EDINBURGH INTERNATIONAL SURFACE LINK

Outline proposals for review and comment

April 2008

Issue v26

DISCLAIMER

This paper has been drafted to set out proposals, stimulate discussion and encourage stakeholders to consider the merits of the proposals.

No liability will be accepted for any errors or omissions in this paper. Readers must satisfy themselves about the accuracy of statements made here, especially about the costs and technical feasibility of the proposals.

The proposals presented here currently have no endorsement by any regulatory, planning or statutory authority. Therefore there are no implications for land acquisition or property values.

This paper and the web-site are regularly updated to incorporate comments and improvements from readers. Please check for the latest update of the paper, available for downloading from:

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Change control

Version No.	Changes	Date
V21	First version issued externally for review	November 2007
V24	Comments incorporated concerning: - Purpose of Dalmeny chord in Government's proposals (traffic balancing, not serving Gogar) - Ingliston junction (Figure 13) redesigned to replace need for Dalmeny chord and need for EISL B3 trains to use E&G lines only - Costs amended to reflect increased complexity of Ingliston junction and signalling	January 2008
V25	Comments incorporated concerning maximum rail speed as function of curve radius: - Track alignments of EISL B1 at Ratho Station revised to assure minimum 55 mph (500m radius) - Line speed for EISL B1 reduced to 40 mph through revised Ingliston junction	March 2008
V26	Document restructured. Original proposals now retitled EISL B. EISL A option added, with new station 1700m south of airport terminal. Rail curvatures and gradients reanalysed and remapped and rail alignment assumptions documented. Edinburgh tram route added.	April 2008

Comments on this paper are welcomed and should be sent to:

eisl.contact@btinternet.com

CONTENTS

1. Summary

Edinburgh International Surface Link (EISL) is a proposed rail link to Edinburgh Airport. Two options are presented here:

- EISL A provides a station 1700m south of the airport terminal;
- EISL B provides a station 300m south of the airport terminal.

Either proposal will provide:

- Up to 17 trains per hour to and from Edinburgh Waverley with no additional rolling stock required;
- A single station with four platforms capable of providing frequent services to most parts of Scotland;
- Step-free indoor access from the station to the airport terminal;
- A phased approach to construction, allowing the project to be developed and financed incrementally to match the prevailing economics and politics;
- No dependency on the move of the Royal Highland Centre from its current location;
- Inherently safe rail design with no at-grade crossings or crossings in tunnels;
- Low construction risk with no tunnelling under any river or airport runway;
- Operational flexibility and service reliability, balancing traffic density on the four tracks through Haymarket (replacing the need for the proposed Dalmeny chord project);
- Protection of high speed running on the flagship Edinburgh and Glasgow line via Falkirk;
- Future-proofing, compatible with either: (a) major expansion of the airport and the construction of a second main airport runway; or (b) a planned decline in aviation for environmental, economic or political reasons, requiring alternative long-distance surface transport within the UK serving the business and exhibition hubs of West Edinburgh.

EISL A provides:

- A grade-separated station at Norton Park, south of the A8 road and integral to the planned new site for the Royal Highland Centre, offering easy rail access for exhibitions and shows, as well as a direct airport link;
- A dedicated elevated airport shuttle between the new station and the airport terminal;
- An initial phase, serving the Edinburgh to Glasgow lines, both via Falkirk and via Airdrie, costing less than £540 million (including 44% optimism bias);
- Costs for all phases (if built simultaneously) less than £850 million.

EISL B provides:

- A station within 300m of the airport terminal in a cutting that will allow future development of the airport to bridge the rail lines if necessary;
- A covered moving walkway to the airport terminal;
- An initial phase, serving only the Airdrie-Bathgate line, costing less than £250 million (including 44% optimism bias);
- Costs for all phases (if built simultaneously) less than £600 million.

These proposals are compatible with and complementary to the Scottish Government's proposals for a new railway station at Gogar, providing interchange with Edinburgh's trams to the airport, but only if that station is sited south of the

A8 road. The proposals also replace the need for any other rail works after building Gogar station, specifically the Government's proposed Dalmeny chord, whose function either of these proposals would more than fulfil.

The purpose of these initial proposals is to solicit interest in developing the proposals further to demonstrate their feasibility, confirm a business case, identify funding options, refine the proposed alignments and refine the cost estimates. Readers are invited to consider the merits of the two proposals (EISL A and EISL B) and to comment on the benefits and disadvantages of each. Readers are encouraged to identify any technical shortcomings in the proposed alignments or outline design and to propose improvements. The proposals will be updated and refined to reflect constructive comments received.

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2. History and EARL

In 2001, the Scottish Government, in association with BAA (the owner of Glasgow and Edinburgh airports), Scottish Enterprise, the Strategic Rail Authority and the Department for Transport, commissioned consultants to carry out a detailed economic and engineering study on the options to link Glasgow and Edinburgh Airports to the rail network. The consultants' report[1] was published in February 2003 and its conclusions concerning the link to Edinburgh airport included (Section 8.5.3):

"….the Surface Diversion option would offer the best value for money. However, this option would impose a significant time delay to passengers using the services diverted into the Airport (10 minutes to Stirling and 15 minutes to Fife). The next best option is the Runway Tunnel option although, under base case assumptions, the value for money would be appreciably lower than that for the Surface Diversion option.

"…Our financial appraisals have shown that, while it would be difficult to attract private sector investment in the Runway Tunnel option, it may be possible to make the Surface Diversion option sufficiently attractive for significant private sector involvement. As matters stand, and under neutral assumptions, the Runway Tunnel option could only be taken forward with a large public sector funding contribution."

Following the report's publication, the Scottish Government, in association with BAA, announced its commitment to further development of the proposals for a link to Edinburgh Airport. The Scottish Government appointed tie ltd, which is owned by the City of Edinburgh Council, to develop the proposals for the Edinburgh Airport Rail Link (EARL). The Runway Tunnel option was adopted for development.

The EARL project was progressed through to an Act of Parliament for which Royal Assent was granted on 19 April 2007. However, on 27 June 2007, following the change of Government in May, the Scottish Parliament passed a motion which, among other matters, called on the Scottish Government to resolve *"… the governance issues identified by the Auditor General before any binding financial commitment is made and to report back to the Parliament in September on the outcome of its discussions with the relevant parties."* Transport Scotland asked tie to suspend active work and expenditure on implementing the project pending the outcome of the review process.

3. Government plans for Gogar and the Dalmeny chord

On 27 September 2007 the Minister for Transport, Stewart Stevenson, announced: *"There is simply no sensible way for EARL to proceed in its original form…….The EARL project proposed:*

- *Tunnelling under a live, operational runway;*
- *Diverting a river and tunnelling underneath it; and*
- *Constructing a sub-surface railway.*

Projects of this complexity and risk profile demand clear and co-ordinated governance and Audit Scotland told us that we do not have this."

[1] Rail links to Glasgow and Edinburgh Airports – Final Report; February 2003. Sinclair Knight Merz. Available at http://www.earlproject.com/new_downloads/feasibility/SKMFinalReport.pdf

The Minister instead proposed an alternative solution of adding an airport station at Gogar on the Fife railway line. This would provide an interchange with Edinburgh City's trams for onward travel to the airport. He also said that the Government intends to build a rail link between the Fife and the Edinburgh & Glasgow (E&G) routes – the Dalmeny chord – that would allow E&G trains to stop at the new airport station.

The current layout of the railway lines and the assumed configuration of the proposed Gogar station and Dalmeny chord are shown in Figure 1 below. There are no plans or documentation currently available in the public domain that provide details or layouts of the Government's proposals.

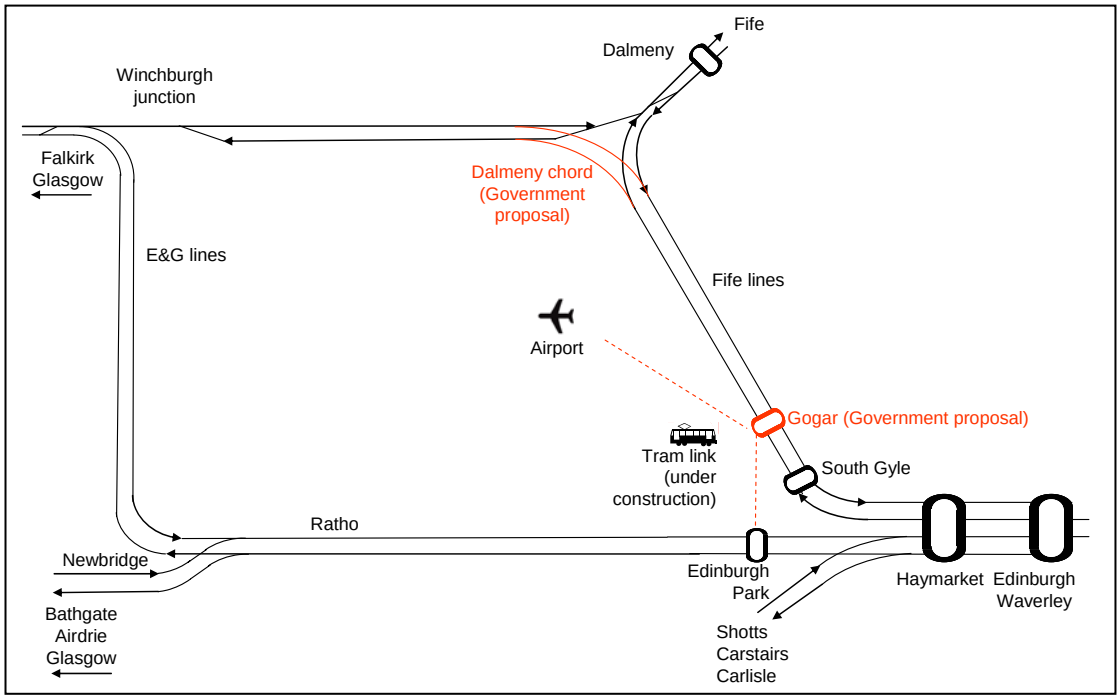


Figure 1: Present rail configuration (not to scale)[2]

Gogar station will serve only the northern two of the four railway tracks that pass through Haymarket and Waverley. Trains to and from Fife use the northern pair of tracks; trains to and from Glasgow, Falkirk and Stirling use the southern pair. Therefore, trains to and from Glasgow that serve Gogar station via the proposed Dalmeny chord would share the northern pair of tracks with Fife trains.

The requirement for the Dalmeny chord appears unrelated to Edinburgh Airport. When the Airdrie-Bathgate line is reopened in 2010, four trains per hour (tph) will run from Glasgow Queen Street, via Newbridge Junction to Edinburgh Waverley. From 2015, Network Rail plans to electrify and increase the capacity of the E&G line to allow six tph. With the existing two tph between Dunblane and Edinburgh, this would require a total of twelve tph to be accommodated on the E&G line through Newbridge junction and Edinburgh Park.

2 The configuration shown in Figure 1 shows Newbridge junction after its imminent remodelling as part of the Airdrie-Bathgate line reopening. Until then, Newbridge is a single lead junction, similar to the arrangement at Winchburgh.

Source: Google Earth

Figure 2: M8 rail crossing at Newbridge

The current track configuration could not cope readily with this traffic. Newbridge junction is a flat junction and it would not be practicable to rebuild it as a grade-separated junction because it spans the M8 motorway, as shown in Figure 2. Moreover, there is political pressure for more trains to stop at Edinburgh Park. These two factors militate against reliable operation at twelve tph on these tracks for mixed services (stopping and express). The initial technical feasibility report[3] on the reopening of the Airdrie-Bathgate line noted (Section 3.1.1) *"If EARL should proceed…it would ease the well-known capacity constraints at and east of Newbridge Junction into Haymarket Station."*

In the absence of EARL (or either EISL proposal), the Dalmeny chord is required to provide the opportunity to divert some of the trains from Glasgow (via Falkirk) onto the Fife lines. The Fife lines carry only five or six tph and Network Rail has plans to improve their capacity. Diverting some of the Glasgow (via Falkirk) trains onto the Fife lines via Dalmeny would balance the loading on the E&G and the Fife lines more evenly and provide operational flexibility to cope with disruption to services. It would enable more trains to be timetabled to stop at Edinburgh Park. It is possible that the opening of the Dalmeny chord would reduce the number of trains that could stop at Gogar because the tracks through that station would then be required by a greater density of traffic and trains that stop would delay following non-stopping trains.

All trains that use the Fife lines will pass through Gogar station, regardless of whether they are stopping there. This is a different arrangement from that which was proposed for EARL, in which an extra set of tracks would have been provided forming a loop that would be used only by trains stopping at the airport station. EARL proposed only two platforms and proposed a timetable that allowed only about half the trains from the Fife lines and half from the E&G lines to be diverted through the EARL loop, because the EARL station's two platforms could not have coped with all the trains that travel west from the four platforms at Haymarket.

Likewise, Gogar station will be able to have no more than about half the trains heading west from Haymarket passing through it, and fewer if many trains are to stop at Gogar. Because all Fife-bound trains must pass through Gogar, this will limit the number of trains that can use the proposed Dalmeny chord. It is not obvious how many trains per hour could stop at Gogar but it appears unlikely that frequent services can be offered to any part of Scotland that is not served by a rail line through Fife.

3 Airdrie – Bathgate Railway Route Re-opening; Initial Technical Feasibility Report. Babtie Group, for West Lothian Council. BTR0009523 June 2004. Available at: http://www.airdriebathgateraillink.co.uk/docs/R4-103%20Airdrie%20Final%20Report180604.pdf

The arrangements at Gogar and Edinburgh Park would be complex for passengers, especially infrequent travellers or tourists arriving at the airport. For example, it would be complex to advise passengers travelling from the airport where they should alight from the tram to board a train to Falkirk. The next train may leave from either Gogar or Edinburgh Park.

The proposed station at Gogar will directly benefit only passengers travelling from Fife, who will be able to transfer to a tram at Gogar, rather than at Haymarket. It is unlikely to provide more than two trains per hour for passengers travelling to or from Glasgow. It will be unable to serve the Airdrie – Bathgate line to Glasgow, due to open in 2010. The Dalmeny chord would offer benefits to the rail network but not directly to passengers travelling to or from Edinburgh Airport.

If the option of developing EISL is to be taken forward, or at least preserved as a development option, it would be preferable for the Government to agree that:

a) The new station at Gogar, providing a link for passengers on the Fife line to join the tram service to the airport, should be constructed south of the A8 road, adjacent to the Gyle shopping centre, to maximise the option for the future grade separated junction for EISL A2 or B2; and

b) The Dalmeny chord should not be constructed because its function could be fulfilled better and more cost effectively by the proposed junction arrangements as part of the EISL A2 or EISL B3 proposals.

4. Edinburgh trams

The Edinburgh tram route is under construction. When complete in 2011, it will provide a frequent service from Leith, through the centre of Edinburgh, to the airport, as shown in Figure 3. The business case for the trams[4] indicates 6 trams per hour on the route to the airport.

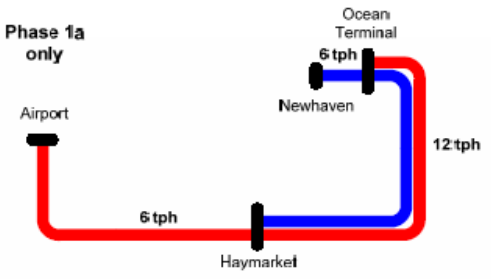


Figure 3: Tram services in 2011[4]

The trams will call at Haymarket station and Edinburgh Park station en route to the airport. The Government's proposal for the new Gogar station includes an interchange with the trams at that station also.

Figure 4 is an aerial view of the western end of the route. This is plotted using the drawings available at http://www.tramtime.com. It shows the line passing to the south of Edinburgh Park station and crossing the E&G line on a viaduct[5]. The line passes through Edinburgh Park to the Gyle shopping centre where the 2005 amendments to the route now take it parallel to the road south west of the car park. From there, the tram line enters a tunnel[6] under the A8 road to emerge north of the A8 by the tram depot. The line then travels west to Gogar burn, and on to the Ingliston Park & Ride and the airport.

4 ETN Final Business Case, Version 2, 7 December 2007

5 http://www.tramtime.com/downloads/plans-tram2/TRAM_LINE_2_SHEET12.pdf

6 http://www.tramtime.com/downloads/jun05pt2/line2/Sub_Sheet15HJun05.pdf

Source (base picture): Google Earth

Figure 4: Aerial view of Edinburgh tram route

There are no drawings evident in the public domain that show the Government's proposal for a tram-train interchange at Gogar. It is not obvious where the station will be sited nor whether an additional or relocated tram stop will be provided. The tram line is very steep where it passes under the A8, with gradients of 1:17. It is not obvious how this interchange will be provided. We have assumed that the station will be south of the A8 road to enable passengers to use the currently planned tram stop at Gyle.

5. Development of EISL options A and B

The proposals set out in this document offer a transport interchange that can be built after Gogar station is commissioned. Unlike the Gogar arrangement, it will be simple and easy for customers to understand and use. Transit from aircraft to train will be possible without going outdoors. The single interchange will offer frequent services to all parts of Scotland. The proposed new grade-separated junction arrangements will offer greater operational flexibility and service reliability than the Dalmeny chord,

because they will remove the present flat junction at Newbridge and remove the need for flat junctions at Dalmeny and Winchburgh.

The EISL proposals have been developed in order to capture many of the comments, objections and concerns that were aired about the EARL project and about the subsequent proposals for the Gogar station and the Dalmeny chord. We are seeking here to present compromise proposals that could attract consensus support. It is therefore unlikely that any one commentator will find everything he or she seeks in these proposals.

Commentators on the EARL proposals covered a diverse range of views, including those who challenged the assumption that demand for air travel will grow, those who considered the plans insufficiently flexible for future growth (because the station had only two platforms), those who believed the EARL plans were technically infeasible, those who claimed the EARL plans carried excessive design and construction risk, and those who challenged the business case and the financeability of the plans.

The Gogar and Dalmeny proposals are fundamentally different and appeal to a different group of commentators. Their principal attractions are the low cost and speed of delivery for the Gogar station.

The EISL proposals were originally issued to stakeholders for comment in November 2007 with the station site and rail alignments that now form the EISL B proposals. Comments were received from a wide range of interests, many supportive but some critical. The dominant objection to the EISL B proposals was the curvature of the tracks, especially the sharp curve proposed for the Airdrie-Bathgate diversion at Ratho. A few commentators suggested that this alignment is impracticable and that it would add materially to journey times.

The EISL proposals were therefore revised in April 2008 to reflect the comments that had been received. The original proposals were renamed EISL B and more analysis and diagrams were presented to show the rail curvatures and gradients to demonstrate the feasibility of EISL B. However, given the preference of several commentators for straighter rail alignments, the EISL A proposals were developed with an off-airport station at Norton Park that minimises the realignment of the Edinburgh & Glasgow route.

6. Objectives, design principles and constraints

6.1. Objectives

The following objectives have been adopted for the EISL proposals, to reflect the comments from as wide a range of commentators as possible:

- Avoid an underground station or runway tunnel;
- Allow a staged project with measured financial outlays and an opportunity to observe the passenger demand for each stage;
- Design the link as a surface transport hub for West Edinburgh, not just to serve the airport;
- Provide rail access to exhibitions at the Royal Highland Centre (RHC), both at its current site and at the proposed new site at Norton Park;
- Provide a frequent rail service for passengers from the Park-and-Ride site at Ingliston;
- Provide four rail platforms, not the two proposed for EARL or at Gogar, to allow at least 12 stopping trains per hour in each direction with reasonable dwell periods at the station for passengers with luggage, including visitors unfamiliar with the transport network; all trains using the four tracks west of Haymarket station should pass through the new station;
- Enable passengers to move between the station and the airport terminal without going outdoors or having to climb stairs, and to take luggage trolleys from the airport baggage carousels to the railway platforms;
- Design the railway to be inherently safe by avoiding new flat junctions (i.e. where one train crosses the path of another) and certainly avoiding crossings in tunnels;
- Rail gradients and line curvatures should be consistent with those already on the lines that are being diverted; the Edinburgh & Glasgow rail line should have no uphill gradient greater than 1:250 and no curve radius less than 1000m to ensure that high speed running can be maintained.

6.2. Station site options

We advocate a major international railway station at Edinburgh Airport, named Edinburgh International. This is modelled on the successful Birmingham International railway station which serves Birmingham Airport and which also provides a transport hub for the adjacent National Exhibition Centre. Birmingham International has subsequently become a major parkway station because it is adjacent to the M42 motorway.

Edinburgh International will serve Edinburgh Airport, the Royal Highland Centre (RHC) and the Ingliston Park & Ride. It offers the prospect for substantial development of international exhibition facilities and business parks. A future motorway spur from the M8 could improve road access to the airport and enable the station to become a parkway for the central belt of Scotland.

The EISL proposals offer two alternative compromise sites for the Edinburgh International rail station:

- EISL A is principally constrained to minimise the deviation of the Edinburgh & Glasgow rail line and so has its station 1700m to the south of the airport terminal. This has the disadvantage that it will incur the capital and operating

costs associated with an airport shuttle service, which is proposed here as an elevated automated shuttle as used at many international airports. EISL A would disrupt the original outline proposals for the RHC's new site at Norton Park but would offer the option of extending that site south past the current rail line (which would be decommissioned) as far as the M8 motorway. EISL A would present minimal constraint on future airport expansion. The EISL A rail platforms are at split level with the tracks at the eastbound and westbound platforms about 10m and 25m higher than the airport runway respectively.

- EISL B is principally constrained to provide a station sufficiently close to the airport terminal that passengers can walk from the station to the terminal under cover. The EISL B station is only 300m south of the airport terminal with tracks at the platforms about 5m lower than the airport runway. The rail alignments are necessarily less straight than EISL A and do include sharp curves and a steep uphill gradient (1:85) for trains on the electrified Airdrie-Bathgate line. EISL B would require minor redesign of the plans for the expanded airport but would create no constraints on the RHC.

6.3. Rail design constraints

Trains' permissible speeds are limited by the curvature and gradient of the track. Appendix C explains the calculation of the speed limits applicable as a function of track curvature. The restrictions that the gradients impose will vary depending on the acceleration and braking characteristics of the rolling stock used on the line.

The EISL proposals take account of the very different nature of the three affected rail lines:

- Edinburgh & Glasgow line (via Falkirk)
- Airdrie – Bathgate line (Edinburgh to Glasgow services via Airdrie)
- Fife lines (Edinburgh to Kirkcaldy, Dundee, Aberdeen and Inverness)

6.3.1. Edinburgh & Glasgow line (E&G)

The E&G is a marvel of 19th century rail engineering. It covers the 46 miles from Haymarket to Cowlairs with no gradient greater than 1:800. Its very gentle gradients and smooth (large radius) curves lend the line to high speed running. The natural topography is overcome by grand viaducts, such as Almond Valley and Castlecary, and tunnels, such as Winchburgh. Only at its extreme ends is the line constrained to low speeds. There is a 1:42 gradient into Queen Street. There is a magnificent description of the line[7] by John Willox written in 1842. This is now out of copyright and available for free download.

The E&G line is currently used principally by three-car Class 170 and two-car Class 158 diesel multiple units from Edinburgh Waverley to Glasgow Queen Street (via Falkirk High) and Dunblane (via Stirling). It is also used occasionally by long-distance trains, such as the daily *Highland Chieftain* HST from Inverness to London.

[7] Guide to the Edinburgh and Glasgow Railway - Historical, topographical and statistical. John Willox, 1842. Available for download at: http://books.google.co.uk/books?id=RpwHAAAAQAAJ&printsec=frontcover

6.3.2. Airdrie-Bathgate line

The Airdrie-Bathgate line is currently being recommissioned for Glasgow – Edinburgh through services from 2010. This line was never intended as an inter-city route, as it was built piecemeal by different railway companies and was not double-tracked until 1904. The route has steep gradients and sharp curves. The feasibility study[3] into its reopening considered the option of realigning tracks to allow 100mph running but this was found to offer minimal improvement to journey times. The route will be restricted to a maximum of 80mph although even this speed will require remodelling of the track either side of Armadale. The sites of both the proposed Caldercruix and Armadale stations have very steep gradients of 1:50 (2%) which are unacceptable for modern station design limits and therefore the reopening project includes work to provide much shallower gradients for the station platforms.

