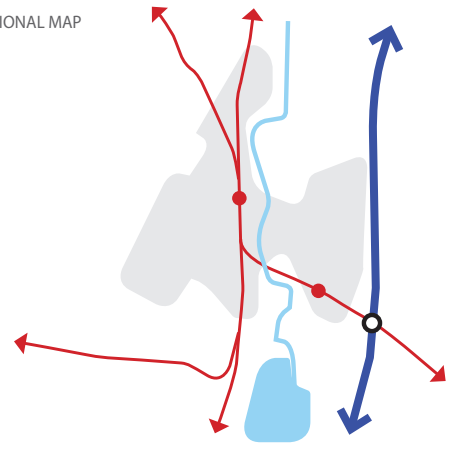


Schematic map showing proposed high speed rail / station

KEY

- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



NNHI proposal – External on Mainline

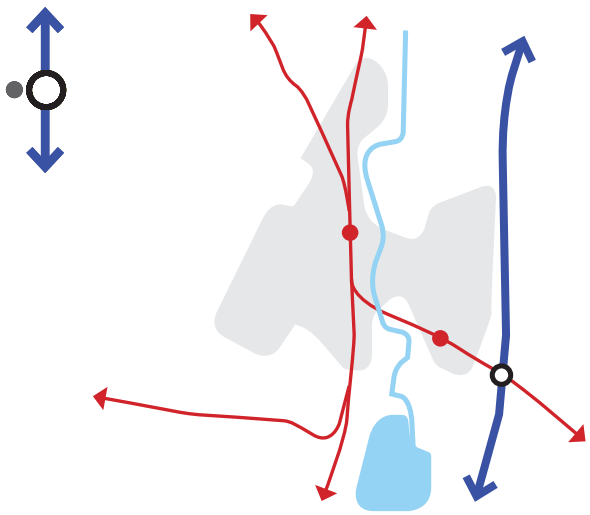
rail - moderate
road - good
walk - poor

regeneration - poor
severance - neutral

land availability - limited
viability - moderate

no major issues identified at this stage

cost efficient



Alternative 1 - Central on Mainline

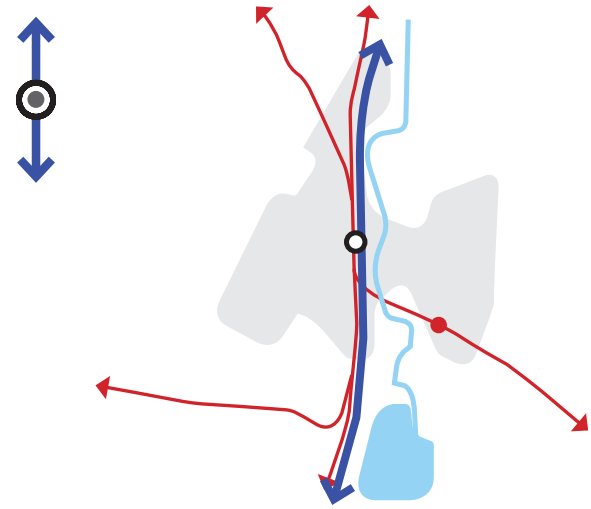
rail - good
road - good
walk - good

regeneration - good
severance - negative

land availability - limited
viability - good

noise in built up area

costs associated with centrality



Alternative 2 - Central on Loop

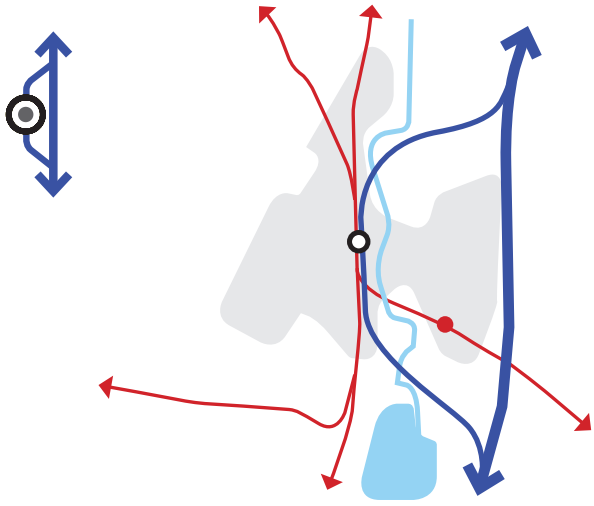
rail - good
road - good
walk - good

regeneration - good
severance - negative

land availability - limited
viability - good

noise in built up area

costs associated with line duplication / centrality



KEY

Connectivity

Development Potential

Delivery

Urban Integration

Environmental Impact

NNHI proposal – External on Mainline

It is understood that the following NNHI text describing the station location forms the basis of negotiation with the relevant Municipality;

Värnamo comprises a railway station in Värnamo, located along the new double-track high-speed railway link between Järna and Lund. The station is located externally with the possibility of changing trains to / from the coast to coast line. The station will be designed for high speed train traffic, with platform lengths according to Trafikverket's regulations (ref. TSS: Technical Specification for high-speed trains).

This option locates the station externally on the mainline on an alignment which is assumed to be optimal and at a point which is coincident with regional rail allowing for the opportunity to interchange.

The station would be a Parkway station with parking provision and good access to the highway network for park & ride passengers.

Alternative 1 - Central on Mainline

This option locates the station centrally on a realigned mainline in order to best capture the interchange potential at the existing Central Station. However it is acknowledged that this will have a major environmental impact on the built up areas of the city, require significant acoustic mitigation and will compound severance caused by the railway thereby compromising urban integration.

Speed restrictions would also be required through the built up urban area to mitigate the environmental impact and this will result in time penalties to the overall end to end journey times.

Alternative 2 - Central on Loop

This option locates the station centrally on a loop off of an optimised mainline. The mainline would be located on the optimal route further to the east and the loop would utilise as much of the existing rail corridor as is possible as this wouldn't be required for full speed HSR.

It is assumed that the loop alignment would be predominantly at grade through the centre and would therefore still require acoustic mitigation compounding the existing rail severance and compromising effective urban integration.

Speed restrictions would still be required through the built up urban area to mitigate the environmental impact and development potential will be limited within the established central area although there will be scope to densify existing low density development over time.

CONSIDERATIONS

This station meets three of the four quantifiable criteria set by NNHI. So on this basis it should not be included as a station on the network. However it is borderline and arguably the figure used for interchange potential would be applicable to a city centre station but less so for an external station.

Using the additional set of Arup criteria it also fails to make a significant case for inclusion. It is connected to regional rail but not as well as a central station would have been and the direct growth benefits to the town will similarly be limited. It is recognised, on the other hand, that if the alignment on which the station is located is optimal that the station itself may not be a significant extra cost.

To summarise, the indications are that there is borderline demand for a station at this location and it would not make a significant contribution to the objectives set out by NHII. Arup would not recommend the inclusion of this station within the network without further study of the potential benefits to regional accessibility or its incorporation into a strategic development plan.

Värnamo is recommended for possible inclusion within the system if it can be developed as an effective interchange station at reasonable cost.

Aerial photo of Hässleholm city centre and existing station

© www.panoramio.com

Hässleholm

© wikipedia - zh:user:Mywood

Hässleholm central station building

© www.industrihistorialskane.se

4.11 HÄSSLEHOLM

LOCATION CHARACTERISTICS

Hässleholm is a town which has grown as a result of the Stockholm to Malmö railway, temporarily being a military hub until the end of the cold war years. The towns Central Station is located to the west end of the town's central avenue

