SERVICE ORDER NO. 23 – UNDER PURCHASE ORDER 4700001489 – SECOND OPINION ON ECONOMIC ANALYSIS OF PROPOSED TEL AVIV METRO

CONSULTING AGREEMENT NO. 90692 BETWEEN ISRAEL RAILWAYS LTD. AND LOUIS BERGER (UK) LTD.

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Tracking tables

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PROJECT KEY POINTS

Figure 1 Socio-economic key points
(By 2075, full light rail without parking policy as baseline option, BC V5 to A01 S2S4, comparison 3131.4111.5111 to 3100.4100.5100)

Socio-economic indicators	Discount rate: 4 %		Discount rate: 7 %	
	Shekel2018 (₪)	Euro2018 (€)	Shekel2018 (₪)	Euro2018 (€)
Actual costs:	**122.3 bn**	**29.1 bn**	**88.0 bn**	**21.0 bn**
Actual capital expenditure (including residual value)	*76.5 bn*	*18.2 bn*	*66.0 bn*	*15.7 bn*
Actual operational expenditure	*41.7 bn*	*9.9 bn*	*19.0 bn*	*4.5 bn*
Disruption	*4.2 bn*	*1.0 bn*	*3.0 bn*	*0.7 bn*
Actual conventional effects:	**294.8 bn**	**70.2 bn**	**125.4 bn**	**29.9 bn**
Vehicles operating costs	*31.8 bn*	*7.6 bn*	*13.2 bn*	*3.1 bn*
Time savings	*165.0 bn*	*39.3 bn*	*70.7 bn*	*16.8 bn*
Freight time savings	*29.5 bn*	*7.0 bn*	*13.2 bn*	*3.1 bn*
Parking cost savings	*21.5 bn*	*5.1 bn*	*8.7 bn*	*2.1 bn*
Vehicle capital savings	*11.4 bn*	*2.7 bn*	*4.6 bn*	*1.1 bn*
Reliability	*34.7 bn*	*8.3 bn*	*14.5 bn*	*3.5 bn*
Actual non-conventional effects:	**145.4 bn**	**34.6 bn**	**63.4 bn**	**15.1 bn**
Environment	*8.8 bn*	*2.1 bn*	*4.2 bn*	*1.0 bn*
Safety	*5.4 bn*	*1.3 bn*	*2.4 bn*	*0.6 bn*
Agglomeration	*114.4 bn*	*27.2 bn*	*49.3 bn*	*11.7 bn*
Landuse savings	*14.2 bn*	*3.4 bn*	*6.3 bn*	*1.5 bn*
Health, comfort and stress	*2.3 bn*	*0.6 bn*	*1.1 bn*	*0.3 bn*
Socio-economic net present value	**318.1 bn**	**75.7 bn**	**100.0 bn**	**24.0 bn**

Figure 2 Metro Infrastructure and Demand

System characteristics					
Alternative	***Characteristics***	**Line M1**	**Line M2**	**Line M3**	**Total**
2030 Central Alternative (3131)	*Length*	*23*	*29*	*23*	***75***
	Stations	*23*	*21*	*14*	***58***
	AM Peak Boarding	*52,630*	*64,083*	*30,348*	***147,061***
	Daily Boarding	*443,620*	*556,777*	*246,583*	***1,246,980***
	Passenger km	-	-	-	***5,862,135***
2030 Combined Alternative (3141)	*Length*	*33*	*29*	*23*	***85***
	Stations	*30*	*21*	*14*	***65***
	AM Peak Boarding	*64,435*	*64,524*	*30,870*	***159,829***
	Daily Boarding	*555,899*	*561,482*	*250,431*	***1,367,813***
	Passenger km	-	-	-	***7,428,671***
2040 High (4110)	*Length*	*74*	*29*	*36*	***140***
	Stations	*59*	*21*	*23*	***103***
	AM Peak Boarding	*120,359*	*75,848*	*61,276*	***257,483***
	Daily Boarding	*1,023,390*	*653,882*	*490,483*	***2,167,754***
	Passenger km	-	-	-	***13,718,025***

System characteristics					
Alternative	***Characteristics***	**Line M1**	**Line M2**	**Line M3**	**Total**
2040 Low (4111)	*Length* *Stations* *AM Peak Boarding* *Daily Boarding* *Passenger km*	*74* *59* *85,150* *729,570* *-*	*29* *21* *56,228* *477,398* *-*	*36* *23* *61,276* *490,483* *-*	***140*** ***103*** ***159,829*** ***1,697,450*** ***9,904,319***
2050 (5111)	*Length* *Stations* *AM Peak Boarding* *Daily Boarding* *Passenger km*	*74* *59* *137,278* *1,165,025* *-*	*29* *21* *79,523* *688,202* *-*	*36* *23* *72,027* *574,026* *-*	***140*** ***103*** ***288,828*** ***2,427,252*** ***15,553,484***

SYNTHESIS OF RECOMMENDATIONS AND OBSERVATIONS

As an introduction to this summary, the Consultant (i.e. second opinion) highlights the substantial and technical work provided by the Experts (i.e. previous analyses) in order to carry out a socio-economic study for such a program like the Tel Aviv metro (TLVM) project.

Unlike more modest and classical transport projects, the TLVM project will generate huge public transit flows between a very dense centre and its periphery. It will involve network effects, interacting with other transport infrastructures and will affect the economic environment of the project area, where there is not any feedback of other mass transit investment in the past. Furthermore, the whole plan also includes light rail projects which will have considerable impacts on mobility and urban development as well.

The solution the Experts have proposed of a metro solution is similar to the solution that has been adopted successfully in many metropolitan areas and is appropriate for the Tel Aviv area.

The economic valuation of such a plan is a real challenge.

The second opinion focused on understanding and questioning the mechanisms and calculations used by to carry out this socio-economic assessment of the Tel Aviv Metro project. The Consultant interviewed NS & Associates experts that have carried out the transport model, the economic model and the socio-economic assessment of the Tel Aviv metro project.

The analysis does not have any thought on any political opportunity of the project. However, it should be note that compared to other similar top ranked urban areas in the world, Gush Dan is one of the few areas that does not encompass any mass transit system such as MRT or LRT systems.

In order to properly assess the socio-economic impact of the TLVM project, the Consultant believes the baseline option (or counterfactual situation), which is the situation which would prevail in the event that the investment under consideration is not carried out, should be the "A01" scenario. Indeed, in the absence of the mass rapid transit project, the implementation of the light rail transit red, purple and green lines is mostly probable. The Consultant recommends that the Experts make no confusion between the "A0" (LRT red line only), and the "A01" (LRT red, purple and green lines) scenarios as baseline option.

The Experts have explained that the capitalization rate of 7% on the Transportation Projects Procedure has been under review to 4% at the time of the economic assessment. The Consultant agrees with that more realistic new rate. Since it has been updated very recently, the Consultant recommends that any communication on the economic results should always be communicated with the capitalization rate being used (4% or 7%).

The total project construction cost (exclusive of VAT and including contingencies) is estimated 132 billion shekels (approximately 31 billion euros, 2018 conversion rate: 1 € = 4.2 ILS). The annual operation and maintenance costs are estimated 2.5 billion shekels (approx. 603 million euros). Actual costs over the period for capital expenditure and operational expenditure, with a capitalization rate of 4%, are respectively estimated 76.5 and 41.7 billion shekels (approx. 18.2 and 9.9 billion euros).

The construction costs have been compared with the Experts' construction cost and the Consultant finds the estimated cost is within the range of construction costs found on similar projects with the average costs being 4.4% less than the Experts' total cost. Similarly, the annual operation and maintenance cost has been compared this to information from other metro operators and the costs are within the range found, the cost for the project being 4% less than the average. The Consultant considers these estimates to be satisfactory for the Economic Analysis.

Finally, the actual costs over the project, with a discount rate of 4 % and a discount rate of 7 % are estimated 122 billion shekels (approx. 29 billion euros) and 88 billion shekels (approx. 21 billion euros) respectively.

The total actual direct benefits are estimated 294.8 billion shekels (approx. 70.2 billion euros) for a discount rate of 4% and 125.4 billion shekels (approx. 29.9 billion euros) for a discount rate of 7%. While the total indirect benefits are estimated 145.4 billion shekels (approx. 34.6 billion euros) for a discount rate of 4% and 63.4 billion shekels (approx. 15.1 billion euros) for a discount rate of 7%.

Main benefits come from time savings and agglomeration (employment) benefits (respectively 37% and 26% of actuals benefits).

Surprisingly, the environment benefits represent only 2% of actual benefits. Even by considering a baseline option where private transport pollution is reduced, this result seems abnormally low. The Consultant suspects at least a factor 5 error into the economic model but wasn't able to find it. The Experts should check and reconfirm environmental benefits from the economic and traffic model.

Over the project life cycle (by 2075), the Consultant notes that the socio-economic net present value (SE-NPV) of the Tel Aviv metro project has a very large surplus. With a discount rate of 4 %, the SE-NPV is about 320 billion shekels (approx. 75 billion euros). By taking into account conventional effects only (excluding non-conventional benefits), the project is still very profitable (170 billion shekels, approx. 40 billion euros).

With a discount rate of 7 %, the project has also an important surplus with a SE-NPV of 100 billion shekels (approx. 24 billion euros) and the conventional benefits alone still cover the project actual costs (SE-NPV: 37 billion shekels, approx. 9 billion euros). Furthermore, the second opinion revelled potential inaccuracies or uncertainties which could lead to increase the Tel Aviv metro project socio-economic net present value (and comfort the results).

The different analyses and design reports for the Tel Aviv metro show that the project is mature and will provide significant value for money and should improve life style and economics for Tel Aviv, Israel, and its inhabitants. Furthermore, the traffic forecast shows that the implementation of the only LRT lines would be probably undersized against the mobility needs of the Tel Avivians. Therefore, the Consultant's second opinion is **favourable** / ~~unfavourable~~ to the Tel Aviv metro project with few recommendations on the method and the presentation of the assessment.

In addition, as the metro project is phased in several stages, if the project is implemented, updated socio-economic assessments will be necessary on the following phases of metro extension as well as ex post analysis.

The second opinion recommendations and observations are related below. In this report the impact gives the Consultant's opinion on the possible impact (positive or negative) of the highlighted issues on the economic assessment results.

