Malta Transport Authority

Malta Bus Rapid Transit Feasibility

Final Report

June 2007

Halcrow Group Limited

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Final Report

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Contents

1 Introduction

1.1 *Introduction*

1.1.1 Halcrow were commissioned in February 2007 by ADT Malta to carry out a strategic level study into the scope for introducing a Bus Rapid Transit (BRT) system for major public transport corridors on the island of Malta. This is the final report of that study. It follows a major study carried out by Halcrow in 2005 into the structure of the industry, its regulation and the role of the Government in planning, regulating and supporting the bus network.

1.2 *Background*

1.2.1 Malta has a population of approximately 380,000 on Malta itself. It is also a major tourist destination and tourists make good use of the current bus network. However the nation has one of Europe's highest rates of motorisation.

1.2.2 Coupled with a development pattern that concentrates development into a coastal strip on the north-east coast and a focus of employment in Valletta-Floriana movement on the island is pronouncedly tidal. Moreover the physical configuration of the road network, with a limited number of approaches to Valletta-Floriana tends to funnel traffic and exacerbate congestion with consequent delays to public transport.

1.2.3 Whilst the 2005 bus study recommendations will put the bus network on a more secure financial footing and form a foundation for an improved and upgraded bus system that will be more attractive to the local population, the Government recognises that there is a need for a new integrated national public transport system to encourage a step change in mode share in favour of public transport.

1.2.4 Research by the Government through MUDR and ADT has shown that BRT in an appropriate format is the most applicable system for the tight road network of the island and could comprise a combination of median or lateral running, dedicated running, signal priority and strategic bus corridors or enhanced bus ways.

1.3 *Bus Rapid Transit*

1.3.1 There is no agreed definition for BRT. The term can refer to very high capacity, high frequency services using 300 passenger capacity buses operating on fully segregated bus roads, often within a wide highway alignment – as exemplified in the systems in a number of Latin American cities and under consideration in Delhi and Jaipur, India. Such systems can move up to 10,000 passengers per hour by direction at a two minute headway.

1.3.2 More conventionally, and in typical European situations, it is exemplified by very high quality vehicles operating on a combination of prioritised roads, lateral or median exclusive alignments within the highway, and sections of dedicated segregated busway, usually with fewer stops than conventional buses. The consented Glasgow, Scotland, Fastlink scheme, designed, developed and assessed by Halcrow is a good example of this type of scheme.

1.3.3 The 'ftr' scheme now operating in York, England, operates in an historic environment of tight streets and relies much more on advanced transport telematics to secure priority at signals and priority access through pinch points. Halcrow developed the priority measures for this scheme on behalf of the City of York Council. An ftr type scheme, largely on highway, could be appropriate for the busy Sliema coastal corridor.

1.3.4 This type of BRT scheme can offer a directional passenger capacity of between 4,000 and 4,500 passengers per hour at a two minute headway. More typically they operate at a five minute headway, shifting 1,500-1,700 passengers by direction.

1.3.5 An important aspect of BRT can be the ability to upgrade to tracked transit should demand justify this and the alignment and infrastructure for the Malta scheme has been considered with this potential in mind.

1.3.6 BRT can be on segregated roads with buses driven conventionally by the driver, or guided using the proven though visually intrusive kerb guidance system or other types of guidance, optical, electronic or mechanical, these being less well established systems.

1.3.7 Integral to almost all BRT systems are important supporting features such as signal pre-emption, high quality passenger infrastructure, passenger information systems in real time and an integrated high speed ticketing system all of which support operating efficiency and improve the image of a system.

1.3.8 The BRT alignment will consist of a package of elements: private way (segregated exclusive alignment for the BRT), bus lanes, bus gates and priority signals. The

BRT system could also feature tram like vehicles, iconic halts (bus stops), pre-paid tickets and a theme to promote an exclusive type of transport.

1.4 *Structure of the report*

1.4.1 Following this introduction, the report is split into the following sections:

- Chapter 2: Technology review
- Chapter 3: BRT system characteristics
- Chapter 4: Supporting systems and infrastructure
- Chapter 5: Selection of alignments
- Chapter 6: Route alignment
- Chapter 7: Current and future demand
- Chapter 8: Integration with current bus services
- Chapter 9: Operating regime, funding and procurement
- Chapter 10: Conclusions and recommendations

2 Technology Review of BRT Systems

2.1 *Introduction*

2.1.1 The proposals for a BRT system for Malta represent a solution that takes account of the physical characteristics of the island and its population distribution and the broad trip patterns that prevail. It is important however that the full range of potential BRT scheme and vehicle types are considered in order that the justification of the recommendations for the Maltese application can be understood.

2.1.2 This chapter of the report is divided into two main sections as follows:

- a discussion of the key characteristics that need to be reviewed when identifying the most appropriate mode choice for a particular situation; and
- a more detailed description of each type, including individual products and their applicability to the Malta situation. The material is supported by two key tables summarising the characteristics of each mode and their level of application globally.

2.2 *Key Mode Characteristics*

2.2.1 The choice of vehicle or system should be influenced by a consideration of the key characteristics of the mode in the context of the requirements of a scheme and the characteristics of the areas to be served.

2.2.2 The key characteristics to be considered are as follows:

- the capacity of the network and vehicles;
- vehicle exterior dimensions;
- vehicle turning circle and wheelbase;
- ease of access;
- type of guidance used (mechanical, optical, electronic, driver);
- maximum speed of mode;
- accommodation works – services;
- system costs;
- experience in service;
- power supply/ energy source;

- on-street running constraints;
- access from either side of the vehicle; and
- depot or garaging constraints.

2.3 *Capacity of the Network and Vehicles*

2.3.1 The choice of vehicle for the service is dependent on a wide range of interlinked factors. Central to the decision is the capacity in terms of passenger flows, but the system capacity is also a function of service frequency.

2.3.2 Vehicle capacity is also heavily influenced by the likelihood of passenger peaks occurring. These can arise when significant employment sites finish work, when event or entertainment locations close or significant events finish, or, as with the Malta proposals, if a scheme incorporates a park and ride site, when city centre shops close or at key work start and finish times.

2.3.3 It would be inappropriate to make capacity provision for less than regular peak demands, for example for demand for park and ride from locations outside main employment areas to the Valletta-Floriana area.

2.3.4 Many modern systems use high capacity vehicles and much of the capacity is achieved through sacrificing the "traditional" arrangements for the majority of the passengers to be seated. Thus a modern articulated bus for example may have a capacity of 45-55 seated but accommodate a further 100 standing passengers.

2.3.5 There are implications for speed of boarding and alighting in terms of the seated/standing balance, especially for multi-door vehicles. Equally there are implications for passenger ride comfort where the majority stand. On a fast and relatively short alignment it may be reasonable to use vehicles with relatively few seats although in Malta there is an expectation on behalf of passengers that seating is provided. It is likely that motorists – an important market for BRT serving park and ride sites – will expect to have a seat for their journey.

2.3.6 Provision for passengers using wheelchairs or for passengers with small children in "buggies" also has an impact on seated capacity.

2.4 *Vehicle Exterior Dimensions*

2.4.1 Vehicle exterior dimensions have a major bearing on operational flexibility and the product chosen is always likely to be constrained by any requirement for on-street operations within urban city centres.

Vehicle Widths

2.4.2 Most modern products, including street-running light rail vehicles, have a maximum width (excluding mirrors) of 2.55m. This is the same width as Malta's 145 strong fleet of recently delivered low floor buses.

Vehicle Lengths

2.4.3 Vehicle lengths vary. A typical rigid single deck bus is 11-12m long but rigid buses are now permitted up to 15m, although the longest of these has a long wheelbase that significantly impacts on manoeuvrability. Maximum length rigid buses are unlikely to be suitable for operation on Malta's constrained highways and in urban centres and small towns.

2.4.4 Articulated vehicles are typically 18-18.75m long. However their configuration means that they are at least as manoeuvrable as 12m rigid buses and more manoeuvrable than longer rigid buses. There are, however, implications in terms of stop protection, approach paths and stop docking for longer vehicles especially when they are multi-doored.

Vehicle Height

2.4.5 Vehicle height varies considerably although there are not significant differences between single deck bus and light rail vehicles excluding the overhead equipment of light rail vehicles. Most modern low floor vehicles are between 2.8m and 3.5 m in height.

2.4.6 If a BRT alignment is to be upgraded to light rail a key upgrade issue is headroom clearance for overhead traction equipment where building structures or overbridges are included on the alignment.

2.5 ***Vehicle Turning Circle and Wheelbase***

2.5.1 Vehicle turning circles are an important consideration in operating vehicles particularly in constrained highway situations such as many parts of Malta. It is important to distinguish between:

- turning circle – the path described by the front wheels of a vehicle; and
- swept path – the area covered by the vehicle when making a turn, including the impact of any front overhang which may, for example, over-run a footway area.

2.5.2 Most buses and light rail vehicles are of a forward control layout – the driver sits ahead of the steered axle or bogie. Thus they have significant overhangs at the front and rear. As a result their swept path is considerably larger than their turning circle and this has implications for stop protection and docking and for the design of alignments particularly in urban centres.

2.5.3 Whilst buses can be (and frequently are) driven so that the front or rear overhangs a footway this is not desirable in terms of road safety. It represents good practice to delineate the swept path of tracked transit, often including a safety margin, in mixed running through the use of contrasting surface material and texture.

2.5.4 Wheelbase is the distance between wheel centres viewed from the side of the vehicle. In general terms, the shorter the wheelbase, the more manoeuvrable is the vehicle. Longer wheelbase vehicles require a wider alignment in order to negotiate corners, and, as noted above, the newly permitted rigid (non-articulated) vehicles of up to 15m total length would present considerable issues in Malta's urban centres. In contrast articulated vehicles even at the maximum length of 18.75m are relatively manoeuvrable although they present different challenges for example in terms of docking at stops.

2.6 *Ease of Access*

2.6.1 The access regulations of most European countries are similar and require all new vehicles to offer easy access through their design. Good passenger accessibility is usually defined in terms of the requirements of passengers with disabilities including those using wheelchairs. The vehicles offer easy access through wide doors and via a flat or gentle gradient floor to a seating area on the same level or to an area that will accommodate a passenger using a wheelchair or with a child in a 'buggy'.

2.6.2 Good access is of benefit to all passengers and can greatly speed up alighting and boarding times especially for multi-door vehicles - more so if all doors are used both for boarding and alighting.

2.6.3 Speedy boarding and alighting are however influenced by many other factors beyond the design and layout of the vehicle itself. These include the ticketing system, for example where off-vehicle ticketing will allow all bus entrances to be used as it is not necessary to interface with the driver. Also the design of stops or stations can be critical especially where multi-door vehicles need to dock accurately.

2.6.4 Passenger security and safety will also need to be considered - this becomes much more important with multi-door vehicles. The design of stops together with the use of measures such as on-board closed circuit television are other major influences.

2.7 ***Type of Guidance Used***

2.7.1 BRT systems may be unguided or guided. In guided systems the vehicle is steered by a guidance device. There are several generic types of guidance in use at present:

- mechanical guidance - kerb guided or slot guided
- optical guidance - the CIVIS system
- electronic guidance - buried wire

2.7.2 All the above guided modes are also capable of being driven on the highway under the conventional control of the driver.

2.7.3 Most of the guided systems introduced have been on sections of longer routes and promoted in the context of wider packages of measures designed to boost operating efficiency and thus patronage. Typical measures include bus priority, the exclusivity of the alignment, enhanced high quality passenger infrastructure and high quality marketing and passenger information.

2.7.4 The construction of an appropriate infrastructure design with an exclusive bus road and docking kerbs, coupled with the use of high quality conventional buses and highly trained drivers could achieve similar benefits to that of a guided system but at a reduced cost. It is important, therefore, when considering guidance systems that the 'driver guidance' option using a conventionally steered bus is also fully assessed.

Mechanical – Kerb Guidance

2.7.5 Kerb guidance requires the construction of an alignment with upstanding kerbs. The kerbs bear against horizontal guide wheels about 150mm in diameter that are connected to the bus steering mechanism. The alignment is a minimum of 6.0m wide between outer kerbs for a two-way facility. Kerbs are formed of pre-cast concrete sections or cast in situ.

2.7.6 Kerb guidance is a proven technology in use in Adelaide, Australia, in the UK in Ipswich, Leeds, Bradford, Crawley, Edinburgh, and in several German cities. The key advantages associated with kerb guidance are that it enables relatively fast operation in situations, for example former rail alignments, where there are width constraints or pinch points, and the system enables accurate docking.

Plate 1: Kerb-guided bus docked at high kerb stop (guidance wheel and arm visible just ahead of tyre)

2.7.7 Disadvantages include the fact that it is relatively costly to construct. Additionally, the alignment can be visually unattractive and present a barrier to pedestrian movement. In addition it is becoming evident that there are medium term maintenance issues that can result in a deterioration of ride quality, rapidly increased vehicle wear and relatively costly repairs to the infrastructure. It is not appropriate to incorporate kerb guidance within the general highway, for example in an urban centre, unless the alignment is segregated or part-segregated, for example in a central reserve or wide lateral strip.

2.7.8 Additionally, and in order to ensure that the edge of the vehicle does not foul the guideway, as a result of the characteristics of the tracked path of the vehicle, horizontal radii must be larger than would be required for routes where the vehicle is steered conventionally by a driver.

Mechanical – Slot Guidance

2.7.9 Whilst most standard width or single width buses can be fitted with kerb guidance equipment, the two emerging technologies for slot guidance are both bespoke products of individual manufacturers - ***Guided Light Transit*** (***GLT***) and ***Translohr***.

2.7.10 Guidance is achieved through central mechanical arms that engage with a rail along the centre of the alignment. The guidance rail is set within a larger pre-cast section laid within the highway. As with kerb guided buses the vehicles are capable of unguided operation.

2.7.11 Whilst the systems are in public service, it is understood that early applications are being operated under the close supervision of the manufacturers and with their technical support. It is understood that neither system has been the subject of an independent technical or operational assessment.

2.7.12 The systems are described in greater detail under ***Guided Bus*** within the individual mode and product review of this section of the report.

Optical – CIVIS

2.7.13 CIVIS is a bespoke product of the ***Irisbus Company*** and relies on optical guidance. A sensor mounted centrally on the front of the vehicle "reads" a contrasting line laid on the road surface. As with the other types of guided operation the vehicles can be used in unguided mode in standard highway operation or through priority measures. The CIVIS system is described in greater detail under ***Guided Bus*** within the individual mode and product review of this chapter.

Electronic – Buried Wire Guidance

2.7.14 Buried wire guidance depends on the vehicle steering being actuated by a detector on the vehicle reading a magnetic field thrown up by a wire shallowly buried beneath the road or alignment surface. As with optically guided buses there is no physical connection between the steering and means of guidance.

2.7.15 The technology is in wide use in industrial applications and is used in the England-France Channel Tunnel service tunnel, and is common in lightweight applications in warehousing. A non-passenger service trial of a wire guided bus in Gateshead, UK in 1996 was deemed successful. The only known UK application, in Greenwich, London however was not used in passenger service.

2.8 ***Maximum Speed of Mode***

2.8.1 The maximum speed of the mode is an important consideration, as are the braking and acceleration performance characteristics. Most of the modes identified are capable of achieving an 80kph (50mph) running speed. However over relatively short routes such as those being considered for Malta even apparently significant performance differences are likely to be unimportant.

2.8.2 On public roads the speed of vehicles will be governed by the prevailing road speed limits. Even on exclusive sections of alignment it is suggested that similar limits should apply in order to meet the general expectations of other road users, for example pedestrians crossing the alignment. It would be the expectation of these road users that vehicles would operate to standard speed limits.

2.8.3 Operation at higher speeds will require a higher level of segregation that in turn will represent an inconvenience to pedestrians and cyclists – the system could itself become a barrier to movement and have an adverse impact on wider accessibility.

2.8.4 Reasonable acceleration and deceleration performance will also be required. However this should be consistent with passenger comfort especially if a significant proportion of passengers are expected to stand.

2.8.5 Ultimately however passenger acceptability will also be influenced by total journey time, not just on-mode journey time. A major factor in this consideration will be the accessibility of stops and their relationship to major generators and attractors.

2.9 ***Accommodation Works***

2.9.1 A key issue may be the ability for the system selected to be capable of upgrade to light rail (or other mode) at a later stage should demand justify this or other factors come to bear upon the situation.

Physical Characteristics of Route

2.9.2 The key issues when considering an upgrade situation are the physical characteristics of the alignment such as width, gradient, and headroom clearance for overhead equipment, and the extent to which the alignment will require or has had accommodation works carried out.

2.9.3 Accommodation works generally represent a very significant proportion of overall scheme infrastructure costs, notably where an alignment uses existing road provision (as opposed to new build) or crosses existing roads at grade.

Utilities

2.9.4 A good example of the accommodation works would be the need to carry out utilities relocation. The issue is the extent to which the operation of a public transport service can tolerate the disruptions necessary to service or repair buried or adjacent services – often these activities are reactionary and thus un-programmed. Disruptions will be costly in terms of additional operating costs, lost revenues and in terms of the image of a service as a reliable and high quality facility.

2.9.5 Clearly any conventional tracked transit such as light rail cannot operate if there is a requirement to gain access to buried or, possibly, lineside services, and it would be necessary to provide a replacement service with a conventional bus, or in the case of a relatively short route length system, to operate an alternative bus service as closely parallel to the whole alignment length as possible.

2.9.6 Some ground level systems such as guided bus have the capability to operate off the guided alignment in conventional street running mode but the extent to which this could take place would depend on the number of access and egress points on the alignment.

2.9.7 Whilst it is essential for most utilities to be ducted or otherwise relocated for conventional tracked transit such as light rail it may only be regarded as desirable for example for kerb guided bus operations.

2.9.8 Accommodation works prior to alignment construction may not be necessary as it is possible to incorporate utilities accesses within a guideway. For example as a cost saving measure the Scott Hall Road kerb guided busway in Leeds, UK incorporates utilities access hatches for buried utilities that have remained in situ.

2.10 ***System Costs***

2.10.1 There are many components both of capital and revenue items that make up the full system costs. Alignment costs are likely to be significant especially if a guided mode is selected.

Infrastructure Costs

2.10.2 There may be unique infrastructure elements, for example guide rails or boarding kerbs, that will impact on costs.

Vehicle Costs

2.10.3 Vehicle purchase price is also a major issue. If the units selected are high specification but otherwise standard products, costs are likely to be lower than if a bespoke system is selected. A useful rule of thumb is to consider costs to lease a vehicle. A "stock" vehicle such as a Lm 145,000 high specification articulated bus leased for six years might cost Lm 21,500 per year to lease.

2.10.4 Costs for a bespoke system vehicle, currently thought to be in the range Lm 390,000-Lm 455,000 per unit are more difficult to obtain as suppliers will consider each scheme individually and generally make arrangements directly with the operator rather than via a leasing company.

2.10.5 Informal discussions with a leasing specialist suggest that if a leasing company were able to obtain specialist vehicles they would set charges to reflect the system risk involved. Reflecting the higher initial costs and these risks leasing charges per unit could be at least five times higher than for a more conventional vehicle. Moreover it may be necessary to use a larger fleet than if conventional vehicles were used as it may be necessary to provide a higher level of bespoke spare vehicles.

2.10.6 Vehicle operating costs are likely to be higher for a bespoke mode – it is too early to forecast what level these may be at as systems have not been operating for a sufficient period and are likely to have been operated under the 'shelter' of a system manufacturer.

"Transfer" Costs

2.10.7 A further major consideration is the transferability of the system to a new application should conversion to an alternative mode be required in the future. Clearly something based on a conventional bus, albeit to a high standard of comfort and equipment, will be easier to redeploy than a bespoke mode requiring new infrastructure works.

2.10.8 A worst case scenario could be that if an emerging mode was selected which does not become established, there would be no demand for the vehicles once an upgrade, for example to light rail, is implemented.

2.11 *Experience in Service*

2.11.1 Should it be decided to investigate further the scope for installing one of the more recently developed modes or systems it would be important to establish the operating experience of the sponsoring authorities. In particular it is important to establish:

- how many examples are operational?
- how many more systems are in the pipeline?
- what independent operational cost evaluations are available?
- has any research been carried out on the patronage/revenue implications of the mode in isolation of wider policy and system factors?
- how much support has been received from the system manufacturer or promoter? and
- where are the risks inherent in using new technology borne?

2.12 ***Power/Energy Sources***

2.12.1 There is much confusion about the types of propulsion available and in particular about whether any one type is unique to a particular manufacturer's product. It is reasonable to generalise that most energy types are available in a wide range of products.

2.12.2 An important characteristic especially for an intermediate system that operates both on a segregated (or exclusive) alignment and on street is its ability to operate independently, that is without depending on say an overhead electricity supply. This factor is less critical for tracked transit that generally enjoys greater alignment exclusivity including a high level of priority on street.

2.12.3 A second consideration is whether the mode has a secondary or emergency power supply to enable it to operate off-alignment or within a garage or depot.

2.12.4 It is also important to establish whether a guaranteed fuel supply can be maintained, whether operation is dependent on a single supplier and whether any unique or specialist fuelling equipment is required, including any depot works to meet health and safety aspects of fuel handling.

2.12.5 Still the most common fuel for conventional or intermediate modes is diesel fuel. Modern diesel engine vehicles, subject to a careful maintenance regime are relatively clean in terms of emissions. All new models are required to comply with the current Euro IV Regulations in terms of fuel and emissions specifications and are low emission. Many new vehicles are already being supplied to meet the more stringent Euro V regulations that come into force in 2009.

2.12.6 Efficient combustion, modern engine management systems and good maintenance ensure that the emission of particulates, particularly PM10s that are regarded as carcinogenic and can contribute to respiratory problems, is kept to a minimum. It is also possible to fit a particulate trap to vehicles to further cut down on the emission of particulates or use other fuel additives or devices to the same end.

2.12.7 However a disadvantage of many current bus designs is that the mechanical units, usually at the rear of the vehicle, mean that the vehicle cannot offer a single level low floor throughout. This creates a typical 'gallery' effect with a group of seats over the rear axle and drive train at the rear are accessed via steps or a ramp and are thus not easily accessible to people with mobility impairment. It also means that doors cannot be located toward the rear of the vehicle, thereby constraining vehicle layout and operational flexibility.

