Malta-Gozo Tunnel

Project Description Statement

Transport Malta

Malta Transport Centre
Triq Pantar,
Ħal Lija LJA 2021
Malta

www.transport.gov.mt

May 2018

<table>
<tr><td>Assignment</td><td colspan="3">Project Description Statement</td></tr>
<tr><td>Project Title</td><td colspan="3">Malta-Gozo Tunnel</td></tr>
<tr><td>Location</td><td colspan="3">Malta, Gozo</td></tr>
<tr><td>Applicant (Developer)</td><td>Mr James Piscopo
Chief Executive Officer
Transport Malta
Malta Transport Centre
Triq Pantar,
Ħal Lija LJA 2021
Malta

T: +356 22914505
E: james.piscopo@transport.gov.mt</td><td>Architect Warrant Holder under the Periti Act, 1996 (Cap. 390)</td><td>Perit Sarah Pace
Major Projects Unit
Roads and Infrastructure Directorate
Transport Malta
Vjal l-Avjazzjoni,
Luqa LQA 9023
Malta

T: +356 25555246
E: sarah.a.pace@transport.gov.mt</td></tr>
</table>

Revisions	No.	Date	By	Reason for Revision
	00	May 2018	SP / EG	First draft.

Table of Contents

Endorsement

James Piscopo
Chief Executive Officer
Transport Malta

Transport Malta

Malta Transport Centre
Triq Pantar,
Ħal Lija LJA 2021
Malta

www.transport.gov.mt
T: +356 2555 5210

Section 1 Introduction

1.1 Outline

This Technical Report is the principal document of the Project Description Statement (PDS) that refers to the development permission for the Malta-Gozo Tunnel project. This document is being prepared in line with the requirements of L.N. 412 of 2017 – Environment Protection Act (Cap. 549), Schedule II (Regulation 12), which outlines the information to be provided in the PDS.

The applicant is Mr James Piscopo, Chief Executive Officer of Transport Malta (TM), whilst Perit Sarah Pace is the Project Leader on behalf of TM.

1.2 Background and Purpose

The two main islands of the Maltese archipelago, Malta and Gozo, are currently linked by the Trans-European Transport Network (TEN-T) through a ferry crossing from Ċirkewwa in Malta to Mġarr in Gozo.

The Government of Malta has embarked on a long-term strategy to address the accessibility between Malta and Gozo, thus addressing the everyday problems being experienced by Gozitans to travel to their place of work, to reap benefits from increase in influx of tourism and increases in general economic activities.

The number of vehicles crossing between Malta and Gozo increased at 4.1% per annum between 2000 and 2010. In 2010, there were an average of 1,500 vehicles per day per direction (AADT = 3000 vehicles) and 5,500 people per day per direction travelling between Malta and Gozo. In 2015, according to the NSO, a total of 1,348,502 vehicles made the crossing – an increase of 5.4% over the previous year.

The expected traffic load (AADT) in a 15 years forecast with a toll payment is an AADT at approximately 9,000 vehicles[1], with around 5% heavy vehicles.

The introduction of a fixed link, apart from ensuring reliability of service, would reduce average journey times between Gozo and Malta by at least 40 minutes, and would ensure that commuters have more control on their travelling schedule. The fixed link would also provide a second means of travel between the two islands.

[1] E-Cubed Consultants (2015). *Establishing a Permanent Link between the Island of Gozo and Mainland Malta: An Economic Cost Benefit Analysis of Available Strategic Options*.

1.3 Previous Studies

A Preliminary Survey Report was compiled in 1972 by the Overseas Technical Cooperation Agency of the government of Japan[2].

In 2012, Mott MacDonald carried out a preliminary analysis of road tunnel link options between Malta and Gozo[3]. The study included a review of fixed sub-sea tunnel links relevant to the Malta-Gozo crossing, and provided four tunnel alignment options which could be considered, taking into consideration the engineering and environmental constraints. The main conclusions of this analysis were the following:

- A tunnel link between Malta and Gozo would be feasible, and does not exceed the capability of current technology.
- A detailed geological and geotechnical investigation is required in order to determine the optimum tunnel alignment and construction methodology.
- An immersed tube tunnel would result in an extensive environmental impact on the seabed, and thus a bored tunnel is recommended.
- The tunnel portal locations need detailed considerations from a geological and environmental perspective.

An Economic Cost Benefit Analysis was prepared in 2015 for the Gozo Business Chamber and Transport Malta[4]. The study analysed the economic and financial feasibility of alternative solutions of connectivity between Malta and Gozo. The conclusions of the analysis, both from an economic and financial perspective, resulted in a tunnel as being the preferred option when compared to a bridge or to no fixed link project.

In 2017, a Social Impact Assessment was carried out by Dr Marvin Formosa[5] whereby the possibility of a permanent tunnel link was analysed. The study found stakeholders in Gozo to be overwhelmingly in favour (82%) towards the construction of a permanent link between the two Islands.

1.4 Ongoing Studies

As from 2016, Transport Malta initiated a process of gathering information on the sub-surface conditions of the proposed tunnel route between Malta and Gozo to ultimately establish a geological model of the area under investigation which will form the basis for the design of the tunnel. These studies are a major milestone in the process to guide the design of the proposed tunnel between the islands.

