Norway High Speed Rail Assessment Study: Phase III

Market Demand and Revenue Analysis - Potential for HSR Feeder Network

Supplementary Report - Draft

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ATKINS

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1. Introduction

1.1. Norwegian High Speed Rail Context

Atkins was commissioned by Jernbaneverket (JBV) to support its study of the development of a High Speed Rail (HSR) network in Norway. The study provided an assessment of the value of various route alignments and stopping patterns, with a view to developing a case for a national HSR network.

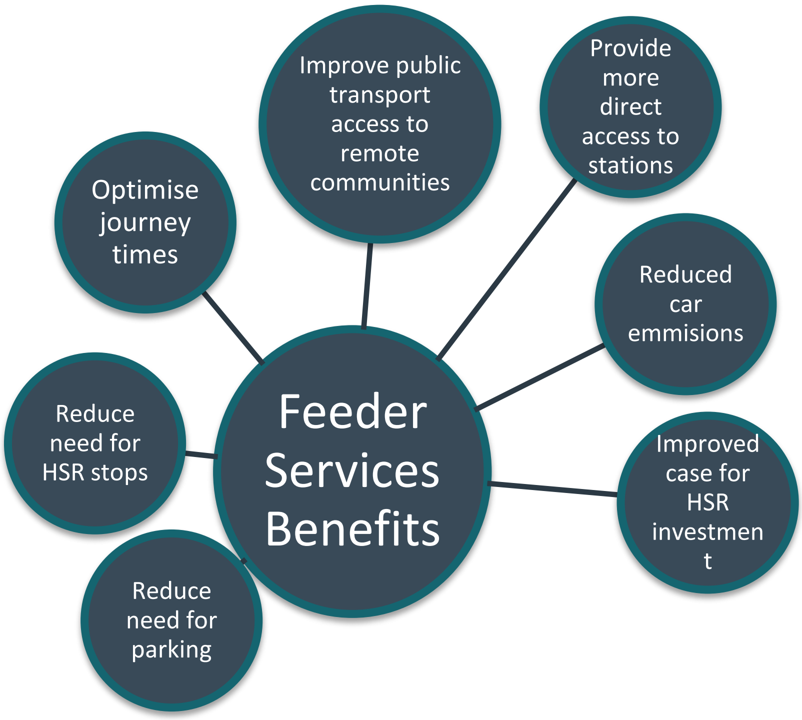
Part of the overall study has focused on potential station locations. A greater number of station stops on the network will provide greater social benefits as more communities are connected to the network. However, it is accepted that in order to attain competitive journey times between these communities the number of stops between the end points along each HSR corridor may need to be limited.

Given this limit to the potential accessibility of the network it is recognised that improving the access to proposed HSR stations by means of feeder services (connecting rail or bus services) may provide improved access for a greater number of communities. Additionally, the increased passengers attracted to HSR stations through improved accessibility may strengthen the overall demand and revenue forecasts for the HSR network. In this way the feeder services provide the link between successful local and national transport integration.

1.2. The Role of Feeder Services

Feeder services are considered to be local public transport services, which connect with HSR services at the proposed HSR station locations. For instance, a classic rail service with multiple stops calling at small communities may be timetabled so that it arrives at an HSR station just before a high speed train is due to depart, allowing for a convenient interchange. In this way the high speed service is able to capture demand from smaller communities along the classic rail line, where it would not be able to call itself. A bus or coach could well form such a feeder service where a railway doesn't exist. The resulting improved accessibility to HSR stations provides several benefits, outlined in Figure 1

Figure 1. The role of public transport in the integration of HSR services



However, whilst the existing classic rail service may in places lend itself to providing such a feeder service it would need to perform its existing activities if these provide an important social function. Classic rail will lose most of its high value long distance patronage if an HSR network is built and so the viability of maintaining the railway may be questioned: buses may offer a more affordable service.

Public transport accessibility is important because it provides mobility to those without private transport. Furthermore, at the destination end of a trip, there is less likely to be a car available.

1.3. This Report

The work presented in this report is designed to provide a high level assessment of the value of feeder services across the potential HSR network. The complexity and the number of alternatives involved mean that a broad methodology has been used with a number of global assumptions. This report is structured as follows:

- Chapter Two, **Principles of Feeder Services**, provides a discursive analysis of HSR station accessibility, drawing on conclusions from Phase Two of the Norwegian HSR study[1]. Examples of how feeder services can improve accessibility, including case studies from around the world, give an insight into the potential in Norway;
- Chapter Three, **Rail Feeder Services**, presents the improvement to accessibility of HSR stations owning to the introduction of rail feeder services. This approach uses geographical information system (GIS) mapping to analyse improvements to population and employment accessibility;
- Chapter Four, **Bus Feeder Services**, provides a review of the potential benefits of bus feeder services as an alternative to rail;
- Chapter Five provides **Conclusions and Recommendations**, including a high level quantification of the potential value of feeder services, and suggestions for further assessments at the more detailed design phase.

The recommendations in Chapter Five combine the evidence from the previous chapters to provide a view on where feeder services are likely to bring the most benefit and under what circumstances. In isolation the numerical figures presented in Chapters Three, and Four cannot be expected to provide concise recommendations, due to inherent uncertainties in the methodologies and the strategic nature of the modelling work.

This work is predominantly focused on the intermediate stations i.e. those between the termini located in major cities. Clearly good interchange modes exist already in the major cities and this is discussed in the Phase Two Report: **Location of Stations & Termini**.

The outputs from this report include:

- Maps of station accessibility improvement when feeder services are provided for the proposed Norwegian HSR stations;
- Charts showing the changes to population catchments when feeder services are provided;
- Graphs showing the estimated demand and revenue on the overall scheme when feeder services are provided.

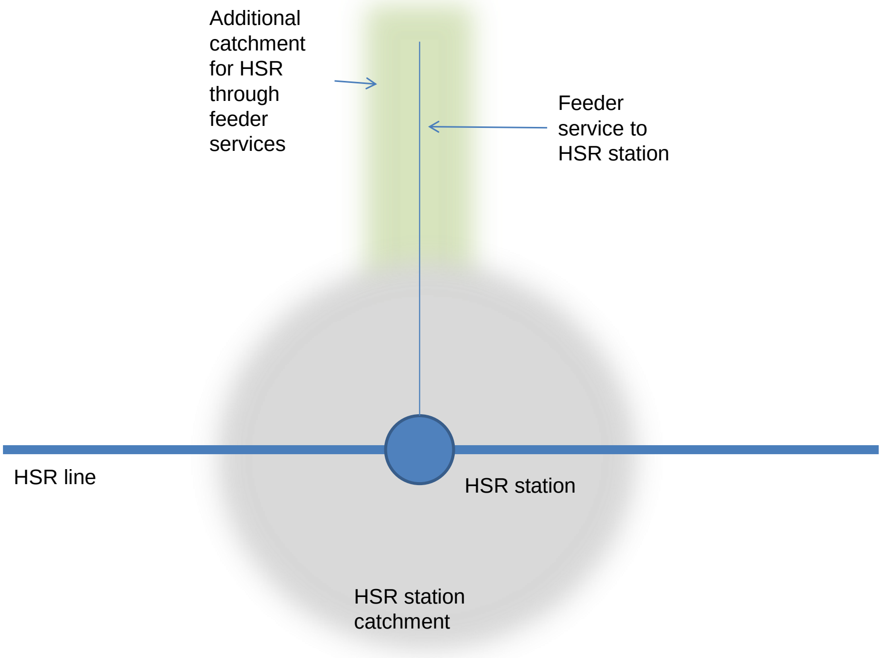
[1] Phase Two: Locations of Stations and Termini

2. Principles of Feeder Services

2.1. Introduction

The introduction of feeder services to HSR has the potential to enlarge the catchment of HSR i.e. more people are likely to travel by HSR compared to without the feeder scenario. This is illustrated in the Figure 2.

Figure 2. Feeder service expanding the HSR catchment



There are several issues to be considered with regards to feeder services:

- Where should be considered? – **Catchment, market and stations**;
- What sort of feeder services should be provided? – **Mode**;
- How feeder services should be integrated with HSR services? – **Timetables**;
- What the financial and socio-economic implications are? – **Revenue, costs, benefits and funding**.

2.2. Catchment, market and stations

There are several ways to access a station:

- On foot – this is often perceived as from the immediate catchment of a station, typically one or two kilometres radius from the station, which is a reasonable distance for people to walk;
- By car – this depends on car availability to people and if there are sufficient car parking spaces at and around the station;
- By public transport – this of course depends on the availability and performance of public transport to and from the station;
- By other modes – such as bicycle, which depends on the availability of cycle parking and other local physical conditions.

The extent to which public transport feeder services are required depends on the extent to which the market for HSR travel is judged to be “constrained” by the level of access.

In cities, for example, railway stations are often connected to other parts of the urban and suburban areas by public transport. Such connections perform a feeder role.

Figure 3. A connecting bus at Lysaker. Urban HSR stations typically have well developed public transport including bus and local railways.

2.3. Feeder Mode

Feeder services can be provided by a number of modes, including bus, light rail and conventional rail, each with its own strengths and issues.

Bus is typically relatively cheap to set up and operate. It is also flexible in terms of routing. However, it typically has a limited capacity and hence may not be appropriate if the feeder service is intended to facilitate mass travel movements. It is often perceived as of a lower quality in terms of travel experience, due to ambience and often longer journey times compared to rail.

Light rail, where no existing alignments exist, can be expensive to build and operate. Operationally it is less flexible compared to bus. However, that lack of flexibility often provides a sense of confidence among people in that once built it is less likely to be withdrawn compared to a bus service. Often, it is perceived as of high quality, offering good ambience and relatively short and more reliable journey times compared to buses.

Conventional rail is more expensive to operate but has greatest potential to offer a seamless travel experience for HSR passengers, as transfers from feeder to HSR services can be achieved without having to leave the station. In Norway the existing classic rail network could be amended to provide classic rail feeder services.

2.4. Integrating feeder and HSR services

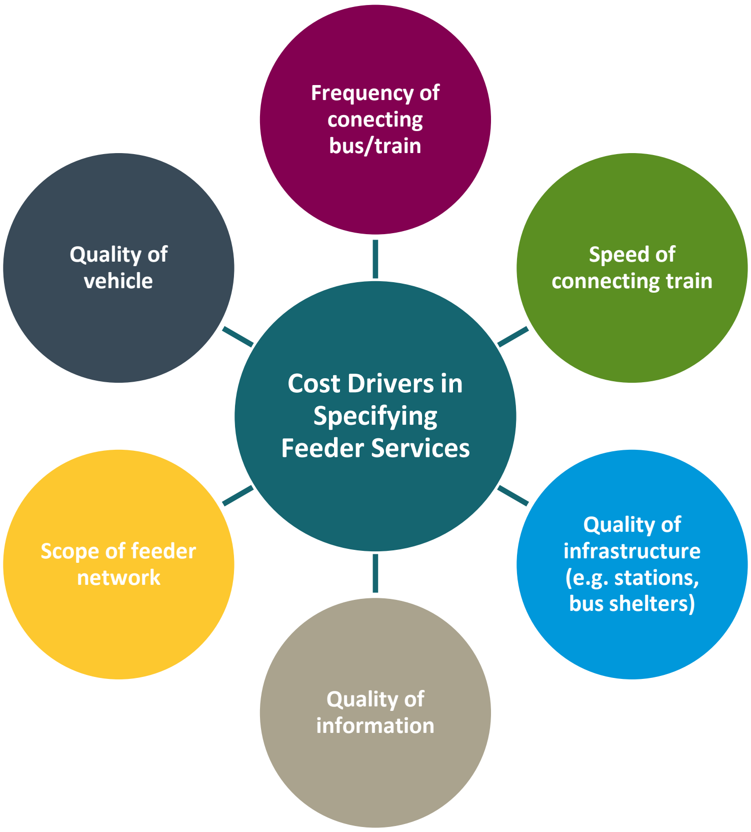
The concept of a feeder service is that it supports HSR. In its supportive role, it is often envisaged that once the HSR timetable has been optimised, the feeder service timetable should then be synchronised with the HSR timetable. However, in reality, it may be the case that HSR and feeder service timetables need to be considered together, especially if the feeder service is provided by an existing mode, such as conventional rail, with its own timetable and path restrictions.

2.5. Financial and socio-economic implications

If the primary objective of the feeder service is to enhance the catchment of HSR, then the revenue implication is that of additional revenue to HSR. This needs to be considered against the cost of providing that feeder service. Depending on the profitability of this service, funding needs to be considered.

In terms of cost, brand new services are expensive. It is often more efficient to optimise existing services to provide feeder functions, as with the case study of HSR in the UK. However, where there is limited existing public transport provision, such as in the more rural areas, new services may have to be introduced to provide that feeder function. As discussed in Chapter 4, bus may be the most affordable mode, and offer sufficient capacity to serve areas with lower population and demand density. There are a number of factors influencing the cost of feeder service provision, as illustrated in the **Error! Reference source not found.**4.

Figure 4. Factors influencing the cost of the feeder service



In Norway the economic viability of parts of the classic rail network will deteriorate once the HSR lines are open. Long distance passengers, who contribute the majority of revenue, will switch to HSR. It may be necessary to scale back classic rail services that are not viable, or replace them with buses. This is discussed in chapter 4.

2.6. Summary of Principles of Feeder Services

Feeder services provide the opportunity for a larger proportion of Norway to be encompassed into an integrated transport system with HSR at its heart. Feeder services bridge the gap between long distance national transport and regional accessibility.

The establishment of feeder services, whether as brand new services or as adjustments to existing services, will enlarge the catchment of HSR. Such an enlargement should provide additional demand for HSR and potentially enhance the project's overall appeal to parties which may not otherwise benefit substantially. Depending on the requirement for the feeder service (brand new or adjusted) and the conditions under which they will operate (population and demand density and cost), bus, light rail and conventional rail can provide the feeder function.

- Feeder services should be aligned with the HSR services so as to provide as seamless a journey experience as possible. It may be a case, if feeder service timetables are constrained, that there is the need to optimise the timetables of feeder and HSR services jointly;
- Feeder services should increase HSR demand and hence revenue and socio-economic benefits. In addition, it may be possible for the feeder service to be chargeable to its users, although this needs to be balanced against the overall objective of these services – user charge is likely to reduce demand for HSR and socio-economic benefits. The cost of these services can be off-set by government and other private sector revenue support, depending on the service specification. A range of parties may contribute to the funding of these services as well as their specification, so as to deliver the commercial, socio-economic and political objectives intended;
- Feeder services can operate, completely independently, as part of the HSR operations, or as a company set up involving a number of interested parties. Through-ticketing should be technically feasible, enhancing the experience of seamless travel.
- Feeder services are important even for individuals who access their home station by car, as it is likely that they will require public transportation at their destination.