2.12.8 New types of vehicle using more compact diesel engines are being introduced that overcome this disadvantage through the use of drop axles. An example of this type of vehicle is the ***Van Hool*** product widely used in continental Europe and used on the Dutch 'Zuidtangent' BRT system, which has the engine mounted on the off-side between the first two axles.

2.12.9 Conventional diesel buses can also be powered using gas based fuels such as ***Liquid Petroleum Gas*** (LPG) or ***Compressed Natural Gas*** (CNG). These vehicles usually feature reinforced high pressure fuel tanks in the roof of the vehicle.

2.12.10 Whilst emissions are somewhat lower than for a conventional diesel bus there is evidence of increased component wear and there have been concerns about variability in the calorific value and thus the efficiency of batches of the fuel.

2.12.11 More recent bus products use a hybrid power source. Typically a small internal combustion engine (petrol, diesel or gas powered) is coupled to a generator that delivers power to relatively small electric motors incorporated in the hub of the driven road wheels. Thus there is no solid drive train between the engine/generator and the wheels, connections being cable. This means that the compact engine and generator can be located more flexibly within the overall vehicle structure, enabling a low flat floor throughout the bus and the possibility of a door behind the rear axle of the bus. The ***Civis*** and ***Phileas*** bespoke products use this technology.

2.12.12 There are also examples where a single electric motor is mounted at the rear of the bus and drives a conventional axle. These are usually adaptations of older designs of vehicles and do not offer the key advantage of a low floor throughout the vehicle.

2.12.13 The most recent developments involve the generation of electricity through the use of replaceable hydrogen fuel cells and trials of such vehicles are underway in several European countries.

2.12.14 More conventional battery powered buses are in use in several European centres. However difficulties with battery life and issues with vehicle weight have tended to mitigate against their more widespread adoption. There were operations as long ago as the 1970s in Manchester, UK and more recently in Oxford, UK and Jersey, all involving minibus-derived low capacity vehicles. There is an Italian product in use in several Italian cities that has been more successful being a purpose built design rather than an adaptation and using a readily exchanged battery pack. Examples were run in Birkenhead and Bristol in the UK, but have recently been withdrawn due to the age and growing unreliability of the vehicles. Their services are now operated using more modern low-emission diesel buses.

2.12.15 One advantage of electric buses was thought to be quiet operation but it has been found necessary to introduce a mechanical noise or bell in otherwise pedestrian areas as a safety measure.

2.12.16 Finally it is necessary to acknowledge the trolleybus. This is a conventional bus but powered by electricity drawn from an overhead supply. Unless the vehicle has an on-board supplementary power supply it represents a comparatively inflexible mode of operation. Moreover since the vehicle operates on rubber tyres and is steered conventionally the connection to the overhead supply is by poles rather than a more compact and less visually intrusive pantograph as used on an LRT vehicle.

2.12.17 There are modern trolleybus products, such as ***Bombardier's Christalis*** product, that have typically been purchased to upgrade existing trolleybus networks.

2.13 *On-street Running Constraints*

2.13.1 It is important to consider any constraints that would impinge on regular switching from the exclusive and possibly guided alignment to street running particularly in mixed conditions. A key consideration would be any delay or mechanical operation necessary to engage with or disengage from guidance infrastructure – an operation that may need to be completed 10 times per hour in each direction.

2.13.2 Whilst kerb guided bus engagement is a simple operation that depends on driving into an engagement taper at a reasonable speed it is understood that engagement onto and disengagement from a slot guided system requires careful alignment and the vehicle to stop. Optical or electronic guidance engagement is relatively straightforward, a simple matter of alignment 'registration', as there is no physical engagement between the vehicle and the guidance mechanism.

2.13.3 Stopping unauthorised alignment use may also be a major issue. Only kerb guidance is likely to prevent unauthorised use as a result of its physical characteristics. All other methods will require signing as a minimum, or signalisation coupled with physical barriers such as a rising step, barrier arm, or rising posts.

2.13.4 On-street manoeuvrability is unlikely to be a major issue with any of the modes. If it is considered necessary to use a guided mode within a general street environment then most forms of guidance are compatible subject to the diameter of turns being consistent with the mode turning circle and swept path. Kerb guidance in the street environment, however, is not possible as the kerb upstands would form a barrier to pedestrian and other vehicular movement. Moreover most turn radii would be too tight to accommodate kerb guidance.

2.13.5 If, however, kerb guidance is selected for application elsewhere on an alignment accurate docking with stops on unguided sections can be guaranteed using the guidance wheel fitted to the nearside of the vehicle to bear against the face of the docking kerb. This approach has been used in Northampton, UK by bus operator First.

2.13.6 Finally it is necessary to consider the location and size of stop infrastructure on street. If any multi-doored intermediate mode is selected then stops will need to be on a straight section of street, be sufficiently long to accommodate the chosen vehicle (or more than one at an interchange stop) and be carefully designed in terms of the approach path to ensure proper docking of all vehicle doors. Given the constrained nature of many Maltese centres this may be difficult to achieve in a comprehensive manner.

2.14 ***Access from Either Side of the Vehicle***

2.14.1 Most LRT vehicles are equipped with doors on each side of the vehicle. This allows for island platforms to serve both directions of movement and, on street, gives flexibility in the location of platforms for example in one-way sections.

2.14.2 Fitting offside doors to conventional buses or intermediate mode vehicles, however, raises a number of issues:

- have manufacturers produced any examples?
- what are the costs of producing a non-standard product?
- what is the impact on seated and total capacity? and
- are there project cost risks in that a vehicle with doors on each side may not be as transferable or saleable as a more conventional vehicle?

2.14.3 A major operational issue would be raised over ticketing. Whilst the Civis has a central driver location and thus can have doors on each side in the same position, most products seat the driver in the conventional offset position with an entrance opposite the driver. This means that an offside (driver's side) door would have to be positioned behind the driver and behind the front axle. This presents a problem if the driver is to interact with boarding passengers for example for ticketing and suggests that ticketing would need to be off mode with self-service ticket verifiers on the vehicle.

2.15 ***Depot and Garaging Constraints***

2.15.1 A number of issues arise when considering accommodating a fleet of vehicles in a garage. Whilst it would be necessary to build a depot for tracked vehicles such as a conventional LRT on the alignment or close to it and linked by track, it is feasible for conventional and intermediate mode vehicles to be garaged elsewhere. Given that the system may well be operated by an existing operator it is likely that the vehicles would be garaged at the operator's premises (In this case it would rest with the operator to ensure that the vehicles could be accommodated at their premises and that the premises could house what is likely to be a longer vehicle). In Malta the present structure of the bus industry with a multitude of one bus operators would present difficulties in garaging a significant fleet of large vehicles especially if fuelling or other requirements dictated that they should be garaged in a single location.

2.15.2 The operator would need to reflect garaging issues and costs including fuelling, cleaning and maintenance in any bid to provide the service. It may be necessary for the operator to comply contractually with special requirements of a vehicle supplier or leasing company, for example in providing space and facilities for maintenance to be carried out.

2.16 *Mode Systems & Products*

2.16.1 Having introduced a range of considerations that need to be addressed in selecting a mode the following section of the report looks in more detail at specific mode products and applications and provides an initial assessment in terms of their appropriateness for operation in Malta.

2.16.2 The various modes under review have been categorised as follows:

- **Monorail**
  - Suspended
  - Straddle
  - Maglev
  - Cantilever
- **Tram**
  - Conventional LRT
  - Ultra-Light Rail (Parry People Mover)
  - Minitram
- **Trolley Bus**
  - Cristalis
- **Guided Bus**
  - Kerb Guided Bus
  - GLT & Translohr
  - Phileas
  - Civis
  - STREAM
  - Stagecoach-Siemens
- **Automatic Driverless People Mover**
  - Ultra
- **Conventional Bus**
  - High Quality Conventional Bus (e.g. Citaro)
  - Alternative Fuel Buses
- **Enhanced Bus**
  - Zuidtangent
  - First – ftr
  - Arriva – Bus of the Future

2.16.3 In determining the suitability of the various modes cited for an application in Malta it is important to recognise the extent to which each is in fact a unique vehicle product, or requires unique supporting infrastructure or is a wider initiative supported by a unique vehicle product.

2.16.4 By way of example the Phileas system in Eindhoven uses a unique vehicle product but the vehicle operates guided or unguided over an alignment that is partly exclusive and partly within the highway. Where guided it uses a product-specific guidance system but otherwise operates on road using conventional priority measures.

2.17 *Monorail*

2.17.1 Monorail operation is popular in Asia especially Japan (where five cities have systems), China and Malaysia. Monorails are also in operation in Russia, Germany and the USA.

2.17.2 Monorails have been slow to take off in the UK as a means of mass transit. A system is in operation at Alton Towers (a theme park in the Midlands) but the Maglev at Birmingham Airport was withdrawn due to technical difficulties and the monorail at the Merry Hill shopping centre in the West Midlands is now dismantled.

2.17.3 The promoters of monorails claim that the main benefits are safety and environmentally related. To date there have been 27 fatalities in total on monorail systems worldwide. Some 23 were in a single accident on the German Transrapid system when due to human error, a monorail train collided with a maintenance vehicle. The good safety record is attributed to two main safety advantages:

- monorails are completely segregated, which limits the number of potential conflicts with other vehicles and pedestrians, and
- they operate on one track, which means that a derailment is almost impossible.

2.17.4 Monorails are said to be environmentally friendly, especially as many are powered electrically and therefore there is no air pollution at source.

2.17.5 Problems associated with monorails are often to do with cost, visual impact, accessibility and the belief that monorail technology is unproven. It has been on these grounds that monorails have been considered and subsequently discounted in many applications in the past in favour of tram and LRT systems. A particular issue is the severance effect if they are installed at grade. However elevated systems also create problems in terms of convenient access especially for people with impaired mobility, although some systems serve buildings at an upper floor level.

2.17.6 Monorails have a good reliability record and there is no evidence of negative maintenance problems (though any repairs that may be needed would require a partial shutdown of the system unless it was something that could be carried out overnight). Monorail systems in use today fall into the following categories:

- suspended;
- straddle;
- magnetic levitation; and
- cantilever.

Suspended Monorail

2.17.7 There are three types of suspended monorail:

- ***Double-Flanged*** - as used in Wuppertal, Germany;
- ***I-Beam*** - which is used as an industrial monorail, and
- ***SAFEGE.***

2.17.8 The monorail in Wuppertal is the oldest in operation, opening in 1901. The system is 13.3km long, has 20 stations and serves approximately 70,000 people a day. The system is a suspended double flanged monorail. The double flanged steel wheels run on a single steel rail laid on a girder. The cars use a single motor driving both wheels with worm gears. The cars are turned on loops at each end of the alignment.

Plate 2: The Wuppertal Monorail

2.17.9 Each monorail train is made up of two cabins. In total the train can carry 204 people of whom 48 are seated. The trains are 9.7m long, which is shorter than a standard saloon bus.

2.17.10 The trains on the Wuppertal system have a maximum speed of 60kmh, operating on a headway of approximately every 2.5 minutes.

2.17.11 Though well proven in service the support structure of ironwork straddling the river is very visually intrusive.

2.17.12 A SAFEGE system operates essentially inside a hollow girder. Of the SAFEGE monorails schemes in Japan many are modern day versions designed by Mitsubishi systems. One of the major reported benefits of this system is its resistance to adverse weather conditions because the track is enclosed and protected.

Straddle Monorails

2.17.13 Straddle Monorails fall into three main types

- ***ALWEG*** - the most common type, where vehicles operate on a concrete track using pneumatic rubber tyres. Used in Japan and the USA (Seattle, Washington and two Disneyland parks);

- ***Steel Box Beam*** and
- ***Inverted T*** - where the cross-section of the beam represents an inverted 'T'. No large-scale examples currently exist.

2.17.14 The system at ***Alton Towers*** in the UK, opened in 1987, is a straddle system which is 3.2km in length. It has two stations and can carry 4,800 per hour. By comparison the ***Sydney Metro Monorail, Australia***, opened in 1988, is a straddle loop system. It is unique in that it is a privately operated and funded system. It was commissioned to serve the Darling Harbour development and provides interchange facilities with trains, ferries and buses at key locations in the central area.

2.17.15 The Sydney monorail links the Harbourside, Australian National Maritime Museum, Powerhouse Museum, Queen Victoria Building, Entertainment Centre, Chinatown and Pitt St Mall. It also provides a public transport link for two inner Sydney suburbs. The system has eight stations with a route length of 3.6km and operates on a frequency of every three to five minutes. The loop can be undertaken in approximately 15 minutes. Currently 30,000 people use the monorail per day.

2.17.16 Each monorail train comprises seven cars and is just over 32m in length. The monorail train has a maximum speed of approximately 21mph. The capacity of the train is 170 but only 56 are able to be seated. The Sydney monorail was developed and became operational in approximately three years.

Plate 3: The Sydney Metro Monorail

Maglev Monorail

2.17.17 Maglev monorails are based on the magnetic levitation technology in which magnetic forces lift, propel, and guide a vehicle over a guideway. Maglev Monorails allow higher speeds and faster acceleration / deceleration because there is no friction with the track.

2.17.18 This technology, which has been applied to traditional railways, is also currently being tested for monorail systems in Germany, Japan and the USA. The ***Transrapid*** in Emsland, Germany opened in 1984 and consists of a 31.5km track. The system operates at speeds of up to 420km/h and over 220,000 paying passengers have used the system since it first opened.

2.17.19 An application links the new ***Shanghai International Airport, China*** with the Pudong area of the city covering the 54 kilometres in nine minutes. A Maglev monorail was used at ***Birmingham Airport*** but suffered technical problems and has been subsequently replaced with a cable-hauled rubber tyred system.

Cantilever Monorail

2.17.20 The fourth type of monorail is the cantilever monorail, whereby it is possible for two vehicles to function in opposing directions operating on a single track. This is sometimes described as a '***Monobeam***' system.

Plate 4: Kuala Lumpur straddle monorail

2.18 *Tram*

2.18.1 Conventional LRT systems are Light railways or tramways often developed from the early electric tram systems that were common to many European cities. These systems were retained in many locations on the continent and have developed significantly on a range of different rail gauges and vehicle designs. Light railways or tramways generally operate from overhead electric wires supplying, typically, 750 Volts DC power. Fully enclosed single deck vehicles usually provide a significant area for standing and are increasingly being developed to a low floor standard.

2.18.2 Several British Cities have re-introduced light rail systems and have secured modern designs with low floor vehicles and/or level boarding. The systems were provided with a high level of information and quality facilities integrated to provide a significant increase in passenger benefits compared to the bus or rail services they replaced.

2.18.3 Electric power provides light rail systems with a significantly improved performance compared to heavy rail, in terms of acceleration and deceleration, due to their lighter weight as they are not designed to withstand the same impact forces as traditional rail vehicles.

2.18.4 Conventional rails provide a smooth ride for passenger comfort and the rails add to passenger perception and confidence in the certainty and stability of the system. The lower forces exerted by the light rail vehicle (LRV) on track and structures results in lower capital costs and the shorter, usually articulated, vehicles enable sharp bends and steep gradients (compared to conventional railways) to be incorporated into the route, including elements of street running.

2.18.5 The ability to operate light rail on tracks fitted into most urban surroundings means that light rail can be made fully compatible with the following situations, with the associated rules applying;

- ***Pedestrianisation*** – requires slow moving LRV's and sufficient pedestrian safety clearance is required alongside. Rails are flush with the surface presenting few problems of access across the alignment and enabling alignment sharing with other vehicles.
- ***Segregated*** – alongside or using existing road or rail alignments. No new alignment required – the ideal, if achievable, for routes from suburb to centre;
- ***Un-segregated*** – with road traffic, congestion is a potential problem and should be limited to small sections if possible;

- ***Grade Separated*** – elevated or underground – expensive and restricted to essential places only; and
- ***Combined Running*** – with conventional rail vehicles – not applicable in Malta. Automatic train protection (ATP) or temporal segregation required. Combined running with general traffic is also feasible or with bus.

2.18.6 Light rail systems usually have a mix of the differing operating conditions, depending on the requirements of the area served. Their specification and performance can also vary depending on the local requirements and should therefore not be seen as one mode, but rather a family of systems with similar characteristics. For example, the need to cope with steep gradients in Sheffield, UK, required a larger and heavier (and more expensive) vehicle with all bogies motored.

2.18.7 The capacity of light rail systems varies. In the UK the Midland Metro trams can carry 152 passengers each but only 56 can be seated. Each tram also has space for two wheelchairs. They have a maximum speed of 75kph. In Nottingham, UK, the five section sets have a passenger carrying capacity of 191 with a maximum speed of 80kph and radius capability equivalent to conventional buses.

Plate 5: NET Line 1, Nottingham (The latest light rail scheme to open in the UK exceeded its patronage target after the first year of operation).

Ultra Light Rail

2.18.8 The cost of light rail systems are considered prohibitive for some towns, particularly where passenger demands are lower, and a number of "***ultra-light rail***" based transport systems are being developed. The ***Parry People Mover***

System (PPM), system involving small vehicles with a driver, has been developed on narrow gauge railway track with a charged flywheel automotive system although it is understood that alternative propulsion is being considered.

Plate 6: The Parry People Mover

2.18.9 The PPM has been in use as a visitor attraction at Himley Hall in the West Midlands, UK for many years and has had a period of regular public service as a people mover between a car park and the SS Great Britain in Bristol. It has recently been introduced to provide a shuttle between a mainline heavy rail station in the UK, Stourbridge, and Stourbridge Town, a central station a short distance away. Following a series of demonstrations on test tracks, the Parry Group are promoting the system as a low-cost alternative to conventional light rail and are investing in the development of a range of vehicles to cope with differing operating requirements.

2.18.10 There are a number of advantages to the PPM system compared to heavier, more traditional, systems, particularly the absence of overhead power lines and its smaller scale, reducing costs. The flywheel is recharged at intermediate and terminus stations when the vehicle draws electric power whilst waiting for passengers to load and unload.

2.18.11 PPM vehicles can be designed to carry between 25 and 40 passengers and run on 600mm, 1000mm or 1435mm (standard) gauge tracks. A larger vehicle currently being developed is expected to be capable of carrying 80 – 90 passengers.

2.18.12 PPM capacity is estimated at 1,500 passengers per hour per direction (pphpd) assuming one minute headways at an average speed of 12kph. This can be compared with conventional light rail capacities of 1,000/2,000pphpd (single vehicle/coupled pair) at 15 minute headways.

2.18.13 The vehicles are powered by energy stored in a rotation flywheel driving through a continuously variable transmission (CVT).The smaller vehicles are 1.95m wide, 2.1m high and 3.2m long and weight between 3 and 4.4 tonnes (dependent on flywheel size). The low vehicle weight means that the tracks do not require as strong a sub-base, reducing construction and maintenance costs.

2.18.14 The size of the flywheel depends on the gradients to be tackled and the size and required range of the vehicles in service. It is estimated that a PPM system could cope with gradients of up to 8%, though this remains un-proven, and the minimum radius of curvature is 15m (narrow gauge) or 25m (standard gauge). The flywheel is also 'recharged' going downhill – a form of regenerative braking. Instead of the flywheel powering the vehicle, the vehicle turns the flywheel, accelerating the flywheel as the vehicle decelerates. Additional braking is provided by disc and track brakes. The maximum speed is 50kph.

2.18.15 The flywheel requires charging at termini and intermediate stops using a short section of electrified 'third' rail. This powers an electric motor to rotate the flywheel more quickly and restore energy within the flywheel. The electricity supply is 72 volts dc and therefore regarded as harmless. Latest vehicles are to be equipped with small diesel or Liquid Petroleum Gas (LPG) motors for emergency (return home) operation and moving vehicles around within the depot. Inter-urban operations require more assessment and trials of the PPM as the maximum station spacing so far provided is 700m and charging times are between 30 seconds and two minutes.

Minitram

2.18.16 A three-month trial was undertaken in Stratford-upon-Avon, UK, of the Minitram. It is claimed that the Minitram incorporates the best features of the tram into a PCV. The vehicles are ultra-light, rubber tyred and can be powered by batteries or fuel cells.

2.18.17 The capacity is 30 passengers of whom 13 are seated; eight are "perched" and nine standing. There are future plans for 90 passenger capacity vehicles and the manufacturer recently announced a low-floor version.

Plate 7: Minitram

2.18.18 The vehicle used in Stratford is 1.75m in width, and 8m in length with a 3.5m wheelbase. They are claimed to be low cost because they use the existing bus based running gear. The product can incorporate buried wire guidance. Additionally the body parts are made from aluminium and are modular and easily replaceable. The vehicle is narrow and thus suitable for narrow streets and short run journeys.

2.18.19 Other cities in the UK have expressed an interest in Minitram. Metro, the West Yorkshire Passenger Transport Executive, considered a Minitram service in Bradford to link the city's two railway stations as part of a redevelopment of the city centre.

2.18.20 A tracked Minitram system is likely to be built in Kalamata, Greece. This will operate under Ultra Light Rail principles of lighter weight, smaller capacity and lower cost infrastructure. This will allow for rails to be laid over existing services.

2.18.21 The proposed Kalamata system will include a 5km of tramway track, depot, 23 stops and 8 hybrid diesel-electric trams. The Minitrams would be able to carry 45 passengers and have a maximum speed of 50kph. It is anticipated the scheme would cost eight million Euros (£5m).

2.19 ***Trolley Bus***

2.19.1 Trolley buses, electrically powered through overhead electrification, are quite common in mainland Europe but there are now no UK examples in regular public service. Advantages of trolley bus operation are the lower fuel and maintenance costs. However, the lack of a 'return rail' means that trolley buses need two overhead wires for current collection and return. This creates a bigger visual impact than LRT overhead lines. Unless the vehicles are dual-mode (see below), trolley buses are very inflexible operationally, being unable to divert off route to avoid blockages or road works.

2.19.2 Several European bus manufacturers build dual-mode trolley buses (usually electric and diesel), although the higher purchase and operation costs of these vehicles to prevent the need for trolley wires increases the scheme costs. The dual vehicles can only safely switch between trolley and diesel whilst at a stop, thereby increasing the overall journey time.

Cristalis

2.19.3 One type of trolleybus currently on the market is the ***Cristalis***, an Irisbus product. Many of the innovations tried and tested on Civis, described elsewhere, can be carried over into the design of Cristalis. It is currently in operation in Lyons, France where it replaced a fleet of ageing trolley buses.

Plate 8: Cristalis

2.20 ***Guided Bus***

2.20.1 There are several generic types of guidance in use at present with various products being developed within each type.

