Glasgow Airport Access Project

Transport Scotland

GAAP - Audit of Outline Business Case - Final Report

B2289FAT/1 | Version 1

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1. Introduction

Jacobs UK Ltd was appointed by Transport Scotland to provide an independent audit of the Outline Business Case (OBC) for the Glasgow Airport Access Project (GAAP). The Task Order issued by Transport Scotland outlined the objective of audit as being *"to provide comfort and reassurance to Scottish Ministers that the business case accurately and objectively reflects the interests of the Scottish economy, including inclusive growth ambitions".*

This work involves the auditing of the OBC, and in particular the Strategic and Economic cases, and supporting technical submissions, including detailed rail planning work the Project Team have undertaken. In terms of model audit, it is limited to the audit of the Glasgow Airport Access Model (GLAAM) and the Glasgow Airport Employee Model (GLEAM) used for airport forecasting.

The version of the OBC audited was version 1.0 dated 21 November 2016.

The report is structured as follows:

- chapter two describes the project;
- chapter three outlines the approach to the audit;
- chapter four provides details on the rationale for the project;
- chapter five covers the operational issues identified through the audit;
- chapter six covers the economic case; and
- chapter seven details the conclusions and recommendations.

2. The Project

2.1 Background

GAAP is a Glasgow City Region City Deal project that is being developed jointly by Glasgow City Council and Renfrewshire Council; the Project Team.

A number of studies were carried out between 2011 and 2014 to consider surface access options serving the airport. The Glasgow Airport Strategic Transport Appraisal Part 1 Study (2013), commissioned by Glasgow City Council, Renfrewshire Council, Glasgow Airport Limited and Transport Scotland, considered 80 options, seven of which were taken forward to the more detailed Part 2 Study (2014). This second study identified the Tram-Train option as the best performing option, followed by the Personal Rapid Transit (PRT) option. The GAAP team then took both options were re-visited during the Strategic Business Case and subsequently taken forward for further analysis as part of the OBC. After the initial multi-criteria assessment within the OBC process, Tram-Train was identified as being the preferred option and assessed in more detail. As a result, the bulk of the OBC relates to the Tram-Train option.

It is proposed that the project would provide a fixed public transport link between Glasgow Airport and Glasgow Central Station (via Paisley Gilmour Street), with the aims of improving connectivity and encouraging modal shift for Airport employees and passengers. The route would start on a tram-only section at Glasgow Airport before joining the heavy rail network on the Inverclyde Line west of Paisley St James station. There would be an intermediate stop at Paisley Gilmour Street before continuing on directly to Glasgow Central. The rolling stock would be Tram-Train units capable of both on-street and heavy rail operation. An example of these is the BR Class 399 units that have been delivered for the Tram-Train pilot project in South Yorkshire. The Tram-Train service frequency is set at four services per hour per direction (4tph), however a Tram-Train (reduced) scenario has also been considered that would reduce the frequency to 3tph during the AM and PM peak periods when additional heavy rail services are in operation.

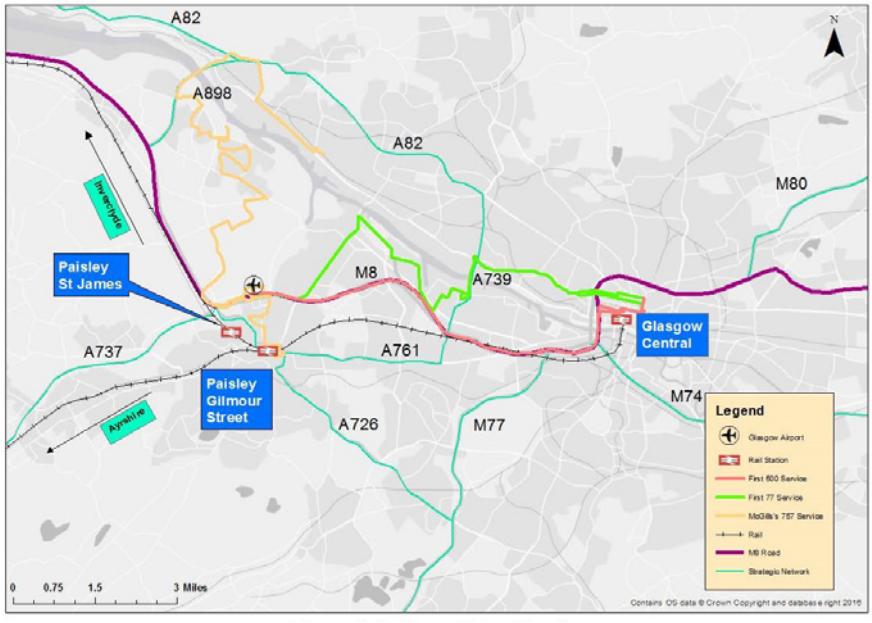

Figure 2.1: Extract from OBC showing current public transport linkages

The GAAP team have estimated the cost of delivering the project at £144m with completion in 2024 to allow scheme operation in 2025.

The following paragraphs provide an overview of the project and the strategic case (taken from section 2 of the OBC), the Project Rationale which is summarised as follows:

- *Transport Availability – currently the airport has relatively poor surface access transport links compared to major competitor airports*
- *Origin and Destination – the majority of the demand at the airport originates in the west of the country*
- *Mode Share – the airport has the second highest car mode share amongst the top 10 UK airports*
- *M8 Traffic Constraints –The M8 Motorway suffers from recurring congestion, particularly at peak times*
- *Passenger Demand – a significant number of passengers on the congested road network during peak periods*
- *Growth at Glasgow Airport – the airport is one of Europe's fastest growing airports*
- *Journey Purpose – almost half of business travellers' origin/destination is located within Glasgow City centre*
- *Origin and Background of the Proposals – the need for improved surface access to the airport has been recognised as a priority for many years*
- *Counterfactual Description – the absence of the City Deal connectivity improvements will result in the vision for good connection to the airport being unfulfilled.*

Section 2.5 of the OBC describes the project and the objectives in detail, and Section 5.1 of the OBC states that *"The Airport Access Project would deliver a long established investment priority and enhance the role of Glasgow Airport and surrounding area in the performance of the economy of the City Region and central Scotland. The project has been developed to align fully with the strategic objectives of City Deal in order to maximise the potential for economic growth through supporting the delivery of an improved transport network, improved public transport across Glasgow and the Clyde Valley and the surrounding areas, the promotion of key development and regeneration sites in the project area and to deliver the maximum growth in GVA across the City Region."*[1]

Section 2.5 of the OBC goes on to state that:

"The Glasgow Airport Investment Area (GAIA) and Clyde Waterfront and Renfrew Riverside (CWRR) City Deal projects are being developed in parallel with the Airport Access Project. Taken together, these projects will help unlock development and create a strategic business location and economic growth corridor from the airport through the GAIA to Renfrew Riverside."

As stated in The Glasgow Airport Access STAG 2[2] report and reiterated in Section 2.5 of the OBC, the following Mission Statement relating to the project has been identified. Furthermore, the Transport Planning Objectives (TPOs) identified within the STAG 2 report have been refined within Section 2.5 of the OBC and are detailed below.

[1] Glasgow City Region City Deal, Glasgow Airport Access Project, Outline Business Case v1.0, Section 2.5 (Glasgow City Council and Renfrewshire Council, 2016)
[2] Glasgow City Region City Deal, Glasgow Airport Access Project, Outline Business Case v1.0 (Glasgow City Council and Renfrewshire Council, 2016)

GAAP Project Mission Statement

"To support the nationally significant economic and social contribution of Glasgow Airport by maintaining and improving sustainable access for passengers and staff."

Transport Planning Objectives

- *increase the modal share of public and active transport modes for passengers and employees to and from Glasgow Airport;*
- *improve journey times to and from Glasgow Airport for public and active transport modes such that they are increasingly competitive with the private car;*
- *improve journey time reliability to and from Glasgow Airport;*
- *improve quality and satisfaction of public transport experience to and from Glasgow Airport for passengers and employees; and*
- *Support sustainable growth of Glasgow Airport and business investment and regeneration of its surrounding area and the City Region.*

Section 2.6 of the OBC states that:

"The scope of the project has been developed to take into account the current issues and the anticipated development and economic potential around the airport and across the wider Glasgow City Region. The councils have worked closely with stakeholders and taken into account feedback and input to date, particularly from Glasgow Airport, Network Rail, and Transport Scotland. The project scope will be subject to further development and refinement as it is taken forward and will be informed by wider stakeholder consultation and engagement. There will be ongoing consideration to ensure access to the airport is improved to maximise the growth potential as a key driver of growth for investment in the Glasgow City Region."

The project builds on various technical analysis studies previously undertaken to develop and deliver enhanced access to the airport that mitigates identified problems associated with road congestion and provides a platform to support future growth in passenger numbers. Through early elements of the appraisal process, the Project Team identified 'Tram-Train' and 'Personal Rapid Transit (PRT)' as being candidate schemes, with Tram-Train being their preferred option.

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3. Audit Process

3.1 Context of the Outline Business Case

The OBC has been prepared by the Project Team as part of an ongoing process to examine enhanced linkage to and from Glasgow Airport. This process has involved the production of a variety of reports, technical notes, and studies over a significant period of time. It was not the intention, nor was it within the scope, of this audit to review and analyse the entirety of this technical background. Where appropriate however, and only in relation to queries and opportunities identified in the OBC, the audit process 'tracked back' to these other documents to review and analyse the reasoning, evidence and decision-making process.

3.2 Requirements

The extent of the audit, which comprised an Interim and Final report, was to:

- review and analyse the OBC as a whole, but in particular the Strategic Case and the Economic Case;
- carry out model audit of the GLAAM and GLEAM models used for airport forecasting;
- review and analyse supporting technical reports relating to the Economic Case;
- review and analyse adherence of the Strategic Case and Economic Case to the approved Assurance Framework; and
- highlight deficiencies, weaknesses, strengths and opportunities in the methodology, findings and presentation of the assessments.

The Interim Audit Report was based on the independent review of the OBC and its supporting documents. Following a process of review and analysis, it was laid out as a series of observations that resulted in 87 questions.

Further to the Interim Audit Report, there was liaison with the Project Team, their consultants and other parties; Network Rail, ScotRail, and Glasgow Airport Ltd. This period was used to jointly and collaboratively examine the observations and questions raised in the Interim Audit Report, with a view to understanding and resolving as many of these as possible. The output of this process forms the basis of this Final Audit Report, with detailed reporting of the specific audit points contained Appendix A.

In developing the Final Audit Report, the focus has been on matters that are considered to be outstanding following discussion on the Interim Audit Report. Effort has been concentrated on significant points that are considered to be material in providing advice to Scottish Ministers. In addition, the Final Audit Report includes analysis and advice relating to the wider implications for the regional and national economy with a focus on rail plans and opportunities.

4. Rationale for the Project

4.1 Demand Modelling

4.1.1 Introduction

The Interim Audit Report presented a number of queries and observations relating to the future passenger demand forecasts for the project. Following discussions with the GAAP Project Team a number of the queries identified in the Interim Audit Report have been resolved. However, there are some outstanding issues which are outlined below on how the proposals deal with the issues of future airport demand:

- Clarification required on why such a high proportion of future passenger demand is predicted to travel to the airport by self-drive modes;
- Explanation on why the modal shift from self-drive modes to public transport appears marginal, despite the implementation of Tram-Train;
- There is a lack of clarity on the daily / hourly profile of future passenger demand which needs to be considered in more detail; and
- There is a lack of clarity on the anticipated origin / destination profile of future airport demand which requires further assessment.

4.1.2 Comparison of Options

The GLAAM models, provided by the GAAP Project Team, compares how the different interventions considered within the OBC (Tram-Train; Tram-Train Reduced Service; and PRT) are forecast to perform in terms of attracting future airport passenger demand. For both the 2025 and 2037 high airport growth scenarios, the following number of passengers are forecast to travel to the airport via Tram-Train, Tram-Train (Reduced Service); and PRT:

- Tram-Train;
  - 2025 – 1,041,000 passengers;
  - 2037 – 1,421,000 passengers;
- Tram-Train (Reduced Service);
  - 2025 – 1,016,000 passengers;
  - 2037 – 1,385,000 passengers;
- PRT;
  - 2025 – 798,000 passengers;
  - 2037 – 1,088,000 passengers.

From the detail provided above, it is clear that the Tram-Train option (with four trains per hour) is forecast to attract more airport passengers per year than the other interventions considered within the OBC, although the difference between the full and reduced service is minimal. As such, in terms of passenger demand and information presented in the OBC, the audit is content that the proposed intervention is the best performing of those considered within the OBC.

4.1.3 Capacity of the Road Network

Detailed output from the GLAAM models provided by the GAAP Project Team have been used to compare future year passenger forecasts with baseline passenger numbers. Figure 4.1 below presents the baseline modal split of existing passengers at the airport as detailed within the OBC, and the forecast passenger modal split for both 2025 and 2037 high airport growth scenarios respectively.

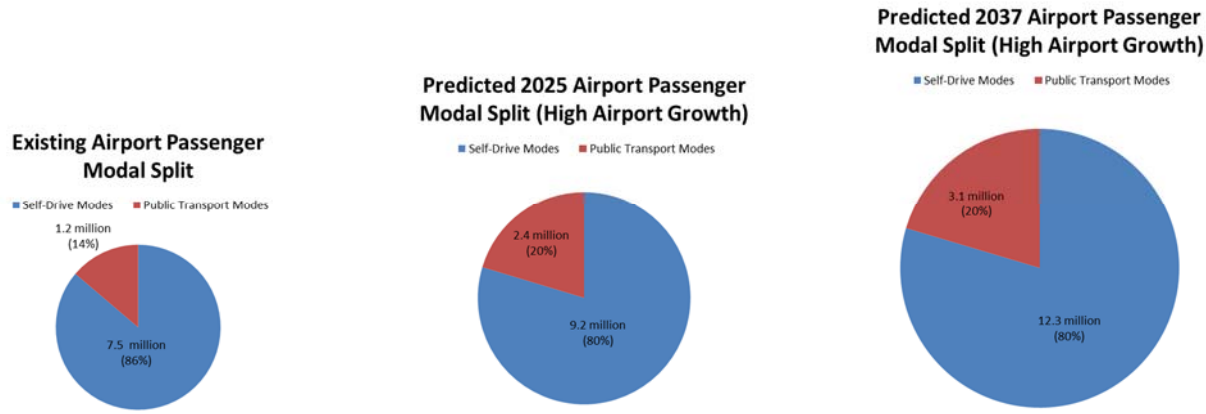

Figure 4.1: Airport Passenger Modal Split 'Self-drive v Public Transport (OBC) for existing, 2025 and 2037

It is clear from Figure 4.1 that the majority of airport passengers (86%) currently travel to the airport via self-drive modes and this trend is forecast to continue into the future. Although the modelling work undertaken to date highlights an increase in the public transport share (from 14% to 20%), the overall growth in demand to the airport is forecast to result in up to an additional 4.8 million passengers[3] travelling by self-drive modes in 2037. This equates to an average of over 13,000 additional passengers per day travelling by road. Such an increase in passenger numbers travelling by road would be expected to further exacerbate existing conditions on the road network while there is no expectation that the Tram-Train proposals alone will ameliorate existing and future issues on the M8. Given that the OBC highlighted the issue of congestion on the M8 Motorway as constraint, which could impact on the growth of the airport and the surrounding area, there remains the question of whether the airport could attract the growth projected, with such a high apparent reliance on the road network.

To put this into context, based on the GLAAM model outputs and under the 2037 high growth scenario, in order to maintain self-drive levels at the existing 7.4 million, the airport would require a public transport mode share of 52%. Chapter 4.4 of this report, which compares Glasgow Airport with other UK and European airports in a benchmarking assessment, explores this more and shows that this level of mode share would be greater than almost all of the comparable airports. This is important in understanding the relatively low impact of Tram-Train on modal transfer, and the subsequent heavy reliance on road-based access to support growth of the airport.

It would be of benefit to consider this further, as any potential increased level of congestion on the road network could result in a number of impacts/consequences that would impact on the business case of the project. The key issues are:

- the airport could fail to attract the passenger numbers forecast; or

[3] GAAP Modelling-Transport Demand Forecasting Summary (PBA, 2017)

- the transfer of trips to/from public transport could be greater than currently forecast if the transport models are under estimating the level of delays on the road network (this issue is covered in more detail later in this chapter).