Hässleholm station

18,500
City population

51,048
Municipality residents

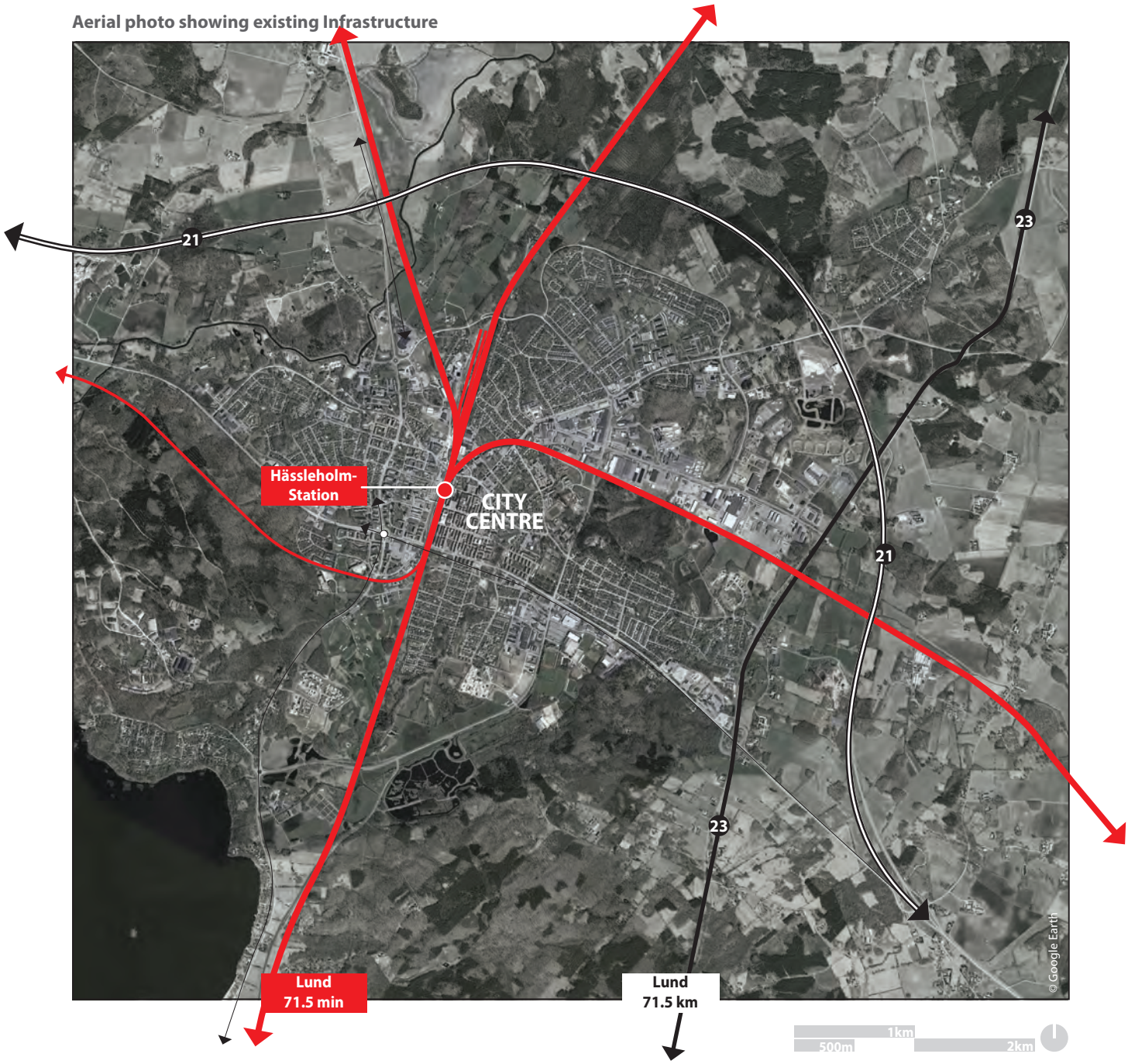
1,537/km2
Density

12.03 km2
Area

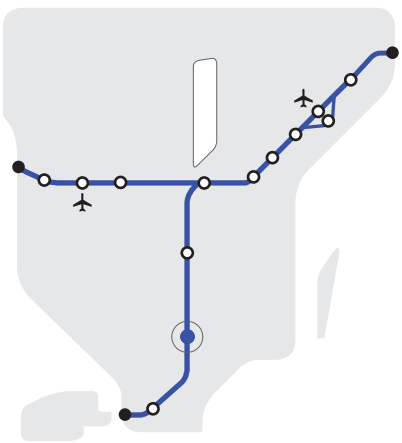
Source: Wikipedia

EXISTING AND PROPOSED INFRASTRUCTURE

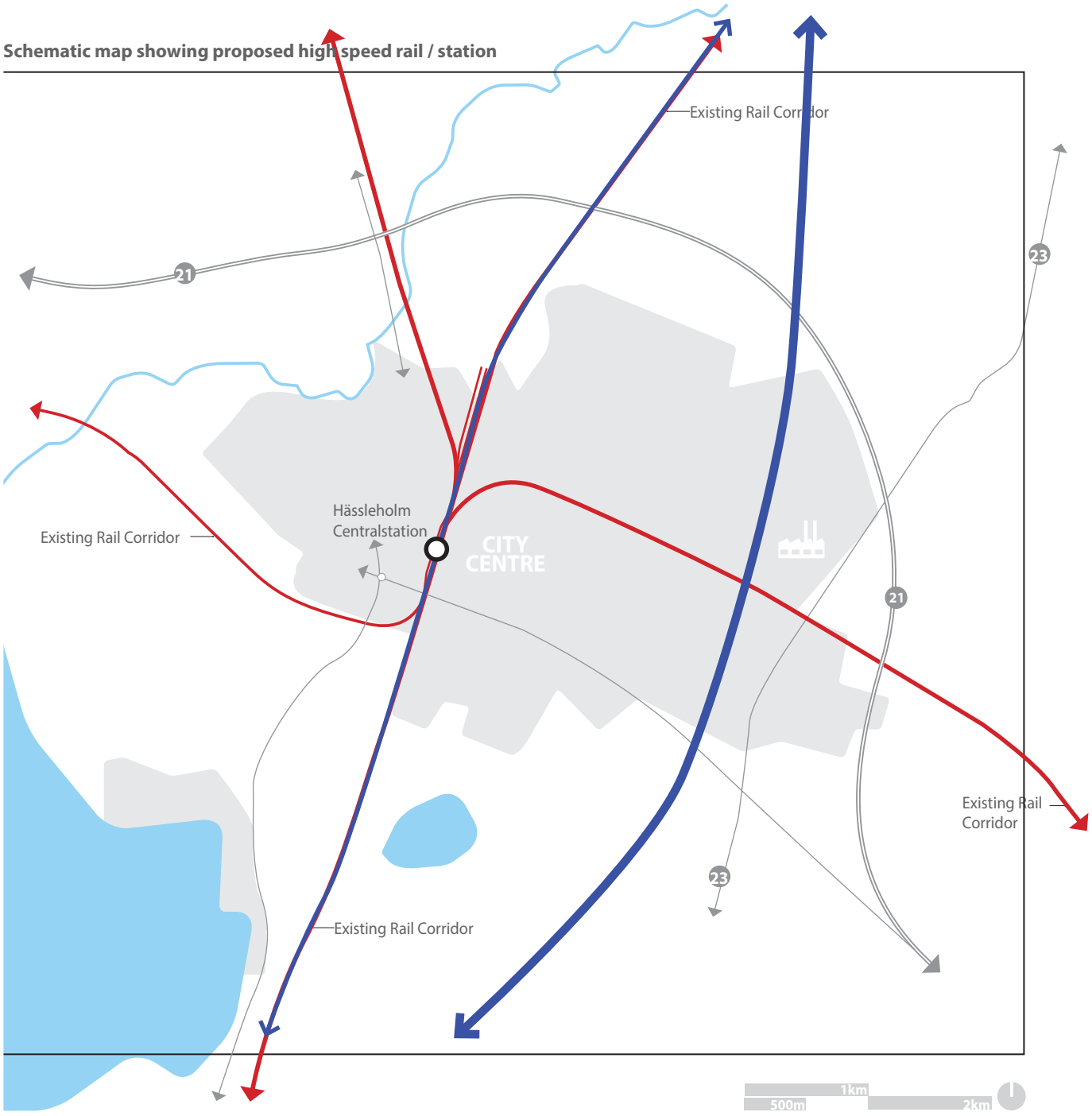
Aerial photo showing existing Infrastructure



KEY HIGH SPEED NETWORK KEY DIAGRAM



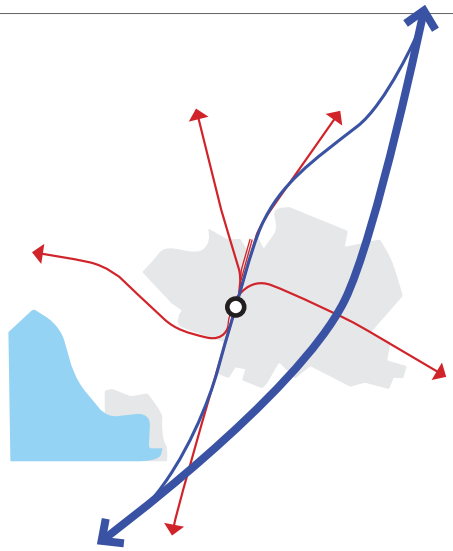
Schematic map showing proposed high speed rail / station



KEY

- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



NNHI proposal – Central on Loop

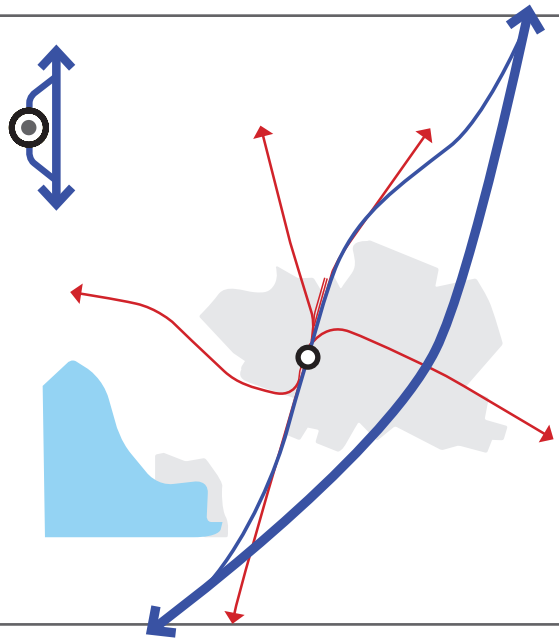
rail - good
road - good
walk - good

regeneration - good
severance - negative

land availability - limited
viability - moderate

noise in built up area

costs associated with line duplication / centrality



Alternative 1 - Central on Mainline

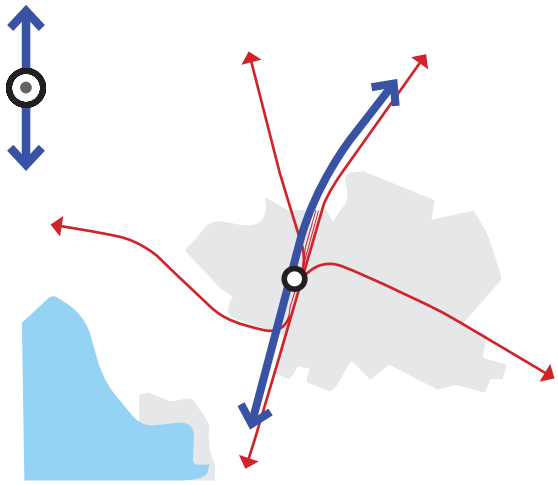
as NNHI

as NNHI

as NNHI

significant noise in built up area

costs associated with centrality



Alternative 2 - External on Mainline

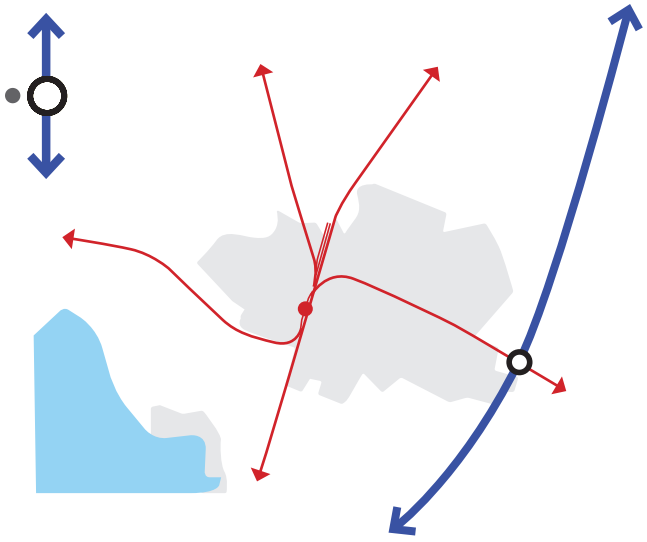
rail - moderate
road - good
walk - poor

regeneration - poor
severance - neutral

land availability - limited
viability - poor

no major issues identified at this stage

cost efficient



KEY

Connectivity

Development Potential

Delivery

Urban Integration

Environmental Impact

NNHI proposal – Central on Loop

It is understood that the following NNHI text describing the station location forms the basis of negotiation with the relevant Municipality;

Hässleholm comprises a railway station located at a branch line which connects into a bypass track. The bypass track is primarily intended for high-speed through trains.

The station will be designed for high speed train traffic with platform lengths according to Trafikverket's regulations (ref. TSS: Technical Specification for high-speed trains).

This option locates the station centrally on a loop off an optimised mainline located on an optimal route further to the east. The loop could utilise as much of the existing rail corridor as is possible as this wouldn't be required for full speed HSR. It is assumed that the loop alignment would be predominantly at grade through the centre and would therefore still require acoustic mitigation compounding the existing rail severance and compromising effective urban integration.

Speed restrictions would still be required through the built up urban area to mitigate the environmental impact and development potential will be limited within the established central area although there will be scope to densify existing low density development over time.

Alternative 1 - Central on Mainline

This option locates the station centrally on a realigned mainline in order to best capture the interchange potential at the existing Central Station. However it is acknowledged that this will have a major environmental impact on the built up areas of the city, require significant acoustic mitigation and will compound severance caused by the railway thereby compromising urban integration.

Speed restrictions would also be required through the built up urban area to mitigate the environmental impact and this will result in time penalties to the overall end to end journey times.

Alternative 2 - External on Mainline

This option locates the station externally on the mainline further to the east on an alignment which is assumed to be optimal and at a point which is coincident with regional rail allowing for the opportunity to interchange.
The station would be a Parkway station with parking provision and good access to the highway network for park & ride passengers.

CONSIDERATIONS

This station fails to meet three of the four quantifiable criteria set by NNHI, specifically on city population and contribution to housing which is not known. So on this basis alone it should not be included as a station on the network.

It should also be noted that demand forecasts provided indicate a high demand of over 21,000 passengers boarding and alighting per day which appears to be high and possibly over optimistic for a city population of only 18,000. However it appears to have potential significance for regional transfer and if these figures can be confirmed, there may be a stronger case for inclusion.

Using the additional set of Arup criteria there is a mixed case for inclusion. Whilst there may be good regional connectivity the potential for growth in the town will be constrained by the already established nature of the town and the severance effect of the high speed line on the city centre options. A key factor worth further review would relate to the identification of a potentially more cost effective alignment to the east and the potential inclusion of a Parkway station.
To summarise, the indications are that there appears to be a demand at this location despite the low population but a station would make little contribution to other objectives set out by NHII. So in the absence of justification against the set criteria or alternatively an over-riding strategic plan, Arup would not recommend the inclusion of Hässleholm Station.

Hässleholm is recommended for possible inclusion within the system if it can be developed as an effective interchange station at reasonable cost.

Lund city centre and cathedral

Lund University

4.12 LUND

LOCATION CHARACTERISTICS

Located in Sweden's largest agricultural district, in the south-west of Scania, Lund is one of Sweden's oldest cities, believed to have been founded around 990.

The city of Malmö is only about 15 km away and Lund University, established in 1666, is Sweden's largest, with 42,000 full or part-time students.

