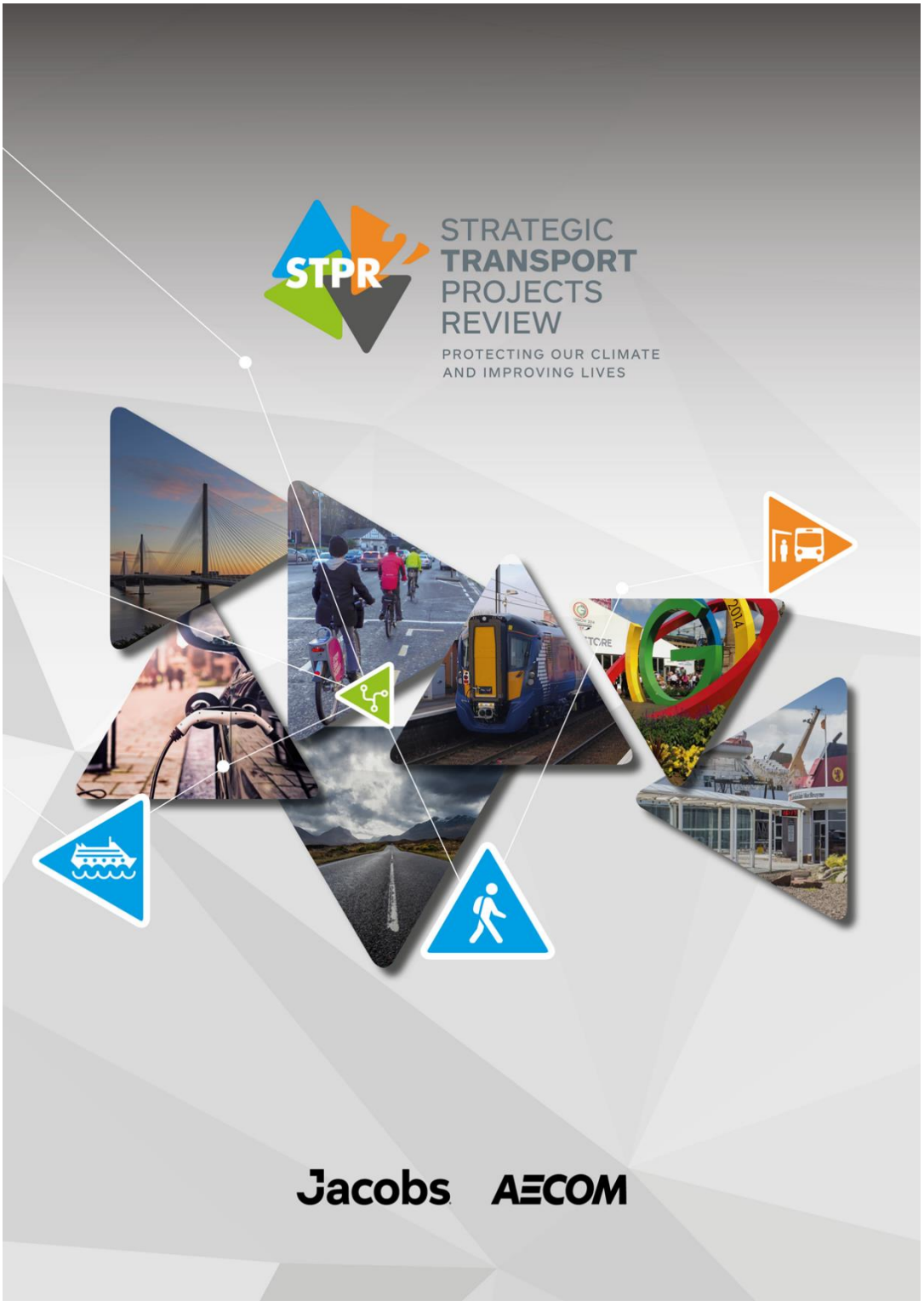
Annex A

Annex B – STPR2 Technical Note on fixed links with regards to feasibility – January 2022



1. Introduction

1.1. Brief

Jacobs/AECOM have been tasked by Transport Scotland to consider the feasibility of fixed link routes between mainland Scotland and the Orkney Islands, the Outer Hebrides and Mull. This report is an initial feasibility of what are seen as the most likely crossing points in each case, albeit other combinations of crossing points could be considered. The options in this report have been conceptualised and developed through the ongoing Strategic Transport Projects Review (STPR2).

The following sections contain an initial assessment of potential solutions for the six fixed link route options identified in the Fixed Link study. An overview of the areas where the links are to be considered is shown in Figure 1.

This report sets out each option in a separate section.