The former would clearly have a detrimental impact on the airport and the business case for the project, whereas the latter would strengthen the case.

In summary the audit has identified the following issue:

- future passenger demand forecasts indicate continued heavy reliance on the road network, with up to 4.8 million additional passengers forecast to travel to the airport by road in 2037.

4.1.4 Passenger Demand Profile

There is little analysis within the OBC on the spread of passenger demand across the day or in relation to the origin / destination profile of inbound or outbound passengers. This is an important factor to consider in relation to accessibility, given that the proposed Tram-Train does not serve any intermediate destinations other than Paisley Gilmour Street.

The Interim Audit Report raised the issue of how demand was spread. The OBC and other technical documents have dealt with demand at an aggregated level; usually the annual figure. It is necessary to understand demand at a more disaggregated level in order to address the following:

- The future split between business and leisure traffic;
- The spread of demand between weekdays and weekends;
- Seasonal variation in demand; and
- The spread of demand by time-of-day.

It is accepted that airport demand forecasting is difficult and involves a certain degree of commercial sensitivity. However, the OBC should provide a 'best estimate' of this in order to allow consideration of Tram-Train demand loading; particularly in the context of the reduced service across the peak periods. The most significant aspect of demand profiling relates to the daily profile. The OBC does include a useful profile of current passenger traffic flows, which is reproduced below in Figure 4.2.

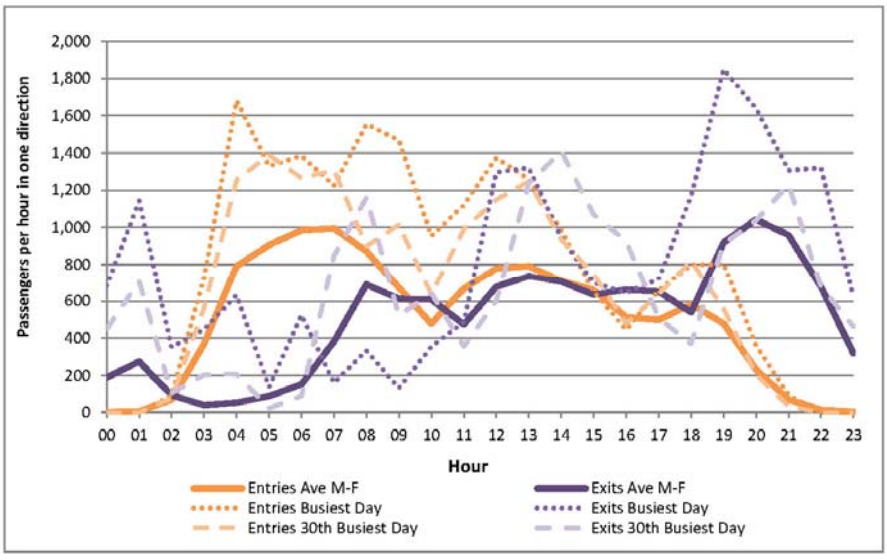

Figure 4.2: Extract from OBC, Passenger Demand Profile at Glasgow Airport 2015

The results of this are not surprising for the location and status of Glasgow Airport. In particular, it shows the high AM outbound peak that corresponds to early morning flights to London and other UK/European destinations that are particularly associated with business travel and access to hub airports for onward international flights. Taking the average situation, this shows that by 7am, around 25% of daily outbound passengers have arrived at the airport, and by 10am that increases to 50%. It also shows the large inbound peak across the evening period; around 25% of inbound passenger arrive between 7pm and midnight`. These focus a large proportion of demand at the extreme ends of the operating day. Of particular note is the situation in the morning where the first arrivals into Glasgow Central for connecting services are, for example, 0643 (Cathcart Circle), 0649 (East Kilbride), 0618 (Low Level from Dalmuir), 0621 (Low Level from Motherwell/Hamilton), and 0608 (Kilmarnock).

The proposed Tram-Train operating hours are noted within the OBC as 18-hours on weekdays, 17-hours on Saturday/Public Holiday, and 15-hours on Sunday. The need to disaggregate the airport demand into daily profiles by origin and destination has been noted above, as even a 6am start time at Central Station would result in a number of passengers missing the first tranche of flights in the morning. Furthermore, in many cases the wider rail network does not become operational early enough in order to enable interchange at Glasgow Central in time for the early Tram-Train services.

It is also notable that this most of this outbound peak occurs before the onset of significant AM congestion on the road network (M8). There are similar issues for inbound flows in the late evening, however most of these would still be able to transfer onto late trains out of Glasgow Central. That inbound peak however starts ramping up as the PM peak on the road network is diminishing.

4.2 Tram-Train Forecasts

The outputs provided from GLAAM and the data presented in the OBC are forecasting relatively low numbers travelling by rail to and from the airport during future scenarios. This takes a conservative position by the team on growth and modal transfer. Table 4.1 below presents details of the average number of passengers travelling by rail and self-drive modes during all assessed scenarios, compared with the Do-Minimum.

Growth Model	Year	Scenario	Self Drive		Rail	
			Total Passengers / Year	Average Total Per Day *	Total Passengers / Year	Average Total Per Day *
Central Growth	2025	Do-Minimum	8,038,000	22,021	512,000	1,402
	2025	Tram-Train	7,752,000	21,238	1,041,000	2,852
	2037	Do-Minimum	9,905,000	27,136	649,000	1,778
	2037	Tram-Train	9,543,000	26,145	1,103,000	3,021
High Growth	2025	Do-Minimum	9,605,000	26,315	611,000	1,673
	2025	Tram-Train	9,264,000	25,380	1,041,000	2,852
	2037	Do-Minimum	12,758,000	34,953	836,000	2,290
	2037	Tram-Train	12,291,000	33,673	1,421,000	3,893

** Assumed Tram-Train operational 365 days per year for the purposes of this calculation.*

Table 4.1: Average Daily Passengers Rail v Self-Drive (All Future Scenarios)

Table 4.1 illustrates the difference between the number of passengers anticipated to travel to the airport by self-drive modes compared to rail on an average day and Table 4.2 below further illustrates

the small number of passengers that are predicted to travel by rail at an hourly level. The Tram-Train is proposed to operate for 18-hours on weekdays, 17-hours on Saturday/Public Holiday, and 15-hours on Sunday. To determine an approximate hourly loading the audit team has taken the daily totals and divided by 17, the average hourly operation across the year, to provide an average hourly passenger figure for each scenario.

Growth Model	Year	Scenario	Tram-Train		
			Average Total Passengers Per Day (from Table 4.1)	Average Total Passengers Per Hour	Difference from Do-Minimum Per Hour
Central Growth	2025	Do-Minimum	1,402	82	+86
	2025	Tram-Train	2,852	168	
	2037	Do-Minimum	1,778	105	+73
	2037	Tram-Train	3,021	178	
Higher Growth	2025	Do-Minimum	1,673	98	+70
	2025	Tram-Train	2,852	168	
	2037	Do-Minimum	2,290	135	+94
	2037	Tram-Train	3,893	229	

Table 4.2: Average Daily Tram-Train Passengers per Hour (All Future Scenarios)

It is clear from Table 4.2 that when considering the impact of the Tram-Train scheme at an hourly level, the number of passengers forecast to travel via this mode is modest. Moreover, when compared to the Do-Minimum across all airport growth scenarios, a minimal number of additional passengers are forecast to travel by rail once the Tram-Train becomes operational.

Based on a vehicle capacity of 236 per Tram-Train (as detailed in the OBC) and an hourly capacity of 944 (based on 4 services per hour), the above table suggests that the average occupancy of the Tram-Train in 2037 (higher growth) for airport passengers would be 25% per hour. It should be noted, however, that as there is no information relating to the daily profile of passengers within GLAAM, it is not possible to calculate a more accurate occupancy level through the course of the day. Notwithstanding this, it is important to note that the Tram-Train will accommodate an anticipated 1 million passengers between Glasgow Central and Paisley Gilmour Street.

The relatively low numbers and occupancy could be as a result of a number of issues:

- underestimation of the demand for Tram-Train in the modelling to date;
- the lack of intermediate stopping points limiting the attractiveness for passengers;
- the route and location of the stopping points not reflecting the catchment area of passengers using the airport; and
- the route and location of the stopping points not reflecting the ultimate destination of inbound passengers.

In summary the audit has identified the following issues:

- the modal shift of future passenger demand from self-drive modes to public transport is considered modest; and
- forecast Tram-Train patronage levels are considered modest.

4.3 Accessibility

As outlined in the Interim Audit, the current express bus service (First 500) has multiple pick-up / drop-off points throughout the city centre, which link to both accessibility and journey time as it relates to actual origin/destination. For many journeys, particularly for passengers arriving into Queen Street or Buchanan Bus Station, the journey time to the airport will be quicker using the airport bus, compared to the Tram-Train, taking cognisance of interchanges via Central Station. While this audit is not suggesting that the express bus meets the future demand requirements of the airport, the relationship between the proposed intervention and the origin / destination of passengers should be explored in greater detail to ensure that the proposals are robust in this regard.

In order to illustrate the current and proposed accessibility of Glasgow City Centre in relation to Glasgow Airport, the programme Transport Accessibility (TRACC) has been applied. TRACC uses public transport timetable information to calculate the fastest journey time between a set of origin points and a destination. In this case the analysis has used a grid of origin points 50m apart across the whole of greater Glasgow with Glasgow Airport as the destination. The programme takes account of people walking reasonable (up to 400m) distances to access public transport services and is based on current year.

To demonstrate the existing accessibility to the airport, an accessibility assessment using the bus and rail network was undertaken, the results of which are shown in Figure 4.3.

It is clear from Figure 4.3 that the airport is currently accessible for the majority of the city centre within a 20 minute journey time. This can be explained by the fact that the Airport bus (500) currently services a spread of origins and destinations within the city centre.

For the purposes of comparison, and to demonstrate the potential future accessibility to the airport following the implementation of the Tram-Train, an accessibility assessment using the bus and rail network (including Tram-Train) was undertaken, the results of which are shown in Figure 4.4.

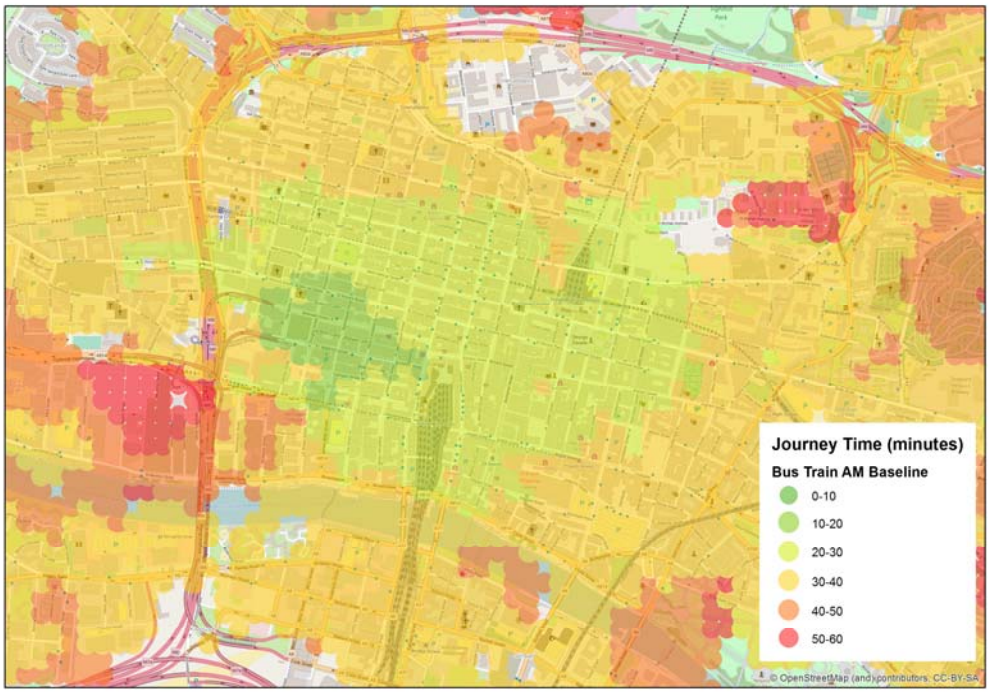

Figure 4.3: Current Situation, Journey Time to Glasgow Airport via bus and rail

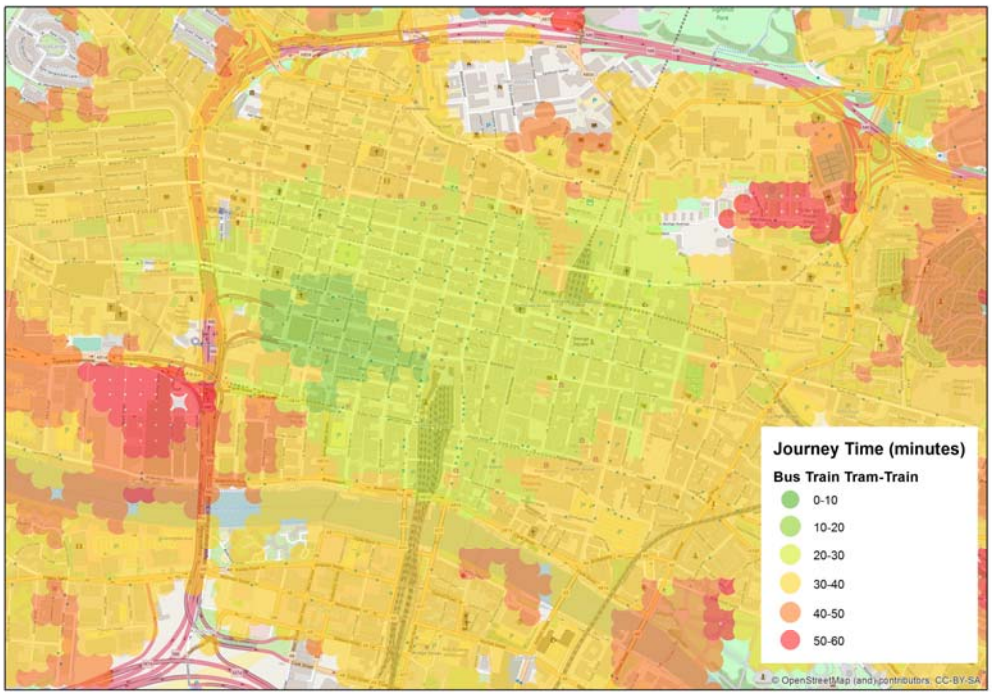

Figure 4.4: Current Situation + Tram-Train, Journey time to Glasgow Airport via bus, rail and proposed Tram-Train

It is clear when comparing Figures 4.3 and 4.4, that the addition of a Tram-Train, makes minimal difference in terms of improving journey times and accessibility from the city centre to the airport given that TRACC calculates the fastest journey time between the origin and destination points, as the timetabled journey time using the bus is faster than the proposed Tram-Train.

It should be noted that the journey times calculated within TRACC do not take into account congestion on the road network and should a bus timetable with congested journey times be used in the calculation it may show the bus journey times to be greater. However as noted previously, the times of peak demand for the airport do not coincide with the times of peak demand on the road network. For outbound and inbound passengers, around 24% and 20% respectively are travelling during the peak periods, so the analysis is applicable to the majority situation, and provides a powerful insight into the effects that the proposed Tram-Train will have in terms of improving the accessibility to the city centre and beyond. Based on the analysis undertaken within this section, it is clear that the provision of the Tram-Train, which only stops at Paisley Gilmour Street, is unlikely to significantly improve the accessibility of the airport for the city centre and associated hub transfer/interchanges.

In summary the audit has identified the following issues:

- lack of clarity on daily / hourly profile of future passenger demand;
- lack of clarity on the anticipated origin / destination profile of future airport demand; and
- lack of clarity on accessibility benefits provided by Tram-Train.

4.4 Benchmarking

4.4.1 Introduction

As part of the audit, a brief comparison of European airports has been undertaken to compare the future scenario at Glasgow Airport, against the existing arrangements at other airports. It considered similar sized airports to Glasgow and reviewed:

- relationship between passenger numbers and mode share;
- type of public transport link provided; and
- the distance from the airport to the city centre.

The benchmarking exercise has considered airports that accommodate broadly similar passenger numbers to Glasgow Airport and/or located a similar distance away from the city centre as Glasgow Airport is from Glasgow City Centre. These airports are detailed in Table 4.3 below.