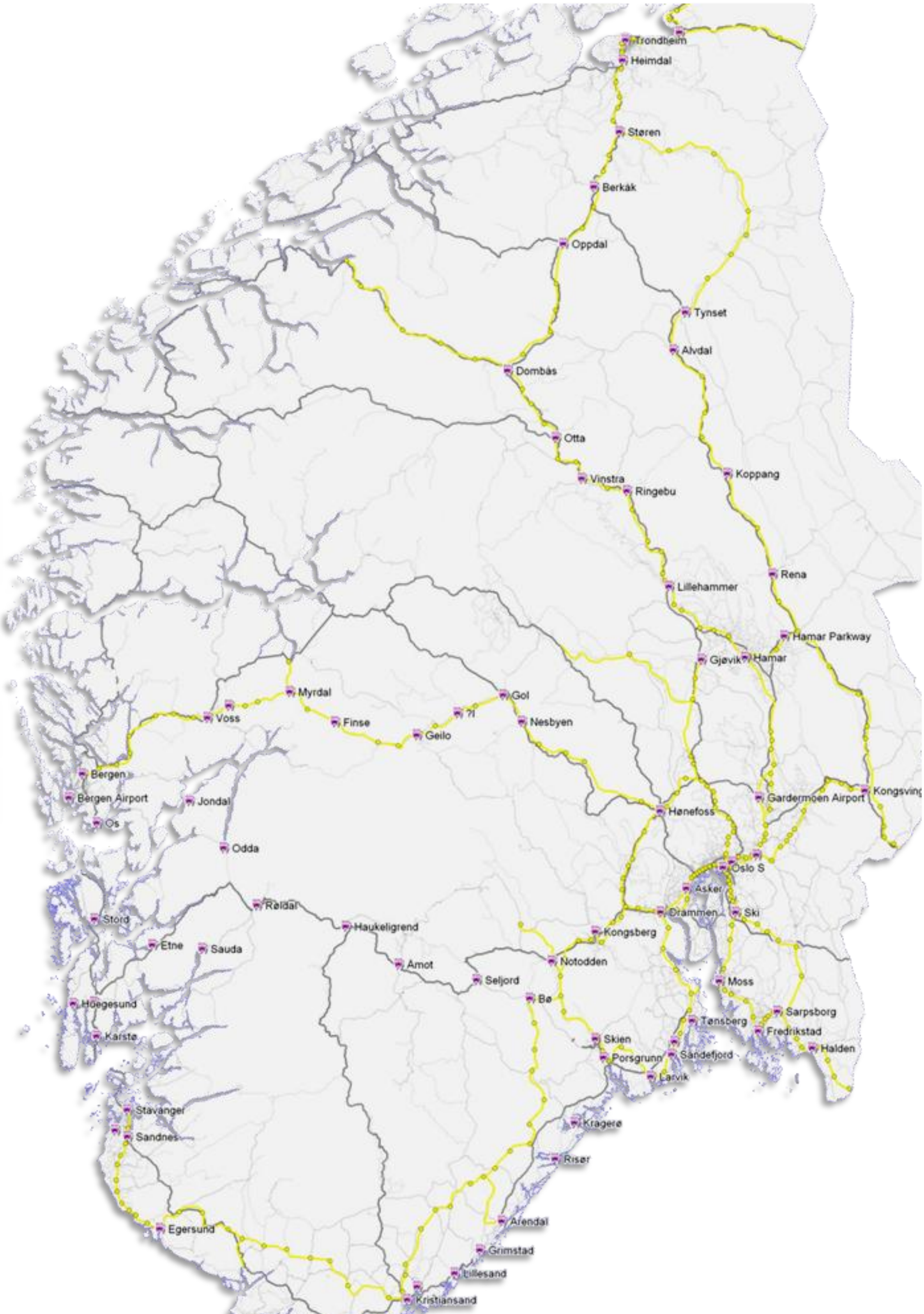
3. Rail Feeder Services

3.1. Introduction

The proposed Norwegian HSR network is constrained in its accessibility particularly in rural areas by the need to minimise end to end journey times, and the clear practical issues relating to cost. There is no such constraint on the existing classic rail system – in corridors where it exists it invariably serves most communities, which have developed around it. Figure 5 on the next page presents the location of the proposed HSR stops and the existing rail network. It can be seen that on most corridors HSR stations are proposed along existing routes (the exception being the Western Haukeli alignment). At the interfaces between the HSR and classic rail networks there is an opportunity to use the classic network to deliver passengers to the HSR services. Clearly the feeder services depend heavily on the station choices, and more important (Tier 1) stations are more likely to support a multitude of rail services.

This chapter firstly discusses how this interface may present itself, and suggests three broad scenarios for feeder service implementation. Then for each of these scenarios changes to accessibility are assessed using our GIS and accessibility modelling tools, to present potential improvements to the catchment of HSR stations. Enhancement to total journey times for communities is also presented.

Figure 5. Location of proposed HSR stations (labelled purple) and the existing classic rail network (yellow), and major roads (grey)



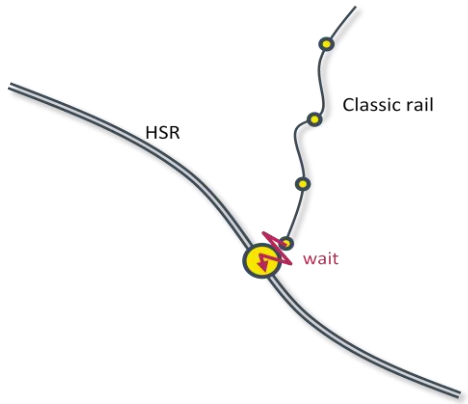
3.2. Rail Feeder Scenarios

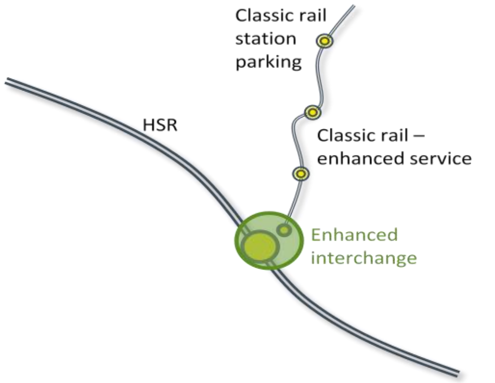
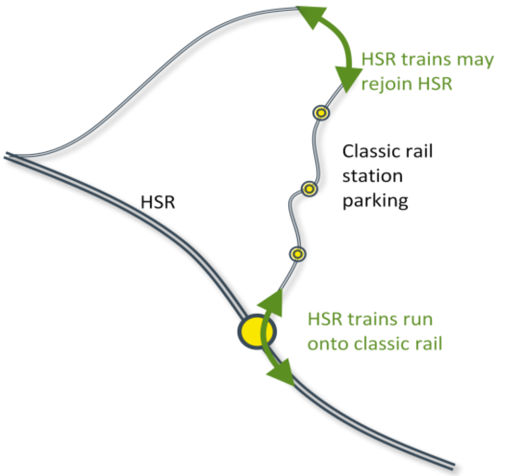
There are a numerous permutations of rail feeder service arrangement, and this will affect the perceived integration of services. The level of integration of feeder services with the core HSR service could fit into the following categories:

- **Existing rail services maintained -** no attempt to retime rail services to coincide with HSR, classic rail trains run exactly as they do today with no attempt to integrate with the new HSR services.
- **Retimed classic rail** – trains timed to allow for immediate cross platform interchange, or for short waiting times at HSR interchanges.
- **HSR trains divert onto classic rail** – in this scenario the HSR trains would be extended from the HSR route onto slower tracks with stops at smaller stations.

In practice, the second scenario is subject to the most variation. For instance, the number of HSR and classic rail services to be integrated might be subject to variation in different locations. **Error! Reference source not found.** summarises these three broad scenarios for classic rail integration.

Table 1. Levels of integration of local rail services

Feeder Service	Advantages	Disadvantages
Existing maintained No attempt to enhance classic rail to feed into HSR  	• No investment required in new rolling stock station facilities, or line speeds • No impact on existing rail operations; • No changes to existing service specifications and any resulting adverse impact on existing travellers.	• Wait time between classic rail train arrival and HSR arrival may be long; • Interchange penalty at station – a result of waiting on the platform and walking between platforms; • Penalties due to waiting and interchange make feeder service plus HSR journey option unattractive.
Retimed and enhanced classic rail Classic rail services continue to call at minor stops but are retimed so that they arrive at the HSR stop to coincide with the HSR service. Enhanced interchange facilities at the HSR stop ensure that passengers have a seamless connection from the classic rail feeder to HSR. In order to encourage use of the classic rail feeder, its stations are upgraded including car parking.	• Almost seamless connection between HSR and local services; • Improved connectivity to local transport enlarges the catchment area of the HSR stations; • Reduced need to travel by car to the HSR station if classic rail serves communities (likely where classic rail is located along populated corridors such as valleys); • Development of stations as regional transport hubs, creating a more integrated system.	• Significant changes to existing classic rail services required, which may be to the detriment of some existing local journey patterns; • Enhancement to classic rail services comes with a cost e.g. additional rolling stock, station enhancements; • There is still an interchange penalty at the HSR interchange – passengers still need to change trains interrupting work or comfort; • Classic rail remains slow and may not be able to

		compete with car mode for HSR station access.
Diverted HSR HSR trains leave the dedicated HSR line and are diverted onto classic rail where local stations are served. 	• HSR able to serve many more communities, which are currently connected to the rail network but may be distant from an HSR station; • Direct trains with no interchange required.	• Diversion from HSR slows down HSR services considerably; • Difficult to conceive how such services would fit into key HSR objective of servicing the large termini at the ends of the HSR line; • Cost of running HSR trains along classic routes to serve areas of low demand; • May need to upgrade classic infrastructure.

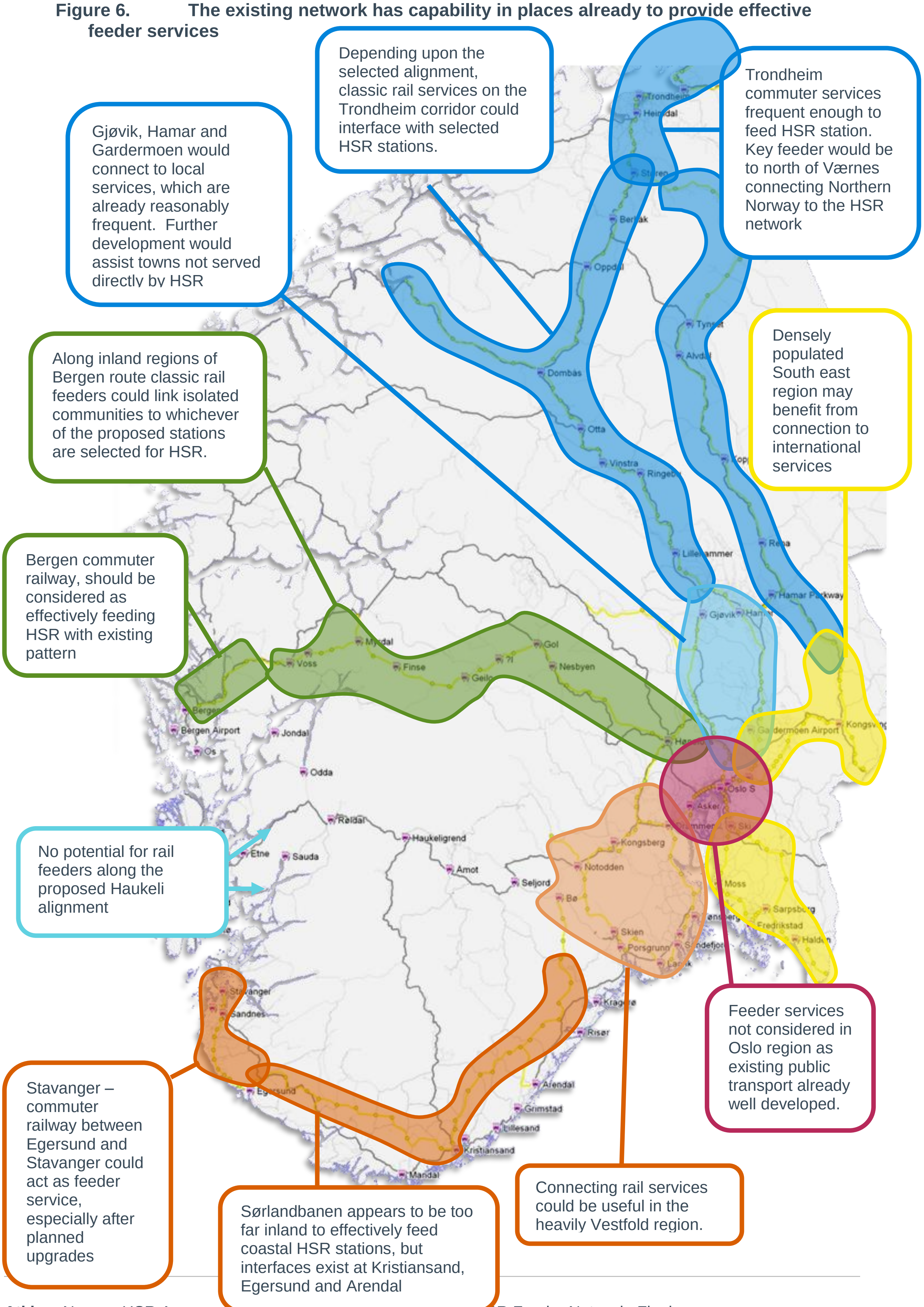
Atkins has designed an accessibility model to test indicatively the impact of the types of classic rail integration described in **Error! Reference source not found.**. In particular, it has been designed to allow any interchange penalty to be used. Furthermore the model allows the mode preference weighting to be changed be specified so the “diverted HSR” scenario could be tested.

In this chapter we will look at the benefits of supplying a connecting classic rail feeder with a five minute interchange time, representing virtually seamless interchange – this corresponds to the second scenario described in **Error! Reference source not found.**.

3.3. Classic Rail Feeder Service Potential

The interfacing classic rail routes have been identified and described in . Different sections of the existing railway may have a role in connecting with the HSR network but this is heavily dependent upon the location of HSR stations. Furthermore the efficacy of a feeder network enhancement is highly dependent upon the HSR service specification. On the one hand if on a particular corridor maximal stations are constructed with regular stops there is less need for feeders. Conversely if intermediate stations are too few, there will be fewer interfaces for feeder service connection.