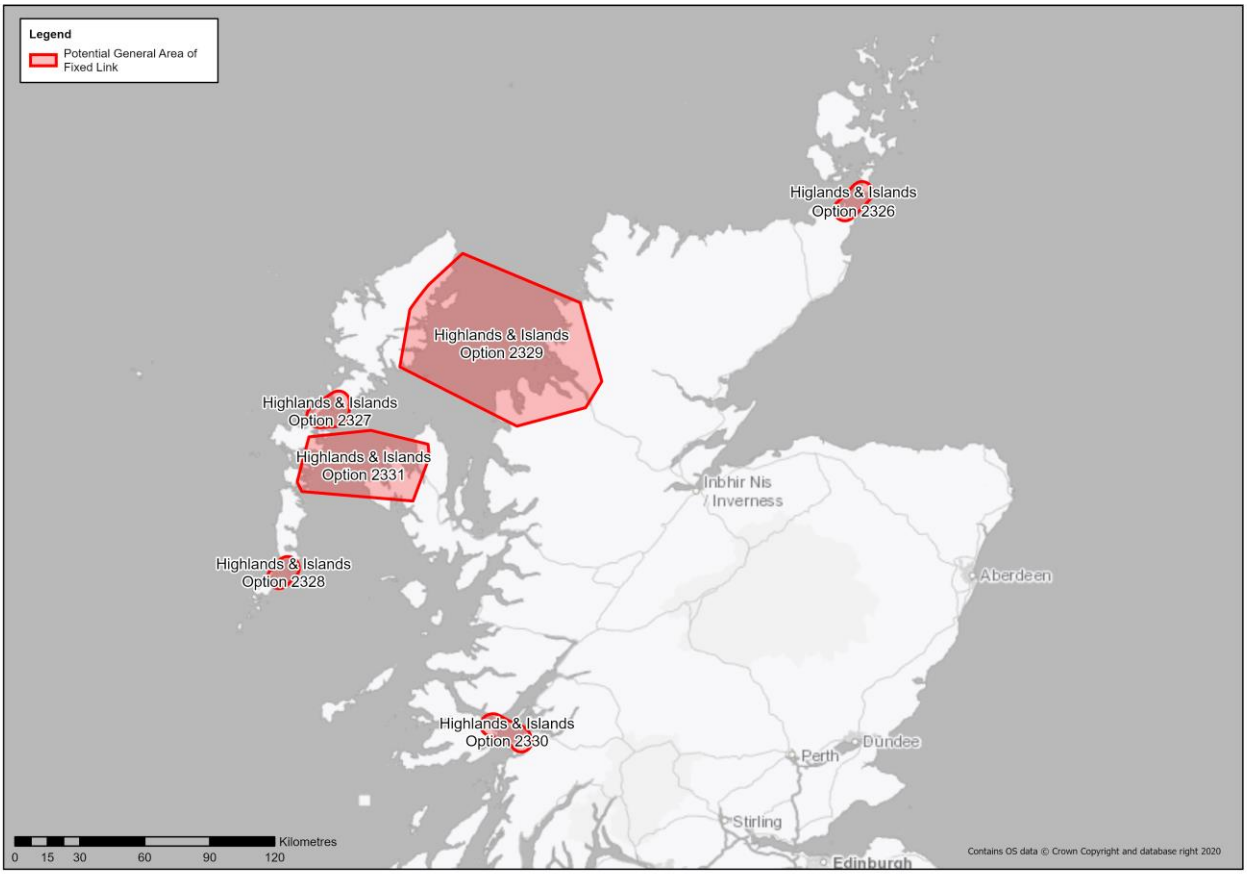


Figure 1: Overview of Options

1.2. Background to Assessment

Figures relating to Tunnelling assessment have been assembled using a combination of Google Earth with a Fishing Maps overlay. In the absence of topographic, hydrological and ground investigation surveys and reporting, this is the only information that is available. This information has been replicated into a graph to avoid any copyright issues.

For the purposes of this study, it is assumed that traffic levels for each option would only require a bi-directional single carriageway.

The tunnel options assume that longitudinal ventilation jet fans would be sufficient to meet requirements.

Tunnels could be excavated by Tunnel Boring Machine, but drill and blast with nominal or no lining would be cheaper if the bedrock is suitable and the risks are acceptable. In Norway these sorts of tunnels are built by drill-and-blast at lower cost. For instance, the Laedal Tunnel in Norway, the longest road tunnel in the world, which opened in 2000, is 24.5km in length and reportedly cost $US113M. Even in 2000 this was a very low cost. Another instance of a 7.8km long undersea road tunnel in Norway cost £7.7M/km at 2010 prices. Elsewhere in Europe a road tunnel in hard rock costs between £20M and £40M per km at 2010 prices (British Tunnelling Society/Infrastructure UK Cost Study – Oct 2010).