Airport	2016 PAX per annum (000,000's)	Distance from city centre (straight line)
London City	4.5	10km
East Midlands	4.7	Derby – 14km Nottingham – 18km Leicester – 25km
Newcastle	4.8	10km
Lyon	9.6	18km
Glasgow	9.3	11km
Stuttgart	10.6	10km
Birmingham	11.6	Birmingham – 11km Coventry – 16km
Edinburgh	12.3	10km
Luton	14.6	44km
Hamburg	16.2	9km
Geneva	16.5	5km
Zurich	27.7	9km
Copenhagen	29.0	8km

Table 4.3: Airports Considered Within Benchmarking Exercise

4.4.2 Comparison of Mode Share

Where available for the list of similar airports, the audit team have explored the type of private versus public transport used to travel to the airport. These results are shown in Figure 4.5.

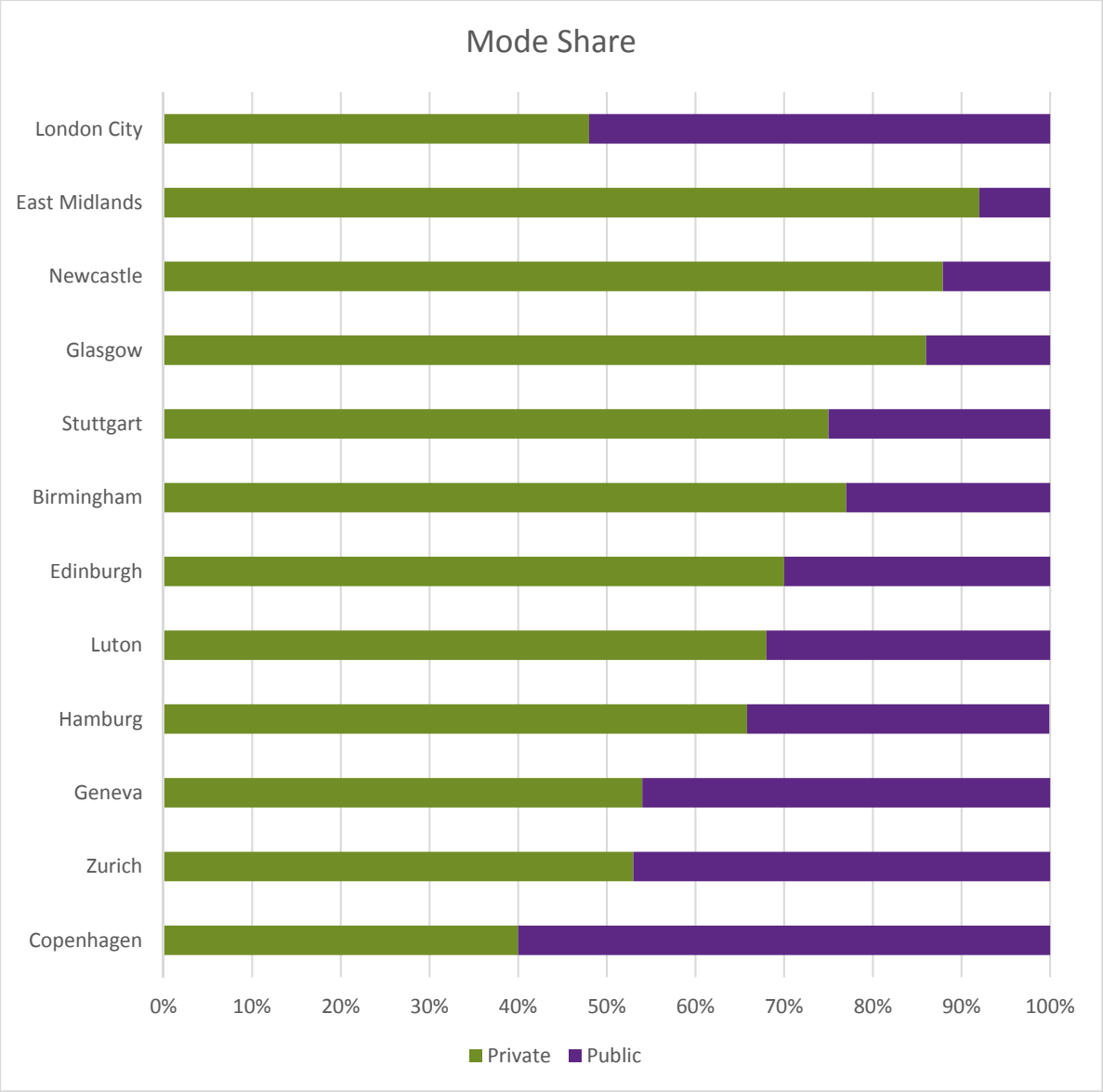

Figure 4.5: Mode Share of Comparable Airports[4]

It is clear from Figure 4.5 that Glasgow Airport currently has amongst the highest percentages of passengers travelling to the airport by private car. As a comparator the OBC forecasts that, with the Tram-Train in place at Glasgow Airport, the private mode share in both 2025 and 2037 would be approximately 80% in the High Airport Growth scenario. This share is still significantly higher than many of the airports listed in the table above that have fixed public transport links in place. To understand the potential reasons for the larger share of public transport at the other airports a review of the nature of the fixed link has been carried out and summarised in Table 4.4. Notes of bus linkages are not generally included unless they are the principal form of public transport, or where they form a linkage with the fixed public transport link.

[4] This data is from a variety of sources. London City, Luton, Edinburgh, Birmingham, Glasgow, Newcastle, East Midlands are from CAA 2013. There is limited data available regarding mode share at international airports, these figures cannot be directly compared as some contain both staff and passenger travel and they are not all from the same year. The graph is purely to give an indication of mode share. The data relating to Edinburgh was gathered prior to the tram opening

Airport	PT rail/metro provision	Private Mode Share	Journey Time to Centre
London City	DLR – incorporated into main network with intermediate stops to central London. Key interchange nearby at Canning Town (LU Jubilee Line and other DLR lines).	48%	Central London – 22 mins
East Midlands	East Midlands Parkway train station (6km distant) has an hourly bus shuttle or Long Eaton (7km distant) has a 20 mins frequency bus service (SkyLink). SkyLink also provides direct bus links to the main centres.	92%	Derby – 40 mins (bus) Nottingham -55 mins (bus) Leicester – 53 mins (bus)
Newcastle	Metro – incorporated into main network with intermediate stops to and beyond city centre. Five trains per hour frequency.	88%	Central Newcastle – 25 mins
Lyon	TGV station on the Rhone-Alps line. Typically one or two trains per hour linking with major cities in southern France. Rhonexpress tram-train. Four trains per hour frequency with limited intermediate stops to city centre.	Not available	Central Lyon – 29 mins
Glasgow	Express Bus. Multiple drop-off/pick-up points through city centre. Bus frequency every 10 minutes.	86%	Bothwell Street – 15 mins Buchanan Bus Station – 25 mins
Stuttgart	S-Bahn – incorporated into main network with intermediate stops to and beyond city centre. Lines S2 and S3. Four trains per hour frequency.	75%	Central Stuttgart – 27 mins
Birmingham	Monorail to train station on west coast mainline. Variety of intercity and local services provide connections to destinations throughout the Midlands and beyond. Around nine trains per hour frequency.	77%	Air-Rail link to Birmingham International – 2 Connection to Birmingham New Street – 11 to 15 mins
Edinburgh	Tram – incorporated into main network with intermediate stops to city centre. Frequency every seven minutes during the day.	70% (pre-tram)	Princes Street – 31 mins (tram)
Luton	Shuttle bus to Luton Airport Parkway train station – direct service to central London. Shuttle bus frequency every ten minutes. Around seven	68%	Luton Airport Shuttle – 10 mins Central London – 40 to 50 mins

	trains per hour frequency.		
Hamburg	S-Bahn – incorporated into main network with intermediate to and beyond city centre. Line S1. Six trains per hour frequency.	66%	Central Hamburg – 24 mins
Geneva	Terminus for rail services linking to various destinations across Switzerland. Five trains per hour frequency.	54%	Central Geneva – 7 mins
Zurich	S-Bahn – incorporated into main network with intermediate stops to and beyond city centre. Lines S2 and S16. Also served by intercity trains linking to other destinations in Switzerland. Thirteen trains per hour frequency. Light Rail – northern destination linked with intermediate stops to and beyond city centre. Eight light rail services per hour.	53%	Central Zurich – 9 to 13 mins (train), 35 mins (light rail)
Copenhagen	Rail – station on the mainline between Denmark and Sweden. Seven trains per hour frequency. Metro – southern terminus of Line M2. Intermediate stops to and beyond city centre. Metro every four minutes at peak.	40%	Central Copenhagen – 14 mins (rail), 15 mins (metro)

Table 4.4: Airport Links to the City Centre

This table highlights that for the similar airports where the private mode share is 60% and under the airport is connected directly into the main network of either train or metro. Newcastle, Birmingham and Stuttgart are exceptions where the airport is incorporated into the main network but the private mode share is still high.

Considering these airports, and the case across airports more generally, it can be seen that the spatial relationship between the airport location and key points such as the city centre, and passenger home origins, can have a significant impact on the type of linkages and the ability of those linkages to attract significant patronage. Figure 4.6 below shows a simplified annotation of the issues around this.

The closer the airport is to the city centre (the shorter distance A is), the more difficult it is to attract passengers from House 1 to travel via the city centre (CA) rather than travel directly (B). At the same time, Distance A may have a far more limited impact on travel choice for House 2 (DA or E). The greater Distance A becomes, within reason, the more potential there is for the city centre to act as a hub. This scenario can be seen at airports such as London Stansted, where the hub is at Liverpool Street station in the centre of London.

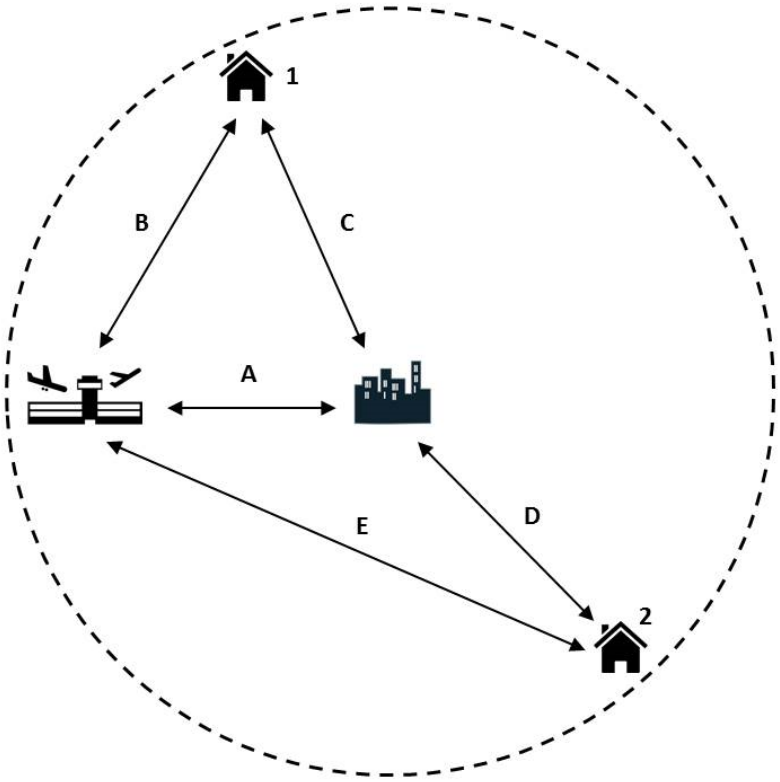

Figure 4.6: Spatial Relationship Diagram

For airports that are located closer to city centres, relative to the overall urban area served, those that are able to sustain significant levels of public transport usage do so by a variety of means, however there are some common threads. Heavy rail stations are often served by through train services, often as part of the overall intercity network, or are terminus stations at one end of that network. Local heavy rail services tend to serve intermediate stations to-and-through the city centre; providing a larger catchment with direct linkage to the airport. This situation is similar for light rail and tram. Where passenger demand is sufficiently high, heavy rail and light rail/tram both provide effective linkages focussed on local, regional and intercity connectivity.

4.4.3 Tram-Train

Considering Tram-Train in the context of benchmarking, there are a number of systems currently operational in Europe that provide some insights. The operational concept is often referred to as the 'Karlsruhe Model' as this is acknowledged as the first principal deployment. It is noted that no system is yet operational in the UK, though the pilot scheme in Rotherham is due to become operational in the near future. The deployments in Europe are across a wide range of settlement sizes and have been developed to address particular issues or exploit particular opportunities that sit within a zone that is not considered to be appropriate for conventional tram or heavy rail. The systems are generally making use of existing infrastructure; both heavy rail and urban tram, and have often been developed as a cost effective means of delivering enhanced connectivity/frequency for peri-urban areas or nearby settlements. The operating model of these systems can be summarised as sharing (or taking over) use of heavy rail infrastructure at the more remote end of the line, and then connecting with the city tram (on-street) network at an appropriate location to proceed into/through the city centre. Two notable schemes in relation to GAAP are the Rhonexpress and the Kassel RegioTram.

The Rhonexpress links central Lyon with Lyon Saint-Exupery airport. Although technically a tram-train, it operates under a single voltage and does not interact with the heavy rail network; with a significant length of new-build track linking Tram Line 3 with the airport. The main reason for selecting tram-train is to have rolling stock capable of exploiting the 100kph speed on the new track, and therefore meeting the sub-30 minute journey time target for the project (most tram-type units are designed for maximum speeds of around 80kph).

The Kassel RegioTram uses heavy rail infrastructure right up to, and into the central station (Hauptbahnhof), after which it joins the tram network. This switch to the tram network is far closer to dense heavy rail operations than has been observed in other systems. However, heavy rail services in and around Kassel were significantly altered after high-speed line construction meaning that the station at Wilhelmshohe (through station) took over from the Hauptbahnhof (terminus station) as the main station in the Kassel area. This provided space at the Hauptbahnhof to remodel track and provide dedicated space for the RegioTram platforms, which go into tunnel at this point under the Hauptbahnhof building to link with the existing surface tram network through the rest of the city.

Through this benchmarking exercise, the audit has been unable to identify any other Tram-Train system currently in operation that shares the operational characteristics of the GAAP proposals in relation to the way in which tram only and heavy rail elements are used, i.e. most systems utilise underutilised heavy rail infrastructure outside of, and on the periphery of, the principal settlement but then switch to the on-street tram infrastructure at an appropriate point between there and the approach to the city centre.

4.4.4 Benchmarking Summary

The following points are considered to be relevant:

- with the Tram-Train in place the public transport mode share at Glasgow Airport is predicted to remain low compared to the airports considered;
- the airports considered are served by either a direct heavy rail link to the city centre, or by a tram/metro style service with a number of intermediate stops; and
- the Tram-Train operating/infrastructure characteristics are unusual in comparison to established Tram-Train systems in Europe.

Summary of Issues

Airport Demand

Tram-Train is the best performing of the interventions considered within the OBC in relation to the number of future passengers accommodated;

With the OBC highlighting the issue of congestion on the M8 Motorway as a constraint, coupled with passenger demand models forecasting up to 4.8 million additional passengers travelling to the airport by road in 2037, there remains the question of whether the airport could attract the growth projected, with such a high apparent continued reliance on the road network.

Based on the future passenger demand forecasts provided by the GAAP Project Team, when considering the impact of the Tram-Train scheme at an hourly level, the number of passengers forecast to travel via Tram-Train is modest. The relatively low numbers and occupancy could be as a result of a number of issues:

- underestimation of the demand for Tram-Train in the modelling to date;
- the lack of intermediate stopping points limiting the opportunity for passengers;
- the route and location of the stopping points not reflecting the catchment area of passengers using the airport; and
- the route and location of the stopping points not reflecting the ultimate destination of inbound passengers;

Airport Accessibility

The relationship between the proposed intervention and the origin / destination of passengers should be explored in greater detail to ensure that the proposals are robust in this regard. In particular, more clarity is required on:

- daily / hourly profile of future passenger demand;
- the anticipated origin / destination profile of future airport demand; and
- accessibility benefits provided by Tram-Train.

Airport Benchmarking

With the Tram-Train in place the public transport mode share at Glasgow Airport is predicted to remain low compared to the airports considered;

The airports considered are served by either a direct heavy rail link to the city centre, or by a tram/metro style service with a number of intermediate stops; and

The Tram-Train operating/infrastructure characteristics are unusual in comparison to established Tram-Train systems in Europe.