Second opinion recommendations and observations:

(1) The Metro solution that has been proposed by the Experts is comparable with the solutions that have been implemented in many other Metropolitan Areas. **Low impact**

(2) In order to properly assess the socio-economic impact of the MRT project, the baseline option should be the more likely to occur in the event that the project is not carried out. This option should therefore include all LRT projects as baseline option (option "A01"). **High impact**

(3) The traffic model seems to reach a satisfactory calibration for O-D matrix and travel time, but the Experts should also present the calibration on road links from traffic counting**. Medium impact**

(4) The traffic forecast model was adjusted in a public transport underperforming situation. That might create important bias in public transit estimation. **Medium impact**

(5) In order to facilitate understanding and being more transparent in reporting results, the Experts should lay out the metro lines graph of load for the project scenario by 2030, 2040 and 2050 (S3131, S4111, S5111). **Low impact**

(6) The Experts should explain why several stations does not have any boarding or any alighting on the traffic model and explain the results of expected boardings in Hashalom Station. **Low impact**

(7) The Experts should review the level of contingencies applied to the CAPEX to ensure that this reflects the stage in project's development. **Medium impact**

(8) The CAPEX of the complete project is considered reasonable and to be within the range of costs derived from other similar recent projects. **Medium impact**

(9) The Experts should review the estimate for utility re-location. The Consultant considers that is lower than could be expected in a highly developed urban area. **Low impact**

(10) The Experts should consider whether the cost of land acquisition and any compensation payable should be included in the cost of the Project. **Low impact**

(11) The OPEX of the complete project is considered reasonable and is within the range of costs derived from other similar metro systems and that the 20% contingency that has been added provides enough mitigation for increased costs. **Low impact**

(12) The Experts should ensure that any additional costs arising from the phased delivery of the project are fully considered in the assessment of the development of the complete project. **Medium impact**

(13) The Experts must specify the subsidies and taxes for public works in Israel, in order to be able to convert economic financial costs to economic costs. **Medium impact**

(14) The Excel-based economic model is not fully compliant with FAST modelling standard. It means that the TLV economic model is not designed to be easily intelligible or usable by a third-party. However this modelling standard, highly recommended for financial models, is not an obligation for economic models. **Low impact**

(15) The economic cost of the project is not clearly detailed. Indeed corporate tax, income tax or any kind of tax as well as subsidies must be exclude from the socio-economic assessment. In the model, the economic cost represents only 97% of the financial cost. That must be clarified. **Medium impact**

(16) The economic model does not apply any CAPEX inflation rate over an investment period of nearly 20 years. The Experts have to explain why. **Medium impact**

(17) The Consultant recommends to apply an annual growth rate on pollutant unit costs. **Medium impact**

(18) The Consultant recommends to review and reconfirm environmental benefits that seems abnormally low with regards to other metro projects. **High impact**

(19) The Government has recently updated the discount rate for urban transport projects (from 7% to 4%). Decision-makers must take into account the discount rate used for any other public investment project before making any comparison. The Consultant suggests that every communication on socio-economic results should be featured with both 7% and 4% discount rates. **Low impact**

1 Introduction

1.1 Nomenclature

In this document:

- The second opinion experts who have written this report are referred as the "**Consultant**".
- The experts of previous analyses being reviewed are referred as the "**Experts**".
- The "**impact"** of the recommendations and observations gives the Consultant's opinion on the possible impact (positive or negative) of the highlighted issues on the economic assessment results.

1.2 Project background

Transport within the Tel Aviv Metropolitan Area is heavily dependent on the use of the private car. However, congestion and air pollution are increasing. The population and employment in the Metropolitan Area is increasing rapidly and this will increase congestion and pollution if transport improvements are not carried out.

There is little scope to be able improve the highway network and parking facilities to provide additional capacity for private cars within the centre of the Metropolitan Area. To ensure mobility and reduce air pollution a high-quality mass transit system has been proposed. This system consists of several new light rail lines and bus rapid transit routes together with three heavy rail metro lines.

1.3 Task order objectives

The objective of this Service Order is to advise the Ministry of Transport about whether the proposed solution is appropriate and is likely to provide value for money for the investment.

1.4 Methodology of for this service order

It is proposed under this Service order that Louis Berger will:

- Carry out a review of the project – examining the appropriateness of the solution for Tel Aviv compared to other comparable city areas
- Review the analysis of demand that has been carried out against similar metro systems already in use in other countries
- Review the capital and operating costs that have been assumed
- Examine the cost benefit analysis that has been prepared by the Experts including:
    - The completeness of the analysis
    - Ensuring all costs have been included and are reasonable compared to benchmark costs from other countries
    - The appropriateness of the benefits that have been included
    - The parameter assumptions that have made for items such as value of time and the discount rate.

Louis Berger will prepare a report, in English, identifying any areas of weakness in the analysis conducted, whether the solutions proposed are in line with successful projects addressing similar problems in other countries. The report will be prepared in Word and will be supplemented by a PowerPoint presentation, if required.

The only objective of this Second Opinion Report is to analyse the methodology deployed, to check inputs and calculation, and to discuss the results and its understanding. In particular, the Consultant does not give any opinion on potential alternatives other than those developed by previous expertise.

1.5 CONTENT OF THIS REPORT

The Second Opinion report of the economic analysis of the Tel Aviv Metro is structured as follows:

1) The present section 1 is the **Introduction** of this report ;
2) Part 2 describes the “**The Tel Aviv Metropolitan Area”**
3) Part 3 analyses “**Comparable Transport Solutions**” to form a view on the suitability of the solution
4) Part 4 analyses the “**Tel Aviv metro reference situation**” that has been set for the socio-economic assessment;
5) Part 5 analyses the “**Traffic forecast**“ from the Tel Aviv model;
6) Part 6 checks “**Operational and capital expenditures**” for the project;
7) Part 7 analyses the “**Socio-economic assessment**” model and assumptions;
8) Part 8 constitutes the “**Conclusion**” of this Second Opinion.

2 The Tel Aviv Metropolitan Area

2.1 The problem

Transport within the Tel Aviv Metropolitan Area (TAM) is heavily dependent on the use of the private car. However, congestion and air pollution are increasing to unacceptable levels during the travel to work peaks. There is little scope to improve the highway network and parking facilities to provide additional capacity for private cars within the centre of the Metropolitan Area. This is a problem that is experienced in many metropolitan areas throughout the world where there is not a highly developed system of high-quality public transport to provide an alternative to the private car for journeys to work.

TomTom N.V. compiles a traffic index from the anonymized data gathered from users of their navigation systems. Their system ranks traffic congestion in Tel Aviv as 21st worst city out of 416 cities across the world for traffic congestion. As the population of Tel Aviv increase and without the scope for significant scope for improvement within the city centre, congestion will get worse. Many of the cities with the worst traffic congestion have no metro or small systems for the size of the city and many are building or extending a metro system.

To ensure mobility and reduce air pollution a high-quality mass transit system has been proposed. This system consists of several new light rail lines and bus rapid transit routes together with three heavy rail metro lines.

2.2 Population

The TAM extends 70 km along the coast from Netanya in the north to Ashdod in the south and inland to Modi'in over 30 km. It is the largest centre of population in Israel with a population of around 4.0 million inhabitants at 31st December 2018, 43% of country's population of 9.0 million. Tel Aviv - Yafo and the Inner Ring[1] has a resident population of 1.4 million, 37% of the population of the Metropolitan Area, a further 1.2 million live in the Middle Ring up to 15-20 km from the centre of Tel Aviv.

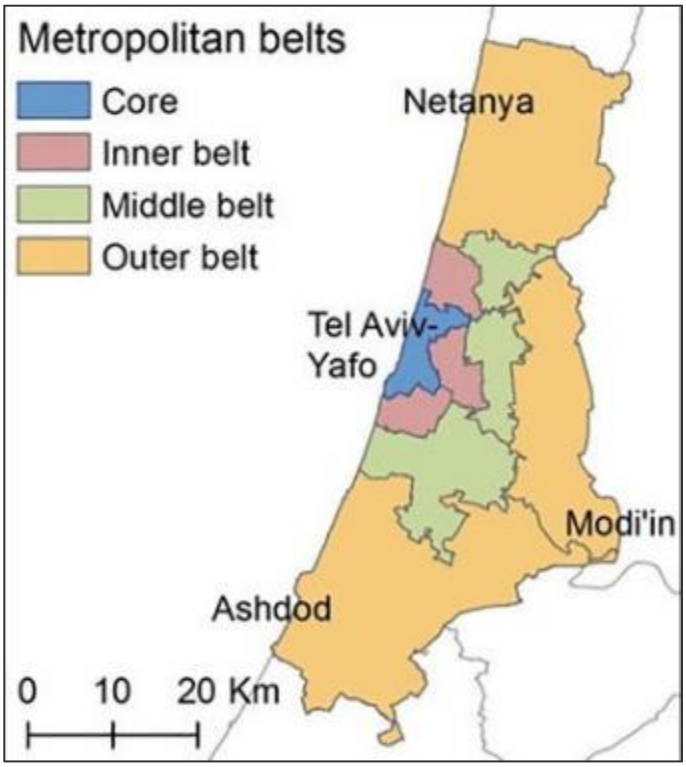
Figure 3 Tel Aviv Metropolitan Area Population

Metropolitan ring	Population (EOY 2018 estimate)	Population density (per km²)	Annual Population growth rate
Core	**451,500**	**8,719**	**1.7%**
Inner Ring	**975,600**	**8,097**	**1.4%**
Northern Section	144,300	3,327	1.3%
Eastern Section	495,100	12,394	1.9%
Southern Section	336,300	9,042	0.6%
Middle Ring	**1,219,800**	**4,157**	**1.6%**
Northern Section	239,500	4,567	1.3%
Eastern Section	325,700	4,559	1.7%
Southern Section	654,500	3,862	1.7%
Metropolitan ring	Population (EOY 2018 estimate)	Population density (per km²)	Annual Population growth rate

[1] Tel Aviv – Yafo and the Inner Ring of the Metropolitan Area (Bat Yam, Holon, Ramat HaSharon, Ramat Gan, Giv'atayim, Bnei Brak, Herzliya, Or Yehuda, Giv'at Shmuel and Kiryat Ono)

Metropolitan ring	Population (EOY 2018 estimate)	Population density (per km²)	Annual Population growth rate
Outer Ring	**1,338,000**	**1,053**	**2.0%**
Northern Section	497,100	1,285	1.3%
Eastern Section	294,700	1,056	3.3%
Southern Section	453,300	877	1.4%
Judea And Samaria	93,000	-	4.3%
Total	**3,984,900**	**2,361**	**1.7%**

Figure 4 Tel Aviv Metropolitan Area



As would expected the population density of the TAM is greatest towards the centre and remains high in the Middle Ring and this area contains several large densely populated cities. The density rapidly reduces in the Outer Ring. In the Outer Ring there are several large cities with high population densities including Netanya, Modi'in and Ashdod.

The population of is Israel is growing very quickly compared to most countries at about 2% per annum between 2008 and 2018, and this is forecast to continue at about the same rate. This increase is supported by a relatively young population with births exceeding deaths and net inward migration. The annual growth of population in the TAM between 2008 and 2018 has been slightly lower than that of the country. As shown in Figure 5 the growth in the TAM is expected to be less than nationally with growth of an average 1.8% per annum to 2030 and 1.5% between 2030 and 2040. In the centre of the TAM the increases are forecast to be 1.3% and 1.2% respectively.