Figure 6. The existing network has capability in places already to provide effective feeder services



The modelling framework has been set up to explore any combination of selected HSR stations, all of which can have the level of feeder specified individually. **However, this chapter focuses on four specific network alternatives, which have been progressed to appraisal in the main scenario testing report: *Market, Demand and Analysis:***

- *Northern Corridor G3:Y* – 250 kph Oslo – Trondheim / Vaernes via Gudsbrandsdalen serving Gardermoen, Hamar, Lillehammer, Otta and, Oppdal;
- Western Corridor HA2:P: 330 kph Oslo – Bergen via Hallingdal serving Hønefoss, Geilo and Voss;
- Southern Corridor S2:P: 330 kph Oslo – Stavanger via direct route serving Drammen, Porsgrunn, Arendal, Kristiansand, Mandal, Egersund and Sandnes;
- Eastern Corridor G01:S: 330 kph Oslo – Gothenburg via direct route serving Sarpsborg, Halden and Trollhättan.

The identification and choice of stops per HSR Option is explained in the report ***Norway HSR Assessment Study, Phase III: Journey Time Analysis, Final Report, January 2012.***

3.4. Northern Corridor – G3:Y

The Trondheim urban area is to be served by an HSR station at a new Trondheim station, with trains continuing to an interchange with the airport at Værnes under this alternative. The two stations are served by the Trøndelag commuter railway, which runs an hourly service (half hourly at peak times) from as far north as Steinkjer station. The analysis has not demonstrated much benefit to journey times of integrating these local services with HSR. This is because of the low speed of the existing railway, and its frequent stops causing journey times to be less competitive than road. However, the Gevingåsen Tunnel and proposed route improvements may bring regional journey times down considerably, and this is not captured in the modelling. Given the relatively high population density along the Trondheim – Steinkjer corridor, there is a case for integrating local services with the HSR timetable at Trondheim S, or at an expanded interchange at Værnes.

Analysis shows that the region that would benefit most from feeder services is the Otta-Oppdal railway section and suggests that both the Dovrebanen and Raumabanen deliver improved journey times to HSR stations over parallel road connections, provided interchange is timetabled at Otta or Oppdal (**Error! Reference source not found.**7). Annual HSR demand to Oppdal and Otta is forecast to be considerably lower than say Trondheim and the value of these stations stops increases with the integration of local services. Presently Raumabanen trains act as feeders for Dovrebananen trains –it may be worthwhile to extend Ramabanen services to Otta if feasible to improve HSR connectivity, although the population along the Raumabanen is very low.

Figure 7. Changes to journey times with classic feeder network interfacing at HSR stations for the G3:Y scenario in the Oppland region

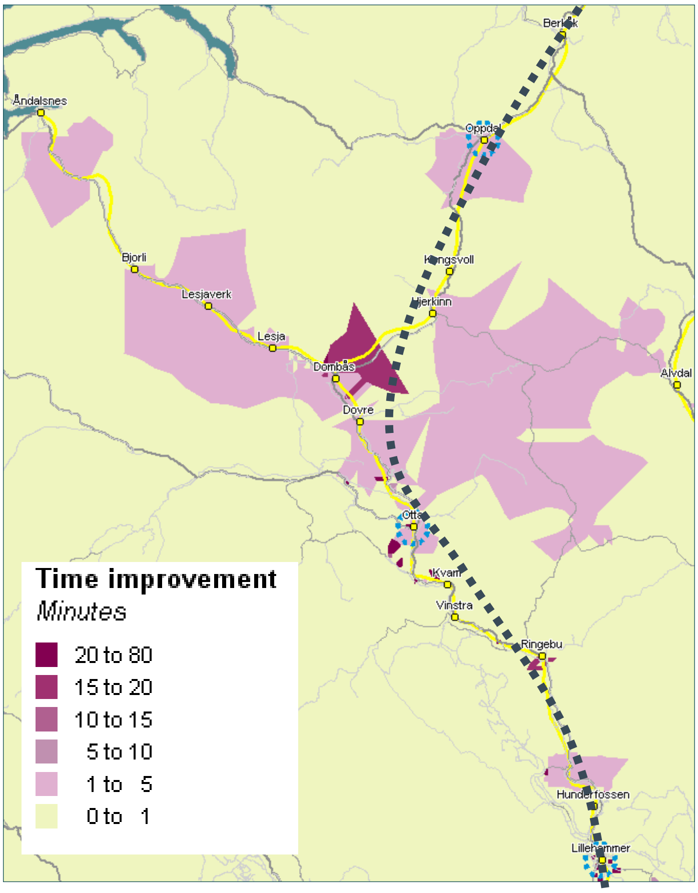
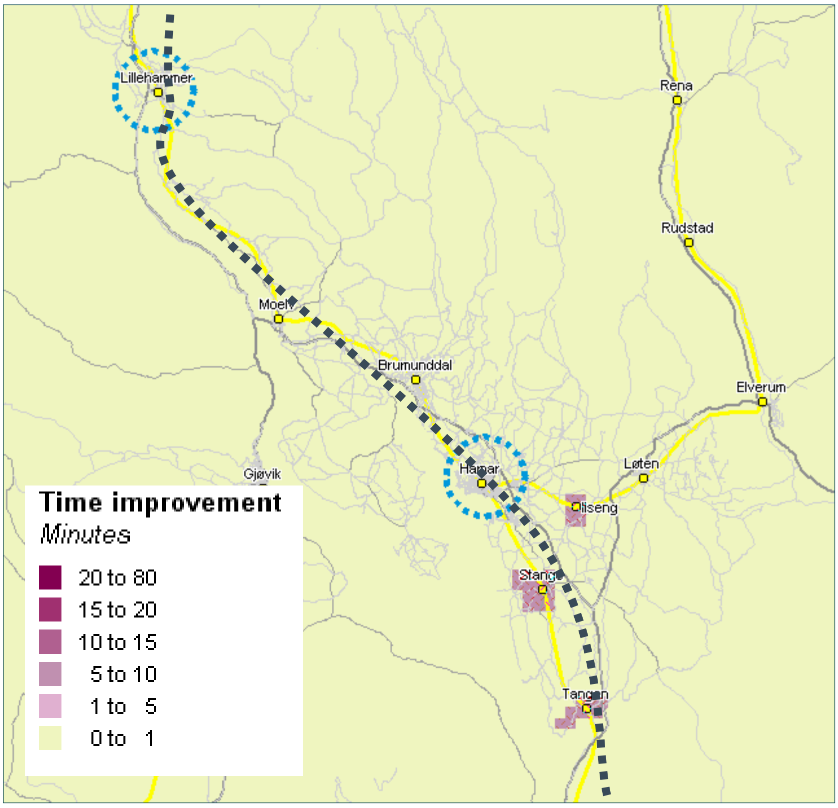


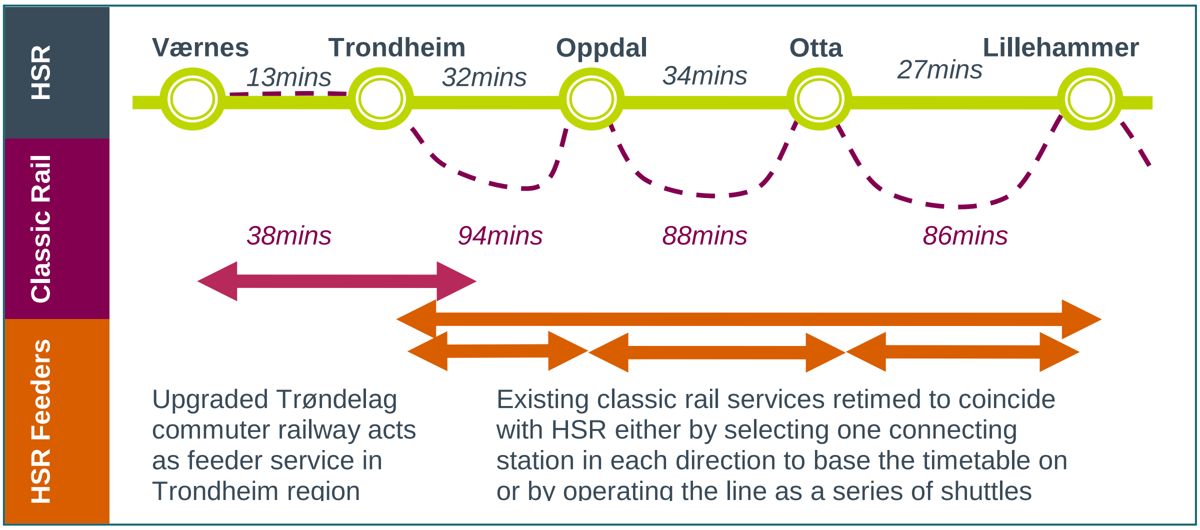
Figure 8. Changes to journey times with classic feeder network interfacing at HSR stations for the G3:Y scenario in the Ringsaker area



Less journey time benefit arises from the integration of feeder services in the Hamar region as shown in **Error! Reference source not found.**8 despite the greater range of potential rail connections. This is due in part to the greater road network density, which means there is less benefit in connecting via the relatively slow rail network. Nevertheless Rørosbanen services could be timed to coincide with HSR at Hamar to reduce rail journey times to Oslo as frequencies on that line are low.

Timetabling the classic rail service to provide a feeder to all the HSR stops is clearly a challenge: if the service is timed to integrate with HSR at Oppdal it may be impossible to use the same train at Otta. Either the timetable would need to prioritize particular stations, or could operate as feeder shuttles as illustrated in **Error! Reference source not found.**.

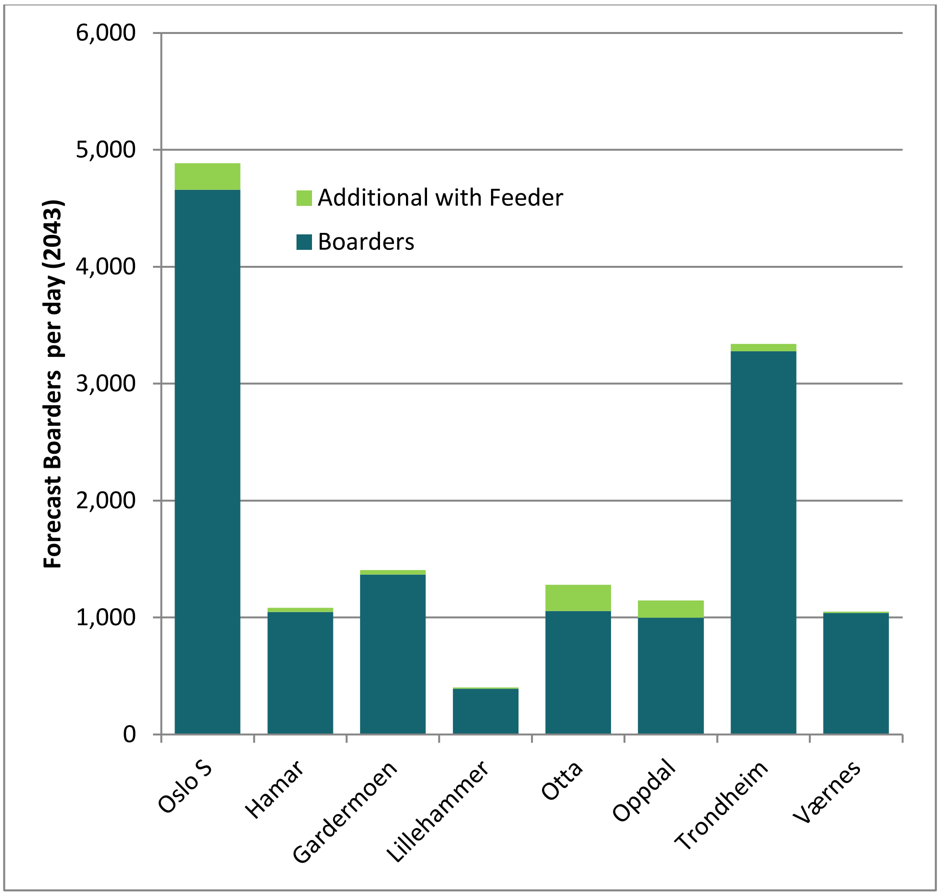
Figure 9. Illustrative potential classic rail network configuration



3.4.1. Network Demand Potential

The improvement to station accessibility may attract additional demand to the network, and Figure 10 illustrates the potential scale of this. These figures, which are intended only to be illustrative, arise from reducing station access times in the areas where the classic rail network could serve as a feeder system. Whilst the figures can only be approximate at this stage, they do demonstrate that on this corridor the Otta and Oppdal area benefits most from the integrated HSR and classic rail timetable.

Figure 10. Indicative additional boarders with feeder enhancement on the Northern corridor



These approximate forecasts demonstrate that an additional 700 passengers could use the HSR service each day, generating revenue of up to 65m NOK per year (2043 forecast). The model indicates that average yields would drop very slightly suggesting that the feeder services enable some degree of journey optimisation. For instance a resident at Brummandal travelling to Trondheim may have driven to Lillehammer HSR station, but with the classic rail feeder could take the train to Hamar, avoiding effectively starting the journey travelling in the wrong direction.

3.5. Western Corridor – HA2:P

The Western corridor railway, the Bergensbanen, passes through the majority of settlements in the region, which are invariably of low population and clustered around the railway. Although the rail route is slow, it offers public transport connectivity to settlements located in difficult terrain, with circuitous road routes. The HA2P alternative offers potential to connect local services with HSR at Bergen, Voss, Geilo and Hønefoss. Bergen is already served by a half hourly local commuter rail, which extends hourly as far West as Voss.

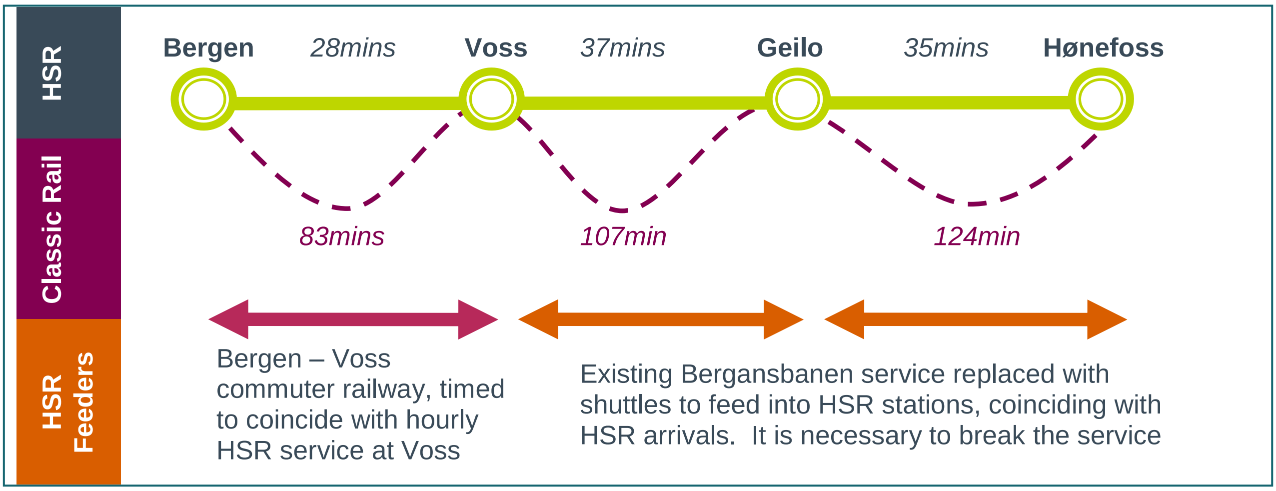
Error! Reference source not found. shows that a judicious recasting of Bergen – Voss local services, to provide a five minute interchange with HSR at Voss can provide significant journey time benefits to populations around Dale and Evanger stations for passengers travelling to Oslo. This increases the value of the station at Voss, which may also prove to be a useful interchange for connecting buses (see Chapter 4).