A recent cost study for the A83 in Scotland considered a database of completed road tunnels excavated in rock in the UK and in Europe. It is understood that these costs are based on out-turn contract costs. The cost study reports the costs per cubic metre of rock excavated. The average is £322 per m^3, but with a standard deviation of £173 per m^3. For a single carriageway road tunnel excavated by drill and blast (noting fire escapes are more difficult to manage) would require a face area of approximately 150m^2, which allows extra cross-sectional area for semi-transverse ventilation and a fire-escape passageway.

However, for tunnels longer than 2km, ventilation/escape shafts or adits should be provided at about 1.5km intervals, which is not generally possible for undersea tunnels, so an allowance of 25% increase in costs is allowed for refuges, lay-bys/turning points and the technology to provide information and escape from fire incidents. For a dual carriageway twin bore tunnel, ventilation and fire-escape are managed by escape to the other bore so the face area for each bore is less, approximately 100m^2, or 200m^2 total.

An enhancement to the above approach can be introduced using the below plot from the Infrastructure and Projects Authority “Case Study: Benchmarking tunnelling costs and production rates in the UK” (2018/19), which takes into account the effect of tunnel length on effective cost rate. The equation for the blue dotted line is 100+0.000333x where x is the volume of tunnelling. So, for example, the cost of a 1.0km tunnel with a face area of 100m^2 is £133M, but the cost of a 10km tunnel with the same face area is only £433M (or £43M/km).

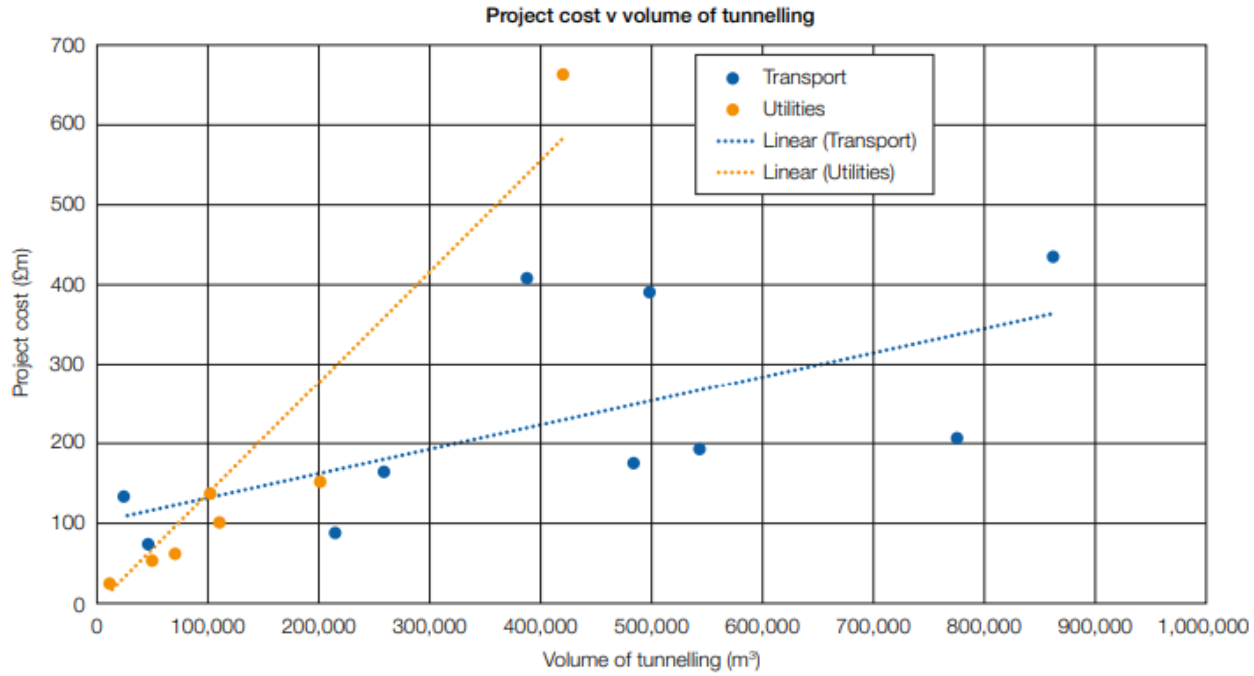


Figure 2: Project Cost v Volume of Tunnelling (all UK transport tunnels)

However, while Figure 2 is wholly for UK tunnel construction, it does not distinguish between the type of tunnel and the method of construction. The cost study referred to above for UK and European highway tunnels using the sequential excavation method in rock could also be plotted in a similar way, to take better account of tunnel length. In this case the equation for the blue dotted line is approximately 50+0.0002x where x is the volume of tunnelling. So, for example, the cost of a 1.0km tunnel with a face area of 100m2 is £70M, but the cost of a 10km tunnel with the same face area is £250M (or £25M/km).