Figure 5- Population Growth Forecast

Sector		Annual Growth		Annual Growth		Annual Growth	
	2017	**2017-30**	**2030**	**2030-40**	**2040**	**2040-50**	**2050**
Core	**443,900**	0.8%	**492,600**	**0.7%**	**527,100**	**0.4%**	**550,000**
Inner Ring	**962,800**	1.4%	**1,150,900**	**1.1%**	**1,282,000**	**0.6%**	**1,366,100**
Northern Section	142,400	2.0%	184,900	2.0%	224,600	2.6%	291,500
Eastern Section	486,000	1.4%	584,000	1.0%	647,700	-0.1%	640,000
Southern Section	334,400	1.0%	382,000	0.7%	409,700	0.6%	434,600
Middle Ring	**1,200,100**	1.5%	**1,450,900**	**1.4%**	**1,668,900**	**1.3%**	**1,889,800**
Northern Section	236,300	1.9%	301,500	1.6%	353,000	1.3%	399,700
Eastern Section	320,200	1.5%	389,500	1.6%	455,500	0.7%	490,100
Southern Section	643,600	1.3%	759,900	1.2%	860,400	1.5%	1,000,000
Outer Ring	**1,178,100**	2.3%	**1,585,900**	**1.8%**	**1,888,300**	**2.2%**	**2,354,600**
Northern Section	490,900	2.2%	655,200	1.5%	762,500	2.1%	939,900
Eastern Section	285,400	2.7%	404,800	2.3%	510,600	2.8%	675,000
Southern Section	401,800	2.1%	525,900	1.6%	615,200	1.9%	739,700
Total	**3,784,900**	1.6%	**4,680,300**	**1.4%**	**5,366,300**	**1.4%**	**6,160,500**
Pop Density	*2,497*		*3,087*		*3,540*		*4,064*
Core+Inner+Middle	2,606,800	1.3%	3,094,400	1.2%	3,478,000	0.9%	3,805,900
Pop Density	*6,989*		*8,296*		*9,324*		*10,203*
Outer Ring	1,178,100		1,585,900		1,888,300		2,354,600
Pop Density	*1,031*		*1,387*		*1,652*		*2,060*

2.3 EMPLOYMENT AND COMMUTING

The 2018 Labour Force Survey indicated that the TAM provides employment for 47% of the workforce in Israel. The survey showed that employment is concentrated in Tel Aviv - Yafo and the Inner Ring, containing nearly half of the employment in the TAM. Employment in Israel has increased by 2.5% between 2008 and 2018, but in the TAM it has increased by 3% per year. Growth has been greatest furthest from the centre of the TAM with employment growing least in the core. This probably reflects the high level of employment density and on the reduced opportunities for employment growth in the core where there are few undeveloped sites.

Of those people employed in Tel Aviv - Yafo and the Inner Ring 65% reside within that area. About 30% of employees working in Tel Aviv and the Inner Ring live in the Middle and Outer Rings mainly in the commuter or dormitory cities such as Rishon LeZiyyon, Petah Tiqwa, Modi'in and Ashdod. Of the other residents of the Outer and Middle rings about 60% are employed in the same section of the ring.

Figure 6 Tel Aviv Metropolitan Area Employment

Metropolitan ring	Employment (EOY 2018 estimate)	Employment density 2018 (employees per km²)	Annual Employment growth rate 2008-2018
Core	**424,700**	**8201**	**1.27%**
Inner Ring	**376,700**	**3126**	**2.83%**
Northern Section	78,700	1815	2.56%
Eastern Section	198,200	4962	3.06%
Southern Section	99,800	2683	2.60%
Middle Ring	**543,400**	**1852**	**2.63%**

Metropolitan ring	Employment (EOY 2018 estimate)	Employment density 2018 (employees per km²)	Annual Employment growth rate 2008-2018
Northern Section	113,900	2172	3.28%
Eastern Section	171,200	2396	2.89%
Southern Section	258,300	1524	2.19%
Outer Ring	**419,500**	**330**	**3.86%**
Northern Section	158,700	410	3.07%
Eastern Section	85,200	305	3.93%
Southern Section	158,000	306	3.50%
Judea and Samaria	17,600		
Unknown	76,000		
Total TAM	**1,840,300**	**1,090**	**3.03%**
Total Israel	**3,905,100**		**2.5%**

There has been slightly larger increase in commuting into the centre from the Outer Ring at 3% per year over the years from 2008 to 2018. Commuting from outside the TAM into the centre has increased very slightly between 2008 and 2018 but remains low at slightly more than 6% of employees. However, almost 3 out of 4 employees who work in the centre of the TAM live in Tel Aviv – Yafo or the Inner or Middle Rings. Many of the employees in who work in the centre of the TAM who live in the Outer Ring live in the cities of Netanya, Modi'in and Ashdod.

Figure 7 - Employment Forecast

Sector		Annual Growth		Annual Growth		Annual Growth	
	2017	**2017-30**	**2030**	**2030-40**	**2040**	**2040-50**	**2050**
Core	**405,400**	1.0%	**459,300**	**0.9%**	**500,300**	**0.8%**	**544,000**
Inner Ring	**363,000**	1.8%	**456,200**	**1.5%**	**527,400**	**1.6%**	**618,800**
Int. North	84,000	1.6%	103,900	1.8%	124,100	2.5%	159,400
Int. East	187,400	1.9%	238,200	1.4%	272,500	1.2%	306,000
Int. South	91,600	1.7%	114,100	1.4%	130,800	1.6%	153,400
Middle Ring	**538,700**	2.0%	**698,000**	**1.7%**	**828,100**	**1.3%**	**944,200**
Mid. North	111,700	1.8%	140,300	1.9%	169,600	1.2%	190,300
Mid. East	172,000	2.2%	226,800	1.7%	267,700	1.3%	304,300
Mid. South	255,000	2.0%	330,900	1.7%	390,800	1.4%	449,600
Outer Ring	**384,300**	3.1%	**568,100**	**2.3%**	**711,000**	**1.6%**	**832,400**
Ext. North	157,600	3.1%	235,600	2.2%	291,500	1.5%	338,700
Ext. East	88,600	4.0%	146,900	2.9%	195,500	1.2%	219,700
Ext. South	138,100	2.3%	185,600	1.9%	224,000	2.0%	274,000
Total	**1,691,400**	**2.0%**	**2,181,600**	**1.6%**	**2,566,800**	**1.4%**	**2,939,400**
Core+Inner+Middle Rings	**1,307,100**	**1.6%**	**1,613,500**	**1.4%**	**1,855,800**	**1.3%**	**2,107,000**

Employment in the TAM has been forecast to increase with growth of an average 2.0 % per annum to 2030 and 1.6% between 2030 and 2040 and in the centre the increases are forecast to be 1.6% and 1.4% respectively. The employment growth, being higher than the population growth, suggests that there will be an increase in movement into the TAM from outside it and from the outer areas towards the central area. This movement will be accommodated using suburban rail services, although the metro system will also play a part distributing these passengers to the employment centres away from the Ayalon Corridor and other rail served areas.

2.4 Existing Transportation in the TAM

The TAM is like many metropolitan areas being composed of a large densely populated area surrounded by a less densely region containing other cities that act in part as dormitory cities. The average population density of the densely populated area, Tel Aviv and the Inner and Middle Rings, is nearly 6,000 persons/km^2 rising to over 8,000 persons/km^2 in Tel Aviv and its Inner Ring, these densities increase as the population rises. Employment is concentrated in Tel Aviv and Inner Ring and this concentration, as in many other similar metropolitan areas, gives rise to large demand for travel towards the centre. Although employment in the outer ring of the TAM increases more than in the centre there remains a significant increase in transport need within the centre.

Tel Aviv is heavily dependent on the private car, within the Metropolitan Area 80% of journeys are made by car reducing to 43% in Tel Aviv-Yafo. The highway network is well developed with major cities linked by limited access routes. These highways extend into the centre of the metropolitan area of Tel Aviv and during the peak commuting hours the network is heavily congested with very low travel speeds.

Within the metropolitan area there are extensive networks of local bus services. These services provide transport within the cities and to adjoining cities. There are bus services to main bus stations and railway stations for longer journeys by express bus services and rail services. Buses also provide some direct services to the main areas of employment within the central area from neighbouring cities.

A network of railway services exists within the metropolitan area providing services from cities in the Middle and Outer Rings including Ashdod, Rishon LeZiyyon, Rehovot, Lod, Modi'in, Netanya, Hod HaSharon, Kfar Saba, Ra'anana, Rosh HaAyin and Petah Tikva. Longer distance services also are provided to Haifa and the North, Jerusalem, Be'er Sheva and Ashkelon.

The existing Transportation System in Tel Aviv is not sustainable, with its dependence of the private car, because there is insufficient highway or parking capacity within most of the employment areas and particularly in the centre of the TAM. The Transportation System is very similar to that adopted in many cities in the United States and was starting to be adopted in some European countries. However, most metropolitan areas had either adopted different models, with greater emphasis on public transportation, or are increasing the provision of public transportation and enhancing its attractiveness to commuters.

Providing increased public transportation which is more attractive to passengers is the correct approach for a metropolitan area such as Tel Aviv. To make it more attractive than the existing system requires the adoption of a mix of solutions that are appropriate for the demand and time and distance travelled.

2.5 Transport proposals for Tel Aviv

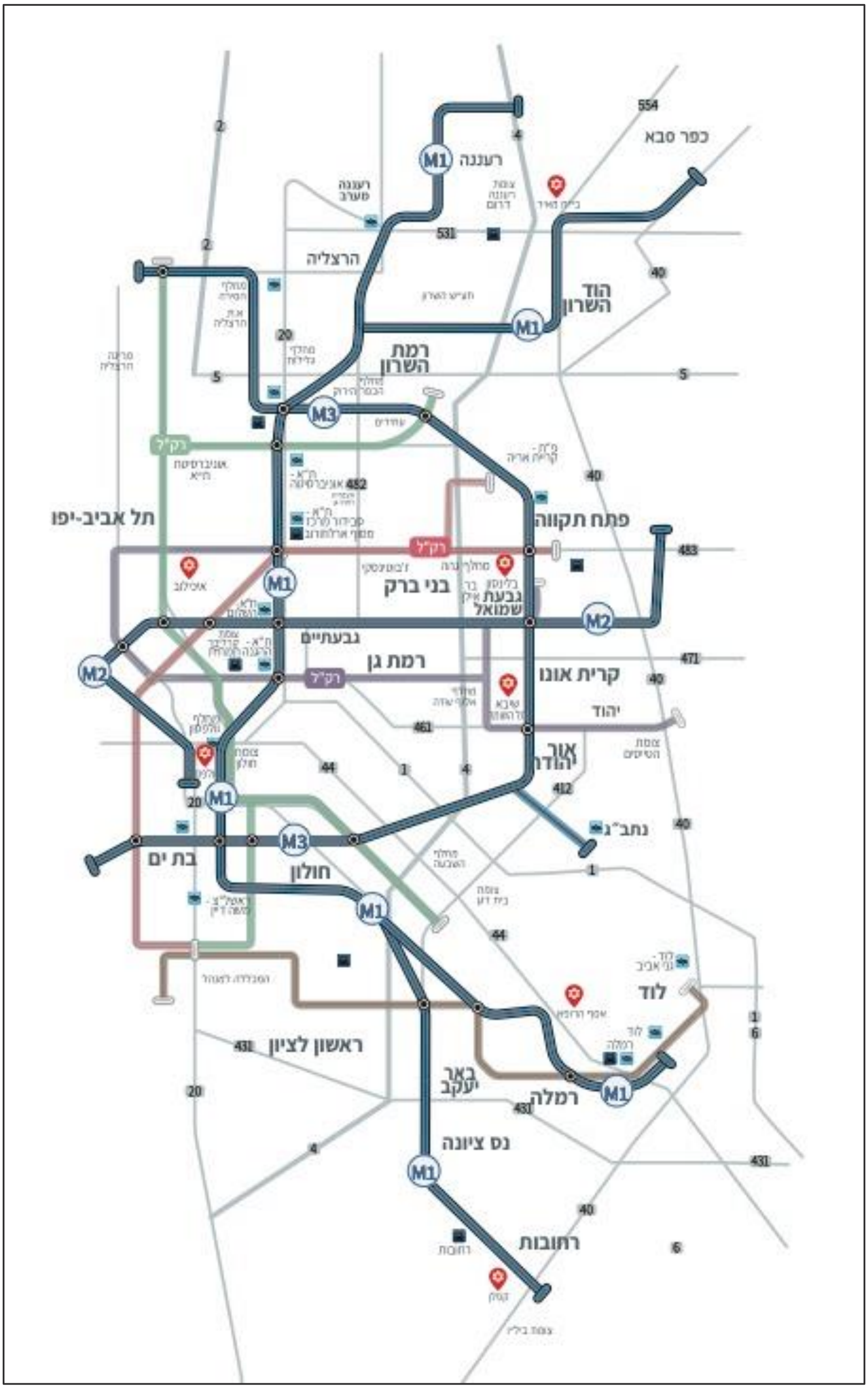
Several proposals have been made to improve transport in Tel Aviv and these have been developed through several plans into the current proposed arrangement, this is shown diagrammatically in Figure 8. The principal elements of the plan are:

- A metro system of 3 lines serving the Core, Inner Ring and Middle Ring of the TAM
- 3 LRT lines: Red (under construction), Green and Purple
- 3 BRT lines: Brown Line, HaSharon Line and Light Blue Line
- Suburban rail lines
    - Highway 431 corridor
    - Eastern Track

The centre of the TAM is served by the metro and LRT systems, the outer areas are linked to the central area by the suburban rail links.

Louis Berger

Figure 8 - Tel Aviv Metro and LRT Systems



3 Comparable Transport Solutions

Second opinion on Comparable Transport Solutions:

(1) The Metro Solution that has been proposed by the Experts is comparable with the solutions that have been implemented in many other Metropolitan Areas. **Low impact**

3.1 Public Transport Modes

In this section we will describe the types of public transport system that are suitable for use in the Tel Aviv Metropolitan Area. It will set out the advantages and disadvantages of each mode and the circumstances where it could be used. Although the division between some of the modes is clear with the rail-based solution the distinctions can be become blurred and the system can incorporate characteristics from more than one type. Other systems such as Personal Rapid Transit are not considered mature enough for consideration.

3.1.1 Conventional Bus

Advantages	Disadvantages
Low capital investment	Low Journey speed – improved with priority measures
Very good accessibility in heavily populated areas – short walking distance – many routes, frequent stops – 200-300m	Frequent stops increase journey time
Efficient mode for serving areas of low population density	Priority measures adversely affect other road users
Flexible – routes and frequency can easily be changed	Not suitable for routes with high demand
Economical solution for areas with lower population density	Unreliable service - caused by sharing road space
Good coverage in areas with lower population density possible	Not popular with passengers – poor image
Stops can be more frequent as little infrastructure required	Adversely affected by road congestion

In general buses are most suitable for providing service to areas with a low population density, acting as feeder services to faster modes of public transportation. They are also suitable in areas of higher population density or employment centers that are beyond reasonable walking distance from other forms of public transport. Bus stops can be located relatively close together providing short walking distances, but frequent stops will increase journey times.

3.1.2 Bus Rapid Transit (BRT)

Advantages	Disadvantages
Lower capital investment than Light Rapid Transit	Fixed route – requires infrastructure to re-route
Dedicated route (Busway) reduces journey time	Priority measures adversely affect other road users
May be able to operate off dedicated route to serve more destinations or in emergency	BRT Guidance system increases cost
BRT Vehicles can have higher passenger carrying capacity than conventional buses	Long articulated BRT vehicles may not be used off Busway
Can operate at higher speeds with track separated from other road users	Less frequent stops to exploit faster speed – reduced accessibility than bus
Requires less space with vehicle guidance systems	Image problem with passengers remains

BRT services are suited to corridors where demand is high because of their larger passenger capacity, but where the demand is insufficient to justify the higher investment needed for an LRT or metro system. The larger capacity of each vehicles, compared to a bus, reduces the number of buses required but with the high demand on the route allows a practical, but frequent service interval. The speed advantage of a dedicated or segregated route, free of interference from other traffic, Makes journey times more attractive.

3.1.3 Light Rapid Transit (LRT)

There are different types of Light Rapid Transit. All have some form of guidance system, rails or beams, and the vehicles follow a fixed route. They range from street running tramways, which are in many ways like the Guided BRT, through to LRT Metros that operate on their own right of way and share some of the characteristics with Heavy Metro systems. Many systems have a combination of different characteristics, such as sections of street running combined with segregated right of way and underground or elevated right of way. Also a few systems also operate services that extend onto the heavy rail network. – Tram-train systems.

Many metropolitan areas had extensive tramway systems, and these have been reduced in extent because of the introduction of metro lines to provide additional capacity or because of increased use of private cars making them uneconomic. Other systems have been upgraded to Pre-metro to remove or reduce the sections of network shared with other road users by constructing tunnels in the city centre and reserved rights of way.

Figure 9 Tram-train running on street in Sheffield, UK

Advantages	Disadvantages
Lower capital investment Metro	Very expensive if operating in tunnels or viaducts
Higher capacity than bus	Fixed route – requires infrastructure to re-route
Requires less space than bus lanes	On street running - Priority at Traffic Signals adversely effects other road users
Can operate at higher speeds with track separated from other road users	Track and power supply system increases cost over guided BRT
Passengers perceive as better than BRT	Possible requirement to divert or alter utilities
Can follow existing street alignment or operate in tunnels or on viaducts above existing streets	Most efficient if stations further apart than bus stops – 500 m
	Requires high population densities

LRT systems are appropriate where demand is higher than that could be provided by a bus-based solution. The capacity of the system increases as the system moves from tram to light metro. However, the lower vehicle capacity of a light metro compared to heavy metro favours heavy metro as passenger demand increases. The flexibility to operate in different environments from on-street to on heavy rail systems can be a significant benefit. In already developed areas the route can be constructed underground or on viaducts, but it can also operate on surface level right of way or on street, if space is available or between settlements or space is provided in new developments.

3.1.4 Heavy Metro

Heavy metro systems operate on their own right of way. Most operate below ground or on viaducts, particularly when constructed in areas that have already been developed, some sections may be at grade where no development exists or is planned.

Advantages	Disadvantages
Higher capacity than LRT	Very expensive tunnels/viaducts
No interference by other vehicles and on street space	Fixed route – changes very expensive
Operates underground or on viaducts	Track and power supply system and stations more expensive than LRT
Reduced impact on tunneled sections	Requires very high demand along route
Requires less space than Tram	Most efficient if stations further apart than LRT about 1km
Can operate at higher speeds with own track	Needs high population densities to provide high demand
High speeds possible whilst crossing gaps between population centers	

Heavy metro is the appropriate solution where demand is very high as a high frequency service with high capacity trains can be provided. It also has the potential for high speeds on sections where there is reduced passenger demand. In already developed areas the route can be constructed underground or on viaducts, but it can also operate on surface level right of way between settlements.

3.1.5 Heavy Suburban Rail

Advantages	Disadvantages
No interference by other vehicles and on street space	Very expensive tunnels in urban areas
Can operate at much higher speeds with own right of way	Station stops should be at least 2 km apart to ensure short journey time
Provides shorter journey times than LRT or Metro for longer journeys	Requires high demand along route
Reduced impact on tunnelled sections	Lower carrying capacity than Metro systems
	Less frequent services

An appropriate solution for longer journeys in the metropolitan area. Less frequent stations to ensure short journey times make it a less appropriate for short journeys in the metropolitan area. Very intrusive in urban areas unless tunnelled. Service frequency lower than possible with Metro systems make it less attractive for short journeys.

3.2 COMPARISON TO WORLD METRO SYSTEMS

3.2.1 MRT systems over the world

The Consultant has tried to analyse several mass rapid transit systems over the world. This analyse focus on Mass Rapid Transit (MRT) systems only. For example, LRT or hybrid systems with higher capacity than tram systems such as in Porto or Frankfurt, or metro projects for example in Dublin or Jeddah are not included in the analyses. However, the database cannot match perfectly with the reality and mistakes can be made.

The Consultant identified 190 MRT systems throughout 57 countries over the world. Most of them are in European and Asian countries.

In terms of population, according to the United Nations Department of Economic and Social Affairs (World Urbanization Prospects: The 2018 Revision), the population of the Gush Dan metropolitan area is expected to be more than 4 000 000 inhabitants in 2020.

With a MRT network length of 143 km and according to the database, if the Tel Aviv metro project were completed in 2020, it would positions itself has a European system in terms of length compared to metropolitan population.

In terms of population and network length, the Tel Aviv metro system would be similar to European cities such as Barcelona, Saint-Petersburg or Berlin, and Asian cities such as Dalian, Zhengzhou or Busan.

Figure 10 World MRT network length compared to metropolitan population size (Source: Louis Berger)