The Airdrie-Bathgate line will be electrified and operated by Electric Multiple Units with adequate power and acceleration to handle the steep gradients and frequent stops. From its planned reopening in 2010, the line will provide four electric trains per hour in each direction between Glasgow Queen Street and Edinburgh Waverley. It will provide a commuter stopping service between Glasgow and Edinburgh for communities including Bathgate, Armadale, Drumgelloch and Airdrie.

6.3.3. Fife line

The Fife line forms part of the East Coast Main Line and is used by inter-city services between Aberdeen and London. Nonetheless, it includes some severe gradients and line curvature that constrain line speeds. Examples are the 30mph restriction for sharp curvature at Burntisland and the 1:70 gradient between Inverkeithing and North Queensferry.

The Fife line is used by a wide range of rolling stock operated by ScotRail, East Coast (National Express services from Aberdeen to London) and Cross Country (Aberdeen to Southern England).

6.3.4. EISL lines

In developing the EISL proposals, we have endeavoured to preserve the running conditions of these three rail lines. We have, however, taken advantage of the different nature of the lines to propose much more challenging alignments for the Airdrie-Bathgate line, which will be served by electric commuter trains, than for the Edinburgh & Glasgow line which will continue to provide high speed inter-city services.

7. EISL A – the off-airport transport hub

7.1. EISL A principles and objectives

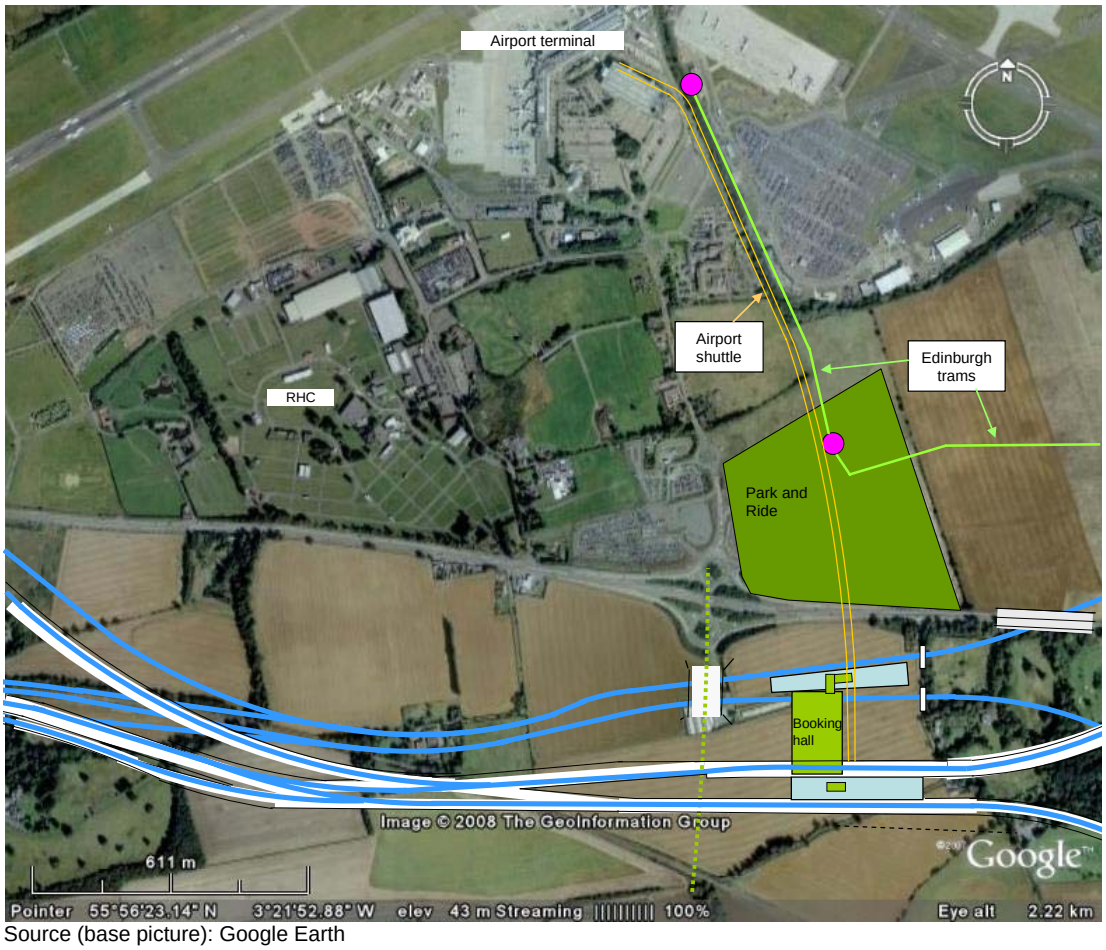
EISL A seeks to minimise the realignment of the Edinburgh & Glasgow rail line. It includes a new grade-separated station at Norton Park, to the south east of the current A8 junction with the airport access road. The EISL A design has no uphill gradient on the E&G line greater than 1:250, nor any E&G curve of radius less than 1000m.

7.2. Edinburgh International station site – EISL A off-airport

The EISL A station will comprise two grade-separated island platforms. The westbound platform serving the two tracks from Edinburgh will be about 5m higher

than the current E&G alignment, the eastbound tracks about 10m lower than the current alignment. The platforms will be 250m long, sufficient to accommodate all current main-line trains up to 11 carriages. The station building will be between the two island platforms and at mid-height between them. There will be ramps for passengers up to the westbound platforms and down to the eastbound platforms.

Figure 5 is an aerial view of the proposed site with the station platforms and rail lines of all three EISL A phases superimposed.



Source (base picture): Google Earth

Figure 5: Edinburgh International station site for EISL A

The grade-separation serves two purposes. Firstly, it enables the junctions that form an inherent part of the EISL proposals to be adjacent to the station and to avoid any flat crossings. Secondly, by lowering the eastbound tracks, it ensures trains climbing from the future Fife line loop to the new station (past the west end of the airport runway under the EISL A3 proposals) will have a gradient no greater than 1:115.

The station will be 1700m south of the airport terminal and connected to it by a dedicated shuttle.

The EISL A1 route will require the acquisition of land from Easter Norton Farm, Norton Mains, the Gogarburn Golf Club and the new site of the RHC at Norton Park. In addition, some land within the grounds of the Norton House hotel will be acquired for the realignment of the tracks to the west of the new station.

7.3. EISL A1

7.3.1. EISL A1 route

EISL A1 diverts the E&G line through the new Edinburgh International station, enabling service by trains to and from Dunblane, Glasgow (via Falkirk) and Glasgow (via Airdrie). The journey to the airport will be approximately forty minutes from Glasgow (via Falkirk), one hour from Glasgow (via Airdrie) and fifteen minutes from Edinburgh Waverley. The introduction of the extra station stop between Edinburgh and Glasgow will add no more than four minutes to the overall journey time of each train, allowing a station dwell time of 150 seconds.

The diversion will use only one face of each of the two island platforms and so will not enable any change to the running pattern of services. However, the rail layout will provide grade separation for the divergence of the Airdrie-Bathgate line from the E&G line and thereby improve operational flexibility. It replaces the current flat junction at Newbridge. With EISL A1, no train from Bathgate will be delayed awaiting a train towards Falkirk to cross its path.

Figure 6 shows the route diagram of stations served. Figure 7 is a diagrammatic representation of the track layout (not to scale). Appendix A1 shows a scale map of the proposed rail alignments. Figure 8 shows an aerial view of the route. Appendix A5 shows the track curvature and line speeds. Appendix A6 shows the rail gradients and elevations.

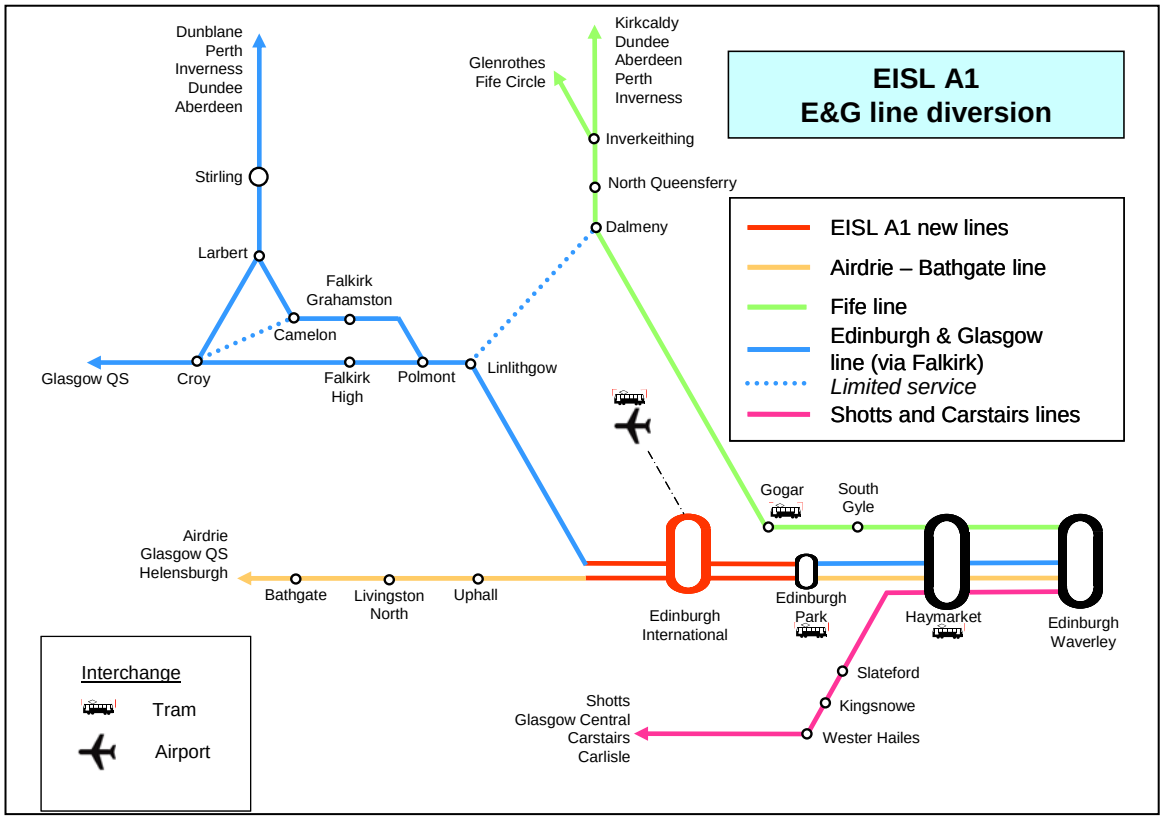


Figure 6: EISL A1 route diagram

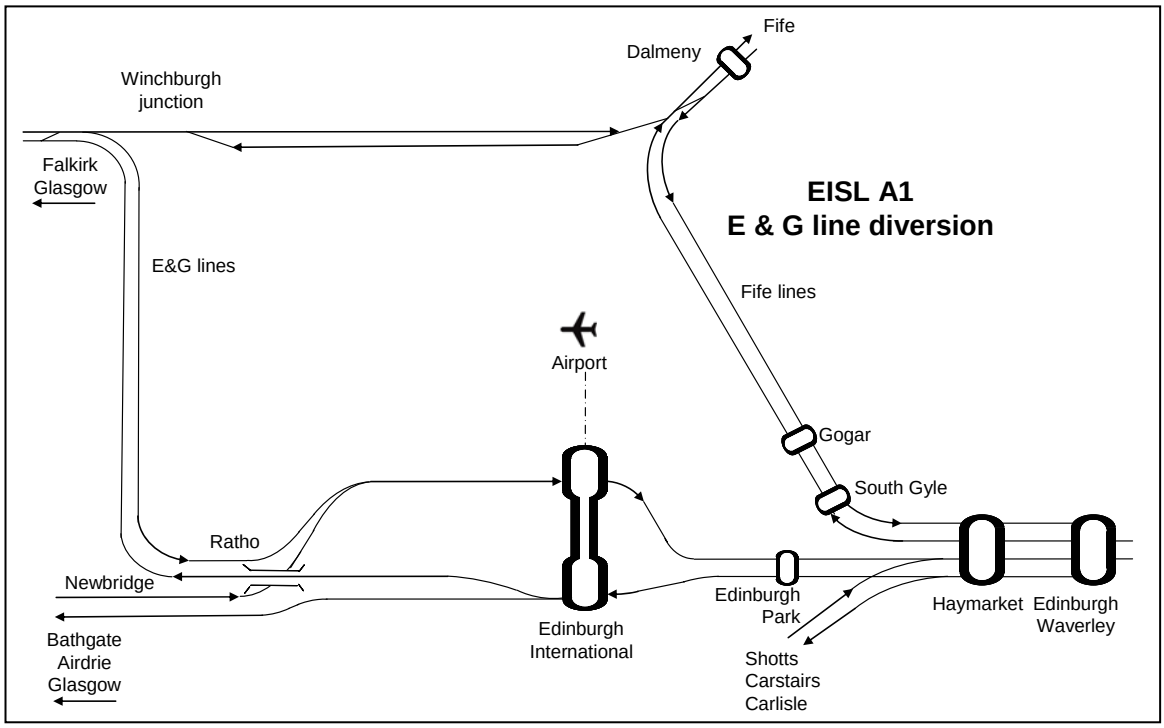
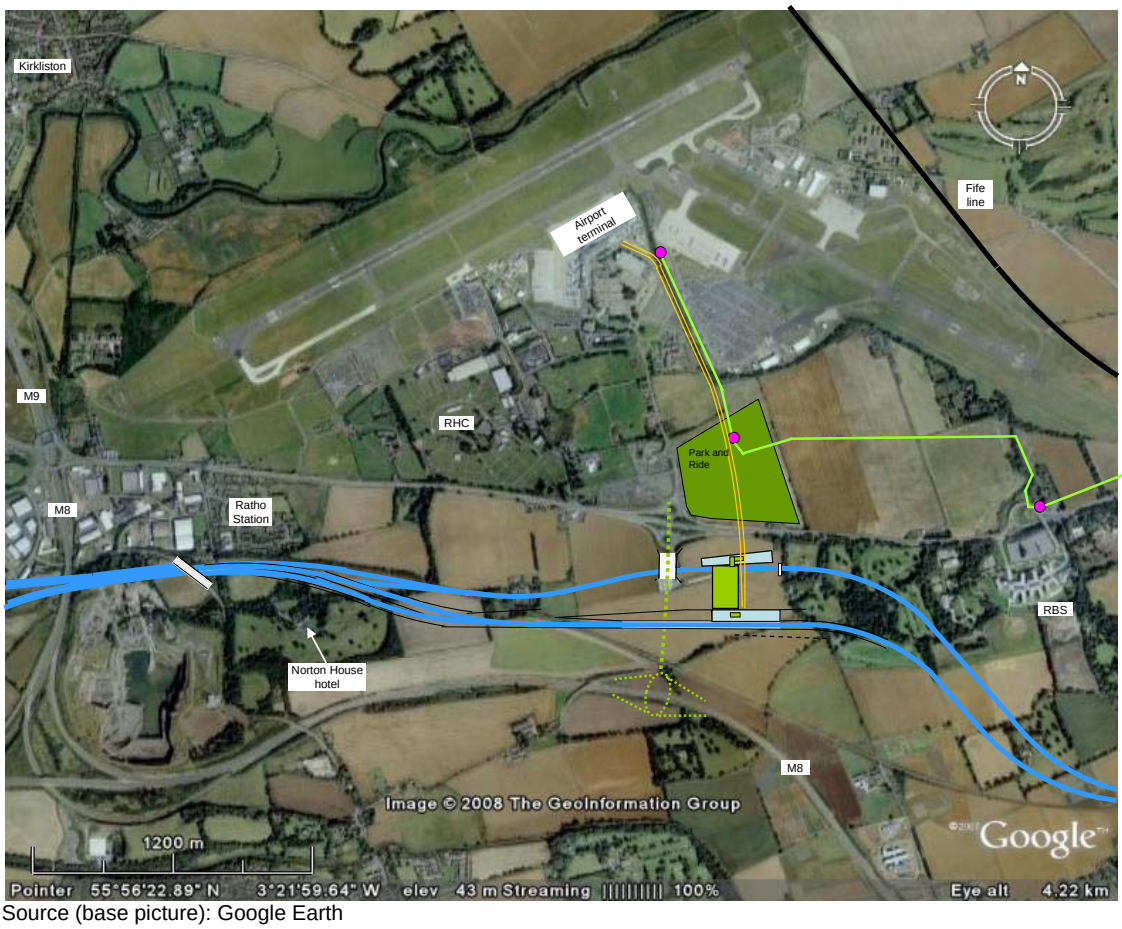


Figure 7: EISL A1 track diagram (not to scale)



Source (base picture): Google Earth

Figure 8: EISL A1: Aerial view

7.3.2. Newbridge to Ratho

The tracks along the 500m between the grade-separated junction at Ratho[8] and the current site of Newbridge junction will be converted from two tracks to four tracks. This will require the reconstruction of the Harvest Road bridge. In addition, the elevations of the tracks will be reconfigured, such that the two tracks towards Edinburgh fall at a gradient of 1:100 from Newbridge to the new Ratho junction. Thereafter the gradient will ease gradually to a fall of about 1:500 through a cutting into the station's lower platform. The current cutting between Ratho and Newbridge, although shallow, is in rock and the widening and deepening of this cutting will be expensive, especially as the work must be done mostly with the E&G lines remaining live. We have estimated £50 million for this civil engineering. We have also allowed £13 million for a bridge over the eastbound tracks west of the station for a future M8 motorway link.

7.3.3. EISL A1 alignment

The two westbound tracks will retain broadly the current elevation from Ratho Station to Newbridge but will be built on a viaduct at the station to allow use of the land underneath by the RHC, and to preserve the route under the viaduct for a future M8 motorway link.

East of Ratho, the eastbound track from Bathgate will pass under the viaduct carrying the westbound track towards Falkirk.

East of the new station, both the eastbound and westbound tracks follow a curve of 1000m radius, allowing 80mph running. The eastbound line climbs from the station's lower platform (elevation +43m) at a gradient of 1:250, initially in a deep cutting through the Gogarburn golf course, to rejoin the current alignment at Roddinglaw, west of the Edinburgh city bypass. The westbound line leaves the current alignment at Roddinglaw and climbs at 1:250 to reach the new westbound station platform on its viaduct (elevation +58m).

7.4. EISL A2

7.4.1. EISL A2 route

EISL A2 provides a chord from Gogar to Edinburgh International, replacing the function of the Government's proposed Dalmeny chord. It will allow trains travelling to Glasgow (via Falkirk) to use the northern pair of tracks from Waverley through Haymarket. This will balance the traffic density on the four tracks through Haymarket and allow more trains to stop at Edinburgh Park, because of the reduced density of traffic on the line through that station.

Figure 9 shows the stations served by EISL A2. Figure 10 is the track diagram (not to scale).

[8] In these proposals, Ratho should be read as meaning Ratho Station. Ratho Station is the name of the community 2km north of Ratho at the site of the former railway station. There is no longer a railway station there, nor any proposal to provide one.