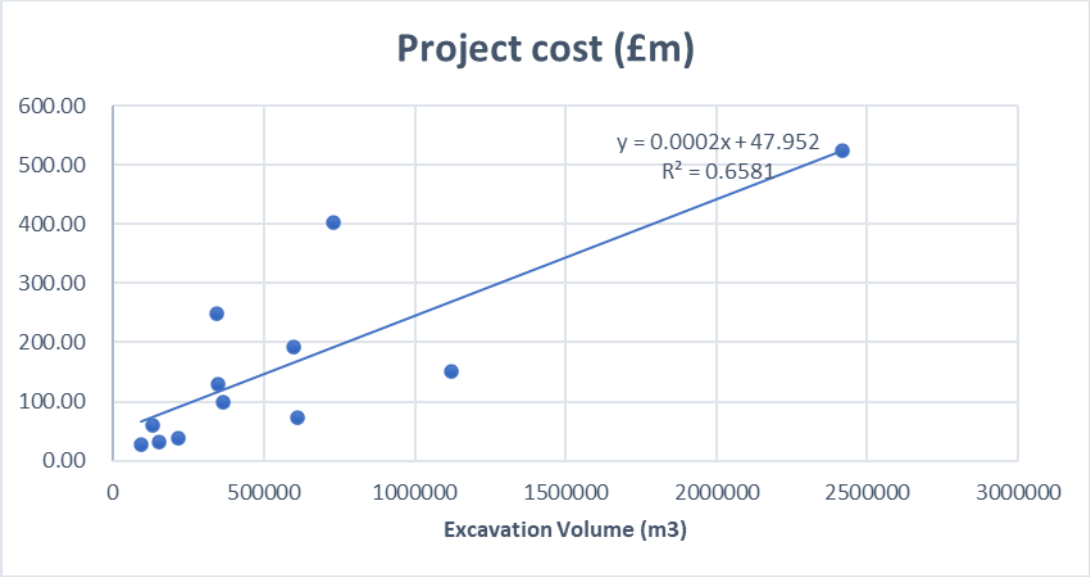


Figure 3: Project Cost v Volume of Tunnelling (sequential rock tunnels UK and EU)

The approaches set out in Figure 2 and Figure 3 are effectively upper and lower bounds to the flat 'rate per m^3' established for the A83 study. As such, it is considered appropriate to adopt the flat rate of £322/m^3 for this report.

This figure is taken to be an all-in contract cost for a tunnel, but does not include design costs or client costs (e.g. land acquisition costs or VAT). The figures do include, by definition, an average contingency and an average optimism bias, so allowance for the maximum contingency and optimism bias appropriate to this preliminary stage has been added in the outturn estimates in the following sections.

In relatively shallow water an immersed tube tunnel may be more economic, but hard rock would be difficult to dredge and strong tides could make the placing of the precast units problematic.

For deep water crossings, the concept of a submerged floating tunnel (SFT) could be considered; however, this type of tunnel has never been constructed to date, so would probably not be an economic option at this time as a result of the additional risk premium.

For both tunnels and bridge options, consideration of facilities for fire escape and rescue, possibly in the form of refuges at intervals, would be required. Access for other emergency vehicles would also be required.

Any large bridge span would have to have wind barriers in some form, the details of which would have to be carefully designed to ensure that the effects of the wind did not excite the bridge.

2. Option Reference: Highlands & Islands 2326 – Gills Bay to South Ronaldsay (Burwick)

2.1. Route Description

The purpose of this option is to provide a link between the Scottish mainland near Gills Bay, John o' Groats area to the island of South Ronaldsay in Orkney, as shown in Figure 4. Existing ferry services operate between Gill's Bay and St Margaret's Hope and between John o' Groats and Burwick.