5. Operational Issues

5.1 Introduction

The success of the Tram-Train link to Glasgow Airport will rely on the successful integration with the existing rail services and operation of the National Rail network. The audit of the scheme has therefore included a review of the impact on the rail network, particularly the section between Glasgow Central Station and Paisley Gilmour Street, including the operation of Glasgow Central Station itself.

The key issues identified in the interim audit which need clarification include the following:

- Operational challenges associated with the introduction of a frequent Tram-Train service onto the already busy Glasgow to Paisley rail corridor. This demonstrates the difficulties associated with adding more services with differing operational characteristics to this already busy mainline;
- That the introduction of Tram-Train appears to result in a worsening of performance to the Ayrshire and Inverclyde rail service in all scenarios, regardless of the mitigations proposed;
- Further operational challenges exist at Glasgow Central. These relate to the introduction of a frequent Tram-Train service into a terminus station with very limited available capacity today; and
- Capacity utilisation of the proposed Tram-Train service. With each Tram-Train using a full train “path”, yet can only convey a maximum of around 250 people assuming the service is well used. This needs to be set against a seven coach class 380, which is capable of conveying around 760 people today. This represents a low level of capacity utilisation, especially when considering that the Tram-Train also has a lower maximum speed than that which is permissible on this line. Therefore, it remains unclear if utilising the limited available capacity at Glasgow Central in this way is the optimal solution to support a growing regional economy.

In addition, and as noted in the Interim Audit Report, further technical work by the GAAP team has now reported, which raises the following issues:

- The impact from an option proposed to mitigate the operational challenges, which includes lengthening journey times on the approach to Glasgow (at Paisley Gilmour Street) for most services from Ayrshire; and
- The impact from a further mitigation proposed, adding a grade separation to Airport Junction. While this would reduce some of the delays caused to Inverclyde services from the introduction of Tram-Train, it has not been considered in the project business case to date, and no revised costs profile has been submitted.

5.1.1 Rail Planning Policy Context

On 20th July 2017, Transport Scotland published The Scottish Ministers’ High Level Output Specification (HLOS). This covers Network Rail Control Period 6 (CP6), setting the policy context for investment in enhancing the rail network in Scotland during the period 2019 to 2024.

The focus of this report cuts across a number of strategic areas relevant to the GAAP proposals for a Tram-Train link to Glasgow Airport, including:

- creating capacity;
- the availability of Cross-Border services;

- improving journey times;
- addressing performance; and
- growing rail freight.

This policy context has been re-stated and as such is not new, and remains entirely consistent with the approach that the Scottish Government set out previously in the last HLOS, for Control Period 5 (2014 – 2019).

5.1.2 Operation of the Glasgow to Paisley rail corridor

The Ayrshire and Inverclyde lines currently share what is, predominantly, a three track railway from Glasgow Central to Paisley Gilmour Street, where the routes diverge. At present this route is a busy mixed traffic mainline railway, which is used by an average of 11 passenger trains per hour in each direction.

At Shields Junction, an additional two trains per hour split from the route to serve the Paisley Canal branch. This makes a total number of 13 trains per hour between Glasgow Central and Shields Junction, excluding numerous empty stock movements to Shields and Corkerhill depots, both of which are key depots for trains serving the Glasgow area. When the EGIP electrification works are completed, there will be an increase in empty stock moves to the depots by new electric units from the Edinburgh route. All these passenger services are electrically operated (with the exception of infrequent services to Girvan and Stranraer), using a variety of rolling stock types.

In addition, there are also a number of freight trains, which have a variety of different operating characteristics, and which generally operate at up to two paths per hour, totalling 29 per day. Due to the typical nature of rail freight traffic variability, not all the paths are utilised every day. There are also occasional heritage trains and Network Rail maintenance trains as well.

5.2 Detailed operational impacts

5.2.1 Overview

There is already a high level of utilisation on the Glasgow to Paisley rail corridor, with up to 70% capacity utilisation during peak periods. The Project Team proposes introducing up to four additional Tram-Trains per hour onto this busy rail corridor. Network Rail's analysis suggests this will increase utilisation levels to between 85% and 90%. At such a level, it is highly likely that the introduction of such a frequent Tram-Train service will cause a degradation of service performance that could have wide-ranging negative impacts on the wider rail network across the West of Scotland.

5.2.2 Operational issues linked to introduction of Tram-Train

There are already overall performance issues on the Ayrshire and Inverclyde services, which the Project Team acknowledge, as a result of various factors. These include the limitations of flat junctions at various locations along the route, e.g. Wallneuk, Arkleston and Shields Junctions, where conflicting moves occur between Ayrshire and Inverclyde services.

At the moment these issues predominantly relate to trains not presenting themselves in the correct order, creating conflicts at the junctions mentioned above. Currently they are not sufficiently serious to trigger regular Public Performance Measure (PPM – how rail performance is measured) failures. However, analysis undertaken by Network Rail suggests the impact of the introduction of a frequent Tram-Train service (which would have different operational profiles to the existing trains on the line), could worsen the PPM by up to 5%. This would mean PPM failures with Tram-Train in place would be

far more likely. This represents a significant risk associated with the Tram-Train's introduction onto this busy section of the National Rail network.

Earlier work by the Project Team indicated that the Tram-Train proposals would exacerbate delays to existing ScotRail services at the following locations and in the following ways:

- at the proposed Airport Junction, where existing Inverclyde services from Gourock and Wemyss Bay to Glasgow will be delayed by the Tram-Train crossing on a "flat" junction to access the Airport; and
- to the centre and western end of the Glasgow to Paisley rail corridor, especially at Wallneuk, Arkleston and Shields Junctions. This is where existing services from Ayr, Ardrossan and Largs to Glasgow will be delayed by the additional traffic operating on this section of the network, because of conflicting movements between these services and the Tram-Train.

The work undertaken for the OBC sets out that the Project Team acknowledge that the introduction of the Tram-Train will result in an exacerbation of existing performance issues. For example, the regular delays noted in the OBC that exist today between Kilwinning and Paisley Gilmour Street, which see trains presenting themselves in the wrong order at Paisley Gilmour Street. Clearly, it was never an objective of the Tram-Train OBC to explain all the operational challenges associated with the Ayrshire and Inverclyde services. However, given there is a lack of evidence around the nature of the existing issues on the network, this makes it difficult to gain a truly objective view in order to fully comprehend the potential impacts of Tram-Train and consequently provide effective and robust mitigation, hence the generation of new mitigation measures at this point that have significant implications for the project appraisal and business case.

Another challenge associated with the introduction of Tram-Train relates to revenue abstraction from existing ScotRail services. Presently only ScotRail services operate between Glasgow Central and Paisley, but with Tram-Train to Glasgow Airport, these would also call at Paisley Gilmour Street en route to the Airport. While it is understood that there is no reliance on this revenue for Tram-Train project itself, the potential impacts on revenue abstraction to existing ScotRail services should have been fully considered as part of the OBC in order to allow Scottish Ministers to understand the implications for the existing franchise.

There is a widespread acknowledgement within the OBC that the introduction of the Tram-Train results in a worsening of performance to both Ayrshire and Inverclyde service groups. This view is also shared by Network Rail, who has confirmed through their review of the OBC documents to date, that the Tram-Train will bring about a degradation in performance on the Glasgow to Paisley rail corridor. The concentration of services on this corridor, together with the relative modernity of both infrastructure and rolling stock, means that it is a significant positive contributor to the performance of the ScotRail network as a whole. Degradation of performance is therefore a significant issue for Scottish Ministers.

5.2.3 Options proposed to partly address operational impacts of Tram-Train

The Project Team has undertaken analysis that they believe shows that options exist to mitigate the principal negative impacts on the performance of other rail services currently using this corridor. Two key options have been presented:

- to consider delivering a grade separation at Airport Junction, where the Tram-Train would leave the Inverclyde line to reach the Airport. This would be designed to reduce conflicts between services from Gourock and Wemyss Bay heading to Glasgow Central, and Tram-Trains heading towards the Airport.

- to extend most Ayrshire service journey times between Kilwinning and Paisley Gilmour Street by 2.5 minutes. This so-called “recovery opportunity” would see most trains commence their journey into Glasgow from the Ayrshire coast 2.5 minutes earlier than is the case today, though departure times from Paisley Gilmour Street to Glasgow would be maintained.

According to the Project Team, the proposed grade separation would lead to a significant lessening in the overall negative impact on performance of Inverclyde services from Tram-Train. In addition, the Project Team also suggest that the grade separation would increase the likelihood that Tram-Trains consistently arrive at the Airport on time. According to the study, the introduction of such a grade separation would reduce the overall performance impact by up to 11% of delays attributed to the introduction of the Tram-Train.

Notwithstanding this, costs associated with what is likely to be an expensive grade separated junction have not been included within the scheme to date. Clearly, the cost implications of this proposal are now required to be fully assessed, with subsequent updating of the Benefit Cost Ratio calculation to deliver the scheme. Based on examples elsewhere, the potential cost of adding such a grade separated junction could be significant.

To date, a set of potential cost estimates for the addition of a grade separation at Airport Junction have not been shared with the audit team. It would ordinarily be expected that options such as the inclusion of a major addition to the infrastructure requirements would have been finalised as an option before OBC, for example, at SBC stage. This impacts the robustness of the project definition and the subsequent relationship of cost estimation, optimism bias and quantified risk assessment.

In terms of the proposed 2.5 minute “recovery opportunity” on the Ayrshire services, based on modelling undertaken by the Project Team, this would improve performance and reduce some of the negative impacts associated with the introduction of the Tram-Train. In effect, this would appear to mean starting most Ayrshire services 2.5 minutes earlier at their origin points, adding 2.5 minutes to journeys to Glasgow Central, though timings departing Paisley would remain unchanged. The train operating work to date illustrates that the “recovery opportunity” provides a theoretical improvement against the Tram-Train base of up to 2.2% of delays attributed to Tram-Train (i.e. the impact of the “recovery opportunity” on performance of Ayrshire services). However, overall performance is still worse than without the Tram-Train proposals.

There are a number of questions surrounding the additional 2.5-minute journey time increase being suggested for most Ayrshire services. Some of these are likely to make the proposed approach of the “recovery opportunity” an unacceptable option to stakeholders. These are as follows:

- the addition of 2.5 minutes to journey times is likely to affect some 8 to 9 million individual trips between Ayrshire and Glasgow Central per year. This in-turn will likely equate to a total additional journey time of approximately 375,000 hours per year for passengers on this route;
- based on an additional journey time of 375,000 hours per year, this impact may result in a monetised economic disbenefit of up to £4m per year, (2017 prices in 2022 and using averaged Values of Time aligned with STAG);
- by proposing to change the way performance is assessed at a mid-point in the corridor (in this case at Paisley Gilmour Street, through the “recovery opportunity”), would represent a significant departure from the current approach to measuring performance that is adopted throughout the rest of the country;
- any increase on Ayrshire service journey times would also be likely to reduce recovery time at the destinations of Ayrshire services. For example, today, some services have quite quick turn-arounds at locations like Ayr, sometimes as little as 9 minutes. Reducing this turn-around recovery time by 2.5 minutes presents a further potential performance risk, especially given ScotRail use this recovery time today to help re-set the timetable during times of perturbation.

It is noted that the proposed 2.5-minute journey time increase is the only proposal to mitigate the performance impacts. It needs to be noted that this is a modelled solution with a theoretical improvement mitigation. If the project is taken forward and this mitigation is implemented, the actual outturn impact on performance is a risk for the heavy rail operation, and ultimately for Scottish Ministers.

Finally, there is little reference to freight services within the Project Team reports, despite the suggestion that 29 paths per day have been included in the modelling work. The reasonably high prevalence of rail freight services on the corridor, serving terminals at locations including Ayr, Bishopton and Hunterston, will provide a logistical challenge to the introduction of Tram-Train and to train performance in general along this route. This will especially be the case given the varying operational characteristics of rail freight services. Similarly, there is no reference to heritage services, or Network Rail maintenance operations, which also use the Glasgow to Paisley rail corridor from time to time.

5.2.4 Impact on Glasgow Central Station

Glasgow Central is a station that has significant operational capacity constraints today. This is evidenced by the practice known as “Double Docking”, where more than one train in service uses the same platform. This is due to a lack of available individual platforms for all timetabled services. “Double Docking” is commonly used in the high numbered platforms (11-15) that serve the Ayrshire and Inverclyde lines, in order to maintain a robust timetable with the 13 trains per hour described above (including the Paisley Canal branch).

While analysis undertaken by the Project Team suggests Glasgow Central could accommodate up to four Tram-Trains per hour (with a reduced service of three per hour during peaks) this analysis appears flawed. This is because it has not fully considered the impact in the longer-term, including to the end of Control Period 6 in 2024, and the potential for other additional or longer services to use Glasgow Central. While Network Rail do not themselves have a final definitive plan of service changes at the end of CP6 in 2024, it is highly likely that demand growth will require strengthening of services. ScotRail aspirations for the start of CP7 include peak formations for Ayr (7-car), Largs/Ardrossan (6-car), Gourock (6-car) and Wemyss Bay (4-car). These would require additional rolling stock provision and therefore have the potential to impact docking and platform operations at Glasgow Central.

The potential impacts of Tram-Train should not be viewed in the isolation of the Ayrshire/Inverclyde lines and the western platform operations at Glasgow Central. The station operations are complex and efficient and effective train planning means that units arriving from one service group (e.g. Paisley Canal) may leave on another (e.g. Cathcart Circle). The use of Double Docking as discussed above is indicative of the capacity pressure that exists at particular times of day. Taking these into consideration, it can be seen that the introduction of Tram-Train could impact operations more widely across routes serving Glasgow Central, and could limit future opportunities to increase services to other destinations. This is explored further in the next chapter.

Taking each of the various operational challenges at and on the immediate approach to Glasgow Central in turn:

1. **Platform utilisation of Tram-Train.** The Tram-Train vehicles would be much shorter than most other conventional railway rolling stock that currently uses Glasgow Central (with the exception of

some single diesel multiple units), at just 37.2 metres in length[5]. While the carrying capacity of the Tram-Train is believed to be around 250 when fully loaded.

Nevertheless, the Tram-Trains would still take up a train "path", which would normally be utilised by a train on the Ayrshire or Inverclyde lines that is at least 69 metres, with some at 161 metres in length when units operate in multiple. A 161m long train has a carrying capacity of up to 756 when fully loaded[6]. Therefore, given the limited capacity available at Glasgow Central, the Tram-Train does not appear to be a particularly efficient use of the limited number of path compared to standard rail services.

2. **Inability to add new services, or add carriages to existing services.** Use of the very limited available platform capacity at Glasgow Central station by Tram-Train would reduce the opportunity for any other train service (or longer existing service) to use that platform space at Glasgow Central.

   This could be significant, given emerging proposals as outlined in the Scotland Routes Study (July 2016). These include exploring electrification of the East Kilbride and Kilmarnock lines, as well as the potential to extend Ayrshire and Inverclyde services by adding more coaches to more trains on this route. Already today, some trains operate as six or seven coach trains, but an aspiration would be to operate more trains with more coaches. This latter point is likely to be a key ScotRail aspiration in order to expand capacity to accommodate greater demand growth through the early 2020s.

   Overall, this is considered a significant challenge in need of further exploration. This is especially the case given electrification plans and the route study review of demand growth on these routes, with a strong link to regional economic growth. In particular, it highlights that there is a direct risk from the introduction of Tram-Train as to how the Ayrshire and Inverclyde services could be expanded in capacity terms in the future, without the addition of substantial new infrastructure, which is likely to be expensive.

3. **Inability for Tram-Train to use the same platform at Glasgow Central.** Another challenge associated with the "Double Docking" process, (and the general lack of available platform space at Glasgow Central which necessitates its use), is that the Tram-Train would not be able to depart from a consistent platform. Clearly, this is not ideal for a branded airport shuttle service. This is especially the case when considering that some platforms at Glasgow Central, especially when being used in "Double Docking" mode, are a considerable walking distance from the main station concourse and entrance.

4. **Potential improvements to cross-border services.** These would likely approach Glasgow via the West Coast Main Line (via Polmadie). Therefore, they would be expected to utilise the low numbered platforms at Glasgow Central (1-5). On this basis, it would seem that the Tram-Train would be unlikely to create any significant conflict for these services, were they to be introduced. Therefore, this is not considered a significant issue.