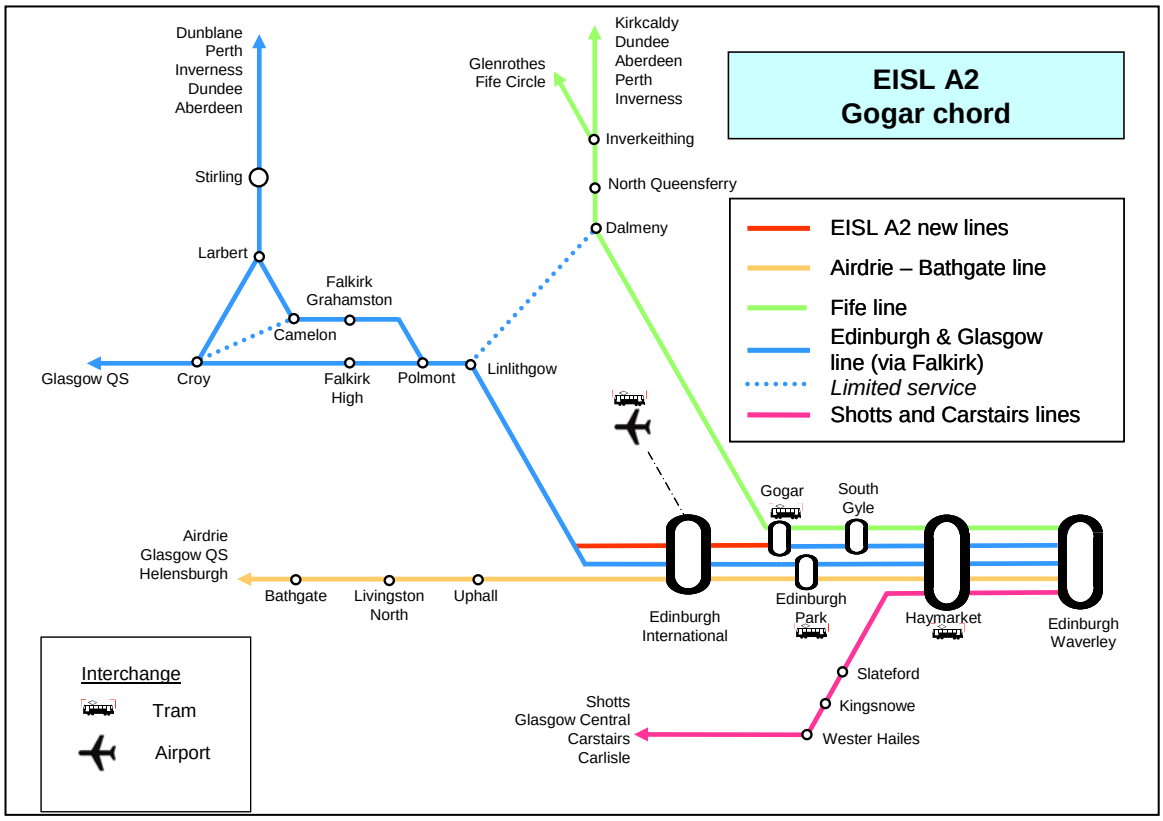


Figure 9: EISL A2 route diagram

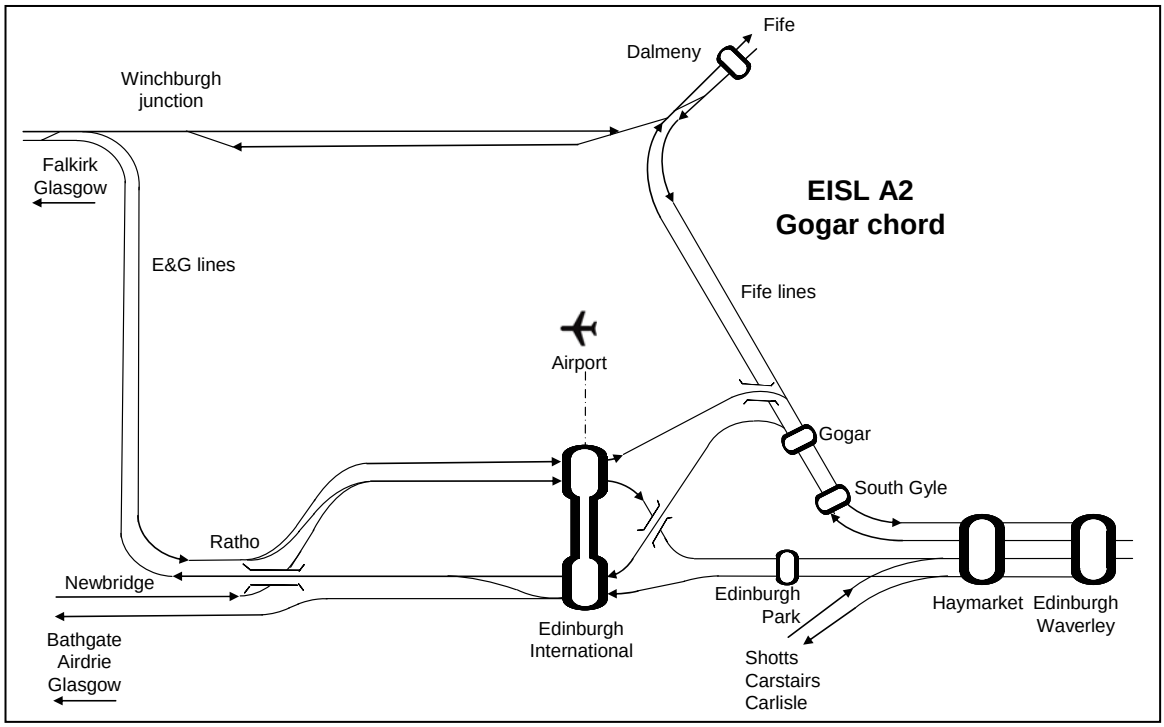
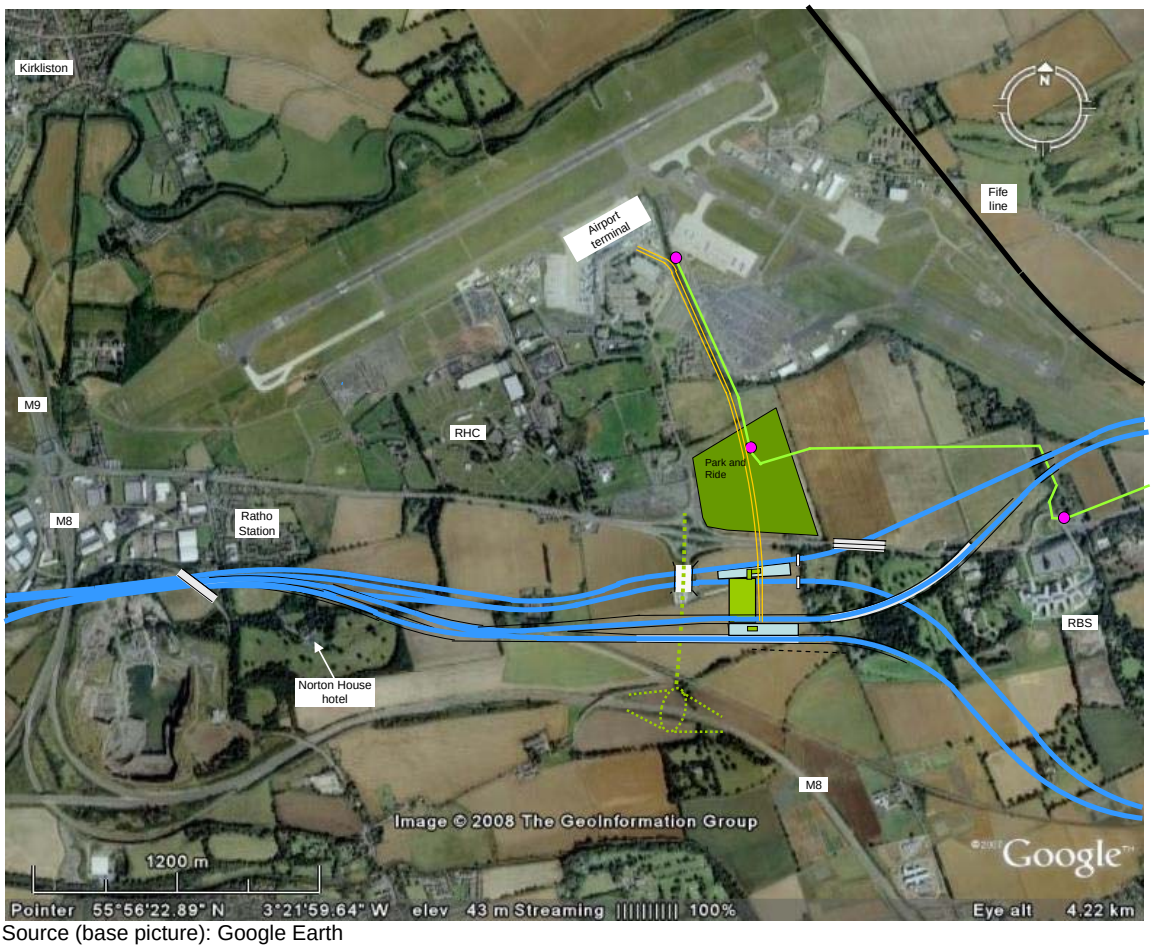


Figure 10: EISL A2 track diagram (not to scale)

EISL A2 will bring into use the northern flanks of each of the two island platforms at Edinburgh International, such that the station will then have four operational platforms. This will greatly improve operational flexibility. Trains to and from Falkirk can use either the northern tracks through Gogar to Haymarket, or the southern pair of tracks through Edinburgh Park. With the projected high density of traffic on both the E&G line and the Airdrie-Bathgate line, this flexibility will be important to allow signallers to recover from train delays or other disruption.

Figure 11 shows an aerial view of the EISL A2 alignment. Appendix A2 shows the alignments in detail and to scale.



Source (base picture): Google Earth

Figure 11: EISL A2 aerial view

7.4.2. Gogar junction

A new grade-separated junction will be built at Gogar on the Fife line, immediately north of the A8 road. This will be eased greatly if the Government's proposed station at Gogar is built south of the A8. The northbound track will be realigned slightly westwards and lowered to pass under a new rail bridge. The westbound EISL A2 track will diverge just south of this new bridge and skirt the depot for the Edinburgh trams. This track will climb steadily at about 1:150 to reach an elevation of +53m to cross over the tram line and the Gogar burn just north of the road bridge serving the RBS campus. The westbound line will then join a viaduct that will carry it over the A8 road and the Gogarburn golf course to run into the north flank of the westbound platform at elevation +58m.

The eastbound track from the northern flank of the lower platform (elevation +43m) will also rise at about 1:150 passing through a new bridge under the A8 road to reach +50m at the Gogar burn, sufficient to clear the tram line as well as the burn. From here, the line will fall gently to the new Gogar junction.

7.4.3. EISL A2 alignment

To the west of Edinburgh International station, the new westbound line will leave the northern flank of the platform on a new viaduct, joining the E&G line east of Ratho.

The new eastbound line will diverge to the north of the E&G line immediately east of the Harvest Road bridge at Ratho Station. It will fall with a maximum gradient of 1:80 into a very deep cutting until it reaches an elevation of +40m. This is the point at which the future EISL A3 line from the Fife loop will join. It is possible that detailed analysis will show that a short section of tunnel would be more cost-effective over this 800m stretch than a deep cutting which will require a high retaining wall for the adjacent EISL A1 eastbound line which will be up to 5m higher. From the point of the future junction, the EISL A2 line rises steadily at about 1:300 to reach the northern flank of the eastbound platform (elevation +43m), passing under the passive box bridge providing for a future M8 link over the rail line.

7.5. EISL A3

7.5.1. EISL A3 route

EISL A3 completes the EISL A project by providing a loop for trains to and from Fife to pass through the new station. It is this phase of the project that has constrained the elevations of the rail lines for the whole EISL A design.

The EISL A3 proposal is for a loop on the Fife line, not a diversion. It complements the existing line to the east of the runway. The flagship timings for services from Edinburgh to Aberdeen and Inverness will only be retained by maintaining the current line and skipping the airport stop. The EISL A3 loop will add about seven minutes to journey times (including a dwell time of 150 seconds at Edinburgh International station).

Figure 12 shows the route diagram of stations served. Figure 13 is a diagrammatic representation of the track layout (not to scale). Appendix A3 shows a scale map of the proposed rail alignments. Figure 14 shows an aerial view of the route. Appendix A5 shows the track curvature and line speeds. Appendix A6 shows the rail gradients and elevations.

7.5.2. EISL A3 alignment

The northbound EISL A3 line will diverge from the track serving the northern flank of the westbound platform at Edinburgh International. It will run over a new high viaduct bridging the eastbound EISL A lines and then fall very rapidly at a gradient increasing to 1:60. It will maintain this steep downward gradient until it passes through a new bridge under the A8 road at Ratho Station. Thereafter, the gradient eases until the line passes into airport property to the west of the main airport runway.

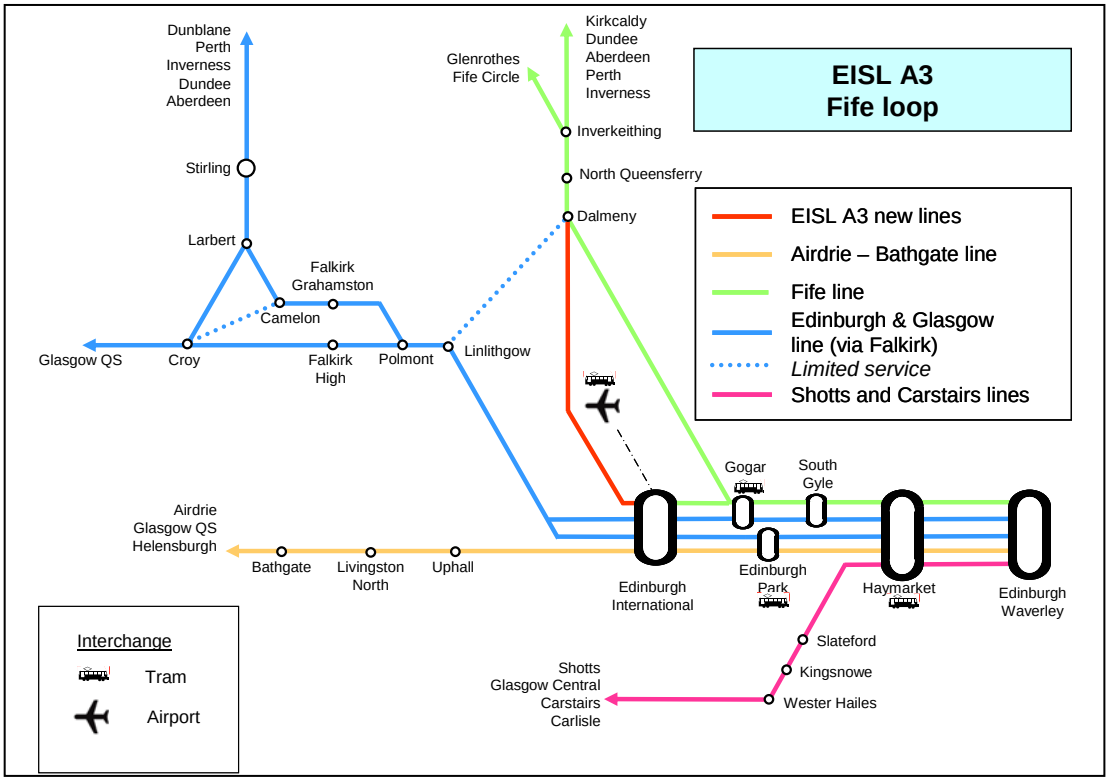


Figure 12: EISL A3 route diagram

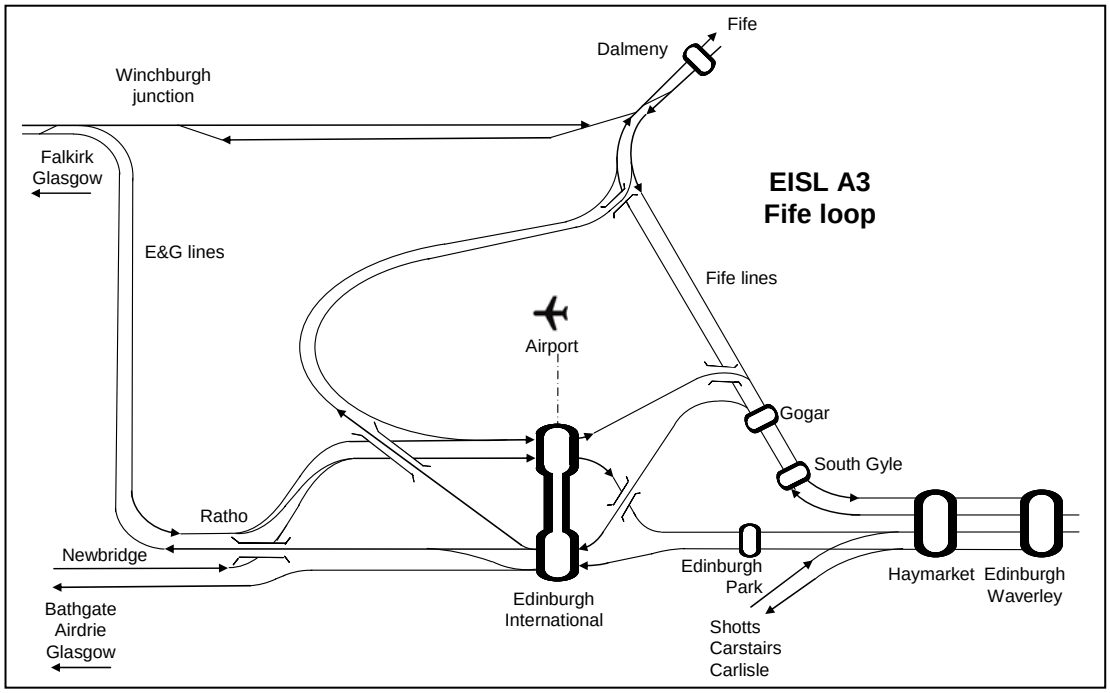
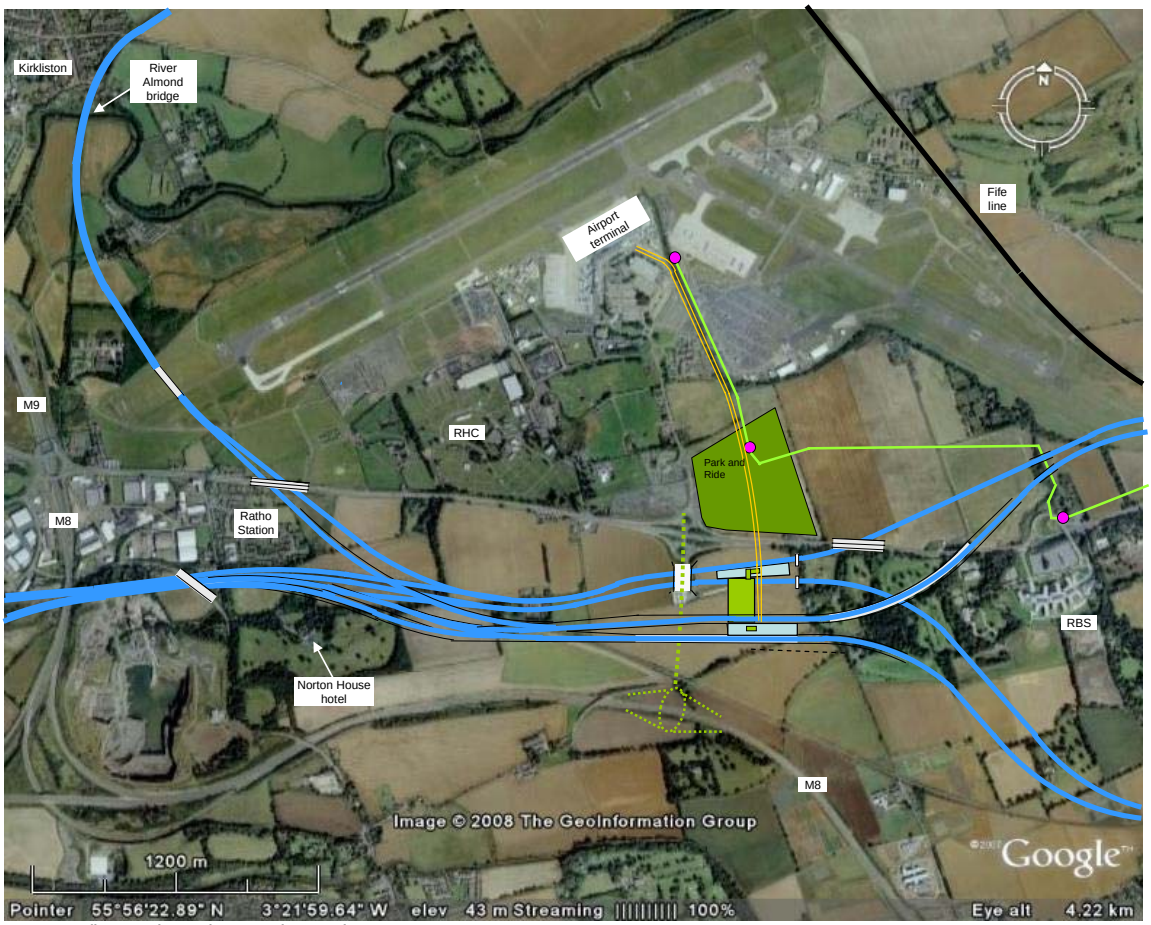


Figure 13: EISL A3 track diagram (not to scale)



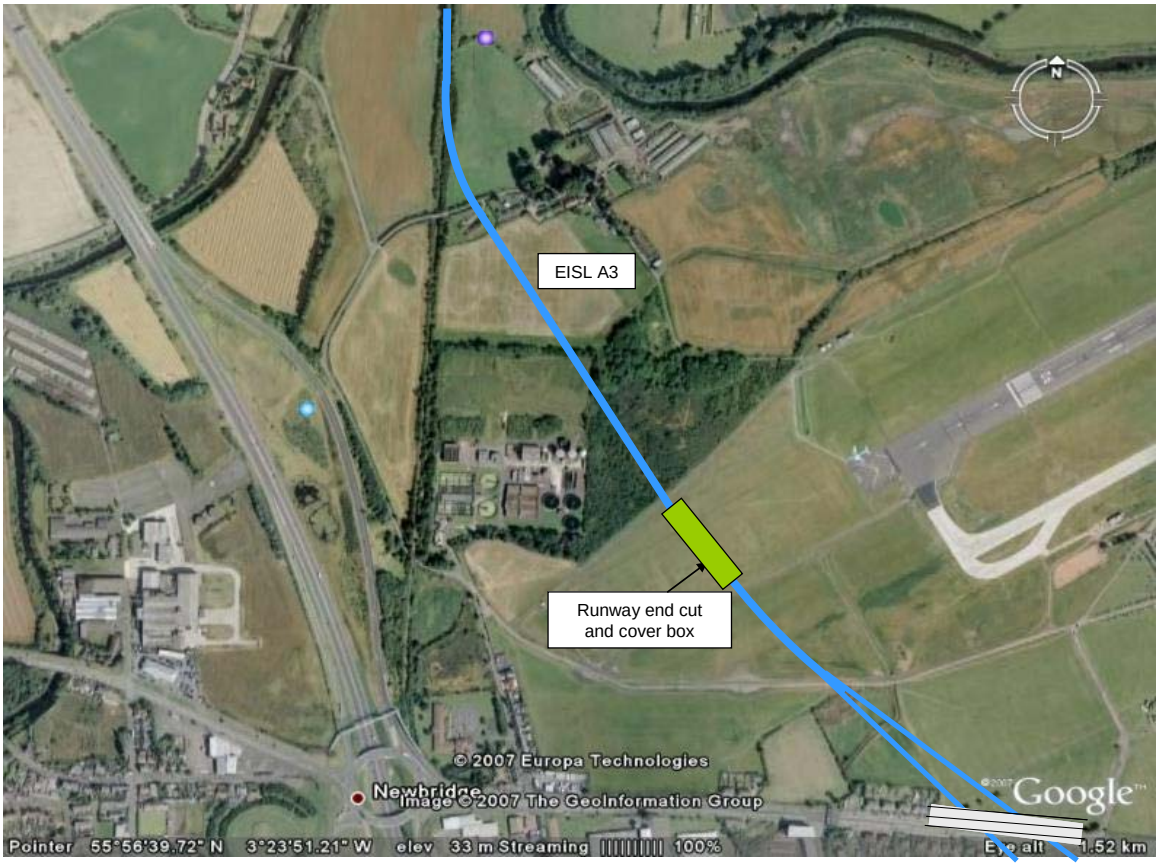
Source (base picture): Google Earth

Figure 14: EISL A3 aerial view

7.5.3. Runway end

The existing Fife line passes to the east of the main airport runway at an elevation of about +35m, sufficient to bridge the River Almond. This is a few metres higher than the airport runway and is an irritant to the airport authorities because it prevents any lengthening of the runway to the east. The EISL A3 proposal does not provide for the line to the east of the runway to be decommissioned.

The EISL A3 alignment crosses the centreline of the runway approximately 300m beyond its south western end. The line will traverse the airport grounds in a cutting such that no rail infrastructure (including future overhead line electrification) will be above current ground level. In line with the runway, the railway will be enclosed in a box, to allow airport lights and other instrumentation to be mounted above it, and to provide a safe overrun area for the runway. It also retains the option of westward lengthening of the runway. Figure 15 below is an aerial view of the alignment.



Source (base picture): Google Earth

Figure 15: EISL A3 runway end (South west end of runway 24)

Construction of this box will use the cut and cover method. This will require close co-operation with the airport authorities and some restrictions on aircraft activities for short periods to allow heavy lifting with cranes. The cost estimates reflect this requirement, assuming that lifting work is limited to night periods when the main runway can be closed or restricted. £38 million has been estimated for the cost of this box alone (£55 million with optimism bias). This is extremely high for a simple twin-track concrete box structure but the estimate has been inflated to reflect the highest possible complexity of project management, restricted site access, and working in unsocial hours. It also allows for the airport operator to be compensated for the cost of temporary relocation of airport lighting and communications and their subsequent reinstatement on the new railway box. It is likely that the box could be constructed for much less if the airport operator co-operates fully[9].

7.5.4. Reinstatement of disused Kirkliston railway

From Newbridge to Dalmeny, the EISL A3 alignment exploits the disused railway track bed through Kirkliston. This track bed is currently used as a footpath and cycleway. We have been unable to confirm whether this line was ever double track but we do know that there was a passing loop at Kirkliston. The line closed to passengers in 1930 and to all trains in 1966. The trackbed appears adequate to carry a double track railway and we judge that relatively little earthwork would be necessary to provide a double trackbed. In Kirkliston there are some new residential buildings in the vicinity of the old station that encroach on the trackbed. These new

[9] One benchmark cost is the M9 spur extension (to relieve the A8000 road). This entire project was completed for less than £40 million and included an underpass at Scotstoun, near Dalmeny, of width nearly equivalent to quadruple track, with length and construction techniques similar to the proposed airport runway box for EISL A3.

houses would be very close to the proposed EISL A3 railway and it will probably be necessary to acquire some of these houses. In any case, residents are likely to object to the construction and operating disturbance. Costings for the reinstatement of the line therefore include an allowance for offering purchase at market value of some of these properties.

Source: Google Earth

Figure 16: Disused railway bridge over River Almond at Kirkliston

Other residents and local politicians are likely to press for the station to be reinstated at Kirkliston. However, the EISL A3 proposals presented here make no provision for a station and do not consider the effects on journey times for Fife trains of a stop at Kirkliston.

The trackbed includes a bridge over the River Almond just south of Kirkliston. This appears to be in reasonable condition but the costings include a sum of £3.5 million for possible restoration works on this bridge. Figure 16 shows an aerial view of the bridge.

7.5.5. Dalmeny junction

At its northern end, the EISL A3 loop will rejoin the Fife lines south of Dalmeny at a new grade-separated junction.

7.6. Airport shuttle

The design of the airport shuttle will need to be subject to a separate feasibility study. The technologies available, and their costs, vary greatly. At one extreme is the simple cable hauled system with two opposing shuttles. Birmingham Airport uses this system but its track length is only 585m and the shuttle travels no faster than 36km/h. Its capacity is limited to 1600 passengers per hour. The cost of replacing Birmingham's original Maglev with this cable hauled system was only £11 million. This system cannot be expanded to have more than two shuttles and it appears unlikely that this technology would be adequate for the distance and passenger numbers required for EISL A.

A much more sophisticated arrangement is the monorail installed at Newark International airport in New Jersey. This extends for 3,000m serving eight stations around the airport terminals and parking lots as well as the railway station. This allows the flexibility of self-propelled vehicles and high capacity. However, its construction attracted great controversy and the final cost of US$600 million (~£300 million) was regarded as

disproportionate.

Clearly this is much grander than the shuttle required at Edinburgh International. Nonetheless, the uncertainty about the optimum technology for the link causes significant uncertainty in the overall costings of the EISL A proposals.

We have adopted assumptions for Edinburgh International of a shuttle service with 24 shuttles per hour, initially each capable of carrying 60 passengers with luggage trolleys. Future expansion, by lengthening the shuttle trains, would enable each shuttle to carry 90 passengers, giving a capacity of 2,160 passengers per hour. For this arrangement, the central cost estimate is £135 million for a self-propelled automatically controlled shuttle service running on conventional elevated tracks, recognising that this is the most uncertain of all EISL costs.

7.7. Airport expansion and RHC relocation

The EISL proposals have been developed to be flexible to future development. Specifically, the proposals are compatible with plans for airport expansion and for the move of the RHC to a new site south of the A8 road. However, the EISL proposals are dependent on neither of these developments.