Poor road accessibility in the Myrdal and Finse areas results in journey time benefits from providing interchange from local services to either Voss or Geilo. As there are only five services per day at present the recasting of these services would require careful consideration to connect with an hourly HSR station at either Voss or Geilo.

Accessibility analysis suggests journey time benefits can add value at Nesbyen and Gol providing a feeder into Geilo and Hønefoss.

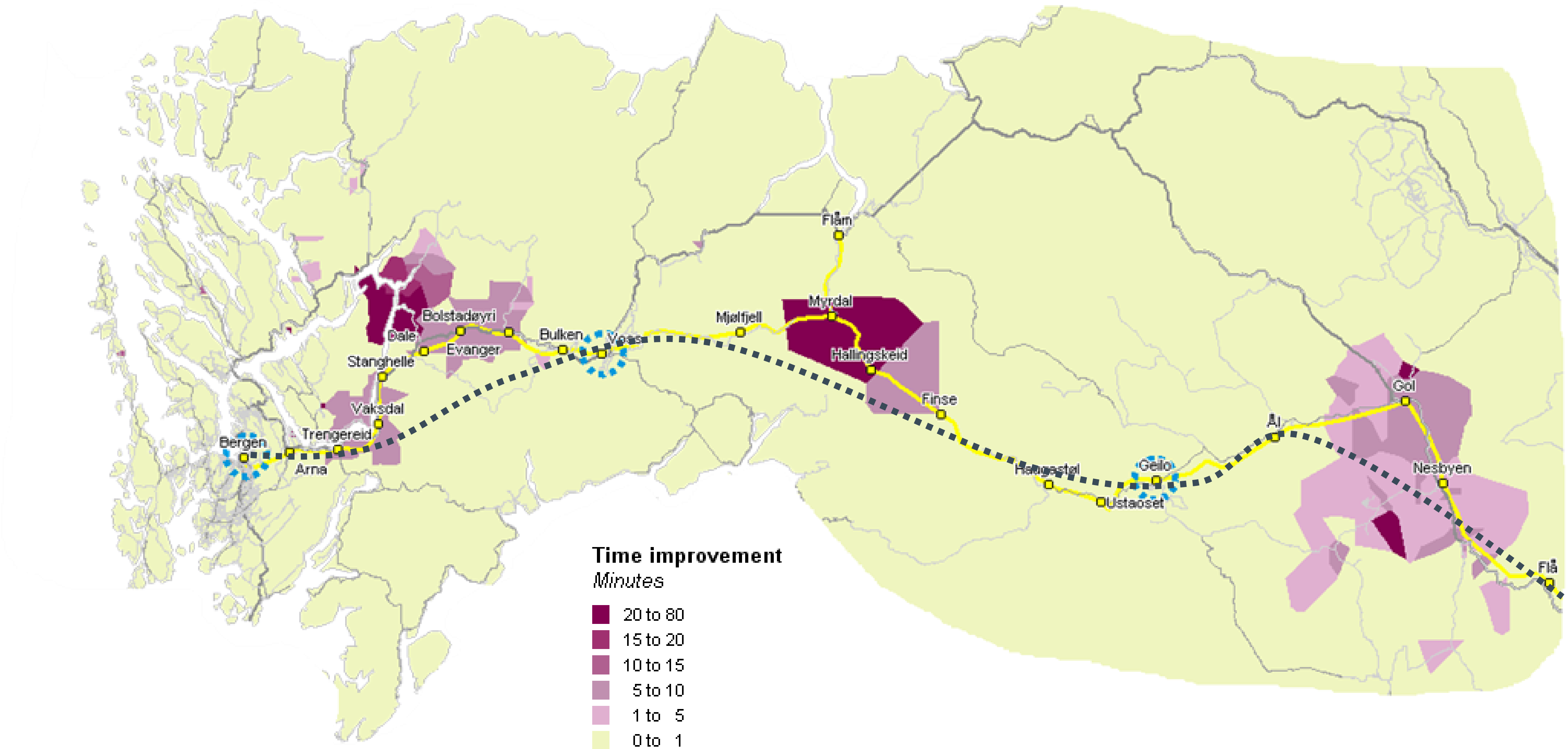
Overall along this corridor there appears to be real potential benefit from coordinating the local services with HSR – the challenge is whether this can be delivered at all interchange points simply by recasting the existing five services. One solution, as illustrated in **Error! Reference source not found.** is to divide the Bergensbanen into shorter shuttles, which are designed to arrive at one of the HSR stations in tandem with the HSR service. This would ensure fast journeys to HSR destinations from the intermediate stations. For example, a local feeder train from Gol would coincide with a Bergen bound HSR service at Geilo providing good overall Gol-Bergen journey time. The problem with dividing the railway in this way is that local journeys across HSR stations, such as Gol to Myrdal would endure a worse than existing service having to wait for a connecting local train at Geilo.

Figure 11. Principle of recasting existing classic rail times to optimise connections with HSR



Detailed analysis of demand from sections of the classic rail route should be undertaken to optimise the rearrangement of trains along this route. In places there may be a case for removing the classic rail service altogether and this is discussed in Chapter 4.

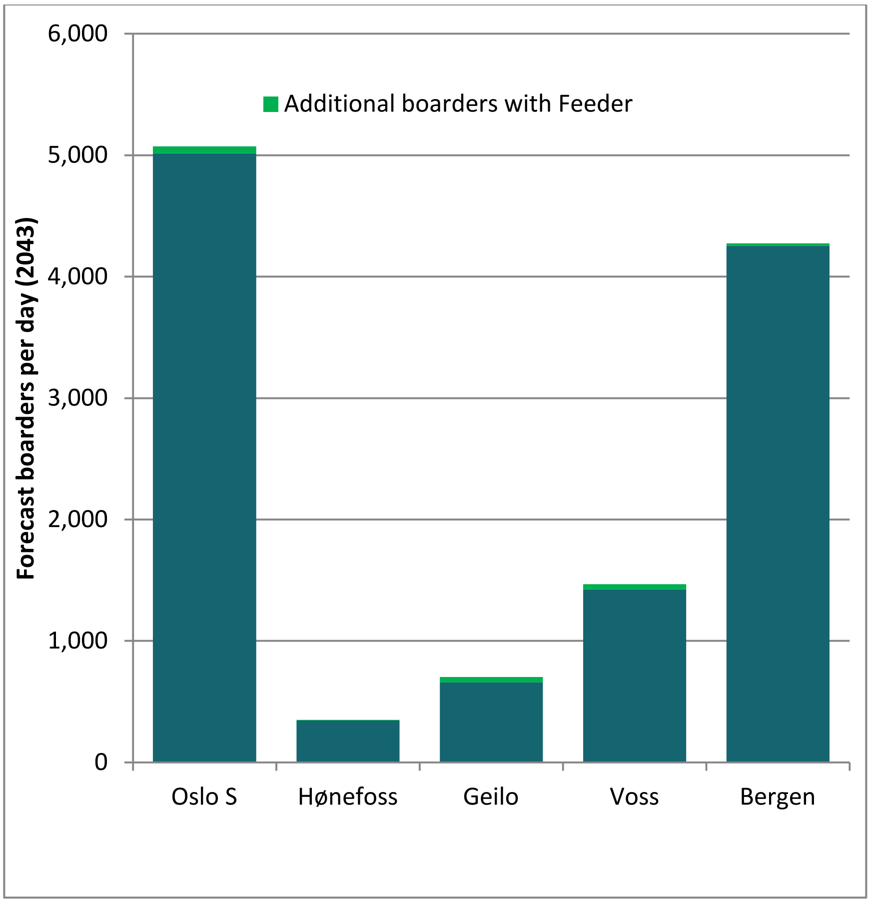
Figure 12. Changes to journey times with classic feeder network interfacing at HSR stations for the HA2P scenario



3.5.1. Network Demand Potential

Despite significant improvement to access times in regions around Voss and Geilo there appears to be small response in the demand forecasting model as presented in **Error! Reference source not found.**. This may be because the mode shift to HSR has already occurred as there is no air alternative. The forecasting suggests that the extra passengers could bring an additional 16m NOK, again it must be emphasised that this is very much an estimation at this stage of analysis.

Figure 13. Indicative additional boarders with feeder enhancement on the Western corridor



3.6. S8Q - Southern Corridor

On the Southern corridor the proposed HSR route is further south than the existing classic rail line, and the two routes would interface at Kristiansand, Egersund and Porsgrunn.

At Stavanger and Sandnes there is already a good local rail service that would connect with HSR. Presently these stations are served by local trains every 15 minutes. However, services on the Sørlandsbanen between Egersund and Kristiansand are slow and infrequent.

Error! Reference source not found. below shows the journey time savings to Kristiansand HSR if the arrival of a classic rail service there integrated with an HSR service with a five minute transfer. Such a service delivers journey time savings of up to 20 minutes for communities to the west of Kristiansand, some of which have relatively indirect road links. In these locations the analysis suggests that access to Kristiansand via the classic rail network would be quicker overall than accessing the HSR station at Mandal. There appears to be little need to connect regional services into Kristiansand from the East because of an absence of population centres and stations.

Egersund would also benefit from improved accessibility from classic rail feeder, although from the West there is already a half hourly local service. It may be appropriate to integrate this commuter rail service with the HSR.

In all of these locations along the southern corridor that appear to benefit from improved journey times it should be recognised that the populations are low and their demand impact on the HSR scheme will be small.

Figure 14. Improvement to journey times as a result of implementation of a classic rail feeder network into Kristiansand, with a 5 minute interchange

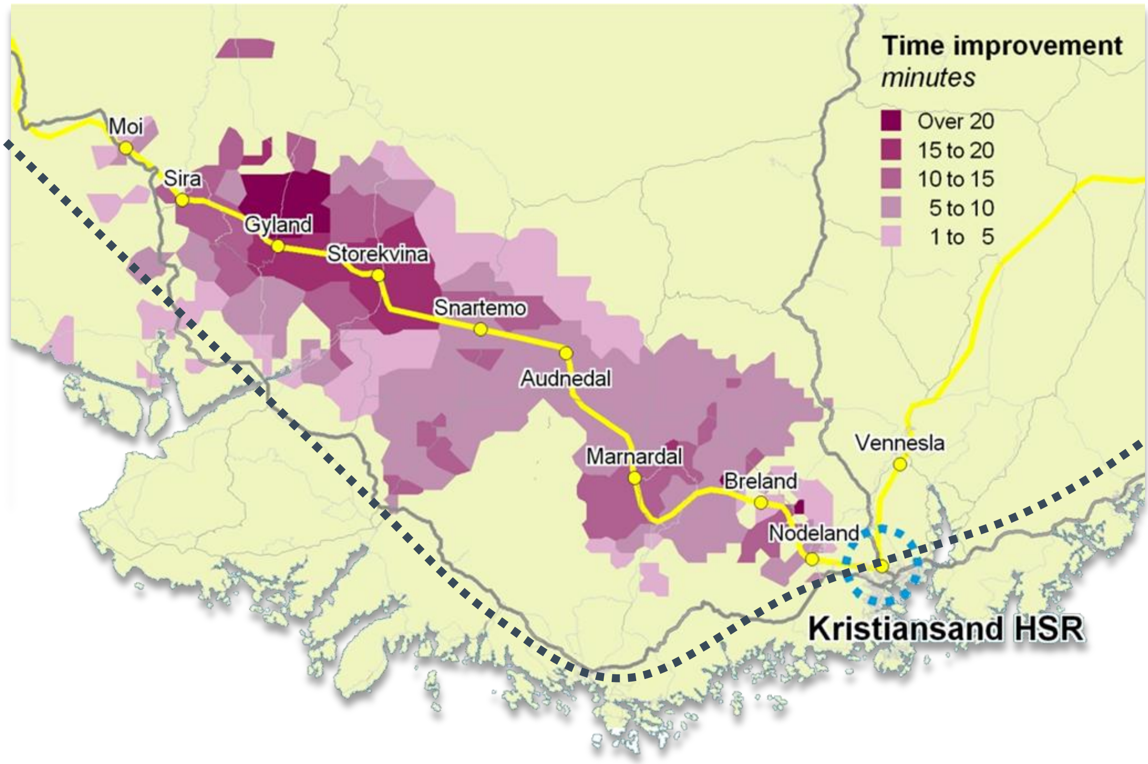
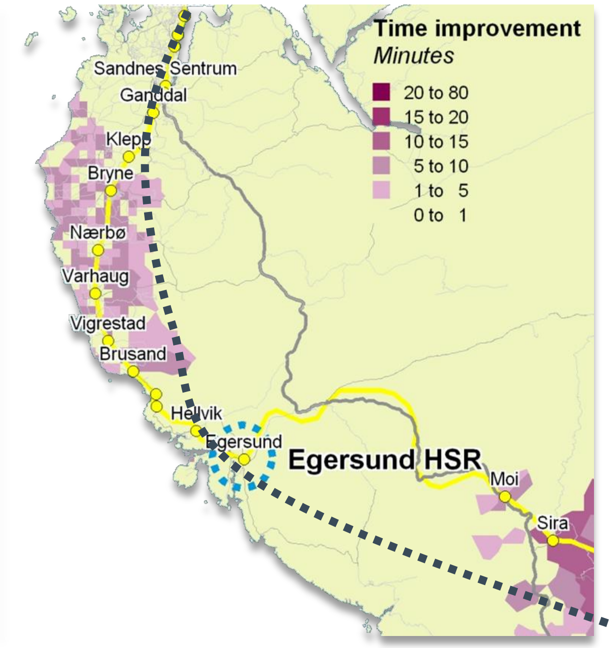


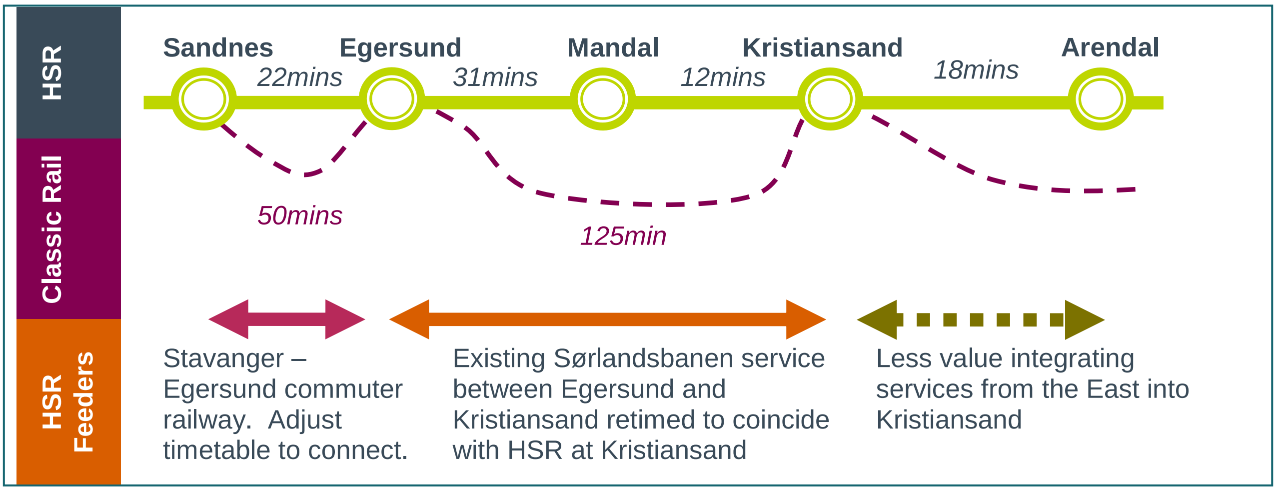
Figure 15. Improvement to journey times as a result of the introduction of feeder services at Egersund



At Porsgrunn the analysis shows less benefit of timing classic rail services to act as feeder services. This may be because the Vestfold line loop is less direct than cutting across the region by road or because the road network is good – much better than for the areas served by the Kristiansand feeders for instance i.e demand from Vestfold is already accessing HSR by road in the core test. Despite this, any further development of local rail services here would benefit from integration with HSR.