[2] Overseas Technical Cooperation Agency – Government of Japan (1972). *Link Road between Malta and Gozo Islands – Preliminary Survey Report*.
[3] Mott MacDonald (2012). *Preliminary Analysis – Assessment of Road Tunnel Options between Malta and Gozo*.
[4] E-Cubed Consultants (2015). *Establishing a Permanent Link between the Island of Gozo and Mainland Malta: An Economic Cost Benefit Analysis of Available Strategic Options*.
[5] Dr Marvin Formosa (2017). *Social Impact Assessment – Tunnel Link between the Island of Gozo and Mainland Malta*.

Through an agreement with the University of Malta, seismic investigations consisting of a series of scientific investigations including desktop and field studies, passive seismic measurements, bathymetric mapping, and a seismic study were commissioned. These investigations were carried out by OGS Trieste, an Italian research institute, and commenced in October 2016 in the channel between Malta and Gozo. A high resolution multi-channel seismic reflection survey and an underwater seismic refraction survey were carried out. These surveys are necessary to obtain information about the geology below the sea floor, in particular the depths of the stratigraphic interfaces and any faults which might be present in the channel, as well as give results on seismic wave velocities. Furthermore, a multibeam echosounding sub-bottom profiler was used to produce a detailed mapping of the sea-floor, which will identify any faults, shallow sediments and any tectonic activity. In addition to these investigations, a survey to investigate fluid seepage in the Malta-Gozo Channel was also carried out, as well as an airborne survey to measure methane and carbon dioxide in the study area.

Further to the seismic investigations, a series of geological investigations were carried out. A total of 9 cores were extracted – 4 in Malta, 3 in Gozo and 2 in the channel off Comino. Each core hole had a diameter of circa 10cm, with drilling reaching approximately between 150m and 275m below sea bed level in some areas, thus going through all the formations that make up the geology of the Maltese Islands (Upper Coralline Limestone, Blue Clay, Globigerina Limestone, Lower Coralline Limestone).

Full core recovery using the wireline method was used wherever possible. The main advantage over conventional rotary methods is that wireline coring allows rapid placement and withdrawal of the core barrel within the drill rods, and thus the rods do not need to be removed to recover each individual core sample. Undisturbed Blue Clay samples and rock samples were collected and sent to specialized laboratories for testing. Water pressure tests were also carried out at different levels of the boreholes in order to better understand the permeability of the rock.

In order to protect the perched acquifer and water table, casing and fresh water was used throughout the drilling process. Transport Malta was in continuous contact with ERA and MRA throughout the duration of the investigations in order to ensure that the processes being followed did not cause any damage to the environment and to the water table. In particular for the cores extracted from the seabed, an ecological monitor was engaged in order to follow the process as well as to ensure that all methods used were in conformance with the permits issued by ERA.

A series of downhole seismic testing was also carried out in the 2 cores closest to the shoreline by the University of Malta in collaboration with OGS Trieste. This test consisted of sending a seismic signal from a surface source down to geophones located in the borehole. The geophones converted wave particle motions into an electrical signal, and the signal was then transferred to a digital recording system. The one-way travel time from surface to depth is obtained by noting the times of arrival on the observed records. Repeated measurements were taken at different depths along the borehole in order to reconstruct the velocity function along the borehole itself. Velocity versus depth information was then used to assign true depths to the events seen in a seismic reflection profile.

The preliminary coring investigations were completed in February 2018, and the results from these extracted cores together with the analysis from the seismic investigations are currently being incorporated to create a geological model of the area under investigation. The results from the coring investigations are important since they will be used to calibrate the data collected from the geophysical surveys, and will give a better understanding of the geological structure between Malta and Gozo as well as provide information on the level of the interface between the Blue Clay and the limestone formation. The geological model will give a clearer idea of the geological formations present between the two islands, and will form the basis of the conceptual design for the tunnel by providing a guide to identify the best route for the tunnel.

In early 2018, Transport Malta commissioned a Financial Model for the project to be carried out. This study will assess the financial feasibility and potential financing options for the proposed fixed link between Malta and Gozo. An updated Cost-Benefit Analysis shall also be undertaken.

A Transport Impact Assessment shall also be carried out for the project. The study shall identify the critical links and junctions in the surrounding road network, and shall include an update of the transport model of the area.

1.5 Project Objectives

The main objectives of this infrastructural project are the following:

- Address the accessibility between Malta and Gozo, thus addressing the everyday problems being experienced by Gozitans to travel to their place of work.
- Reduce average journey times between Gozo and Malta and ensuring reliability of service.
- Provide a second means of travel between the two islands.
- Remove the traffic bottleneck at Xemxija on the TEN-T Route 1.
- Reap benefits from increase in influx of tourism and increases in general economic activities.

Section 2 Description of the Project

2.1 Preliminary Design

Following the previous studies carried out for the permanent link between Malta and Gozo, in particular the Preliminary Assessment carried out by Mott MacDonald[6], a review of the options proposed in the Mott MacDonald report was made. Four (4) options for a tunnel were made in the Mott MacDonald report as outlined in Figure 1.