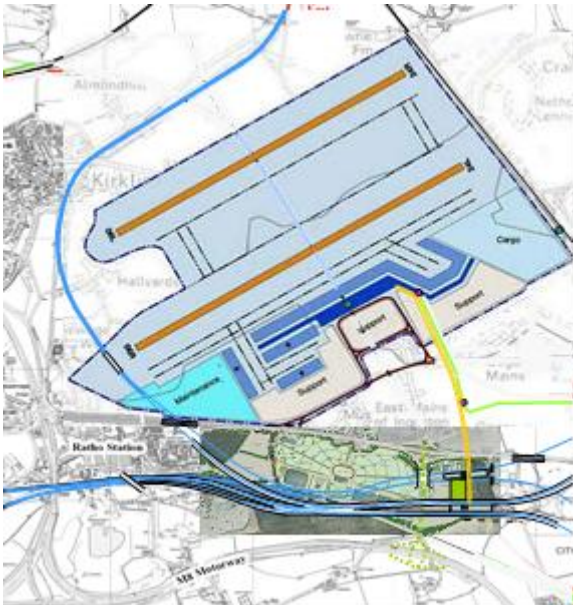


Figure 17: EISL A with airport expansion and RHC relocation
(Low resolution extract from Appendix A4)

In analysing future airport expansion, we have used the plans included in the 2003 DfT assessment[10] which considered options for expansion of Edinburgh Airport. The more recent BAA MasterPlan[11] for Edinburgh Airport is less specific about plans for the terminal building but the indicated footprint of the airport is similar to that used by the DfT assessment.

Plans are advancing to relocate the RHC to Norton Park, south of the A8 road. However, this move is not yet financed and it cannot be assumed that the move will occur. We have taken the sketch from the RHC's 2006 Annual Report[12] as the best indication of the proposed plans for the new site.

10 RHASS – Edinburgh Airport; Potential long term development options beyond 2030. Ove Arup for the Department for Transport, December 2003. Available at: http://www.dft.gov.uk/about/strategy/whitepapers/air/responses/rhassedinburghpotentiallongt5690

11 Edinburgh Airport Master Plan; July 2006. BAA. Associated drawings are available at: http://www.edinburghairport.com/assets/B2CPortal/Static%20Files/Edinburgh%20Master%20Plan%20Drawings%20July%202006.pdf

12 Royal Highland and Agricultural Society of Scotland (RHASS); Annual Report 2006 http://www.rhass.org.uk/public/articles/content/annualreport2006?view=3301

Appendix A4 shows an overlay of the EISL A proposals on the drawings of the airport expansion and the relocation of the RHC to Norton Park. Figure 17 is a low resolution extract from this Appendix.

7.8. EISL A costs

7.8.1. Capital costs

Table 2 overleaf shows the benchmark costs for each phase of the EISL A proposals, assuming that they are constructed over a number of years as three separate projects. Table 1 is a summary of these costs. However, if there were the political and economic imperative to construct all three phases simultaneously, there could be savings of about £46 million.

These costs have been prepared based solely on desk studies benchmarked against comparable projects. No site surveys have been conducted. The costs are generally likely to fall well within the optimism bias allowed for, but the costs of the airport shuttle remain very uncertain until the technology to be employed is determined.

The total benchmark costs for all three phases of the EISL A proposals, including 44% optimism bias, are £890 million. This is more than the EARL proposal but offers a major boost to the transport infrastructure of the central belt of Scotland with a transport hub that is future-proofed against a decline in aviation and would protect the economy of west Edinburgh and the central belt.

£ million	Total
Station	105
Shuttle	135
Airport crossing	38
Newbridge - Ratho quadrupling	35
Rail junctions and viaducts	118
Road and tram bridges	30
Rail trackbed	22
Other civil works	14
Rail trackworks	44
Rail signalling and comms	30
Rail electrification	12
Land	36
Sub-total	618
Optimism bias (44%)	272
Total estimate	**890**

Table 1: EISL A summary of costs

7.8.2. Operating costs

Indicative marginal annual operating costs for EISL A are £6 million. This includes: £1.5 million for the operation and maintenance of the station buildings and facilities; £1.5 million for the maintenance of 15km of extra track (compared with the Gogar station and Dalmeny chord alone); no net increase in signalling costs; £3 million for the operation and maintenance of the airport shuttle.

7.8.3. Lower cost options

The EISL B proposals below offer a lower cost alternative, both in capital and operating costs.

Item	EISL A1 (£m)	EISL A2 (£m)	EISL A3 (£m)	TOTAL	EISL A1-A3 (£m)	TOTAL
	E&G line diversion	Gogar chord	Fife loop	All phases - staged	Savings from simultaneous construction EISL A1- A3	All phases - simultaneous
Civil engineering						
Edinburgh International station	90	15	0	105	-5	100
Airport shuttle (elevated trackbed)	35	0	0	35	0	35
Ratho junction (grade separated)	42	0	0	42	0	42
Freelands Road and Roddinglaw Road realignment	2	0	0	2	0	2
Roddinglaw rail diversion and regrading	10	0	0	10	0	10
A8 underbridges	0	5	7	12	-1	11
Gogarburn viaduct	0	8	0	8	0	8
Harvest Road bridge replacement	3	0	0	3	0	3
Newbridge to Ratho track quadrupling	35	0	0	35	0	35
Airport cut and cover box (beyond SW end of main runway)	0	0	38	38	0	38
Gogarburn bridges and tram crossing (2 x single track)	0	4	0	4	0	4
Gogar grade-separated junction	0	28	0	28	0	28
Dalmeny junction south	0	0	19	19	0	19
River Almond bridge refurbishment	0	0	4	4	0	4
Ratho viaduct (Fife down line)	0	0	21	21	-3	18
Bridge for future M8 link	9	0	0	9	0	9
Trackbed preparation, cuttings and embankments	10	3	9	22	0	22
Mechanical and electrical works						
Railway trackwork	15	6	23	44	-6	38
Railway signalling, control and communications	10	10	10	30	-7	23
Railway electrification at 25kV AC	8	4	0	12	-2	10
Airport shuttle cars, trackwork and drivegear	85	0	15	100	-7	93
Land purchase						
Norton Park land acquisition	5	1	1	7	-1	6
Gogar Golf Club	2	1	0	3		3
Housing acquired in Kirkliston	0	0	5	5		5
Agricultural land	8	3	2	13		13
Other land purchase	2	2	4	8		8
Sub-total	**371**	**90**	**157**	**618**	**-32**	**586**
Optimism bias	163	40	69	272	-14	258
TOTAL ESTIMATE	**534**	**130**	**226**	**890**	**-46**	**844**

Table 2: EISL A costs

8. EISL B – the on-airport low cost low risk link

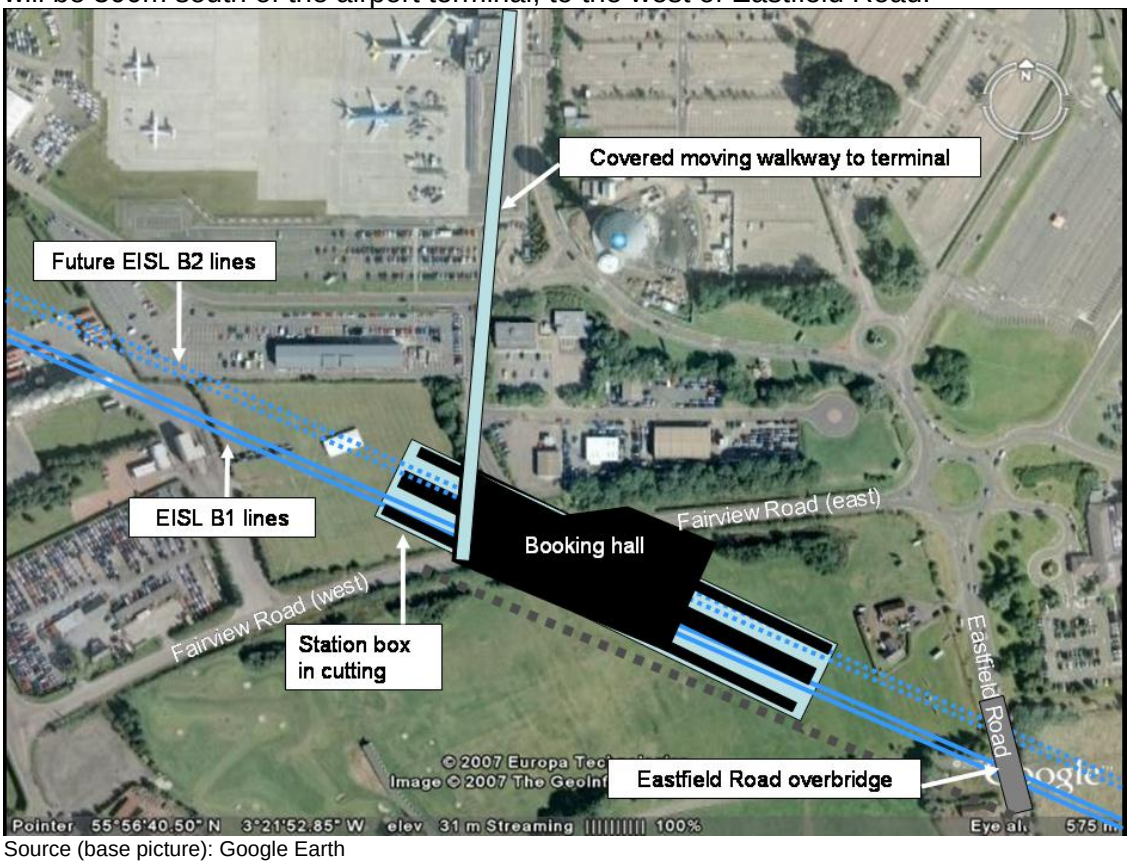
8.1. EISL B principles and objectives

EISL B will provide an on-airport rail station from which passengers can walk to the airport terminal. The station will provide surface connections to all parts of Scotland and beyond and thereby support development of the business area that surrounds the airport for much lower cost than the EARL project or EISL A.

The EISL B rail alignments do not meet the objectives set out in Section 6.1 concerning track curvature and gradients for the E&G line. Nonetheless, the EISL B proposals are entirely feasible and will cause no unacceptable increase in rail journey times. The alignments proposed here were not considered in the 2003 EARL feasibility study[1]. The proposed rail alignments are on the surface or in cuttings using conventional proven technology with low risk of construction delay or cost overrun.

8.2. Edinburgh International station site – EISL B on-airport

Figure 18 shows the proposed EISL B station site. Edinburgh International station will be 300m south of the airport terminal, to the west of Eastfield Road.



Source (base picture): Google Earth

Figure 18: Edinburgh International station site for EISL B

The railway station will initially have two full length (250m) platforms capable of receiving all current main line trains up to 11 carriages. It will be in a cutting but not enclosed. The cutting for the station will be sufficient to accommodate expansion to four platforms, with a platform arrangement and sizes similar to those at Haymarket station. The tracks at the station will be about 5m below the current ground level.

Most of the land for the new station will be acquired from the Port Royal golf range, which should be capable of remaining viable with the reduced land area.

An overbridge will be built to carry Eastfield Road on its present alignment and at its present elevation over the new railway which will be in a cutting beneath it. Fairview Road will be bisected by the new station. The Western stub of Fairview Road, serving the RHC, will be diverted to run south of the new railway to join Eastfield Road just south of its new overbridge.

A booking hall will be constructed over the station at the present ground level. Road access will be from the eastern stub of Fairview Road which will become the station access road.

Edinburgh International station will expand to four platforms with EISL B2, each platform capable of accommodating 11-car trains, suitable for all current East Coast Main Line and Cross-Country long-distance trains. The configuration of the platforms will make it easy for infrequent rail passengers, such as visitors arriving at the airport, to find the first train to Edinburgh. Figure 19 below shows the arrangement.

The central island platform will serve trains bound for Edinburgh from both the Fife lines and the Glasgow lines. This enables passengers from the airport to be directed simply at the station to this platform and to board the first train that arrives in order to reach Edinburgh Waverley. (This differs from the arrangement at Haymarket station, where trains to Waverley leave from two non-adjacent platforms connected by a footbridge.)

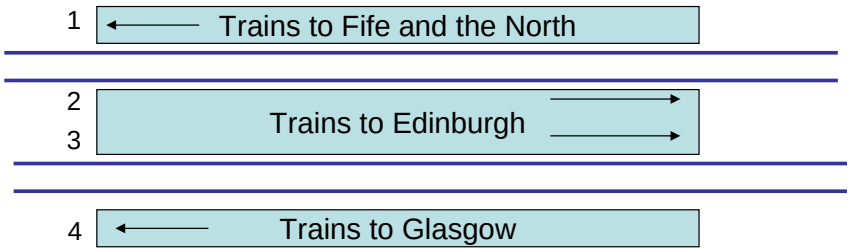


Figure 19: Platform arrangement at Edinburgh International for EISL B

8.3. EISL B1

8.3.1. EISL B1 route

EISL B1 will divert only the Airdrie-Bathgate line through the new Edinburgh International station. Figure 20 below shows the route diagram. The Edinburgh and Glasgow line via Falkirk (E&G) is not directly affected by this initial EISL B1 route. Services on that line will benefit, however, from the removal of the flat crossing at Newbridge that could otherwise delay trains that are on conflicting paths with those on the Airdrie-Bathgate line. EISL B1 therefore supports improvements to the frequency and speed of the E&G service.

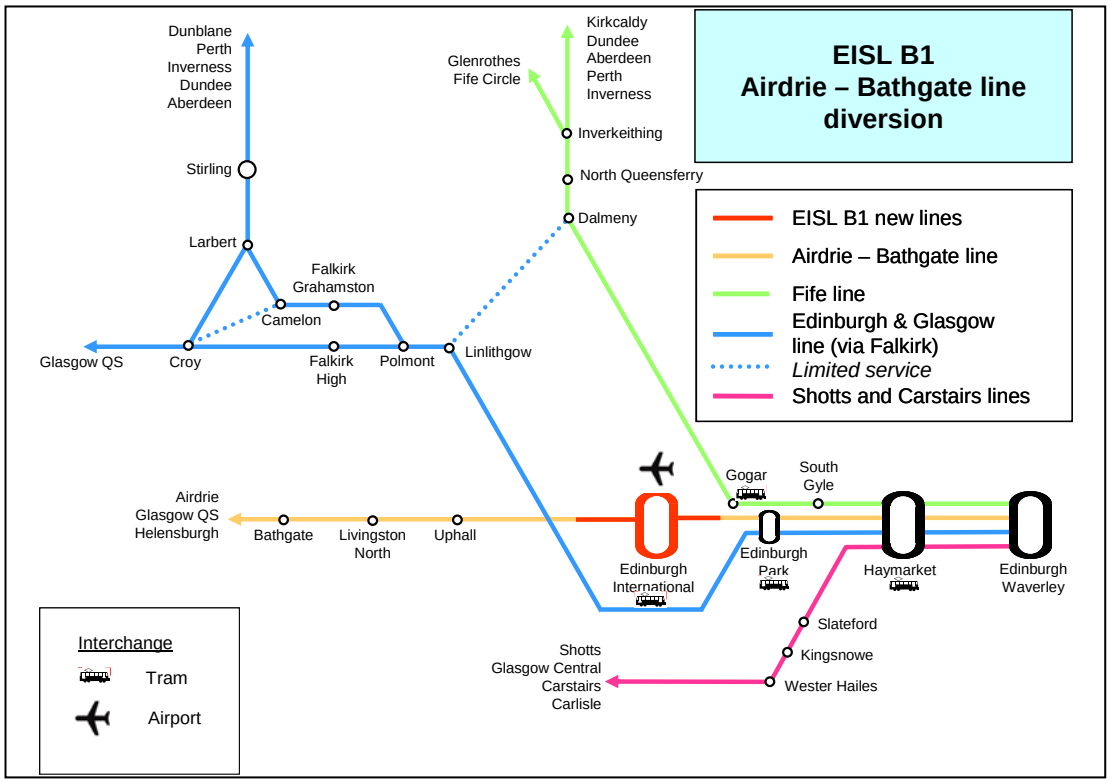


Figure 20: EISL B1 route diagram

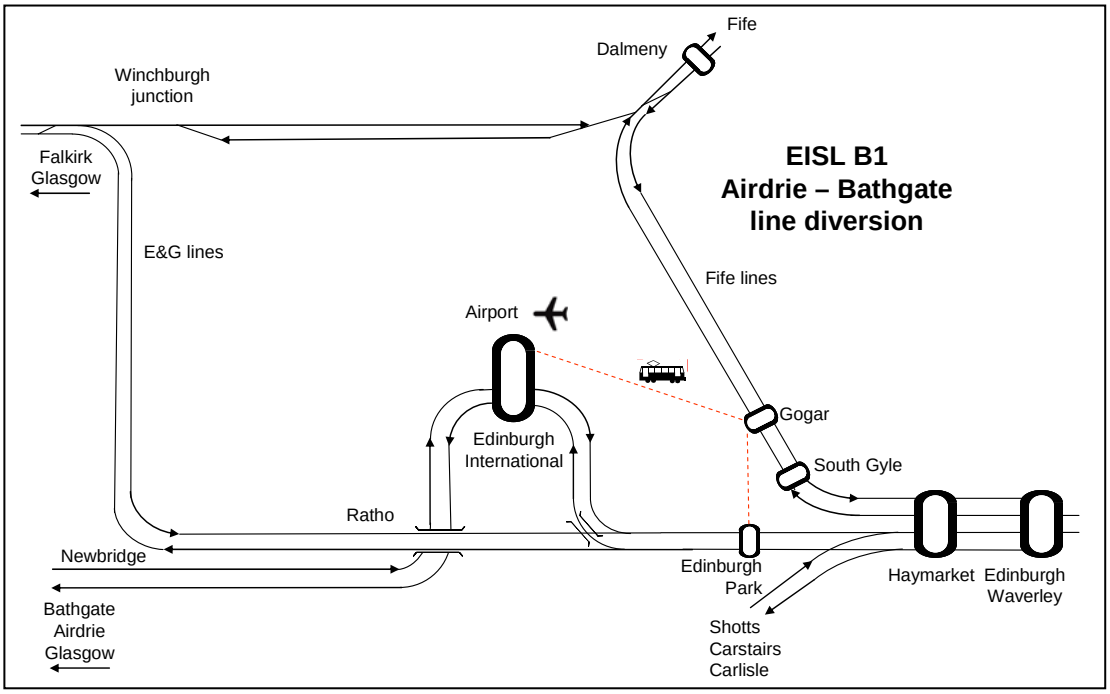
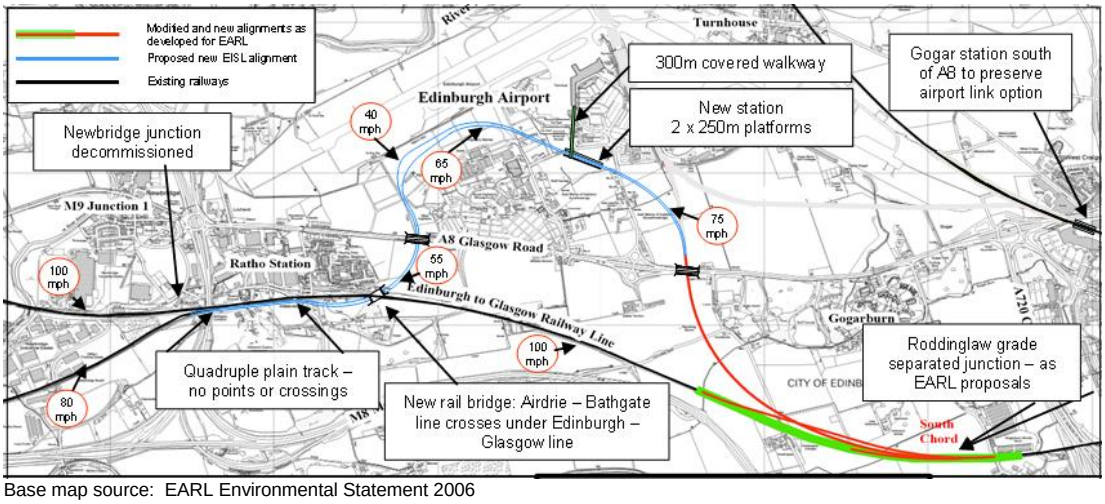


Figure 21: EISL B1 track diagram (not to scale)

The configuration of the rail lines is shown diagrammatically in Figure 21 above.

Figure 22 shows the EISL B1 rail alignment and Figure 23 is an aerial view.



Base map source: EARL Environmental Statement 2006

Figure 22: EISL B1 rail alignment

8.3.2. Newbridge to Ratho

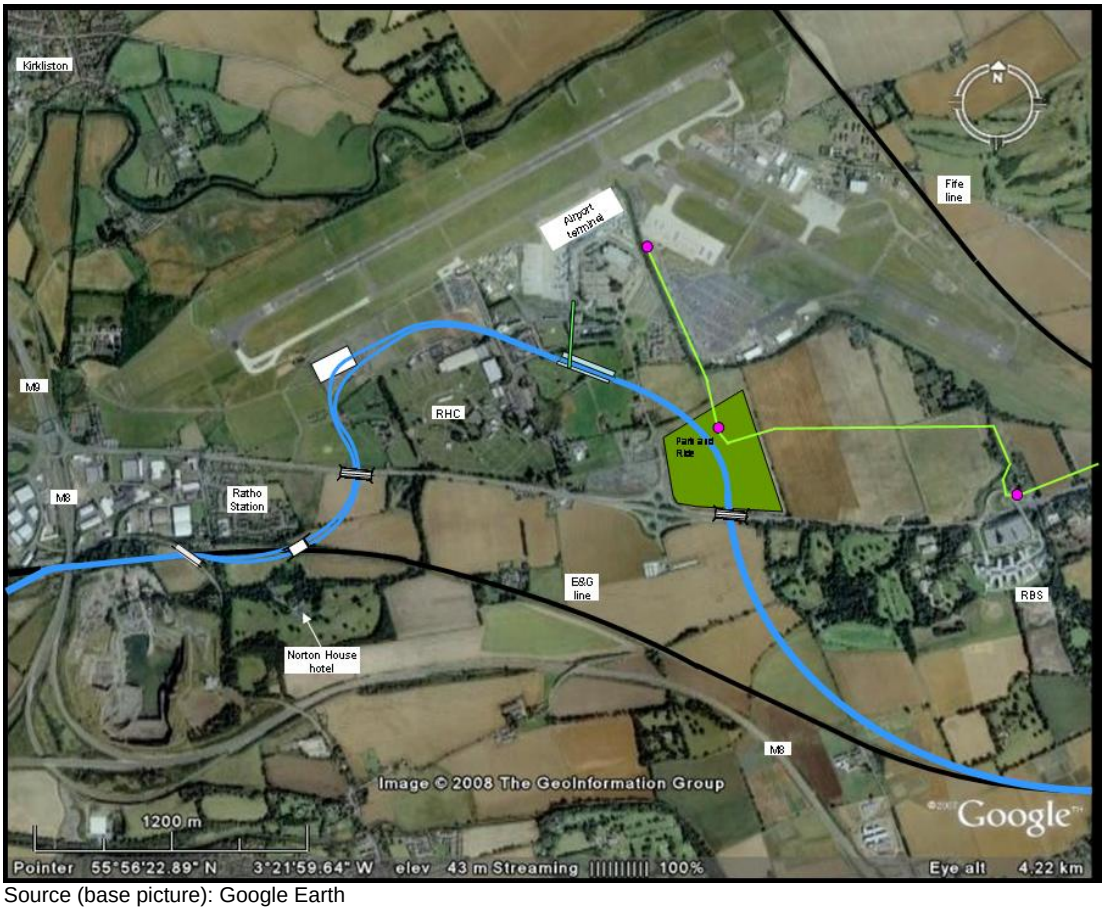
The line from Ratho to Newbridge will be converted from two to four tracks. This will require the Harvest Road bridge at Ratho Station to be reconstructed. The conversion to four tracks for the EISL B proposals will be less complex that that for the EISL A proposals. The two tracks serving the E&G line will not be directly affected and can remain live during most of the work. The two new tracks for the Airdrie – Bathgate line can be constructed to the south of the existing tracks, albeit with a steeper gradient requiring a retaining wall to secure the E&G line. The new tracks will have a gradient of 1:85, much steeper than the 1:960 of the E&G line. It is possible that a detailed feasibility study of the configuration east of Ratho for EISL B1 may show that a short section of tunnel would be more cost effective than the deep cuttings and new rail bridge contemplated here. A tunnel, when completed, would be less intrusive for the grounds of the Norton House hotel.