Error! Reference source not found. summarises a potential reconfiguration of the classic rail timetable to integrate with the HSR service; it is evident that on the southern corridor the classic rail network only has limited potential to provide feeder services, and in developed areas frequent local rail services already exist.

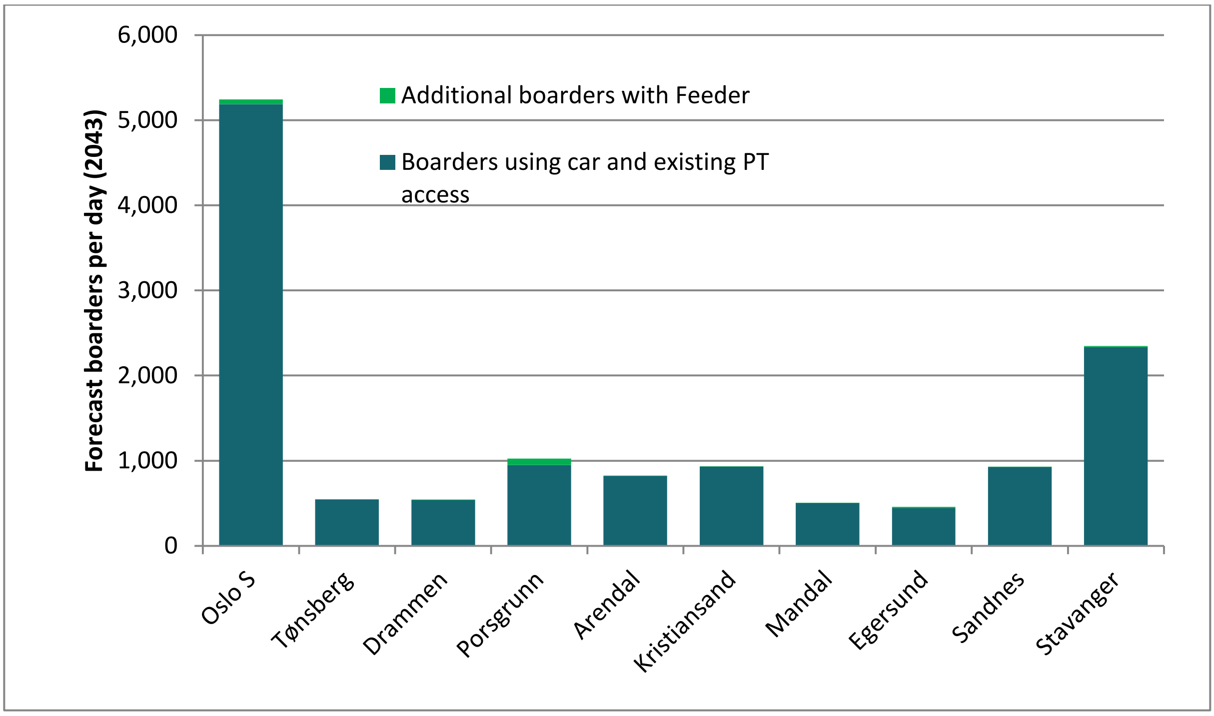
Figure 16. Illustrative changes to classic rail services along the Southern corridor



3.6.1. Network Demand Potential

Despite promising journey time improvements around Kristiansand and Egersund, only a small number of additional passengers are attracted to the HSR network, in the main because the benefitting regions are very sparsely populated. The classic rail line, whilst important to the communities it serves, fails to add connectivity to the more developed coastal regions, which may be better served by a bus (see Chapter 4).

Figure 17. Indicative additional boarders with feeder enhancement on the Southern corridor

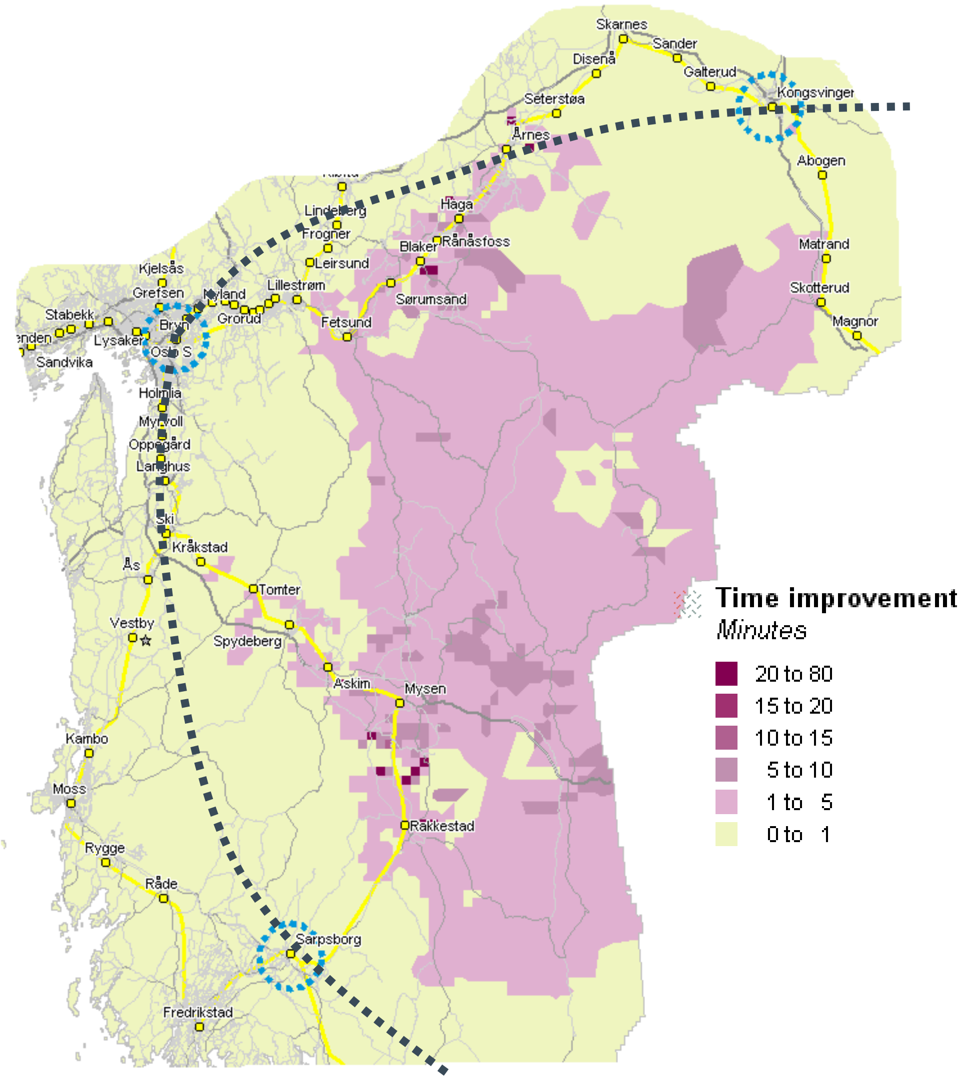


Overall the model suggests that an additional 15m NOK revenue could be added by the demand generated through rail feeder networks.

3.7. Eastern Corridor

On the Eastern corridor analysis of a classic rail feeder service into an HSR station at Sarpsborg shows journey time benefits to communities around Rakkestad and Mysen. Stations on the route towards Kongsvinger would also benefit from a feeder service, integrating the infrequent service along this corridor with any HSR service at Kongsvinger would provide journey time benefits, albeit to a small number of passengers.

Figure 18. Journey time savings in the Eastern corridors



3.8. Interchange Time

A fast and simple interchange between the classic rail feeder and HSR is critical to the successful integration of the two modes. It is difficult to model quality of interchange at the current level of detail but it would be expected that the distance between the classic rail and HSR platforms is minimal. The time waiting between trains can be altered in the model Atkins has developed and **Error! Reference source not found.** can be compared with **Error! Reference source not found.** to demonstrate the impact of increasing the interchange time from 5 minutes to 20 minutes. The increased time substantially reduced the journey time savings of the feeder network. Increasing the interchange time to one hour would eliminate any benefit to journey time of the feeder service.

Figure 19. Improvement to journey times as a result of implementation of a classic rail feeder network into Kristiansand, with a 5 minute interchange

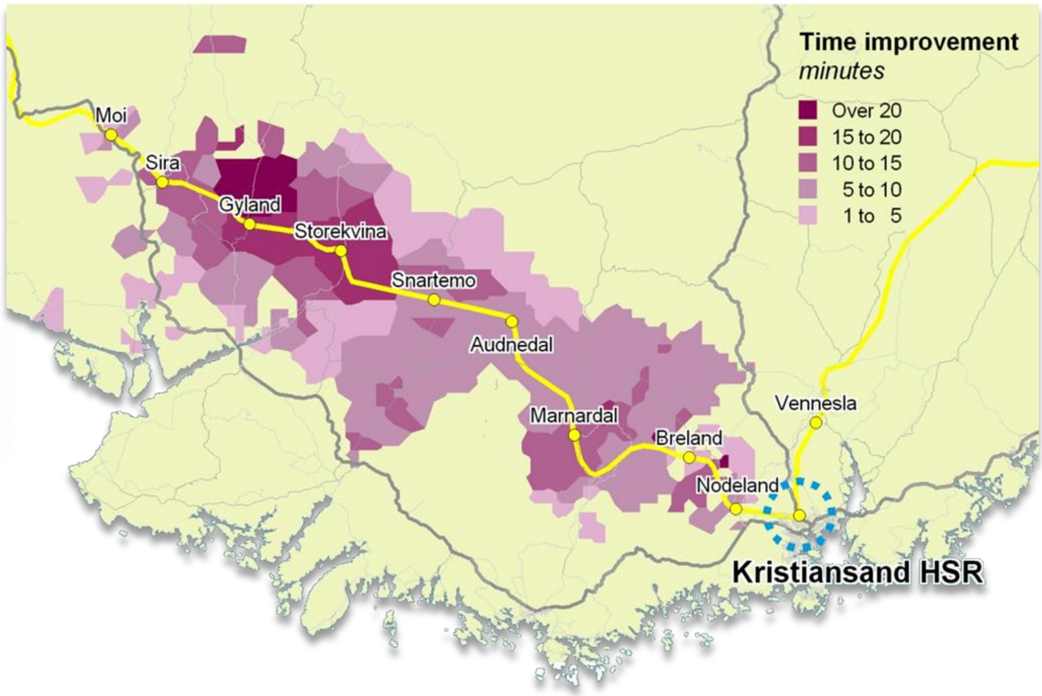
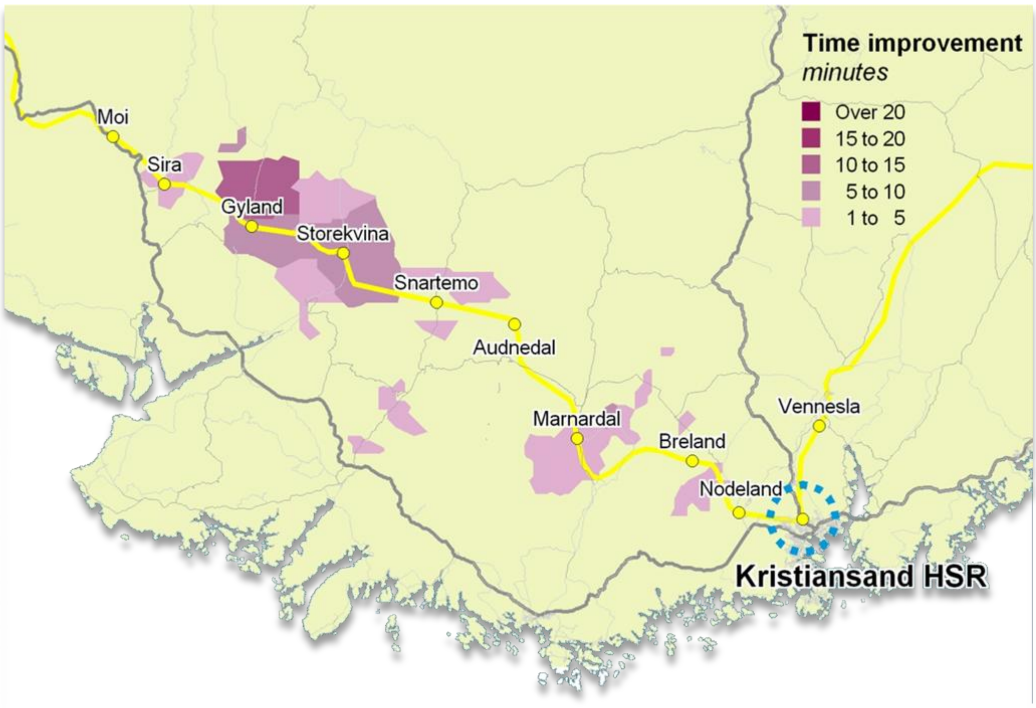


Figure 20. Improvement to journey times as a result of implementation of a classic rail feeder network into Kristiansand, with a 20 minute interchange



Interchange viability depends upon reliable connections and whilst expectations of the new rail infrastructure will be high, perceptions of the existing classic rail network may need to be improved.