The implications from a wider regional and national context of items 1, 2 above are discussed further in Section 6.6.

With the exception of the Tram-Train length point above, it should be noted that many of the impacts reported in this section would equally apply to any additional rail services operating between Paisley Gilmour Street and Glasgow Central Station and are therefore not unique to the Tram-Train scheme. It does however highlight the need for the project to be considered within the wider context of the rail network in the West of Scotland.

[5] Based on the class 399 Tram-Trains that have been built for the Sheffield Tram-Train trial that is yet to commence.
[6] Based on seated and standing capacity of a 7 coach class 380 train, as normally used on the Ayrshire services.

Summary of Issues

Regardless of the mitigations proposed, (some of which are unlikely to be acceptable to stakeholders, because of their impacts, e.g. extending journey times to Ayrshire services), introducing up to four Tram-Trains per hour to the Glasgow to Paisley rail corridor means that overall performance will be worse than it is today.

Furthermore, the planning for Tram-Train in the Business Case to date, does not adequately address its potential impact at Glasgow Central beyond 2019, from adding in new services, to lengthening existing ones.

Operational challenges to the corridor

Performance on the Glasgow Central to Paisley rail corridor with the introduction of up to four Tram-Trains per hour is likely to negatively affect the PPM for the corridor by a worsening of up to 5%. This is also indicative of the impact on capacity that the Tram-Train would have. The introduction of Tram-Train would mean that the current peak operating capacity would be run throughout the day, and in both directions. The 'surge' at peak is generally dealing with high demand in one direction. Extending this to both directions throughout the day would significantly reduce or remove recovery opportunities, with the result that operational issues could have a disproportionate level of impact.

Altering the way performance is measured by the introduction of a 2.5 minute journey time delay to most Ayrshire services between Kilwinning and Paisley Gilmour Street, would be a significant departure from the current approach to measuring performance that is adopted throughout the rest of the country.

By lengthening most journey times from Ayrshire to Glasgow by 2.5 mins, over the course of a year, the economic disbenefit to existing rail users would be up to £4million.

Adding a grade separation at Airport Junction is a potentially expensive element that has not yet been accounted for in the scheme business case.

No costs for the grade separation option have been shared by the Project Team to date.

Challenges specific to Glasgow Central

While analysis by the Project Team suggests up to four Tram-Trains could be accommodated at Glasgow Central, and notwithstanding the proposals to operate a reduced frequency (3tph) during peak periods, this work appears flawed. This is because it fails to consider the longer-term opportunities to add other new services, or lengthen existing ones by the end of CP6 in 2024, or beyond. Addressing this is significant, in order to identify the optimal way to maximise use of the finite capacity available at Glasgow Central.

With a Tram-Train carrying a maximum of around 250 people in a 37.2 m long vehicle, but still using a train "path", the Tram-Train represents poor platform capacity utilisation at Glasgow Central.

6. Economic Case

6.1 Introduction

The key issues identified in the interim audit covered the following:

- Clarity required on why the level of confidence and risk assumed to date are not commensurate with the level expected at the OBC stage;
- The OBC confirms that project costs currently sit at £144 million, however an explanation should be provided on why a number of key costs have yet to be included in the overall cost and the implications of these omissions on the overall cost of the project;
- Reasoning required on why costs within the OBC appear to have been underestimated;
- the robustness of contingency levels is not proven given current project uncertainties with further explanation required;
- Recognition of the uncertainties of both delivery and operating models; and
- At present the OBC does not report on wider economic impacts, with little analysis of the direct economic benefits that are considered to stem from the scheme, and any commentary is generally qualitative in nature. Further assessment required.

The following paragraphs cover these issues in more detail.

6.2 Approach to Cost Estimation

The 'Green Book Appraisal and Evaluation in Central Government' is a document written by HM Treasury and is supplemented by The Department for Transport's 'Transport Appraisal Guidance' and by Transport Scotland's 'Scottish Transport Appraisal Guidance (STAG)'.

The approach to estimating the cost of schemes relies not only on establishing a solid and robust estimate of capital and revenue costs, but also on the application of Optimism Bias (OB), Quantified Risk Assessment (QRA) and Contingency. Briefly the purpose and function of these is:

- Optimism Bias – applied to reflect the documented tendency for project estimation to be overly optimistic, particularly in the early stages of scheme development. Reduces through the scheme development process as greater cost certainty is achieved through technical assessment.
- Quantified Risk Assessment – can be thought of as the mirror image of OB. As elements are technically assessed, the risks to the project are better understood (likelihood and severity) and a quantifiable allowance can be made in the scheme budget for these. QRA is likely to rise as OB falls, but it is not usually a direct correlation.
- Contingency – a provision for events or circumstances that are possible but cannot be predicted or assessed during scheme development. Levels of contingency depend heavily on the type of project, location, complexity, and usually informed by the previous experience of comparable projects.

The percentage to be added to the cost estimate to allow for Optimism Bias is dependent on the type of project and the stage of the development. The Green Book guidance is supplemented by The Department for Transport's 'Transport Appraisal Guidance'. The guidelines suggest that Optimism Bias levels should be set at 40% at OBC stage, however it is noted that in relation to the proposals, Optimism Bias levels of 66% have been assumed and while this is contrary to Green Book guidance, the higher level is considered appropriate in this case given the levels of project uncertainty at this

time in relation to project design and the lack of any quantitative risk assessment for identification and quantification of project-specific risks.

Notwithstanding this, given that GAAP is at OBC stage, it would be expected that the project would be further along the design process, with a degree of early risk quantification having been carried out. As such, while Optimism Bias levels are appropriate given the existing project uncertainties, it is the view of the audit that the project is not currently at OBC stage in terms of scheme costing and design. A similar concern exists with respect to the Optimism Bias, as outlined in section 6.3.

6.3 Cost Estimates

A review of the cost estimates provided within the OBC has uncovered a number of key issues. Firstly the estimate has not been measured to 'Rail Method of Measurement 1', which is the industry standard for quantification of works involving rail transport at early design stages. The use of a "bespoke" measurement method means it is difficult to know what work is covered within each item of the construction cost estimate, leading to complications with any cost analysis and comparison to other rail projects and leaving open to question whether the estimate has captured the entire scope of work.

The GAAP Project Team has proposed various mitigation measures to counter impacts of the proposed Tram-Train on the existing and future operation of the rail network, one of which includes the provision of a grade separation at Airport Junction. The costs associated with what is likely to be an expensive grade separated junction have not been included within the scheme to date and the cost implications of this proposal require to be fully assessed, with subsequent updating of the BCR calculation, in order to ensure the OBC is suitably robust. Based on examples elsewhere, the potential cost of adding such a grade separated junction could represent a significant additional cost to the scheme.

In relation to 'Scheme Costs', the OBC notes other improvements to the network that are planned or in development in order to meet future demand and states that discussions on these, *"…will also include the potential for cost sharing on capacity interventions, which would be mutually beneficial to the Airport Access Project and the wider rail network."* Noting that the costs are currently reported at £144m, it is unclear what scope there is in the project budget to take additional cost-share from other capacity interventions.

The OBC states that*, "No provision has been made for major capacity upgrades on the rail network or for platform upgrades at Central Station."* This is also referenced to Section 5.5 that states, "*This is based on the assumption that the Tram-Train specification will be developed for running on the heavy rail network as it currently exists (rail modelling work suggests this may be possible..)The need for any infrastructure interventions will be explored, as will the potential for cost sharing associated with them, reflecting the joint aim of growing the Glasgow City Region and Scottish economy by improving rail capacity. Work carried out in developing the economic case would suggest that, even with any such additional costs incurred, the Tram-Train project would still present a more preferable option than PRT, not only from a Value for Money perspective but also across the wide range of assessment criteria reviewed in the Options Appraisal section of the Economic Case".* There appears to be little exploration of the cost sharing burden associated with infrastructure interventions and what proportion the project would accept. There is a suggestion, however, that the project will be liable to absorb some of these associated costs and the impacts of this on the project budget have not been clearly outlined. Also, given the recently identified grade separation mitigation, there is a risk that any scope for cost sharing is diminished and the cost burden for upgrades would rest with Scottish Ministers.

It is noted that compensation payments for disruptive possessions has been excluded from the cost estimate. The compensation payments to Train Operating Companies (TOCs) and Freight Operating Companies (FOCs) for disruption caused by planned possessions, otherwise known as "Schedule 4"

costs, are potentially a significant cost factor in rail construction projects. They are calculated by using a complex formula which takes into account factors such as train delay minutes and replacement bus service costs. Since such factors are unique to each worksite, it is almost impossible to make a reasonable allowance for these at any stage prior to the development of a construction and access strategy. It is recommended that Network Rail be contacted as soon as this strategy has been developed to ascertain whether these costs would be chargeable in full or in part to Transport Scotland and, if so, an estimate of these costs should be requested from Network Rail for inclusion within the project budget. At present, the GAAP Team could draw evidence from both the Tram-Train pilot scheme in South Yorkshire, and historical evidence from Network Rail for previous works on this route in order to present a commentary on the potential scale of financial risk.

No analysis of the rolling stock purchase estimate has been carried out because no detail of the £40m cost has been provided. Nevertheless, the justification for reducing Optimism Bias from 66% to 18% is given in the first paragraph of p.98 of the OBC, wherein it is stated that the Project Team have met with potential Tram-Train suppliers to obtain specialist advice. While this consultation will undoubtedly provide a higher level of cost assurance and allow a lowering of Optimism Bias from the 66% upper limit, DfT TAG Unit A1.2 recommends that Optimism Bias at OBC stage for Light Rail projects be 40%, whereas 18% is the allowance to be made for conventional rail. As this project has a combination of both types of project, it would be reasonably expected that the Optimism Bias percentage would be within the 18%-40% range rather than at its lowest end; however a more detailed analysis of the cost data for rolling stock would be required to advise a more accurate allowance.

A summary of the key points in relation to cost estimates are as follows:

- Construction Costs – most rates appear reasonable with some notable exceptions:
  - Drainage costs appear to be exceptionally low;
  - The rail connection of the tram line to the main line may be significantly overpriced, however this may be due to the lack of detail concerning the type of connection required: if the connection is a turnout as stated in the cost estimate, then the cost is higher than would be expected. That said, it is more likely that a double junction rather than a turnout will be required for a two-track tram line to connect to the existing main line. If this is the case, then the connection allowance is reasonable and the works description in the estimate is incorrect.
  - Plain line track may be overpriced by up to one third.
- Preliminaries –
  - Percentage for contractor's preliminaries is low for a rail project at 15% of direct construction costs. Analysis of tendered rail projects suggests that preliminaries are typically between 20% and 40% of direct construction costs, dependent on the nature of the work in hand and the magnitude of the cost.
- Design –
  - Levels of design cost provided are at the lowest end of railway design cost benchmarks, therefore they are only suitable for very simple design work. Since this work is likely to be more complex in nature, the allowance for design costs is considered inadequate.
- Inflation –
  - The methodology used to calculate inflation is a departure from best practice for cost plans at this level of development;
  - The method in this estimate may be used once a detailed cost estimate, programme and expenditure profile have been put together to advise precisely how much work will be

carried out every year. Without these, the annual value of work is based on arbitrary percentages.

Furthermore, given that the developmental is only at OBC stage, it is uncertain whether the overall contingency level of 9% is considered adequate given the lack of clarity on delivery, operational and ownership models and other parameters, and the complexity of delivering within a busy rail corridor. The complexity issues are compounded by the need to integrate a new station/stop facility at the airport. Construction and will require to maintain operation of landside access and comply with the necessary security and blast regulations.

There should be greater clarity in the makeup of the contingency element within the OBC, and the disaggregation of the same into the constituent risk elements and pure contingency element. Without this, the contingency appears to be a fully top-down allowance, rather than having been built from an evidence base.

There are a number of potential delivery and operating models that have been identified in the OBC and supporting documentation. These have differing risk profiles that have not been reflected in the economic case. It is appreciated that these will only be finalised at a later stage, but the business case should reflect the potential impacts.

The National Audit Office in April 2017 published an audit into 'The Sheffield to Rotherham tram-train project: investigation into the modification of the national rail network[7]'. A key conclusion of the audit surrounds Network Rail confirmation in June 2016 that forecast costs had risen by up to £25 million, which constitutes a cumulative increase of nearly 400% against the original budget. It can be argued, therefore, that as of yet there is not a good understanding of costing within the industry for this type of project. Coupled with the existing uncertainties around GAAP, as demonstrated within this chapter, a cautious approach should be taken in regards to estimating costs associated with GAAP.

In summary, therefore there are concerns regarding the robustness of the cost estimate as presented in the OBC as documented.

6.4 Core Economic Case

The economic appraisal, as reported in the OBC, concluded that the Benefit-Cost Ratio (BCR) would fall between 2.8 and 3.7 for the four trains per hour Tram-Train service. This appears to demonstrate high value for money. However, as outlined above, there are elements of the cost estimation that are considered to be underestimated or not included to date, which would consequently lead to an overestimation of the BCR.

In reviewing the economic case the audit team have not had sight of the detailed workings and outputs of the various modelling and analysis undertaken. In the absence of such insights the audit team are not able to check the reasons why some of the findings reported appear to us anomalous, hence these issues are set out below:

6.4.1 Mode shift

Typically rail schemes will abstract passengers from alternative public transport services, ie bus services. It is interesting to note that there is little mode shift from bus/coach but a sizeable shift from taxi/private hire.

[7] 'The Sheffield to Rotherham tram-train project: investigation into the modification of the national rail network' (National Audit Office, 2017)

Mode Share Percentage

Modes		Central Growth							
		Do Minimum		PRT		Tram-Train		Tram-Train Reduced Service	
		2025	2037	2025	2037	2025	2037	2025	2037
Self Drive	Hire Car	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%
	Park Long Stay	5.1%	5.2%	5.1%	5.1%	5.0%	5.0%	5.0%	5.1%
	Park Short Stay	5.4%	5.3%	5.3%	5.2%	5.2%	5.1%	5.2%	5.1%
Get Lift	dropped off	20.8%	20.8%	20.6%	20.6%	20.4%	20.4%	20.4%	20.4%
	seen off	14.3%	14.3%	14.2%	14.2%	14.1%	14.0%	14.1%	14.1%
Taxi	includes private hire	28.9%	29.0%	28.2%	28.2%	27.2%	27.2%	27.3%	27.3%
Other	includes hotel	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%
Public Transport	Bus/Coach	9.6%	9.3%	9.2%	9.0%	8.8%	8.6%	8.8%	8.6%
	Rail	5.3%	5.4%	6.9%	7.0%	9.0%	9.2%	8.7%	9.0%
	Chartered Vehicle	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
	Off Airport Long Stay	7.4%	7.5%	7.3%	7.4%	7.2%	7.2%	7.2%	7.2%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Figure 6.1: GAAP Airport Passenger Demand Forecasts - Airport Demand Forecasting and User Benefits (PBA, 2016)

6.4.2 User benefits

PRT delivers greater travel time benefits than the Tram-Train options despite having fewer passengers, that is, user benefits per passenger are higher – this would suggest the generalised time savings are higher which in turn would appear to suggest that patronage should be higher than for the Tram-Train.

	High VOT	Standard VOT	High VOT	Standard VOT	High VOT	Standard VOT	High VOT	Standard VOT	High VOT	Standard VOT	High VOT	Standar VOT
	PRT		Tram-Train		Tram-Train Reduced Service		PRT		Tram-Train		Tram-Train Reduced Service	
	Central Demand						High Demand					
Private Sector Operator - Revenue	20,718	20,718	57,143	57,143	55,497	55,497	26,003	26,003	72,361	72,361	70,306	70,306
User Charges	-1,265	-1,265	-1,427	-1,427	-1,415	-1,415	-1,582	-1,582	-1,789	-1,789	-1,774	-1,774
Travel Time Benefits	243,049	99,260	231,829	93,463	204,328	82,387	307,986	124,334	294,498	117,769	259,675	103,92

Figure 6.2: GAAP User Benefits (2010 Prices) - Airport Demand Forecasting and User Benefits, (PBA, 2016)

The same figure above shows that private sector operator revenue for Tram-Train is considerably higher than for PRT despite only 30% more passengers being carried. Gross rail revenue is given as £80.5m PV compared to £29.4m PV for PRT which suggests people are travelling further with Tram-Train option but not clear why if journey time benefits are less with PRT.