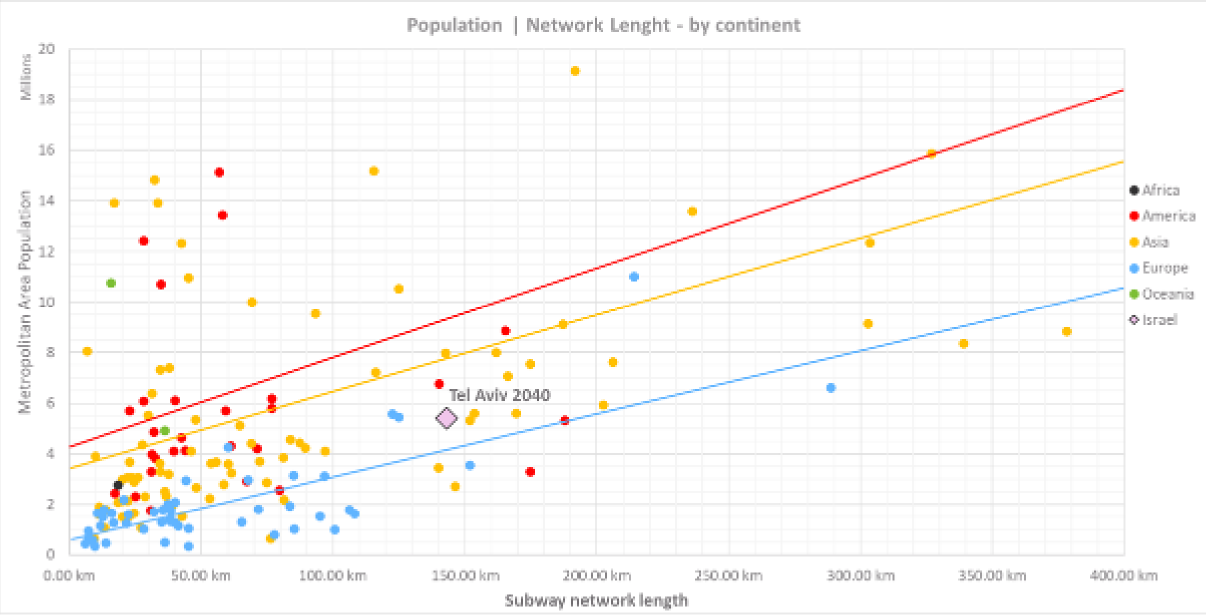
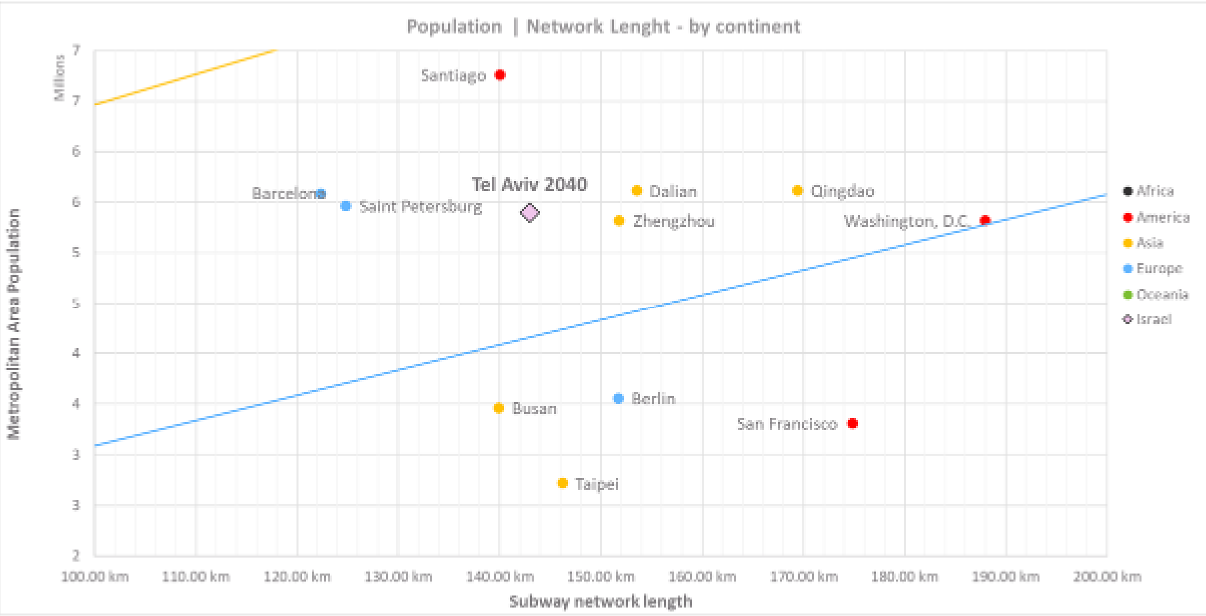


Figure 11 Gush Dan similar areas by MRT network length and metropolitan population size (Source: Louis Berger)



3.2.2 Similar urban areas with and without MRT systems (in terms of population)

By looking from another point of view, with regards with the UN World Urbanization Prospects (2018 Revision), there are in 2020 up to 180 urban areas with a population between 2 and 5 million inhabitants and 35 % of these encompass a MRT system. For high income countries like Israel, that percentage is close to 50 %. There is a clear causal link between the MRT systems, level of income and heavily populated areas.

The table below shows that results:

Figure 12 Percentage of 2 to 5 million people urban areas with a MRT system (Source: Louis Berger)

Percentage of urban areas with a population between 2 and 5 million inhabitants that encompass a MRT system					
	High income	Upper middle income	Lower middle income	Low income	**Total**
Africa	-	1 out of 5 (20%)	0 out of 14 (0%)	0 out of 8 (0%)	**1 out of 27 (4%)**
America	6 out of 21 (29%)	8 out of 25 (32%)	-	0 out of 1 (0%)	**14 out of 47 (30%)**
Asia	10 out of 15 (67%)	22 out of 39 (56%)	5 out of 33 (15%)	1 out of 4 (25%)	**38 out of 91 (42%)**
Europe	7 out of 9 (78%)	1 out of 1 (100%)	1 out of 1 (100%)	-	**9 out of 11 (82%)**
Oceania	1 out of 4 (25%)	-	-	-	**1 out of 4 (25%)**
Total	**24 out of 49 (49%)**	**32 out of 70 (46%)**	**6 out of 48 (13%)**	**1 out of 13 (8%)**	**63 out of 180 (35%)**

With a closer look at these data, we can see that:

- In America, only large car designed areas from the United States of America do not have an MRT system. However, 70 % of American metropolitan areas between 3 and 6 million inhabitants encompass a MRT system (the criteria is higher but the causal link is still there);
- In Asia:
  - Hamamatsu (Japan) seems not to have a MRT system nor any mass transit system;
  - Xinbei (Taiwan) is wrongly graded has a non MRT provided agglomeration since it should be included into the Taipei urban area;
  - Kuwait City (Kuwait) does not have a MRT system but there is a project for it;
  - Jeddah (Saudi Arabia) does not have a MRT system but there is a project for it;
  - Mecca (Saudi Arabia) does not have a MRT system (except a 18 km metro line operating only during the Hajj) but there is a project for it;
- In Europe, the two urban areas that do not have MRT system, Birmingham and Manchester (England), still have a Pre-MRT system. Furthermore, 100 % of European urban areas between 3 and 6 million inhabitants encompass a MRT system;
- In Oceania, the cities of Brisbane, Melbourne and Perth (Australia) does not have MRT system but have strong suburban railways and metro projects (Melbourne).

3.2.3 World cities with and without MRT system (in terms of global socio-economic affairs)

There are several indexes that rank worldwide cities by economic and trade power.

According to one of them, the 2018 Globalization and World Cities Research Network (GaWC) index, Tel Aviv is one of the 75 most influent cities in the world. The city is ranked as a “Beta+“, meaning this is an “important world city that is instrumental in linking its region or state into the world economy”. Note that in other indexes, ranking could differ due to other comparison methods.

Figure 13 The World According to GaWC 2018
(Source: Globalization and World Cities Research Network)

Alpha++	London	Alpha	Milan	Alpha-	Amsterdam	Beta+	Ho Chi Minh City
Alpha++	New York City	Alpha	Chicago	Alpha-	Stockholm	Beta+	Boston
Alpha+	Paris	Alpha	Moscow	Alpha-	San Francisco	Beta+	Cairo
Alpha+	Tokyo	Alpha	Toronto	Alpha-	Delhi	Beta+	Hamburg
Alpha+	Hong Kong	Alpha	São Paulo	Alpha-	Santiago	Beta+	Düsseldorf
Alpha+	Beijing	Alpha	Frankfurt	Alpha-	Johannesburg	Beta+	Tel Aviv
Alpha+	Singapore	Alpha	Los Angeles	Alpha-	Dublin	Beta+	Atlanta
Alpha+	Shanghai	Alpha	Madrid	Alpha-	Vienna	Beta+	Athens
Alpha+	Sydney	Alpha	Mexico City	Alpha-	Montreal	Beta+	Doha
Alpha+	Dubai	Alpha	Kuala Lumpur	Alpha-	Lisbon	Beta+	Lima
		Alpha	Seoul	Alpha-	Barcelona	Beta+	Bengaluru
		Alpha	Jakarta	Alpha-	Luxembourg	Beta+	Dallas
		Alpha	Mumbai	Alpha-	Bogota	Beta+	Copenhagen
		Alpha	Miami	Alpha-	Manila	Beta+	Hanoi
		Alpha	Brussels	Alpha-	Washington	Beta+	Perth
		Alpha	Taipei	Alpha-	Prague	Beta+	Chengdu
		Alpha	Guangzhou	Alpha-	Munich	Beta+	Bucharest
		Alpha	Buenos Aires	Alpha-	Rome	Beta+	Auckland
		Alpha	Zurich	Alpha-	Riyadh	Beta+	Vancouver
		Alpha	Warsaw	Alpha-	Budapest	Beta+	Hangzhou
		Alpha	Istanbul	Alpha-	Houston		
		Alpha	Bangkok	Alpha-	Shenzhen		
		Alpha	Melbourne				

In that list, 16 cities including Tel Aviv does not encompass MRT system yet (see the yellow coloured cells). That means only 20 percent of top ranked cities does not have any MRT line.

However, some of these cities have high quality mass transit systems:

- Frankfurt U-Bahn (LRT) with 9 lines over 65 km that carrying 360 000 passengers a day;
- Zurich Tram with 15 lines over 120 km that carrying 560 000 passengers a day;
- Düsseldorf Stadtbahn (LRT) with 11 lines over 70 km;

Other have metro projects expected to open between 2020 and 2030:

- Melbourne Metro Tunnel, under construction, opening expected by 2025;
- Dublin Metrolink, under construction, opening expected by 2027;
- Bogota Metro, under project, opening expected by 2028;
- Riyadh Metro, under construction, opening expected by 2020;
- Ho Chi Minh City Metro, under construction, opening expected by 2021;
- Hanoi Metro, under construction, opening expected by 2020;

And 6 of these, based on the American model, have a low or medium performance urban transit system (in terms of ridership or modal share with car):

- Johannesburg Gauteng Metrorail (suburban railway);
- Luxembourg Tram (light rail system);
- Houston Metro Rail (light rail system);
- Dallas DART Light Rail (light rail system);

- Perth Transperth Trains (suburban railway);
- Auckland commuter rail lines (suburban railway).

Finally, if compared with other similar metropolitan areas, Tel Aviv seems to be far behind in terms of mass transit systems. This analyse tends to confirm the Experts observations and results. The Consultant does not have any other comments that the Experts have already stated.

3.3 Comparable Metropolitan Areas

Several Metropolitan Areas have been identified that are comparable to the TAM. Most of comparable metropolitan areas are in Europe. Several factors have been considered in making the comparison.

3.3.1 Type of Metropolitan Area

Different transport solutions are likely to satisfy the needs of differing types of area. The solution adopted for a metropolitan area that has a single centre of population with a sparsely populated hinterland is likely to be different from a metropolitan area with its core area surrounded by several other cities that serve as a dormitory for the core city.

3.3.2 Total Population and Population Density

The transport solutions that have been adopted are influenced not only by the total population but also by the variation of population density. Very large densely populated areas lend themselves to the provision of large heavy rail metro solution whereas areas with a smaller core or with lower population density may better served by LRT systems.

3.3.3 Size of Metropolitan Area

The size of the Metropolitan Area and its core can also influence the solution that is adopted. In large metropolitan areas where the population is concentrated in many centers the transport system may rely more heavily on the provision of a heavy rail suburban rail network than where there are few centers of population outside the core. If the metropolitan area is small but densely populated suburban rail services may be less important, favouring a solution with a more extensive metro system.