- ***Mechanical Guidance*** - kerb guided or slot guided
- ***Optical Guidance*** - the CIVIS system
- ***Electronic Guidance*** - buried wire

Mechanical Guidance -Kerb Guided Bus

2.20.2 Kerb Guided Bus uses vehicles with horizontal guide wheels mounted on the front steered axle, these being restrained by upstand kerbs. Some applications such as the Adelaide system also have guide wheels fitted to other axles.

2.20.3 The buses are guided along a predetermined route, which must be segregated from other traffic. Since the guide wheels do not extend more than a few millimetres beyond the width of the bus, such vehicles may easily leave the guided route and operate over standard roads as any other bus.

2.20.4 Most proposals for guideways are in areas where buses need to by-pass congestion but applications are appropriate where an alignment width is constrained, for example on a former rail alignment. Guideways eliminate the possibility of any lateral movement of the bus, for example within a lane of traffic. They are seen as being suitable where road space is in short supply and conventional bus lanes are seen as impractical.

2.20.5 Kerb guidance can be fitted to most bus products although any one system must use vehicles of the same width – some minibuses and narrow products such as the ***Slimbus Solo*** could not use the same guideway as conventional 2.55m wide buses. Malta's recent low floor buses and indeed most modern bus products are to this standard width.

2.20.6 Kerb guided bus systems operate in a number of locations across the world. A trial system was created in ***Essen***, Germany, and a full-scale system was built in a corridor of ***Adelaide***, Australia.

2.20.7 In the UK, there are currently four examples in operation:

- ***West Yorkshire***, three separate alignments;
- A 200m section at ***Ipswich;***
- ***Gatwick Fastway*** in Crawley; and the
- ***Edinburgh WEBS*** system.

2.20.8 All the UK systems use modern, low-floor buses to enable easier access.

2.20.9 The Crawley Fastway system sells itself as being '***intelligent integrated transport***'. Here the vehicles are equipped with automatic vehicle location systems that help maintain schedules and provide on-board real-time information. In addition, on Phase 1, there are 2,200m of segregated bus lane, 650m of guided busway and seven modified bus friendly junctions to enhance the attractiveness of the service. Once all phases are completed there will be 2.5km of guided busway within a route length of 24km.

2.20.10 The Fastway scheme in Crawley saw the first phase commence in 2002 and was completed in 18 months. The remaining phases are expected to be completed by September 2005.

2.20.11 The first guided busway in Leeds was constructed over a four year period but the second scheme built in the east of the city was built in one phase in approximately 18 months.

Plate 9: Kerb Guided Bus

2.20.12 The cost of fitting horizontal guide wheels to a conventional vehicle varies between about £5,000 and £10,000 providing a cost-effective solution compared to either light or heavy rail.

2.20.13 The main advantage of the kerb guided bus is its flexibility, mixing segregated running with on-street operation. The guided busways are also self enforcing. The guide wheels required for the bus to use the guideway make it harder for other vehicles to use the guideway.

2.20.14 Guideways also increase bus accessibility because as new infrastructure is being fitted it means aspects such as level boarding become possible compared to standard roadside stops.

2.20.15 It should be noted, however, that because of their obtrusiveness, the up stand guides do not lend themselves to use in areas where pedestrians and shop frontages are encountered. The guideways can also be severe in appearance.

2.20.16 There are some concerns about the long-term maintenance costs of kerb guided bus and in Essen the system is being replaced by light rail due in part to the high maintenance costs of the concrete guideway, which suffers from rutting of the running surface and deterioration of the guide walls especially as a result of freeze-thaw action in winter. Also, it is understood that although it was designed to operate in tunnel with an underground tram system, signalling difficulties were never satisfactorily resolved.

2.20.17 It is understood that in Leeds the system is already suffering from degradation of the up stands and horizontal wheels, possibly due to construction tolerances being too generous. Foundation problems have also been encountered.

2.20.18 The guided bus system installed in Adelaide, Australia continues to operate well. However, to ensure a robust system was implemented, the foundations for the track were piled and most of the track way comprises prefabricated sections. Consequently, the construction costs were comparable to those for an LRT system.

Mechanical Guidance - GLT & Translohr

2.20.19 The second type of mechanically guided bus uses a purpose built articulated rubber tyred vehicle and requires a central guide rail to be set into the route over which the vehicles are to be guided (this could be a dedicated alignment or a general traffic route). The rail can be set flush with the road surface although exacting engineering tolerances are necessary. Locating rollers at each steered axle engage with the rail thereby providing steering. This type of guided bus is being developed by two companies:

- ***Bombardier*** – product is marketed as ***Guided Light Transit*** (GLT/TVR), and
- ***Lohr Industrie*** – product is called the ***Translohr***.

2.20.20 The GLT and Translohr systems both draw current via an overhead wire that provides power. The vehicles may also leave the guide way and operate on ordinary roads utilising an on-board diesel or gas powered generator to provide the electricity for the motors or indeed may use this as the principle or only means of propulsion. In street running mode, as a result of their articulation, they can negotiate tight radii and thus do not require special on-street construction.

2.20.21 The main benefit of GLT is its rail and road bi-modality. It can be operated on a segregated electrified lane with a single central guiding rail, or as a road vehicle on tyres, driven independently and powered by a diesel-electric system.

Plate 10: Guided Light Transit - GLT

2.20.22 The GLT requires less infrastructure than traditional trams and can be easily maintained at bus depots. The GLT vehicles are double articulated with a capacity of 145 passengers including standing passengers, all low-floor with air-conditioning. GLT is able to negotiate 12 metre radius curves and 13% gradients.

2.20.23 The GLT system has been sought to provide a cheaper alternative to light rail in a number of French towns and cities, including Caen and Nancy. However, the systems are nevertheless expensive, with the bespoke vehicle costs comparable to a light rail vehicle of similar capacity, and significant costs involved in installing the guidance system and overhead lines.

2.20.24 Construction of a single route in Caen began in March 2000 following delays in the planning process and entered service in September 2002. Meanwhile the line in Nancy, replacing former trolley bus services, started operation in February 2001. On the Nancy network, the units are guided for 80% of the time whereas in Caen they are 100% guided.

2.20.25 In Nancy the vehicles used are 24.5m long and 2.5m wide with four doors on each side. They have capacity for 200 passengers of whom 48 are seated, including folding seats. However in March 2001 the system suffered two accidents at the same location (one involving passenger injury from flying glass) when the rear section of the vehicle struck a traction pole at a change point between guided and unguided sections of route. It is understood, however, that following a period when the operation was suspended technical modifications have been made that address the difficulties.

2.20.26 The Translohr system has been trialled on the 12.5km Trans Val de Marne Bus Rapid Transit corridor. It is being developed as a contender to GLT, seeking to overcome what were then two specific drawbacks of the older design:

- noise from the guidance system (GLT was reported to be noisy, resulting from lateral vibration of the guide wheel, which is pushed down onto the rail), and
- provision of a low floor model (GLT is now available as a low floor product).

2.20.27 The Translohr system uses two guide wheels, at either end of the box frame to which the wheels are attached. The two small-flanged guide wheels effectively grip the centre rail, each at an angle of 45 degrees.

Plate 11: Translohr in Clermont Ferand

2.20.28 The Translohr vehicle varies in length from 18m to 39m and can carry between 2,000 to 5,000 passengers per hour depending on the number of modules chosen and service frequency.

2.20.29 Translohr is able to go "off line" under its own battery power to return to the depot or negotiate wireless stretches or tunnels. As with GLT the vehicle is low floor throughout, with a narrow turning circle, and can negotiate gradients up to 13%. The backers of Translohr claim it costs half as much to build as a conventional tramway.

2.20.30 A further advantage of the Translohr system is expected in the infrastructure costs of installing the guide rail. The reduced downward force compared to the GLT results in a need for less construction depth.

2.20.31 The first example of Translohr opened in Clermont-Ferrand, France in 2005. The scheme is reportedly going to cost 120 millions Euros (approx Lm 54 millions) of which 80 millions Euros (approx Lm 36 millions) is attributable to the dedicated traffic lane.

2.20.32 Each vehicle is said to cost 1.8 millions Euros (approx Lm 790,000) with the overall system costing 5.7 millions Euros per kilometre (approx Lm 2.5 millions). Translohr has also been selected by the authorities in Padoue, Aquila and on the Mestre-Venice corridor which are all in Italy.

2.20.33 Apart from the two high profile accidents on the Nancy system, there have been no major maintenance or reliability issues reported on any of the other GLT or

Translohr systems. Any maintenance issues are likely to concern the guidance system on the vehicle and the road.

Optical Guidance - Civis

2.20.34 Civis is a joint development between Irisbus and Siemens. Though operating on street on rubber tyres it is marketed as a system of light urban public transport on a par with modern tramways. It is based on optical guidance with diesel-electric propulsion and can be used on ordinary roads as well as dedicated lanes.

2.20.35 In France it was introduced in Rouen and Clermont-Ferrand in 2005. Civis is already in operation in Las Vegas in the USA and was launched there in 2004.

Plate 12: Civis (during a demonstration in Manchester UK)

2.20.36 Civis uses image-processing technology to provide guidance. A camera situated in the vehicle front dome reads road surface markings to indicate the optimal path for maximum passenger comfort. This is then fed to a microprocessor that anticipates the route to follow, detect deviations and automatically nudge the vehicle back on track by activating an electric motor in the steering column. The detection works up to 30m ahead of the vehicle.

2.20.37 The guidance, however, is less reliable if it is based on fewer than three guidance stripes and can be affected by adverse weather conditions or if the stripes are obscured.

Plate 13: Civis' Optical Guidance Technology (Stagecoach has entered into an agreement with Siemens to develop similar technology on-board their existing fleet)

2.20.38 The guidance system enables the vehicle to dock at platforms within a few centimetres of the kerb. Optical guidance, it is claimed, also allows for a smooth ride free of rail problems and it brings with it silent operation. Manual steering can be enabled if circumstances dictate without the need to stop the vehicle.

2.20.39 Civis operates using electrical propulsion by motorised wheels. An electric motor is fitted inside the rim of a specially designed tyre. This directly drives the wheel. Four of these powered wheels are used for optimal driving on each set.

2.20.40 Civis allows for different energy sources. These include:

- overhead pickup;
- on-board electricity generation using a low pollution internal combustion engine; and
- batteries or dual mode combination versions.

2.20.41 The Civis unit weight of approximately 17 tonnes does have the adverse impact that it is likely to have significantly higher fuel costs than other equivalent modes.

2.20.42 Civis is able to offer a flat floor throughout accessed through up to four swing-out doors on one side. The vehicle capacity is 150 passengers. There is also greater freedom to move around the vehicle. Passenger comfort is enhanced through low noise levels and no jerking during acceleration and deceleration.

2.20.43 The system is said to be inexpensive to install as the infrastructure is light and similar to the lanes used for operating standard bus services. Civis runs on conventional rubber tyres, which means it can adapt to different types of terrain especially as it has a tight turning radius and ability to climb steep inclines. The length of Civis units currently in service is approximately 18.5m – the same as a standard articulated bus.

2.20.44 It is claimed by the promoters of Phileas that in areas where it rains, there are autumn leaves, snow and the low angle of the sun, that Civis is not suitable, as the detection is based on three guidance stripes.

2.20.45 The Civis vehicles are reputed to cost 1 million Euros (approx Lm 430,000) each. An equivalent high specification articulated bus costs approximately Lm 162,000. Unit costs are likely to come down if volume production is secured.

2.20.46 The Las Vegas Civis vehicles were launched in 2004 after a construction period of approximately two years. The system was delayed after some initial computer problems were discovered but these have since been resolved. There have been no reported maintenance or reliability issues since the launch.

Optical Guidance - Stagecoach-Siemens proposal

2.20.47 In addition to the 'designline' electric hybrid vehicle that has been demonstrated to local authorities across the UK, Stagecoach has announced that it has signed an agreement with Siemens to develop a guidance system for its UK bus fleet.

2.20.48 The agreement will see Stagecoach and Siemens look at the potential for adapting the Siemens optical guidance system, as used on Civis, to conventional buses. The deal will allow for discussion with local stakeholders on the potential for introducing a pilot within a heritage city in the UK.

2.20.49 The system includes a camera mounted in front of the steering wheel which will read coded markings in the road. An image processor follows the road markings and detects deviations by activating a motor on the steering column. The tolerance is a few centimetres and allows vehicles to pull in accurately to bus stops. The guidance bars are painted on the road surface which means that no expensive infrastructure is required.

2.20.50 The Stagecoach-Siemens announcement was made towards the end of 2004 and as such is still a concept under investigation. No trial vehicles have been devised and no indication of timescales for prototype production have been released.

Electronic Guidance - Phileas

2.20.51 Phileas is a system that it is claimed combines the advantages of tram and metro systems with the flexibility and low costs of a bus system. With modes such as light rail, tram or a metro system there is a high infrastructure cost because of the need for signalisation, rails and overhead equipment. With Phileas these additional infrastructure costs are not required as it is able to operate on street.

Plate 14: Phileas

2.20.52 The scheme has been introduced in the Dutch city of Eindhoven. It became operational in 2004. Eindhoven was selected to trial this system because the city was seen as being too small for a light rail network and too large for an enhanced bus network. In addition a new district is being proposed for 20,000 inhabitants at Meerhoven and it is proposed to incorporate at the design stage purpose built and dedicated alignment for Phileas.

2.20.53 This innovative form is claimed will be fast, flexible, comfortable, reliable, attractive, punctual, safe and environmentally friendly although clearly these qualities could apply equally to many other schemes if supported by enhanced infrastructure and priorities.

2.20.54 The scheme has been funded through a public-private partnership. This includes both central and local government as well as the manufacturers of Phileas. It is anticipated that the initial phase will be the first line in a regional network of

Phileas lines centred on Eindhoven. Some four lines in total are in the process of development.

2.20.55 The Phileas vehicle is made up of several body modules, sub-frame modules for the axles and a modular hybrid driveline (diesel-electric). As a result, different variants are possible with lengths of 18m (single articulation), 24m or 25.5m (each double articulation).

2.20.56 Phileas can carry 120 to 180 passengers depending on length and the ratio of seated to standing passengers specified. The vehicles have a flat, low floor with large doors to enable easier access. The seating is suspended from the sidewalls making it easier to clean.

2.20.57 Unlike other passenger vehicles, the front axle is situated under the driver's cabin, the rear axle under the engine compartment and intermediate axles close to the articulated section. This creates more passenger space and the axle spacing combined with independent wheel suspension gives an improved driving stability and ride quality.

2.20.58 The Eindhoven application has electronic lane assistance and a precision docking system with all-wheel steering. Phileas has an automatic driving mode where it can follow a pre-determined trajectory which means only a small lane width is required. For two-way dedicated lanes operating at 70km/h only a 6.4m alignment width is needed.

2.20.59 The guidance system is based on magnetic plugs in the road surface which allow for speeds up to 80km/h. Given the length of the vehicles, manoeuvrability is claimed to be as good as standard bus and better than light rail with a turning radius less than 12m and a swept path less than 14.5m.

2.20.60 The driveline of Phileas is modular electric-hybrid, where all the wheels except the front are driven separately by electric motors. The advantages of this are higher comfort with gradual acceleration/deceleration, low energy consumptions and emissions and a continuous low floor between axles.

2.20.61 The vehicles contain a storage system that allows for a secondary source of energy so that Phileas can operate all-electric over short distances for example within town centres or other pedestrian priority zones. The hybrid driveline means a lower weight and lower fuel consumption in comparison to a standard vehicle. The driveline can be equipped with LPG, petrol or diesel combustion or possibly fuel cell. For storage, a Ni-Meh battery or flywheel can be used.

2.20.62 In terms of infrastructure Phileas typically requires as many dedicated concrete lanes as possible, 6.4m wide double lanes, magnetic markers every four metres in the road surface, interfaces with traffic control, adapted pavement height at stops and interactive information systems at stops. Again of course these are not features that are unique to Phileas.

2.20.63 To ensure rapid payment, electronic payment in vehicles and at stops will be incorporated. Again, however, most of these elements are items of infrastructure or system support that should apply equally to any public transport system and are not unique to Phileas.

2.20.64 With an electronic guidance system it is easily possible to track vehicles. A punctuality assistance system can be equipped that enables the driver to receive information to adjust speed to follow a timetable accurately. This system can provide information at stops and on vehicles. However vehicle tracking is also a feature of many other technologies and, for example, most modern on-mode ticketing systems have the capability of providing vehicle tracking.

2.20.65 The promoters of Phileas believe the revenue cost coverage (often referred to as the farebox ratio) will be in the region of 50% as opposed to 30% for more standard forms of public transport. For comparison Malta's current bus network (2005 figures) covers at least 80% of costs. Although the vehicles are significantly more expensive than equivalent conventional buses, and are likely to suffer higher depreciation, the promoters believe this will be compensated for by lower fuel costs. As the vehicles have an increased average speed and the frequency is greatly improved this will increase passenger numbers. The Eindhoven application of Phileas is understood to cost 1.25 million euros per kilometre (approximately Lm 540,000) for the infrastructure.

2.20.66 Due to open in late 2003, the first phase of the scheme came into operation in 2004 having suffered minor teething problems. The first line in the network took approximately two years to construct and work is progressing on the three other lines that will make up the network. At one point in the early stage of operation the Phileas system was taken out of service following a number of system failures.

Electronic Guidance - STREAM

2.20.67 Created by Italian company, Ansaldo Breda, STREAM is a magnetic pick up electric transportation system. It works by electric power being transferred to the vehicle from a power strip embedded at surface level in the street pavement, which is only energised under stationary or moving vehicles. The slot in the traffic lane is 30cm deep and the embedded 'track' 60cm wide.

Plate 15: STREAM

2.20.68 At other points the strip is not energised so it does not pose a hazard to groups such as pedestrians. An advantage of this system is that it eliminates the need for overhead contact systems. Early applications of the system used rubber tyred buses but it can also be used for light rail.

2.20.69 A STREAM system has been installed in Trieste, Italy, initially on a 300m test track though it is hoped that it will extend onto to 3.3km route. Currently 12m and 18m buses are used but it is intended to move up to bi-articulated vehicles.

2.20.70 STREAM is a relatively untried technology and it is expected that there would be maintenance issues related to the performance of the magnetic strip.

2.21 *Automatic Driverless People Mover*

Ultra

2.21.1 Marketed as a '***personal rapid transport system***' by the promoters, ULTRA has yet to take off in the UK. The local authority in Cardiff was keen to introduce this system but has yet to achieve funding, although a demonstration project is installed in Cardiff. BAA (the former British Airports Authority) has committed to a system at the new Terminal 5 at London Heathrow Airport to link the terminal building with the parking areas and interest has been expressed by a number of UK authorities including the small town of Daventry.

Plate 16: ULTRA

2.21.2 ULTRA claims to 'embody the best attributes of the car' with availability whenever required. ULTRA are vehicles are described as driverless taxis operating on segregated often elevated tracks made from concrete. The reduced need to make lots of stops means that faster journeys are possible.

2.21.3 The driverless pods are able to carry a maximum of four people. Even though they are driverless the cars have an automatic protection system, which acts as a safety net around the vehicle and preventing potential collisions. The cars themselves have a car type chassis and rubber tyres. They are guided electronically with battery power. Fully loaded each vehicle weighs 800kg.

2.21.4 ULTRA is a relatively untried technology with no successful commercial applications. In this respect it is not possible to highlight any maintenance or reliability issues as these are not yet known. There would however be major severance issues in any system operating at grade especially over a significant distance.

2.22 ***Conventional Bus***

High Quality Conventional Bus (such as Mercedes-Benz Citaro)

2.22.1 It is possible to bring about a perception change about vehicle quality by acquiring vehicles that are equipped to a higher standard than the average vehicle. For example Mercedes Benz has launched the Citaro bus which is a standard bus but equipped to a higher specification. It is available in three lengths, 12m, 15m and 18.5m. The 18.5m vehicle is articulated. Equally other products are available to an enhanced specification.

2.22.2 The articulated version of the Citaro is becoming common in London with some 400 in operation as part of the Transport for London (TfL) policy to replace conductor operated buses with cashless, high capacity vehicles to improve boarding and journey times. The articulated version can also be found in service in Birmingham and Coventry. Some 12m examples have entered service in towns and cities such as Oxford, Manchester and Cheltenham.

2.22.3 A 12m Citaro with one door is able to seat up to 43 passengers, two doors 35-37 passengers and three doors 28 passengers. This Citaro has a turning circle in the region of 21m. A 15m Citaro is able to take 57-seated passengers with a turning circle of 24m. The articulated Citaro is 18.5m and has a typical seating capacity of 48 and a total capacity of 130-150.

2.22.4 All the Citaros are low floor throughout except towards the rear of the vehicles where there is a step up to additional seating.

Plate 17: Mercedes-Benz Citaro

2.22.5 With articulated Citaros and articulated buses in general, they are seen as being easier to drive especially in terms of manoeuvrability. However for the operator there are some issues that need consideration. Unsurprisingly given the length of the vehicles a greater amount of floor space is required in the depot. This also means that extended or altered workshops may be required. A London operator has, however, stated that this is not always necessary.

2.22.6 It is usually necessary to carry out a thorough review of highway and kerbside infrastructure when articulated buses are introduced. In the UK much of the current roadside infrastructure was implemented without consideration for their possible use. As such it is important that before articulated buses are introduced on a route that the positioning of railings and shelters are surveyed to ensure there are no obstructions especially for the rear door, and that the stop has an approach path that allows all doors to dock properly.

Alternative Fuel Buses

2.22.7 There is a range of alternative fuel buses based public transport systems in operation, which might offer benefit in terms of the reduced infrastructure requirements. These include:

- ***Trolley Buses*** (Refer to Section 3.4);
- ***Duo-buses*** (hybrid trolley/diesel/LPG/battery buses) for operational flexibility;
- ***Battery/fuel cell buses***, and
- Buses running on ***ethanol***, ***rape seed oil***, ***compressed natural gas*** (***CNG***) and ***Liquid Petroleum Gas*** (***LPG***).

2.22.8 Existing bus services can be converted to these fuels which are generally lower emission at the point of use. Experience of these alternative fuels in commercial operation is varied, especially when considering gas, ethanol, rapeseed oil and fuel cell technologies. Both gas types have been trialled in the UK and more widely in Europe, although few new buses are being built for these fuels. Early schemes concentrated on CNG, with comparatively large fleets operated by FirstGroup in particular in Southampton, UK.