Lund station

82.800
City population

116,834
Municipality residents

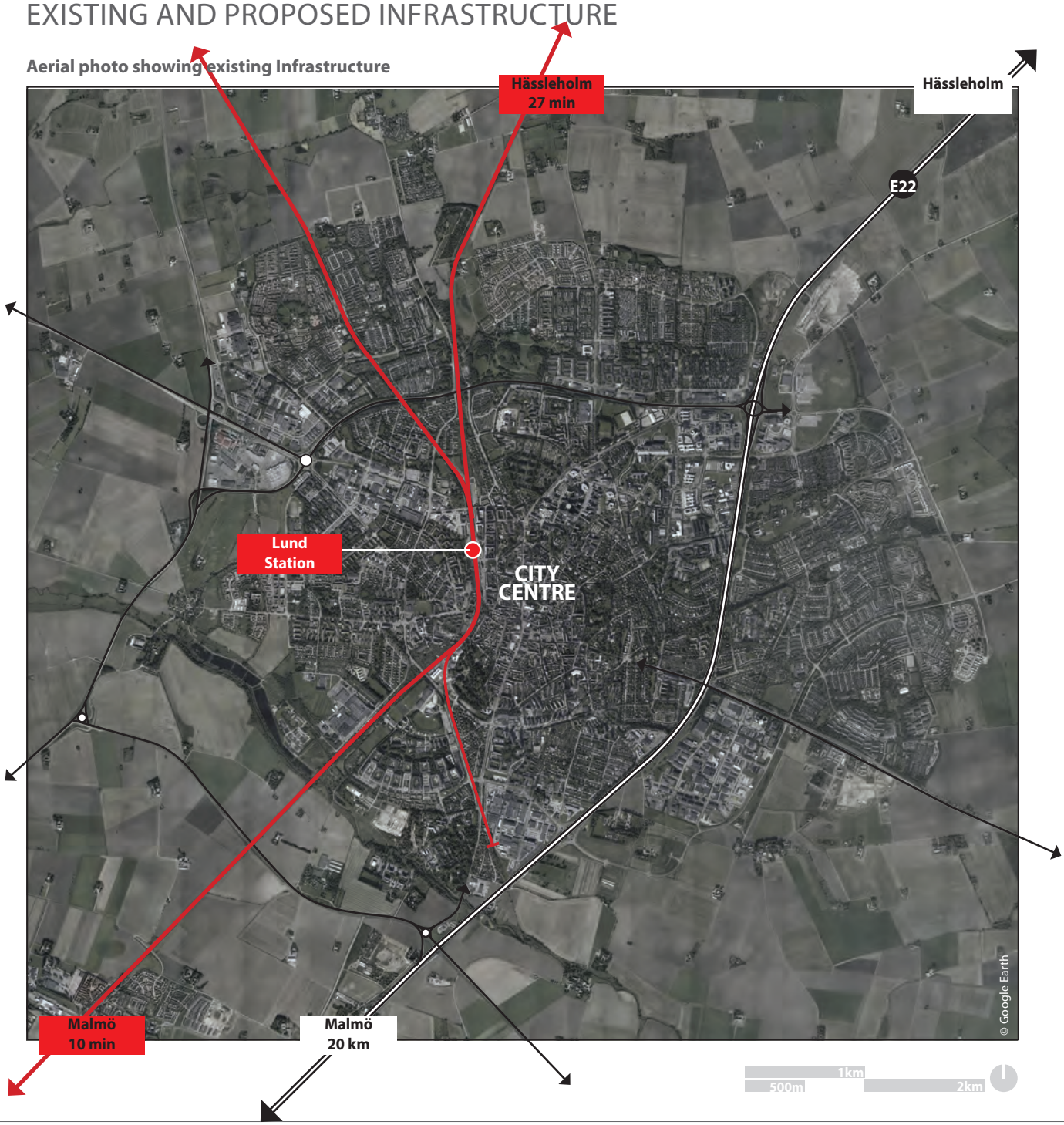
3.215/km2
Density

25.75 km2
Area

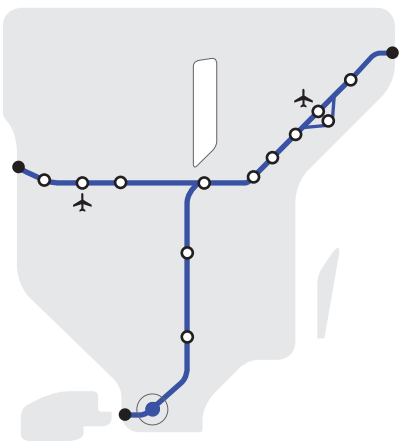
Source: Wikipedia

EXISTING AND PROPOSED INFRASTRUCTURE

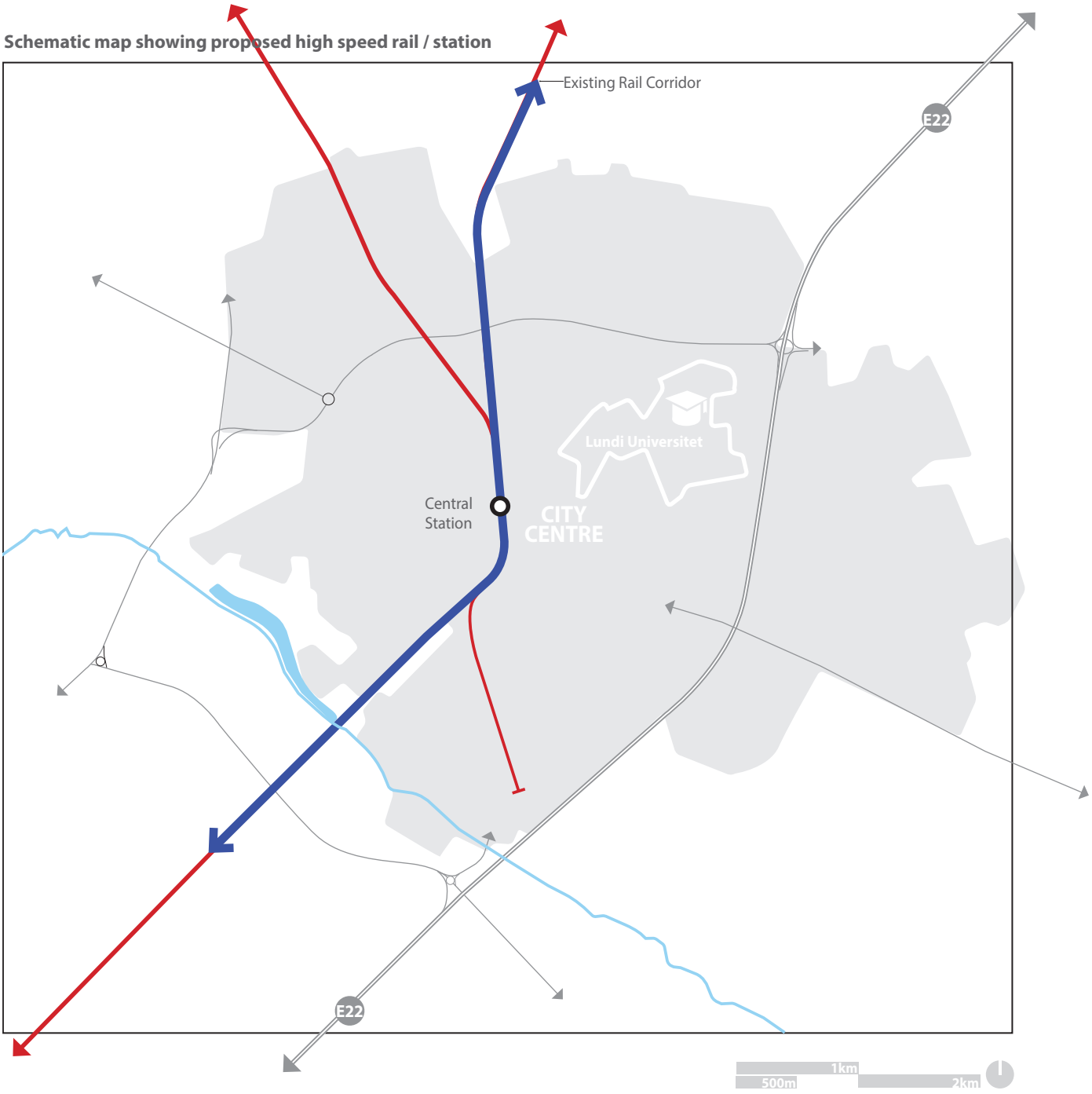
Aerial photo showing existing Infrastructure



KEY HIGH SPEED NETWORK KEY DIAGRAM

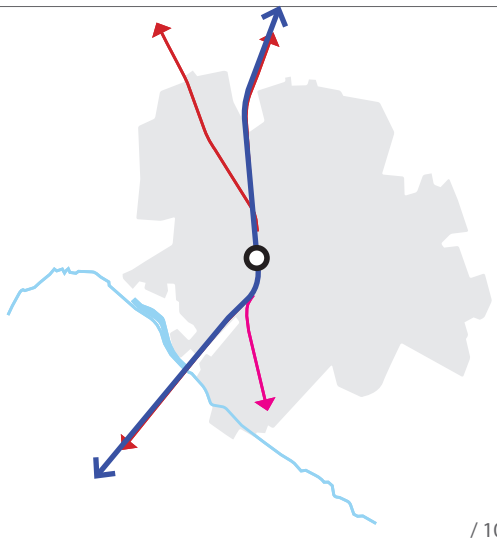


Schematic map showing proposed high speed rail / station



KEY

- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road



NNHI proposal – Central on Mainline

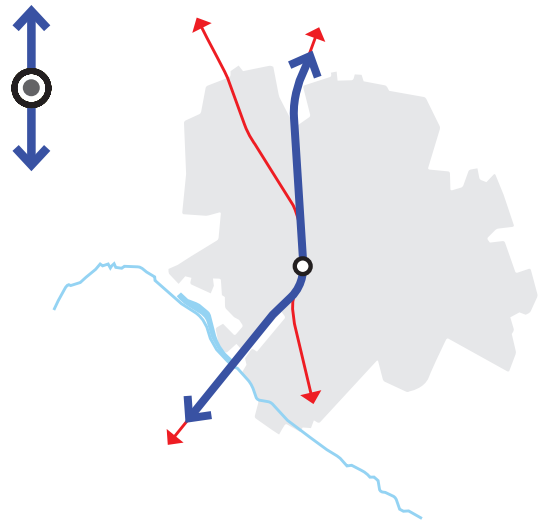
rail - good
road - good
walk - good

regeneration - good
severance - negative

land availability - limited
viability - moderate

significant noise in built up area

costs associated with centrality



Alternative 1 -Central on loop

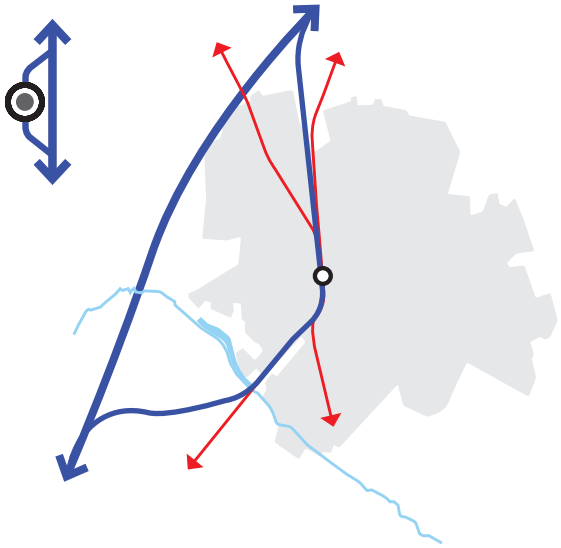
as NNHI

as NNHI

as NNHI

noise in built up area

costs associated with line duplication



Alternative 2 - External on Mainline

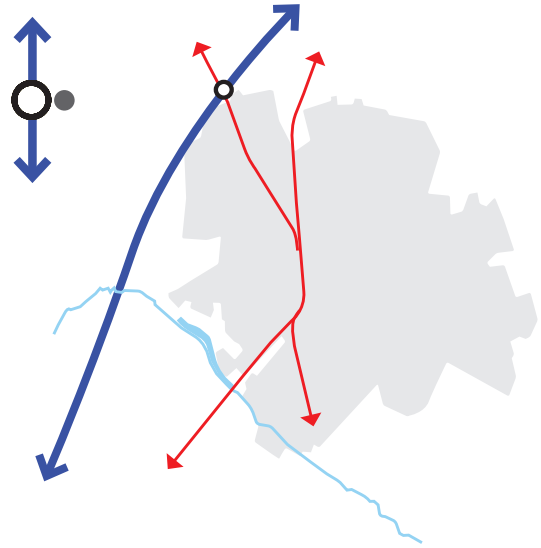
rail - moderate
road - good
walk - poor

regeneration - poor
severance - neutral

land availability - good
viability - poor

no major issues identified at this stage

cost efficient



KEY

Connectivity

Development Potential

Delivery

Urban Integration

Environmental Impact

NNHI proposal – Central on Mainline

It is understood that the following NNHI text describing the station location forms the basis of negotiation with the relevant Municipality;

Lund comprises adapting the existing railway station in order to accommodate the new double-track high-speed railway link between Järna and Lund. The station will be designed for high speed train traffic, with platform lengths according to Trafikverket's regulations
(ref. TSS: Technical Specification for high-speed trains).

This option locates the station centrally on the HSR mainline in order to best capture the interchange potential at the existing Central Station. However it is acknowledged that this will have a major environmental impact on the built up areas of the city, will require significant acoustic mitigation and will compound severance caused by the railway thereby compromising urban integration.

Speed restrictions would also be required through the built up urban area to mitigate the environmental impact and this will result in time penalties to the overall end to end journey times. It is acknowledged that the line southwards to Malmö will follow the existing rail corridor and will be subject to speed restrictions in any event, so a slower service at this point may have less impact.

Alternative 1 - Central on Loop

This option locates the station centrally on a loop off of an optimised mainline. The mainline would be located on the optimal route further to the east and the loop would utilise as much of the existing rail corridor as is possible as this wouldn't be required for full speed HSR.

It is assumed that the loop alignment would be predominantly at grade through the centre and would therefore still require acoustic mitigation compounding the existing rail severance and compromising effective urban integration.

Speed restrictions would still be required through the built up urban area to mitigate the environmental impact and development potential will be limited within the established central area although there will be scope to densify existing low density development over time.

Alternative 2 - External on Mainline

This option locates the station externally on the mainline further to the east on an alignment which is assumed to be optimal and at a point which is coincident with regional rail allowing for the opportunity to interchange.

The station would be a Parkway station with parking provision and good access to the highway network for park & ride passengers.

CONSIDERATIONS

Lund passes 3 of the 4 NHII criteria with contribution to increased housing construction not identified. So on this basis alone it should be included as a station on the network.

Using the additional set of Arup criteria it also makes a strong case for inclusion, with good connectivity to existing rail and potential contribution to city growth.
The issues arising from running the HSR mainline through a built up urban area are potentially significant but in this particular case it is understood that the train speeds will reduce from Lund onwards in any event, as the system joins the existing conventional railway corridor to Malmö. Subject to further assessment it may be possible to mitigate any increased impact introduced by HSR.

Lund is recommended as a central station on the HSR system.

5

CONCLUSIONS

long distance high speed trains will be combined with regional train services'

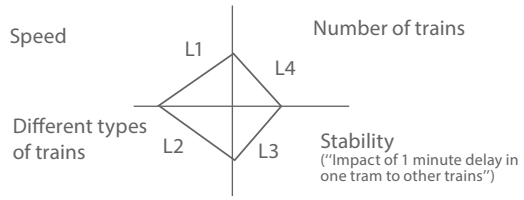
5.1 SYSTEM & FREQUENCY

SYSTEM & FREQUENCY OF TRAFFIC

As noted above, careful service planning will be required to maximise the capacity, inter-regional connections and other benefits of the HSR proposals, particularly in terms of combining the long-distance, high-speed services with the major regional trains.