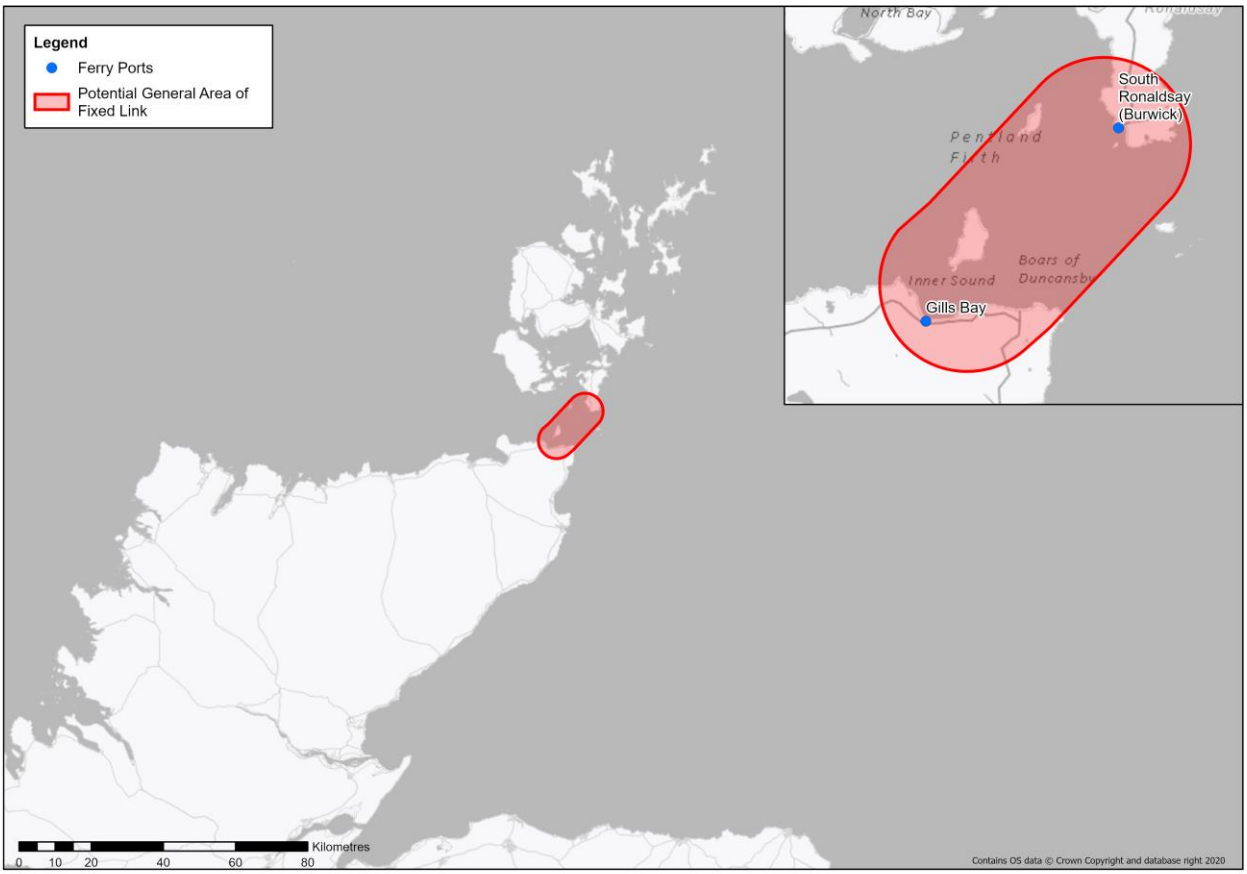


Figure 4: General area for Orkney – Scottish mainland fixed link option

Several potential corridors exist for this option. These corridors are:

- Green route – Tunnel Option
- Green route – Bridge Option A
- Orange route – Bridge Option B

- Red route – Bridge Option C
- Blue route – Bridge Option D

The indicative alignments of these potential corridors are shown in Figure 5 with a cross section showing vertical levels in Figure 6.