2.22.9 More recent schemes have focussed on LPG, as this does not require such large on-vehicle storage tanks, and so weight savings can be made. In the case of Southampton, however, it is claimed that the fuel costs are 20-25% higher than equivalent diesel buses.

2.22.10 There are also problems with variability in the calorific value of batches of fuels and a consequent impact on vehicle performance in particular when heavily loaded or on gradients.

Plate 18: Alternative Fuel Bus

2.22.11 Fuel cell technology is being developed worldwide, and in the field of public transport applications there are several small-scale trials of 8m and 12m buses both in Europe and the US. Most of the main bus manufacturers, MAN, Mercedes, Scania and Neoplan are developing fuel cell vehicles.

2.22.12 As part of a Europe-wide trial, First London received three Mercedes vehicles in early 2004, which will operate in service alongside normal diesel powered vehicles, under the EU CUTE initiative (see below).

2.22.13 Recently, a fuel cell Mercedes Benz Citaro has been introduced into Madrid, Spain. It can carry 70 passengers with a range of 200km. It is powered by roof mounted pressure cylinders that contain hydrogen compressed to 350 bar.

2.22.14 The fuel company Shell has developed a 'clean' diesel fuel. This is a natural gas transformed into a very clean form of diesel. It is a synthetic fuel product that is crystal clear, free of sulphur and can be used neat or blended with regular diesel. This 'gas to liquid' can be used in any vehicle without the need for complicated alternative engines and refuelling infrastructures. Another advantage is that it produces lower emissions. This is to be trialled on one of the articulated bus routes in London, UK.

2.22.15 Another alternative fuelled concept is ***Clean Urban Transport for Europe*** (***CUTE***). Here the buses are powered through burned pressurised hydrogen gas stored in fibre-glass reinforced aluminium containers on the roof. The power generated is similar to diesel and it discharges a clean water vapour. Three of these fuel cell buses are presently on trial in London, UK.

2.22.16 The city of Christchurch in New Zealand has introduced electric hybrid buses into service – the Designline. A batch of ten of these vehicles is in service in Newcastle-upon-Tyne in the UK. These vehicles were introduced as part of a campaign to reduce city pollution, especially from CO_2 emissions, and vehicle noise. The vehicles have 'super low floor' access with wide entry/exit doors and a capacity of 37 passengers (20 seated, 16 standing and one wheelchair).

2.22.17 The vehicle's electric motors are powered by solid gel, water-cooled batteries. An LPG powered turbine charges the vehicles batteries. The vehicles are able to cover 340km a day with virtually zero emissions.

2.22.18 Alternative fuel technology is still in its infancy and is continuing to evolve. There are question marks over its suitability especially as diesel powered vehicles continue to be better performers, especially in terms of fuel consumption and cost.

2.22.19 From operator experience no major doubts have been expressed about maintenance though some have questioned the reliability of such technology.

2.22.20 A key issue with all alternatively fuelled vehicles is fuelling infrastructure including storage, and fuelling procedures. This is especially the case where a small fleet of such vehicles operates in combination with larger numbers of conventional vehicles. Operational safety requirements generally require that fuel is stored away from conventional fuels, often implying that additional depot space is needed.

2.23 *Enhanced Bus*

Zuidtangent

2.23.1 Completed in 2002, the Zuidtangent is a high quality public transport link centred on the Schipol Airport area of Amsterdam. It has been constructed with the capability of upgrade to LRT and is a link of 24km that connects Haarlem with

Schipol North. It is intended that in future phases the service will be extended to Ijmuiden and east to a new residential area in north Amsterdam.

Plate 19: Zuidtangent

2.23.2 The service uses a 'free road', a bus only road but without any form of vehicle guidance, the latest in telematics and in-vehicle technology. When Zuidtangent is running on sections of road that are not 'free' then it has priority over other traffic through the use of conventional bus priority measures.

2.23.3 Instead of using detection in the actual road, a satellite connection is used for communication. This aids punctuality. The peak timetable is eight buses per hour per direction, operating at four to six per hour off peak. At several key points on the route are 'node' stops so that passengers can interchange with more local buses and trains. The route serves as many residential and business areas as possible along the line of route to meet its objectives.

2.23.4 The passenger capacity of the Zuidtangent bus, a very high specification articulated vehicle, is 135. Of these only 45 are seated. As with modes such as Phileas and Civis, generous provision has been made on the vehicles for a good seat pitch and luggage space. As with all new technologies, there is space for a wheelchair.

2.23.5 Since Zuidtangent started operation, there have been no reports of any significant issues with maintenance or reliability.

First – ftr StreetCar

2.23.6 ***ftr*** is a joint venture between the manufacturers Wright Group and the transport operator First Group. It is promoted as the UK equivalent of a ***Bus Rapid Transit*** (***BRT***) system as founded in the US. ***ftr*** was a concept designed by First which aims to incorporate the best features of public transport and the private car. ***ftr*** is text message shorthand for 'future'. The Wright Group are marketing the vehicle more widely as the ***StreetCar***.

Plate 20: ftr/StreetCar

2.23.7 The vehicle was launched in March 2005, with testing to be carried out afterwards. The first production vehicle will be on a modified Volvo chassis and powered by diesel. The rest of the order was built on tested and proven running units. It has been designed so it can be produced as an electric-hybrid bus at a later date.

2.23.8 The StreetCar vehicle is slightly longer than an articulated vehicle, up to 18.75m compared to a typical articulated bus length of 18.5m. It is also be taller than a standard articulated vehicle. The StreetCar will be constructed from an Aluminique bolted aluminium system body structure with multiplexed electrics – a conventional modern method of construction – and has two sets of sliding plug doors.

2.23.9 The driver is shut away from the passenger saloon in an air-conditioned compartment with full width screen and an intercom for communication. The driving position is raised giving a commanding view of the road ahead.

2.23.10 Depending on specification the vehicle is likely to cost £300,000-£350,000 (Lm 190,000-Lm220,000) substantially less than a bespoke product such as the Civis (approx £660,000 or Lm420,000 per vehicle).

2.23.11 The first fleet of ten vehicles were placed into service in York UK in May 2006, on the cross-city service number 4 between Acomb and the University. This service upgrade was launched with all vehicles introduced onto the route at the same time. Teething problems with the vehicles, in particular the new ticketing system, caused initial problems but these have now been resolved.

2.23.12 Learning from the York experience, First is now slowly introducing the second batch of vehicles onto Leeds, UK route 4, so that the passengers get used to the new style of ticketing and operation.

2.23.13 There are strict caveats attached to the introduction of ftr. First will only introduce where a transport authority will come up with a package of measures to complement and improve the journey experience such as dedicated highway and improved waiting facilities. This would mean that First and the local authority would have to sign up to a partnership agreement of some sort.

2.23.14 First have not specified what measures these would be though it is expected that it would include high quality stop infrastructure that is comparable to light rail or similar to Zuidtangent. Other aspects First would be looking for include well lit walk routes and at-stop ticket machines.

Arriva – 'Bus of the future'

2.23.15 Arriva devised the 'bus of the future' based on research of passengers and those that do not use buses at all. The concept was first demonstrated in 2002.

2.23.16 It is based on a standard low floor, easy accessible saloon bus, with added features that seek to enhance the existing image of the bus. The vehicle has coach style 'lop eared' mirrors, alloy wheels, dark tinted windows and air conditioning, attributes that are found on a car.

2.23.17 The entrance area on the vehicle is de-cluttered to improve boarding and alighting. Carpet effect flooring is laid throughout though in fact this is a hard wearing floor covering. This is said to give the impression that passengers are boarding a luxury coach. Arriva stated at the launch the fabrics used throughout the vehicle were chosen to give the interior of the bus the ambience of a small car and is based on the Volkswagen Polo. Traditional bus lighting was reduced to give a softer lighted on board the vehicle.

Plate 21: Arriva's "Bus of the Future"

2.23.18 With the seating some but not all of the seats have high backs. The high back seats are located in the front section of the vehicle. In the front section of the vehicles the seats are arranged as two seats on the offside of the vehicle with a single seat on the near side. The double seats have spacers, which gives the impression people are sitting in a car seat and gives a greater sense of personal space. Towards the rear of the bus some of the seats are arranged in a group of four, as Arriva research stated some groups of passengers prefer to travel in a group – the ftr bus also has this feature.

2.23.19 The seating has been laid out so that it gives more legroom than the traditional bus. Traditionally the luggage area used to be at the front of the bus in a dedicated pen on the Arriva vehicle the luggage space has been moved to racks above the seating.

2.23.20 The Arriva research also showed that one of the sources of stress for the passenger was at which stop they have to alight. To remove this feeling, the bus of the future is fitted with a digital display which includes a voice synthesiser that advises passengers of the next stop, a feature already in use with UK operators such as TrentBarton, and widely in continental Europe.

2.23.21 As a consequence of this specification one of the big drawbacks of the vehicle is that although it is 12m in length, it can only carry 35 seated passengers. A comparable 12m standard low floor saloon bus is able to carry 40-43 seated passengers.

2.23.22 The bus of the future was trialled on a Stafford town service soon after the launch in 2002 and was demonstrated to other subsidiaries within Arriva but no orders have been placed and at the present time it remains very much a 'one-off'.

trentbarton – high-quality buses

2.23.23 Having a highly passenger-focussed ethos, the 300-vehicle East Midlands independent operator trentbarton undertakes extensive market research when introducing new vehicle types. Regularly replacing their front-line vehicles, in order to maintain appeal to motorists, 2007 has seen trentbarton introduce their highest quality vehicles yet.

2.23.24 Based on a standard production 12 metre bus, significant effort has been put into the new interior, with the vehicle's manufacturer upgrading the quality of the finishes. Inspired by the growth of the 'café culture', the new interiors follow the lead of high-street coffee shops, with comfortable seating, attractive flooring and muted colours. The aim is to provide a vehicle that will appeal to motorists.

Plate 22: Interior of new trentbarton high-quality vehicle, showing bright spacious vehicle, leather seats and wood-effect flooring.

2.24 ***Emerging Views – the Systems in the Malta Situation***

2.24.1 In summary in selecting a preferred mode or type of mode the scheme promoters need to consider a number of key questions:

- if one of the newer intermediate modes is selected what are the risks in terms of costs, reliability and the need for and cost of close support from the manufacturer or supplier?
- is the use of guidance really appropriate given that much of the alignment will be street running with or without bus priority, or segregated?
- what constraints arise from the present largely single bus ownership structure of the Maltese bus industry – and are there any revised structures that can accommodate BRT operation and co-exist with the existing structure?
- if a newer mode is selected will an operator build a risk based premium into its bid?

2.25 ***Summary Tables***

2.25.1 The various key characteristics considered in relation to each of the different modes presented in this report are drawn together and summarised in the following tables:

- ***Table 4.1*: *Mode Comparison Summary***, and
- ***Table 4.2: Mode Comparison Summary – Operational Experience.***

2.26 ***Emerging Views***

2.26.1 Based on the initial appraisal of available modes against the study objectives and approach the emerging views are that the most appropriate mode for the Malta BRT scheme would be either a ***High Quality Conventional Bus*** or an ***Enhanced Conventional Bus*** again of the highest quality. This would operate on a combination of conventional highways, prioritised highways and segregated alignment within the highway boundary or adjacent to it.

2.26.2 As presently envisaged there is no requirement for any form of vehicle guidance although kerb guidance may be considered over short lengths where alignment width is restricted.

2.26.3 In order to maximise the potential for success it is proposed that either option would require:

- a fleet of new high quality buses of an appropriate capacity – probably articulated buses with a total capacity of some 140 passengers;
- vehicles dedicated to the service and finished in a distinctive colour scheme;
- a single operator of the system;
- the development of interchanges with revised conventional services;
- a ticketing system that supports speedy operation and interchange;
- a high level of priority on the street running sections;
- bus stop kerbs long enough to accommodate the selected mode;
- high quality "landmark" shelters and passenger infrastructure;
- a ticketing system that maximises off-bus revenue, minimises boarding times and offers operational flexibility;
- 'Ambassadorial' dedicated drivers trained in customer care; and
- high quality promotional material and conventional & electronic passenger information that allows passengers to plan travel and confirms service availability on the journey.

2.26.4 Many of these features are already in common use in major European systems but it is the knitting together of measures into a package that is central to a successful scheme.

2.26.5 At this stage a system similar to the ***Zuidtangent Project*** in the Netherlands would appear appropriate, using a vehicle product such as that used on Zuidtangent or similar to the recently launched First ftr bus. Whereas the Zuidtangent project uses long sections of dedicated bus only road it is inevitable that the proportion of exclusive alignment in the Maltese application will be considerably lower.

Mode Comparison

Mode	Capacity	Vehicle Length	Vehicle Width	Easy Access	Turning Circle	Guidance Used	Maximum Speed	Infrastructure works	Costs	Experience Elsewhere	Power source	Characteristics	Special Features	Able to run 'on street'	Depot Constraints
Phileas	120 - 180. Majority standing.	18m - 24m	2.5m	Yes. Low floor access with space for wheelchair. Also wide entry/exit doors	12m turning radius. Swept path of 4.5m	Can operate on normal roads under manual control. Preferable to have a dedicated traffic lane with electronic guidance. Ideally use 6.4m wide double lanes.	60-80km/h	Can sit within existing street environment. Preferable to have as many dedicated concrete lanes as possible. Magnetic markers required for road surface plus interfaces with traffic control. Adapted pavement height at stops to ensure level boarding. No rails or overhead cable required.	Each vehicle reportedly costs £1m due to high depreciation costs but fuel costs are considerably lower. The cost of the route is claimed to be £834,000 per km.	Eindhoven was the first city to launch this concept in 2004, otherwise unproven. More routes are planned on the Eindhoven network.	Modular electric-hybrid driveline. Built in flywheel as part of the drive system. All wheels except front driven by electric motors separately. Non- electric parts run by LPG	Vehicles used are tyre based. Able to deviate from lane when required. Vehicles are modular lightweight body construction.	Seating suspended from side walls so it is easier to clean. Air Conditioning. Temperature Control system. Information displays & PA system provide details of times and stop details.	Yes	No major separate facilities are needed. Able to use existing bus depots, though some work would be needed to accommodate the longer vehicles.
Civis	Up to 150 dependent on seating configuration	18.5m	2.55m	Yes. Low floor access with space for wheelchair. Also wide entry/exit doors	Similar to above	Can operate on normal roads under manual control. Otherwise system operates utilising optical guidance. Based on image processing, camera reads lane markings, information fed to a microprocessor which anticipates route to follow.	60-80 km/h	Can sit within existing street environment. Inexpensive to install as infrastructure is light and uses similar dedicated lanes to buses. No rail or overhead cable is required.	Vehicles are reported to cost £666,000 each. This is offset by reduced costs of infrastructure	Las Vegas system launched in 2004. There have been numerous glitches that have delayed its introduction. Rouen and Clermont-Ferrand are planning on introducing systems. Vehicle exhibited in Manchester 2004.	Can be overhead pick up or on board power. Driven by motorised vehicle technology. Electric motor fitted inside rim of specially designed tyre.	Vehicles used are tyre based rather than rail as this ensures quiet operation.	Seating suspended from side walls so it is easier to clean. Air Conditioning. Temperature Control system. Information displays.	Yes	No major separate facilities are needed. Able to use existing bus depots, though some work would be needed to accommodate the longer vehicles.

Cristalis	140 max including standing	Either 12m or 18m	2.55m	Yes. Low floor access with space for wheelchair. Also wide entry/exit doors	11.2m to 11.5m	Can operate on normal roads. It does not have the guidance technology of CiViS. Vehicle is driven manually and powered via overhead wires.	60-80 km/h	Similar to Civis in many respects. Able to sit within existing street environment. No rail needed but overhead cable is required. Some roadside work needed to ensure level boarding at stops.	Unknown	Introduced in Lyon to replace ageing fleet of trolleybuses, infrastructure largely in place.	Same as Civis	Same as Civis	Similar to Civis	Yes	No major separate facilities are needed. Able to use existing bus depots, though some work would be needed to accommodate the longer vehicles.
Kerb Guided Bus	same as conventional single or double deck bus, maximum 150 total capacity	up to 18.5m	2.55m. Narrower buses cannot be used in guideway.	Yes. Low floor in first half of vehicle. Rear section likely to be raised due to engine location, but fully low floor types such as diesel/electric /flywheel can be kerb guided.	Up to 24m. Similar to Conventional buses in unguided mode but 100+m for guideway.	Buses are equipped with guidewheels that allow a bus to travel along a specially constructed concrete or steel kerb guideway. The guidewheels connect the kerbs with the steering mechanism and guide the bus. When the vehicle is not in guideway it can operate along normal roads as a standard bus.	In urban areas, limit is that of parallel carriageway e.g. 30 mph. Potentially up to either 80-100 km/h for a completely segregated route.	Need to build special kerb guideways that are only accessible to suitably equipped buses. About 3m width is needed to construct a guideway. Therefore minimal space is required. This can be done within the existing street environment, though work would be needed to ensure level boarding at stops.	In Leeds the initial 450m section cost £750,000 or £1,600 per lane metre. It is estimated that a 2-way/2-lane section would cost £1.8m per km. Standard vehicle costs plus £5,000-£10,000 for guidance equipment.	In Leeds, introduction of guided buses saw a large increase in passenger numbers (although research could not isolate the guideway effect from other quality factors), therefore improving the financial viability of the existing commercial services. Systems also introduced in Bradford and Crawley and a short length in Ipswich.	Diesel or any hybrid or overhead power supply. Possible to be fuelled utilising 'alternative' fuels such as LPG/CNG.	Vehicles are tyre based. Lower cost alternative to light rail whilst having the advantages of dedicated rights of way. Within guideways, steering taken away from the driver. Guideway can also incorporate street running tracked transit.	Level boarding possible at guideways and roadside stops with raised kerbs. Buses are wheelchair accessible with air conditioning, double glazing and power steering according to specification required.	Yes, when not in guideway.	None. Vehicles used are standard buses with guidewheels attached, therefore no issues with depots.

High Quality Conventional Bus. Mercedes-Benz Citaro	26-48 plus standing.	12/15m	2.55m	Yes. Low floor in first area of of vehicle. Rear section likely to be raised due to engine location	12m - 21m/15m - 24m	Operates on normal roads under manual control. No guidance technology required.	100 km/h	Possible alterations at bus stops required to improve wheelchair access but no substantial works required.	Approx £140,000 per vehicle.	Examples widely used in UK. Very high specificatio n vehicles in use in Birmingha m.	Diesel to Euro IV. Can use fuels such as LPG/CNG or hydrogen fuel cell.	Vehicles are tyre based.	Vehicles tend to have air conditionin g, double glazing, power steering and wheelchair accessible.	Yes	None needed although length can present problems in older buildings.
Guided Light Transit (GLT)	145, only 40 are seated in typical configuration	up to 24.5m	2.5m	Yes. Low floor access with space for wheelchair. Also wide entry/exit doors	12m radius curves	Can operate two ways. Firstly using automatic guidance via a single rail embedded in the roadway or secondly as a road vehicle driven independen tly.	approx 70 km/h	Can either be operated on a segregated electrified lane or as a road vehicle driven independentl y and powered by a diesel-electric system. In UK length limited to 18.5m if used on highway	Nancy spent approximatel y £30.4m alone on 25 GLT vehicles.	A relatively new concept that has been introduced in Nancy in 1998 with plans for other cities in France. There have been concerns raised about its safety, after two serious accidents at the same location when th rear section of the vehicle struck a traction pole at a change point between guided and unguided sections (one involved passenger injury from flying glass).	Road and rail bi-modality system. Either by a electrified lane with a central guiding rail, or as a road vehicle, driven independently and powered by a diesel-electric system.	A bi-modal system, operates either on tyres or rail. Requires less infrastructure than a traditional tram. Reputed to be noisy because of the lateral vibration of the guidewheel which is pushed onto the rail. Requires exacting engineering tolerances for guide rail.	Vehicles tend to have air conditionin g, double glazing, power steering and wheelchair accessible.	Yes	Easily maintained in bus depots, though likely some alterations would be needed in the workshop areas.