At Newbridge, the existing junction will be decommissioned and the two Airdrie-Bathgate tracks diverge from the two E&G tracks with no points or crossings. The rail crossing of the M8 motorway already incorporates two double-track width bridges which can accommodate the proposed EISL B1 alignments without modification, as shown in the aerial view in Figure 2.

8.3.3. EISL B1 alignment

Travelling west, EISL B1 will leave the E&G line at Roddinglaw, using the design of grade-separated junction already developed for the EARL project. It will follow the EARL alignment to pass under the A8 before turning north west to the new station site in a cutting. Thereafter, the line passes north of the RHC. The line turns to the south west through the area currently used for car parking by the RHC, parallel to the airport runway and still in a cutting. The line then turns south to pass back under the A8 to Ratho where it passes under the new rail bridge under the E&G line. There is no connection to the E&G line here.

The alignment for EISL B1 includes sharp radius curves at Ratho, as well as the 1:85 gradient. These curves may have to be as sharp as 500m radius which would limit the speed of the trains to about 55 mph. Moreover, the design of Ingliston junction (see Figure 28) is such that the Airdrie – Bathgate line is likely to carry a speed restriction of about 40 mph there. However, because all trains on the Airdrie - Bathgate line will be stopping at the new station, the rail alignment itself should not add materially to the journey times of the service.



Source (base picture): Google Earth

Figure 23: EISL B1 aerial view of rail alignment

A full alignment of the EISL B1 proposal is shown in Appendix B1. Track curvature and line speeds are shown in Appendix B5. Track gradients and elevations are shown in Appendix B6.

8.4. EISL B2

8.4.1. EISL B2 route

EISL B2 will provide a loop on the Fife lines to enable trains to and from Fife, Dundee, Aberdeen, Perth and Inverness to call at Edinburgh International. The route diagram is shown in Figure 24 below. There will be at least eight trains per hour from Edinburgh International to Edinburgh Waverley (four from Fife and four from Glasgow via Airdrie). The present Fife line to the east of the airport will be retained to ensure that trains not stopping at Edinburgh International on the Fife lines can maintain their flagship journey times to Aberdeen and Inverness. Otherwise the loop and the extra station stop would add approximately seven minutes to their journey times.

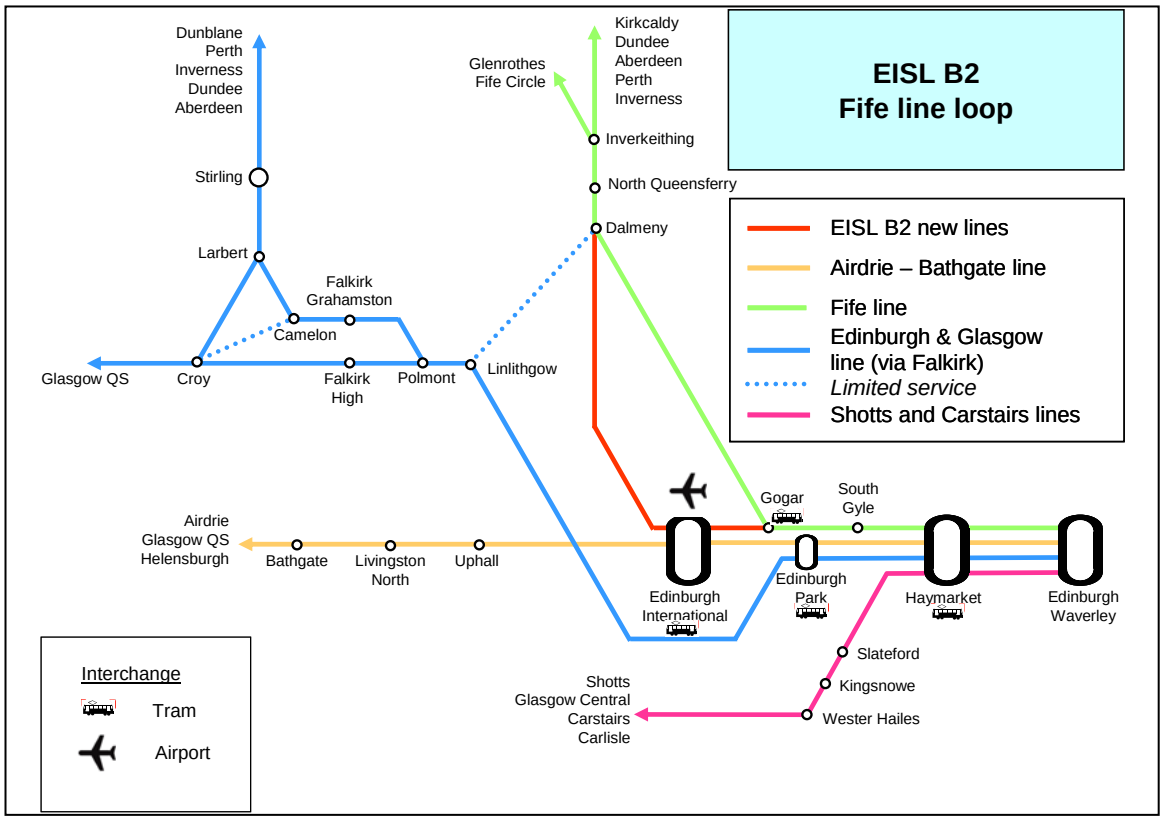


Figure 24: EISL B2 route diagram

The proposed configuration of the rail lines is shown in Figure 25 below.

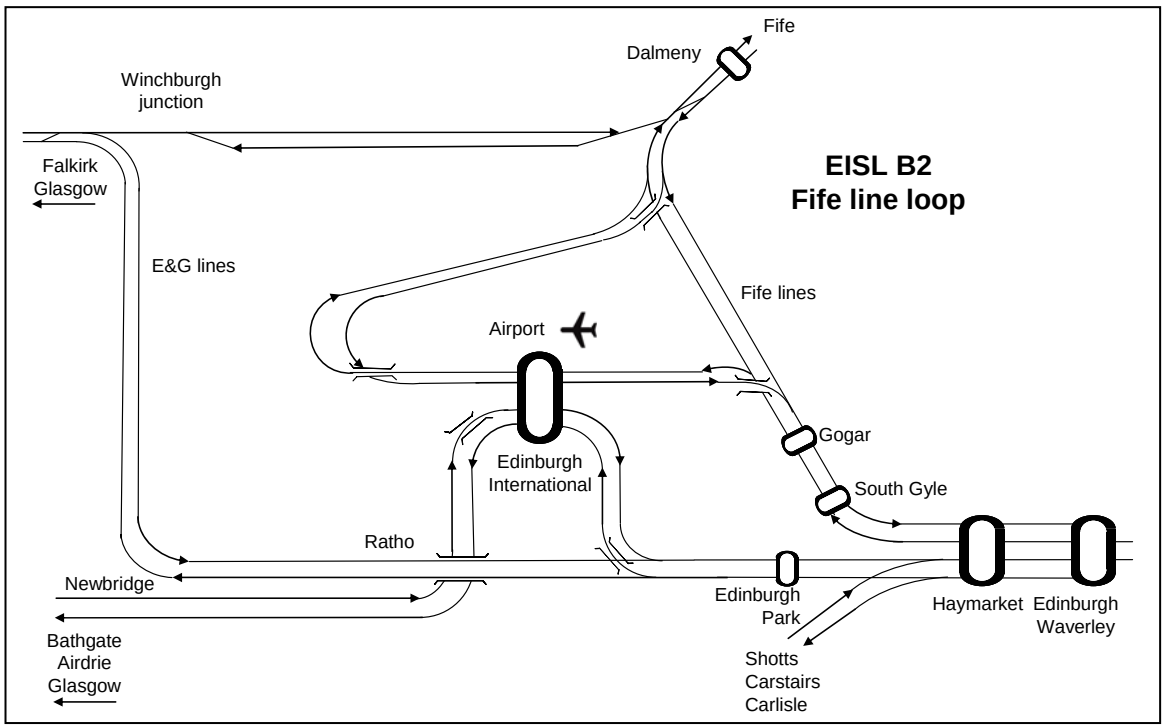


Figure 25 : EISL B2 track diagram (not to scale)

The EISL B2 lines will be flipped, such that trains run on the right hand track, for approximately 1,500m of the new route to enable the EISL B platform arrangement at Edinburgh International, shown in Figure 19.

The proposed alignment for EISL B2 is shown in Figure 26 below. Figure 27 shows an aerial view of the alignment.

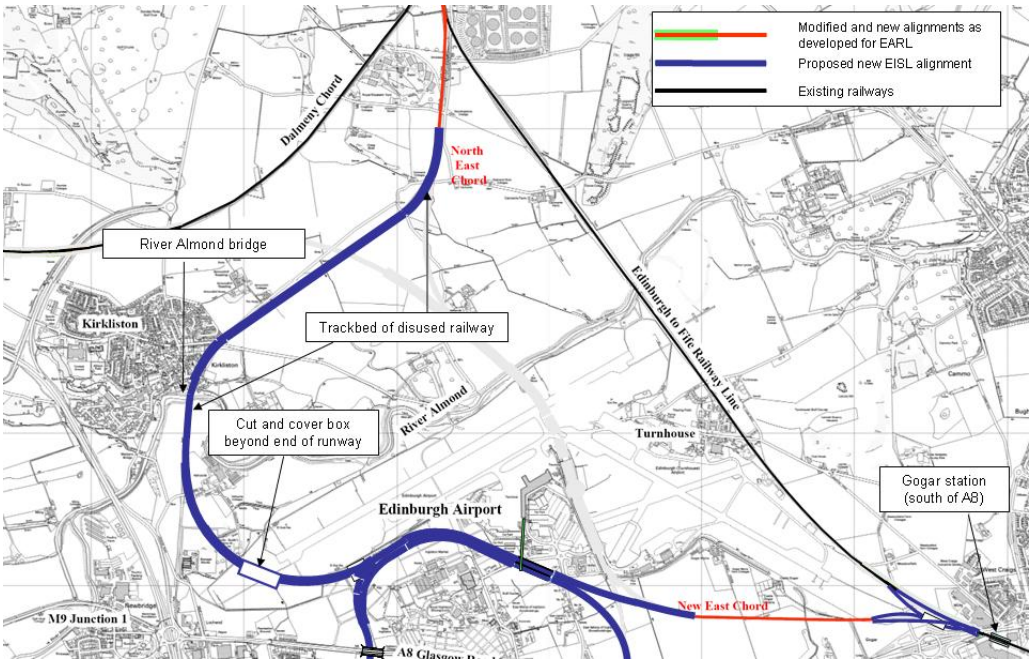
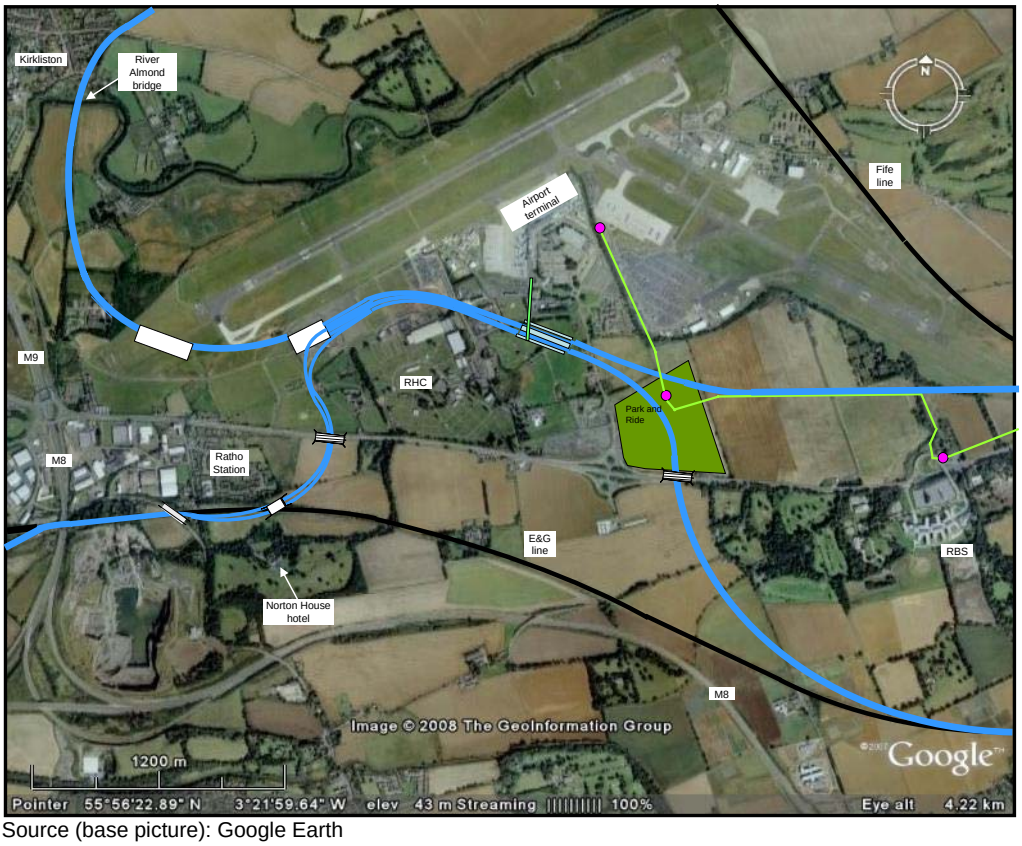


Figure 26: EISL B2 rail alignment



Source (base picture): Google Earth

Figure 27: EISL B2 aerial view

8.4.2. Gogar junction

The EISL B2 tracks will diverge from the Fife lines immediately north of the A8 road bridge at Gogar. A grade separated junction will be created whereby the northbound Fife line will dive under a new rail bridge carrying the southbound EISL B2 line. The northbound EISL B2 line will diverge from the existing Fife line north of the new rail bridge, thereby flipping the EISL B2 lines to run on the right hand tracks.

The EISL B2 lines will follow the EARL alignment westwards, crossing the Gogar burn just to the north of the tram line and at the same height as the trams. It will run parallel to the tram line but fall after the Gogar burn at a gradient of about 1:100 until it passes under the tram line to the north of the Park & Ride site. It will continue in a cutting to cross under the Eastfield Road bridge constructed for EISL B1. The EISL B2 lines will serve the two additional platforms at Edinburgh International and continue parallel to the EISL B1 lines in four track formation. Prior to the EISL B3 phase, the EISL B1 and EISL B2 lines will have no connection to each other, thereby minimising operating costs and operational complexity.

8.4.3. Ingliston junction

To the north west of the current RHC site, where the EISL B1 lines turn to the south, a new grade-separated junction will be built, to be known as Ingliston junction. This facilitates the future construction of EISL B3 and provides the second flip for the EISL B2 lines to return them to left side running.

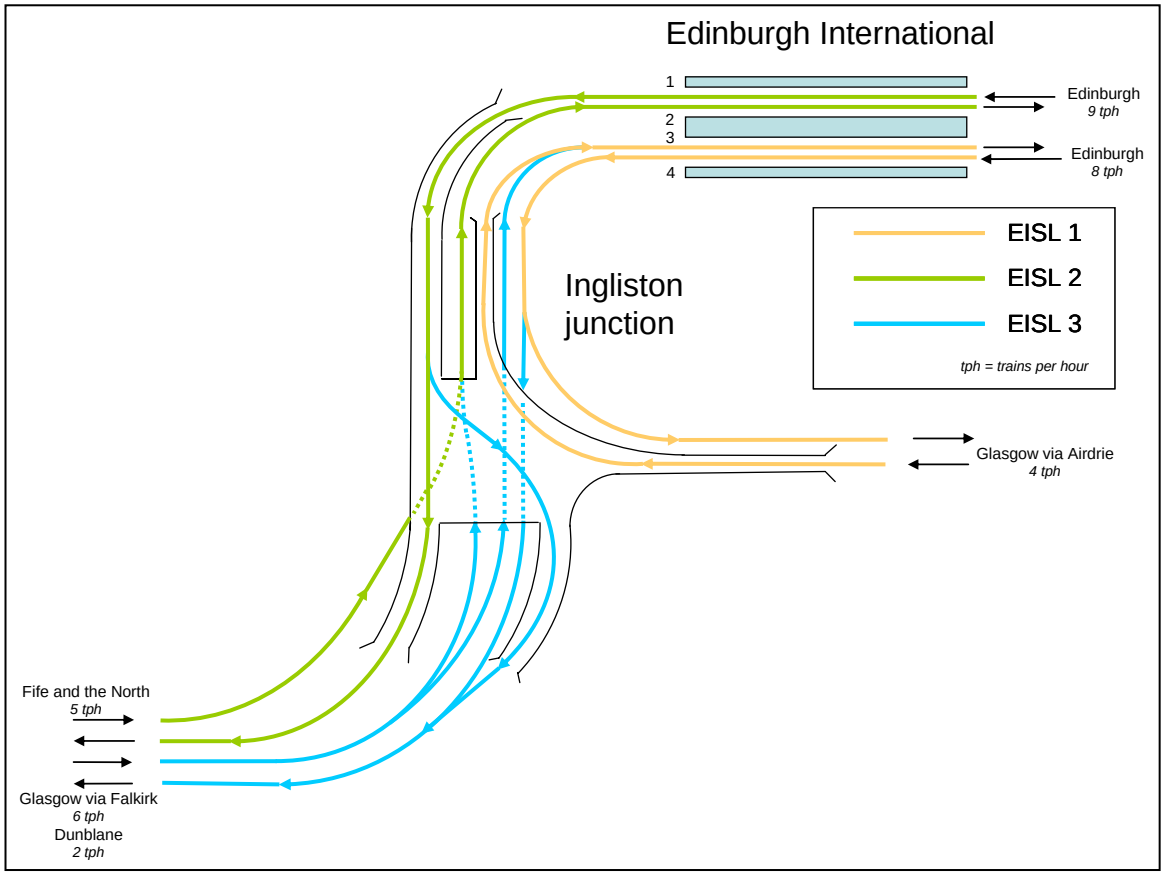


Figure 28: Ingliston junction configuration (not to scale)

The configuration of the proposed Ingliston junction is shown in Figure 28, which includes (in blue) provision for the future EISL B3 lines. Until EISL B3 is built, there will be no junction or points at Ingliston. The box constructed as part of EISL B2 will

serve only to effect the flip of the EISL B2 (Fife loop) lines. However, this civil engineering is necessary to enable the EISL B1 (Airdrie – Bathgate) lines to diverge from the future EISL B3 (Falkirk) lines and to enable the operational flexibility for the future EISL B3 lines to connect with both the EISL B1 and EISL B2 lines. This junction box should therefore be constructed as part of the EISL B2 project if there is any realistic prospect of EISL B3 proceeding in the foreseeable future.

This single junction box provides grade-separated junctions that will fulfill the intentions of the Government's proposals for the Dalmeny chord and obviate the need for building or upgrading junctions at Dalmeny and Winchburgh. The funtionality of Ingliston junction, proposed here, is an alternative to the provision of three separate grade-separated junctions at Dalmeny, Winchburgh and Newbridge and offers a more cost-effective solution to providing operational flexibility to maximise the usage of the four tracks through Haymarket.

Ingliston junction will be created by the construction of a box in the cutting, such that (a) the EISL B2 track from Edinburgh to Fife and (b) the EISL B1 track to Edinburgh from Glasgow via Airdrie pass over the top of the box, while the EISL B3 tracks to and from Falkirk and the southbound EISL B2 line from Fife pass through the box. EISL B3 will include a junction on the top of the box for the EISL B3 line from Edinburgh to diverge from the EISL B2 line from Edinburgh.

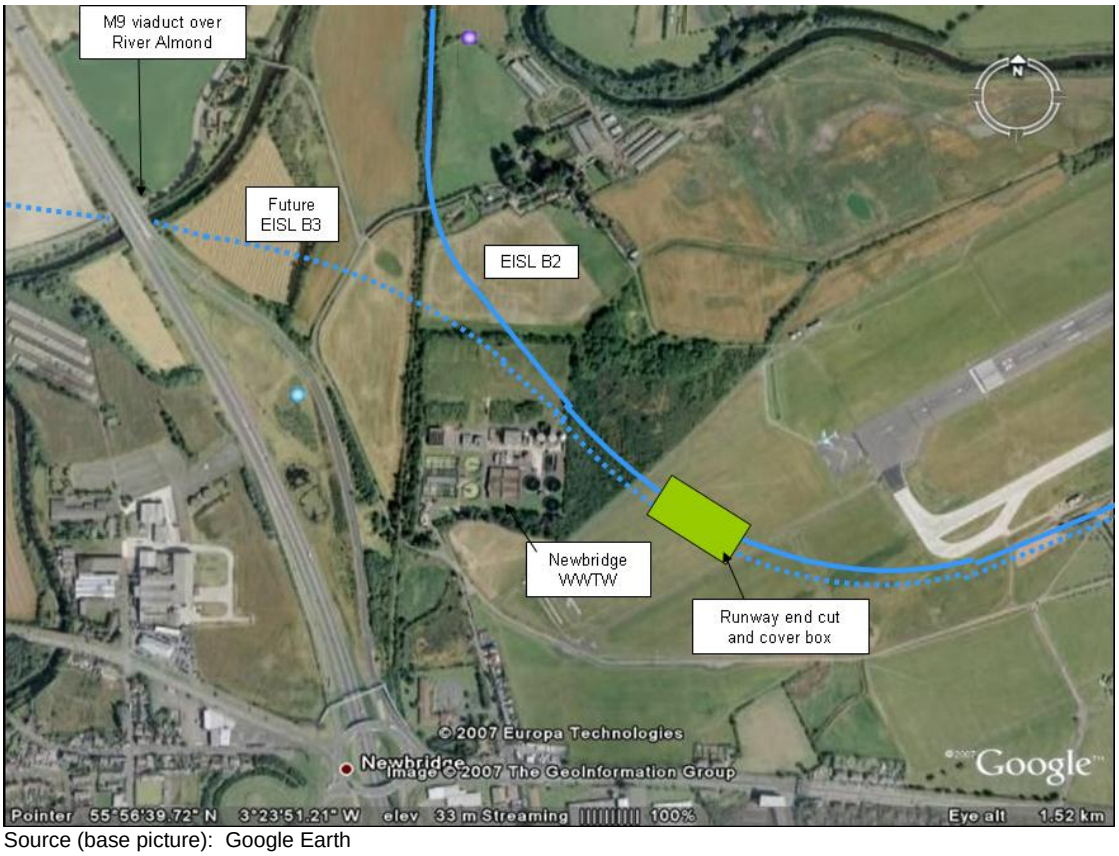
The two tracks that pass over the box will do so close to ground level. Downhill gradients from the box are likely to be close to 1:50 to return the track elevation into the cutting as rapidly as possible and thereby minimise the land that cannot be used for future airport expansion. The uphill gradients, however, will not exceed 1:100 to ensure that all current rolling stock can operate effectively and reliably in all weathers. The electrified Airdrie – Bathgate route developed under EISL B1 will already have an uphill gradient of 1:85 south of Ingliston.

8.4.4. Runway end

The rail alignment is designed to avoid crossing the airport runways and generally does not intrude on airport property. However, at the western end of the main runway (runway 24), the rail alignment will have to cross airport property to maintain a reasonable curvature and maintain high line speeds.

The EISL B2 alignment crosses the centreline of the runway approximately 300m beyond its end. The line will traverse the airport grounds in a cutting such that no rail infrastructure (including future overhead line electrification) will be above current ground level. In line with the runway, the railway will be enclosed in a box similar to that proposed for EISL A3 (section 7.5). Figure 29 below is an aerial view of the alignment.

Construction of this box will use the cut and cover method. The cost will be greater than for the two-track EISL A box. £52 million has been estimated for the cost of the four-track EISL B box (£76 million with optimism bias). As with the EISL A proposal, it is likely that the box could be constructed for much less if the airport operator co-operates fully.



Source (base picture): Google Earth

Figure 29: Runway end (South west end of runway 24)

8.4.5. Newbridge wastewater treatment works

Newbridge wastewater treatment works (WWTW) is in a constrained site between the south western perimeter of the airport and the M9 / M8 junction at Newbridge. Figure 29 shows its location. The alignments of EISL B2 and EISL B3 have been determined to avoid any significant acquisition of land from this works. However, it may be possible to improve line speeds by acquiring land from this site and easing the alignment of the railway. Newbridge WWTW is operated by Thames Water under a Public Private Partnership (PPP) contract for Scottish Water.