3.9. Rail Feeder Conclusions

This chapter has presented the accessibility impacts of operating classic rail feeder services into HSR stations for selected HSR network alternatives. There are clearly numerous permutations, relating to service quality but this chapter has rationalised these options to a single connecting feeder service at every selected high speed station with minimal interchange penalty i.e. it is assumed that classic rail feeder services connect directly with HSR trains.

There appears to be a case for feeder services to improve accessibility, particularly in rural areas not well served by public transport. On the Northern corridor the accessibility of HSR would be substantially improved in the Otta/Oppdal area. On the Western corridor a similar pattern emerges, with Voss and Geilo stations potentially having a more prominent role with improved classic rail access. The Southern corridor may not gain as much benefit from integrating services, as the railway is not located in the area of highest population density.

Although some locations appear to make a good case for feeder services on accessibility grounds, the viability of additional services, determined by uptake, will depend upon additional demand attracted to HSR through the feeder network. This early analysis suggests that additional uptake as a result of the improvement would be fairly low as areas benefiting from journey time improvement tend to have very low populations.

4. Bus/Coach Feeder Services

4.1. Introduction

Provision of bus/coach services to HSR stations has been considered and implemented elsewhere globally, as discussed in Chapter 2. This chapter is concerned with presenting a qualitative assessment of potential networks with some examples in the Norwegian context where such services might be worthwhile.

Clearly a connecting bus service does not provide the same level of benefit as a directly connecting rail service, as the interchange is bound to be more difficult and bus is perceived as a less comfortable, slow and impermanent mode.

This chapter looks at

- Potential use of buses to connect communities to HSR;
- Regions of Norway which may be suited to bus connections including local examples;
- Classic rail corridors in Norway, which may be more suited to bus operation rather than rail once HSR is complete.

For analysis of bus and intermodal connections at existing HSR station locations see Market Analysis Subject Four: Location of Stations and Termini

4.2. Use of buses to connect HSR to communities

Across the world HSR stations tend to form local transport hubs and this invariably results in a good bus service provision serving the environs of the station. There are cases however, where a connecting bus service is developed to act as a feeder to infrequent (less than one train per hour) HSR services. This approach may be appropriate in some of the sparsely populated areas of Norway.

4.2.1. Existing rail-bus connections within Norway

In several areas buses are timed to meet trains:

- Oppdal – Sunndasøra;
- Oppdal – Kristiansund;
- Åndalsnes – Molde;
- Åndalsnes – Ålesund;
- Sira – Flekkefjord.

4.2.2. International HSR examples

Studies of HSR bus feeder services at Gare Le Creusot TGV, Estanción de Segovia-Guiomar AVE, Ebbsfleet International and Limburg Süd demonstrate the potential operation, benefits and potential challenges of connecting bus services.

There are several key lessons that can be learnt from these examples:

- Feeder bus services have been withdrawn due to lack of demand. At the same time the HSR services to remote stations have been maintained suggesting that car access is preferred. This could be because of the flexibility of car, the comfort or ease of carrying luggage;
- Bus feeders are more successful when timetables are integrated;
- Bus services carrying HSR passengers are most successful when high quality buses are used. In general busses are perceived as offering a lower quality level than trains and this perception gap needs to be bridged.

In Norway and across the world, airports are typically served by comprehensive high quality bus feeder systems. If HSR is to compete with air, it is reasonable to benchmark access quality to airport standards.

4.3. Bus Feeder Potential in Norway

Chapter 3 identified the classic rail corridors where rail could be adjusted to provide feeder services, however in some areas lacking rail connections a bus may be the only solution. At the same time there is a limit to how far passengers will be willing to travel on a bus to access an HSR station.

This section looks at potential communities that could be connected by bus in the remote parts of the Western, Southern and Northern corridors. The Eastern corridors, and areas around the major cities, tend to be more built up and already have a well developed local transport network.

Even where classic rail does exist it may prove that buses are more cost effective, particularly when high value long distance rail demand has shifted to HSR.

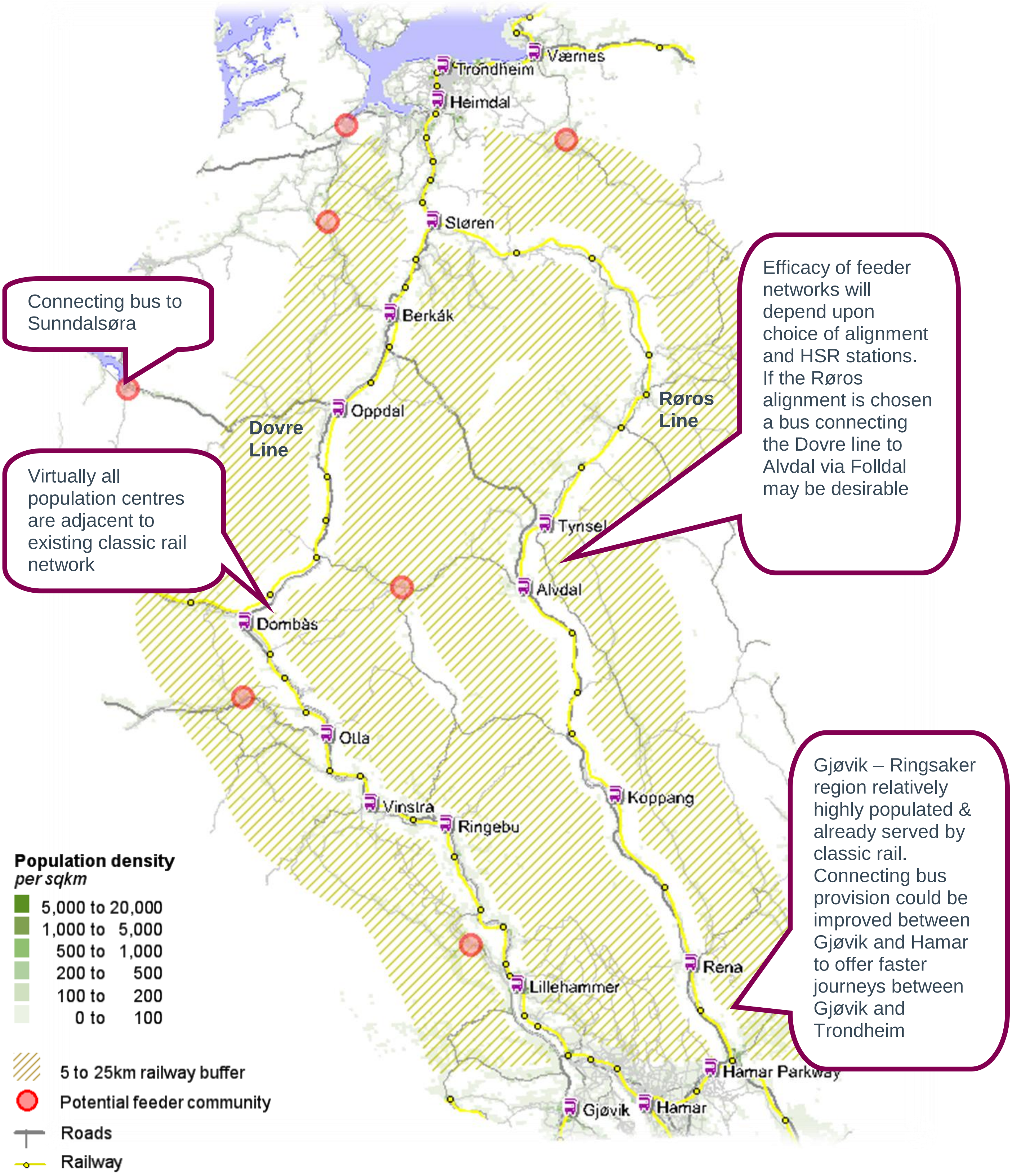
4.3.1. Northern

The Northern route has the majority of its population distributed along railway lines, and as seen in Chapter 3, these may lend themselves to supplying local feeder services. However, there is a complication here in that the HSR route could either pass closer to the Dovre or Røros line depending on the alternative chosen, so the other will remain isolated. It may be beneficial to run a connecting bus service between the routes to any HSR station (e.g. Avdal - Dombås).

Already bus services are coordinated to join with the existing rail network at Oppdal with routes reaching out as far as Kristiansund and Sunndalsøra. highlights some communities which may benefit from connection to HSR services via a bus based feeder. The communities identified lie within a reasonable distance from the HSR route, so as to have relatively short bus journey times, but are not within immediate vicinity of a classic rail station. demonstrates that virtually all population centres are located around the existing railway.

A connecting bus service may be useful to bring Gjøvik into the HSR network if the city cannot be directly served by HSR..

Figure 21. Northern routes showing virtually all population served by classic rail, with very few centres



4.3.2. Western

A number of HSR routes have been proposed west of Oslo to serve Bergen and Stavanger. In this context these routes fall into two categories. First are the routes that mirror existing railway routes. Here there is scope for interaction with existing classic rail as a feeder as discussed. In **Error! Reference source not found.** the communities that are not served by classic rail are highlighted.

Communities that could be connected include:

- Hardangerfjorden – some of the communities with good access to Voss such as Granvin and Ulvik may justify a bus service to connect with HSR at Voss.
- Hemsedal – Ulsåk and Tuv already served by coach route 17 connecting to Gol. It would make sense to time the connection at Gol if an HSR station is constructed there.
- Hønefoss – some communities around the town could be connected e.g. Jevnaker.

Secondly are routes further south (Haukeli alignment) that do not mirror any existing rail corridor and may serve communities currently remote from the rail network. shows the proposed HSR stations and additionally some communities that may be large enough to warrant a feeder bus service. The viability of a bus service will depend on how many of the proposed HSR stations become a reality. Haugesund is an interesting case because costs of serving it on the HSR line may prove to be much higher than benefits. A connecting bus, possibly at Ølen, may be a solution, if the Y shaped HSR network option is progressed.

A challenge in this region is the dispersal of communities – populations are very low. On the other hand because existing airport connectivity is poor the change in service level will still be a vast improvement even with convoluted bus routes and so may perform an important social function.

Figure 22. Potential communities away from the railway for bus service

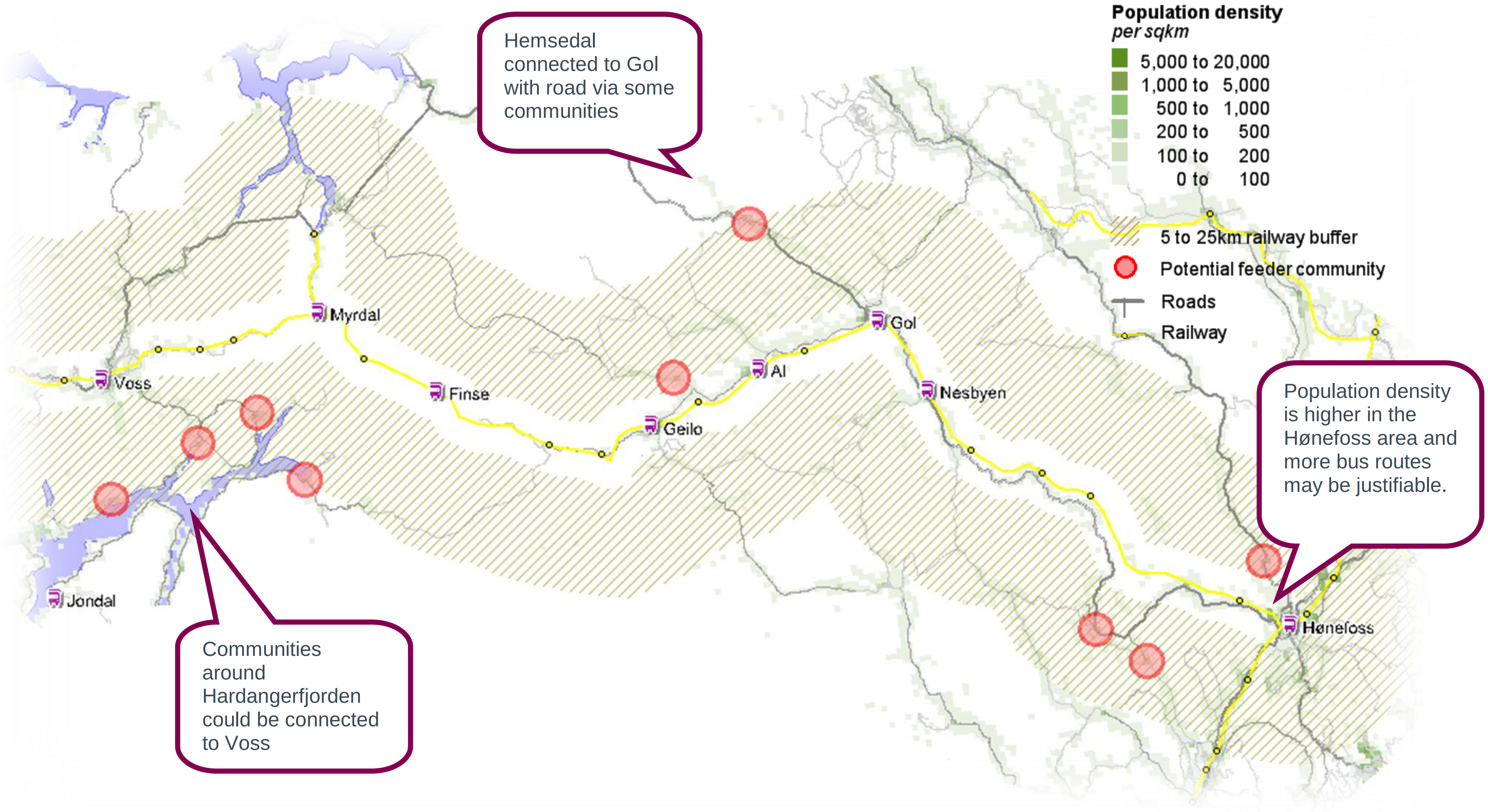
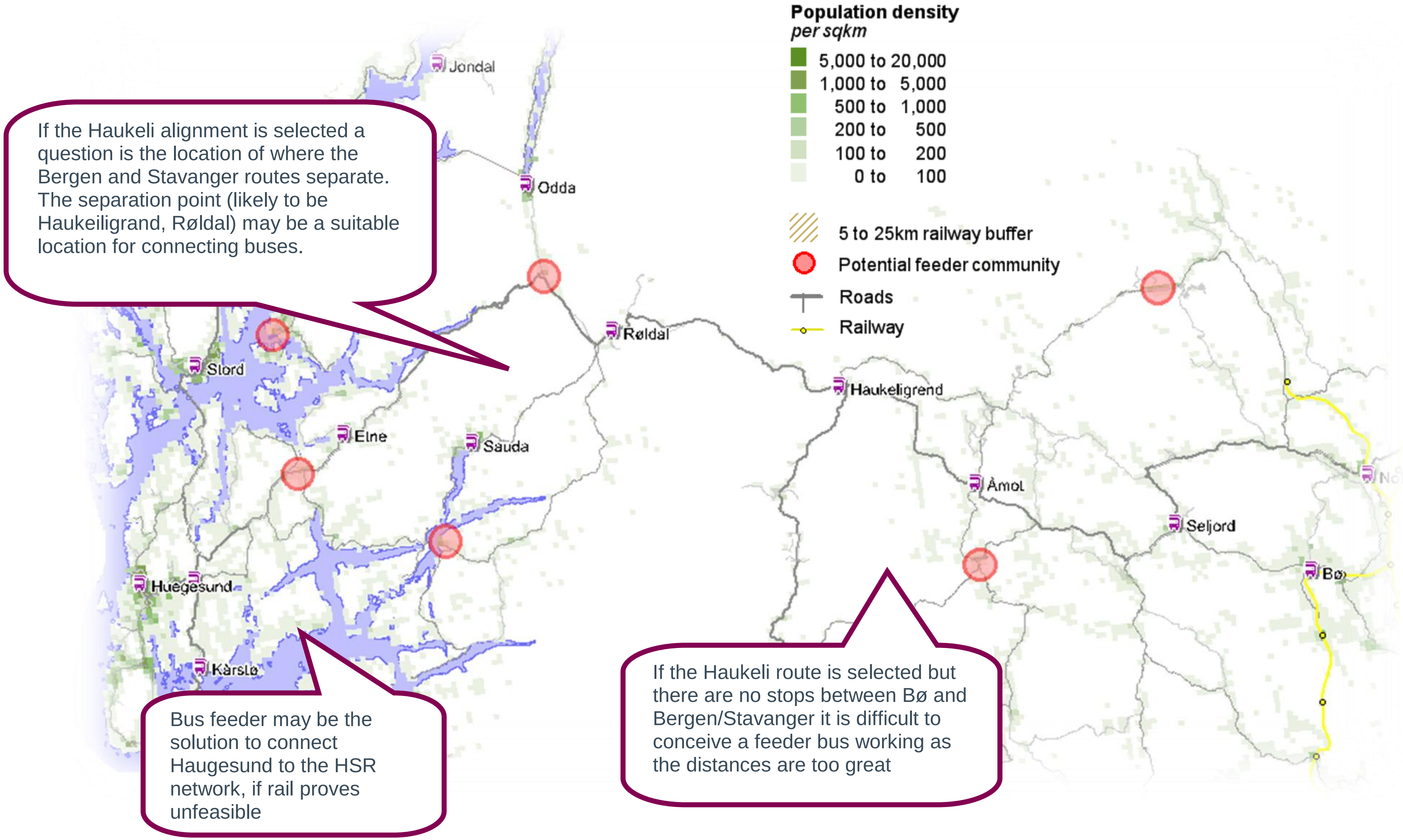