Translohr	Up to 150 dependent on seating configuration	24.5m	2.5m	Yes. Low floor access with space for wheelchair. Also wide entry/exit doors	12m radius curves	As GLT	approx 70 km/h	Same works as GLT would be needed. However the reduced downward force compared to GLT means less construction depth is needed for the guiderail.	The Clermont Ferrand system due to open in 2005 is set to cost £80m. £54m is for a dedicated traffic lane. This works out at approximately £3.8m per km. The vehicles are reported to be costing £1.2m each.	Trialled on the Trans Val-de-Marne corridor in Paris in 2000-2001. To be introduced in Clermont Ferrand in 2005 and in the Italian cities of Padova, Aquila and Venice.	As GLT.	A rival to GLT. Instead of one guidewheel, two guidewheels at either end of box frame are attached to the wheels. Two small flanged guidewheels effectively grip the centre rail, each at 45 degrees	Similar to GLT	Yes	As GLT
Light Rail	Depends on vehicle length, can be 120-300	20 - 35m typically	2.5m	Yes. Low floor access with space for wheelchair. Also wide entry/exit doors	Typically 10m but depends on vehicle type and configuration	Operates on dedicated, segregated track or on highway with priorities as appropriate. Driven manually but power received from overhead wires.	80 km/h off-street, within speed limits on-street. (Nottingham)	In many cities that have reintroduced trams, the costs and work have been considerable. Besides new tracks there is the costs of rerouting utilities and building new facilities. However they can be accommodated within the existing street environment. Rails and overhead cables would need to be installed.	Line 1 of the Nottingham system (20 km) has cost approximately £200m. This has included purchase of the vehicles, laying new tracks, constructing a new depot and associated civil works.	Light rail schemes have been launched in Sheffield, Manchester, Croydon and the West Midlands. New scheme started in Nottingham in March 2004. Plans for schemes well advanced in Liverpool, and extensions to Manchester and Nottingham but subject to funding.	Overhead electric wires.	Vehicles operate on rails and have a lighter weight which means they have a significantly improved performance in terms of acceleration and deceleration. Power received from overhead wires.	Comparatively high initial capital funding for infrastructure and vehicle costs. A long lead time between plans and implementation	Yes, still on rails set flush with road surface	New depot and associated facilities would need to be constructed.
Parry People Mover	30 - 50 max. including standing	7.4m - 8.7m	2m - 2.4m	Yes. Floor is level with platform.	15m radius for standard gauge	Unable to operate on street. System needs separate track and platforms.	70 km/h	Claimed is possible to operate within street environment but is unproven. New rails need to be laid down	Unknown	Unproven. Test schemes demonstrated or trialled in several locations, such as Bristol	Uses flywheel technology and electrical supply to platforms.	Vehicles operate on rails. No need for overhead electricity supply	Wheelchair accessible from boarding platform	Yes	New depot and associated facilities would need to be constructed.

								and platforms to be constructed plus associated works.		Harbourside and Weymouth.					
ULTra	Max 4 people, driverless	Approx 3m	Approx 2m	Vehicles or 'Pods' are wheelchair accessible. Lifts or ramps provided at stations to enable wheelchairs to access service.	Approx 4m	Unable to operate on street. System needs separate track and platforms.	40 km/h	Not suited to operating within a street environment. Considerable work needed to construct guideways and platforms. No rails or overhead cables required.	The proposed Cardiff system was costed by the promoters at £20m, which would have paid for the first phase linking the City Centre with the Bay area including constructing guideways and purchasing vehicles.	Recent trial in Cardiff has been scrapped. Issues raised about funding, safety and viability. Other towns reported to be interested, notably Corby.	Electrically powered	Vehicles are tyre based and operate within a dedicated guideway. Vehicles are light with zero emissions. Claimed journey times 3 times quicker than bus/car/light rail with lower operating costs.	Wheelchair accessible	No	New depot and associated facilities would need to be constructed.
Minitram	30	8m	1.75m	Not wheelchair accessible due to its size. However manufacturer intends to introduce low floor version.	As per conventional bus	Operates on normal roads under manual control. No guidance technology required. However Kalamata version will utilise tramway tracks.	45 km/h	Can operate easily within a street environment. No rails or overhead cabling required. Possible adjustments to bus stops may be needed.	The Kalamata scheme is set to cost £5m which will cover 5km of track, 8 hybrid vehicles and associated civil works.	3 month trial in Stratford-upon-Avon now concluded but no developments since. Stratford council seeking funding for introduction. Scheme was scheduled to be introduced in Kalamata, Greece in mid 2004.	Powered by batteries or fuel cells	Vehicles is tyre based. Claimed to incorporate the best features of a tram into a PCV. Low cost because it utilises PCV running gear plus body is modular and aluminium which is easy to replace.	The vehicle is narrow and suitable for short run journeys.	Yes	Able to be garaged with existing bus fleet. However, special charging facilities will need to be constructed.
STREAM	160 - 180 max	12/18/24m	2.5m	Yes. Low floor access with space for wheelchair. Also wide entry/exit doors	Estimated 10m	Installed in roadway. It collects traction power and over which it exchanges control signals and messages. Vehicle can operate	Unknown	Can operate within a street environment. Contact lines need to be installed in the roadway and improvements to be made to roadside	Unknown	A small trial has been undertaken in Trieste. No other examples in service.	Powered electrically through the contact line in the road.	As bus passes, a powerful magnet pulls up a guidance wire in the contact cable, with which electrical contact is made.	The contact line feeds back to the control centre information about the position of the bus and can be used to control	Yes, but only if the road has a contact line installed.	Special depot facilities would need to be constructed.

						using manual control.		infrastructure to ensure level boarding.					traffic lights and provide Real Time Informatio n.		
Electric hybrid buses - I.e. 'designline'/'electroc ity'	30 - 40	9 - 11m at present but up to standard permitted length (15m rigid, 18.5m articulated) on UK highways	2.5m	Yes. Low floor access with space for wheelchair. Also wide entry/exit doors	As per conventional bus	Operates on normal roads under manual control. No guidance technology required.	80 km/h (Christchurch, NZ)	Can operate easily within a street environment. No rails or overhead cabling required. Possible alterations at bus stops to improve wheelchair accessibility.	Unknown	Designline used in Christchurc h, NZ has been successful. Demonstar ted in UK by Stagecoach Electrocity undergone trials in UK.	From solid gel, water cooled batteries. Turbine charges batteries as required. Turbine powered with LPG/Diesel.	Vehicles are tyre based and produce very low emissions with a maximum distance of up to 340 km per day.	Wheelchair accessible. Quiet with low emissions.	Yes	Able to be garaged with exisiting bus fleet. However, special charging facilities will need to be constructed.
Articulated Bus - I.e. 'zuidtangent' - Van Hool AG300	Up to 150 dependent on seating configuration	18.5m (or 24.5m in Europe)	2.55m	Yes. Low floor access with space for wheelchair. Also wide entry/exit doors	22m	Operates on normal/ded icated roads under manual control. No guidance technology required.	100 km/h	Can operate easily within a street environment. No rails or overhead cabling required. Possible alterations at bus stops to improve docking and wheelchair accessibility.	Vehicles cost approximatel y £160,000-£200,000 each.	In UK, articulated buses are in operation in Bath, York, Birmingha m, Leeds, London and Glasgow. Vehicles very common in Continental Europe.	Diesel. Possible to be fuelled utilising 'alternative' fuels such as LPG/CNG, hydrogen fuel cell	Zuidtangent is a dedicated bus corridor in greater Amsterdam, operating along many sections of dedicated roadway under manual control. This is effectively a free road with priority over other vehicles when not on its dedicated road.	Air Conditioni ng, Double Glazing, Power Steering, Wheelchair accessible.	Yes	May not fit into conventional depots. Need to drive in/drive out. Special workshop facilities would need to be constructed.
Alternative Fuel Buses - Gas/Hydrogen/Bio-diesel	Up to 150 dependent on seating configuration	9m - 18.5m	2.55m	Yes. Dependent on vehicle type will depend the extent. Some vehicles may only be low floor in front portion.	Depending on length, it would be the same as a conventional or articulated bus.	Operates on normal roads under manual control. No guidance technology required.	100 km/h	Can operate easily within a street environment. No rails or overhead cabling required. Possible alterations at bus stops to improve wheelchair accessibility.	Hydrogen fuel cell buses in London (three in service) are reported to cost approx £1million per vehicle.	Gas buses trialled in Southampt on, Northampt on and Bristol. Rape seed oil trialled in Reading. Fuel cell buses on trial in London.	Different options available inc CNG, LPG, Fuel cells, Rape seed oil and ethanol.	Effectively a standard bus that is not powered by conventional diesel.	for gas powered buses fuel tank tends to be on roof of vehicle. Otherwise able to offer high quality features as with convention al/articulat ed buses.	Yes	Able to be garaged with existing bus fleet. However, special fuelling facilities would need to be constructed.
ftr	Up to 102. 55 would be seated.	18.55m	Approx 2.55m	Yes. Low floor access with space for wheelchair. Also wide entry/exit doors	Unknown	Operates on normal roads under manual control. No guidance technology	Unknown	For it to be attractive enough to work, First want the local authorities to	Vehicles reportedly to cost £250,000-300,000 each.	An entirely new concept. Possible launch in Sheffield, Leeds or	Currently will operate using diesel. Can become electric-hybrid at a later date.	Designed to be the UK equivalent of a US Bus Rapid Transit. Designed to offer a tram	Longer and taller than a standard articulated bus. Driver would be shut away	Yes	Able to be garaged with existing bus fleet. However, special fuelling

						required.		provide as much dedicated road space as possible with sufficiently attractive waiting facilities.		York within the next 12-18 months. Details still to be finalised.		like service.	with fare collection carried out on-street. Vehicles will be equipped with Real Time Informatio n and GPS technology.		facilities would need to be constructed.
Arriva 'Bus of the Future' Wilts and Dorset 'More' Blazefield Holdings '36' and '662 the shuttle'	Up to 35 seated – single deck Up to 68 seated – double deck	12m	Approx 2.55m	Yes. Low floor access with space for wheelchair. Also wide entry/exit doors	Approx 21m	None.	100km/h	Possible alterations at bus stops required to improve wheelchair access but no substantial works required.	Up to £200,000	Arriva prototype trialled in service on a Stafford town service alongside standard buses. No further orders have been placed. Wilts and Dorset and Blazefield vehicles all in service	Diesel	Effectively a high quality low floor bus but with a reduced seating capacity.	Vehicles tend to have air conditionin g, double glazing, power steering and wheelchair accessible. Reduced seating means increased legroom. Also more individual seating is available.	Yes	Able to be garaged with existing bus fleet.

Table 4.2: Mode Comparison Summary – Operational Experience

Mode	Capacity (seated)	20 mins Passing Point Capacity	10 mins Passing Point Capacity	5 mins Passing Point Capacity	UK Operation	Operation Elsewhere	Status
Monorail - Wuppertal	204 (48)	612 (144)	1224 (288)	2448 (576)	Maglev trialled at Birmingham Airport. Schemes introduced at Merry Hill and Alton Towers.	Substantial schemes in operation in places such as the USA, Asia and Germany.	A
Monorail - Sydney	170 (56)	510 (168)	1020 (336)	2040 (672)	See above	See above	A
Light Rail (Nottingham)	191 (62)	573 (186)	1146 (372)	2292 (744)	Also operational in Sheffield, Manchester, Tyne & Wear, Croydon and West Midlands.	Light rail is common in most major European cities.	A
Parry People Mover	50 (30)	150 (90)	300 (180)	600 (360)	Trial schemes demonstrated such as Bristol Harbourside	No known examples.	B
Minitram	30	90	180	360	Trial scheme demonstrated in Stratford-upon-Avon	Scheme planned for Kalamata, Greece	C
Cristalis	140 (34)	420 (102)	840 (204)	1680 (408)	No examples in service	Only examples in service in Lyon.	B
Kerb Guided Bus	150 (55)	450 (165)	900 (330)	1800 (660)	Introduced in Leeds, Bradford, Ipswich, Crawley, Edinburgh	Examples in Essen, Germany and Adelaide, Australia.	A
GLT	145 (40)	435 (120)	870 (240)	1740 (480)	None	Introduced in Nancy and Caen.	B
Translohr	145 (40)	435 (120)	870 (240)	1740 (480)	None	First scheme to launch in 2005 in Clermont Ferrand. Orders placed by authorities in Padua and Aquila and for the Mestre-Venice corridor in Italy.	C

Notes: Status

A - Established mode
B - Operational but trial example or just one scheme.
C - No operational examples
Figures quoted in brackets are seating capacities except for ULTra, Minitram and River Bus where standing is not possible.

Table 4.2: Mode Comparison Summary – Operational Experience (Continued)

Mode	Capacity (seated)	20 mins Passing Point Capacity	10 mins Passing Point Capacity	5 mins Passing Point Capacity	UK Operation	Operation Elsewhere	Status
CiViS	150 (34)	450 (102)	900 (204)	1800 (408)	Exhibited in Manchester. No examples in service.	Launched in Las Vegas in 2004. Scheme to be introduced in Rouen and Clermont Ferrand.	B
Phileas	180 (50)	540 (150)	1080 (300)	2160 (600)	No examples in service	Eindhoven the first city to launch concept in 2004. No other examples.	B
STREAM	180 (50)	540 (150)	1080 (300)	2160 (500)	No examples in service	Small trial being undertaken in Trieste. No other examples.	B
ULTRA	4	12	24	48	Trial scheme demonstrated in Cardiff.	No known examples.	C
Ftr	120 (37)	360	720	1440	York, Leeds	Hybrid version to be introduced in Las Vegas, Nevada, USA	A
High Quality Conventional Bus. Mercedes-Benz Citaro	60 (38)	180 (114)	360 (228)	720 (456)	Examples in service in Oxford and London	Vehicle type common in Continental Europe.	A
Electric hybrid buses ('designline'/ 'electrocity')	40 (24)	120 (72)	240 (144)	480 (288)	Electrocity trialled in Bristol.	Designline introduced in Christchurch, New Zealand.	A

Notes: Status

A - Established mode
B - Operational but trial example or just one scheme.
C - No operational examples
Figures quoted in brackets are seating capacities except for ULTra, Minitram and River Bus where standing is not possible.

Table 4.2: Mode Comparison Summary – Operational Experience (Continued)

Mode	Capacity (seated)	20 mins Passing Point Capacity	10 mins Passing Point Capacity	5 mins Passing Point Capacity	UK Operation	Operation Elsewhere	Status
Alternative Fuel Buses - Gas/Hydrogen /Bio-diesel	150 (55)	450 (165)	900 (330)	1800 (660)	Gas buses trialled in Southampton, Northampton and Bristol. Rape seed oil trial in Reading and Fuel Cells in London.	No known examples.	B
Articulated Bus - e.g. 'zuidtangent'	150 (55)	450 (165)	900 (330)	1800 (660)	Operational in London, Bath, York, Leeds, Nottingham and Glasgow.	Zuidtangent introduced in Amsterdam. Vehicles common in other European cities.	A
Arriva - 'Bus of the future'	55 (35)	165 (105)	330 (210)	660 (420)	Bus trialled in Stafford. No other examples in service.	No known examples.	B

Notes: Status

A - Established mode
B - Operational but trial example or just one scheme.
C - No operational examples
Figures quoted in brackets are seating capacities except for ULTra, Minitram and River Bus where standing is not possible.

3 Typical BRT System Characteristics

3.1.1 The make-up of a BRT system consists of a package of elements. The more elements added the greater opportunity of attracting more patronage, thus a larger benefit. A detailed description of each element is described below.

3.2 ***Private way***

3.2.1 The private way is an exclusive roadway, better referred to as the "track", and most commonly provided in locations where congestion is experienced on the road. Use is restricted to selective vehicles to help ensure journey time reliability. An example of a private way is shown in Figure 3.1.

Figure 3.1 Example of Private Way, Proposed Fastlink Scheme, Glasgow UK

3.3 ***Halts***

3.3.1 A halt provides a high quality passenger waiting environment, including good security, protection from adverse weather and accurate customer information (real time information). Accessibility is also improved by having a raised platform to complement the low-floor of the enhanced bus. The provision of halts also gives the BRT system a unique sense of place and identity.

3.4 ***Signal Priority***

3.4.1 Vehicles are equipped with an on board computer which transmits information to a central computer system. The system will allow equipped vehicles to traverse traffic signal intersections with minimal delay by automatically requesting priority on the approach. A typical system example uses a vehicle actuated traffic control system called SCOOT (Split, Cycle, Offset, Optimisation Techniques).

3.4.2 A pre-signal is normally used on the approach to a pinch-point where the highway reduces in width and the BRT system requires to run on-street mixing with other traffic. In association with the bus lane, a pre-signal would operate approximately 60 metres from the stop line. This will create a bus advance area and allow BRT to "skip" the queue and minimise delay. An illustration of a pre-signal is shown in Figure 3.2.

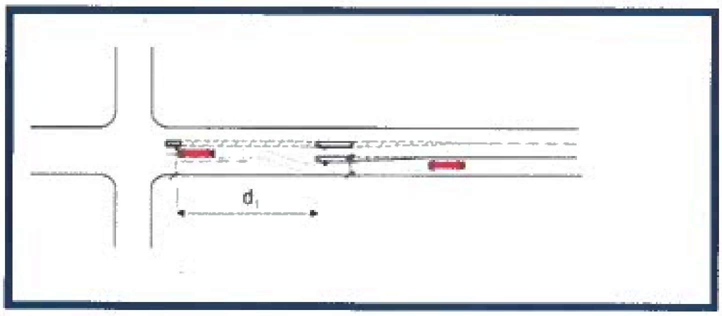


Figure 3.2 Example of Bus Pre-Signal

3.5 ***Tram Like Vehicles***

3.5.1 The system operates with a fleet of high quality, state of the art low floor vehicles, which give an "attractiveness" factor.

3.6 ***Conductors***

3.6.1 Conductors assist in operating the fastest possible level of service as boarding times are minimised (the driver is no longer required to collect fares or verify tickets) and both doors of the dual-door buses can be used for alighting and boarding passengers. They also contribute to a greater passenger security or the perceived feeling that passengers are more secure and have the ability to interface with and provide information for passengers. Finally, there is the potential to reduce passenger fraud as conductors carry out a revenue protection role both because they interact with passengers and their known presence is likely to reduce the inclination to travel fraudulently.

4 Supporting Systems and Infrastructure

4.1 *Introduction*

4.1.1 This section of the report briefly outlines a range of general traffic measures which are considered complementary to the physical priority measures for BRT, and which when implemented as part of the overall package will help to reinforce the strength of the BRT scheme as an attractive alternative mode to the private car.

4.2 *Supporting systems*

4.2.1 In addition to the physical bus lanes, whether on-street or segregated alignment, there are a series of other traffic measures that can be used to assist the free-flow of the BRT vehicles, thereby ensuring the reliable journey time.

4.2.2 Some of these measures are aimed at giving BRT vehicles 'virtual' priority, where no physical features are used, but technology or road layouts can be used to get the vehicles through pinch-points with minimal delays to general traffic.

4.2.3 Other measures tackle causes of delays to BRT vehicles, so although not actually giving priority to the vehicle, they instead remove a potential source of delay which could otherwise impact on the service.

4.2.4 Brief descriptions of some of the types of measure are given below:

- Local traffic management strategies could be implemented to help provide journey time reliability to the BRT system by rationalising traffic movements and provide bus lanes;
- Residents' parking may be reduced from on-street areas to accommodate bus lanes, or the layout of parking changed from parallel to angled spaces, so that cars can access them more easily;
- The reduction or management of non-residential parking will restrain the number of people driving to an area. The proposed Park & Ride facilities will alleviate the shortages brought about by parking management and may increase patronage on the BRT.
- Park and Ride facilities could reduce the traffic on the roads and encourage more people to use the BRT. The reduction in traffic will help to provide journey time reliability and free-flowing services.

4.3 *Infrastructure*

4.3.1 The construction of new infrastructure is generally the most expensive element of a major scheme such as the proposed BRT system. As such, efforts will be made to minimise new build, partly so as to avoid the disruption that construction often brings, but also in an effort to get more efficient use of existing infrastructure (in part this may also act as a demand restraint measure).

4.3.2 Specific infrastructure requirements are discussed in the detailed route descriptions in Chapter 6.

5 Selection of Alignments in Malta

5.1 *Introduction*

5.1.1 The selection of alignments for a BRT route must be carefully undertaken in order to maximise the attractiveness of the route and hence revenue collected and policy effectiveness. Considerations such as long-term upgradeability to heavier modes (potentially with more onerous operating parameters such as curve radii) may force slight compromises to be made, but overall broad alignments should be achievable using the range of priority measures outlined previously.

5.2 *Policy background*

5.2.1 Two policy documents are driving the consideration of a BRT network. "A Public Transport Strategy for Malta", published in November 2005 and "BRT – a bus RAPID transit system for the Maltese islands. A consultation report and request for proposals", dated August 2005, set out the broad framework for a BRT system in Malta.

5.2.2 The BRT System report identifies routes for more detailed consideration, suggesting links which are either currently not provided or are existing bus routes sufficiently well used to consider upgrading to a heavier mode.

5.2.3 This study has taken the proposed corridors and briefly examined them for suitability for BRT. Those corridors considered more suitable are then assessed in more detail in the following chapter.

5.3 *Outline alignment assessment*

5.3.1 The BRT System report proposes a network of three BRT lines, connecting:

- Sea Terminal (both the Cruise Liner and the Gozo Ferry);
- Airport;
- City centre; and
- the Capital Projects.

5.3.2 Operationally three services are suggested:

- **Harbour Link** – St Julian's – St Elmo – Pinto Wharf – Valletta – Marsa – Paola – Dock No. 1 – Scamps Palace or Ricasoli

- **Air Xpress** – St Julian's – St Elmo – Pinto Wharf – Valletta – Marsa – Paola – Airport – Paola – Marsa – Islands Ferry Terminal
- **Islands Link** – Islands Ferry Terminal – Marsa – Valletta

5.3.3 Comparing the proposed corridors to the existing bus network, it is apparent that the sections of route from Valletta to St Julians and Cottonera are key movements on the island, with significant numbers of buses on these sections. As such it is logical that these corridors will be suitable for further investigation for upgrading to BRT.

5.3.4 As mentioned in the Halcrow 2005 report, Malta Airport is in an unusual position of being an international airport without a high-quality public transport link to its main city. Although potentially not the most significant of traffic generators on the network, the provision of a BRT link between Valletta and the airport will send a strong message that Malta is serious about dealing with growth in car traffic and is offering a viable alternative for arriving passengers.

5.3.5 The proposed Air Xpress route provides the further benefit of linking the airport with the Sliema/St Julians/Paceville area, meaning that tourists can reach their hotels along this section of coast without needing to resort to taxis or other transfer arrangements.

5.3.6 The benefits of providing this wider network of services is acknowledged, and is perhaps a suitable long-term plan in order to bring the benefits of higher-quality public transport to a wider population across the island. However, some of the proposed links, such as those to the Cruise Terminal and Island Ferries, have limited scope for carrying large numbers of regular passengers, and so should be considered as future phases of the BRT network, or provided by some other means with a high-quality but on an as-needed basis.

5.3.7 The relocation of the hospital from St Luke's to opposite the University, brings two significant destinations close together. Patronage on the University bus services seems to be building, and as can be seen from the existing pattern of services to the existing hospital, there is strong demand from all parts of the island to reach the hospital.

5.3.8 It is therefore a surprise that the Hospital/University has not been considered as part of the BRT network, giving quick access from the City Gate bus station to these destinations, thereby encouraging interchange between island-wide routes and the BRT for onward journeys to either institution.

5.3.9 Given the brief of this study, only a selected number of corridors are being considered for the first phase of BRT. However, long-term it would be hoped that this network could be expanded as developments come on stream and the 'ordinary' bus network is restructured and made more accessible to passengers.

5.4 *Summary*

5.4.1 The network of BRT services proposed in the BRT System report is considered to be a good starting point for further consideration. However, it is felt that some of the links proposed are not as strong as others, and so should not be progressed at this initial stage.

5.4.2 Similarly, it is felt that the University/Hospital complex should be examined as another branch of the network, so as to provide quick and high-quality links to Valletta for interchange with the island-wide bus network.

5.4.3 It is therefore recommended that routes from the Three Cities, Paceville, the airport and the University/Hospital be taken forward for more detailed consideration in this study.

6 Route Alignment

6.1 *Introduction*

6.1.1 The route alignment of the proposed network has been broken into nine sections. These are:

- Section 1: Malta International Airport to East of Luqa;
- Section 2: East of Luqa to Marsa Sports Club Park & Ride;
- Section 3: Three Cities;
- Section 4: Marsa Sports Club Park & Ride to Valletta;
- Section 5: Valletta;
- Section 6: Valletta to Msida Marina;
- Section 7: University of Malta/University to Msida Marina;
- Section 8: Ta Xbiex to Silema Point, and
- Section 9: Sliema Point to Paceville.