8.4.6. Reinstatement of disused Kirkliston railway

From Newbridge to Dalmeny, the EISL B2 alignment follows that proposed for EISL A3, described in Section 7.5.4.

8.4.7. Dalmeny junction

At its northern end, the EISL B2 loop will rejoin the Fife lines south of Dalmeny at a new grade-separated junction.

8.5. EISL B3

8.5.1. EISL B3 route

EISL B3 will divert the Edinburgh and Glasgow line via Falkirk (E&G) through Edinburgh International station. It will be a diversion, not a loop. The existing E&G line through Ratho and Newbridge will be decommissioned. EISL B3 offers the prospect of 17 trains per hour from Edinburgh International to Edinburgh Waverley (4 from Glasgow via Airdrie, 4 from Fife, 6 from Glasgow via Falkirk, 2 from Dunblane, 1 from Aberdeen or Inverness).

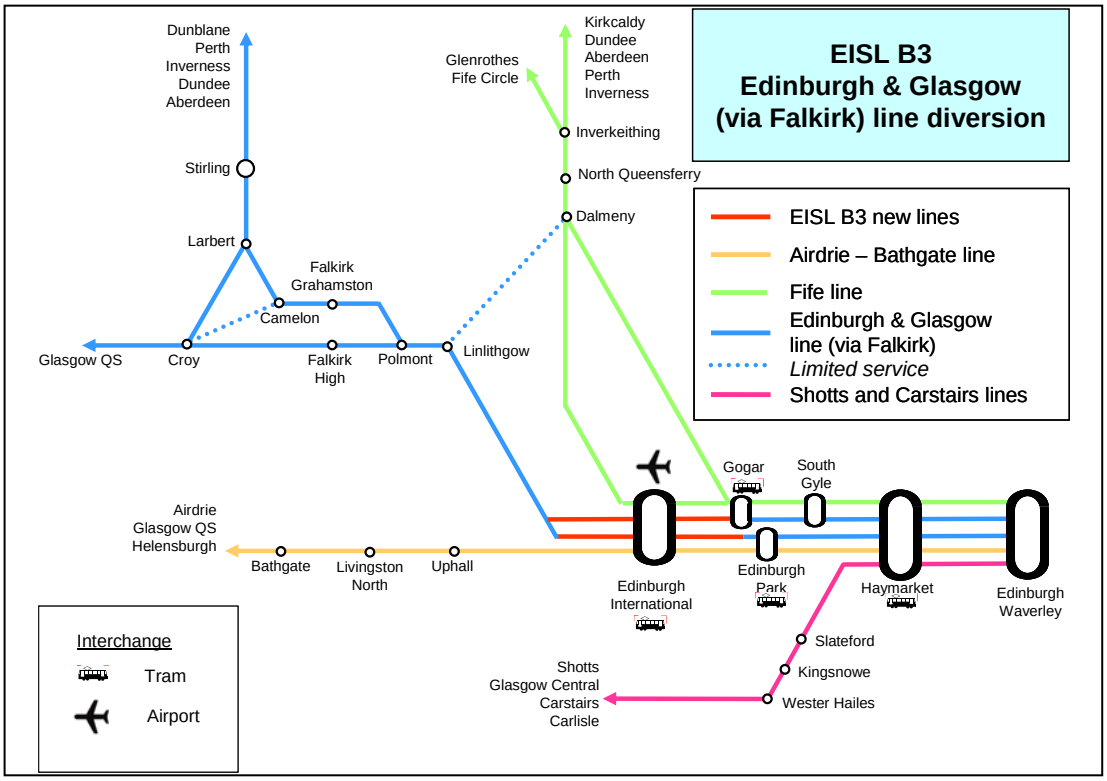


Figure 30: EISL B3 route diagram

A loop was considered as an alternative (i.e. the EISL B3 diversion and retention of the existing route). However, this would add operational complexity and cost and offer only very limited savings in journey time compared with the diversion via EISL B3. EISL B3 will only proceed if there is a sufficiently strong business case for trains on the E&G line to call at Edinburgh International. Therefore, most trains on the E&G line will be stopping at the station and their journey times will be affected only by the additional station stop, not by the EISL B3 alignment. We estimate the increase in journey time to be five minutes, including 150 seconds dwell time at the station.

Figure 30 shows the EISL B3 route diagram and Figure 31 shows the proposed rail configuration.

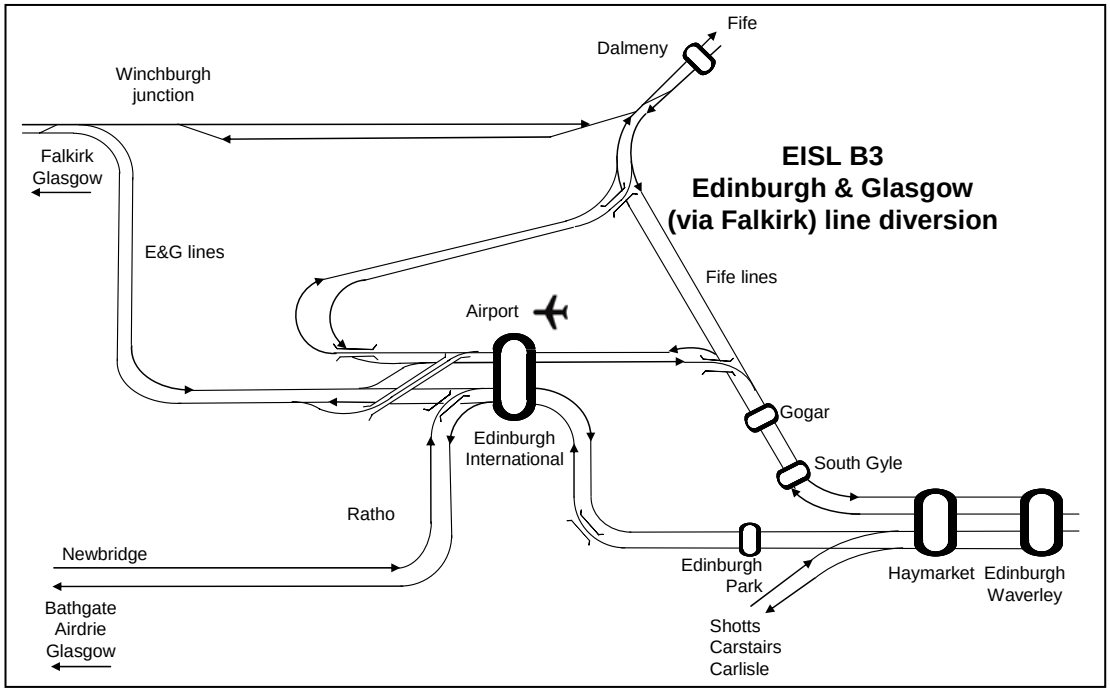


Figure 31: EISL B3 track diagram (not to scale)

EISL B3 will use both the EISL B1 tracks from Edinburgh Park through Roddinglaw junction, which will be decommissioned to become plain track, and the EISL B2 tracks from Gogar, to use all four platforms at Edinburgh International. EISL B3 will complete Ingliston junction, for which the layout is shown in Figure 28. This will provide operational flexibility for trains to and from Glasgow (via Falkirk) to use either (a) the EISL B2 and Fife lines or (b) the EISL B1 and E&G lines through Haymarket to and from Edinburgh. This enables the four tracks through Haymarket to be exploited to their full capacity.

8.5.2. EISL B3 alignment

Heading west from Edinburgh International, EISL B3 will diverge from EISL B1 and EISL B2 at the grade-separated Ingliston junction, for which the civil engineering will have been completed as part of EISL B2. The EISL B3 alignment will then run parallel to the EISL B2 tracks through the box at the end of the airport runway built for EISL B2. It will diverge from EISL B2 to the north of the Newbridge wastewater treatment works, as shown in Figure 29.

The EISL B3 diversion will involve a restricted line speed of approximately 65 mph immediately north west of Edinburgh International station. This will add less than one minute to journey times for trains not stopping there, compared with the current route. The line speed could be increased by easing the rail alignment through land currently occupied by the RHC, if it were confirmed that the RHC's move has been funded, and realigning Edinburgh International station. This realignment option has not been assessed here.

8.5.3. M9 motorway and River Almond

EISL B3 will pass under the M9 motorway and cross the River Almond at the same point by subsuming the B800 road there. The B800 runs parallel to the river and does not cross it. The railway will cross the river on two new single-track bridges built under the M9 motorway to pass through the arches of the existing motorway viaduct, with no modification required to that viaduct. The rail elevation will probably have to be higher than the current B800 to ensure that periodic flooding of the River Almond will not affect rail services. Figure 32 shows the alignment and Figure 33 is an aerial view of the River Almond crossing.

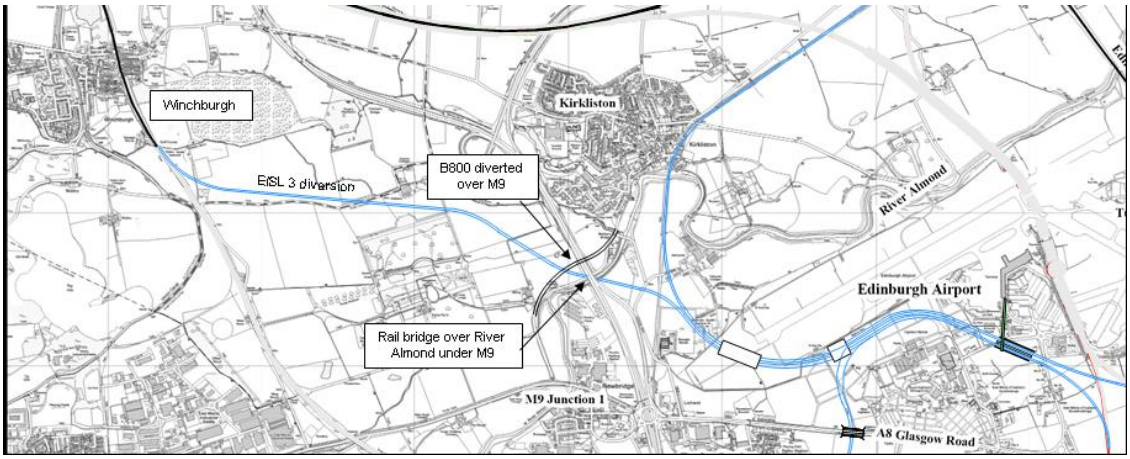
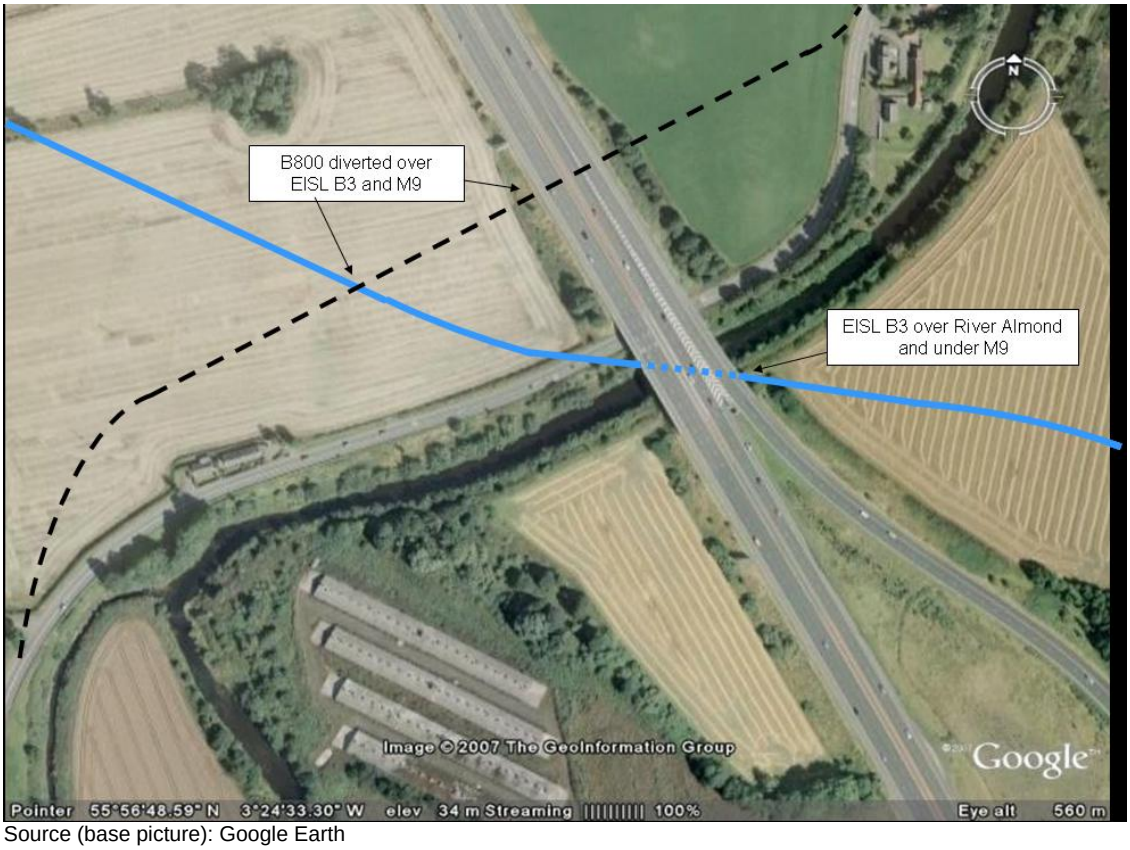


Figure 32: EISL B3 rail alignment

The B800 road will be diverted onto a new road bridge over the EISL B3 railway and the M9 motorway. This will be a high bridge with an associated high cost and it will reduce the visual amenity locally in Kirkliston. It is possible that detailed design work could identify alignments for both the EISL B3 railway and the B800 under the M9 through the current viaduct, avoiding the need for this expensive high bridge. However, this option is not obvious and the costings here include the possible £33 million cost of the new road bridge over the M9 with associated approach embankments.



Source (base picture): Google Earth

Figure 33: Aerial view of EISL B3 alignment over River Almond and under M9 motorway at Kirkliston

8.5.4. Winchburgh diversion

At its western end, EISL B3 will diverge from the current E&G alignment south of Winchburgh, immediately south of the existing rail bridge over the Niddry Burn. The new alignment will skirt Niddry Castle but require some land from the Niddry Castle Golf Club. The new EISL B3 alignment will run across agricultural land at a gradient of 1:110 to pass south of Overton but north of the grounds of Newliston House to reach the M9 and River Almond crossing. This alignment will ensure current line speeds of 100mph can be maintained and would facilitate higher future line speeds.

EISL B3 will enable the decommissioning of over 5km of the current E&G line, from Winchburgh to Roddinglaw.

8.5.5. Almond Valley viaduct

The Almond Valley viaduct is a landmark on the E&G line. It will be decommissioned as a consequence of EISL B3, offering significant savings in maintenance costs.

Source: http://www.geograph.org.uk/photo/44303 (© Richard Webb)

Figure 34: Almond Valley viaduct

8.5.6. M8 motorway spur to airport

Decommissioning of the E&G line will facilitate future construction of a motorway spur from the M8 motorway near Roddinglaw (see Figure 22) to the airport. It will remove the need to bridge the railway. No costs for a motorway spur have been included in the EISL proposals.

8.6. Airport expansion and RHC relocation

Section 7.7 explained the assumptions concerning expansion of the airport and relocation of the RHC. Appendix B4 shows an overlay of the EISL B proposals on the drawings of the airport expansion and the relocation of the RHC to Norton Park. Figure 35 is a low resolution extract from this Appendix.

Ingliston junction is the only point within the EISL B rail alignments that will require land at the current ground level to be protected, other than the railway station. In the event of major airport expansion, Ingliston junction will become an island within the expanded airport complex. All other parts of the EISL alignment can be bridged at current ground level to provide new taxi-ways and airport roads.

In Figure 35, airport expansion is indicated using a new slab over the railway to the north west of the station, to carry an expansion of the terminal building and aircraft taxiways. It also shows a suggested aircraft bridge over the railway at the western end of the runway.

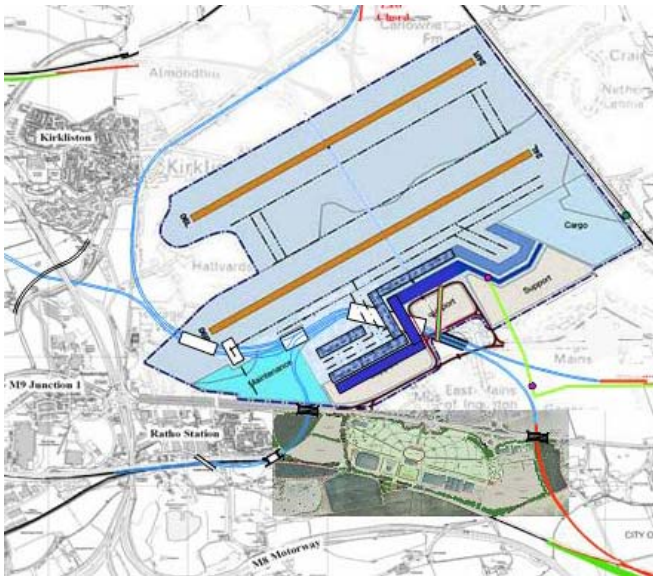


Figure 35: EISL B with airport expansion and RHC relocation
(Low resolution extract from Appendix B4)

8.7. EISL B costs

8.7.1. Capital costs

Table 4 overleaf shows the benchmark costs for each phase of the EISL B proposals, assuming that they are constructed over a number of years as three separate projects. Table 3 is a summary of these costs.

These costs have been prepared based solely on desk studies benchmarked against comparable projects. No site surveys have been conducted. If there were the political and economic imperative to construct all three phases simultaneously, there could be savings of about £82 million. Constructing EISL B3 at the same time as EISL B1 would avoid the need for a grade-separated junction at Roddinglaw (see Figure 22). It would also avoid the need to provide four rail tracks between Ratho and Newbridge because the EISL B1 lines would take over part of the alignment of the existing E&G lines over that route. The permanent rail underbridge proposed for EISL B1 at Ratho (see Figure 22) would be unnecessary if EISL B3 were built at the same time.

£ million	Total
Station	58
Airport walkway	6
Airport crossing	53
Newbridge - Ratho quadrupling	15
Rail junctions and viaducts	137
Road and tram bridges	55
Rail trackbed	20
Other civil works	4
Rail trackworks	50
Rail signalling and comms	25
Rail electrification	17
Land	35
Sub-total	474
Optimism bias (44%)	208
Total estimate	**682**
Less: savings from simultaneous construction	-82
Reduced estimate	**600**

Table 3: EISL B summary of costs

Table 4 shows that the total benchmark costs for all three phases of the EISL B proposal, including 44% optimism bias, are less than £600 million. This is less than the EARL proposal and offers a major boost to the transport infrastructure of the central belt of Scotland.

8.7.2. Operating costs

Indicative marginal annual operating costs for EISL B are £2.6 million. This includes: £1 million for the operation and maintenance of the station buildings and facilities and the travelators to the airport terminal; £1.6 million for the maintenance of 16km of extra track (compared with the Gogar station and Dalmeny chord alone); and no net increase in signalling costs.

Item	EISL B1 (£m)	EISL B2 (£m)	EISL B3 (£m)	TOTAL	EISL B1-B3 (£m)	TOTAL
	Airdrie - Bathgate line diversion	Fife line airport loop	E&G (Falkirk) line airport diversion	All phases - staged	Savings from simultaneous construction EISL 1- 3	All phases - simultaneous
Civil engineering						
Edinburgh International station	47.3	11.0		58.3		58.3
Walkway from station to airport terminal	3.5			3.5		3.5
Eastfield Road in-line underbridge	1.5			1.5		1.5
Other road realignment and bridges around new station	2.0			2.0		2.0
Roddinglaw grade separated junction	24.3			24.3	-18.0	6.3
A8 underbridges (x2)	15.0			15.0		15.0
Ratho underbridge (Airdrie - Bathgate line crossing under E&G line)	11.0			11.0	-9.5	1.5
Harvest Road bridge replacement	3.0			3.0	-3.0	0.0
Newbridge to Ratho track quadrupling	15.0			15.0	-15.0	0.0
Airport cut and cover box (beyond SW end of main runway)		52.5		52.5		52.5
Gogar grade separated junction		28.0		28.0		28.0
Ingliston junction box and approach viaducts		32.0		32.0		32.0
Dalmeny junction south		18.5		18.5		18.5
River Almond bridge refurbishment		3.5		3.5		3.5
New rail bridges over River Almond (under existing M9 motorway viaduct)			23.0	23.0		23.0
Diversion of B800 over new railway and M9 viaduct (at River Almond)			33.0	33.0		33.0
Trackbed preparation, cuttings and embankments	8.0	5.0	7.0	20.0		20.0
Mechanical and electrical works						
Railway trackwork	10.0	23.0	17.0	50.0	-6.0	44.0
Railway signalling, control and communications	8.0	10.0	7.0	25.0	-5.0	20.0
Railway electrification at 25kV AC	5.0	0.0	12.0	17.0		17.0
Travelators for walkway from station to airport terminal	2.0			2.0		2.0
Land purchase						
Royal Highland Centre car parking displaced by railway	2.5			2.5		2.5
Port Royal golf range	1.0			1.0		1.0
RHC outbuildings	1.0	1.0		2.0		2.0
Agricultural land	7.9	6.1	3.0	17.0		17.0
Housing acquired in Kirkliston	0.0	5.0	0.0	5.0		5.0
Other land purchase	5.0	1.0	2.0	8.0	-0.5	7.5
Sub-total	**173.0**	**196.6**	**104.0**	**473.6**	**-57.0**	**416.6**
Optimism bias	76.1	86.5	45.8	208.4	-25.1	183.3
TOTAL ESTIMATE	**249.2**	**283.1**	**149.8**	**682.0**	**-82.1**	**599.9**

Table 4: EISL B costs

9. Conclusions and comparison of options

Two options have been presented here for review and comment. The principal characteristics of each option are summarised in Table 5 below.