For services using the HSR (and running beyond it, within Sweden and between Sweden, Denmark and Germany), the timetable and train plan will need to achieve an appropriate balance between capacity provision (and consumption), and service frequencies, stopping patterns and interchange opportunities at intermediate stations, while maintaining acceptable levels of performance and timetable stability. The trade-offs involved are summarised in the diagram below.

Balancing capacity in case of mix traffic:



L1 + L2 + L3 + L4 = Constant

Diagram source: http://www.uic.org/highspeed

For services on the conventional network that connect with the HSR, the timetable should be arranged to maximise convenient and reliable connections to and from the HSR, and thus for inter-regional travel.

The eventual timetables on the HSR and conventional network will reflect the desired service specification and underlying demand, but also capacity and other operational constraints, including minimum headways, dwell times and turnaround times at termini. Data and information on all of these will be required in order for the work to proceed.

Generalised Journey Time Analysis

Generalised Journey Times (GJTs) will be assessed for station pairs, based on in-vehicle times and service intervals, using indicative service patterns and calculated journey times. The initial focus will be on journeys between the termini and other major stations.

Generalised Journey Time Comparison

The GJT's for HSR will be compared with those for the road and air travel alternatives. Indicative road journey times will be obtained from Google Maps or other appropriate sources.

For air travel, the focus will be on services between Arlanda, Skavsta, Landvetter and Malmo airports (plus any others specified by Trafikverket), and will consider airport access and minimum check-in times, as well as flight times and frequencies. The initial comparison will be on the basis of city centre – to – city centre travel, and will include airport access times from/to the relevant urban areas.

International Benchmarking

The Swedish proposals will be compared with the characteristics of other HSR systems (existing and planned/ proposed) in terms of availability, resilience and journey time effects, particularly in respect of stopping times, train operating patterns and value for money of the infrastructure.

5.2 GEOMETRIC RESTRICTIONS

METHODOLOGY

To help assess the Trafikverket Technical System Standard for High-speed Railway Lines Standard (TDOK 2014:0159 version 2.0, 2015-07-01), referred to in this report as the "Swedish HSR Standard", a number of High Speed Railway (HSR) standards and guidance documents have been reviewed to aid the comparison study. These are listed in the table below.

This list is not exhaustive when compared to the number of HSR systems in operation (or in the design phase) globally, but the documents listed form a useful resource and represent current industry thinking and good practice. Other HSR systems have been in operation (or in the design phase) for some time but their standards are either confidential or unavailable to us, or are not considered reasonable currently.

Other Swedish standards such as those listed below have not been reviewed.

1. TDOK 2014:0555 (formerly BVS 1586.20) – no title given
2. TDOK 2014:0075 Banöverbyggnad – Spårgeometri Krav på sp¨årets geometri vid nybyggnad, reinvestering/ upprustning, underhåll och drift (Track superstructure – Track geometry Requirements for track geometry in connection with new construction, reinvestment/ upgrading, maintenance and operation)
3. TDOK 2014:0686 (tidigare/ formerly BVS 1586.26) – no title given
4. "Standard range of turnouts from Swedish Transport Administration"

Criteria for all standards have been tabulated, with a further table of recommended criteria provided.

Several assumptions and exclusions made during this study are given in Sections "Assumptions" and "Exclusions" below. Section 5.2 gives commentary on the findings and recommendations.

Assumptions

Several assumptions have been made when carrying out the standards review and comparison which are given below:

1. Only the headline criteria that have significant influence over global route alignment have been assessed.
2. The criteria have been assessed assuming a dedicated high speed passenger railway, with no freight use (or differential speed) envisaged.
3. The criteria have been assessed assuming all construction is new, with no adoption or upgrade of existing infrastructure.
4. Factors effecting the fundamental constructability of the railway have not been assessed e.g. specific earthworks or tunnelling criteria.
5. No judgements on linespeed or journey time against factors such as topography and cost have been considered.
6. Where standards give different criteria values for different bands of linespeeds the most relevant have been taken as those of 250kph and above.
7. The other comparison standards and documents that were reviewed place passenger comfort and infrastructure maintainability as core principles.

Name	Title	Document reference no.
TSI INF	Technical Specifications for Interoperability relating to the 'Infrastructure' subsystem of the rail system in the European union	1299/2014
EN	Railway applications – Track – Track alignment design parameters – Track gauges 1435mm and wider, Part 1 – plain line Railway applications – Track – Track alignment design parameters – Track gauges 1435mm and wider, Part 2 – Switches and crossings and comparable	BS EN 13803-1:2010 BS EN 13803-2:2006+A1:2009
UK HS1	Track Alignment Design for the Channel Tunnel Rail Link (CTRL)	000-GDS-LCEET-00078-08
USA California	Technical Memorandum – Alignment Design Standards for High-Speed Train Operation	TM 2.1.2
Singapore	Arup document: ER469 Engineering Feasibility Study for the Proposed High Speed Rail, Final Report Volume 1	DOC/ER469/QUA/PL/0003/A

HIGH SPEED LINE DESIGN PARAMETERS

			STANDARDS/ CODES		
		STANDARDS / COUNTRY	Sweden		
		REFERENCE/ SOURCE OF DATA	Trafikverket TDOK 2014:0159 Version 2.0 2015-07-01 Technical System Standard for High-speed Railway Lines	Notes/Comments	Further remarks
TRACK	Maximum Line Speed (kph)	Passenger	320	200mph	OK
		Freight			
	Maximum Turnout Speeds (kph)		80	Where V > 160kph	X
	Cant (mm)	Standard/Recommended Limiting Value			
		Maximum Limiting Value	160		160mm, OK as a normal maximum. Exceptional limit added (180mm) in Recommendations
	Cant Through Platforms (mm)	Standard/Recommended Limiting Value			
		Maximum Limiting Value	70		Non-preferred. Optimum arrangement is straight platform tracks
	Cant Deficiency (mm)	Standard/Recommended Limiting Value		see TSI INF	100mm, OK as a normal maximum. Exceptional limit added (150mm) in Recommendations
		Maximum Limiting Value			
	Cant Excess (mm)	Standard/Recommended Limiting Value			
		Maximum Limiting Value	100		OK. Increased to 110mm in Recommendations
	Cant Gradient (1 in xx)	Standard/Recommended Limiting Value			
		Maximum Limiting Value			
	Rate of Change of Cant (mm/s)	Standard/Recommended Limiting Value			
		Maximum Limiting Value			
	Rate of Change of Cant Deficiency (mm/s)	Standard/Recommended Limiting Value			
		Maximum Limiting Value			
	Minimum Horizontal Radius (m)	Standard/Recommended Limiting Value			
		Maximum Limiting Value	5050		OK. Minimum radius based on speed, cant and cant defiency is 4655m
	Maximum Horizontal Radius (m)	Maximum Limiting Value			
	Minimum Length of Alignment Elements (m) (Circular Curves and Straights)	Standard/Recommended Limiting Value			
		Maximum Limiting Value			
	Horizontal Transition Type				
	Minimum Vertical Radius (m)	Standard/Recommended Limiting Value			
		Maximum Limiting Value	18000		This is based on vertical acceleration of 4.5%g (acceptable). 4%g given as reccomended maximum.
	Maximum Vertical Radius (m)	Maximum Limiting Value			
	Vertical acceleration (% g)	Standard/Recommended Limiting Value			
		Maximum Limiting Value			
	Raising and Falling Gradient (%)	Standard/Recommended Limiting Value	1.5 - 2.5%	mean gradient may not exceed 1.5-2.5% over 10km and 2.5-3.5% over 2km	OK. Matches general practice
		Maximum Limiting Value	3.50%	Platforms 0.5% max, coupling area 0.25% max	OK. Matches general HSR practice (3.5% maximum gradient). Maximum gradient in platforms too steep - flatten to 0.25% recommended maximum.
	Length of Vertical Curve (m)	Standard/Recommended Limiting Value			
	Track Centreline Spacing (m)		4.5m		Acceptable for 320kph linespeed. 5m recommended to permit faster future linespeed.
	Track Gauge (mm)		1435		OK
	Track Formation (Ballasted or Slab Track)	Cut	Slab	Ballast permitted with V < 200kph	OK
		Fill	Slab		
		Short Bridge	Slab		
		Viaduct	Slab		
	Rail Type		CEN60E2	R260 steel CEN60E1 for V < 200kph	OK
	Sleeper Type			650mm centres	OK
	Track Fixing Type			Inclination 1 in 30, adjustments required 40mm vertically and 10mm horizontally	OK
	Axle Load (tons)				
	Track Drainage Type				
	Catchpit Spacing				
	Access Point Spacings (km)				
	Position of Safety From Running Line (m)				
TUNNEL	Tunnel Size (xsectional area -m2)	Single Track			
		Twin Track			
	Sealed Train (Yes/No)				
	Sealing Time Constant (sec)				
TCS	Train Control System	ETCS Level	2		
		ETCS Version			
		Other ATC			
		Fullback Signalling			
ELECTRIFICATION	Spacing of Feeder Station				
	Capacity of Transformer				
	Traction Feeding System			15kV, 16.7Hz	OK
	Type of Contact system			TSI Energy	OK
	Power Supply Rating				
VARIOUS	Frequency of Trains	Max No of Train per Hour			
	Train Length (m)				
	Train Cross-sectional Area (m2)				
	Vehicle Gauge That The Route is Cleared For				
	Platform Length (m)		400m	Regional - 250m	OK
	Minimum Platform Width (m)			Min R=500m through platforms	Platforms to be straight. Width to be determined by passenger numbers.
	Planar Platform Dimensions	Offset (mm)			
		Height (mm)	550mm		OK. Compliant with TSI
	Maintenance/Engineering Hours	Weekday	00.00 - 06.00		OK
		Weekend		None specific	OK
		Long Possessions	1-2 nights / year		OK
	Vertical Bridge Clearance (m)				
COST	Cost (m/km)	Tunnel			
		Viaduct			
		Embankment/Cutting			
		Average Cost			
OTHER	Length of straight track or circular curve between transition curv	Length (m)	V/3	assume V in kph	OK
	Temperature range				

Exclusions

There are various factors that, whilst potentially relevant to overall alignment and corridor design at a later stage in the process, have been omitted from this high-level standards review and comparison.

1. No comparison has been made regarding climatic parameters such as average temperature ranges and cross-winds.
2. No comparison has been made regarding flora or fauna (livestock security fencing, distance from trees etc).
3. No comparison has been made regarding structure or earthwork design (load cases, dynamic performance etc).
4. Any commentary regards standards and parameters individually and does not treat them holistically, as would a design team in the development phase.
5. Tilting trains and any different parameter limits for them have not been considered.
6. Criteria limits around "abrupt changes in cant deficiency", or virtual transitions, have not been considered as these are only relevant at lower speeds which will not be applicable for overall route identification.

COMMENTARY &RECOMMENDATIONS

The Swedish Standard that has been reviewed is broadly similar to the other documents reviewed, and the process has identified areas where it could be enhanced. Below are some suggestions for detail to be added or modified.

Standards "gaps"

There are several design areas that the Swedish Standard is either silent on, or should enhance the level of detail.

1. Locating switches and crossings (S&C) on the mainlines, and factors constraining the mainline around S&C (to improve S&C construction, installation and maintainability).
2. Minimum element length to avoid rapid changes of direction, or, maximum number of elements in a rolling km (to avoid frequent changes of direction and improve passenger comfort).
3. Overlapping vertical curves with either horizontal curves or horizontal transitions (to improve the constructability and maintainability of the alignment and passenger comfort).
4. Alignment constraints for electrification Neutral Sections (to ensure power distribution and supply can be facilitated).

HSR Standard amendments

The table given in Appendix A shows the recommended standards criteria, and can be compared to the table Appendix B that lists the existing Standards alongside those of the other documents.

It is recommended that these criteria be adopted for the development of the HSR corridor alignment, noting the additional comments below.

Standards flexibility

In designing a railway corridor it is necessary that a balance must be found between linespeeds/ journey time, costs, engineering and passenger comfort, as well as other considerations such as political climate and sustainability. The alignment engineering standards that the railway corridor is based upon should therefore accommodate enough flexibility to permit "value engineering" of the overall system, which the recommended values attempt to do.

HSR "system"

A railway is a system comprising infrastructure and rolling stock, which both have their own peculiarities and also interdependencies. The interdependencies (involving design criteria), are amplified for a high-speed railway, as the safe passage of vehicles relies on specific infrastructure that meets their needs. Essentially, a high-speed railway system must be designed with compatibility in mind. It is therefore important to identify as early as possible the "system" that the railway will be designed to adopt. For example, a Japanese Shinkansen train could not immediately integrate on the TGV network in France. In this way, specific design criteria should be refined with respect to the rolling stock/ system as the design development of the route progresses.