Figure 23. There are no classic rail feeder options along the Haukeli alignment



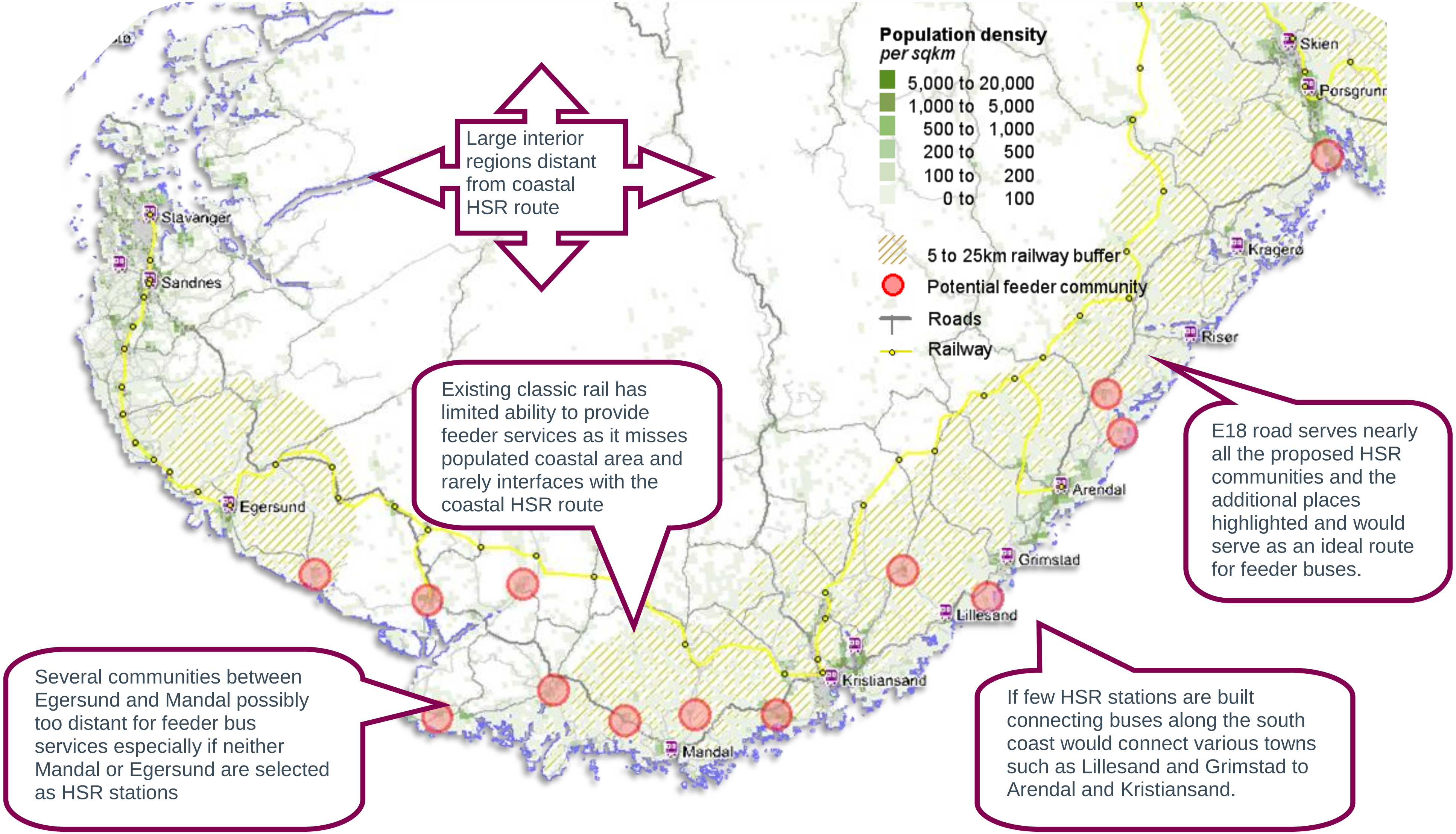
4.3.3. Southern

On the southern corridor the proposed HSR route follows closer to the coast than the existing classic rail lines and the two would only interface at Kristiansand and Egersund (if the latter is selected as an HSR station). For this reason the classic rail network will not serve as a feeder serve along the south coast. shows the large number of communities along the south coast that could be connected by a feeder bus serve supporting any of the proposed HSR stations. On this corridor settlements are generally located along the E18 and E39 roads, which lie alongside the HSR route, with potential interfaces at every selected HSR station. Here there appears to be a good case for feeder bus services to tie together communities not served by HSR. Furthermore, the end-to-end journey time imperative would reduce available HSR calling points further strengthening the case for feeder bus services. Presently *Nor-way* Bussekspress routes 300 and 190 serve this route and this service could be operated to coincide with HSR.

An integrated transport planning policy would need to take account of the competing needs of the existing coaches and the HSR feeders, including operator arrangements.

Retimed coaches and classic rail to connect with HSR at Kristiansand will provide a major interchange hub in the city. A key facet of HSR design is the establishment of such key interchange hubs.

Figure 24. Southern corridor showing communities that could be served by feeder buses in addition to proposed HSR stops

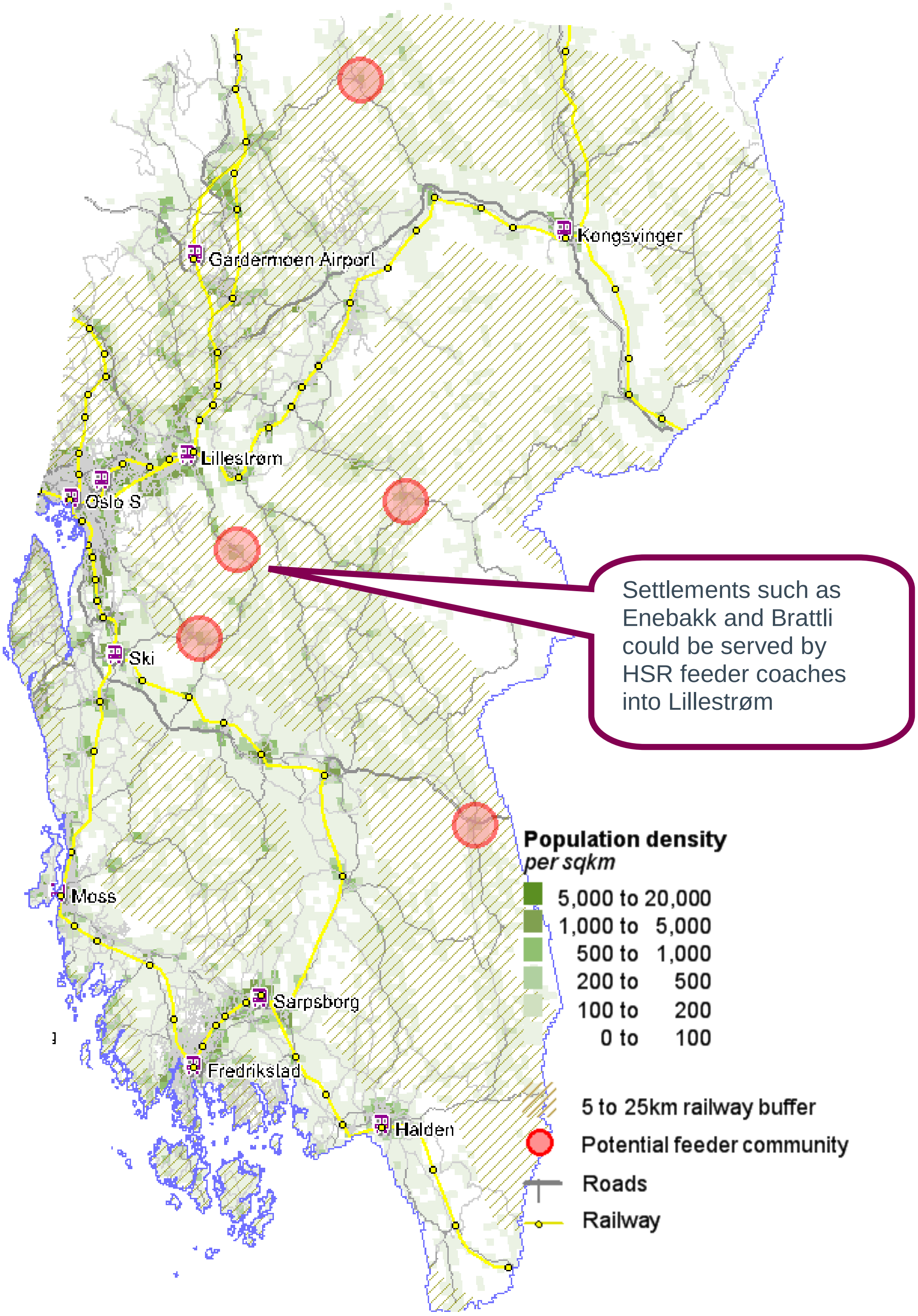


4.3.1. Eastern

The HSR routes to Sweden cover a relatively small area of Norway, a region served comprehensively by classic rail. The key issue here is connectivity to Oslo rather than to proposed HSR stations.

highlights a few areas not served by rail, but these are close to Oslo and needs are better met through schemes associated with Oslo based schemes.

Figure 25. Eastern corridor showing communities that could be served by feeder buses in addition to proposed HSR stops



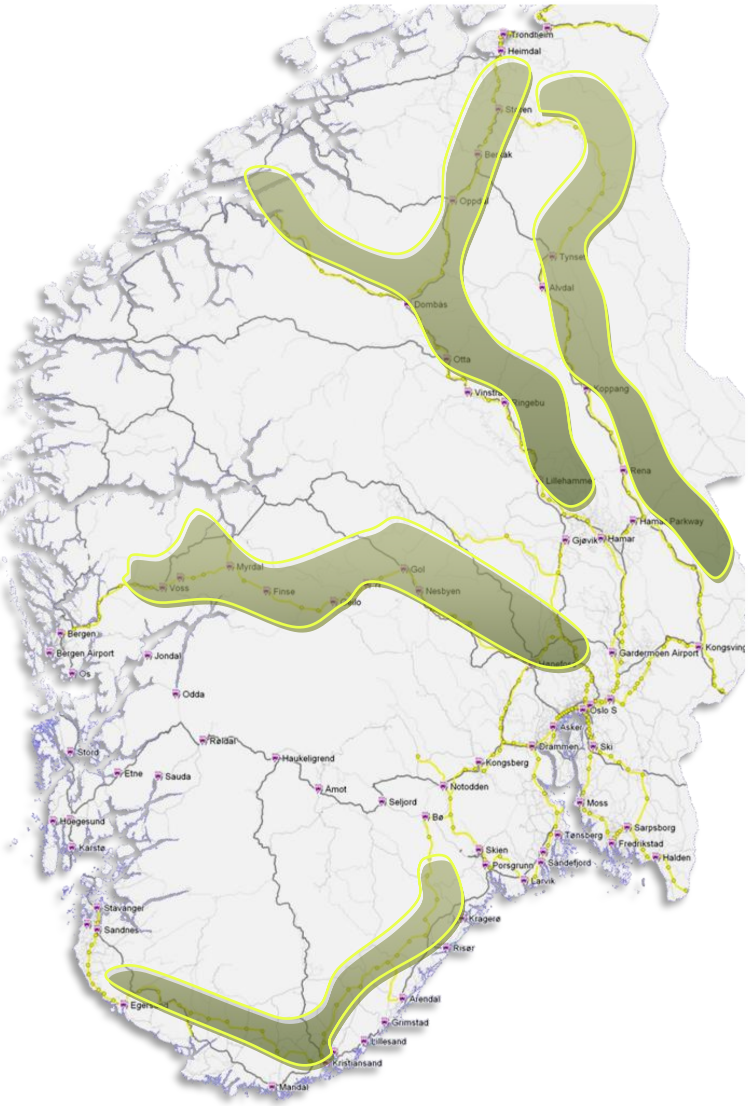
4.4. Connecting bus as a replacement for classic rail

The new HSR infrastructure will reduce the demand on classic rail services in the rural insular areas significantly, possibly reducing the number of classic rail trains operating. Some of the track paths may be used for HSR feeder services as discussed in Chapter 3, others may be used for freight. On the other hand existing services may be maintained exactly as they are. Money could clearly be saved by replacing some rail services with buses, but this may lead to deterioration in public transport accessibility.