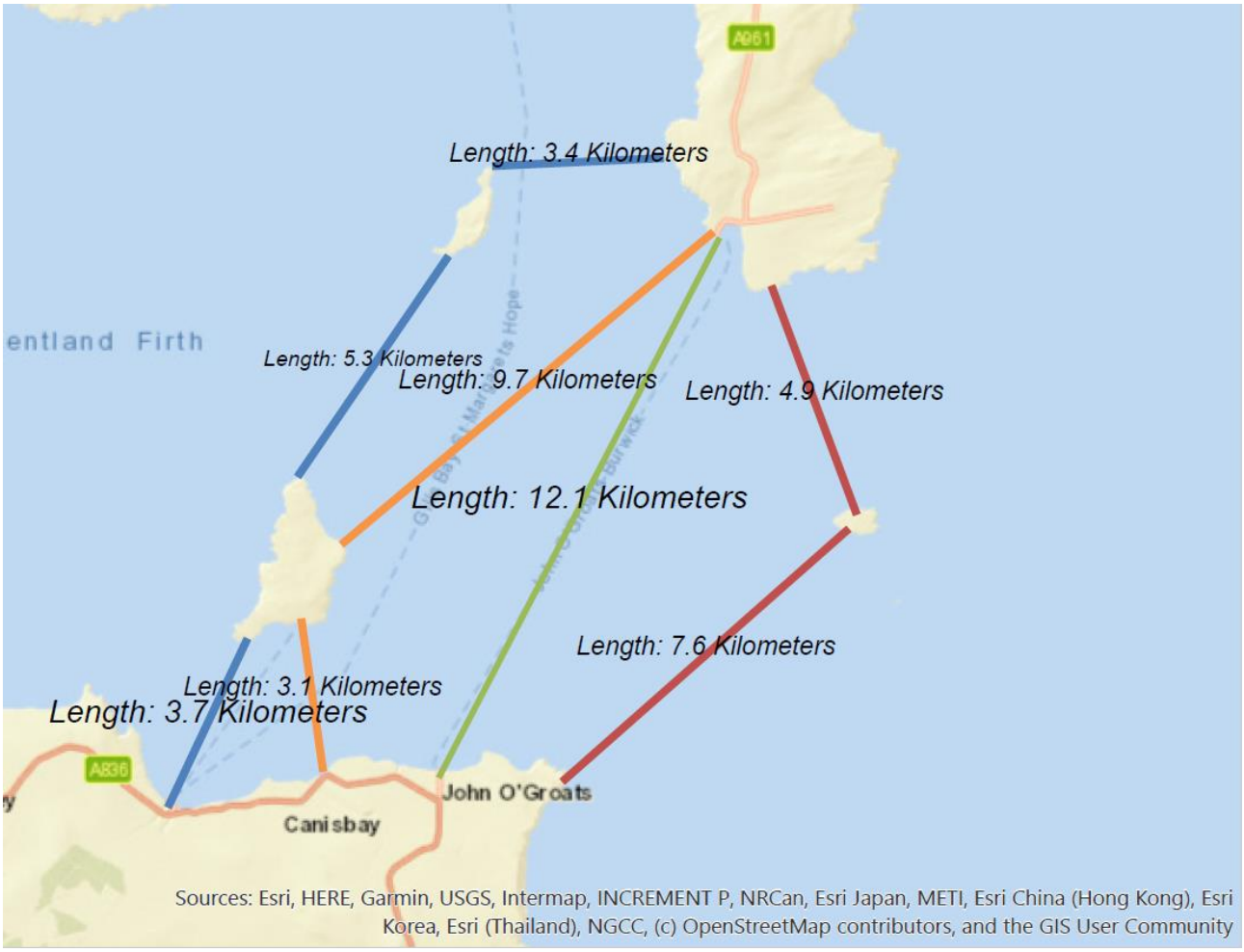


Figure 5: Potential Corridor Routes

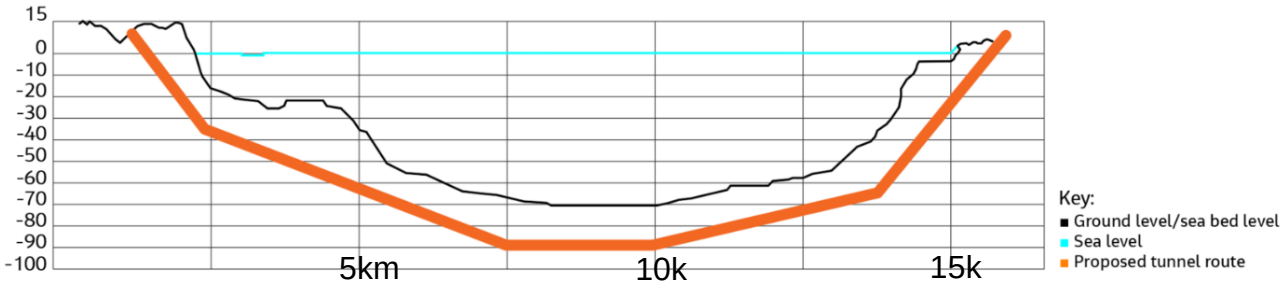


Figure 6: Longitudinal Section of Possible Tunnel Route (Green)

2.2. Tunnel Appraisal

The water depth is a maximum of approximately 70m between the mainland and South Ronaldsay. A tunnel horizontal and vertical alignment for a 15km long tunnel has been proposed as shown in Figure 6. The maximum gradient is about 3% at the South Ronaldsay end.

This would be the sixth longest road tunnel in the world and the longest underwater road tunnel in the world. Ryfylke tunnel in Norway is 14.3km long and 292m below sea level, making it the longest and deepest underwater road tunnel.

Based on £322 per m^3 of rock excavated (and allowing for other scheme costs and optimism bias), a dual carriageway road tunnel would cost approximately £1.7bn-£2.3bn. For a single

carriageway tunnel the cost would be approx. £1.6bn-£2.1bn, but risks associated with fire incidents may not be fully mitigated.

It is considered that costs of this magnitude are likely to preclude this as a viable option albeit any cost savings on the NIFS network could be offset against this cost.

2.3. Bridge Appraisal

Option A is a direct crossing between the mainland and the Orkney Islands. This crossing has a total length of over 12km. Due to the depth of the sea bed (>65m), the towers for any central span would have to be placed outwith the deepest channel, meaning that the longest span of this option would have to be in the region of 9.5km.

The longest span of any bridge in the world is currently approximately 2km long. Therefore, this option is not considered feasible.

Option B attempts to cross the deep channel width in a shorter distance utilising Stroma island as an intermediate break between two bridges. This reduces the longest span to approx. 7.6km, which is still too large to be considered feasible.