Trackform/ structure interaction:
The standards reviewed are generally silent regarding rail expansion joints for structures (e.g. viaducts). These require a constant gradient and straight alignment, with sufficient distance from S&C. Viaduct design, and the consequent need for expansion switches, can therefore have an influence over alignment design which must be considered holistically.

Trackform:
Various trackforms are available to construct new railways, including variations on ballasted and ballastless (slab) track. These all have differing advantages and disadvantages across a wide range of issues, such as capital cost, installation method, alignment fixity, maintenance frequency, whole life cost and so on. Whilst most design criteria/ values are supported by both general trackforms it should be noted that ballastless/ slab trackforms are more resilient to the stresses placed on the track from traffic. For example, a higher cant deficiency value (lateral force) through a curve is more easily restrained by a slab-track form and consequently may be more suitable for future linespeed enhancement.

5.3 CONCLUSION ON STATION NUMBERS & LOCATIONS

CONCLUSION ON STATION NUMBERS & LOCATIONS

In the summer of 2015, the Swedish Transport Administration was tasked by the National Negotiation on Housing and Infrastructure with developing an expansion strategy for high-speed network;

A new-generation railway, the high-speed railway from Stockholm to Göteborg/Malmö will be Sweden's biggest infrastructure project in the past 150 years. This railway will play an important role in Sweden's development, providing increased access to several of its largest cities. This will lead to larger labour market regions, which will in turn promote a surge in housing construction. With high-speed railways it will be possible to conduct more journeys and transport more freight by rail, contributing to a transport system that is more sustainable in the long term.

It is recognised that the overall viability of the proposed railway is dependent on the options selected regarding the railway's route and station locations.

Using the selection criteria established by NHII supplemented by Arup's own criteria and further analysis a second opinion on the number of stations and location of stations has been derived. This alternative network proposal is intended to identify those stations which will best meet the project criteria discussed within this report in a way which supports the overall viability of the project. Following this provisional assessment Arup have identified for further investigation, stations which could be omitted from the HSR network.

All NNHI proposed stations have been summarised and are shown on the Assessment Table on the following page.
A number of stations are considered to be borderline for inclusion and it is recommended that further study is carried out, in particular relating to the relative cost of proposals and the potential for regional connectivity through interchange with existing regional rail services.

In summary Arup have recommended subject to further study the potential omission of the following stations on the network;

- Vagnhärad
- Nyköping (combined with Skavsta)
- Tranås
- Mölnlycke
- Värnamo
- Hässleholm

STATION TYPOLOGY RECOMMENDATIONS

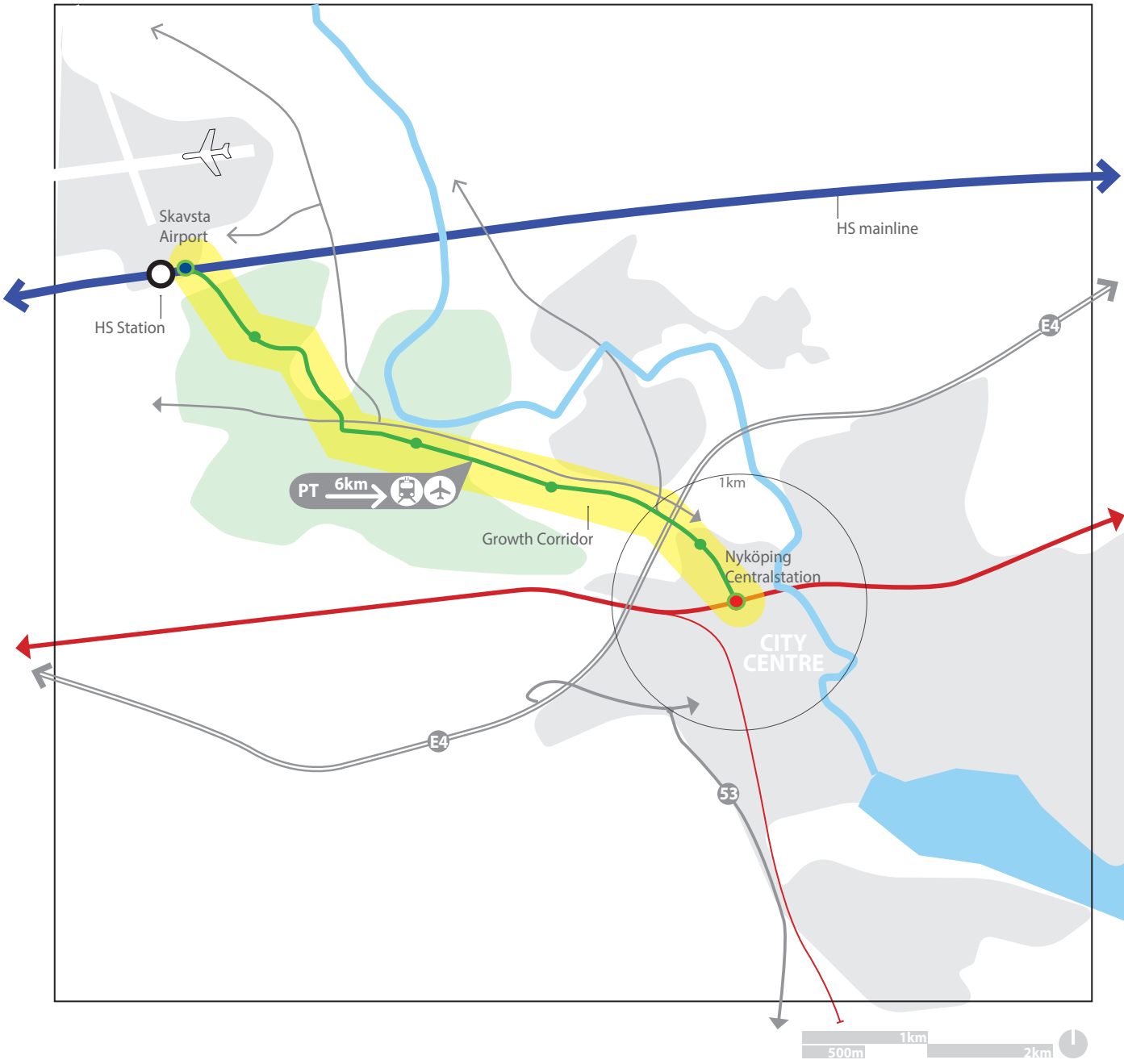
In addition to providing a second opinion on which stations should be included in the system, Arup have made a number of recommendations on the specific location typology. This has been informed by the supplementary Arup criteria which are explained in the earlier sections of this report. Three alternative typologies have been considered for each station including the NNHI proposal. These have been assessed against 5 station location criteria leading to a provisional recommendation.

In summary Arup have recommended the following changes to NHII proposed station typologies;

- Nyköping / Skavsta (airport) – stations to be combined with PT corridor to centre avoiding duplication of station and line costs
- Norrköping – station to be relocated to city edge connecting with existing rail and tramway to city centre to shorten alignment and avoid costly tunnels
- Linköping – station to be relocated to new transport hub in development zone east of the river
- Jönköping – station to be in same location but on mainline to allow for future stopping express service trains
- Borås – station to be relocated at the existing Central Station to form a consolidated transport hub utilising existing rail corridor from north if feasible
- Landvetter (airport) – station to be relocated further north and integrated with the airport city development avoiding costly tunnels

SKAVSTA / NYKÖPING

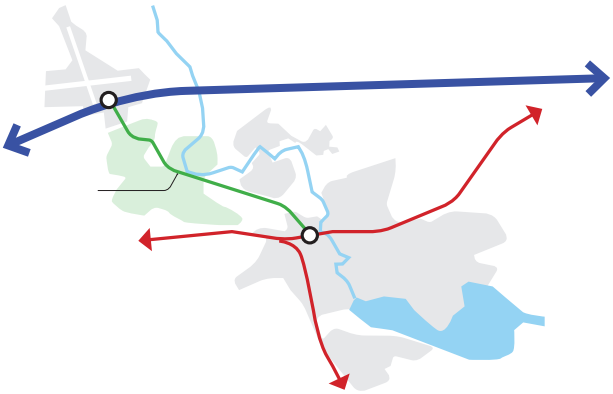
Schematic map showing Station typology recommendation



KEY

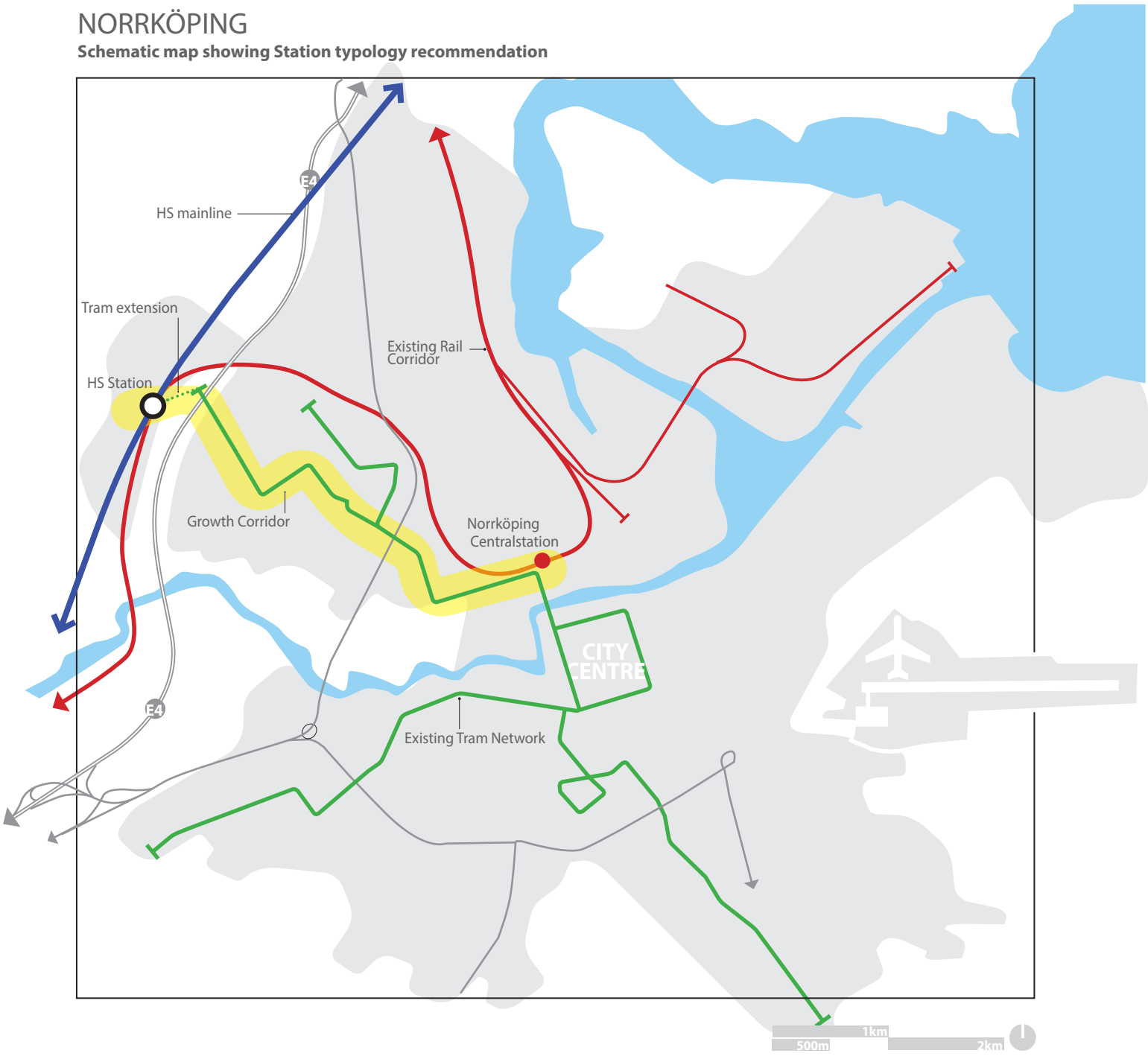
- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



NORRKÖPING

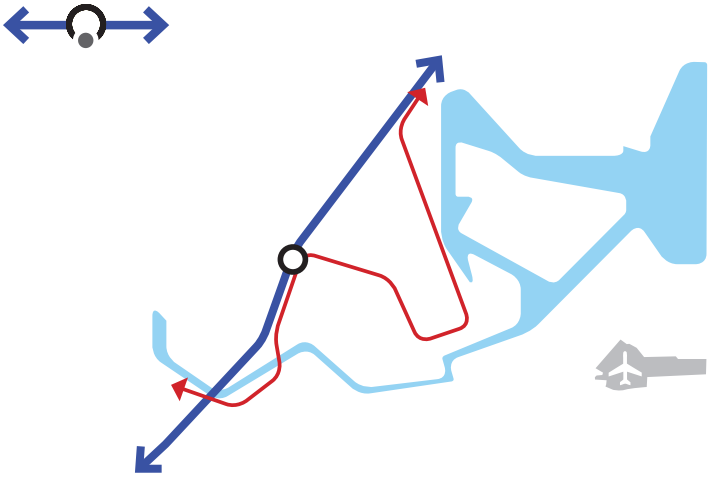
Schematic map showing Station typology recommendation