	EISL A	EISL B
Distance from station to airport terminal	1,700m	300m
Link from station to terminal	Automatically controlled elevated shuttles	Moving walkway
Trains per hour each way – Phase 1 – Phase 2 – Phase 3	 8 12 17	 4 9 17
Capital cost – Phase 1 – Phase 2 – Phase 3 – Total (phased)	 £534m £130m £226m £890m	 £249m £283m £150m £682m
Capital cost – simultaneous build	 £844m	 £600m
Additional operating and maintenance costs	~£6m p.a. (inc. airport shuttle)	~£2.6m p.a.
Minimum rail curve radius – E&G line – Airdrie – Bathgate line – Fife loop	 1000m 1000m 800m	 625m 500m 625m
Track elevation at station – Westbound – Eastbound	 +58m +43m	 +28m +28m
Steepest uphill gradient – E&G line – Airdrie – Bathgate line – Fife loop	 1:250 1:250 1:115	 1:110 1:85 1:100
Steepest downhill gradient – E&G line – Airdrie – Bathgate line – Fife loop	 1:100 1:100 1:60	 1:110 1:50 1:50
Lowest speed constraint – E&G line – Airdrie – Bathgate line – Fife loop	 80mph 80mph 70mph	 65mph 40mph 65mph
Journey time increase (including 150 seconds dwell at station) – E&G line – Airdrie – Bathgate line – Fife loop	 4 min 4 min 7 min	 5 min 6 min 7 min
Airport expansion restrictions	None	Some minor redesign of expanded terminal and apron
RHC relocation restrictions	Redesign of new RHC to include station and expansion south to M8	None

Table 5: Principal characteristics: EISL A and EISL B

10. Next steps

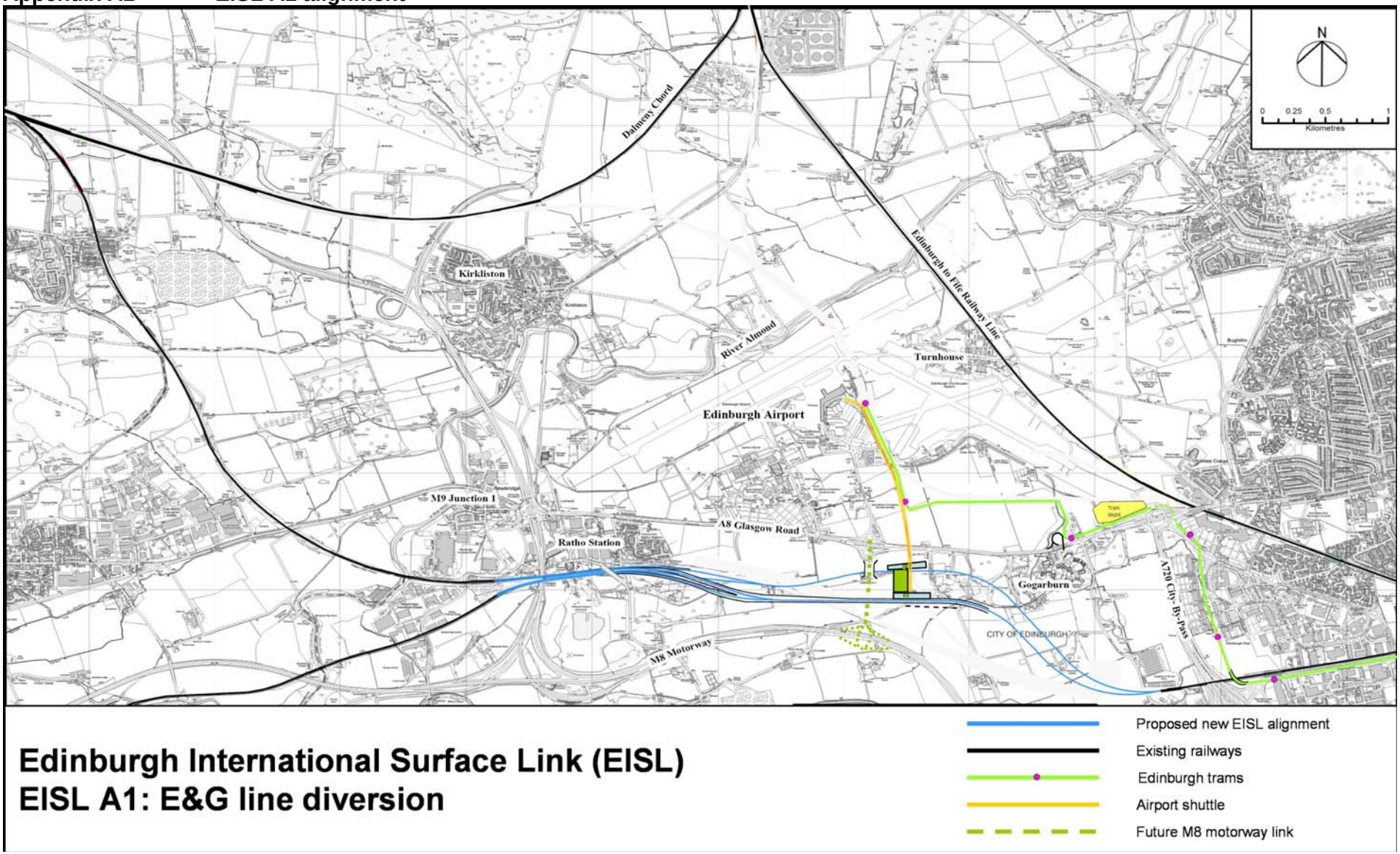
This paper is intended to solicit comments about the desirability and attractiveness of the EISL A and B proposals. If respondents find either or both proposals attractive, the next step is to identify a project developer who would confirm the technical, environmental and financial feasibility.

APPENDICES

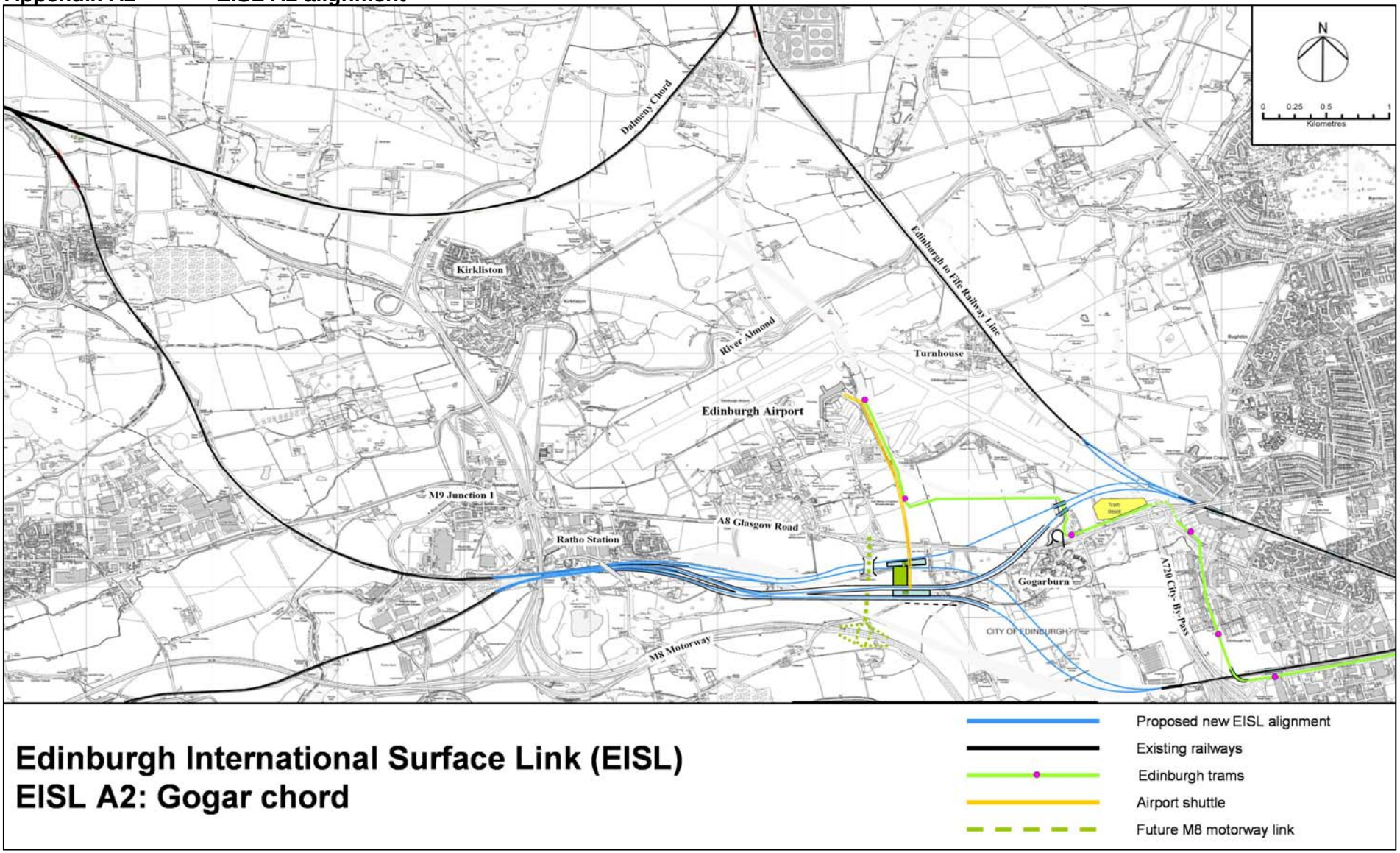
The Appendices reproduced in this document have low resolution prints of maps to restrict the file size for downloading. Higher resolution prints are available for downloading separately from:

www.eisl.org.uk

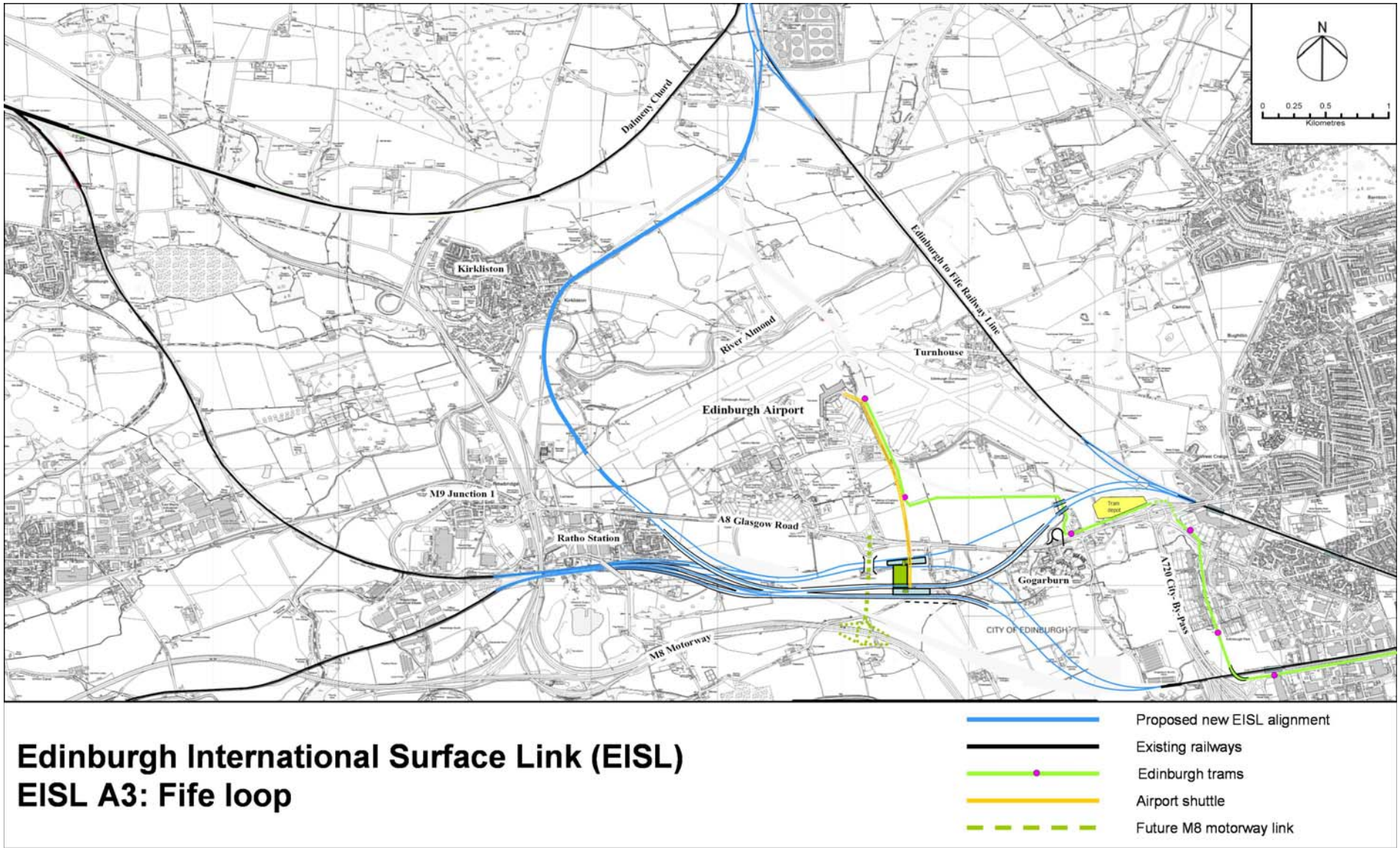
Appendix A1 - EISL A1 alignment



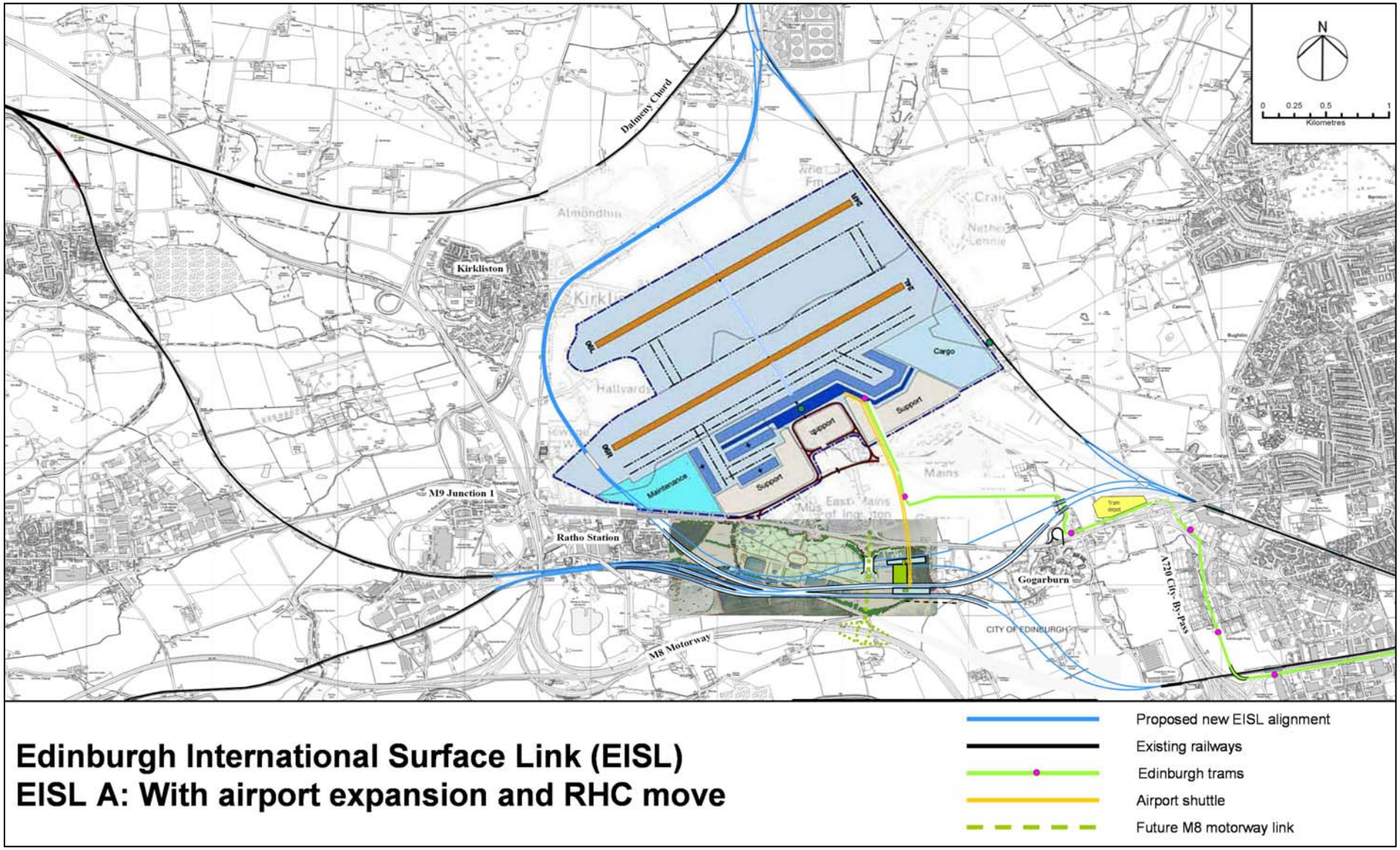
Appendix A2 - EISL A2 alignment



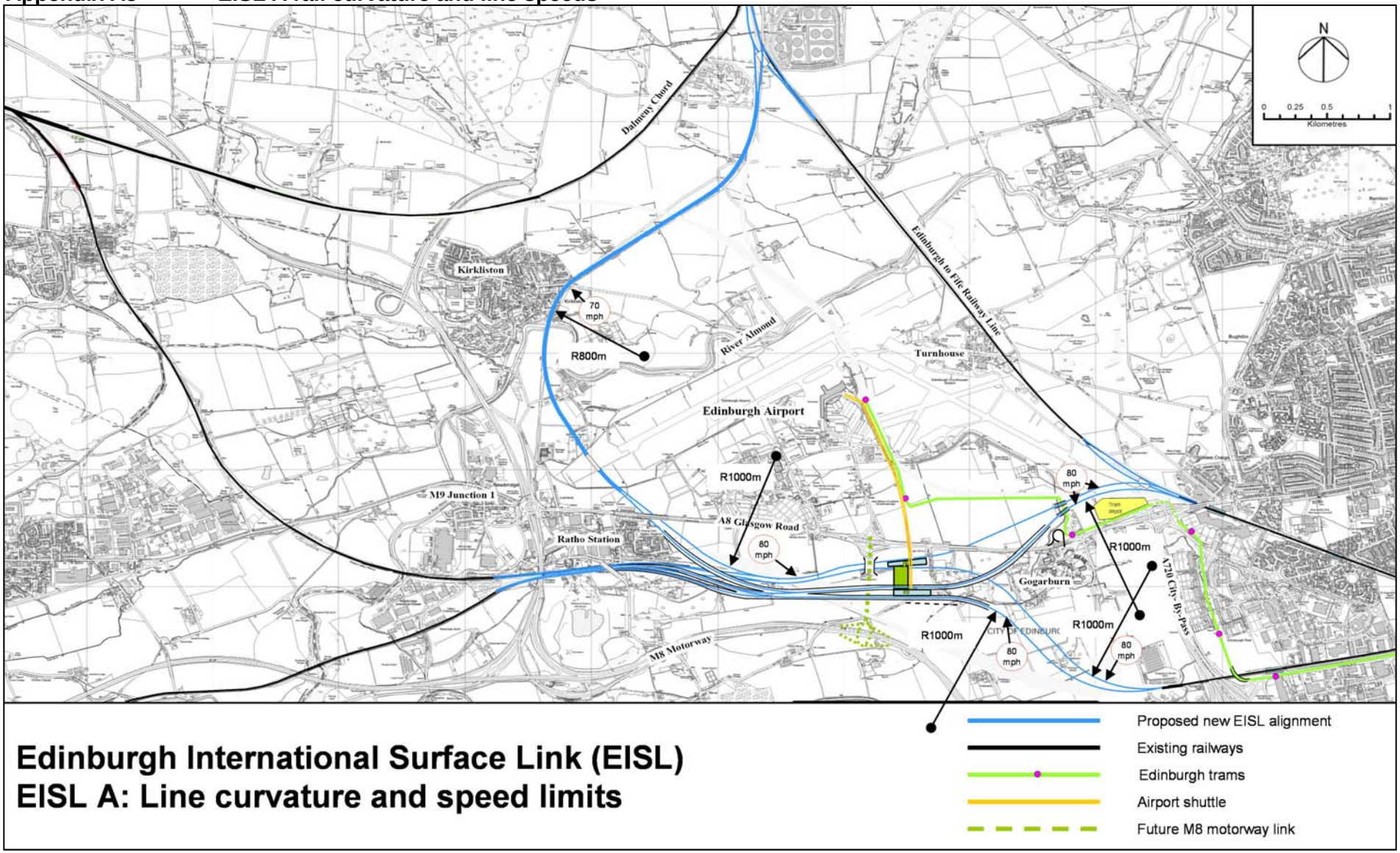
Appendix A3 - EISL A3 alignment



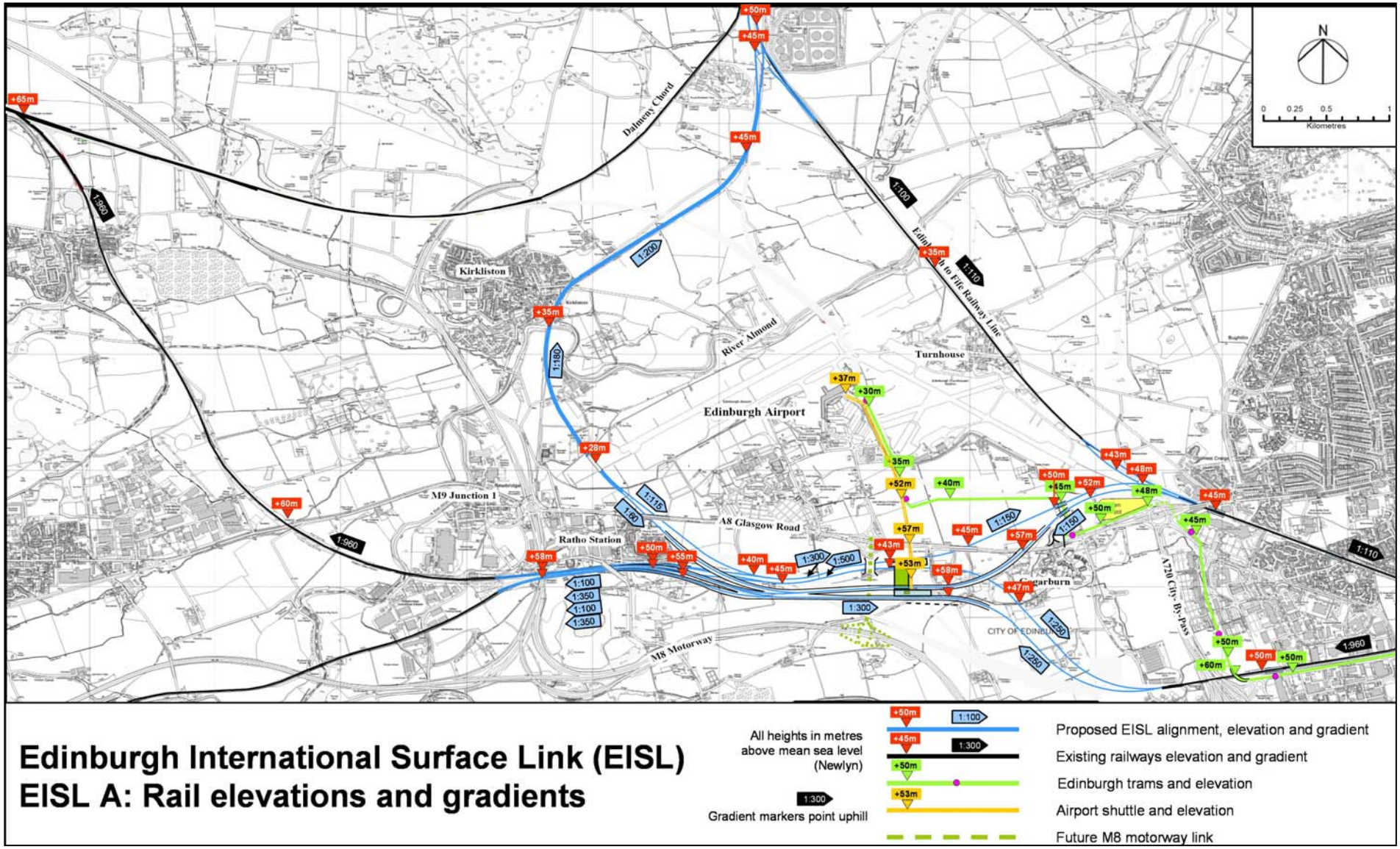
Appendix A4 - EISL A with expansion of airport and relocation of RHC