Option C utilises Muckle Skerry Island to split the crossing into two bridges. Again, this reduces the width of the deepest channel, to approx. 5.8km; however, this is still too large to be considered feasible.

Option D looks to reduce the crossing length even further by utilising the islands of Stroma and Swona to create 3 separate bridges. This results in the longest span being approx. 3.5km. Whilst this span is getting closer to being technically feasible, it is still a stretch off the longest current bridge span. Due to the low traffic volumes expected on this route, it is considered that the cost of this crossing would be difficult to justify on value for money grounds albeit any cost savings on the NIFS network could be offset against this cost. This option is not recommended for further study.

3. Option Reference: Highlands & Islands 2327 – Berneray to Harris (Leverburgh)

[Redacted – Out of Scope]

4. Option Reference: Highlands & Islands 2328 – Barra (Aird Mhor) to Eriskay (Ceann a Gharaidh)

[Redacted – Out of Scope]

5. Option Reference: Highlands & Islands 2329 – Lewis (Stornoway) to Ullapool

[Redacted – Out of Scope]

6. Option Reference: Highlands & Islands 2331 – North Uist (Lochmaddy) to Skye (Uig)

[Redacted – Out of Scope]

7. Option Reference: Highlands & Islands 2330 – Mull

(Craignure) to Oban

[Redacted – Out of Scope]

8. Colintraive to Rhubodach (Bute)

[Redacted – Out of Scope]

9. Ferry-Fixed Links Costing Assessments

[Redacted – Out of Scope]

Annex B

From: [Redacted]
Sent: 29 April 2020 15:34
To: [Redacted]
Cc: [Redacted]; [Redacted]; [Redacted]; [Redacted]; [Redacted]; [Redacted]; [Redacted]; [Redacted]; [Redacted];
Subject: RE: STPR2 - Ferries and Aviation: Follow-Up Actions

Hi [Redacted];

No problem.

The following fixed link options feature in the long-list, subject to sifting.

Ayrshire and Arran

- Fixed link to Arran
- Fixed link (tunnel or bridge) to Northern Ireland

Highlands and Islands

- Corran Ferry fixed link
- Internal fixed links on Western isles between Leverburgh and Berneray
- Internal fixed links on Western isles between Barra and South Uist
- Fixed link from Western Isles to Mainland
- Fixed link from Orkney to Mainland across the Pentland Firth
- Tunnel (dual carriageway width) between Benbecula (Rarnish) and Skye (Neist Point)
- Rail bridges over the Dornoch and Cromarty firths on the Far North Line and direct trains to inverness or even Inverness Airport.

Shetland

- Fixed link between Shetland and Whalsay
- Fixed link between Bressay and Shetland
- Fixed link between Shetland and Yell
- Fixed link between Yell and Unst

Argyll and Bute

- Replace all ferries with fixed links
- Targeted fixed links to, and between, island communities/peninsulas, including:
    - Ardmaleish to Knockdow (Cowal to Bute)
    - Colintraive to Rhubodach (Cowal to Bute)
    - Lochaline to Fishnish (Mull to Ardnamurchan)
    - Lismore to Port Appin
    - Seil to Luing
    - Portavadie to Tarbert
    - Dunoon to Rosneath peninsula
    - Dunoon to Inverclyde
- Loch Fyne crossing (ferry or fixed link – as part of a road option between Mid Argyll / Kintyre and the A82)
- Rail bridge between Gourock and Inverclyde (as part of an extension to the rail network into Cowal)
- Rail bridge across Loch Long and/or Loch Fyne (as part of an extension of the rail network into Mid Argyll / Kintyre)

I hope this is helpful.

Regards

[Redacted];

Annex C

From: [Redacted]
Sent: 20 March 2021 23:23
To: Scottish Ministers
Subject: Bridge/Tunnel Proposal

Good evening Mr Matheson

I was reading about how the Shetland Isles want to connect themselves with tunnels like the faeroes, I thought this was i great idea but it got me thinking how feasible would it be to connect Scotland to Orkney via bridges and tunnels and then Orkney to Fair Isle and then Fair Isle to Shetland. The tunnels would have to be about 40 km long each, which i know is a big ask but it has been done already and as deep so it would not be a new task.

The only problem is funding but i think if you started with connecting Orkney to Scotland and its inhabited islands and Shetland with its inhabited islands then there may be a roadmap to connecting the whole lot.

Please let me know your thoughts as this will forever be on my mind.