KEY

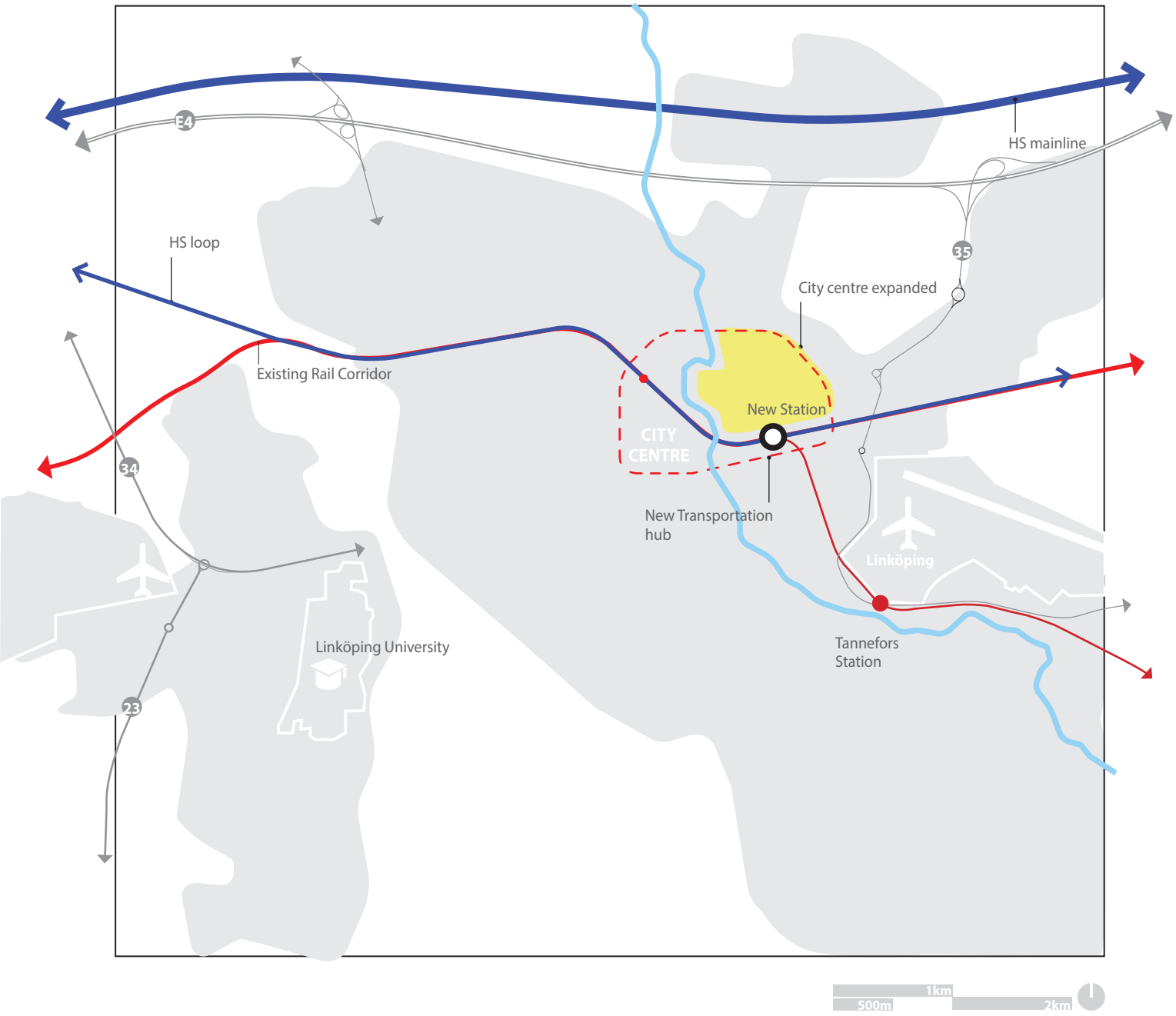
- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



LINKÖPING

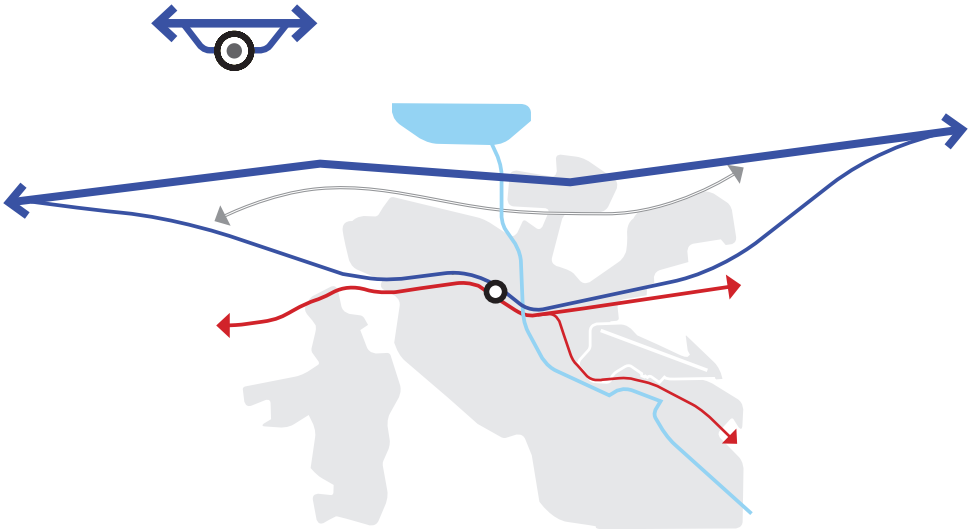
Schematic map showing Station typology recommendation



KEY

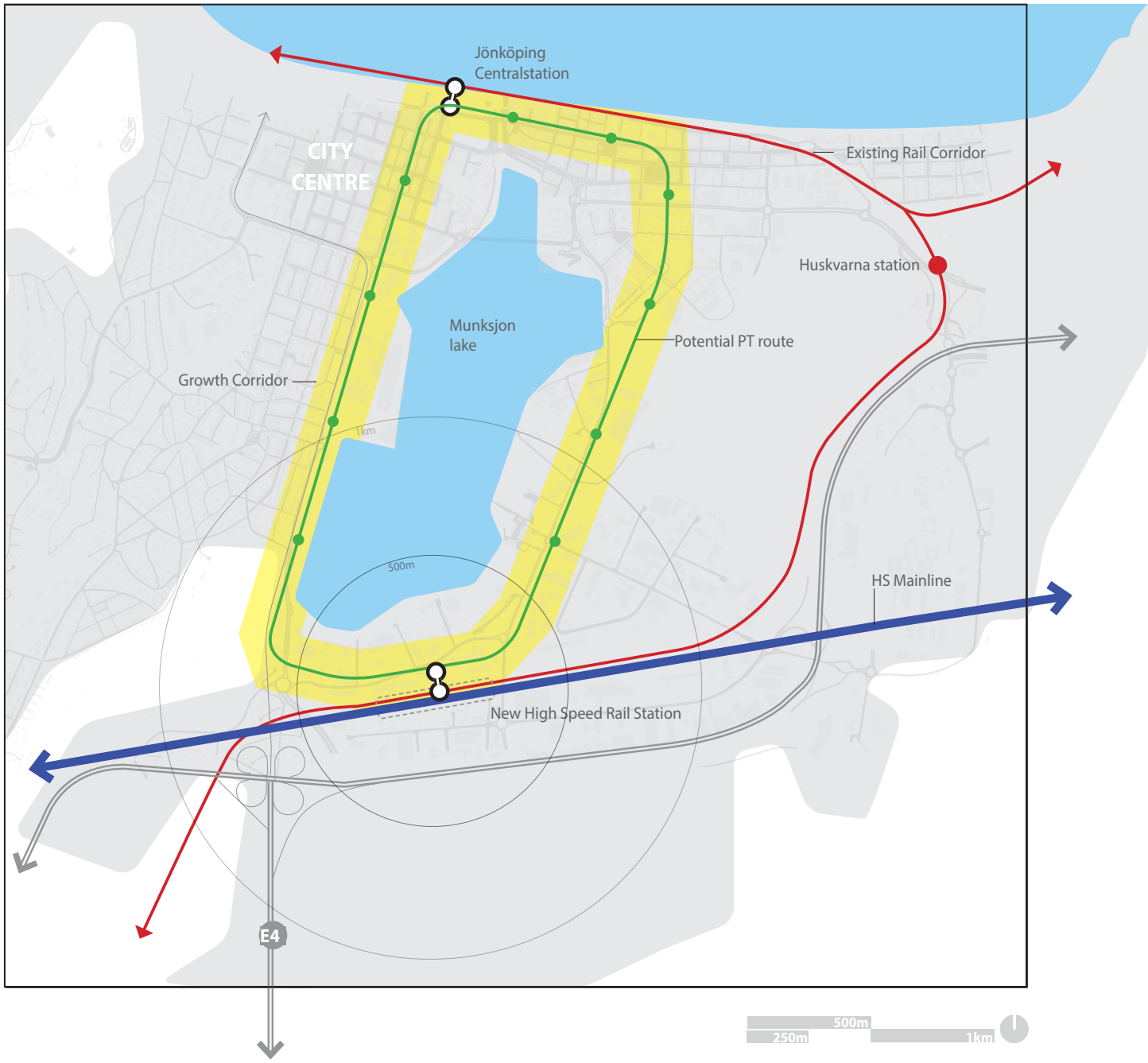
- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



JÖNKÖPING

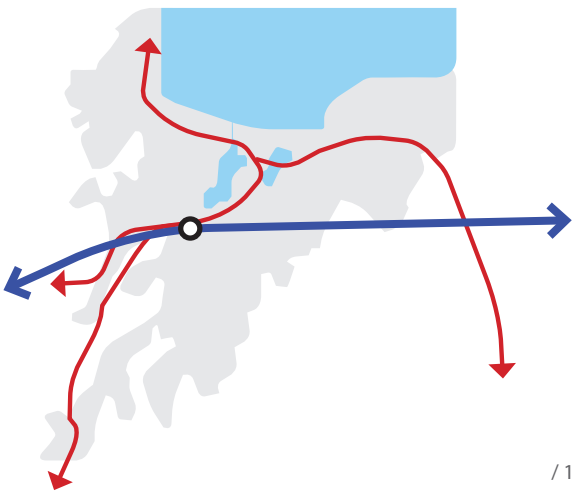
Schematic map showing Station typology recommendation



KEY

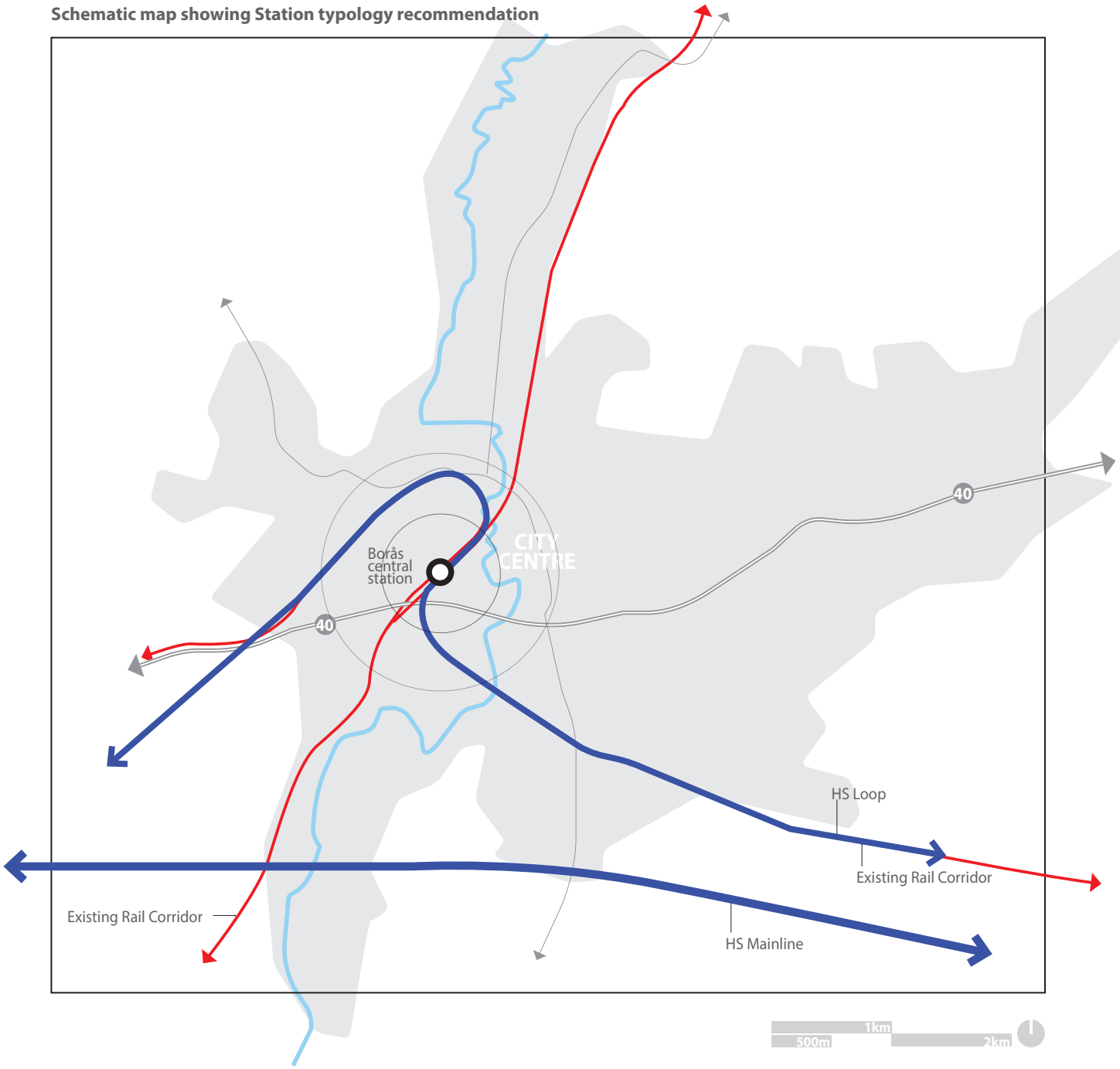
- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