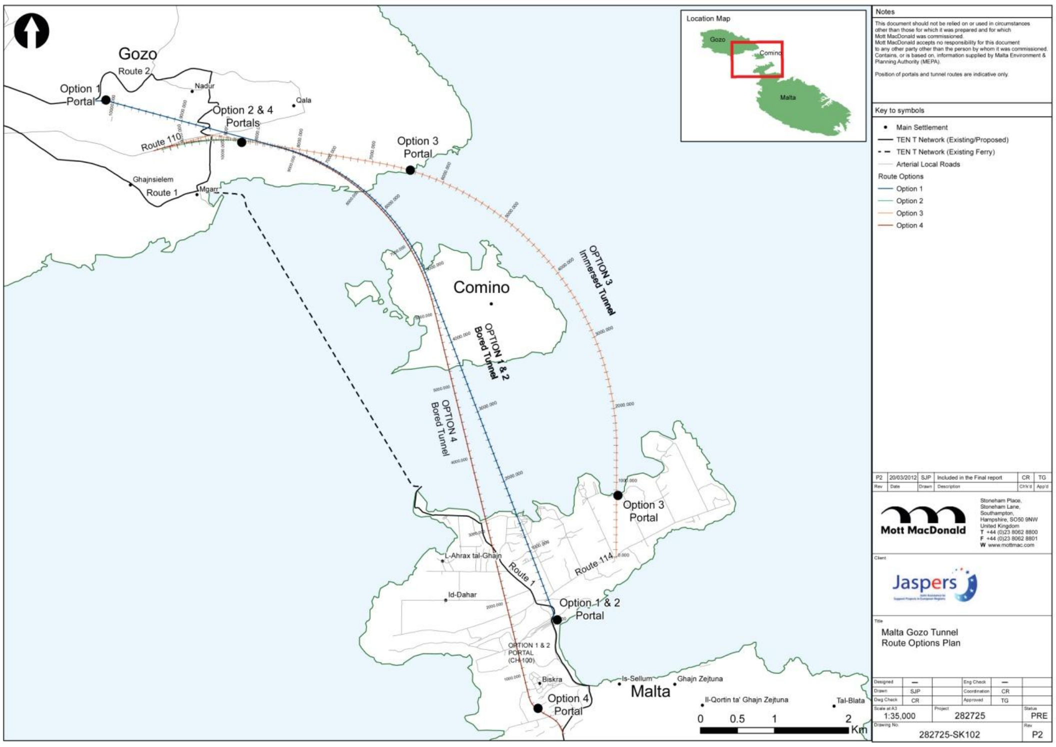

Figure 1: Preliminary Analysis route options

Since the immersed tube tunnel option (Option 3 in Figure 1 above) would result in an extensive environmental impact on the seabed, and as recommended in the Mott MacDonald report, this option was not considered further. The tunnel alignment and portal locations for Options 1, 2, and 3 in Figure 1 above were thus considered further.

The portal locations considered for Options 1, 2 and 3 were as follows:

- For Option 1: Portals located in Malta on Route 1 on the southern slope of Marfa Ridge, and in Gozo on Route 2 west of Nadur and east of the racecourse, on the ridge just below the Kenuna Tower.

[6] Mott MacDonald (2012). *Preliminary Analysis – Assessment of Road Tunnel Options between Malta and Gozo*.

- For Option 2: Portals located in Malta on Route 1 on the southern slope of Marfa Ridge, and in Gozo near the junction of Route 2 and Route 110 north of Mġarr.
- For Option 4: Portals located in Malta near Biskra in the Mellieħa Bay Valley, south of the Natura 200 site and bird sanctuary, with a short connection to Route 1 over agricultural land on the northern slope of Mellieħa Ridge, and in Gozo near the junction of Route 2 and Route 110 north of Mġarr.

Upon reviewing the portal options considered, it was clear that the portal location on the Malta side for Options 1 and 2 would negatively impact the Għadira Nature Reserve, especially during the construction stages of the project. This fact, as well as the inclination to keep the tunnel portal as distant as possible from the Natura 2000 site, prompted the consideration of the portal location for Option 4 as the baseline portal on the Malta side.

Furthermore, it was evident that the investment required for tunnel between Malta and Gozo would be significant, and whilst acknowledging that the fixed link would alleviate the delays currently experienced when crossing between the two islands, a congestion problem would still be experienced in Xemxija due to the physical width limitations of the main road. The possibility of by-passing Xemxija was thus taken into consideration, and an extension to the tunnel from the proposed portal in Mellieħa to a portal at Imbordin was considered. This portal would then link to St Paul's Bay Bypass (NA7) on Route 1 of the TEN-T.

It should be noted that the two portal locations were chosen to be located as close as possible to existing / future planned infrastructure, and as low in elevation as possible, in order to reduce the length of the tunnel. Furthermore, the footprint of the portal should be kept to the minimum area possible, in order to minimize earthworks before entering the tunnel. This can be achieved by entering through an area where there is an existing steep hillside. The actual design of the portal will be such so as to blend with the surroundings.

Taking into account the above considerations, a new proposed tunnel alignment was drawn up (Figure 2), which resulted by linking through the shortest route possible the portal at Imbordin with the portal west of Nadur.

Figure 2: Proposed tunnel alignment

It should be noted that the tunnel alignment and portal exact areas are still not set, since these will be decided at Conceptual Design stage.

The area being considered for the portal on the Malta side is located at Imbordin, between Manikata and the Pwales valley, along the entire escarpment outlined in Figure 4. The main reason for this being a good portal area is that the tunnel will enter into the steep rock escarpment, thus resulting in a short portal area, with the rock cover building up quickly. Along the escarpment, a portal location can be found that will minimize the footprint of the project. Furthermore, this location is at a short distance to the road leading to Route 1 on the TEN-T, thus limiting the length of access infrastructure required. The elevation is also very close to sea level, thus the tunnel length would be minimized.