Again the same figure shows the reduced Tram-Train service option would lead to a 10% drop in travel time benefits over a full Tram-Train service despite a very small reduction in number of Tram-Trains operated and only a 2% reduction in passenger numbers. There may be 'pull through' issues impacting the assessments stemming from the lack of demand disaggregation as discussed in previous sections. The issues raised above reinforce the need for more disaggregated understanding of demand, usage profiles and unit loadings.

The Value of Time for airport passengers are around 10% higher for both business and non-business passengers than those presently being used for surface access schemes for London Heathrow. This is despite median incomes in Glasgow being on par with those in south east England and nearly 30% lower than those in Greater London.

Journey Purpose	AAP Airport User VOT	Standard STAG / WebTAG VOT
Business	48.93	26.86
Commute	6.81	6.81
Leisure	17.93	6.04

Table 6.1: GAAP TEE Values of Time (VOT), 2010 Prices (£ per hour) - Airport Demand Forecasting and User Benefits (PBA, 2016)

In comparison, the values of time presently used for Heathrow surface access project are shown below.

	UK Business	UK Leisure	Non-UK Business	Non-UK Leisure
Heathrow VoT (£/hr) (2008)	44.16	16.21	38.86	16.18

Table 6.2: Heathrow Surface Access VOT

The implications of this are that there is an overestimation of the value of travel time benefits from an overall economy basis and relative to the scheme cost. There may also be impacts on demand forecasting that, because of the marginal nature of the journey time benefits, could have a material impact.

In addition to the above the following points should be noted:

- discounted operating costs of PRT are given as £61.7m (with no drivers and light weight pods) compared to £60.7m for Tram-Trains (with drivers). Given a significant element of cost is personnel, this appears to be counterintuitive. There may be an assumption for on-board guards/hosts for PRT but this would be an unusual operating practice;
- under tram-train scenarios there are congestion disbenefits which don't change in the high demand scenario when the system is carrying more passengers;
- it is not clear why there are government operating costs for the Tram-Train options as the scheme's additional revenues appear to exceed operating costs; and
- it is noted that in the higher VOT scenarios there is no change in passenger numbers as they have not been modelled with these higher values. Different values of time will have different impacts for all schemes and might change relativities of scheme options. This supports the need for greater understanding and disaggregation of demand.

6.5 Wider Economic Impacts

6.5.1 OBC and Locality

As Scottish Transport Appraisal Guidance (STAG) sets out the purpose of analysing wider economic impacts is:

"To provide information to decision makers about the nature of outcomes that a project is expected to deliver, and their distribution; and

To adjust modelled monetised welfare impacts to take account of market failures in non-transport markets."

The present OBC does not report on wider economic impacts. The "Glasgow Airport Access Projects, Economic Impacts" report (September 2016) sets out the importance of Glasgow Airport to the economy rather than the impact of improved surface access. The information contained in the report outlines the economic context at both a UK and Glasgow level. However, there is little analysis of the direct economic benefits that are considered to stem from the scheme, and any commentary is generally qualitative in nature.

The problems faced by air passengers, employees at the airport and businesses located in its vicinity in relation to accessibility are not clearly set out in the documentation. As STAG guidance states "*It is necessary … to consider the baseline economic conditions within the area affected and identify how other markets and behaviours may be affected by the current performance of the transport system".*

While a business survey has been undertaken it does not seem to have covered accessibility issues in terms of identifying barriers to business and employment. However, it asked questions about how businesses felt a fixed link would improve business performance as shown in the table below. The percentage changes comparing now to a future fixed link tend to be relatively small. Interestingly one area with the biggest expected impact is in relation to ease of bringing in supplies and distributing supplies despite a fixed link having very little mode shift so minimal road access benefits would be expected. Interestingly respondents expected a substantially bigger benefit in terms of suppliers/clients visiting them than vice versa which suggests the issue may be more down to perception than the reality of poor accessibility.

Business Performance	High Positive Impact (>15%)		
	Now	With F.L.	% Uplift
Staff travelling to meet clients / visiting other locations	30%	35%	5%
Clients / suppliers to come and visit	23%	36%	13%
Business growth	21%	25%	4%
Access to foreign markets	21%	23%	2%
Level of exports	9%	12%	3%
Ease of bringing in supplies and distributing goods	3%	12%	9%

Table 6.3 Glasgow Airport With and Without a Fixed Link

Given the scale of intervention the audit team would expect to see some analysis as to how the investment would impact on use of the airport, ability of employers to recruit and retain staff and the scale of catalytic employment around the airport. This could be based on a survey approach or a full land use and transport interaction model i.e. using Transport Scotland's TELMoS model.

There is little discussion how improved accessibility could lead to regeneration and development around the airport or how it could enable those in the wider area to access more employment opportunities. This is important given the context of the overall City Deal and the development of an understanding of how Tram-Train could support and/or enhance the potential economic performance of other projects. At a more localised level, there are two other City Deal projects in close proximity to the airport:

- Glasgow Airport Investment Area (£51.4m), which will better connect new and existing employment areas and facilitate regeneration; and
- Clyde Waterfront and Renfrew Riverside (£78.3m), which will fund a new opening bridge across the River Clyde to improve access to employment, education, health and leisure.

There is no assessment of how Tram-Train would or could interact with these. This could potentially increase patronage on the service and provide enhanced public transport linkage for the new developments; increasing the potential return on investment and giving direct fixed link public transport access to increase development stimulation and take-up.

There is no assessment of agglomeration benefits; given the large transport user benefits for both PRT and Tram-Train options these could be significant.

In summary the business case does not set out the wider economic benefits of the proposed scheme which could be significant.

6.5.2 Regional and National Investment Context

The recent train operations work undertaken has developed a mitigation plan for both the Inverclyde and Ayrshire lines. For Inverclyde, the inclusion of a grade separated junction should significantly reduce or eliminate operational impacts on services at this location. This will however require additional capital expenditure within the project at a level that will have a material impact. For Ayrshire, the identified mitigation of an additional 2.5-minutes on inbound journeys to Glasgow would result in annual disbenefits of around £4m as set out previously in this report.

In 2016, East, North and South Ayrshire Councils submitted an 'Ayrshire Growth Deal Prospectus[8]' to both the Scottish and UK Governments, to assist in the development of a long-term economic and investment strategy to transform both public and private sector efforts to regenerate the region.

The importance of both local and international connections are stressed throughout the strategy, most notably the importance of the strategic transport links with Glasgow, where it is stated that *'transport connections mean short travel times to Glasgow, making parts of Ayrshire popular commuter territory. A train service provides regular direct services to Glasgow city centre from many of Ayrshire's towns…But more can be done to help businesses and communities access economic opportunities.'*

Clearly, lengthening the journey time runs contrary to the objectives of the strategy. Not only would there be a material impact, the £4m disbenefits, but significantly more journeys would be negatively impacted than would be benefitted through Tram-Train patronage. Such a situation is counterintuitive in terms of scheme promotion.

As set out previously in this report, the period up to the start of Tram-Train operations in 2025 is likely to see an increase in demand for services into and out of Glasgow Central. This could take the form of wholly new services or strengthening of existing services through train lengthening. This is based on the following logic:

1) The most forward-looking timetable/docker information from Network Rail for Glasgow Central shows increased service provision to be accommodated within the working plan for the station.
2) Indications from trend analysis and forward projections (e.g. Scotland Route Study) shows continuing increases in demand.
3) Electrification of lines to East Kilbride and Barrhead (Kilmarnock) are likely to have been delivered or will be in the process of being delivered. Previous experience indicates that the

[8] Ayrshire Growth Deal Draft Prospectus (South, East and North Ayrshire Councils, March 2016)

electrification of lines tends to result in increases in demand to travel, which in turn can require additional and/or strengthened services.

It is therefore highly likely that there will be demand for additional/strengthened services at Glasgow Central in the intervening period up to 2025 (and certainly beyond). Considering station usage figures for 2015/16 as set out by the Office of Road and Rail, these show total boarding and alighting as:

- Ayrshire Electric Group (Ayr to Johnstone inclusive) 8.8m;
- Inverclyde Electric Group (Gourock to Cardonald inclusive) 8.7m

To understand the equivalence value of these at the level of a service, by taking the total passenger entry/exits in these groups (17.5m) and dividing by the standard hour profile (11tph), this means that 1tph represents 1.59m passengers at an annualised level. By way of comparison, and in order to consider the service group that may change most in coming years:

- East Kilbride / Barrhead / Kilmarnock (not including station south of Kilmarnock) 6.1m

This has a standard service pattern of 6tph, giving an equivalence of 1tph representing 1.0m passengers. Carrying out the same exercise for Tram-Train, this has a patronage level in 2025 of ~1.9m (airport + Paisley Gilmour Street additional). For 4tph this gives an equivalence of 1 tph to 0.48m; less than one third of the heavy rail performance for Ayrshire/Inverclyde and less than half that of East Kilbride/Barrhead/Kilmarnock. This heavy rail equivalence is also an underestimate in the comparison as it is 2015/16 figures. This equivalence gives a proxy for understanding the relative value of train paths in these service groups, and it can be seen that for a given train path, the heavy rail services representative of, and convey, significantly more passengers.

Network Rail's Scotland Route Study contains projections of the relationship between available seats and passenger demand in 2023/24 and 2043 across four different scenarios. An extract is provided below in Figure 6.3 that shows the potential situation on the service groups that would be directly impacted by Tram-Train.

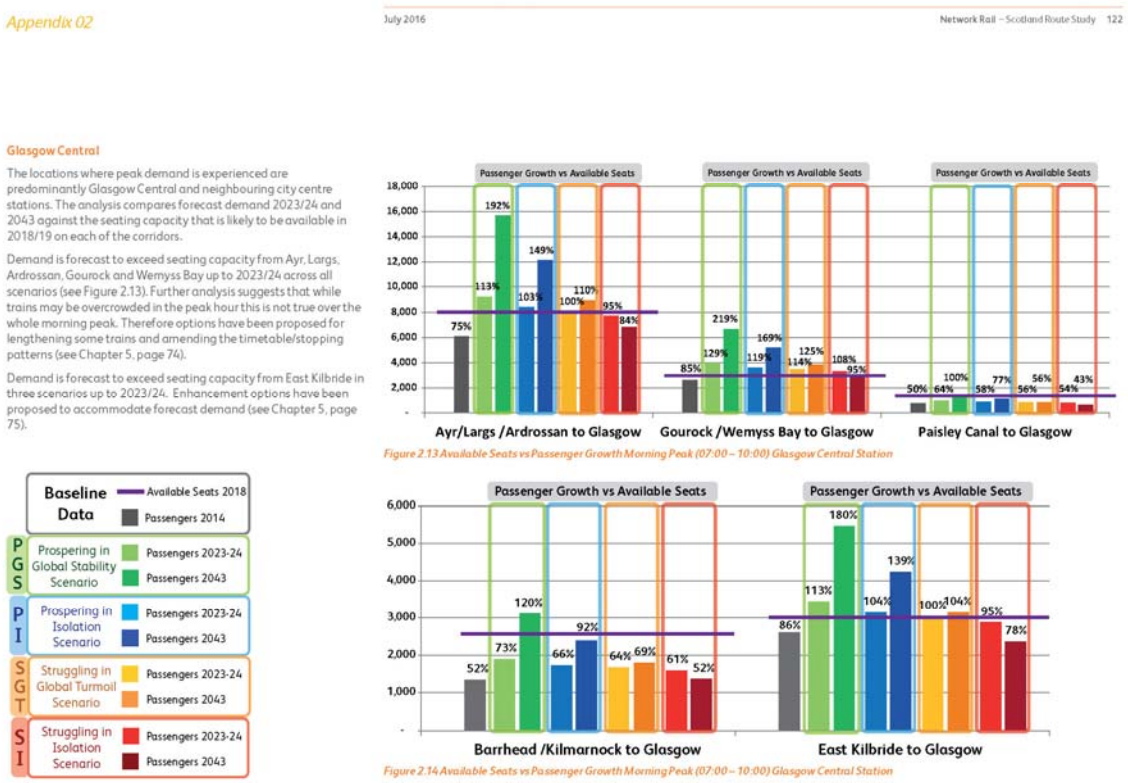

Figure 6.3: Extract from Network Rail Scotland Route Study Appendices page 122

In trying to understand the competing issues for investment, and advise Ministers accordingly, there are three key components from the above analysis:

A: Investment in Tram-Train

B: Providing for shorter-term growth needs on routes at Glasgow Central including Ayrshire/Inverclyde, Kilmarnock and East Kilbride

C: Providing for longer-term growth needs on routes at Glasgow Central including on Ayrshire/Inverclyde, Kilmarnock and East Kilbride

While the shorter term solutions for Ayrshire/Inverclyde services are planned to be achieved with strengthening of current services through train lengthening, the potential delivery of electrification and new units/service patterns for East Kilbride and Barrhead/Kilmarnock could require significant changes to capacity at Glasgow Central. It is noted that these changes could also have capacity benefits by allowing more efficient working across lines of electric multiple units. What is clear is that committing to Tram-Train now before the implications of this significant change are better understood could preclude selection of the most effective and efficient options at a later stage.

In order to provide for the 2043 situation, Network Rail has identified a basic requirement to increase the standard operating pattern in the Ayrshire/Inverclyde group from 11tph to 14tph by adding additional services from Largs and Wemyss Bay, and a new service from Kilwinning. Coupled with the needs of other service groups and the identified need to consider capacity at Glasgow Central, longer term planning could result in solutions that support, augment or supersede the Tram-Train. It is highly likely that these will be considered in detail within the second iteration of the Strategic Transport Projects Review, which is understood to be commencing in 2018.

Summary of Issues

Approach to Cost Estimation

Optimism Bias levels are considered appropriate given the existing project uncertainties; however it is the view of the audit team that the project is not currently at OBC stage in terms of scheme costing and design. A comprehensive and structured explanation of the approach to Optimism Bias, Quantified Risk Assessment and Contingency would increase confidence in the costing approach.

Cost Estimates

Cost estimates have not been measured to industry standard for quantification of works involving rail transport at early design stages;

It is noted that costs currently sit at £144 million, however a number of key costs have yet to be included in the overall costing, including

- Cost sharing burden of future capacity interventions;
- Compensation payments for disruptive possessions; and
- Costs associated with proposed mitigation measures have not been included within the scheme to date or the cost implications of the proposals fully assessed.

Given the complexity of interfaces, systems and the operational environment of both the railway and airport, the level of contingency is lower than might be expected, and lacks evidence of how it has been built up.

Cognisance should be taken of the potential impacts of different delivery and operating models, as these are still uncertain at this stage.

Core Economic Case

The Benefit-Cost-Ratio (BCR) appears to demonstrate high value for money, however there are elements of the cost estimation that are considered to be underestimated or not included to date, which would consequently lead to an overestimation of the BCR.

Wider Economic Impacts

At present the OBC does not report on wider economic impacts, with little analysis of the direct economic benefits that are considered to stem from the scheme, and any commentary is generally qualitative in nature. There is no assessment of the benefits/interactions with the Airport Investment Area and Renfrew Riverside City Deal projects.

At a regional and national level, the proposed mitigation impact of an additional 2.5-minutes to Ayrshire services inbound to Glasgow creates significant promotional issues. While it is common in transportation schemes to have disbenefits, effective promotion relies on the overall net ‘gain’ from an economic and policy perspective being high. The forecast levels of airport patronage for Tram-Train do not represent the type of ‘step-change’ that would be necessary to carry the 2.5-minute disbenefit.

Taking the shorter- and longer-term situation into account, and the competing needs in terms of capacity, a decision to proceed with Tram-Train at present could significantly impact the ability to realise the shorter-term opportunity gains associated with heavy rail services. Similarly, proceeding now with Tram-Train could result in abortive work if a more comprehensive solution comes forward through STPR2; taking into account the cumulative needs of city deal, the city/city region context, and the sector/geographical needs in south-west Glasgow and Renfrewshire.

7. Conclusions and Recommendations

7.1 Conclusions

Based on the information reported to date there is no reason to suggest that the Tram-Train is not the best performing option of those considered, however there are a number of key concerns regarding the robustness of the OBC which make such a conclusion difficult to substantiate at this stage. A summary of the key concerns are as follows:

7.1.1 Rationale for the Project

Airport Demand

Tram-Train is the best performing of the interventions considered within the OBC in relation to the number of future passengers accommodated;

With the OBC highlighting the issue of congestion on the M8 Motorway as a constraint, coupled with passenger demand models forecasting up to 4.8 million additional passengers travelling to the airport by road in 2037, there remains the question of whether the airport could attract the growth projected, with such a high apparent continued reliance on the road network.