BORÅS

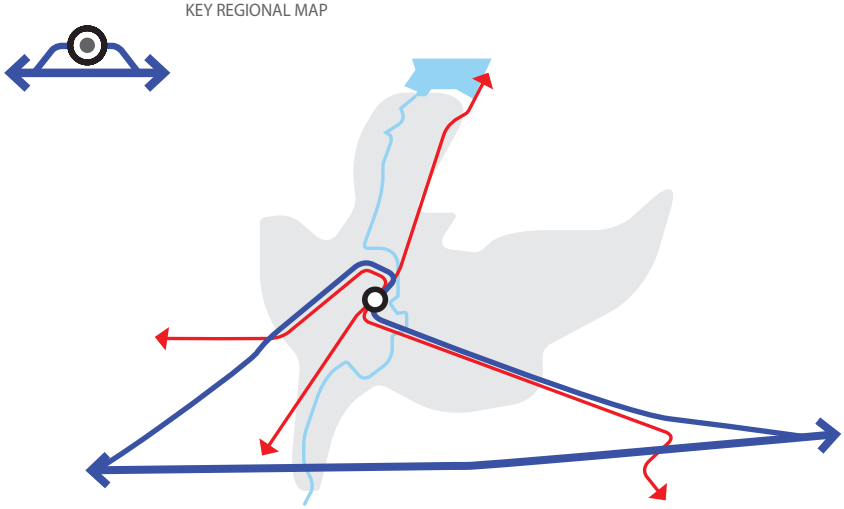
Schematic map showing Station typology recommendation



KEY

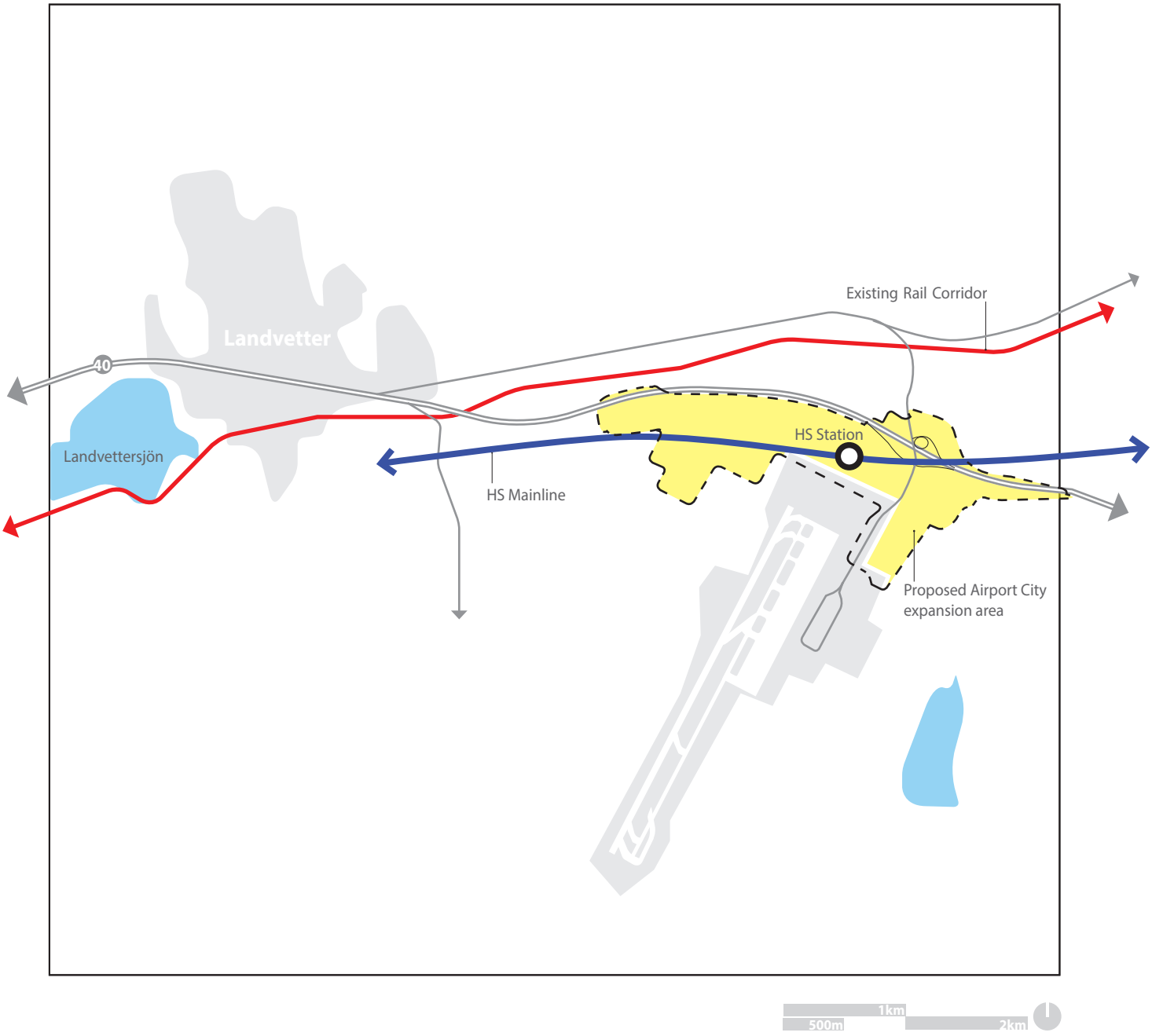
- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



LANDVETTER

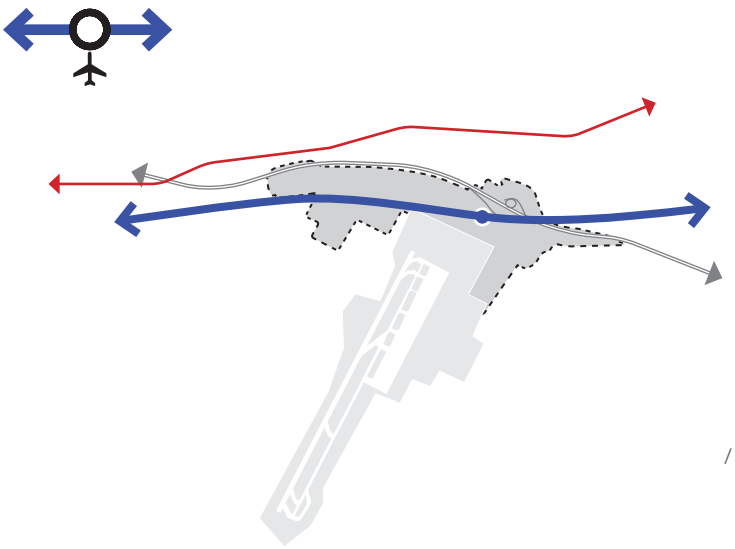
Schematic map showing Station typology recommendation



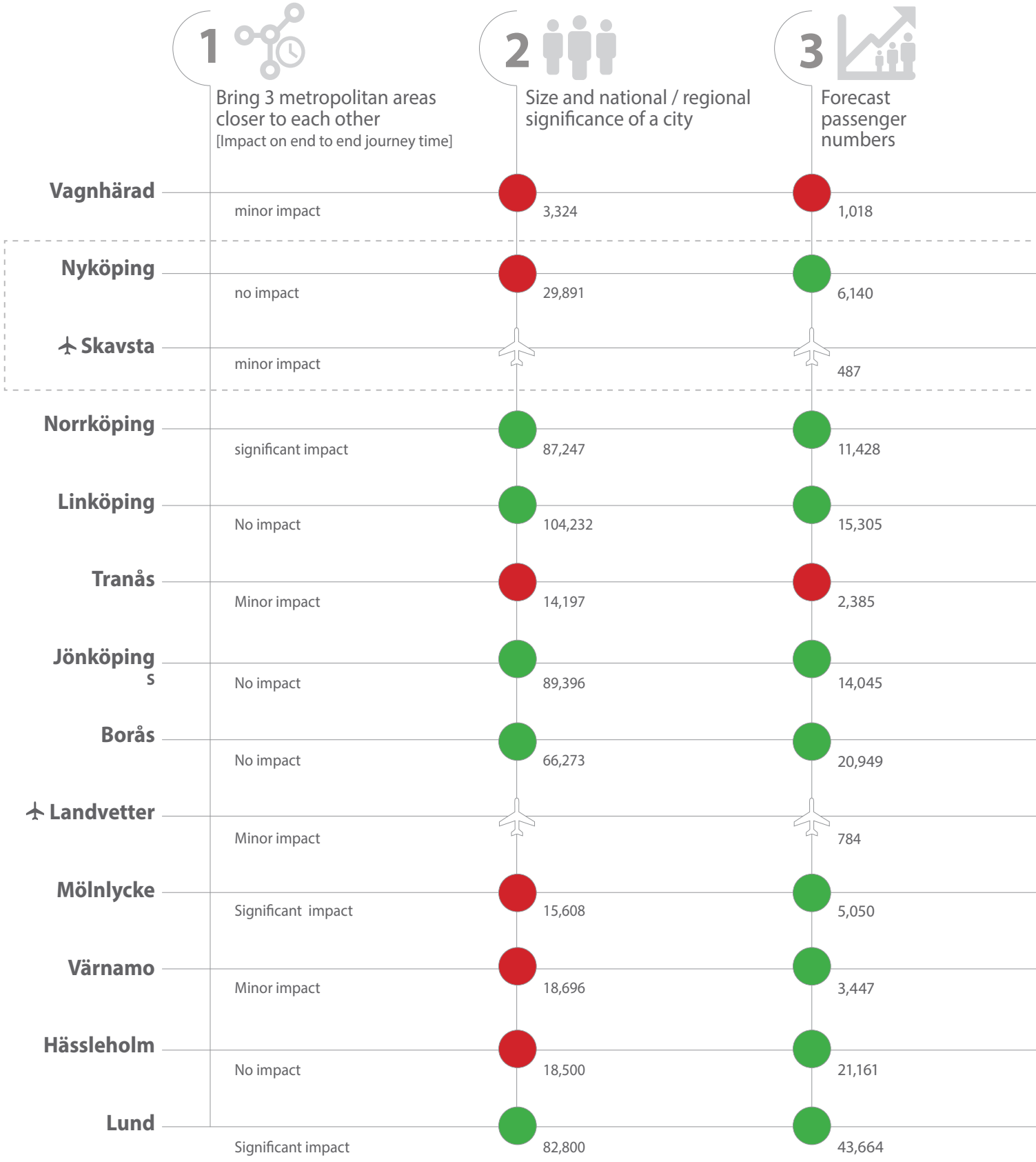
KEY

- Existing Rail
- Proposed High Speed Rail
- Proposed High Speed Station
- Existing Station
- Interchange Station
- Tram line
- Tram stop
- Highway
- Road

KEY REGIONAL MAP



SUMMARY TABLE




4
Contribute to increased housing construction
5
Station's significance for transfer: conventional and HS
Provisional Recommendations
Currently unknown
891
Potentially not included - subject to further studies
Currently unknown
6,525
Combined with Skavsta (Alternative 1)
0
Included (NHHI proposal)
Currently unknown
10,682
Included but peripheral on mainline (Alternative 2)
14,150
12,208
Included but alternative location (Alternative 1)
1,500
1,541
Potentially not included - subject to further studies
Currently unknown
7,689
Included but peripheral on mainline (Alternative 1)
16,100
8,237
Included but central on loop (Alternative 2)
474
Included but alternative location (Alternative 1)
2,950
3,669
Potentially not included - subject to further studies
1,770
54
Rorstop
Possible Station
Currently unknown
18,300
Possible Station
Ej klart (not clear)
41,772
Included (NHHI proposal)
Sverigeförhandlingens bud 2016-02-01

Alternative network map

OVERALL NETWORK RECOMMENDATION

Combing the recommendation for which stations should be on the system and the alternative typologies proposed for some of the remaining stations an alternative network proposal has been identified. It is suggested that this forms the basis for further investigation and assessment.