For the purpose of this document and subsequent studies prior to the finalisation of the Conceptual Design, the area outlined in Figure 3 shall be considered for the location of the portal on the Malta side.

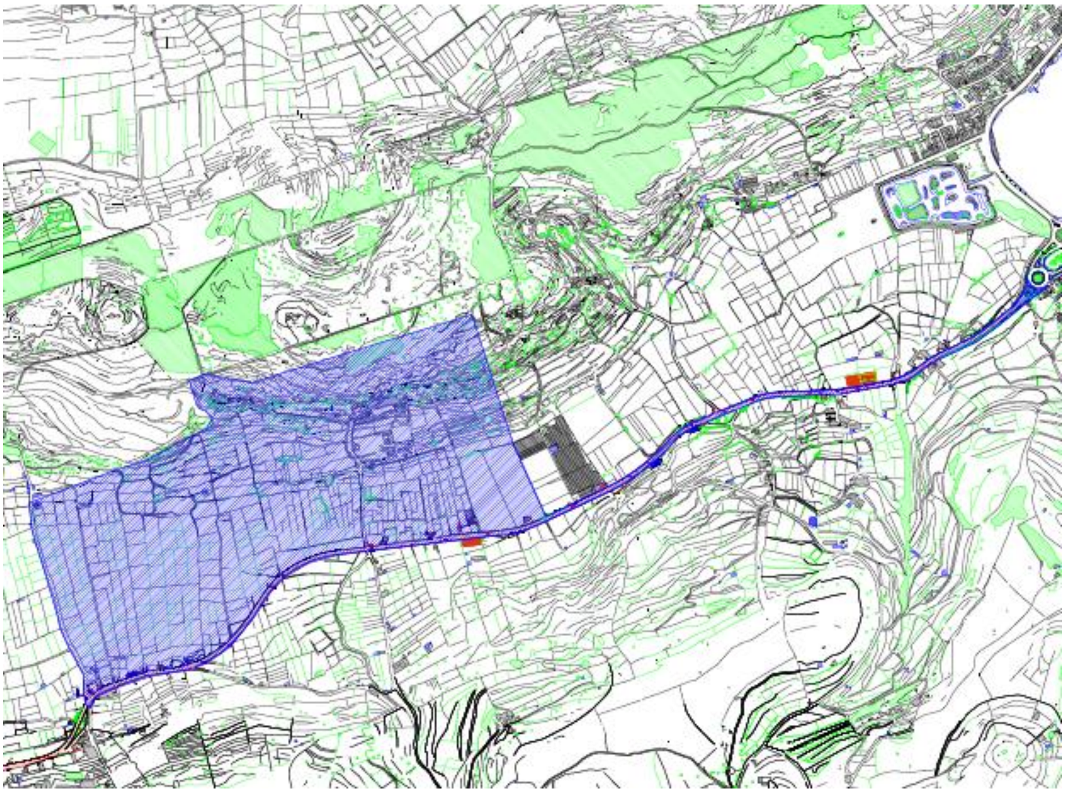

Figure 3: Area considered for the portal on the Malta side

Figure 4: A possible portal location for the Malta portal (grey circle)

The area being considered for the portal on the Gozo side is on the ridge just below the Kenuna Tower (Figure 6). The advantage of this location is the hillside which climbs quite steep in the direction of the tunnel, which would enable good rock cover very quickly. Furthermore it is very close to Triq ir-Rabat, which makes the access from the tunnel to the connecting road network quite short. The area seems to be limited in soil cover, thus geological surface mapping can be done very easily and tunnelling can commence without too much earthworks involving the removal of residual soil.

For the purpose of this document and subsequent studies prior to the finalisation of the Conceptual Design, the area outlined in Figure 5 shall be considered for the location of the portal on the Gozo side.