Kind regards

[Redacted]

Annex D

Transport Strategy and Analysis
Buchanan House, 58 Port Dundas Road, Glasgow G4 0HF
Direct Line: [Redacted]
[Redacted]

TRANSPORT SCOTLAND
CÒMHDHAIL ALBA

Our ref:
202100181736

Date:
20 April 2021

[Redacted]

By Email:
[Redacted]

Dear Mr [Redacted]

Thank you for your email of 20 March 2021 to Cabinet Secretary for Transport, Infrastructure and Connectivity, Michael Matheson regarding the feasibility of a series of tunnels that would link the Shetland islands to the Scottish mainland similar to those in the Faroe islands. As this response falls within the pre-election period I have been asked to respond on behalf of Transport Scotland.

The Scottish Government are aware of the interconnected tunnel systems built in the Faroes and Norway and the technological approach and solutions that were applied in their construction. However, the distances and technical considerations as well as the financial implications for your proposed concept for a series of fixed links between Scotland, Orkney, Fair Isle and the Shetlands are significantly different to those constructed in Scandinavia and the Faroes Islands.

It should be noted that the Scottish Government currently undertaking the second Strategic Transport Projects Review (STPR2). This review will inform transport investment in Scotland for the next 20 years and this is where large capital projects such as your proposed tunnel concept would be appraised. Further information can be found on the Transport Scotland STPR2 webpages available at: Strategic Transport Projects Review 2.

Further details on options can be found in the STPR2 National Case for Change Report published on 3 February 2021 (including Appendix E – List of sifted In options) available at: Initial appraisal: Case for Change - National - STPR2

Also published on 3 February was the STPR2 Phase 1 Highlands and Islands – Case for Change Report available here: Initial appraisal: Case for Change - Highlands and Islands - STPR2.

STPR2 Phase 1 Shetland Islands – Case for Change Report available here: Initial Appraisal: Case for Change The Shetland Islands Region.

Please be advised that the following option is being taken forward for further consideration in STPR2: - National 97 Implement fixed links which connect the Scottish mainland to main populated islands Ferries / Island Connectivity Fixed Links.However only fixed links, or tunnels, that are within scope are being considered, the criteria for

this below:

- Connect the Scottish mainland to an island;
- Reduce the operating costs of the Clyde & Hebrides Ferry Services (CHFS) or Northern Isles Ferry Service (NIFS) network;
- Address a strategic problem as identified through evidence-based appraisal that cannot be addressed by reasonable alternatives.

Ultimately any decisions on fixed links be it tunnel or bridges connecting Scotland's mainland or islands will emerge from the on-going appraisal as part of Phase 2 of the Review which will conclude in late 2021.

I hope this is helpful.

Yours sincerely

[Redacted]
[Redacted]

Annex E

From: [Redacted]
Sent: 24 May 2021 20:16
To: Scottish Ministers <Scottish_Ministers@gov.scot>
Cc: [Redacted]
Subject: Orkney Tunnels

Dear Minister,

My friend and colleague [Redacted] and I were recently looking at the feasibility of constructing tunnels between Orkney and the main land (this is the sort of strategising we do for fun…). We just wondered whether you'd had a formal feasibility study undertaken or would you be interested in us pulling one together?

Kind regards

[Redacted]
[Redacted]

Annex F

Transport Strategy and Analysis
Buchanan House, 58 Port Dundas Road, Glasgow G4 0HF
Direct Line: [Redacted]
[Redacted]

[Redacted]
[Redacted]
Consultancy Services Limited
By Email:
[Redacted]

Our ref:
202100206210

Date:
18 June 2021

Dear [Redacted]

Thank you for your email of 24 May 2021 to Scottish Ministers regarding the feasibility of the construction of tunnels between Orkney and the Scottish mainland. As this matter is delegated to Transport Scotland I have been asked to respond.

I would note that the Scottish Government is currently undertaking the second Strategic Transport Projects Review (STPR2). This review will inform strategic transport investment in - Scotland for the next 20 years and is where decisions on large capital projects such as new fixed link will be made. Further information can be found on the Transport Scotland STPR2 webpages available at: Strategic Transport Projects Review 2.

I would further note that as part of the work on STPR2 an option for a fixed link between Gills Bay on the mainland and South Ronaldsay in the Orkney Isles is being considered as part of a Preliminary Appraisal work. Further details on options can be found in the STPR2 National Case for Change Report which was published on 3 February 2021 (including Appendix E – list of Sifted In options) available at: Initial appraisal: Case for Change - National - STPR2,

Also published on 3 February was the Highlands and Islands – Case for Change Report available at: Initial appraisal: Case for Change - Highlands and Islands - STPR2.

This option together with the list of interventions contained in Appendix E are now subject to more detailed appraisal as part of Phase 2 of the Review. The final outcomes of which will inform transport investment priorities from 2022 to 2042 and will conclude in late 2021. This will be followed by a formal consultation period during which stakeholders and the public can provide feedback. Until the review is completed it is not possible to offer a view on the emerging outcomes, including any decision on a fixed link between the Scottish mainland and the Orkney Isles.

I hope this is helpful.

Yours Sincerely

[Redacted]
[Redacted]