Alternative network diagram with major interchanges

6

APPENDIX

DOCUMENT REGISTER

Date Received	Description	Folder	Language	Source	Priority ta	Comment	Description
01/03/16	GIS Files of Swedish demographic data	160301 - Demographic Information		Trafikverket			GIS data
02/03/16	Report in Swedish from 01/12/15	160302 - Höghastighetsjärnväg Linköping-Borås (Swedish)	Swedish	Trafikverket	2		Section Report Ramboll Arup
02/03/16	Report in Swedish from 01/12/15	160302 - Main report for Phase 1 South from Jönköping (Swedish)	Swedish	Trafikverket	2		Section Report WSP Report Jonkoping to Malmo
02/03/16	Report in Swedish from March 2010	160302 - Pre-study for Almedal-Mölnlycke (Swedish)	Swedish	Trafikverket	2		First section from Gothenburg (Phase 1, old but describes area railway should be built in) subsection report of the Gothenbu
02/03/16	Translated short document from Trafikverket	160302 - Principles of Station Locations	English	Trafikverket			For information on station locations (Presentation for potential station options/styles)
02/03/16	Report in Swedish	160302 - Study of Mölnlycke-Bollebygd (Swedish)	Swedish	Trafikverket	2		Subsection of Gothenburg to Boras. Decision of the route
02/03/16	Report in Swedish from 15/04/03	160302 - Study of Mölnlycke-Bollebygd (Swedish)	Swedish	Trafikverket	2		Subsection of Gothenburg to Boras. Study of the route
02/03/16	Report in Swedish from 12/01/16	160302 - Swedish Traffic Report (Swedish)	Swedish	Trafikverket	2		Train pathing information. Number of high speed trains on the network. A new version of this is due end of June. This cover
02/03/16	Website link	160302 - Trafikverket Website					
02/03/16	Report in Swedish from 29/01/16	160302 - West of Borås Report (Swedish)	Swedish	Trafikverket	2	Work in pr	Subsection 3 report sent to the public and cities along the route. Public consultation document. Doesn't respond to the Swe
11/03/16	Presentation of meeting	160311 - 2nd Opinion Presentation		Trafikverket			
11/03/16	Minutes of meeting	160311 - 090316 Meeting Minutes		Trafikverket			
14/03/16	Eastern corridor maps	160314 - Corridor Maps East Link		Trafikverket	1		Review of this section as part of 2nd opinion work
15/03/16	Minutes of meeting	160315 - 110316 Meeting Minutes		Trafikverket			
15/03/16	Presentation of meeting	160315 - Presentation Meeting 01		Trafikverket			
15/03/16	Swedish HSR Standards in English	160315 - Swedish HSR Standards	English	Trafikverket	1		Latest copy of HSR design standards
16/03/16	Uncertainty analysis of route in English	160316 - A Cost Analysis using the successive principle	English	Trafikverket			
16/03/16	Choice of line and station document in English	160316 - Choice of Line Sections and Stations	English	Swedish Neg	1		Important document as this makes the descion
16/03/16	Referenced in Decision document	160316 - Choice of Line Sections and Stations	Swedish	Swedish Negotiations			Executive summary of Neg report SOU-2016_03 in row 21
16/03/16	Referenced in Decision document	160316 - Choice of Line Sections and Stations	Swedish	Swedish Neg	2	Based on c	Business case/commercial conditions?
16/03/16	Documents in Swedish	160316 - East link from JH	Swedish	Trafikverket	2		Latest official section documents for the whole of the East Link
17/03/16	Website link	160317 - Forhandling Swedish Website					
17/03/16	Website link	160317 - NextNorrköping Website					
17/03/16	GIS files	160317 - Southern Swedish Workplaces		Trafikverket			GIS file of working population
17/03/16	Station reports in Swedish	160317 - Stations from JS	Swedish		3		Background information of local plans (visionary documents)
18/03/16	Western link information in English	160318 - downloaded from Trakif	English		??	Clarify which report	
21/03/16	Expansion strategies and supporting documentation for the negotiations on high-speed railways Report from December 2015 in English	160321 - Translated Documents	English	Trafikverket	2	Based on c	Do we need the Swedish version of this for images
21/03/16	Image text translation for the above report	160321 - Translated Documents	English	Trafikverket	2	Based on old system	
21/03/16	Uncertainty analysis of route in English	160321 - Translated Documents	English	Trafikverket			
21/03/16	Basis for costs presented in December 2015	160321 - Translated Documents	English	Trafikverket			
21/03/16	Uncertainty analysis of route in English	160321 - Translated Documents	English	Trafikverket			
21/03/16	Cost and time report from 13/11/15	160321 - Translated Documents	English	Trafikverket			
21/03/16	Uncertainty analysis of route in English	160321 - Translated Documents	English	Trafikverket			
21/03/16	Figure from above report	160321 - Translated Documents	English	Trafikverket			
21/03/16	Cost and time report from 13/11/15	160321 - Translated Documents	English	Trafikverket			
21/03/16	Benchmarking of HSR	160321 - HSR Benchmarking	English	Arup	2	Sent for translation	
23/03/16	Ostlanken East Link Report	160323 - Ostlanken East Link Report	English	Trafikverket	2	Sent for tra	Marketing Document
29/03/16	TSI Infrastructure	160329 - TSI documents	English	WWW			
29/03/16	TSI Energy	160329 - TSI documents	English	WWW			
29/03/16	TSI Rolling Stock	160329 - TSI documents	English	WWW			
29/03/16	TSI Safety in Railway Tunnels	160329 - TSI documents	English	WWW			
29/03/16	California High Speed Rail Standard	160329 - CAHSR Tech Memos	English	WWW			
29/03/16	California High Speed Rail Standard	160329 - CAHSR Tech Memos	English	WWW			
29/03/16	California High Speed Rail Standard	160329 - CAHSR Tech Memos	English	WWW			
29/03/16	California High Speed Rail Standard	160329 - CAHSR Tech Memos	English	WWW			
29/03/16	California High Speed Rail Standard	160329 - CAHSR Tech Memos	English	WWW			
29/03/16	California High Speed Rail Standard	160329 - CAHSR Tech Memos	English	WWW			
29/03/16	California High Speed Rail Standard	160329 - CAHSR Tech Memos	English	WWW			
29/03/16	California High Speed Rail Standard	160329 - CAHSR Tech Memos	English	WWW			
29/03/16	California High Speed Rail Standard	160329 - CAHSR Tech Memos	English	WWW			
29/03/16	California High Speed Rail Standard	160329 - CAHSR Tech Memos	English	WWW			
29/03/16	California High Speed Rail Standard	160329 - CAHSR Tech Memos	English	WWW			
30/03/16	Table of contents from the NNHI report (SOU-2016_03_webbpdf-160112-2.pdf)	160330 - Table of Contents ANEG Report	English	Trafikverket			
30/03/16	Inventory of stations and station close environments	160330 - The Stations Basic Functions and Classification - TDOK2013	Swedish	Trafikverket			
31/03/16	The National Negotiation on Housing and Infrastructure. Commercial conditions for high speed trains in Sweden.	160331 - Translated Reports	English	Trafikverket			
31/03/16	The National Negotiation on Housing and Infrastructure.The high-speed railway: funding and commercial conditions	160331 - Translated Reports	English	Trafikverket			
06/04/16	Trafikverket timeline for the project	160406 - HSR Reporting Timeline	Swedish	Trafikverket			
07/04/16	24 Bids to the municipalities from 1st February	160407 - 24 Bids to municipalities	Swedish	Swedish Negotiations			

Task 1	Received	Title	Folder
Successive principle exercise	16/03/16	Cost analysis using the successiveprinciple Linköping-Borås.docx	160316 - A Cost Analysis using the successive principle
Commentary on route			
Risk Analysis Files			

Task 2a	Received	Title	Folder
Swedish Negotiation report 11/02/16	16/03/16	DECISION DOCUMENT - CHOICE OF LINE SECTIONS AND STATIONS 2016-02-01.pdf	160316 - Choice of Line Sections and Stations
Demographic data for station locations	01/03/16	Demographic data.zip	160301 - Demographic Information

Task 2b	Received	Title	Folder
Swedish Negotiation report 11/02/16	16/03/16	DECISION DOCUMENT - CHOICE OF LINE SECTIONS AND STATIONS 2016-02-01.pdf	160316 - Choice of Line Sections and Stations
Consultant Reports on geographical route sections			
Documents from GAP analysis			

Task 2c (on hold)	Received	Title	Folder
Swedish Negotiation report 11/02/16	16/03/16	DECISION DOCUMENT - CHOICE OF LINE SECTIONS AND STATIONS 2016-02-01.pdf	160316 - Choice of Line Sections and Stations
Timetable / train frequency requirements			
High level Demand forecast			
Consultant Reports on geographical route sections			

Task 2d	Received	Title	Folder
Swedish Negotiation report 11/02/16	16/03/16	DECISION DOCUMENT - CHOICE OF LINE SECTIONS AND STATIONS 2016-02-01.pdf	160316 - Choice of Line Sections and Stations
Trafikverket HSR geometry standards	15/03/16	TDOK 2014_0159 version 2.0 (eng information).docx	160315 - Swedish HSR Standards
Consultant Reports on geographical route sections			
Drawings and plans for terrain and characteristics of route			

Swedish Title/Reference	Title	Author	Description	Date	Status	Translated
	DECISION DOCUMENT - CHOICE OF LINE SECTIONS AND STATIONS 2016-02-01.pdf	Swedish Negotiations	This document aims to describe the background to the selection of line sections and station locations that The National Negotiation on Housing and Infrastructure has decided will be the basis of the negotiations for the Stockholm - Gothenburg and Stockholm-Malmö high-speed railway lines.	01/02/2016	Current	Yes
	NNHI bids/offers to the municipalities	Swedish Negotiations	The 24 bids submitted on 1 February the number of homes that the municipality commits to build and co-financing based on the value increase. For some municipalities have received the dossier was unclear or incomplete, and in these cases, the offer no information on the financing and residential expansion. The hearing begins when the work to achieve better data.	01/02/2016	Current	No
Höghastighetsjärnvägens finansiering och kommersiella förutsättningar	SOU-2016_03_webbpdf-160112-2.pdf	Government Document	High Speed Rail's financial and commercial conditions	12/01/2016	Phase 1	Only contents
Sammanfattning av delrapport från Höghastighetsjärnvägens finansiering och kommersiella förutsättningar	Sammanfattning-delrapport-webben.pdf	Government Document	Executive summary of the SOU-2016_03_webbpdf-160112-2.pdf report	12/01/2016	Phase 1	No
REPORT Expansion strategies and supporting documentation for the negotiations on high-speed railwaysPublication number: 2015:241	Expansion strategies for high-speed railways 2015-12-04.docx	Trafikverket	Expansion strategies and supporting documentation for the negotiations on high-speed railways Report from December 2015 in English	04/12/2015	Current	Yes
Dokumenttitel: Trafikeringsrapport, trafikering höghastighetsjärnväg i olika tidsperspektiv	trafikeringsrapport.pdf	Trafikverket	Train pathing information. Number of high speed trains on the network. A new version of this is due end of June. This covers the entire route. Precopy available in 2 weeks time.	12/01/2016	Current	No
Dokumenttitel: Bollebygd-Borås, en del av Götalandsbanan, Samrådshandling	lu_boy_bs_samradshandling.pdf	Trafikverket	Subsection 3 report sent to the public and cities along the route. Public consultation document. Doesn't respond to the Swedish Negs report.	29/01/2016	Current	No
Järnvägsutredning Ostlänken avsnitt Järna - Norrköping och Järnvägsutredning Ostlänken Norrköping C — Linköping C	j-nkp_kap6.pdf & n-lkp-kap-5-6.pdf	Trafikverket	Latest official section documents for the whole of the East Link		Current	No
Dokumenttitel: Översiktlig design och systemlösning. Höghastighetsjärnväg Linköping-Borås	oversiktlig_design_systemlosning.pdf	Trafikverket	Höghastighetsjärnväg Linköping-Borås Section Report (Ramboll Arup)	01/12/2015	Phase 1	No
Dokumenttitel: Översiktlig design och systemlösning Höghastighetsjärnväg Jönköping-Malmö – PM Huvudrapport	pm_huvudrapport.pdf	Trafikverket	Main report for Phase 1 South from Jönköping to Malmo Section Report (WSP)	01/12/2015	Phase 1	No
Almedal–Mölnlycke. En del av Götalandsbanan	forstudie_slutrapport_almedal_molnlycke.pdf	Trafikverket	Pre-study for Almedal-Mölnlycke, the first section from Gothenburg to Borås (Phase 1, old but describes area railway should be built in)	01/03/2010	Phase 1	No
Delen Mölnlycke – Rävlanda/Bollebygd. Beslutshandling	jarnvagsutredning_beslutshandling_molnlycke_bollebygd.pdf	Trafikverket	Mölnlycke-Bollebygd decision on the route. Subsection of Gothenburg to Borås.	01/04/2007	Phase 1	No
Delen Mölnlycke – Rävlanda/Bollebygd	jarnvagsutredning_mkb_112_mb.pdf	Trafikverket	Mölnlycke-Bollebygd study of the route. Subsection of Gothenburg to Borås.	15/04/2003	Phase 1	No

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