3.4 Selected Comparable Metropolitan Areas

In the Master Plan Review update conducted by Egis Rail identified the cities of Lyon, Prague, Brussels, Barcelona, Berlin and Milan as having integrated LRT and Metro systems that are comparable with that proposed for the central Tel Aviv conurbation.

The table below sets those metropolitan areas in Europe that have a population between 2.5 and 6.5 million inhabitants.

Figure 14 – Metropolitan Areas Population Data

Metropolitan Area[2]	Population ***Million***	Area ***km²***	Population Density ***1,000/km²***
Madrid	6.378	5,336	1,195
Tel Aviv (2040)	5.356	1,516	3,533
Tel Aviv (2030)	4.680	1,516	3,087
Berlin[3]	4.460	3,743	1,192
Milan	4.268	1,348	3,166
Rome	4.354	5,352	813
Tel Aviv	3.984	1,516	2,573
Athens	3.864	2,929	1,319

[2] In EU Larger urban zone

[3] Berliner Umland

Metropolitan Area[2]	Population	Area	Population Density
	Million	*km²*	*1,000/km²*
Budapest	3.304	7,626	433
Barcelona	3.220	636	5,063
Hamburg	3.174	7,293	435
Amsterdam	2.772	2,580	1,074
Manchester	2.615	1,276	2,049

Comparison between metropolitan areas is difficult because of the varying composition of the area. All metropolitan areas contain a major city or conurbation of cities where the population density is greatest; this is surrounded by less densely populated areas that are linked for employment and social activities to the major city. In some cases, the surrounding metropolitan area will contain other cities with a high population density, but this is not always the case. In other metropolitan areas, such as Rhine-Ruhr, there are more than one major city, and such areas have been excluded.

The TAM like most metropolitan areas of divided into a central conurbation of a single city or group of cities that are contiguous and have a high population density. This central conurbation is the area where most if not all the LRT and Metro systems are located. Outside these central conurbations the population density is much reduced with concentrations of population located in discrete communities separated by areas of limited development with low population density. These communities can be located up to 50 km from the central conurbation. These discrete communities will be linked by suburban heavy rail or express bus services. Beyond the outer area the central conurbation will continue to draw people to it, but the proportion of passengers will be low and here heavy rail services will link them to the metropolitan area.

The cities within the TAM that is proposed to include in the central core are those listed below, these are the cities that are in general served by the proposed Metro lines: -

Core and Inner Ring		Middle Ring	
Tel Aviv - Yafo	Bnei Brak	Ra'anana	Lod
Bat Yam	Herzliya	Kfar Saba	Ramla
Holon	Or Yehuda	Hod HaSharon	Ness Ziona
Ramat HaSharon	Giv'at Shmuel	Rosh HaAyin	Rehovot
Ramat Gan	Kiryat Ono	Petah Tikva	Rishon LeZion
Giv'atayim		Yehud	

Similar adjustment have been made to the comparable metropolitan areas to estimate the areas and populations that are served by the metro.

Figure 15 Population for the central core of the selected Metropolitan areas

Metropolitan Area	Central Conurbation			Outer Areas		
	Population	Area	Population Density	Population	Area	Population Density
	Million	*km²*	*1,000/km²*	*Million*	*km²*	*1,000/km²*
Berlin	3.769	891	4,231	0.691	2,852	242
Tel Aviv (2040)	3.478	373	9,324	1.888	1,143	1,652
Madrid	3.402	552	6,168	2.976	4,784	622
Tel Aviv (2030)	3,094	373	8,296	1.586	1,143	1,387
Athens	3.090	415	7,452	0.774	2,514	308
Tel Aviv (2018)	2.600	373	6,971	1.384	1,143	1,211
Barcelona	2.227	146	15,276	0.993	490	2,027
Hamburg	1.814	755	2,402	1.360	6,538	208
Budapest	1.752	525	3,338	1.552	7,101	219
Milan	1.533	248	6,180	2.735	1,100	2,486

Metropolitan Area	Central Conurbation			Outer Areas		
	Population	Area	Population Density	Population	Area	Population Density
	Million	*km²*	*1,000/km²*	*Million*	*km²*	*1,000/km²*
Rome	1.421	308	4,621	2.933	5,044	581
Manchester	1.270	382	3,325	1.345	894	1,504
Amsterdam	0.906	238	3,805	1.866	2,342	797

The TAM is different to most of metropolitan areas, its closest comparator in terms of population densities and area are Milan and Madrid, but the population density of Tel Aviv will rise above all except Barcelona. Most metropolitan areas have significant differences between either the character of the Central Conurbation and the remainder of the area or the size of the metropolitan area. For example:

- The central conurbation of the TAM has a high population density like Madrid but the density outside it is much lower.
- Central Athens has a similar population in both the metropolitan area and central area to the TAM and the central area is a similar size, but the metropolitan area of Athens is much larger.
- Berlin has a similar population, but it is much larger in area, also Berlin has a metro system and a metro like suburban railway network.

All the other metropolitan areas have a range of transport systems that are considered appropriate for the TAM. All these metropolitan areas, except Manchester, have a metro system. Manchester relying on an LRT system (Pre-metro- converted suburban railway) and extensive suburban rail services.

Figure 16 Public Transport in Comparable Metropolitan Areas

City	Suburban Rail	Metro	LRT	Tram	Bus
Madrid	√	√	√		√
Berlin	√	√		√	√
Milan	√	√	√	√	√
Rome	√	√		√	√
Athens	√	√		√	√
Budapest	√	√		√	√
Barcelona	√	√		√	√
Hamburg	√	√			√
Amsterdam	√	√		√	√
Manchester	√		√	√	√

One of the most significant difference between metropolitan areas is the nature of the area outside the major city. Not all metropolitan areas have significant centers of population outside the major city, as is the case in the TAM. Therefore, it is proposed to make comparison between cities that have similar characteristics to TAM in respect of the central conurbation, where the Metro system is proposed. The metropolitan areas with the closest fit are:

- Madrid – very similar population density but larger area and population
- Berlin – very similar population, with growth, and area contains some areas with low population density and no metro
- Milan - very similar population density but smaller area and population
- Rome – lower population density, but similar area
- Athens – similar but higher population density and area
- Budapest – lower population and larger area

3.4.1 Madrid

Madrid has an extensive metro system consisting of 13 lines with a total length of 293 km and an annual ridership of 657 million passengers. The network extends between 20 and 30 km from the centre. Most lines radiate from the centre of the city and there is also a circular line around the city centre that serves to distribute passengers. There is another circular line that links the main metro lines to the large towns south and southwest of Madrid.

The metro system is also supplemented by four light rail systems that link the metro with suburban areas outside the area served by the metro system and an extensive bus network of over 200 routes. For the metropolitan area beyond the metro served area there is a suburban rail system, Cercanías Madrid, with 6 basic routes serving towns and cities up to 50 km from the centre.

Figure 17 Central Madrid – Metro and LRT Lines

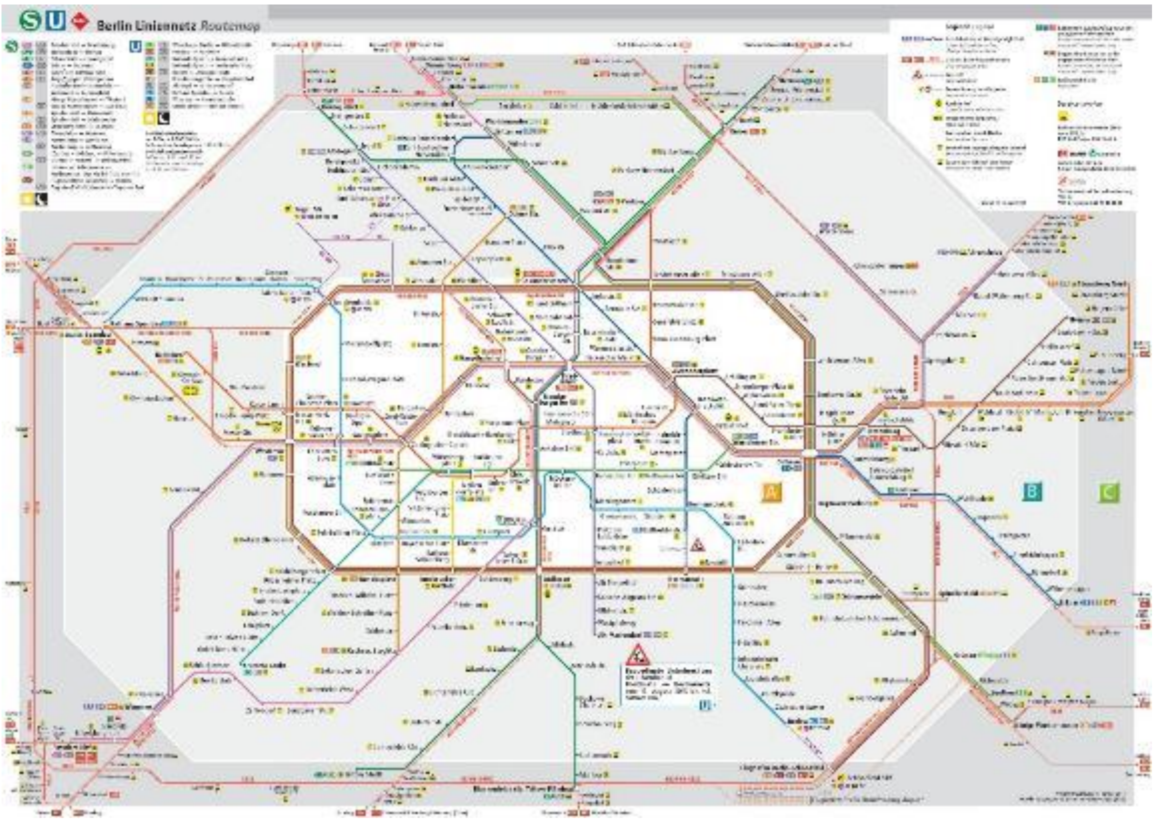
The population density of Madrid is like that in the TAM at present, the population density will be overtaken by the TAM as the population is forecast to rise to the present population of Madrid. The area of Madrid is larger than Tel Aviv and the population is concentrated more in the central area than in the TAM.

3.4.2 Berlin

Berlin has a network of 10 underground metro lines with a total length of 152 km and 173 stations, although not all is underground, and an annual ridership of 553 million passengers, this is mostly in the western part of the city and extends 10 to 15 km from the centre. In addition, there is the S Bahn with an annual ridership of 431 million passengers.

The S-Bahn has a network of 16 metro lines, elevated or at ground level, with a length 327 km and 166 stations including a ring line. These provide service in the central area of Berlin and serve the outer areas of the metropolitan area, up to 35 km from the centre. In the east of the city there is an extensive network of tram lines, some radial into areas not served by the S-Bahn and others linking residential areas to the S-Bahn. There is also a network of 154 bus lines operating over 1,675 km of route and carrying 440 million passenger a year.