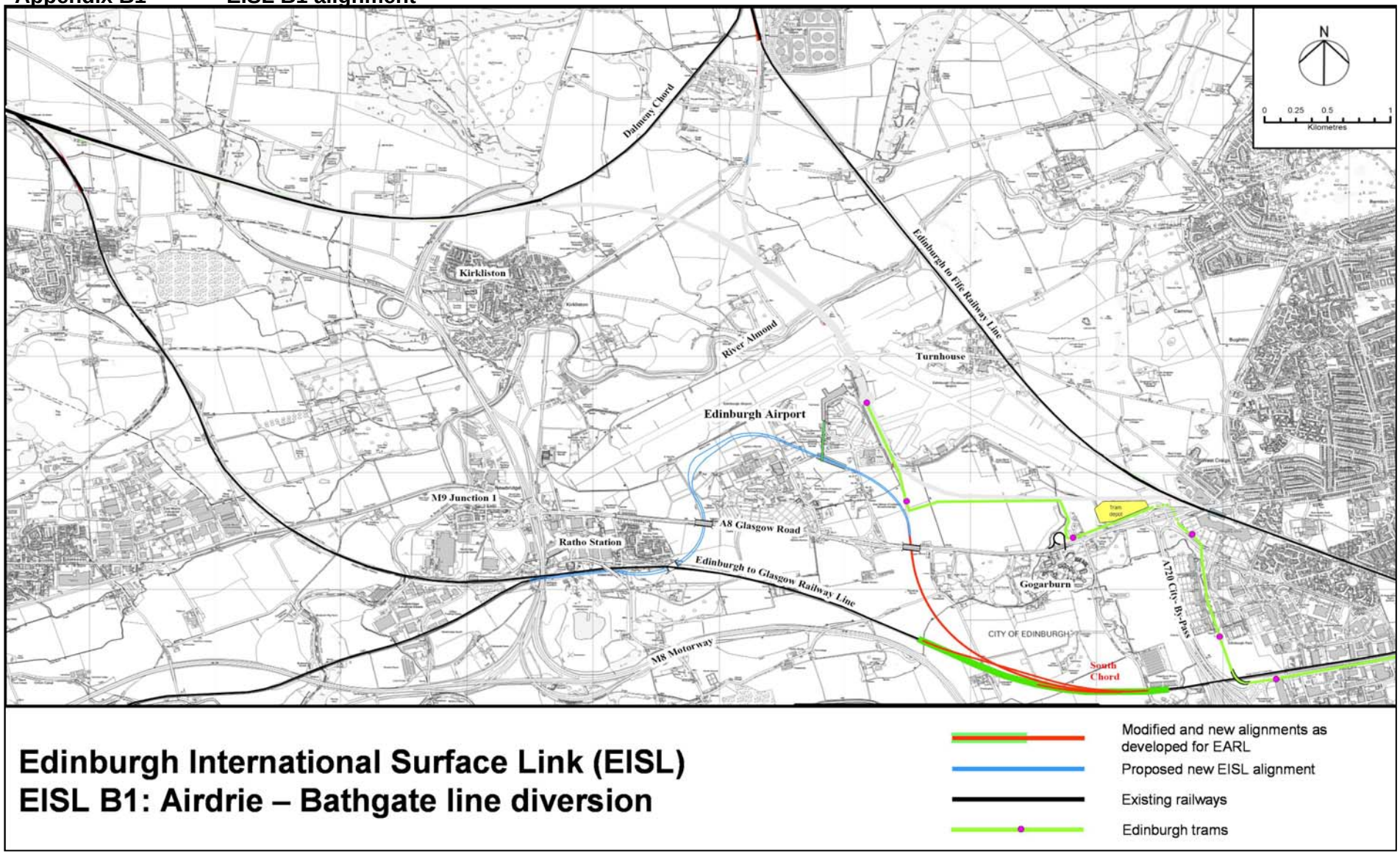
Appendix A5 - EISL A rail curvature and line speeds



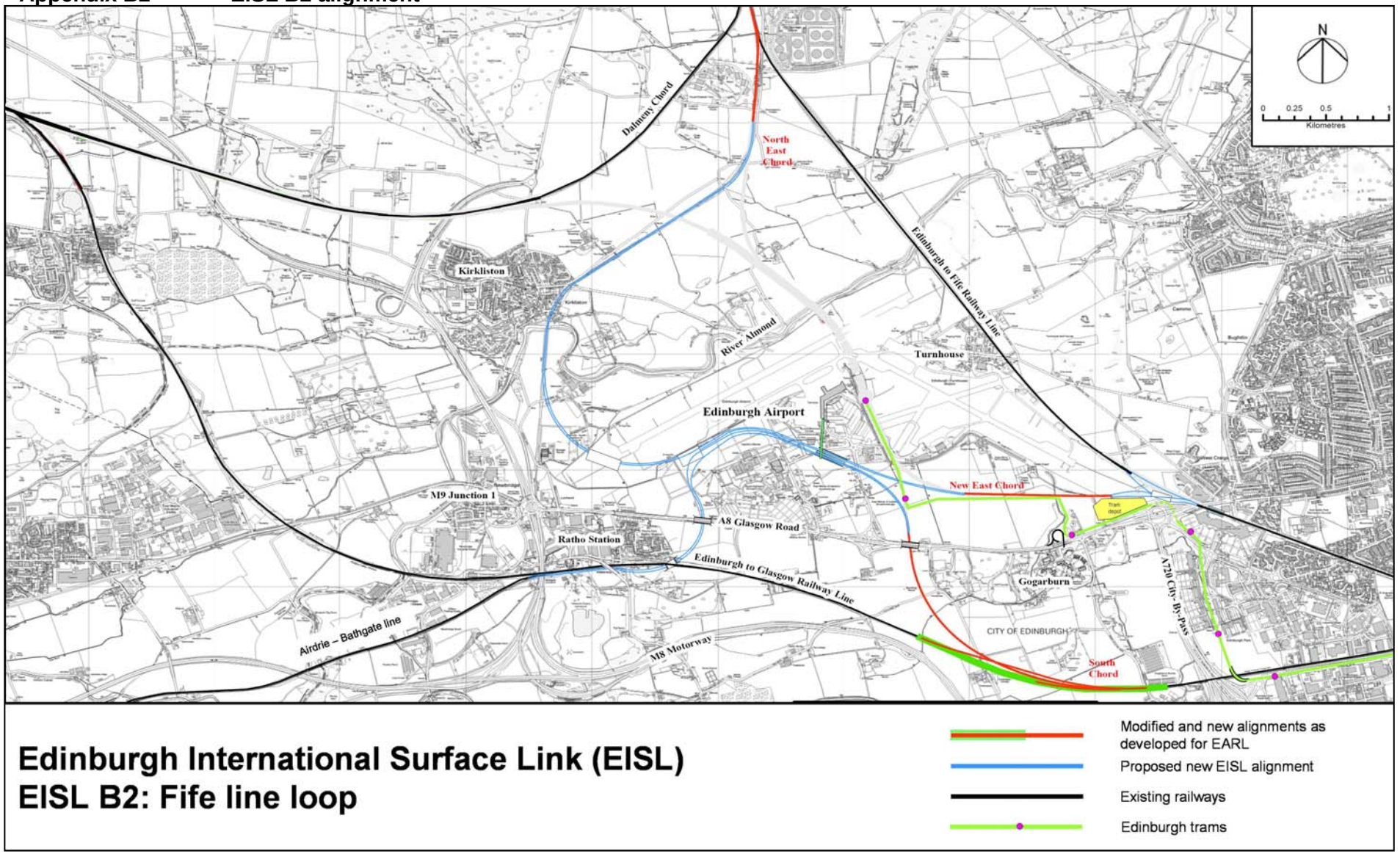
Appendix A6 - EISL A rail gradients and elevations



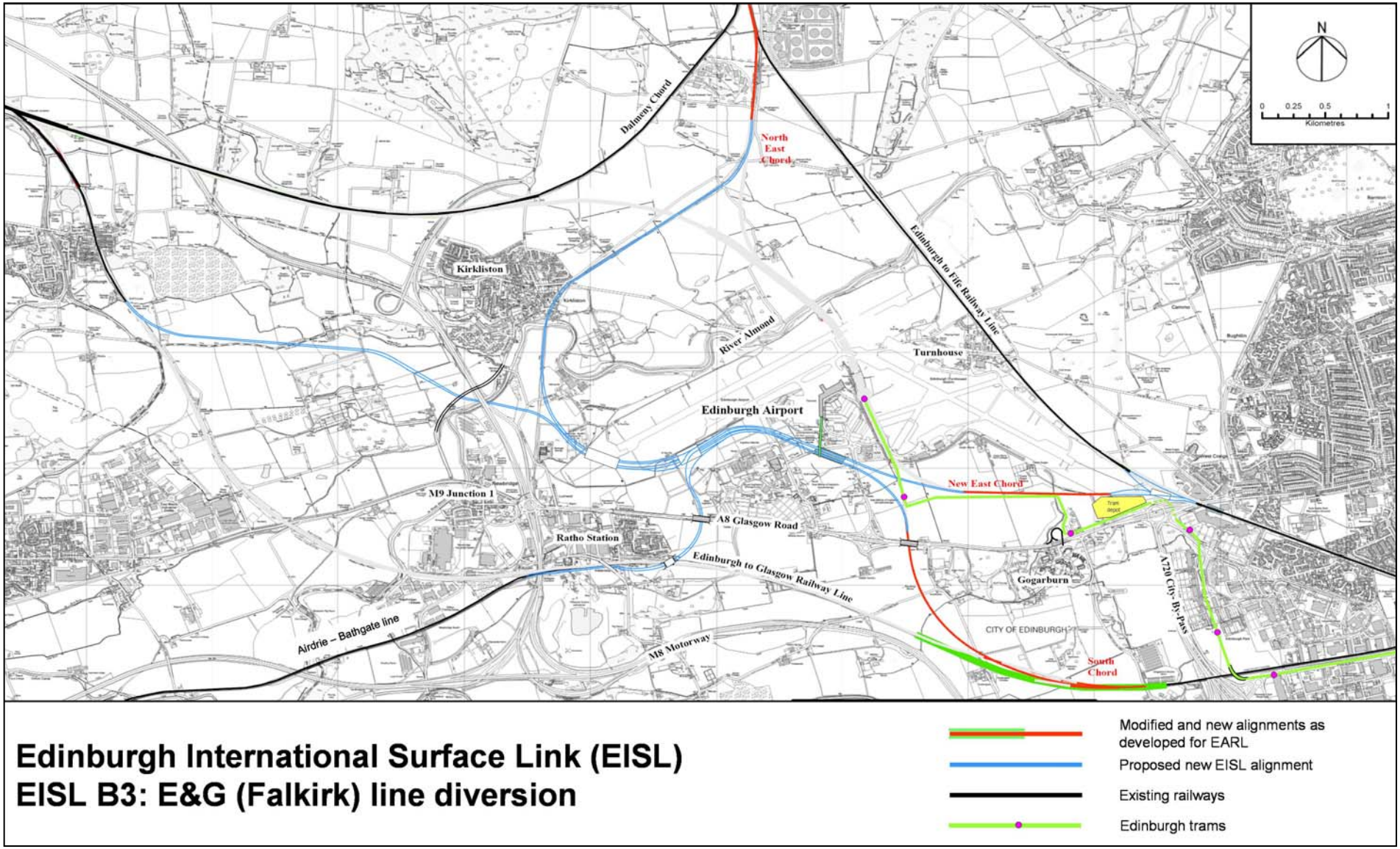
Appendix B1 - EISL B1 alignment



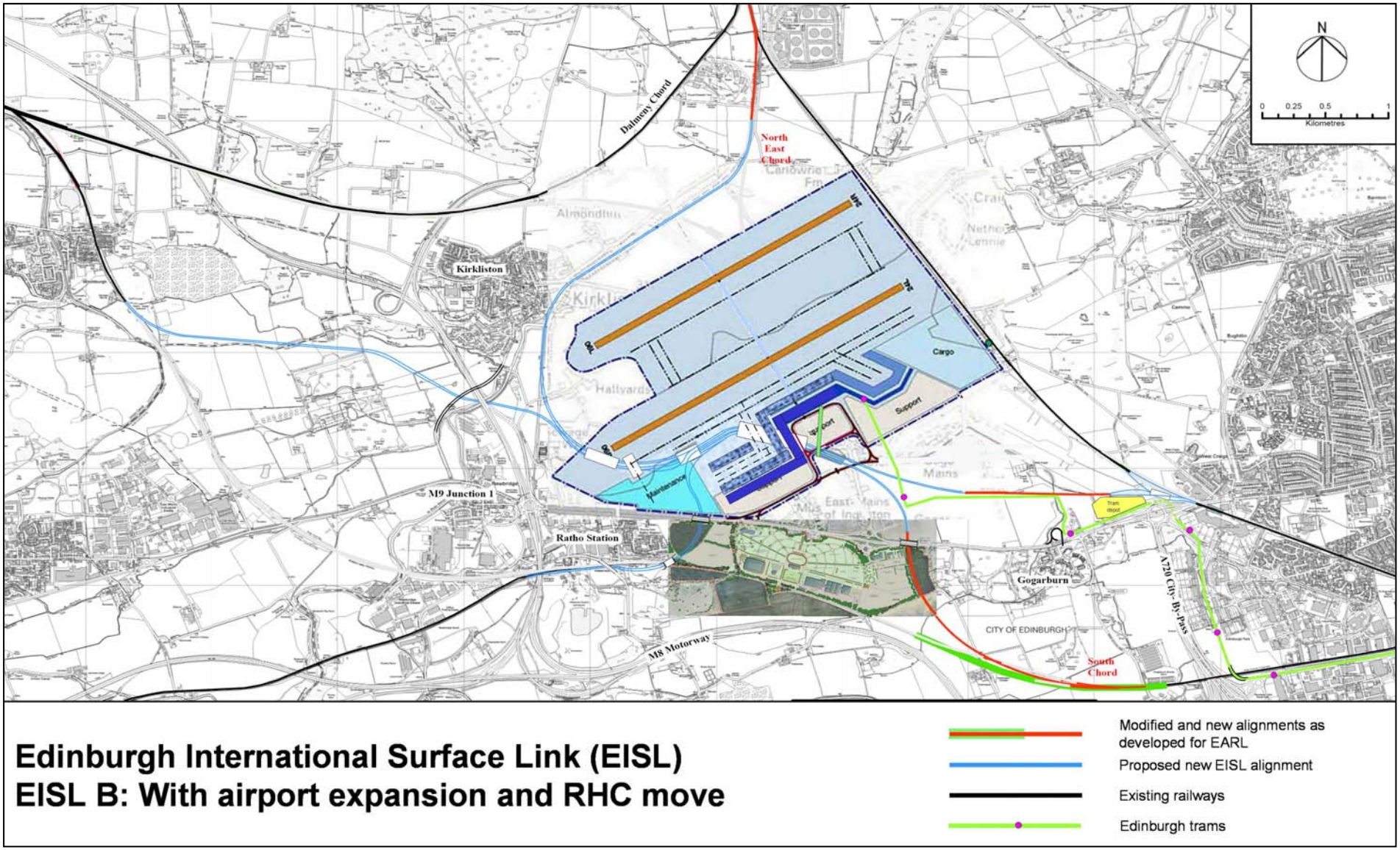
Appendix B2 - EISL B2 alignment



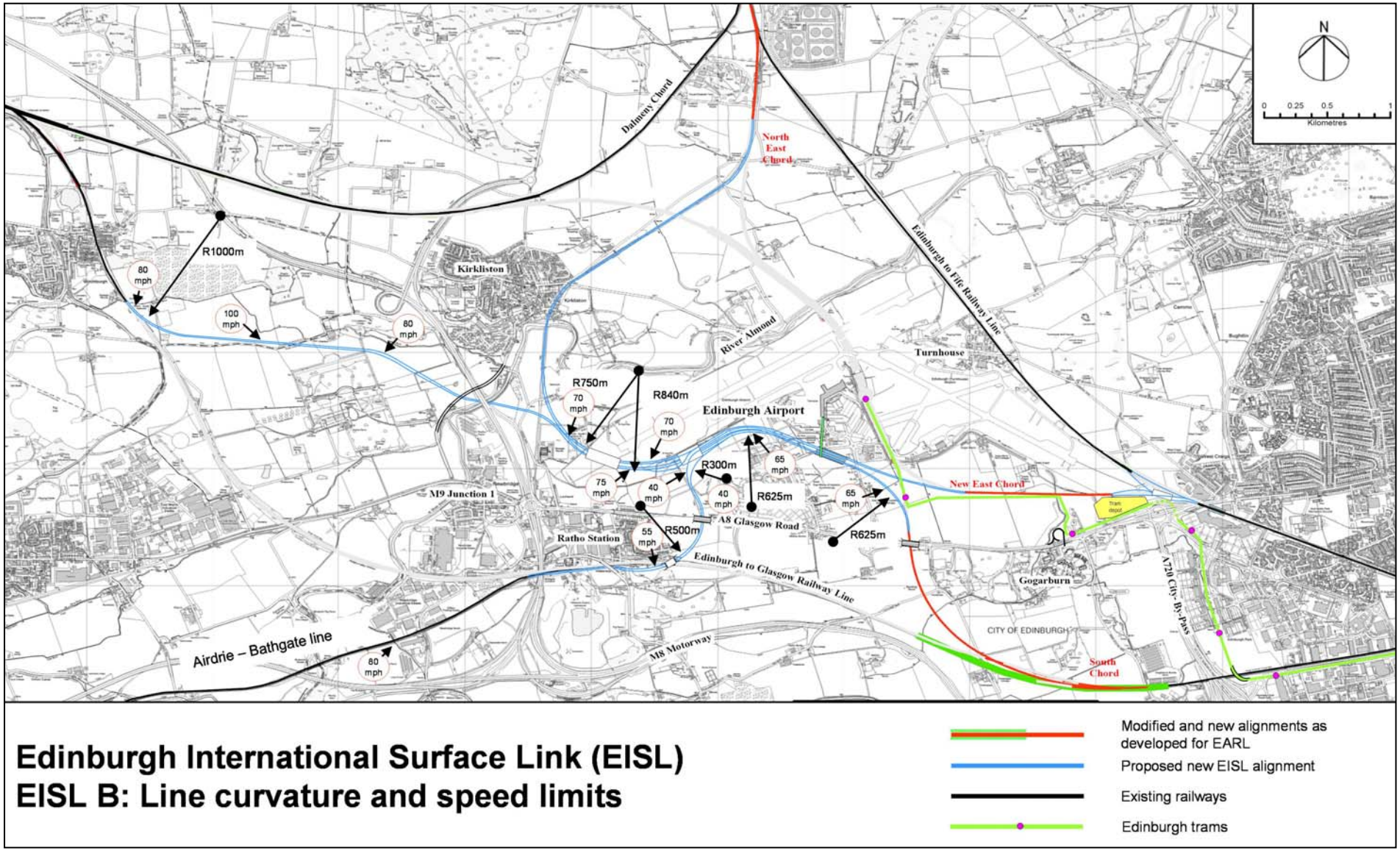
Appendix B3 - EISL B3 alignment



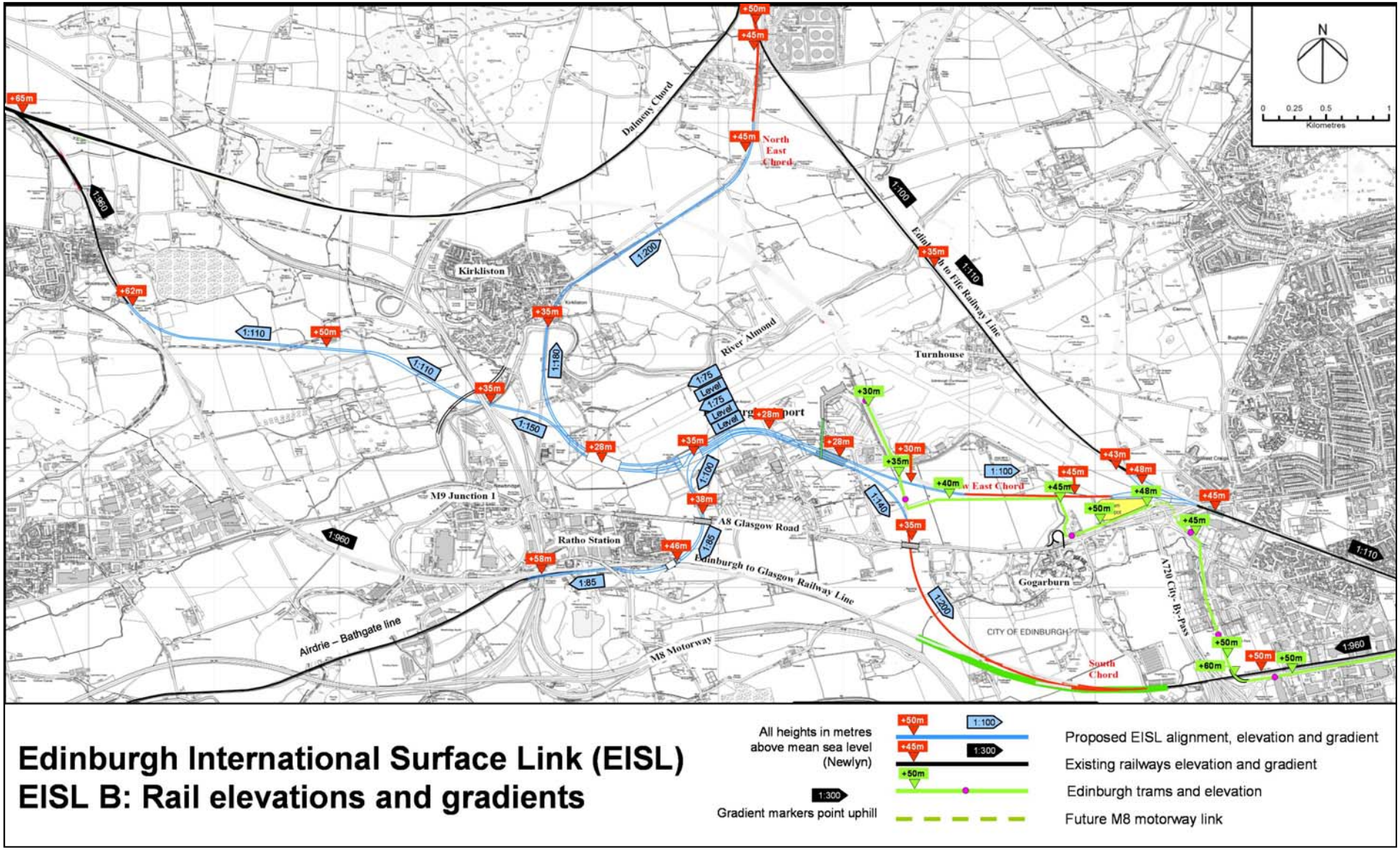
Appendix B4 - EISL B with expansion of airport and relocation of RHC



Appendix B5 - EISL B rail curvature and line speeds



Appendix B6 - EISL B rail gradients and elevations



Appendix C: Calculation of rail line speed as a function of track curvature

We have adopted the following limit for curve radius as a function of line speed[13]:

$$R_{\min} = \frac{35.528 \times V^2}{(C + D)}$$

where:

R_{min}	=	Minimum curve radius (m)
V	=	Line speed (mph)
C	=	Rail cant (mm)
D	=	Maximum cant deficiency (mm)

Rail cant is the amount of banking, or super-elevation of the outer rail above the inner rail. At equilibrium speed, the cant is such that the combined forces of the reaction to the train's weight and its lateral acceleration are at right angles to the canted track (i.e. passengers' soup will appear to stay level in the bowl). If a train travels faster than the equilibrium speed, passengers will feel a force towards the outside of the curve; if it travels more slowly, they will feel a force towards the inside of the curve. If the train stops on the curve, they will feel a sideways force caused by the tilted track. Cant deficiency is the amount by which the rail cant differs from that which would cause the train speed to be the equilibrium speed. Rail designers place limits on cant deficiency, both for passenger comfort and to limit rail wear. The typical maximum cant deficiency is 75mm.

Maximum rail cants differ with different line specifications and with different national design standards. However, typical ranges are 140mm – 165mm. The Airdrie – Bathgate technical feasibility report[3] adopted a rail cant of 150mm.

The EISL proposals have used a rail cant of 165mm. Figure 36 shows the minimum curve radius as a function of line speed for rail cants of 140mm and 165mm.

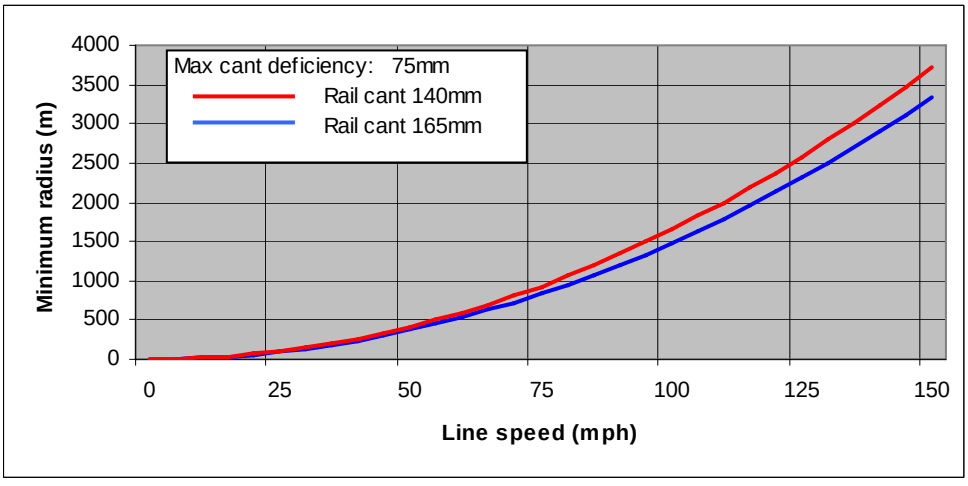


Figure 36: Rail curvature limits

[13] This is a commonly used formula, differing only in the units of measurement (mph or km/h). One such public source is: http://www.irfca.org/faq/faq-pway.html