Based on the future passenger demand forecasts provided by the GAAP Project Team, when considering the impact of the Tram-Train scheme at an hourly level, the number of passengers forecast to travel via Tram-Train is modest. The relatively low numbers and occupancy could be as a result of a number of issues:

- underestimation of the demand for Tram-Train in the modelling to date;
- the lack of intermediate stopping points limiting the opportunity for passengers;
- the route and location of the stopping points not reflecting the catchment area of passengers using the airport; and
- the route and location of the stopping points not reflecting the ultimate destination of inbound passengers;

Airport Accessibility

The relationship between the proposed intervention and the origin / destination of passengers should be explored in greater detail to ensure that the proposals are robust in this regard. In particular, more clarity is required on:

- daily / hourly profile of future passenger demand;
- the anticipated origin / destination profile of future airport demand; and
- accessibility benefits provided by Tram-Train.

Airport Benchmarking

- With the Tram-Train in place the public transport mode share at Glasgow Airport is predicted to remain low compared to the airports considered;
- The airports considered are served by either a direct heavy rail link to the city centre, or by a tram/metro style service with a number of intermediate stops; and
- The Tram-Train operating/infrastructure characteristics are unusual in comparison to established Tram-Train systems in Europe.

7.1.2 Operational Issues

Regardless of the mitigations proposed, (some of which are unlikely to be acceptable to stakeholders, because of their impacts, e.g. extending journey times to Ayrshire services), introducing up to four Tram-Trains per hour to the Glasgow to Paisley rail corridor means that overall performance will be worse than it is today.

Furthermore, the planning for Tram-Train in the Business Case to date, does not adequately address its potential impact at Glasgow Central beyond 2019, from adding in new services, to lengthening existing ones.

Operational challenges to the corridor

- Performance on the Glasgow Central to Paisley rail corridor with the introduction of up to four Tram-Trains per hour is likely to negatively affect the PPM for the corridor by a worsening of up to 5%. This is also indicative of the impact on capacity that the Tram-Train would have. The introduction of Tram-Train would mean that the current peak operating capacity would be run throughout the day, and in both directions. The 'surge' at peak is generally dealing with high demand in one direction. Extending this to both directions throughout the day would significantly reduce or remove recovery opportunities, with the result that operational issues could have a disproportionate level of impact.
- Altering the way performance is measured by the introduction of a 2.5-minute journey time delay to most Ayrshire services between Kilwinning and Paisley Gilmour Street, would be a significant departure from the current approach to measuring performance that is adopted throughout the rest of the country.
- By lengthening most journey times from Ayrshire to Glasgow by 2.5 mins, over the course of a year, the economic disbenefit to existing rail users would be up to £4million.
- Adding a grade separation at Airport Junction is a potentially expensive element that has not yet been accounted for in the scheme business case.
- No costs for the grade separation option have been shared by the Project Team to date.

Challenges specific to Glasgow Central

While analysis by the Project Team suggests up to four Tram-Trains could be accommodated at Glasgow Central, and notwithstanding the proposals to operate a reduced frequency (3tph) during peak periods, this work appears flawed. This is because it fails to consider the longer-term opportunities to add other new services, or lengthen existing ones by the end of CP6 in 2024, or beyond. Addressing this is significant, in order to identify the optimal way to maximise use of the finite capacity available at Glasgow Central.

With a Tram-Train carrying a maximum of around 250 people in a 37.2 m long vehicle, but still using a train "path", the Tram-Train represents poor platform capacity utilisation at Glasgow Central.

7.1.3 Economic Case

Approach to Cost Estimation

- Optimism Bias levels are considered appropriate given the existing project uncertainties; however it is the view of the audit team that the project is not currently at OBC stage in terms of scheme costing and design. A comprehensive and structured explanation of the approach to Optimism Bias, Quantified Risk Assessment and Contingency would increase confidence in the costing approach.

Cost Estimates

- Cost estimates have not been measured to industry standard for quantification of works involving rail transport at early design stages;
- It is noted that costs currently sit at £144 million, however a number of key costs have yet to be included in the overall costing, including
  - Cost sharing burden of future capacity interventions;
  - Compensation payments for disruptive possessions; and
  - Costs associated with proposed mitigation measures have not been included within the scheme to date or the cost implications of the proposals fully assessed.
- Given the complexity of interfaces, systems and the operational environment of both the railway and airport, the level of contingency is lower than might be expected, and lacks evidence of how it has been built up.
- Cognisance should be taken of the potential impacts of different delivery and operating models, as these are still uncertain at this stage.

Core Economic Case

- The Benefit-Cost-Ratio (BCR) appears to demonstrate high value for money, however there are elements of the cost estimation that are considered to be underestimated or not included to date, which would consequently lead to an overestimation of the BCR.

Wider Economic Impacts

At present the OBC does not report on wider economic impacts, with little analysis of the direct economic benefits that are considered to stem from the scheme, and any commentary is generally qualitative in nature. There is no assessment of the benefits/interactions with the Airport Investment Area and Renfrew Riverside City Deal projects.

At a regional and national level, the proposed mitigation impact of an additional 2.5-minutes to Ayrshire services inbound to Glasgow creates significant promotional issues. While it is common in transportation schemes to have disbenefits, effective promotion relies on the overall net 'gain' from an economic and policy perspective being high. The forecast levels of airport patronage for Tram-Train do not represent the type of 'step-change' that would be necessary to carry the 2.5-minute disbenefit.

Taking the shorter- and longer-term situation into account, and the competing needs in terms of capacity, a decision to proceed with Tram-Train at present could significantly impact the ability to realise the shorter-term opportunity gains associated with heavy rail services. Similarly, proceeding now with Tram-Train could result in abortive work if a more comprehensive solution comes forward through STPR2; taking into account the cumulative needs of city deal, the city/city region context, and the sector/geographical needs in south-west Glasgow and Renfrewshire.

7.1.4 Summary of Key Conclusions of Audit

- Future passenger demand forecasts are not sufficiently robust given that there is little detail on the spread of passenger demand across the day or in relation to the origin / destination profile of inbound or outbound passengers;
- Impacts of the proposed Tram-Train on the existing and future operation of rail network and on operations in Central Station have not been robustly assessed within the OBC;
- The impacts of the Tram-Train, and associated mitigation measures on the rail network, on the wider economy have not been robustly assessed;

- The level of confidence and risk assumed to date are not commensurate with the level expected at the OBC stage; and
- Costs within the OBC have been underestimated.

7.2 Recommendations

Following the independent review of the Glasgow Airport Access Project Outline Business Case, it is the recommendation of this audit that the GAAP Project Team address the issues raised within this audit. Furthermore, the GAAP Project Team should re-visit the Strategic Business Case and the list of potential interventions in order provide comfort that the most appropriate airport access intervention is selected, that not only effectively serves the future demand associated with the airport, but meets the needs of and is not detrimental to the wider City Deal Region and Scottish economies.

Appendix A. Status of Points Raised in Interim Audit

Appendix A. Status of Points Raised in Interim Audit

A.1 Review of Supporting Information – Demand

A.1.1 GLAAM Analysis – GLAAM Old New Output Comparison Spreadsheets Review

Interim Audit Question(s)
Why has the 2025 opening year not been modelled directly?
Status at Final Audit (G)
Issue has been addressed satisfactorily

A.1.1.1 Observation – Modelled Years

A.1.1.2 Observation – Elasticity of GLAAM Model

Interim Audit Question(s)
a) What is the expectation of how this increase will present itself in terms of daily/hourly profile?
b) Given the objective relating to journey time reliability, what is the overall position of journey time reliability across modes?
Status at Final Audit (R)
Due to lack of additional information within the GLAAM and GLEAM models it is not possible to comment on the future daily profile of demand on the Tram-Train. This issue should be addressed.
Forecast to be significant increase in the number of passengers travelling to the airport via self-drive modes in all future scenarios despite implementation of Tram-Train. Continuing concerns on the ability of the transport network (including the proposed Tram-Train scheme) to accommodate future additional airport demand and the ability of project to meet the objective of improving journey time reliability to and from Glasgow Airport.

A.1.1.3 Observation – 'Minimal reduction to Self-Drive and Taxi Modal Split across all projected scenarios and interventions

Interim Audit Question(s)
(a) Why is the predicted reduction in self-drive/taxi so small?
(b) What is the expected impact of this at a daily/hourly level?
Status at Final Audit (R)
(a) The GLAAM model is forecasting a level of demand for Tram-Train that is lower than the passenger surveys indicate. Further investigation would be required to determine whether the models are underestimating the level of demand on the Tram-Train.
(b) Although data has been provided by Glasgow Airport, due to lack of additional information within the GLAAM and GLEAM models it is not possible to comment on the future daily profile of demand by self-drive/taxi. This issue should be addressed to confirm the robustness of the OBC.

A.1.2 GLAAM Passenger Forecasts by Time of Day

Interim Audit Question(s)
(a) What is the anticipated profile of growth at the airport across the day?
(b) What is the anticipated origin / destination profile (home location, etc) for the airport in the future years?

Status at Final Audit (R)

(a) There is little explanation within the OBC and supporting documents on the split of future passenger demand across the day. This is important in the case for the scheme for a number of reasons including:

- ***the ability of the public transport services to cater for demand to the airport in early morning/late evening; and***
- ***the relationship between peak passenger demand and times of congestion on the M8.***

(b) There is little analysis on the origin and destination profiles of future passenger demand. This is important when considering the accessibility of the proposed Tram-Train and how it caters for the needs of future demand. This issue should be addressed to confirm the robustness of the OBC.

A.1.3 Glasgow Airport Access Project Modelling Support, Review of Airport Data for GLAAM and GLEAM – SIAS and PBA (December 2016)

A.1.3.1 Observation – Section 2 GLAAM Passenger Data, Paragraph 2.1

Interim Audit Question(s)

Is the full 2015 data set now available, and if so what does it show?

Status at Final Audit (R)

This is a minor point in the context of the audit and the response is acceptable. There is no requirement to update GLAAM.

A.1.3.2 Observation - Section 2 GLAAM Passenger Data, Tables 2 and 3

Interim Audit Question(s)

Accepting that the data is provisional, is there an understanding of the reasons behind the drop in rail usage?

Status at Final Audit (G)

This is an acceptable response and ties in with response to 1.3.1

A.1.4 Glasgow Airport Access Project Modelling Support, Airport Demand Forecasting and User Benefits - SIAS & PBA (December, 2016)

A.1.4.1 Observation – Executive Summary, Page 2

Interim Audit Question(s)

Has any accessibility modelling been undertaken to understand the detail of accessibility changes, for example, if the Tram-Train replaces the express bus?

Status at Final Audit (A)

The accessibility of the proposed Tram-Train is not adequately explored within the OBC and supporting documents. The existing 500 bus serves a number of destinations within Glasgow City Centre and the accessibility of the service has been developed over a number of years. The comparative accessibility of the proposed Tram-Train is not proven within the OBC and while responses from the GAAP Project Team downplay the importance of this comparison, it is the conclusion of the audit that further analysis is required.

This issue relates to the lack of analysis on the origins / destinations of future passenger demand which is not explored in enough detail within the study as stated previously. There is a requirement for more analysis on the comparative accessibility of the existing public transport provision against

the proposed Tram-Train, with consideration of future passenger origins / destinations.

A.1.4.2 Observation – Section 3.2.1, Airport Demand Forecasting Models, GLAAM, Page 5

Interim Audit Question(s)

Manchester Airport has had its own heavy rail station and associated services for some time. More recently this has been augmented by Metrolink. Is Manchester therefore an appropriate proxy for Glasgow given its significantly different baseline position?

Status at Final Audit (A)

If the surveys referred to pre-date the Manchester Airport Rail opening they could be considered to be more representative of the current situation at Glasgow Airport. However these surveys now date back over 20 years and therefore their validaty should be reviewed.

A.1.4.3 Observation – Section 4.2, Passenger Mode Share

Interim Audit Question(s)

Is there greater disaggregation of rail trips available to aid understanding of the do-minimum vs do-something scenarios?

Status at Final Audit (G)

The audit team is content with the commentary provided by the GAAP Project Team and the issue is closed.

A.1.4.4 Observation – Section 4.3, Employee Characteristics, Page 8

Interim Audit Question(s)

Given the response rate of 10%, what additional data has been used to validate the expansion to full population?

Status at Final Audit (G)

The GAAP Project Team have expressed confidence in the statistical significance of the survey sample size and the audit is content with this response.

A.1.4.5 Observation – Section 4.4.3, Journey Times to/from Airport, Page 11

Interim Audit Question(s)

Has any work been undertaken to consider the outputs of Paramics modelling associated with Renfrew Riverside / Airport Investment Area to understand combined effects and/or comparative journey time changes?

Status at Final Audit (R)

The relationship between GAAP, Glasgow Airport Investment Area and Renfrew Riverside has not been adequately assessed within the OBC. The OBC does emphasise the economic importance of all three, however there is no assessment of how they interact in terms of combined effects or accessibility.

A.1.4.6 Observation – Section 5.3, Modelling Scenarios, Tables 5.1 and 5.2, Pages 14 & 15

Questions

What is the basis of the interchange value applied at Paisley Gilmour Street, and has any sensitivity testing of that been undertaken?

Is there sensitivity testing or other accounting through generalised journey time for direction wait-

time differential, i.e. user chosen arrival time to access services to the airport, but randomised arrival time to access services from the airport?
GAAP Project Team Response ***The GAAP Project Team confirmed that "sensitivity tests are to be considered as potential further work beyond OBC; On the specific point, it is unlikely the effect of padding on the level we're considering would have a significant impact on the option appraisal".***
Status at Final Audit (A) ***Sensitivity tests should be undertaken at this stage in the process in order to provide confirmation of the robustness of the proposals.***

A.1.4.7 Observation – Section 7.2.6, Values of Time, Table 7.1, Page 22

Question ***How are the values-of-time applied to the passenger and staff profile for the airport?***
Status at Final Audit (A) ***VOT numbers for Glasgow Airport passengers are circa 10% higher for business and non-business than those presently used for surface access schemes for London Heathrow despite median incomes nearly 30% lower than Greater London. The rationale behind the specific values of time for Airport passengers requires more explanation and/or updated given the age of the data.***

A.1.4.8 Observation – Appendix A, Airport Passenger Data Forecasts

Question ***Has there been any sensitivity testing around this to understand the cause/effect of increased rail usage, such as an increased rail frequency between Glasgow Central and Paisley Gilmour Street?***
Status at Final Audit (G) ***The audit team is content with the commentary provided by the GAAP Project Team and the issue is closed.***

A.1.5 Glasgow Airport Access Project Modelling Support, Non-Airport Transport Impacts - SIAS & PBA (December 2016)

Questions ***Given the number of services, the large attraction of existing PT users, the nature of demand profiles and the type of vehicles, have the annualised figures been broken down to allow examination of peak hour performance?***
Status at Final Audit (R) ***See response to 1.1.2***

Questions ***In addition to CSTM12, has any accessibility modelling been undertaken to understand how PRT / Tram-Train changes the accessibility of the airport?*** ***The potential changes to journey time resulting from 'padding' as part of rail timetable are significant. Has any sensitivity testing around journey time been undertaken?*** ***What assumptions have been made (or sensitivities tested) relating to the status of the existing express bus in future years, e.g. general viability, reduction in bus fare as a result of competition, impact on revenue stream to the airport?*** ***What are considered to be the reasons for the 'Private Sector Operator – Revenue' changing radically***

from +31 to -99 between the full service and reduced service scenarios?
Why are the TEE User Benefits greater for the Reduced Service option than the full service option, as this appears counter intuitive?
Status at Final Audit (A)
The accessibility impacts of the proposed Tram-Train have not been explored sufficiently within the OBC. The relationship between the proposed intervention and the origin / destination of passengers should be explored in greater detail to ensure that the proposals are robust in this regard.