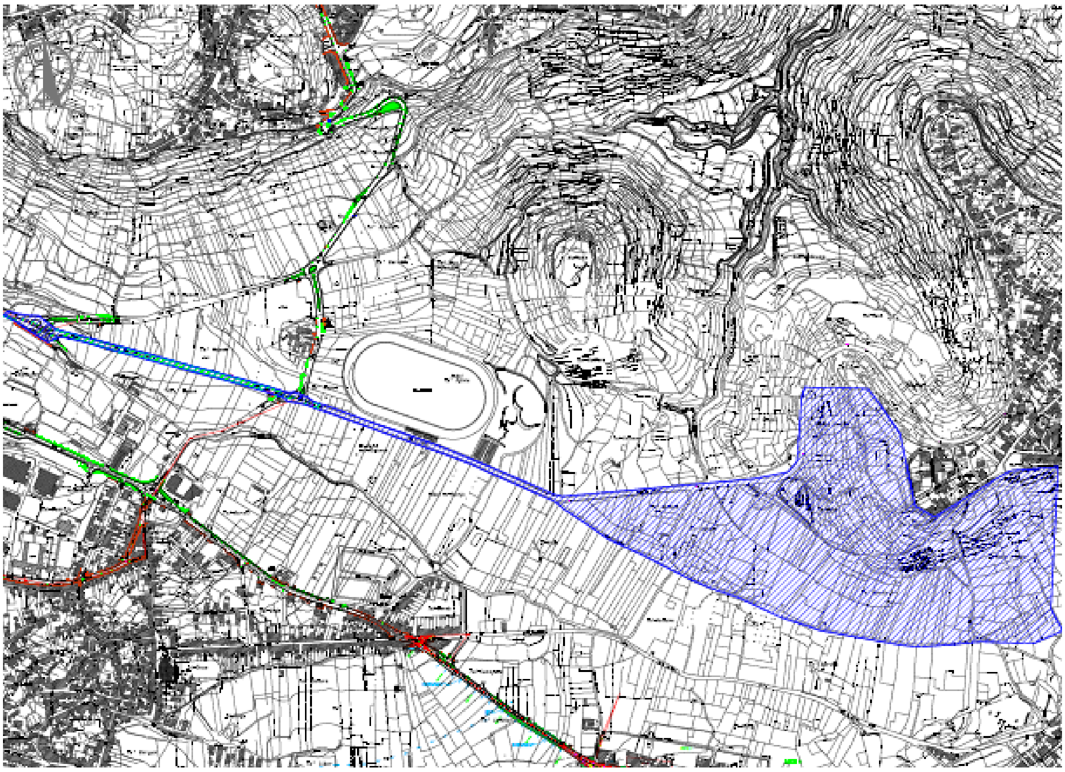

Figure 5: Area considered for the portal on the Gozo side

Figure 6: A possible portal location for the Gozo portal (grey circle)

2.2 Physical Characteristics of the Project

The tunnel is intended to be a single-tube tunnel with two lanes, one in each direction. Each vehicle lane shall be between 3.25m and 3.50m wide, and the two lanes shall be divided by a central buffer area of approximately 1.0m width. This buffer area might include rumble strips in order to enforce a warning area for stray vehicles. Emergency lay-bys of 90m in length shall be present at every 250m – 300m, alternating on both sides. A 1.0m width shoulder shall be present at both sides of the carriageway.

The above dimensions shall reflect the requirements outlined in EU design standards for installations and equipment. The project will also look into the UK standards outlined in the Design Manual for Roads and Bridges (DMRB), Volume 2, Section 2, Part 9, BD 78/99 – Design of Road Tunnels, whilst Norwegian standard N500 shall be considered for specific sub-sea issues.

Amongst the most important typical installations for the tunnel would be ventilators, illumination, water protection measures, drainage pipes and pumping pipes, pumps and water storage areas, transformer stations, switch gears, cable ladders, various sensors, safety installations and detection/survey systems. These will be installed according to relevant standards.

Figure 7 shows a typical road tunnel cross section whilst Figure 8 shows a relatively modern Norwegian road tunnel, with cable ladders and illumination in the roof and one pair of ventilators for longitudinal ventilation.

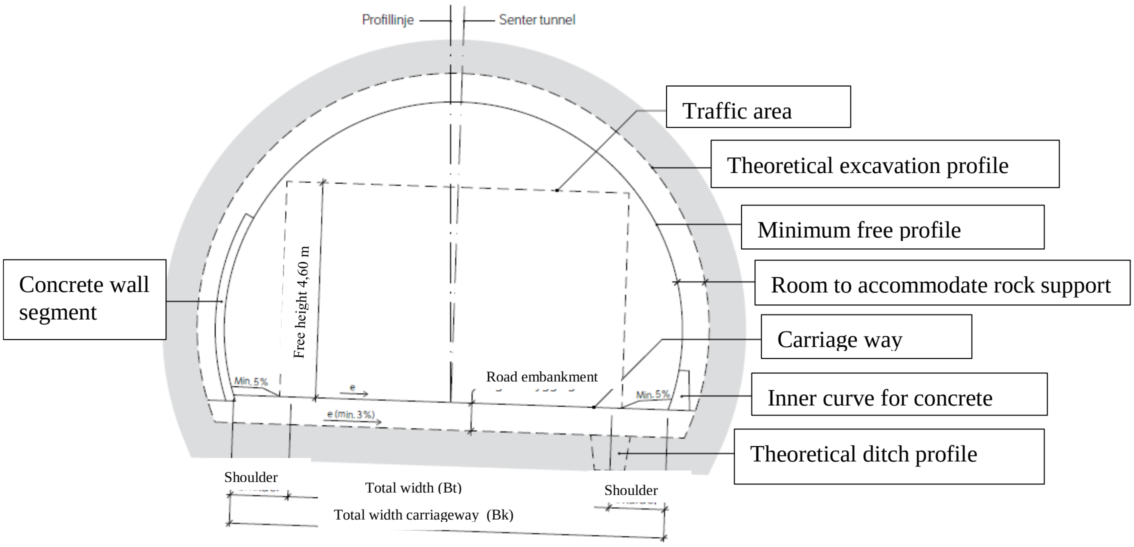

Figure 7: Typical road tunnel cross section

Figure 8: Road tunnel in Norway

2.3 Surrounding Infrastructure

The design of the surrounding infrastructure shall be detailed once the exact location of the portals is known. It is expected that the infrastructure from the two tunnel portals until the nearest connection to the TEN-T is upgraded as part of the Malta-Gozo tunnel project.

The tunnel shall be operated with a remote toll system, and thus there will be no need for any queuing areas or ancillary facilities at the portals.

There shall however be a requirement for a Central Unit at the portal areas during the operation phase of the project.

2.4 Project Phasing

The project works are expected to be divided in the following main phases and approximate durations:

- Planning and Design: 3 years
- Mobilisation at the portal areas: 3 months
- Excavation works: 3 years
- Finishing works: 1 year
- Testing and completion: 3 months
- Operation and financing: 20 years
- Hand-over and commissioning to TM: 6 months

This timeline is for the moment still a very broad estimate, since the actual duration of works will depend greatly on the tunnelling method(s) chosen by the contractor, as well as the geological environment encountered during the tunnelling works.