Figure 18 Berlin U-Bahn and S-Bahn Network



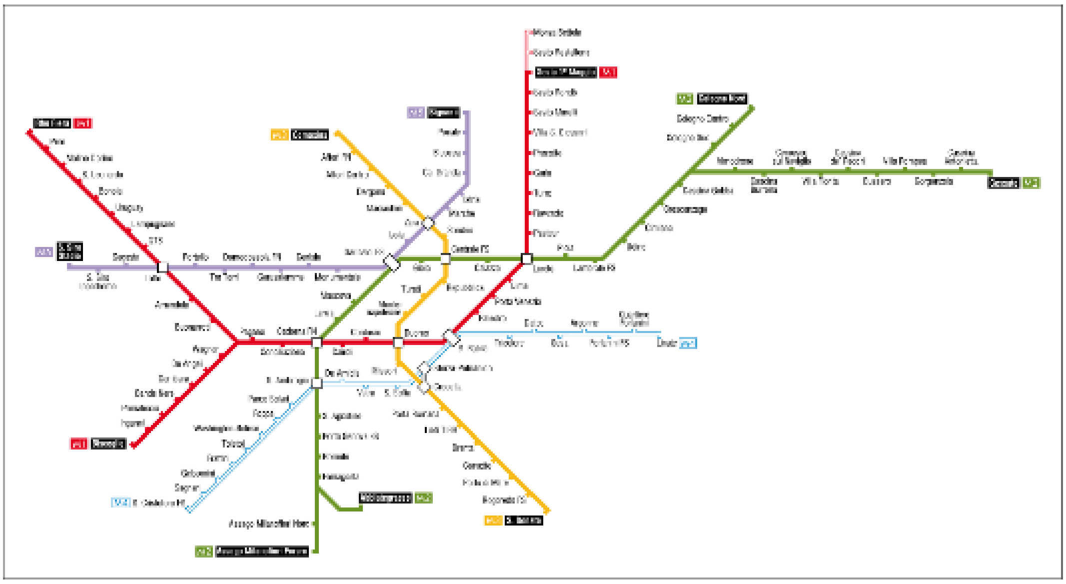
Berlin has a lower population density than Tel Aviv and a much larger area served by the metro network. The population is more concentrated in the centre than in the TAM. For historic reasons, the eastern central part of the city has less metro coverage than the west. In the east, where most of the tram network is located, the tram network has been reorganised to provide more direct service towards the city centre.

3.4.3 Milan

The city of Milan has a network of 4 lines with a total length of 96 km with 108 stations and an annual ridership of 369 million passengers. The lines are radial with different routes in the centre of the city. The lines extend about 10 km from the centre of the city. A fifth line is under construction.

Outside the city there are 12 suburban railway lines connecting Milan to the greater metropolitan area. In the city there is an extensive network of 17 tram lines, mostly radial. The lines have been reduced as the metro lines were constructed, but the lines have modernized in recent times and extended outwards as “fast trams”. There is also an extensive network of bus services with 100 lines in the city and a further 100 serving the metropolitan area.

Figure 19 Milan Metro Network



Milan’s centre has a similar population density to the present Tel Aviv’s centre it is smaller in area , yet it has an extensive metro system.

3.4.4 Rome

In Rome there is a metro system composed of 3 lines with a total length of 60 km with 73 stations and annual ridership of 320 million passengers. The lines are radial with two lines (orange and blue) passing through the centre of the city forming an “X” shape and the third line (green) is being extended through the city centre. These extend up to 15 km from the centre, but most only reach 7 km from the centre.

Figure 20 Rome Metro Network

In addition, there are 3 above ground metro lines, one of which has been largely replaced by the green line metro, the other 2 lines link stations on the metro to communities up to 45 km from central Rome but acting as a metro within Rome. Serving other communities within the metropolitan area are a network of 8 suburban rail services, these have 128 stations. Within the central area there are also a network of trams, much reduced from its greatest extent to six lines mainly feeding into the metro network. There is also an extensive network of buses with over 300 lines operating over 2,300km of route.

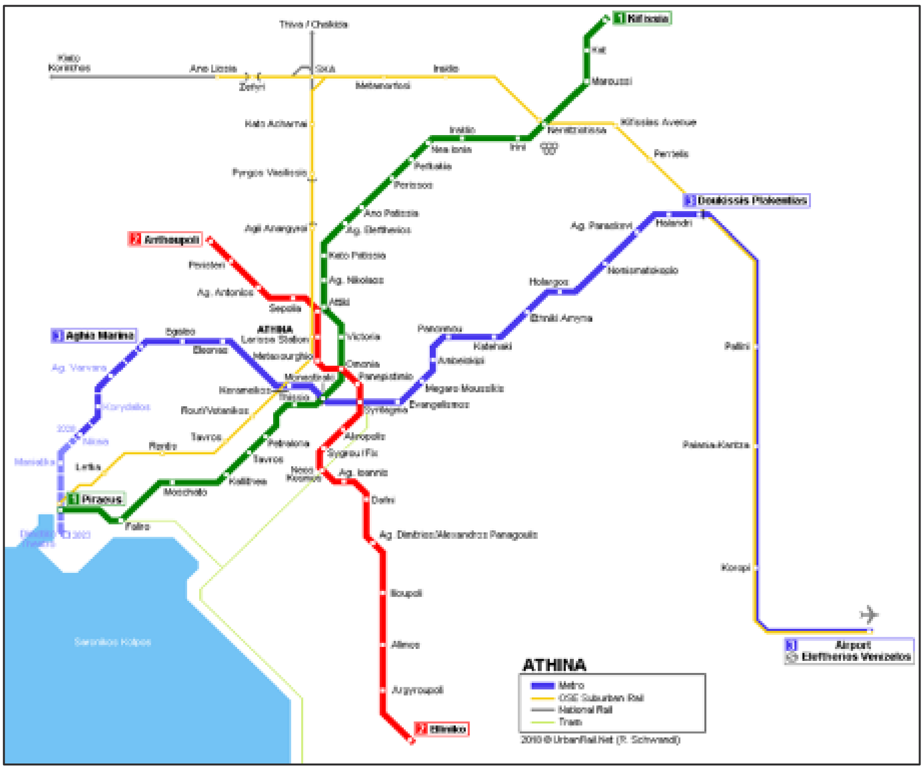
Rome has a similar sized centre to Tel Aviv but with a lower population density, however, there are large areas without limited development. The population density in those areas served by the metro is higher and lower population served by the metro has reduced its size compared to that proposed for Tel Aviv.

3.4.5 Athens

The Athens metro is composed of 3 lines, total length 85 km, with 61 stations with an annual ridership of 494 million passengers. The network extends about 10 km from the city centre, excluding the link to the airport. The metropolitan area is also served by 4 suburban railway routes with over 231 km of track and 45 stations, these routes serve the metropolitan area also extend outside the metropolitan area, up to 80 km from the centre.

The Athens metropolitan area is also served by a tram system of 27 km with three routes linking the centre of Athens to and along the coastal areas. There is also a network consists of about 300 bus lines which cover the Athens Metropolitan Area.

Figure 21 Athens Metro and Tram/LRT Network



The population density and size of the centre of Athens is comparable with that of Tel Aviv. The metro network is similar to that proposed for Tel Aviv in 2030, Extension of Line 3 to Piraeus, under construction, will add 7.5 km and 7 stations and plans to add a fourth line 38 km long with 35 stations will produce a metro of similar size to Tel Aviv in 2040.

3.4.6 Budapest

Within the metropolitan area of Budapest there is a relatively small metro system composed of 4 lines, total length 40 km with 48 stations. However, it is very well used with an annual ridership of 409 million passengers. It is supplemented by 4 suburban rail lines of the Budapesti Helyiérdekű Vasút (HÉV) that act as parts of the metro system and serve much of Budapest and extend out into the surrounding metropolitan area.

About 53 km of the suburban railway has an intensive metro like service, serving 54 stations. Other rail lines serve areas further from Budapest. Within Budapest there is a very large network of tram services, with 27 routes over 159 km of track and carrying nearly 400 million passenger a year and this is supplemented by about 280 bus lines.

Figure 22 Budapest Metro and HÉV systems

Budapest is less populous than Tel Aviv and has a lower population density it has a small metro system together with a metro like suburban rail system making it comparable to the first phase in Tel Aviv. There are plans to extend HÉV line 6 to an interchange with Metro Line 3 with a new tunnel and then extend this to join it to HÉV line 5.

3.5 TEL AVIV

The Experts' recommendation for the Metro in the TAM is for a system of 3 metro lines of 140 km to supplement the LRT lines. The Consultant has compared the solution proposed with solutions that are in use in other metropolitan areas and the scale of and layout is comparable with them. All the comparable European metropolitan areas, listed in Figure 16, except Manchester, have built and continue to expand their metro systems to serve the central areas of the metropolitan area. As demand has increased in some areas existing LRT lines have been unable to provide the capacity or level of service required to remain attractive and have been augmented or replaced by metro lines.

The scale of metro proposed for the poulation served is similar to those of the selected comparable metro systems, listed in Figure 23 below, allowing for the size difference of the comparable cities and the expansion of the population of the TAM within the period of implementation of the metro. Many of the compared metro systems are expanding their networks to encourage greater use and or relieve overcrowding.

Figure 23 Metro Network Data for Selected Areas

Metropolitan Area	**Population in Millions ‡ (Central Areas)**	**Area in km²**	**No of lines**	**Length of line**	**Number of stations**
Tel Aviv -2040	*3.478*	*373*	3	140	103
Tel Aviv -2030	*3.094*		3	75	58
Madrid	*3.402*	*552*	13	293	302
Berlin ø	*3.769*	*891*	26	479	339
Milan	*1.533*	*248*	4	96	108
Rome *	*1.421*	*308*	5	100	101
Athens	*3.090*	*415*	3	85	61
Budapest ¶	*1.752*	*525*	8	93	102