4.4.1. Benefits of conversion

Most of the benefits of a conversion would be in reduced costs. It is likely that heavy subsidy would be required to support classic rail services, which have lost demand between points served by HSR. Buses may also provide greater flexibility than classic rail: more communities could be linked to the HSR network with a feeder bus service. A demonstration of this is above which shows the numerous communities on the south coast that can be served by bus, which are too numerous to serve by rail. Buses can be more demand responsive than trains, and could be taken out of service if users did not materialise.

Figure 26. Classic rail corridors where a bus service could be considered to replace local train services after HSR implementation



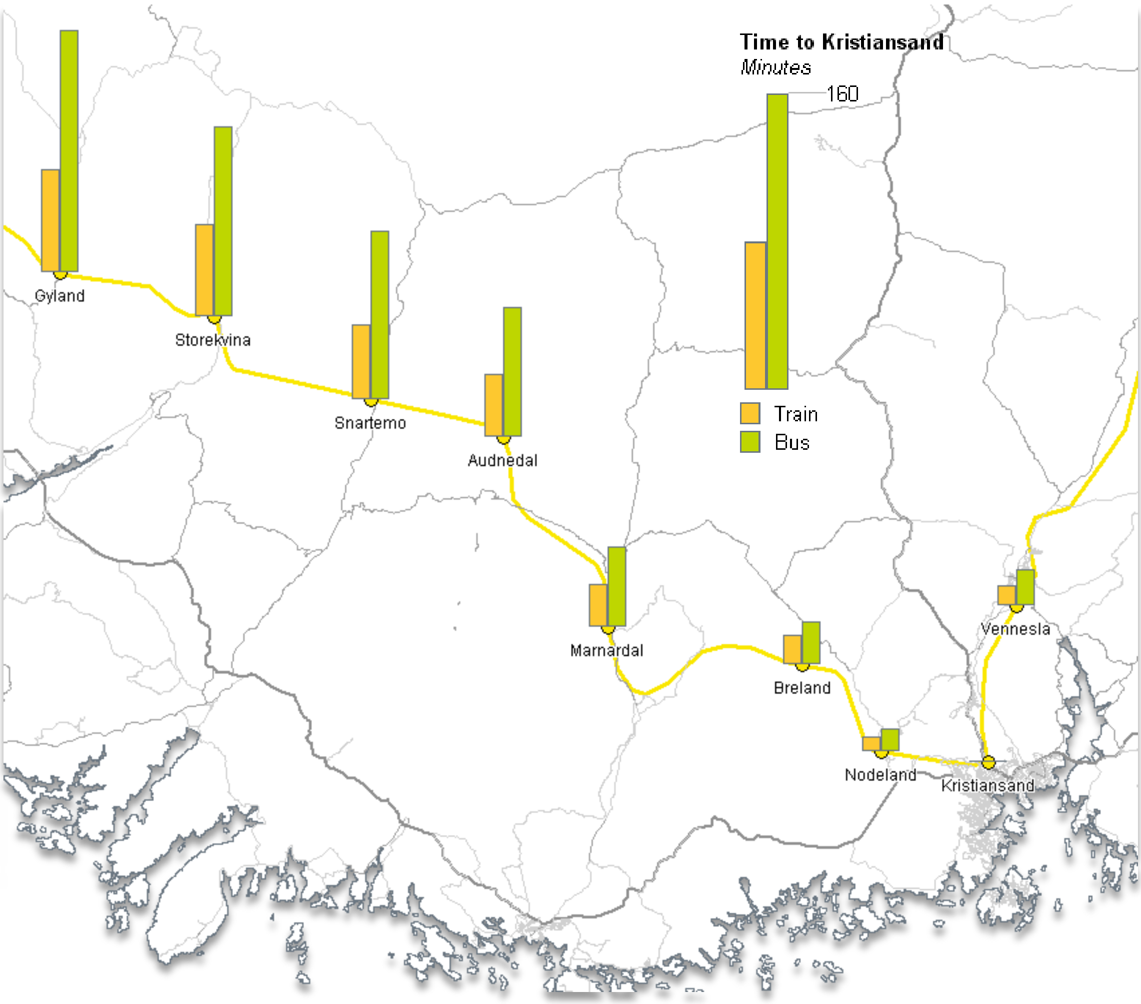
Error! Reference source not found. highlights the rural rail services that would lose patronage if the HSR lines in their respective regions were to be constructed. These railways pass through areas of low population density.

4.4.2. Changes to journey times

In most circumstances a bus service would be slower than a rail service, however in Norway the situation is complicated by the indirect nature of both rail and road routes owing to the mountainous terrain.

In order for a bus route to serve the existing rail station locations it has been found in many cases that the routing is inefficient for bus operations.

Figure 27. Comparison of train and bus times to Kristiansand from existing stations



4.4.3. Other issues arising from conversion

Even if it could be proven that journey times were broadly unaffected by conversion to bus, there are many other problems with such a conversion, as shown in

, some of which don’t have solutions.

Table 2. Issues arising from conversion to bus feeder services

Issue	Problems arising	Solutions
Comfort	Bus services perceived as being less comfortable than trains, and harder to work on.	High quality buses are now manufactured and used throughout Europe and could be procured, albeit at higher cost
Resilience	Connecting bus services less resilient to bad weather, due to icy roads, whereas railways would have been cleared by snow clearing trains	It is questionable whether the railway really is much more resilient to harsh weather
Permanence	Perception that bus services are much easier to withdraw than train services. Perception may reflect reality as seen in case studies	Political guarantees
Irreversible loss of infrastructure	If rail lines are closed and the infrastructure removed or not maintained in would be very difficult to reinstall it should policy change in future.	Remedial measures during dismantling to ensure structural integrity is preserved.
Loss of freight route	Depends upon the specification of the new HSR lines. But if no freight route is available there will be more heavy goods vehicles on the road.	Road based freight solutions
Journey times	Journey times likely to be slower by bus	No solution identified
Environment	Could be argued that buses are noisy and pollute, as well as consuming oil.	Some areas of the rail network suggested for conversion are not electrified anyway.
Tourism	Loss of scenic railways would reduce tourism. Buses obviously do not have the same appeal.	Coach tours to internal scenic area (as seen in Iceland with no railways).
Access equity	Buses may be harder to board for mobility impaired or those with luggage	High quality accessible buses

4.5. Conclusions

The analysis in this chapter indicates the communities likely to benefit from the introduction of bus/coach based feeder services.

On the Northern and Western corridors there are few communities located away from the classic rail network where a bus would be preferable. However, on the Southern corridor there may be a case for operating a high quality coach feeder service along the south coast to connect more communities to the HSR network. This could be achieved by retiming and improvement of the existing coach service.

The potential to replace classic rail with feeder bus services has been studied at a high level. In general bus times are slower than classic rail, and buses are perceived as being a lower quality option. However, considerable cost savings could be made, especially on lines which lose much of their patronage due to the HSR scheme.

5. Conclusions

5.1. The Need for Feeder Services

The Phase Two Report: Location of Stations and Termini, identified the challenging balance that needs to be struck between maximal geographical coverage of the HSR network through its stations and the minimisation of journey times between termini. A greater number of station stops on the network provides social benefits to a wider range of communities. However, in order to attain competitive journey times the number of stops between the end points along each HSR corridor has to be limited.

Given this constraint to the potential reach of the HSR network it is recognised that improving the access to proposed HSR stations by means of feeder services (connecting rail or bus services) may provide a wider spread of beneficiaries. Furthermore improved accessibility may strengthen the overall demand for the HSR network and its overall national economic efficacy. The development of integrated transport systems around HSR station hubs increases the value of local public transport whilst strengthening the case for the HSR investment. In this way integrated local feeder services provide the link between successful local and national transport policy.

5.2. Design and integration of local feeder services

Since the majority of the proposed HSR stations in Norway are located close to existing classic railway stations, and since in the sparsely populated inner regions most development occurs in a linear fashion along valleys served by existing railways, there is potential to realign those services to connect with the HSR timetable. Elsewhere, high quality bus or coach services offer further flexibility to the extension of HSR catchment areas.

The cost of these services can be offset by government and other private sector revenue support, depending on the service specification. A range of parties, local and national, may contribute to the funding of these services as well as their specification, so as to deliver the commercial, socio-economic and political objectives intended. Feeder services can operate, completely independently, as part of the HSR operations, or as a company set up involving a number of interested parties. Through-ticketing is clearly desirable enhancing the experience of seamless travel.

Globally there have been many examples of the use of multi-modal connecting services to drive up the value of HSR at a local level and to provide links further afield beyond the HSR network. In Spain and France relatively remote HSR stations such as Estación de Segovia-Guiomar and Gare Le Creusot have employed connecting buses to reach a number of communities around a compromised location. In the UK the HSR station at Ebbsfleet forms the focus of a major development region via a local BRT system, Kent Fastrack. In the USA, Amtrak offer a coach based Thruway service, which connects regions lacking railway infrastructure to its national rail network. The UK HS1 expands the benefits of the HSR investment by having high speed trains running onto connecting classic rail lines. Global experience highlights the benefits and risks of establishing new feeder services: there are examples of feeder bus services proving to be unsustainable in the long term.

5.3. Potential feeder services on the Norway HSR network

5.3.1. Northern corridor

Accessibility analysis indicates that there is value in adjusting residual classic rail services to integrate with the proposed distribution of HSR stations. HSR stations at Værnes and Trondheim are already served by regular local rail services, which would widen the catchment of HSR stations. However, there is a case for aligning long distance services from the North with HSR services, to effectively extend the reach of HSR.

Analysis shows that the region that would benefit most from feeder services in the Otta-Oppdal railway section and suggests that both the Dovrebanen and Raumabanen deliver improved journey times to HSR stations over parallel road connections, provided interchange is timetabled at Otta or Oppdal. Analysis shows less journey time benefit from the integration of feeder services in the Hamar region despite the greater range of potential rail connections. This is due in part to the greater road network density, which means there is less benefit in connecting via the relatively slow rail network.

Population mapping indicates that along this corridor development is concentrated around the existing railway, and that provided it is viable, the classic rail network provides the optimal alignment for feeder services.

5.3.2. Western Corridor

The Western corridor route passes through a number of small communities where rail provides a quicker and more direct access to HSR stations than roads. Accessibility analysis studying the impact of feeder services in conjunction with the HA2P HSR specification suggests journey time benefits can add value at Nesbyen and Gol providing a feeder into Geilo. A similar benefit occurs at Finse and Myrdal. The analysis has demonstrated that a judicious recasting of Bergen – Voss local services, to provide a 5 minute interchange at Voss can provide significant journey time benefits to populations around Dale and Evanger stations.

Whilst the classic rail network could successfully augment and enhance HSR along this route, there are other locations where a connecting coach service may be prudent to expand the scope of beneficiaries. At Voss, local road based transit could connect to communities around the Hardangerfjorden such as Granvin and Ulvik, providing dramatically improved public transport accessibility to Oslo and Bergen. There are other examples such as at Gol where coach route 17 (Hemsedal – Ulsåk and Tuv) could be timetabled to coincide with HSR arrival times, however for the HA2P specification the nearest HSR station is Geilo. At Hønefoss some communities around the town could be connected e.g. Jevnaker.

A challenge in this region is the dispersal of communities – populations of settlements occurring away from the linear development alongside the railway are very low. On the other hand because existing airport connectivity is poor the change in service level will still be a significant improvement even with convoluted bus routes.

5.3.3. Southern Corridor

Unlike the Northern and Western corridors, the railway route does not follow the main settlement chain, which is along the coast south of the railway. The proposed HSR route also lies further south than the existing classic rail line, and the two routes could interface at Kristiansand, Egersund and Porsgrunn (S8Q service specification). Analysis shows feeder network timetabling could produce significant journey time improvements for communities along the Sørlandsbanen into Kristiansand and Egersund. However, sparse population along the existing rail route means the number of beneficiaries would be relatively low.

The remoteness of the classic rail line from the HSR route and some of the largest coastal towns means that connecting coach services may have a larger role. Settlements are generally located along the E18 and E39, which lie alongside the indicative HSR route, with potential interfaces at every selected HSR station. There appears to be a good case for feeder bus services to tie together communities not served by HSR to the proposed stations. Presently Nor-way Bussekspress routes 300 and 190 serve this route and timetabled connections at Mandal, Kristiansand and Arendal a new multimodal interchange would broaden scheme beneficiaries.

5.3.4. Eastern Corridor

On the Eastern corridor analysis of a classic rail feeder service into an HSR station at Sarpsborg shows journey time benefits to communities around Rakkesatd and Mysen. Stations on the route towards Kongsvinger would also benefit from a feeder service, integrating the infrequent service along this corridor with any HSR service at Kongsvinger would provide journey time benefits albeit to a small number of passengers. Accessibility to Oslo is the key issue in this region.

5.4. Overall benefits to the HSR scheme

Spatial analysis in the Phase Two Report: Location of Stations and Termini demonstrated that in the largest five Norwegian cities the location of HSR stations and their relationship with local transport networks can play a significant role in the attractiveness of the HSR system as a whole. The analysis of feeder networks extends this concept to wider, rural regions where arguably local transport needs are even greater. Intermediate stations that have been included in the appraised network specifications often attract low patronage, particularly in the sparsely populated regions of the Western and Northern corridors. Harnessing the existing local rail network, which tends to serve most of the population of the rural areas on the Northern and Western corridors, increases the value of these intermediate HSR stations immensely, provided that the necessary timetable, service quality and ticketing arrangements are in place. In some areas, particularly on the southern coast, the historic railway geography precludes it forming the optimised feeder network solution, and here a high quality connecting coach may be a more appropriate means of widening network coverage.

Improving the accessibility of HSR stations will result in higher usage and overall higher revenues on the system. This is significant because higher forecast revenues from particular stations may help justify some routes or stops. A remote stop may appear to provide poor value for money, but if it represents a large catchment that can be fed into the station by means of feeder services, it may be beneficial to include. Maintaining classic rail services as feeders is expensive, particularly when other rail patronage is significantly reduced, and buses may offer a more affordable solution to public transport accessibility in some places.

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