Since the tunnel will have 2 portals, one at each side, all construction works, material, equipment and personnel during the entire construction time will be going in through these 2 portals.

It is estimated that over one million cubic metres of excavated rock will be hauled out during the excavation phase, and all this material will be passing through the two portals.

2.5 Project Location

The preliminary location of the project is outlined in Figure 2.

The tunnel is expected to be bored (Tunnel Boring Machine) or mined (conventional Drill & Blast or Road Header) along one of the following options:

- A deep seated tunnel which is located in the Globigerina Limestone layer below the Blue Clay Layer and crossing the latter on either side of the Malta-Gozo channel.
- A shallow seated tunnel which is located above the Blue Clay layer in the Upper Coralline Limestone.

The portals will comprise a concrete structure that connects the rock tunnel and surface. The concrete structures will be designed to blend as much as possible into the landscape.

The exact location of the portals and the tunnel path will however be clear once the Conceptual Design is available.

The tunnel will be designed and constructed to be able to deal with ground water in such a way that it shall not have any permanent negative impact on the ground water conditions. Rock support in the tunnel will be designed and constructed to handle the local ground conditions along the tunnel length without jeopardising the stability and integrity of the tunnel itself or cause any negative impact on the surface such as sinkholes or similar occurrences.

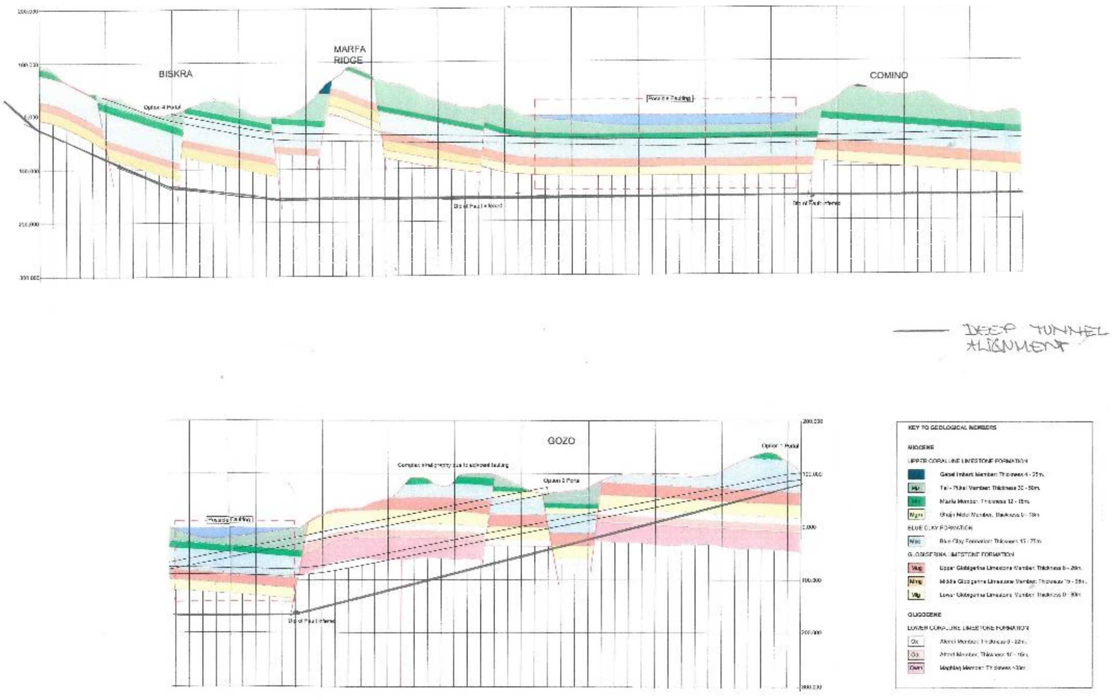

Figure 9: Section showing tunnel options in stratigraphy[7]

Figure 9 outlines the two different solutions on a longitudinal section. One option shows a deep seated alignment that goes below the Blue Clay layer and into the Globigerina Limestone. The Globigerina Limestone will be investigated for the purpose of documenting its suitability of hosting a tunnel. The Blue Clay layer will be evaluated to identify a reasonable tunnelling method. Alternatively, should the tunnel be designed to pass beneath the Blue Clay layer, this will be acting as a tight membrane above the tunnel structure.

The second option shows a tunnel located above the Blue Clay layer in the Upper Coralline Limestone, which is a layer that is well known from various tunnelling activity locally. However, should this shallow location be sought, there would not be any benefit from the impermeability of the Blue Clay layer.

[7] Base drawing taken from Mott MacDonald (2012). *Preliminary Analysis – Assessment of Road Tunnel Options between Malta and Gozo.*

These two alternatives shall be looked at during the Conceptual Design stage.

2.6 Tunnelling Methodologies

In principle, there are three different tunnelling methods that could possibly be employed for the excavation of the tunnel. These are a fully mechanised TBM (tunnel boring machine) that will produce a circular tunnel shape, a conventional drill and blast method which is often the preferred method in hard rock tunnel excavation, and finally another mechanised method using a road header, a method that was employed for the two most recent tunnel projects in Malta (the flood relief tunnels forming part of the National Flood Relief Project (NFRP), and the high voltage cable tunnel). All these three methods have their unique characteristics and individual advantages and limitations/disadvantages, and would be relevant to consider as methods of tunnelling for the Malta Gozo tunnel.