6.1.2 Each of the above sections of the corridors is described in detail below.

6.1.3 The number of halts associated with each of the corridors is shown in Table 1. The two corridors overlap and share "common" section alignments. At such locations, node interchange points will be promoted that enable users easy access to other destinations.

Corridor	Halts	Shared Halts
Paceville to Three Cities	15	6
University of Malta/Hospital to Malta Airport	9	

Table 1: Summary of Halts

6.2 ***Section 1: Malta International Airport to East of Luqa***

6.2.1 It is recommended that the BRT system starts at the door step to Malta International Airport. This would emphasise to all people arriving into the country that Malta has an iconic, state-of-the-art, safe, secure and rapid public transport system.

6.2.2 The alignment will access Malta International Airport from the north, diverging from *Route 28* utilising the access that is adjacent to McDonald's. At that point, a southbound contra-flow bus lane could operate parallel and adjacent to the airport terminus. Just south of the airport terminal (utilising the grass land), the BRT vehicle could carry out a 180 degree manoeuvre and travel nearside on a northbound bus lane, dropping passengers off at the departure section. The vehicle would then pick-up passengers adjacent to the arrivals section, which could also form a transport interchange node with possible reorganised local bus services from the south.

6.2.3 To egress Malta International Airport, a BRT gate could be provided (adjacent to Garages/McDonalds) giving vehicles egress directly onto *Triq L- Avjazzjoni* (*Route 1*), thus avoiding the airport's internal elongated road network.

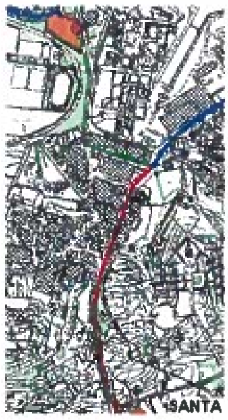
6.2.4 The **core alignment** then travels in the northeast direction, crossing fields before forming a new fourth arm with the roundabout east of Luqa (junction of *Triq Kunsill Ta'L Ewropa* with *Triq Garibaldi*). It is recommended to operate a park and ride site to the south of this roundabout. The land is currently used for small-scale agriculture or is dormant. Construction of a park and ride site would give car commuters from the south and east of the island a mode choice and help alleviate and control congestion by removing car trips from the network. The site has good catchment potential from areas such as Zejtun, Fgura and Santa Lucija. The addition of a park and ride site would also help increase patronage and thus revenue on the BRT service.

6.2.5 The **alternative alignment** would be to provide a private way between the two roundabouts on *Route 1* (towards Luqa) in the centre of the road. The section has recently been resurfaced and also undergone landscaping works. It would be necessary to modify the current highway and may also require some additional land. The alignment then heads east at the roundabout, passing south of Luqa and forming another private way, which connects to the eastern roundabout (junction of *Triq Kunsill Ta'L Ewropa* with *Triq Garibaldi*) via the park and ride site. At Luqa, it is possible to avoid the elongated roundabout by installing partial signals and utilising some of the landscaped land. In the latter section, the highway would be reduced to one lane in each direction for normal traffic (from observations, this is how it currently operates) to accommodate the two-way private way.

6.2.6 The route alignment is contained in **Appendix A**.

6.3 ***Section 2: East of Luqa to Marsa Sports Club Park & Ride***

6.3.1 From the proposed park and ride site, the alignment heads north, travelling on *Triq Garibaldi* towards the *Marsa Gyratory*. There appears to be adequate width to accommodate a private way, which would be located in the middle section of the highway, thus avoiding conflict with local accesses such as to the Marsa Industrial Estate. The roundabout at the proposed park and ride site would be modified to incorporate signals and thus minimise vehicle delay. On the approach to the *Marsa Gyratory*, and taking account of the proposed Marsa-Paola highway improvement scheme, the alignment would shift northeast, forming a short private way that connects onto the east-west roadway (middle road of existing *Marsa Gyratory*), which has proposals to be made into a spacious local access road. To accommodate the BRT recommendation, the Marsa-Paola highway improvement scheme proposal should take account of the BRT alignment and redesign or seek additional land, providing passive provision for the BRT alignment. An indicative sketch of the BRT alignment at the *Marsa Gyratory* is shown in **Appendix B**.

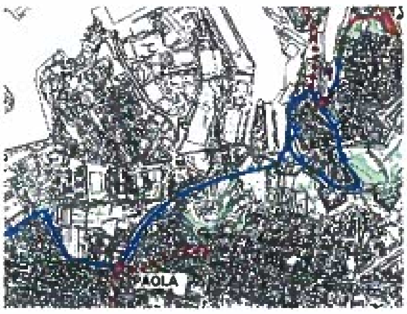


6.3.2 Both corridor services would utilise the proposed local parallel road adjacent to Marsa Sports Centre. If the proposed Marsa-Paola highway improvement scheme could accommodate bus lanes in the parallel road that would safeguard journey time reliability along the busy section.

6.3.3 A park and ride site is recommended at the Marsa Sports Centre, which the BRT would serve.

6.4 ***Section 3: Three Cities***

6.4.1 East of the *Marsa Gyratory*, the alignment (Service: Paceville to Three Cities) would travel east towards Vittoriosa and terminate at the bus terminus situated at the top of the hill. Due to geometric constrains it would be very difficult to achieve complete priority without major new infrastructure. In the section between the bus terminus and Cospicua,



it is proposed to have part private way and part bus lanes. On the approach to the square, space is tight and therefore a bus lane would be provided in the direction of the critical traffic peak.

6.4.2 From the roundabout (*Triq Ghajn Dwiells*) and Cospicua the alignment runs mainly on-street, sharing with other traffic - however there are stretches where one-directional bus lanes could be provided.

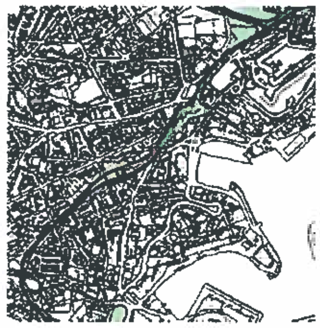
6.4.3 Between *Marsa Gyratory* and the roundabout (*Triq Ghajn Dwiells*) the alignment is via Paola Square, where an interchange node is proposed that links into the local bus services. The area has limited opportunity for exclusive BRT alignment, however partial bus lanes can be provided near Paola Square.

6.4.4 The route alignment of this section is contained in **Appendix A**.

6.4.5 The corridor has the flexibility to be extended further north-east into the proposed **Smart City** and serve the mixed use residential and commercial development. A BRT alignment should be incorporated within their Masterplan so to minimise car use and promote sustainable transport. Halcrow **strongly recommend** that the planning section of the council seek the provision of a fully segregated BRT alignment, which connects into the heart of the development as part of the Smart City planning condition. At an agreed date, in the future, the developer could be responsible for building the private way and associated halts as an item of planning gain.

6.5 **_Section 4: Marsa Sports Centre Park & Ride to Valletta_**

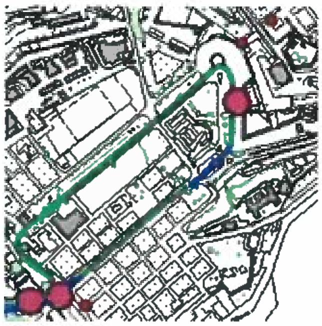
6.5.1 With the assumption the Marsa-Paola highway improvement scheme will be in place, the BRT will connect onto the *Triq Nazzjonali* from the local parallel route (as described in section 2) after leaving the Marsa Sports Centre. In the northbound direction, towards Valletta, there is an opportunity to provide either nearside bus lanes (buses and BRT) or an exclusive offside private way for the BRT. Along the section there are a series of bridge structures that restrict a continuous bus lane or private way due to width restrictions. To achieve a high quality BRT system, it is recommended to provide offside private ways, which on the approach to pinch points are equipped with bus pre-signals to minimise BRT delay.



6.5.2 Travelling in the southbound direction on *Triq Nazzjonali* a nearside bus lane could be accommodated in the section adjacent to Malta.Com. The BRT would then travel on-street sharing with other traffic towards the Marsa Sports Centre.

6.6 **_Section 5: Valletta_**

6.6.1 On the approach to Valletta the BRT would utilise the existing eastbound bus lane on *Triq Nazzjonali* then travel via *Triq Sarria* into a dedicated area within Valletta Bus Station. To improve journey time reliability it is recommended to extend the existing bus lane and also provide a small median strip between bus lane and highway on the street of *Triq Sarria.*



6.6.2 It is recommended to upgrade the junction of *Triq Sarria* with *Triq L' Assedju L-Kbir* to traffic signal control, which would be linked to the BRT vehicle to enable a "hurry call" facility, but taking account of any requirements for park and ride buses from the existing facility in Floriana.

6.6.3 The alignment would operate in a one-way clockwise loop onto *Triq Sant Anna* via Valletta bus station. *Triq Sant Anna* has adequate width for the provision of a nearside bus lane at the expense of removing a small element of parking.

6.6.4 West of the Marble Arch, as shown in **Figure 6.1** there is an opportunity to reduce the number of vehicle conflicts and help improve saturation flow to all vehicle users. At present two lanes of traffic from both the slip and *Triq Nazzjonali* merge into two lanes (passing the arch to the north) of which the nearside lane turns into a bus lane some 50 metres further east. The presence of the bus lane means all traffic is trying to merge into one lane. The illustration shows a simplified layout with additional nearside bus lanes on the merge and *Triq Nazzjonali.*

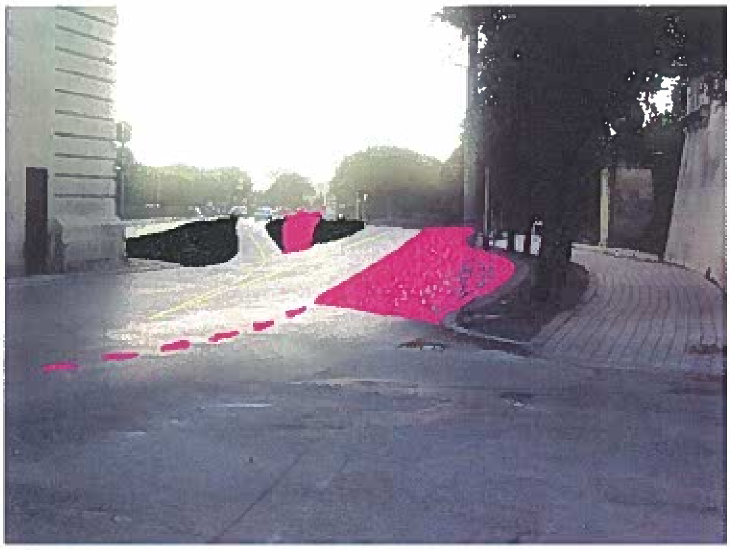
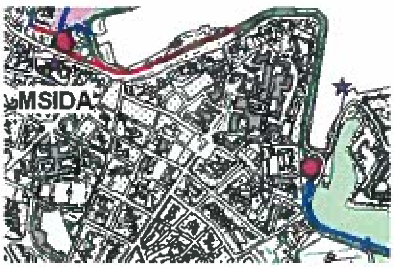


Figure 6.1 Bus priority measures at Portes des Bombes

6.7 ***Section 6: Valletta to Msida Marina***

6.7.1 It is proposed to provide a northbound bus lane on the outside lane of *Triq Il-Principessa Melita* (the slip) towards the roundabout at Pieta Creek. In the other direction, it is proposed to provide a nearside bus lane at the bend where the highway splits. This measure will benefit both BRT and local bus services.

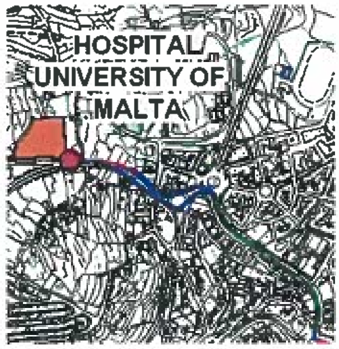


6.7.2 The theme of offside and nearside bus lanes will feature towards *Ix Xatt Ta L-Imsida* from the roundabout. There is an opportunity to upgrade the roundabout into a more compact junction, such as a T-junction, giving no delay to through traffic. On the approach to the Marina a private way is proposed in the landscaping area to the north (understanding that this is private land and may be difficult to achieve). At the end of the Marina, it is proposed to shift the westbound private way into the middle of the road and stop it short of the gyratory. At this point it will share with other traffic for a very short section before turning right (north) through the middle of the Gyratory (refer to **Figure 3.4**). There is an opportunity to reconfigure the gyratory and create a more direct connection to *Route 22* (corridor to University of Malta) and also a connection to *Triq D Argena.*

6.7.3 A westbound bus lane will be provided in the nearside lane of *Ix Xatt Ta' Ta' Xbiex* at the expense of removing parking, which will connect to the private way on *Ix Xatt Ta' L-Imsida.*

Figure 6.2 Route of busway through current parking area at Msida roundabout

6.8 ***Section 7: University of Malta/Hospital to Msida Marina***



6.8.1 This section would form the terminus of the University of Malta/Hospital to Malta International Airport Corridor. *Triq Dun Karm* (*Route 5*) serves areas to the west of Msida and offers the opportunity to provide an excellent park and ride location within land adjacent to the hospital. From our site observations, the area of land south of the bus terminus could be used and form a multi-storey car park. The land, which has a bitumen surface is believed to be owned by the University of Malta and currently operates as a car park. Alternatively, Malta Transport Authority (ADT) suggested that land allocated for a new bus station could be used and act as a park & ride site, potentially with the car parking located underneath the new University/Hospital interchange. Using either site, access from *Triq Dun Karm* is direct, utilising the grade-separated slips and roundabout adjacent to University of Malta.

6.8.2 On leaving the terminus, the BRT would use *Route 22* at the roundabout adjacent to Msida Marina. The route has two lanes in each direction and connects with *Triq Dun Karm* via a large roundabout, which is grade separated, connecting with *Triq Regionali* (*Route 1*). This short section could accommodate bus lanes by converting one lane of traffic over to a bus lane. This would help maintain journey time reliability but to maximise saturation for all other traffic a pre-signal could operate on the approaches. This means when there are no BRT vehicles in the section, vehicles utilise both lanes at the give-way of roundabout (westbound direction) and signals (eastbound direction), maximising saturation flow for other traffic. Alternatively, traffic signals can be installed operating with a "hurry call".

6.8.3 It may be possible to fit an eastbound private way on *Triq Dun Karm* on merging from the slip. A pre-signal would operate prior to the roundabout with Route 22.

6.9 ***Section 8: Ta Xbiex to Silema Point***

6.9.1 Between Msida Marina and Lazzaretto Creek the BRT alignment would run on-street sharing with other traffic on the streets of *Triq D'Argens/Triq L-Imsida* (northbound) and *Triq L'Abate Rogord* (southbound). A local traffic management strategy could be implemented to rationalise traffic movements and provide bus lanes, which would help provide journey time reliability to the BRT system.

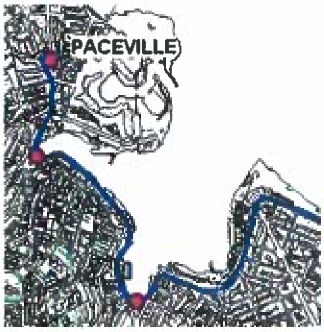
6.9.2 It is proposed to operate a private way parallel to the promenade on *Triq Marina/Triq Ix-Xatt*. To achieve this, the parking on the east side of *Triq Marina/Triq Ix-Xatt* would be removed and also involve the removal of a southbound traffic lane. To alleviate the removal of parking on the east side, the parking on the western side could be increased by altering the configuration from parallel parking to echelon parking. To gain the additional width required would mean removal of one traffic lane in the northbound direction. South of Manoel Island, the private way would run within the gardens, which means the removal or relocation of the petrol station and confectionary hut. The southbound BRT would then leave the private way and run on-street (*Triq L'Abate Rigord*). The northbound BRT would join the private way via *Triq L-Imsida*. To make such a manoeuvre, the short one-way section of *Triq L-Imsida* needs to be reversed to eastbound, thus providing easier access to a proposed private way in the gardens.

6.9.3 ADT have proposals for a new Manoel Island link road, which features two roundabouts, one built out over water and the other built within the gardens. These plans have a direct impact on the proposals discussed above. It is recommended that ADT take account of our recommendations and 'future proof' the BRT alignment.

6.9.4 Between *Triq Marina* and *Triq It-Torri* there are traffic management proposals that feature a northbound bus lane and the rationalisation of traffic movements. These benefit the BRT scheme. Adjacent to *Triq It-Torri* there is an opportunity to provide a private way on the promenade between TGI's and the junction of *Triq It-Torri* with *Ix Xatt Ta' Qui Si Sana*. However, discussions with ADT suggest the private way would not be acceptable due to the streetscape enhancement works currently being implemented along the promenade, which would need to be removed to accommodate the private way.

6.10 ***Section 9: Sliema Point to Paceville***

6.10.1 In this section there are limited opportunities to provide bus priority measures due to the tight geometric restrains and winding coast alignment. The BRT system will involve on-street running with all other vehicles unless major expense is provided to built out the quay walls. The section does not suffer significant congestion as the traffic flows are lighter compared to other parts of the network. Although BRT will be on-street there are some measures that can be accommodated to help journey time reliability for BRT and all other traffic. These are discussed in the "General Highway Issues" section.



6.10.2 The corridor starts and terminates in Paceville with a halt located on *Triq Gort*, at the north side of the recently landscaped square. The BRT vehicles would utilise the roundabout on *Triq Gort* as a turn round facility.

6.10.3 An alternative terminal option is to continue the BRT up past the existing Paceville bus terminus to another new Park & Ride site located immediately off the Regional Road, thereby intercepting cars heading from the coastal area towards Valletta.

6.11 ***General Highway Issues***

6.11.1 To help BRT, bus services and all other traffic a package of measures could be implemented along the corridor. In general, clear precise signage, visible lane markings (many are now worn), enforce give-ways and minimise confusion of weaving between lanes will help keep the network moving more smoothly and also improving the saturation of traffic lanes.

6.11.2 The following measures should be examined in detail:

- Rationalie traffic movements - local traffic only.
- Limit number of parking locations on corridor.
- Manage operation of service vehicles to restricted operational hours.
- Specify service bays – minimise blocking of highway.
- Promote "better driving" by instructing bus drivers to utilise current bus lay-bys. This will help free flowing traffic conditions to all other traffic. Also review bus lay-by provision with a view to removing unnecessary ones or enhancing others.

- Tidy up existing junctions to minimise conflicts.

6.11.3 At this stage of the study, traffic flows have not been considered and would form the next stage of the study. The area of land required and the amount of landscaping to be removed or relocated would also form part of the next stage.

7 Current and Future Demand for Public Transport

7.1 *Introduction*

7.1.1 Having undertaken a review of the routes deemed more suited for conversion to BRT on an engineering basis, this section of the report provides a broad overview of the current public transport demand on these corridors and comments on the future potential of the BRT services if implemented as discussed.

7.2 *Current Demand*

7.2.1 The Halcrow 2005 report undertook a route-by-route analysis of the performance of the existing bus network. Grouping services together on a geographic basis, it examined the financial performance of the routes and then made suggestions as to how resources could be better matched to existing demand.

7.2.2 The four 'arms' of the proposed BRT network generally mirror existing service groups, and so it is possible to gain an appreciation of the potential performance of the BRT by looking at the profit/loss accounts for the current services.

7.2.3 Using the 'Government Cost' value for the operation of the bus services in 2005, and comparing this with the revenue taken, Table 7.1 overleaf shows the profit or loss information available on the route groups for the seven week period analysed.

Table 7.1 Profit/loss for existing routes on proposed BRT corridors

Route	Destination	7 week profit/loss, Lm
1	Vittoriosa via Verdala	-4,136.87
3	Senglea	+574.45
4	Kalkara	-1,910.49
6	Vittoriosa	+7,377.91
8	Gudja – Airport	-2,369.52
62	St Julians	+10,649.48
64	Swieqi – circular	+6,762.70
66	Pembroke	+2,942.29
67	St Andrews	-6,414.99
68	Bahar Ic-Caghaq	-234.43
667	St Andrews – Regional Road	-2,025.53
69	University	-337.84
75	St Luke's Hospital	+6,747.18

7.2.4 As can be seen from the table above, the BRT is proposed to serve corridors which currently generally make a profit. Whilst not all the revenue would transfer to the BRT service, for example some intermediate movements may still be made by retained 'ordinary' buses between stops in-between BRT stops, the profit and loss gives a good indication as to the overall potential for the corridor.

7.3 *Additional revenue*

7.3.1 The table above deals only with the revenue situation on current services. As well as the revenue from the existing services on the BRT corridor, there is potential for significant further revenue to come from various sources, such as:

- passengers interchanging from other services, for example at Paola Square, for quicker overall journeys
- passengers swapping from their current route to BRT, if they currently have a choice of routes
- the high-profile service generating new demand, notably from car drivers
- the impact of demand management measures notably in the Floriana and Valletta areas

- provision of journey opportunities where none currently exist, or are difficult to make – Airport to Sliema for example.

7.3.2 The other main source of revenue is anticipated to be from the park and ride sites. The success of the new park and ride service into Valletta is a good example of local people choosing to avoid the difficulties associated with trying to find a parking space in or near Valletta, and so relieving congestion in the central area. When the revised Valletta parking arrangements come into force, it will be a useful benchmark to see how sensitive motorists are to the new parking regime and the associated cost.

7.3.3 As discussed in the previous section, the Strategic Park and Ride sites have been chosen due to their potential to intercept Valletta/Floriana bound motorists, and so relieve congestion and make road space for the BRT's own requirements. In the morning peak, the traffic queues are long coming down the hills from Luqa and Santa Lucija and feeding into the Marsa gyratory. By intercepting some of this traffic before it reaches the congested area, pressure is reduced on road space, thereby permitting road space re-allocation in favour of public transport.

7.3.4 Through the clever use of marketing and ticket pricing, the potential exists for encouraging weekday users of the Strategic Park and Ride sites also to use the facilities at the weekends or in the evenings, again reducing demand on the parking stock in Valletta and Floriana.

7.4 *Urban Mobility & Access to Valletta – questionnaire*

7.4.1 The survey of people who work in Valletta undertaken in October 2006 provides some useful indications as to what would be required to entice people to shift to public transport for trips to or from Valletta.