A.1.6 Glasgow Airport Access Project Modelling Support, Transport Economics Summary - SIAS & PBA (December 2016)

Questions
For the Airport Users (Central Growth Scenario 2025, Airport VOT), the number of passengers for PRT is 667,000 and Tram-Train (reduced timetable) is 850,000. This means PRT is 78% of Tram-Train (reduced timetable). The private sector operator revenue for 'airport rail users' (i.e. not including the non-airport users) is £29,418,000 for PRT and £78,153,000 for Tram-Train. So PRT is 38% of Tram-Train. Why are these percentages not more consistent?
For non-airport uses, why are there crowd time benefits for consumer-commuter, but disbenefits for consumer-other and business?
Status at Final Audit (G)
The audit team is content with the commentary provided by the GAAP Project Team and the issue is closed.

Questions
Is there a discussion/notation on the discontinuity in indirect tax revenues between PRT and Tram-Train?
How do the operating cost models for Tram-Train and PRT feed through into the TEE assessment?
Status at Final Audit (A)
It remains unclear how the operating cost models for Tram-Train and PRT feed through into the TEE assessment and further clarification is required.

A.2 Review of Supporting Information – Operations

A.2.1 Glasgow Airport Access Study: OBC, Operational Arrangements, AECOM, (June 2016)

Questions
What costing allowances have been made for the different ownership/delivery and operating models?
What consideration has been given to the capital value uplift and revenue increases at the airport? The Heathrow Express case study notes the role of the airport operator in funding elements of the infrastructure. Are there similar opportunities at Glasgow?
In an open access operating situation, how would removal of revenue from the existing franchise (transfer of existing heavy rail trips) be dealt with?
Status at Final Audit (A)
The nature of the ownership / delivery model and operating models remains unclear.
There are no guarantees regarding the ability to include this within the existing ScotRail franchise. From an appraisal perspective the robust approach would be to assume open access arrangements. This scenario is easier to translate to ScotRail operation later than assuming ScotRail operation now, and having to reverse that back to open access at a later stage. The appraisal is largely mute on this point however as the exclusion of operational risk and the assertion that operating revenues will meet operating costs nullifies the potential impact concerns. Costs for the administrative setup of an open access operator should be included either as a cost or as a risk.

Questions
What consideration has been given to the flexibility of the system in terms of increasing capacity, physical extension(s) or similar, and how the operating model could support this?
Status at Final Audit (R)
While costs are reported at £144m, it is unclear within the OBC what scope there is in the project budget to take additional cost-share from other capacity interventions.

A.2.2 Glasgow Airport Business Case, Notes on Operating, Maintenance and Renewals Cost Model, AECOM, (June 2016)

Questions
Given the identified concerns from Tracsis relating to timetable padding, has the 33 minute (2 x 16.5 minutes) been subject to any sensitivity testing?
Status at Final Audit (R)
The audit team have not received a response to this question.

Questions
What benchmarking of the mid-life refurbishment costs has been undertaken?
Status at Final Audit (A)
The audit team have not received a response to this question.

A.2.3 Glasgow Airport Access Project, Exploratory Timetables for a Tram-Train Service, Tracsis, (May 2016)

Question
How will the outcome of the Tracsis timetable work be fed into the OBC?
Status at Final Audit (R)
The Traci's works is fundamental in terms of understanding the impacts of the proposed intervention on the operation of the rail network and the OBC should take detailed cognisance of this work.

A.3 Review of Supporting Information – Costs

A.3.1 Glasgow Airport Access, Tram-Train Costing Note, AECOM (August 2016) & Glasgow Airport Access – Tram-Train – South of M8 Route, Order of Cost 6, AECOM (June 2016)

Questions
Given the lack of maturity in the tram-train vehicle market in the UK, how robust is the decision to reduce OB from 66% to 18%?
Given that the interface between the light rail and heavy rail sections is still the subject of design, and the ownership / operating model is yet to be concluded, should the costs not include allowance for disruption of rail service during construction?
Given the final route of the light rail section is still to be fully concluded, would it not be prudent to include inflation and optimism bias in land costs?
Status at Final Audit (R)
The audit team continue to have concerns in relation to the robustness of the cost estimates presented in the OBC and further proof is required to provide comfort in relation to the following: • ***The robustness of Optimism Bias and contingency levels;*** • ***Consideration of ownership models within the OBC; and*** • ***Cost implications of as yet un-costed elements e.g. grade separation, final route of light rail section, cost-sharing for future capacity enhancing interventions, disruption to existing services during construction.***

Questions
Have any discussions taken place on the likely track access charges in light of potential operational risk?
Status at Final Audit (A)
Further clarity on how future operational models have been considered within the OBC is required.

A.4 Review of Supporting Information – Economics

Questions
Given that the airport project is such an important aspect of the overall City Deal, what quantitative analysis is there of the economic benefits that the scheme will support?
Status at Final Audit (R)
The OBC does not provide an appropriate level of assessment of wider economic impacts. There is little analysis of the direct economic benefits that are considered to stem from the scheme, with any commentary generally qualitative in nature. This needs to be addressed.

Questions
What was the question / format of the business response questionnaire?
Status at Final Audit (G)
The audit team is content with the commentary provided by the GAAP Project Team and the issue is closed.

A.5 Review of the Strategic Case

Question
What cognisance has been taken in the appraisal of the relative accessibility of the different options?
Status at Final Audit (R)
There is little analysis on the origin and destination profiles of future passenger demand and little consideration of the accessibility of the proposed Tram-Train and how it caters for the needs of future demand. This issue should be addressed to confirm the robustness of the OBC.

A.5.1 Observation – Section 2.2 Strategic Need: The Case for Change, Rail Services, Page 21

Question
Given the proximity of the airport to the rail network and other infrastructure, what benchmarking was undertaken to understand the types of connectivity at other airports and the success or otherwise of those ventures?
Status at Final Audit (R)
There is no reference to benchmarking within the OBC of airports with a similar profile to Glasgow or of similar Tram-Train schemes. This needs to be addressed within the OBC.

A.5.2 Observation – Section 2.3 Project Rationale, Table 2.3 Summary of Surface Access Links to Major UK Airports, Page 22

Question
What criteria are used in this assessment?
Status at Final Audit (A)
This is unclear and requires further clarification.

A.5.3 Observation – Section 2.3 Project Rationale, M8 Traffic Constraints, Figures 2.5, 2.6 and 2.8, Pages 25-27

Questions
What is the relationship among (i) periods of extended/unreliable journey time on the M8, (ii) arrival time for departing and arriving passengers in future years, and (iii) periods of reduced frequency for tram-train operations?
What is the arrival/departure profile for staff at the airport?
What is the projected passenger flow profile for (i) business and (ii) leisure passengers?
Status at Final Audit (R)
See responses in Section 1.1.

A.5.4 Observation – Section 2.3 Project Rationale, Journey Purpose, Figure 2.9 Central & High Linear Growth Scenarios Vs Actual Passenger Numbers, Page 29

Question
Notwithstanding that future demand will depend on airline routes etc at that point in time, what is the current estimate of future demand based on type (business/leisure), inbound vs outbound, seasonal profile, and daily profile?
Status at Final Audit (R)
See responses in Section 1.1.

A.5.5 Observation – Section 2.5 Project Objectives, Page 41

Question
What benchmarking of other tram-train schemes has been undertaken?
Status at Final Audit (R)
See response to 5.1.1.

A.5.6 Observation – Section 2.6 Project Summary, Page 43

Reference is made to the PRT requiring an ongoing subsidy (in comparison to the tram-train which is proposed to be self-financing in terms of operating costs).

Question
Given the operating model for the tram-train is still to be agreed, what cognisance of the impact of this has been taken in this element of the appraisal?
Status at Final Audit (A)
See responses in section 3.1.

A.5.7 Observation – Section 2.6 Project Summary, Page 44

Question
What knowledge from existing systems has been fed into the appraisal process?
Status at Final Audit (A)
See responses in Section 3.1

A.5.8 Observation – Section 2.9 Risks, Page 50

Question
In terms of WebTAG, has any quantitative risk assessment been undertaken thus far?
Status at Final Audit (A)
See responses in Section 4.

A.6 Review of the Economic Case

A.6.1 Observation – Section 3.1 Introduction, Establishment of Do-Minimum, Page 56

Question
Given the timeframe involved in delivery and the subsequent uncertainty of the accompanying projects that may be in place by that point, was a 'reference case' considered as a means of developing a probable future situation?
Status at Final Audit (R)
The OBC has considered the 'do-minimum' as the reference case for comparison purposes, which only considers committed transport interventions in the study area. There is no consideration of the uncertainty around accompanying projects that may be in place by 2025. This needs to be addressed.

A.6.2 Observation – Section 3.1 Introduction, Establishment of Do-Minimum, Page 56

Questions
Are the options genuinely comparative in nature from (i) a cost perspective, i.e. if the PRT and Tram-Train options are +£100m, is there a genuinely comparable bus option that is in-keeping with that level of investment, and (ii) a benefits perspective, i.e. Tram-Train relies on non-airport travellers providing a significant portion of the benefits? Have the options satisfactorily explored the leveraging of non-airport user benefits?
The Managed Motorways option seems to be limited in scope. Was the use of hard shoulder running explored (where available) for express bus services?
The summary of STAG Part 2 and the reasons for taking/not taking options forward is qualitative in nature. Is there quantitative data that shows the comparative performance of the options on various measures?
Status at Final Audit (A)
The OBC does not demonstrate that a robust appraisal of options has been undertaken and as such the audit cannot conclude that the most effective interventions has been taken forward. Further appraisal of options is required within the OBC.

A.6.3 Observation – Section 3.2 Options Appraisal, Page 65

Question
Given the tram-train timetable modelling to date has identified a need for 'padding' of between 1 and 2.5 minutes; a significant increase on the 16.5 minutes journey time, is the comparison of journey times consistent between PRT and tram-train?
Status at Final Audit (A)
The OBC refers to developing an understanding of the "worst case total journey times" for PRT but given the need for 'padding' of journey times for Tram-Train the audit team retain concerns on the comparisons between both interventions which should be explained more within the OBC.

A.6.4 Observation – Section 3.2 Options Appraisal, Appraisal Approach, Table 3.1 Do-Minimum and Do-Something Page 66

Question
What technical work and optioneering was undertaken to address identified issues with PRT to achieve the best practical scheme for comparison?
Status at Final Audit (A)
See response to 6.1.3.

A.6.5 Observation – Section 3.2 Options Appraisal, Transport Planning Objective 02, Page 71

Question
What consideration was given to the concept of opportunities-to-travel? Tram-train will provide four opportunities per hour (reduced during peak) whereas PRT will provide what is in effect a turn-up-and-go service linking to Paisley Gilmour Street where current services provide a minimum of nine opportunities per hour to travel to Glasgow.
Status at Final Audit (A)
It is the view of the audit team that the OBC does not provide a reasonable comparison of the benefits and impacts of Tram-Train vs PRT and this should be addressed within the OBC.

A.6.6 Observation – Section 3.2 Options Appraisal, Transport Planning Objective 03, Page 71

Question
What is the definition here of 'medium frequency' – the PGS to Glasgow Central line has one of the highest frequencies in Scotland? How has frequency vs wait time been taken account of here in the respective assessments for tram-train and PRT?
Status at Final Audit (A)
See response to 6.1.5.

A.6.7 Observation – Section 3.2 Options Appraisal, Transport Planning Objective 04, Page 71

Question
Given that the TPO relates to improving the quality and satisfaction of the public transport experience, how has service frequency (the opportunity to travel) been taken into account given that PRT would have nine opportunities per hour to travel compared with four (or fewer at peak) under the Tram-Train scenario?
Status at Final Audit (A)
See response to 6.1.5

A.6.8 Observation – Section 3.2 Options Appraisal, STAG Criteria, Economy, Page 73

Question
What cognisance of service frequency between Paisley Gilmour Street and Glasgow Central has been taken?
Status at Final Audit (A)
See response to 6.1.5

A.6.9 Observation – Section 3.2 Options Appraisal, STAG Criteria, Deliverability, Page 75

Question
What technical challenges for the project has the tram-train pilot study resolved, and how have these enhanced deliverability?
Status at Final Audit (A)
The National Audit Office in April 2017 published an audit into 'The Sheffield to Rotherham tram-train project, a key element of which surrounded Network Rail's confirmation in June 2016 that forecast costs had risen by nearly 400% against the original budget. It can be argued, therefore, that as of yet there is not a good understanding of costing within the industry for this type of project and as such many questions remain on the deliverability of the project.

A.6.10 Observation – Section 3.2 Options Appraisal, Modelling Scenarios, Page 79

Questions ***What testing has been carried out in the modelling to understand the sensitivity of demand in relation to journey time?*** ***Has similar testing been undertaken for PRT?***
Status at Final Audit (A) ***See response to 6.1.5.***

Questions ***Is the potential loading understood at a per service level to inform capacity/quality-of-service appraisals?***
Status at Final Audit (R) ***See response to 6.1.5.***

A.6.11 Observation – Section 3.3 Value for Money for the Preferred Option, Values of Time, Page 86

Question ***Given that the OBC identifies a general split of 75% leisure and 25% business, is the use of a single value-of-time appropriate?***
Status at Final Audit (G) ***The audit team is content with the commentary provided by the GAAP Project Team and the issue is closed.***

A.6.12 Observation – Section 3.3 Value for Money for the Preferred Option, Scheme Costs, Page 89

Question ***Noting that the costs are currently reported at £144m, what scope is there in the project budget to take additional cost-share from other capacity interventions?***
Status at Final Audit (R) ***See response in Section 3.1.***

A.6.13 Observation – Section 3.4 Expected Benefits, Page 93

Question ***In terms of demand (location, type, time-of-day), is there clear evidence of who will benefit from the intervention and why?***
Status at Final Audit (R) ***See responses in Sections 1.1 and 1.2.***

A.7 Review of the Commercial Case

A.7.1 Observation – Section 4.1 Delivery Specification, Page 97

Question
With reference to the Management Case, there is no evidence provided that the team has experience of successful delivery of multi-million pound complex rail or transport environment project. Could this be set out?
Status at Final Audit (A)
Still to receive a direct response to this question.

Question
Is the statement regarding viability fully analysed with reference to the risk register and outstanding technical work (e.g. timetable modelling)?
Status at Final Audit (R)
It is the view of the audit team that the OBC as it stands does not provide confidence in the deliverability or feasibility of the project.

A.7.2 Observation – Section 4.3 Procurement and Community Benefits Strategy, Procurement Strategy, Page 99-100

Question
Is the OBC being presented on the basis of a single procurement strategy, as this would seem difficult given the uncertainties relating to delivery, ownership and operating models/organisations?
Status at Final Audit (A)
See response in Section 2.1.

A.8 Review of the Financial Case

A.8.1 Observation – Section 5.1 Introduction: Financial Expenditure, Page 105

Question
Does the stated contingency include both allowance for risks and contingency?
Status at Final Audit (A)
See response in Section 3.1.

Question
Given that the project is at OBC stage, the lack of clarity on delivery, operational and ownership models and other parameters, is a 9% overall contingency robust?
Status at Final Audit (R)
See response in Section 3.1.

A.8.2 Observation – Section 5.3 Project Costs, Page 106

Question
Could Table 5.1 be clarified to show base costs, OB and total?
In addition, the text notes a reduction in the land costs from SBC to OBC. With reference to the costs presented at SBC-stage, could an explanation of the changes in developing these be given to add context to the Financial Case?
Status at Final Audit (A)
See response in Section 3.1.

A.8.3 Observation – Section 5.3 Project Costs, Page 107

Question
What exploration has been made of other infrastructure interventions and what cost sharing burden would the project consider it could take?
What is the evidence basis for the comparative statement relating to PRT?
Status at Final Audit (R)
See response in Section 3.1.

A.9 Review of the Management Case

A.9.1 Observation – Section 7.1 Project Management Arrangements, Pages 123-125

Question
What governance/procurement approach is the Project Team taking for the delivery of the project?
Will the Project Team augment with industry expertise, and if so how and when?
In the view of the Project Team, what are the major risks and what financial allowance has been made for these?
Status at Final Audit (A)
The Management Case as currently presented does not provide compelling evidence of the Project Team having past experience of delivering a multi-million pound transportation project (or similar system-type project) involving complex operational interfaces with an existing key asset, nor does it set out how the team will leverage industry expertise.

A.9.2 Observation – Section 7.3 Overall Risk Management, Pages 132-133

Question
What is the view of the Project Team on the suite of documentation that they will present for the TAWS and what additional technical / environmental / stakeholder / procedural submissions will need to be prepared?
Status at Final Audit (A)
See response to 9.1.1.