It should be noted that the Channel Tunnel between England and France was built using TBMs, whilst all the sub-sea tunnels in Scandinavia have been built using conventional drilling and blasting. For the local tunnelling projects, both a road header and drill and blast methods were used.

It is obvious that there are many factors to be evaluated before a final decision on the tunnelling method is arrived at.

A Tunnelling Boring Machine is circular head that is rotating clockwise. Several tens of disc cutters are placed at the cutter head, which also rotates around its own axis with a certain part of the cutter being in contact with the rock face at all times. Through this movement, chips are released from the tunnel face due to tensional failure and this results in the TBM 'eating' its way forward. Behind the main unit of the TBM there is a 'train' of support sections that provides services to the main activity. Often a segmental lining is placed as the TBM advances forward. A TBM is operating in a more or less continuous way, where excavation, mucking out and supporting takes place simultaneously. The end product will be a circular tunnel opening.

Conventional drill and blast is a more binary operation where the following main operations must follow in sequence: drilling blast holes, charging and blasting, loading and mucking out and rock supporting. These activities are repeated continuously in the same sequence. This is a method that fits well to hard rock tunnel sites but is also feasible in weaker rock. Conventional drill and blast methods are typically used to produce horseshoe shaped tunnel openings.

Road header excavation is a type of mechanical excavation as no explosives are involved in the excavation process. In the same way as for the TBM, a continuous process where several activities like excavation, mucking out and supporting take place at the same time. It is a well acknowledged excavation type in rock mass which is not hard rock or abrasive rock. The shape of the tunnel can be formed as designed.

The final decision on the tunnelling method cannot be taken until the outcome from the pre-investigations have been considered and analysed in the conceptual design. Based on the geological model and the evaluations of the conceptual design, the choice of a deep or shallow tunnel will be made and subsequently the tunnelling method.

2.7 Envisaged Operations

The Contractor who shall be employed to prepare the design and carry out the construction of the works will also be responsible for the daily operation of the tunnel until the end of the Concessionaire period. The contract shall include all such costs for operation and maintenance, and the contractor shall be responsible for keeping the tunnel to the level of operation as agreed with the Client. A maximum number of yearly 'out of operation mode' hours shall be agreed. These hours shall include the periods of time for carrying out the necessary repair works, manage regular repair and maintenance, and operate and manage the toll payment system. All these activities have to be carried out with a minimum down time in the tunnel operation. It shall be important to include communication with the public, in order to inform the public on the availability of the tunnel at all times.

A road tunnel has typically a wide range of specified service life for its installations and equipment, ranging from 20 years to 120 years, which means that some of the installations in the tunnel will reach the end of their service life during the Concessionaire period.

The environment in the tunnel is harsh, comprising of a mix of saline water and exhaust fumes. This is compounded with residues from asphalt and rubber from abrasion of tyres. Regular and frequent cleaning of tunnel surfaces shall thus be required to be programmed by the operating contractor, as well as regular cleaning and repair of installations. A regular status control of the installations and equipment needs to be established to secure that all are functional and operational without the risk of malfunctioning and without the procurement of damages that could have an impact on the tunnel itself or its users.

The operating contractor will also be responsible for testing all devices for functionality as shall be outlined in a schedule programme in the contract with the Concessionaire.

2.8 Access

Access to the tunnel will be limited through the two access points (portals) at each tunnel end. A possibility may also exist to establish vertical shafts close to the sea shore on one or both sides of the channel. These shaft accesses could be limited to emergency evacuation or rescue.

The viability and location of these shafts shall have to be evaluated during the Conceptual Design stage. It should be clear that such vertical shafts would not have any purpose for the construction phase. Establishing such shafts and combining them with rescue chambers at the niches at the bottom of the shafts would have a positive impact on the safety aspect in the tunnel.

2.9 Infrastructural Services

As outlined in Section 2.3, the tunnel shall be operated with a remote toll system, and thus there will be no need for any queuing areas or ancillary facilities at the portals.

There shall however be a requirement for a Central Unit at the portal areas during the operation phase of the project. From this Central Unit all steering and Control operations can be executed, no matter if the tunnel is in an emergency operation or at normal operation. Messages and information can be presented to the public who are in the tunnel. This will include a communication access to emergency vehicles (Police Department, Fire Department and Hospital). This Central Unit will require an area for parking of emergency vehicles at the two portals. Furthermore, there will also be a locked switch box where approved personnel can operate the ventilation system and other systems manually.

It is important to note that all harbour facilities and ferry transport have to be in place and kept to a high level of maintenance, in order to ensure a back-up solution in case the tunnel is closed for emergency reasons, or during routine maintenance.

Section 3 Environmental Aspects and Effects

It should be noted that the main environmental effects will be experienced at the tunnel portal locations, especially during the construction phases of the project.

All these aspects are to be dealt with in detail both quantitatively and qualitatively in the Environmental Impact Assessment (EIA), whereby a status report shall be presented, highlighting the sensitive areas and possible acceptance levels. Such acceptance levels will be followed up and the necessary mitigation measures shall be put in place. During construction works, all activities will be monitored in different ways in order to mitigate the adverse environmental effects. It will be the contractor's responsibility to ensure that all work is carried out within the limits outlined in the EIA.