7.4.2 The current perception of the bus network by car drivers is generally poor, although recognition is given that some improvements have been made in recent years.

7.4.3 One of the most encouraging findings of the survey was that 72% of those interviewed said that they would consider using a BRT service if it were available. It is taken that this level of willingness for modal shift is partly due to the real issue of competitive journey times between car and other modes. The present bus network is generally uncompetitive due to the excessive journey time resulting for frequent stops and a lack of priority measures.

7.4.4 Another market which could be better served, is the evening leisure market into Valletta. Some respondents stated that the lack of a late bus service deterred them from going into Valletta for evening leisure, or that they drove. If a high-quality service were provided until late in the evening, after 11pm, more people may consider using the service.

7.5 *Summary*

7.5.1 Whilst the sample achieved for the travel survey was relatively small, it does provide some useful indications of trends and attitudes with regard to the potential market for BRT on the island.

7.5.2 As well as being used by existing bus passengers, the provision of a high-quality, reliable, frequent, all-day service, coupled with Strategic Park and Ride sites, means that the BRT network has great potential in attracting many new passengers onto public transport.

7.5.3 The choice of existing strong corridors is sensible as it provides the opportunity to revise the bus services on the corridor, but also puts the new service along routes of existing high demand. Additional measures to encourage further patronage, such as the park and ride sites and the re-organisation of more poorly performing bus services to act as feeders into the BRT routes, means that the new network has the potential for significant growth.

8 Integrating with Current Bus Services

8.1 *Introduction*

8.1.1 This note has been prepared to examine the impact and changes necessary to the proposed network of bus services put forward in the 2005 Halcrow Report.

8.1.2 The network proposed was based around the principal of core corridors that ensured that high frequencies were sustainable and therefore the principle of 'turn up and go' was available at a large number of stops.

8.1.3 The coverage of the island was inevitably reduced in that some services were deemed to be non-commercial. In these cases there would be services in some format as they would have been deemed as being 'socially necessary' and therefore procured and supported by the Government. The proposed network placed more emphasis on interchange journeys. The BRT proposals have followed the main sections of the proposed network but taken into account the full potential of the Hospital/University and the airport.

8.1.4 In any assessment of the changes necessary it must be remembered that interchange has a penalty in terms of time but also in the confidence of the user. This will be more apparent for people travelling on the BRT to make a connection rather that the other way round.

8.1.5 The BRT is assumed to have a core section of Marsa Gyratory – Floriana – Valletta – Floriana – Msida Creek with two spurs at each end being Airport/Paola Square and Hospital/Paceville.

8.2 *Paola Square to Sliema Shuttle*

8.2.1 In the proposals for the core commercial network it was recommended that a service be introduced that followed a route from Paola Square towards Valletta as far as Port de Bombes at which point it would head for Msida Creek and then follow the Coast Road as far a Paceville.

8.2.2 The principle of this service was a recognition that Sliema is an area of high employment and that Paola Square has passing through it a large number of services from the south-east sector of the island. At present significant numbers of passengers make this journey and that at the moment through interchange either at the Valletta Terminus or, more likely, at Port de Bombes.

8.2.3 The rationale of the Sliema Shuttle was to simplify this movement, make the interchange easier and it would also offer a potential time saving as for many it would avoid the journey from Port de Bombes into and out of Valletta.

8.2.4 As a separate benefit it would provide more capacity on the Valletta services by removing some of the interchange passengers.

8.2.5 Under a BRT option, the BRT vehicles would inevitably have to travel to Valletta in the short term but in the medium term an option of services following the shuttle route could be an option.

8.2.6 With no interchange required at Valletta and faster more reliable journey times then it could well be that the time saving offered by direct services is not cost-effective

8.3 *Paola Square – Valletta Services*

8.3.1 Under the core commercial network proposals of 2005 there were three route groups serving Paola Square with all services continuing through to Valletta:

- Route Group A: Three Cities – 3 services totalling 8 buses per hour
- Route Group B: Marsascala – 4 services totalling 7 buses per hour
- Route Group C: Marsaxlokk/Birzebbugia – 5 services totalling 9 buses per hour

8.3.2 This means that under the core commercial network a total of 24 buses per hour were scheduled to operate from Paola Square to Valletta which on the basis of 45 seats and 20 standing passengers per vehicle gives a total capacity of 1,560 per hour in each direction.

8.3.3 However none of the services start at Paola Square – it is merely the point at which the routes merge.

8.3.4 A complex issue here is that with 12 different services it means that there is a selection issue as to which services are to be terminated at Paola Square and which continue to Valletta. It is unlikely that the BRT could cope with the total volume of demand and that with the numbers of passengers transferring there would be a considerable time delay.

8.3.5 The approach to adopt is likely to be to terminate some of the lower frequency services at Paola Square – for example: the Marsaskala via Zonqor Point, Xghajra, Hal Far and Kalkara services and transfer to the BRT. The remaining higher frequency services could continue through to Valletta.

8.3.6 The issue of Smart City was not considered as part of the original bus plan as it was not at an advanced stage of development. However it is likely that it will require a frequent bus service whether provided by a modification or extension to the proposed network or by an extension of BRT.

8.4 *Route Group D – Airport and the South*

8.4.1 In the original proposals this group of services was found to be very poor in terms of revenue being generated and the network was complex. The airport was particularly poorly served as the only service serving the terminal was infrequent, irregular and indirect.

8.4.2 The 2005 proposals were to serve the area to the south of the airport with two services, one operating on a 20 minute frequency (Luqu, Mquabba, Qrendi and Blue Grotto) and the other on a 30 minute frequency (Kirkop, Safi and Zurrieq). The airport itself would be served by a 20 minute frequency direct service that would extend to Gudja.

8.4.3 The BRT service to the airport gives the opportunity to make considerable savings on this route group and improve its economic performance.

8.4.4 The revised airport service would be replaced by the BRT but the BRT would not serve Gudja and therefore this would either need to be served by a shuttle service. This could be expensive or another option could be to use the Kirkop, Safi and Zurrieq service and require interchange with the BRT for Valletta passengers. The service would then be extended to Gudja and possibly Paola thus serving Gudja but also linking the airport to Paola Square from where there are services to the Three Cities, .Marsaskala and Marsaslokk.

8.4.5 There would also be the option for the Luqa/Mquabba/Qrendi/Blue Grotto service to interchange but it is likely to need to continue to Valletta in order to fully serve Luqu (depending on route of BRT).

8.5 ***Route Group E – Rabat, Qormi and Zeebug***

8.5.1 These services would not be impacted by BRT as they would join the route at the racecourse for the final short leg into Valletta. To require interchange would result in a severe interchange penalty and it is unlikely that BRT would be able to cope with the volume of passengers.

8.5.2 If BRT services were to serve Sliema directly and not via Valletta then there would be a benefit in an interchange at either the racecourse or Port de Bombes to facilitate passengers making such a journey.

8.6 ***North-West Services***

8.6.1 Under the core commercial network proposals of 2005 there were two route groups serving the north-west of the island, most services going through to Valletta:

- Route Group F: Cirkewwa, Golden Bay, Mellieha/Ghadira
- Route Group G: Bugibba, Ghadira and Naxxar

8.6.2 Most of these services would meet the BRT at Msida Creek and again due to the interchange penalty and the short distance of their onward journey to Valletta it is recommended that these services continue through to Valletta. However currently there is already considerable interchange between services at Msida Creek (to Sliema) and at Port de Bombes (services south) and therefore the development of these facilities as proper interchanges is appropriate under any scenario. The impact of BRT would be to increase the potential and importance by increasing journey options.

8.7 ***Route Group H – Sliema and St Julians***

8.7.1 This route group is the busiest on the island in terms of passenger volumes and revenue. Under the 2005 arrangements it was proposed that there should be 14 buses per hour serving the main corridor from Valletta to the Paceville terminus and of these eight were on the current 62 service which would be directly replaced by the BRT.

8.7.2 The issue to be resolved is the services that carry on beyond Paceville, to Sweigi (1 bus per hour), Pembroke (1 bph), St Andrews (2 bph) and Bahar/Caghag (2 bph). The options would depend on how many of their passengers were on the individual legs compared with the core section. Assuming that the frequency and capacity of the BRT is sufficient it is recommended that these outer legs should all be served by local connecting services that either link in at Paceville or at St Julians. There may be the option to overcome the interchange penalty by offering a better frequency on the outer legs than was proposed subject to a demand analysis – in other words to make a more effective use of the bus hours committed to the services.

8.7.3 The other option would be to operate some of these services to Valletta direct via the Regional Road thus offering a faster journey time and potentially a link to the hospital.

8.8 *Route Group I - Birkirkara Valley*

8.8.1 This group of services is dominated by a 15 minute frequency service to the Hospital/University which if BRT was to serve this location would not be required.

8.8.2 The other services generally penetrate the densely urbanised area and therefore would remain largely unchanged although they would benefit from any interchange with BRT to enable additional journey options.

8.9 *Access to Priority Measures by Non-BRT Services*

8.9.1 Although the aim of the BRT network is to have an exclusive dedicated alignment, in order to provide attractive journey opportunities and reliable journey times, the land constraints along the identified corridors mean that some sections of the BRT route will be on-highway 'normal' bus lane. In particular the approaches to Valletta are very restricted in terms of available land, but are subject to high flows of buses to and from the main terminus.

8.9.2 Recognising the benefits of BRT to the wider bus network, it is proposed that selected sections of new bus lane will be available to all bus services passing along that section. This will help with the business case for the infrastructure, as more services will benefit from more reliable journey times, thereby increasing the attractiveness of the bus network as an alternative mode of transport to the private car. It will however be necessary to review the location of regular bus service stops to ensure wherever possible that stopping regular services do not impede through BRT services.

9 Operating Regime, Funding and Procurement

9.1 *Introduction*

9.1.1 This chapter examines issues associated with procuring the operation of Malta BRT service. It discusses the advantages and disadvantages of alternative procurement options and outlines the issues that need to be covered in any contract between the ADT as sponsors and an operator of the BRT service.

9.1.2 There are very strong advantages in proceeding on the basis that the services are to a single specification, promoted under a single identity to consistent standards, with unified publicity, information and ticketing. This will considerably enhance public comprehension and the impact of the new services which will be essential to building confidence and traffic. It will also make management of the contract with a single supplier straightforward as operators would be unable to take on a route with different specifications, different contractual start and end dates or conflicting operating standards. It is therefore assumed that a single contract - or co-terminus back-to-back contracts subject to a single procurement process - will be secured, whatever contractual framework is adopted. This means that a single entity will be contractually responsible for the provision of the network of BRT services or for individual sevices.

9.1.3 The ability to specify and secure the desired quality of service, its frequency of operation, operating hours and fares will depend upon the nature of the contractual agreements that can be made between the sponsor and the operator. The purpose of this section of the report is to explore each of the contractual relationships that are available to the sponsor. There are two broad types:

- direct in-house operation by an operating company or organisation owned by the sponsors;
- contract operation by a bus service operator selected by tendering process working exclusively to a service specification and contract terms set by the sponsor.

9.1.4 The service will be open to competition from other operators at least on the on public road section of the route. This distinction is important as the status of the alignment has a direct bearing on the ability of ADT to influence, control or restrict the operators that use it. This ability is important in order to ensure that service quality standards are maintained and that competing services do not erode revenue and patronage forecasts.

9.2 ***The Operating Contract***

9.2.1 By way of example authorities in the UK which have established in-house operations have chosen to do so through an arms-length operating unit in order to ensure transparency of accounting, and to demonstrate best value. A UK council cannot contract with itself, but it is essential if such transparency is to be provided that terms of operation are set out in similarly precise and unambiguous terms.

9.2.2 However it is procured, in essence the contract to provide the service will be little different to any other bus service procurement contract that seeks to establish a high quality contracted service. Halcrow's recent contracting for the Jersey network and Stratford-upon-Avon park and ride are good examples of service provision to a high standard. There is an important difference in Jersey where Halcrow also advised on establishing new legislation in that service provision is on the basis of competition for a seven year sole operator franchise – the competition takes place off the road. In addition to contractual requirements regarding the quality of vehicles, staff training and standards of operation, there are financial incentives for the operator for growing patronage and penalties for poor performance.

9.2.3 In the UK there are a number of contracted services, typically park and ride services, that require very high standards and include the following features:

- elements of operation off the highway that enable the contracting authority to legitimately restrict access;
- precise vehicle specifications;
- training requirements of drivers and restricted rota of drivers;
- requirement to carry a promotional livery;
- requirements to meet marketing and passenger information standards and/or to provide vehicles equipped to drive automated real-time passenger information systems;
- associated services (sometimes let as a separate contract) such as site or interchange security, maintenance and management.

9.2.4 Each of these elements is of relevance to the BRT concept.

9.2.5 There are two areas that require particularly careful consideration – the ownership of vehicles and the treatment, contractually, of revenue risk.

9.3 *Vehicle Ownership*

9.3.1 It is increasingly common for tendering authorities to purchase vehicles and make them available to successful tendered operators to provide services. The advantages of this approach are that it allows operators – often smaller, lower cost providers, who regard the cost of acquiring new buses for tendered work as high, an opportunity to bid for services. It also buffers operators against the risk of being saddled with ownership or ongoing leasing charges should a service be withdrawn early or, in the UK situation, should another operator provide it commercially causing early termination of the operating contract.

9.3.2 With a major risk and cost element transferred to the contracting body operators are likely to price more keenly. This is clearly advantageous to the authority. With a wide range of contracted services the implications of early termination of one particular contract are fewer for a tendering authority as vehicles, provided that they are of a reasonably standard specification, can be returned to a lease company or transferred to other tendered work. It is seen as important that the authority purchasing vehicles takes a view on the saleability of vehicles at the end of the lease or contracting period. Outright ownership of a highly specialist or experimental technology vehicle may mean it is difficult to dispose of at the end of a contract period. If the vehicles are leased the leasing company will take a view on the disposal risks involved and price the leasing arrangements accordingly. Specialist vehicles tend to incur higher leasing charges than conventional vehicles with a ready market for re-lease. This is likely to be a particular issue in a location such as Malta where disposal options are fewer.

9.3.3 Most tendering authorities that provide their own vehicles do so for the operation of complete services as opposed to low demand 'top-ups' or route extensions. Thus the practice is most common for rural services or specialist services such as access bus services or dial-a-ride. However Warwickshire County Council has assumed responsibility for the vehicles that will provide the Stratford – on – Avon park and ride service and it is likely that Glasgow City Council will do the same for their BRT system.

9.3.4 If however the operator retains ownership of the buses the sponsoring authority is relieved of the financial and operating risks associated with ownership. Whilst the operator will increase its operating cost to take account of the risk, any failures due to vehicle problems such as those associated with new technologies become a contractual matter between the sponsor and operator, with the operator responsible for ensuring the operation of a compliant service. These risks of ownership are more readily absorbed, and will consequently priced at a lower risk premium, where vehicle specifications are close to the normal standards the operator would apply so that vehicles can be redeployed to other work should the contract ultimately fail to be renewed.

9.4 *Revenue Risk*

9.4.1 Where revenue risk lies contractually is of primary importance. There are two basic contract formats for shouldering revenue risk. These are known by various terms but in essence in differ in one respect – where the risk is carried. In cost based contracts the risk is carried by the sponsor. An operator tenders an operating cost and is paid that sum. All revenue is vested with the sponsor and the risk that revenue falls below forecasts is carried by the sponsor.

9.4.2 In subsidy based contracts the operator simply tenders a sum that they require to provide the service. They take the revenue risk and retain all revenues taken. This latter model is most appropriate where a tendered provision tops up or in some other way complements a commercial service, additional evening journeys for example. There are also hybrid models in which, for example, bonuses can be paid to encourage operators to maximise revenue within a cost based contract. This model does not preclude an operator paying a sponsor a premium if a service revenue is judged to exceed costs.

9.4.3 In order that the overall contract costs to the authorities are minimised it would be prudent for them to shoulder the revenue risk and to contract on a minimum cost basis with an operator. Consideration could be given to establishing a revenue incentive regime with the operator to encourage revenue generation and the operator share additional revenue over agreed thresholds to reward operator initiative. Once revenue patterns have become established there may be merit in changing the basis of tendering for the second and subsequent terms, or, as a minimum, seeking bids on several bases, for example cost based (sponsor takes the risk), subsidy based (operator takes the risk) or a hybrid basis with risk thresholds.

9.5 *Main Contract Elements*

9.5.1 The main areas to be delineated in a contract to ensure quality standards are met and capable of monitoring include the following. The same issues need to be considered and resolved if in-house operation is contemplated, though with the advantage that in some aspects in-house operation could allow more flexibility where a contract may have to run its full term before certain elements could be respecified.

Contract Term

9.5.2 A contract term will require to be specified with the start and expiry dates for the contract. The contract term may be for a fixed period with an extension if performance meets agreed standards. Standard conditions of contract are expected to include topics such as sub-contracting, indemnity, price variations and so forth. ADT will have standard contract terms but for this specialised service it may be appropriate to supplement contract conditions. The maximum contract term for a standard bus subsidy contract in the UK is five years with no minimum period. There is no specified limit to the period for which in house operation might be undertaken, although the sponsor will have to continuously demonstrate Best Value in such an undertaking. In general Halcrow recommend somewhat longer periods especially where a service ramp-up is involved or significant investment is required.

Service Specification

9.5.3 As a basic requirement this will include days and dates of operation, route description, stopping points, first and last bus times and frequencies or timetable where there are irregularities in the frequency. If there are route variations a separate frequency/timetable and tender offer is required. Quotations should be invited for variations on a per bus-kilometre or bus-hour basis to allow for the expansion or contraction of the original specification if foreseen circumstances change during the currency of the contract.

Vehicle Specification

9.5.4 Whilst high quality vehicles are an essential element of the concept the costs of tendering on a number of vehicle options, which may convey different images but nevertheless will fulfil the requirements of the service should be tendered for to establish price differentials. Vehicles with a maximum age at the commencement of the contract or with a maximum age throughout the life of the contract can be specified. Alternatively the purchase or lease of vehicles by the tendering authority as described above is another avenue that could be pursued

9.5.5 Within the vehicle specification items such as seating capacity, step heights, and features such as luggage space should be specified although there should be a valid case for exceeding statutory requirements as this may result in the need for a non-standard product that is likely to cost more to buy or lease. Note that many such standards are specified in the Disability Discrimination Act (DDA) in the UK so that the real scope for higher standards set by the sponsor lies in design factors such as increased luggage provision, leg room or seating quality. These standards are based on wider European requirements such that there are few differences between requirements across the EU. The livery of vehicles and back-up arrangements, (not of necessity with liveried vehicles), require specification. Whether liveried vehicles may be used on other services by the operator needs determination – such a practice can undermine the purpose and value of promotions.

Fares

9.5.6 On a cost based contract the fares revenue is remitted to the sponsor who will therefore be the controlling authority in relation to fares levels and will require to take the commercial judgement about fares levels against levels of patronage and net income. In a subsidy based contract the sponsor may seek to control fares or leave them to be determined by the operator in accordance with market circumstances. If the sponsor has specific objectives in relation to affordability either direct control of fares or some form of fares cap may be required to ensure those objectives are met. In such an event an operator will require a very clear statement of the basis on which fares are to be set, on which they may be subsequently varied and any price adjustments to the contract that would follow from a fares adjustment, or it would be impossible to price the contract. Similarly if a revenue incentive arrangement is in place with the operator there needs to be a mechanism for agreeing changes set out from the outset. In general a sponsor should not inhibit competition by the terms on which they set service levels and fares, which means in practice that any fare levels which are not in line with the normal level of prevailing fares in the area require to be justified by reference to data, policy and clear evidence of social needs.

9.5.7 The treatment and accounting of concessionary fares where they apply should be covered – the service should be fully integrated with any wider area scheme.

9.5.8 To ensure integration between BRT and other services and to maximise the value of BRT to the island as a whole it is important to ensure that the users of the service can take advantage of any operator or network and pre-purchase tickets which are more widely available. The proposed service is sufficiently important to warrant the appointment of a service 'champion' whose sole job is to promote its availability and qualities.

Driver Standards

9.5.9 To ensure high standards of passenger care consistent with all other aspects of the operation a requirement for all drivers used on the service to have successfully undergone a recognised customer care training course should form a part of the contract. They should receive appropriate top-up training and training in disability awareness. It is reasonable for a service of this importance for the procuring agency to require a statement from tenderers on their training policy and for the contract to incorporate specific conditions relating to training.

Vehicle Cleanliness and Cleaning

9.5.10 Vehicle cleanliness is an important aspect in the projection of the image of a service. The contract should set standards of internal and external cleanliness in terms of wash frequency, internal cleaning and deep cleaning. It is reasonable to require the bus to be emptied of dry litter once per hour or so, for example by the driver walking through each time the bus returns to the terminal. Vandal damage should be reinstated at frequent intervals and exterior panel damage repaired quickly with any livery graphics fully reinstated.

Publicity

9.5.11 The respective split of responsibilities between the sponsor and the contractor needs determination. Standards for the provision and maintenance of bus stop, on-bus and other off-bus publicity will need thinking through and included in the contract as appropriate.

Monitoring

9.5.12 Where fare revenue is remitted to the sponsor an audit of fares collection and revenue collected needs to be specified in the contract and the sponsor will need to bear the cost of doing so. This is also likely to be necessary in the case of in-house operation in order to ensure that money collected and banked can be fully accounted for. Where revenue is retained by the operator, the sponsor will still need to secure access to the data for monitoring purposes through contract conditions. Arrangements could be based on those already in place between ADT and the operators' association, with suitable amendments.

9.5.13 A comprehensive but easily deliverable set of operating statistics needs to be determined and included in the contract documentation covering all areas of operator performance. Consideration should be given to monitoring quality aspects including driver behaviour and customer care through mystery traveller sampling. A points system for contract non-compliance and ultimate payment deductions can be included.

9.5.14 The issue of recovery of vehicles from any exclusive alignment needs addressing and whether this is a contractual issue needs determination. If this is the responsibility of the operator then a maximum recovery time needs to be determined and a penalty regime included in the contract to ensure that there is a strict discipline for informing and transferring passengers and not losing service journeys in the event of vehicle blockage of the alignment.

Service Management

9.5.15 It is important that the service is managed in an integrated manner. The conditions of contract should specify a maximum frequency for management group meetings and require a nominated empowered individual (or post) to attend on behalf of the operator. This is no less important in relation to in-house operation, especially as there would be two sponsors.