The main environmental effects envisaged are listed below and are only qualitatively described.

3.1 Waste Management

The extent of waste material from tunnelling and its reuse and/or disposal shall be one of the major environmental impacts to be considered.

Tunnelling activities will result in a large volume of rock waste material, which is estimated to be in access of 1 million cubic metres. There might be options of disposing of the waste in the sea, as well as through land reclamation projects.

The amount of disposal and reuse will heavily depend on the type of material which is excavated, and the method by which excavation takes place. Globigerina limestone will most likely have to be disposed of since there is no current use for it. On the other hand, Blue Clay material can be re-used in projects where lining of a landfill is required, whilst Coralline limestone can also be possibly reused.

The cheaper option would seem to be that of dealing with the waste locally, and this can be obtained through using it as a fill material or else to rehabilitate scarred areas on the Islands.

The use of tunnel muck will also have to be investigated further.

3.2 Discharges from Operational Functions

The project will incorporate two independent drainage systems. The first is the one which will collect water that is used to clean the dirty road surface, whilst the second separate system is the one which will collect water seeping in from the surrounding rock mass. The latter will be clean water, whilst the former will be dirty water.

Sedimentation and oil separation will take place in a water collection area at the lowest point of the tunnel. The clean water will then be pumped out of the tunnel stepwise to the discharge point. The cleaning facility in the water collection area will be emptied by dedicated companies and handled appropriately.

During the excavation stage, all production of water that has been used by the excavator will be pumped to the surface on either side and processed through a temporary water cleaning facility.

3.3 Residues and Emissions during the Construction and Operation Phases

All water inflow to the tunnel will be discharged at the portal areas and/or led to the sea through the shortest way possible. In cases where the portals are close to the shore, such water is discharged to the sea directly. In the case of the Malta-Gozo tunnel, both portals are located in-land, away from the sea shore.

There also exists a possibility of having a shaft in an area much closer to the sea shore along the tunnel alignment, and using this shaft for discharge of water. This shaft could be combined to act as an evacuation shaft, however this possibility will have to be explored further at a later stage.

With reference to ventilation, air is normally discharged at the portals when adopting a longitudinal ventilation system. This discharge will include emissions from the vehicles using the tunnel. Alternatively, one can make use of a ventilation shaft, which could be combined with the water discharge shaft outlined above. This option will however require a different ventilation system, not a longitudinal one. All options have to be considered in order to arrive to the best solution which will work for this project.

During construction stage, there will be large ventilators at the portals, which shall be blowing fresh air through ducts to the tunnel face to replace dirty air coming from inside the tunnel. Such dirty air could be contaminated by CO and NOx, dust and emissions from the blasting. Normally no particular cleaning of air takes place during operation, unless it is particularly required.

3.4 Noise and Vibrations

During the construction phases, there will be noise at the tunnelling site due to this being the main area where all the activity will be ongoing. Furthermore, temporary ventilation fans at the portal will make noise similar to the noise emitted from jet engines, however not as loud.

During tunnelling, there might be vibrations experienced in the properties which are located right above the tunnel path whilst the excavation is passing the actual area. This area can be identified once the conceptual design is in place, and a corridor following the tunnel alignment and having a width of a few hundred meters will be designated as the affected area. The width of the corridor will change depending on the depth of the tunnel and thus the distance from the tunnel to the surface structures.

No particular effects on the seabed are envisaged during both the construction and operation phases.

During the operation of the tunnel, there will be no particular noise problems, just the normal noise levels of vehicles going in and out of the tunnel.

3.5 Groundwater Low-Down

The lowering of the water table is always a risk when tunnelling. This can be mitigated against during construction mainly by having an impermeable cap around the tunnel and control of the maximum allowable inflow to the tunnel, and the necessary rock mass grouting as a consequence. The impact of tunnelling on the ground water level will thus be outlined.

It will be important to check whether any groundwater wells are present in the tunnel path, as well as any investigation core holes. This will enable the monitoring of ground water levels during construction. Prior to any tunnelling excavation, a baseline has to be set with respect to the groundwater level and the water level in wells. This will provide an initial reading of the state of groundwater when tunnelling commences. Based on this data, the maximum allowable inflow will be determined, which will probably vary from one section of the tunnel to the other. This will also depend greatly on the geological conditions.

3.6 Flora and Fauna

In principle, there will be no impact on flora and fauna along the tunnel route. However, there might be an effect on these at the tunnel portals. It will be important to review the surface habitats and identify if there are any particular species that need particular attention. Once again, the maximum allowable inflow is the key and the rock mass grouting is the measure to control water inflow.

3.7 Agricultural Soil Take-Up

The areas which will be affected are the tunnel portal areas. All efforts are to be made to limit as much as possible the take-up of agricultural soil, however it must be understood that this is unavoidable. Efforts will be made to reinstate as much as possible of the construction site areas once the project is completed.

3.8 Air Quality

During the construction phases, since the temporary ventilation system will have its discharge at the portals, there will be some exhaust air and maybe dust at these areas. There will also be dust production in the air resulting from the vehicles coming in and out of the tunnel, some of which will be fully loaded with rock muck.

An alternative to this could be to analyse a conveyor belt transportation system that is installed as an embedded system outside of the tunnel. This measure will reduce both dust as well as noise at the portal areas, and will also result in a better carbon footprint when compared to diesel-operated heavy trucks.