9.6 Fare Collection

9.6.1 Any service in which the sponsor takes the revenue risk and where there is no financial incentive for the operator to maximise revenue runs the risk of the operator failing to make every effort to ensure that revenue collection is as efficient as possible. Measures to maximise fare collection will depend on the fare structure, the ticketing regime and the level of enforcement.

9.6.2 It is likely that the fare structure of the service will be fairly simple with a small number of single fares. These will be available to passengers paying at the point of travel. As in central London, boarding times can be greatly reduced through a policy of not issuing any tickets on the bus. Passengers buy a ticket from an at-stop machine and this is verified on boarding visually by the driver or by an electronic ticket reader.

9.6.3 However in reality such systems require very extensive levels of ticket inspection in order to minimise fare evasion. Moreover if there is no on-bus sales by the driver the provision of at-stop machines needs to be comprehensive and the machines kept well stocked and maintained and, for security reasons, emptied of cash on a frequent basis. In London and on other machine based networks such as Manchester Metrolink at least one machine is stationed at each stop. This implies a large number of machines for Malta BRT with machines at every stop including little used boarding stops such as the penultimate stop at each end of the route in the terminus direction.

9.6.4 Systems that had been predicated on at-stop machines such as Midland Metro and Nottingham Express Transit have abandoned the concept. Midland Metro installed machines but stopped using them shortly after the start of service as did Sheffield Supertram. Nottingham decided to switch to conductors prior to start of service so did not incur significant aborted costs. Sheffield Supertram switched to conductors after early difficulties with machines. The problems with machines in these locations centred on vandal damage, attempted theft, concerns about personal security and machine maintenance and servicing issues.

9.6.5 However two systems that use off-vehicle purchase, Manchester Metrolink and Tyne and Wear Metro suffer relatively high levels of evasion.

9.6.6 There are issues with conductors, although at least two of the systems believe that the costs of conductors is similar to that of machines bearing in mind servicing and other maintenance costs. The key operational issue is the ability of a conductor to get round the vehicle in order to verify tickets or collect fares. If the vehicle is full it will be difficult for a conductor to circulate. Equally if there are significant boardings at a stop relatively close to the terminus, for example Porte de Bombes in the direction of Valletta, it may not be possible to issue all tickets. Nottingham Express Transit has overcome this problem at its inner park and ride site through the use of an at-stop conductor.

9.6.7 If First's 'ftr' vehicle were to be used on the service the vehicle can be equipped with on board ticket issuing and verifying machines at all entrances. However the ergonomics of the vehicle impacts on boarding streams and boarding times and the system is understood to have been abandoned. There appears to be no reason why, if appropriate, a similar system cannot be specified on any operator's vehicle although revenue and technical risks need to be carefully assessed. It is also worth pointing out that the 'ftr' vehicle is being marketed by its manufacturer to any operator and whilst the operating package is unique to First, the vehicle is not.

9.6.8 It is important that the onus for comprehensive fare collection is placed on the operator. However it would be inappropriate to saddle an operator with an operating situation that means that it is very difficult to achieve an acceptable level of collection. There is a case for early discussions with operators regarding the issue of fare collection. The issue of early operator involvement is discussed below.

9.6.9 A further ticketing and revenue issue to address is the way in which interchange revenue is credited to the service. It is desirable and likely that many journeys on BRT will be interchange journeys with passengers transferring to or from other bus services. The service will need to be credited with an element of revenue from pre-purchase or network tickets and, as appropriate any operator based tickets. Where the operator is required to bear the revenue risk it will be essential that the terms of participation in multi-operator ticketing are clear prior to tendering so that the operator can factor realistic revenue assumptions into his price.

9.7 *Other Incentive Issues*

9.7.1 The proposed service represents a step change for Malta in terms of service delivery, with very high standards of vehicles, reliability, cleanliness, marketing and publicity, passenger information and driver customer service standards. It is suggested that drivers work from a limited rota and that they are incentivised to become very familiar with the service in terms of locations served and so forth. They will act as ambassadors for the service. Throughout Europe the better run park and ride services (mainly contracted) and commercial services provided by high quality operators are provided on this basis.

9.7.2 The service specification and conditions of contract on the face of it should be capable of addressing the issues required to ensure high quality provision. However the image and quality of the service will be dependent on the attitude and actions of a much wider group of partners including roads maintenance agencies, those responsible for shelter maintenance and cleaning, posting timetable information, the agencies responsible for maintaining any electronic information and so forth, and traffic enforcement agencies.

9.7.3 As noted earlier it is strongly recommended that in order to promote and support the service a BRT 'champion' be appointed to promote the service. This person would be dedicated to promoting the service, with no other responsibilities. It is suggested that they operate from a 'shopfront' premises on the line of route and that they are in post at least six months in advance of the start of the service. Duties could include:

- liaison with employers on the line of route regarding employees travel planning;
- managing a budget to make promotional offers to employers;
- arranging at-stop marketing and passenger information;
- setting up any at stop VMS messaging;

- creating marketing material for businesses, for example BRT 'flashes' to attach to letter heads, websites, etc;
- ensuring tourist guides, airline magazines, holiday brochures and websites promote the service from Luqa Airport and more widely;
- promoting park and ride facilities;
- promoting the service on interchange modes; and
- servicing the scheme management and monitoring group (see below).

9.7.4 It is important also that the scheme has a regular management and monitoring regime. It would be the responsibility of the champion to service this group. Membership of the group should include:

- representatives of the operator;
- ADT officers;
- local employers' representatives;
- developers and housing agents;
- the airport, hospital and university;
- major leisure attractions; and
- a drivers' representative, for example the lead driver for the team.

9.7.5 Notwithstanding the existence of the service specification, contracts and penalties regime it is important to devise and widely promote a partnership document between key partners in the scheme expressing their commitment to quality operation, service development and customer service. The scheme may also include a driver award programme. More generally once revenue patterns have become established there may be scope in creating an operator bonus arrangement where, as a result of the efforts of operators, a bonus can be paid. This could be linked to a driver bonus arrangement.

9.8 *Early Operator Involvement*

9.8.1 Although the current tendering arrangements preclude the selection of a preferred operator prior to tendering there is merit in including operator involvement at the planning stage. This could be achieved through the involvement of more than one operator and inputs could be sought also from a representative of the ATP.

9.8.2 The advantages of early operator involvement are that operational issues could be identified early in the service planning process. Inputs could also be made to detailed implementation issues such as the precise detail of bus priorities and the detailed configuration of stops and passenger information.

9.9 ***Franchise Operation/In-house Operation by the sponsor***

9.9.1 Consideration has also been given to the possibility of operating the service as a franchise or direct operation by ADT. If a franchise is to be pursued it would be necessary to go to the bus operations market in much the same way as if the service were being procured under the transport legislation. If however the service were to be operated by ADT directly then there are further legislative issues to consider. Although there are examples of limited public operations by authorities in the UK, these may be open to legal challenge and there is no case-law to establish the limits of authorities' powers in this area. A number of authorities use in-house fleets to provide client transport, for example for social work department clients and special needs and general education transport. Some vehicles are used to provide limited socially necessary services.

9.9.2 However Norfolk County Council in the UK operates two of the six park and ride services in the Norwich area. The provision is made by an "arms length" company owned by the County Council that also provides in-house transport provision for social work clients and operates the County's large fleet of yellow school buses. The significant difference between park and ride provision, a fare paying service open to the general public, is that the services were procured through competitive tender and the council's company was required to tender along with local bus operators. The council's company has also won a contract to provide a new Norwich orbital bus service, again a fare paying service open to the general public, but now withdrawn as a result of poor patronage.

9.9.3 It is understood that the ADT does not have any established companies with "arms length" status capable of providing the service. Assuming that Maltese legislation permitted this approach it would therefore be necessary to set one up and for this company to meet the necessary requirements regarding professional competence, maintenance and so forth. This would be a major requirement for a relatively small operation unless it is integrated with other elements of the ADT's transport operations

9.9.4 In the UK the legislation for London is very different, and closer to the models that apply elsewhere in Europe. There is not a full deregulation situation and there is no on-the-road competition. Bus operation in London is secured by Transport for London (TfL) through a series of contracts or franchises secured through competitive tender. They are on a cost basis with all revenue banked with TfL. Operators are required to declare their profit margin in the process and there is a maximum margin permitted by TfL. There are no other local bus services franchises in the UK although in the British Isles there are franchise arrangements operating in the Isle of Man, Guernsey and Jersey, these locations being outside the scope of the current UK transport legislation.

9.10 *Summary and Conclusions*

9.10.1 Two options for the procurement of the BRT service have been identified and discussed. Whatever approach is taken the need for a clear, unambiguous specification for the service is evident. This is both to ensure that the service provided matches expectations and delivers the scheme objectives, and also to ensure that both sponsors come to an agreed expectation about the details of service levels and standards. This will also provide a clear basis on which to monitor outcomes and to adapt the service to the evolving circumstances.

9.10.2 The pros and cons of each service delivery option are as set out in table format below:

Advantages	***Disadvantages***
In-House Operation by Sponsor	
Direct Control over all aspects of the operation Flexible/adaptable at short notice No 'risk premium' Any ultimate operating profits would be in-house	All costs including set-up costs fall on sponsor High management overheads Limited back-up including management Total risk falls on sponsor No control over competition Long term asset acquisition with risk that asset outlasts the BRT service itself Possible legal challenge
Contract Operations: (includes options for contractor or sponsor ownership of vehicles and cost based or subsidy based pricing)	
High degree of control over service and vehicles specifications Potential for risk and revenue sharing Low marginal costs of overheads Shared management expertise Short-term commitment Direct enforcement of standards	Risk premium incorporated into the price No control over competition

10 Conclusions and Recommendations

10.1 *Introduction*

10.1.1 Malta's growth and development is placing heavy demands on the existing highway and public transport network, leading to increasing congestion on the highway network and problems associated with a high-density urban fabric with little scope for significant capacity enhancement.

10.1.2 In order to address some of the issues associated with the development of the island, it is felt that the public transport network could play an increasingly important role in encouraging journeys to be made by modes other than the private car.

10.1.3 Whilst the 2005 bus study recommendations will put the bus network on a more secure financial footing and form a foundation for a bus system more attractive to the local population, the Government recognises that there is a need for a new integrated national public transport system to encourage a step change in mode share in favour of public transport.

10.1.4 Research by MUDR/ADT has shown that BRT is the most applicable system in the tight road network of the island and could comprise a combination of median running, dedicated running, signal priority and strategic bus corridors or enhanced bus ways.

10.2 *Bus Rapid Transit*

10.2.1 European-style BRT is typified by very high quality vehicles operating on a combination of prioritised roads, lateral or median exclusive alignments within the highway, and sections of dedicated segregated busway, usually with fewer stops than conventional buses. The consented Glasgow, Scotland Fastlink scheme, is a good example of this type of scheme. The 'ftr' scheme now operating in York, England, operates in an historic environment of tight streets and relies much more on advanced transport telematics to secure priority at signals and priority access through pinch points.

10.2.2 This type of BRT scheme can offer a directional passenger capacity of between 4,000 and 4,500 passengers per hour at a two minute headway. More typically they operate at a five minute headway, shifting 1,500-1,700 passengers by direction.

10.2.3 An important aspect of BRT can be the ability to upgrade to tracked transit should demand justify this and the alignment and parts of the infrastructure for the Malta scheme has been designed with this potential in mind.

10.2.4 BRT can be on segregated roads driven conventionally by the driver or guided using the proven though the intrusive kerb guidance system or other types of guidance, optical, electronic or mechanical, all less well established systems.

10.2.5 Integral to almost all systems are important supporting features such as signal pre-emption, high quality passenger infrastructure passenger information systems in real time and an integrated high speed ticketing system all of which support operating efficiency and system image.

10.2.6 The BRT alignment will consist of a package of elements: private way (segregated exclusive alignment for the BRT), bus lanes, bus gates and priority signals. The BRT system could also feature tram like vehicles, iconic halts (bus stops), pre-paid tickets and a theme to promote an exclusive type of transport.

10.3 *Conclusions*

10.3.1 The study has examined a number of corridors for the potential for conversion to BRT, and has then gone on to provide more detail about engineering options for the preferred routes.

10.3.2 A core section of route running from the Marsa gyratory, into Valletta and back out the Msida creek, would be used by all BRT services, with branches at the outer ends serving the Airport and Cottonera (with the potential for extension on to Smart City) on the eastern side and the University/Hospital complex and Paceville on the western side.

10.3.3 A combination of priority measures is proposed along the routes, including on-street bus lanes, general running with traffic and new segregated alignments. These physical measures are to be reinforced by other measures such as residents parking schemes and slight revisions to one-way systems.

10.3.4 In addition, new Strategic Park and Ride sites are proposed at locations prior to existing congestion black-spots, at Luqa/Santa Lucija and the University/Hospital. A potential third site could be located just off the Regional Road in Paceville.

10.3.5 Broad analysis of the performance of the existing bus services on the corridors identified, shows that the BRT services have significant potential. As well as attracting existing bus passengers, the routes are likely to be more attractive to car drivers by offering consistent and competitive journey times to those currently achieved by car. Transfer to BRT could be reinforced through demand management measures such as parking control and the proposed Valletta/Floriana charge scheme.

10.3.6 It is this reliability of journey time that offers the strongest benefits of a systematic network of priority measures implemented for the BRT network.

10.4 *Recommendations*

10.4.1 It is recommended that further work now be commissioned to progress the outline priority proposals to a more detailed level, to verify that the measures are feasible and further examine the scope for additional small measures (such as revisions to parking arrangements) that will help achieve a high-profile BRT service.

10.4.2 This more detailed work will allow costs to be generated for the infrastructure improvements, and hence a full economic appraisal to be undertaken for the scheme.

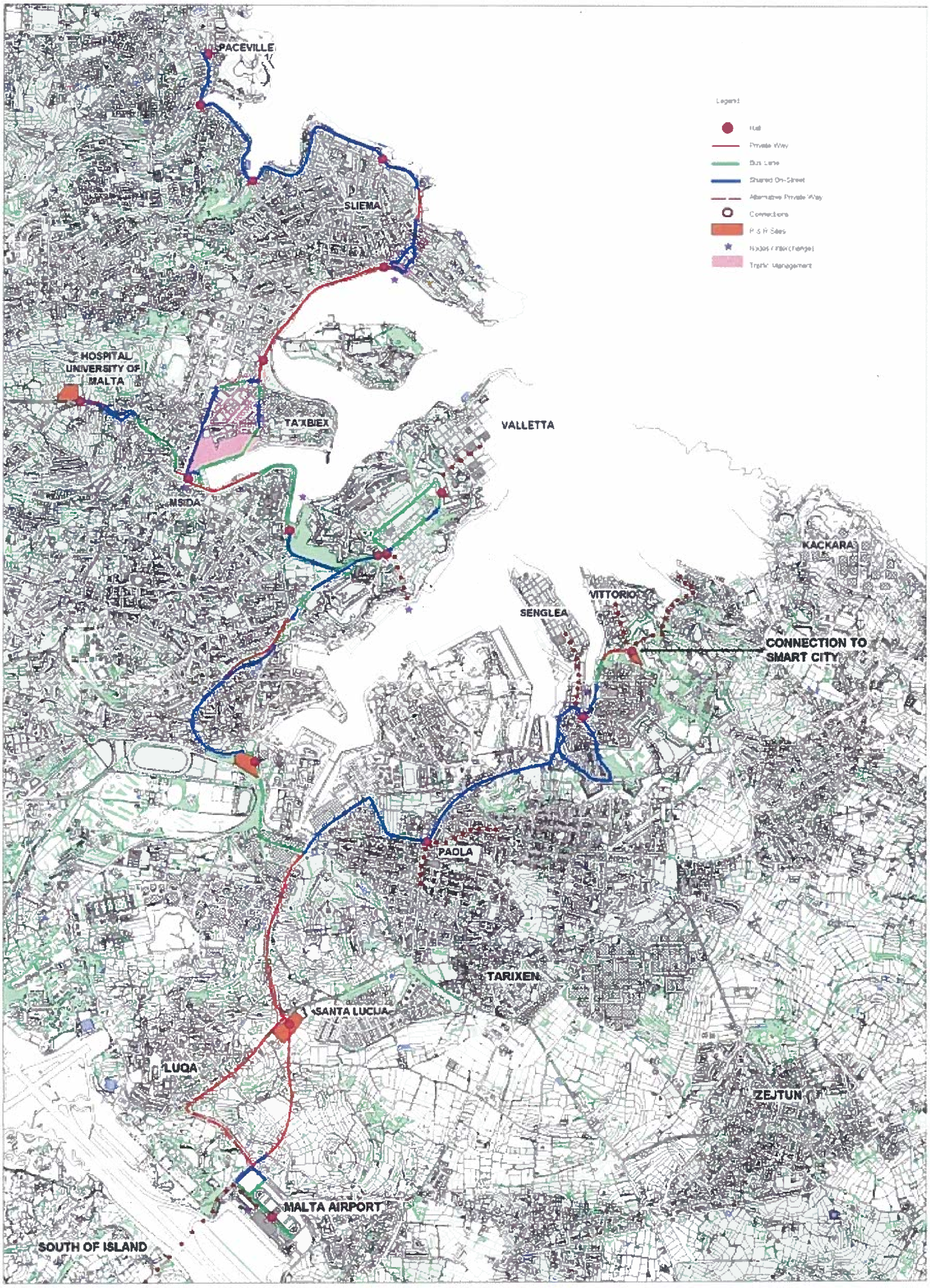
10.4.3 In terms of preferred mode for the system, in the initial stages some form of high-quality upgraded bus should be used, so as to protect from the risks associated with trialling new unproven technologies and also giving a lower-cost start-up to the system.

10.4.4 The use of low-emission, low-floor diesel buses (either 12m rigid or 18m articulated), with an attractive and bold livery and associated marketing and ticketing systems, will very much distinguish the BRT service from the existing bus network. The use of high-specification but standard vehicles will also allow the easy upgrading to heavier modes such as Wright's Street Car, by having vehicles which retain their value on the secondhand market and therefore reducing the financial exposure associated with less standard vehicles.

10.4.5 Consideration needs to be given as to the desired level of revisions to the existing bus network, so as to complement the new BRT services. The proposals outlined in this report, for the truncation of some services to feed into BRT at selected interchange locations, should be considered in detail. The release of resources on the existing network could the either be re-invested elsewhere in the local bus network, enhancing other services away from the BRT corridors, or could permit the withdrawal from service of some of the less suitable vehicles currently used.

10.4.6 Overall it is felt that BRT has great scope for offering a new level of public transport to the Maltese islands, and hence encourage modal shift to more sustainable modes of travel.

A Route alignments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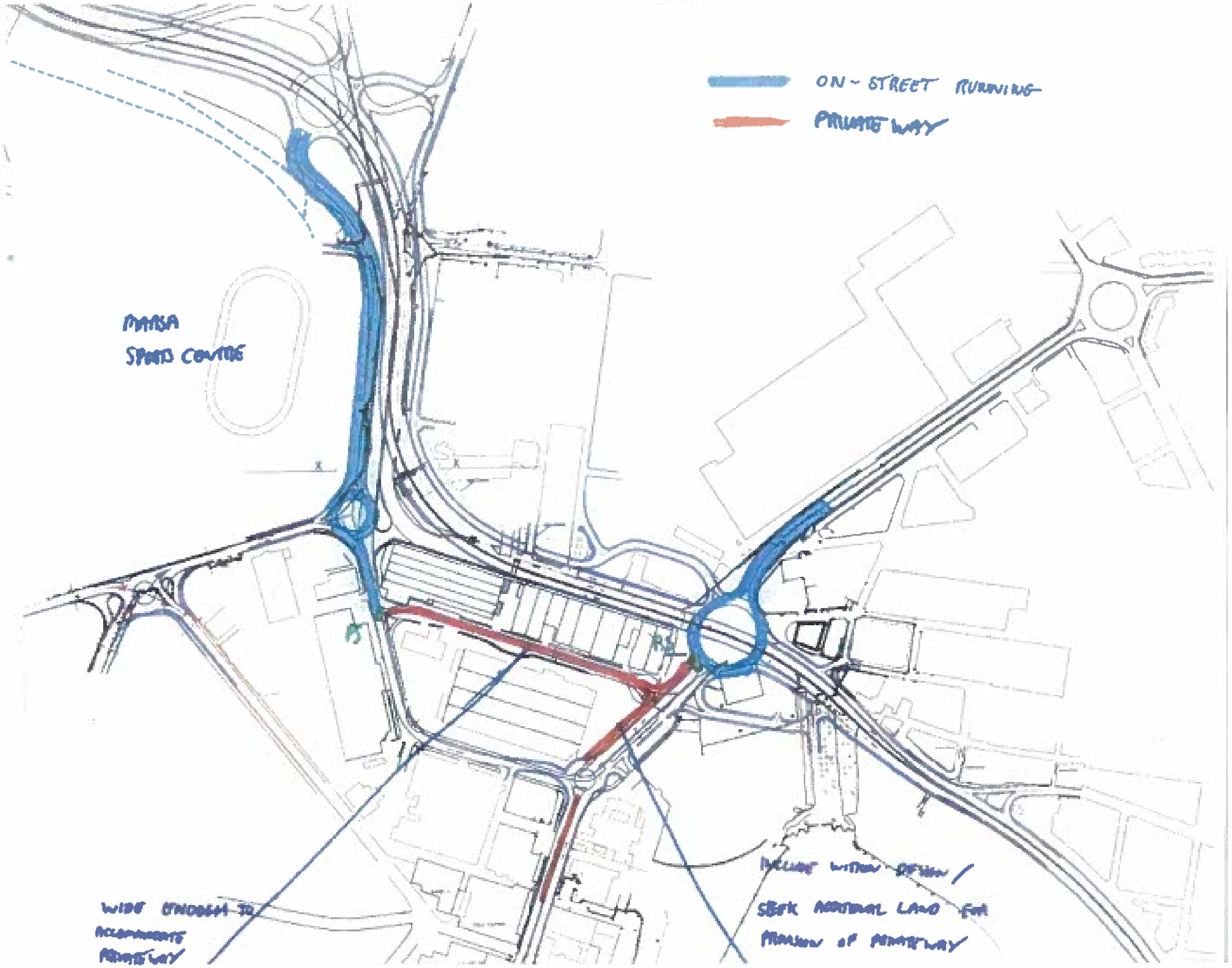
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