Notes

‡Current population except forecast populations for Tel Aviv

ø including both U- Bahn and S-Bahn

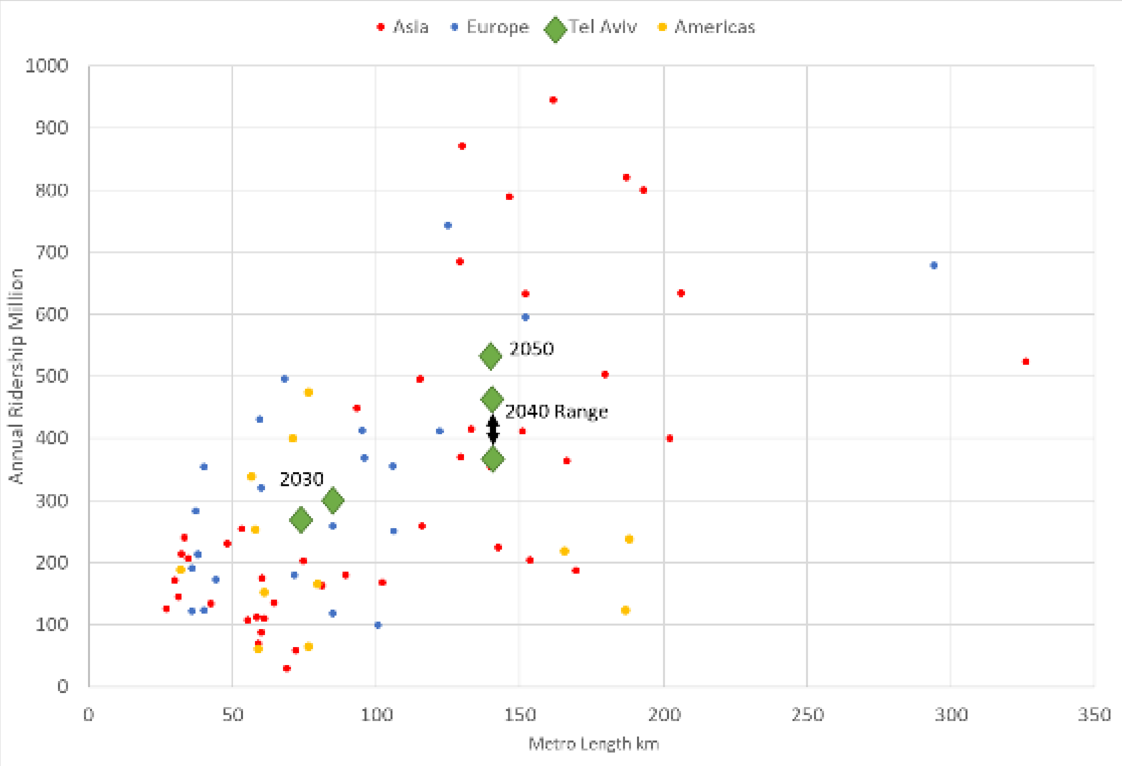
* including sections of Roma–Lido and Roma Nord railways within Rome

¶ including sections of BHÉV railways within Budapest

Figure 24 Population compared to Metro Network length

The annual ridership of the Tel Aviv metro system has been estimated based on the number of boardings from the model runs, factored to allow for passngers that transfer from one line to anothrer at the 4 interchange stations by assuming that 1 in 6 passengers transfer. This has then been copmared with the annual ridership of other metro systems with an annual ridership of between 120 and 1,000 million or a network lenght of over 50 km. Metro systems with more than 1,000 million passengers have metropolitan areas far bigger than the TAM and are not inlcuded.

Figure 25 Estimated Annual Ridership against Metro Length



This shows that there is a wide range of annual ridership for a metro of a given length but the ridership for the tel Aviv metro system is comparable with a range of similar sized metro systems.

Many of the cities with metro systems have much lower congestion levels than Tel Aviv today and as the population rises, with projected growth of between 1.5% and 1.8%, congestion will become worse and this will encourage increased ridership. In many of the cities with high levels of congestion and without a metro system are being planned or constructed. Other simialrly congested cities with metro ssytems are expanding their systems to reduce congestion.

In the outer parts of the metropolitan areas the public transport provided is generally by suburban rail network, local bus and in larger cities by BRT or LRT networks. Extending the metro systemto serve these areas would result in longer journey times than can be achieved with suburban rail because of the higher speeds and reduced number of station stops. In the TAM the main cities in the outer ring are Netanya, Modi'in and Ashdod, these cities together with others are already served by suburban rail services. The 2040 Railway Strategy improves the existing services from these cities and adds further suburban rail services along the Eastern Track and Highway 431.

4 CONTEXT AND MACROECONOMIC FRAMEWORK

Second opinion on context and macroeconomic framework:
(2) In order to properly assess the socio-economic impact of the MRT project, the baseline option should be the more likely to occur in the event that the project is not carried out. This option should therefore include all LRT projects as baseline option (option "A01"). **High impact**

4.1 TEL AVIV METRO REFERENCE SITUATION

The reference situation can be divided into two parts. The first in which a general framework is defined, independent of completion of the investment that could give a reference scenario of economic and social development in the Tel Aviv area. The second is a baseline option which refers to the situation that would prevail in the absence of the investment.

The socio-economic assessment should assess the project opportunity with regard to the reference situation.

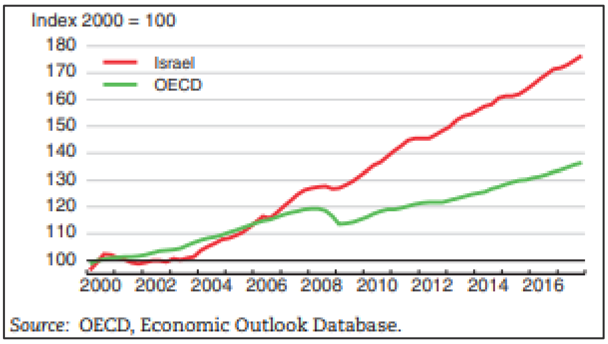
4.1.1 Context and macroeconomic framework

Israel

The Consultant analysed the macroeconomic and local context of Israel and Gush Dan specific area. However it should be mention that international Consultant is not the most appropriate to check the Experts assumptions and methodology since the Consultant cannot fully and exhaustively master local level urban, economic and spatial dynamics.

According to the 2018 OECD Economic Survey of Israel, compared with other high income countries, Israel shows strong economic growth thanks to a low and declining public debt and a performant high-tech sector that boosts exports.

Figure 26 Real GDP developments
(Source: OECD, Economic Outlook Database)



But this good governance on public expenditure management inevitably leads to public underinvestment and a large infrastructure deficit. The OECD analysis shows that there is a lack of investment in several sectors but especially in public transport, that causes road congestion and poor air quality in Israel.

This concurs with the findings of the Experts who stated that the gap in investments in public transport infrastructure in Israeli metropolitan areas compared to the developed world at approximately ILS 250 billion an investment in public transport per capita of $2,000 compared to $15,000 per capita in the countries of Western Europe.

The Consultant corroborate that public investment in Israel is lower than public investment in other OECD countries, but is not able to confirm that particular statements (and it would also be possible that Western Europe countries make too large investments on public transport).

However the results stand out: road traffic intensity in Israel is, by far, the worst in all OECD countries and environmental indicators or not good. This is due to the lack of space in Israel and the high population densities that are not compatible with urban development policies and investment relying on private car based mobility.

Figure 27 Road traffic intensity per network length for OECD countries (Source: OECD (2015), Environment at a Glance 2015: OECD Indicators)

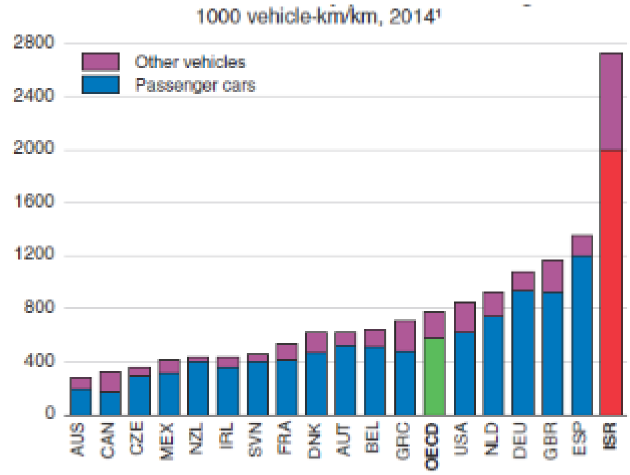
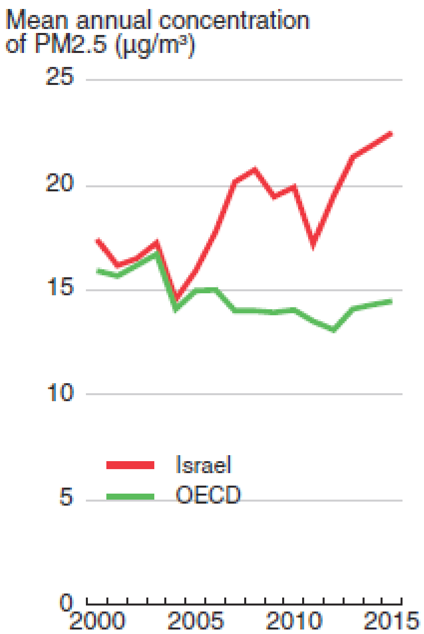


Figure 28 Mean annual concentration of PM2.5 (µg/m³) in Israel compared to OECD average (Source: OECD Economic Surveys: Israel© OECD 2018)



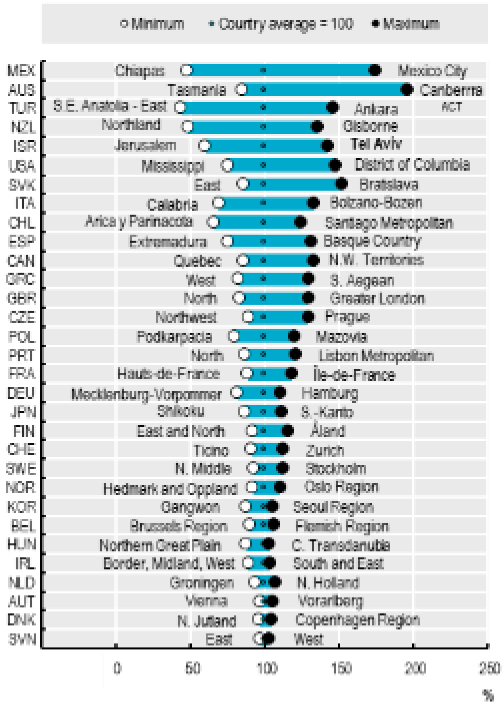
Tel Aviv

Tel Aviv metropolitan area constitutes the nerve centre for finance, economics, trades and research in Israel. Quoting the Experts, "Over 50% of workplaces in Israel are within the metropolis, including the headquarters of many international and local companies. 68% of high-tech companies and 77% of parent companies in Israel are located in Tel Aviv. In addition, most of the medical institutions and about 50% of higher education institutions and students are located in Tel Aviv.".

According the OECD publication OECD Regions and Cities at a Glance 2018, Tel Aviv is among the top 5 % of OECD regions in terms of jobs outcomes and among the 20% in terms of jobs and self-assessed life satisfaction. But on the other side, all Israeli regions rank among the bottom 20 % of the OECD regions in environment, as measured in terms of levels of PM 2.5.

There is also large regional disparities in Israel, found in jobs, access to services and community. According to the OECD, the average disposable income per capita in Tel Aviv region represents 140 % of national average.

Figure 29 Disposable income per capita in OECD "TL2" regions as a share of national average (Source: OECD 2018, OECD Regional Statistics)



TLV Metro reference situation parameters

Based on their experience and a huge literary work, the experts have set up the main macroeconomic parameters for the economic assessment. These parameters are outlined above.

As said before, the Consultant is not the best entity to discuss these parameters. However, here are the main observations:

- Each parameter coming from a national guideline or source is the most likely to be used because the economic studies of every kind should rely as much as possible on official data for a complete comparison;
- The Consultant did not understand if the capitalization rate is 4 % or 7 % on the Transportation Projects Procedure. It seems to be 7 % but being under review at the time of the economic assessment. The Consultant has made its recommendation further in this report (see section 7.1.3 "Discount rate"). As a reminder, in order to avoid any miscomprehension, the Consultant recommends that any communication on the economic results should always be communicated with the capitalization rate being used (4 % or 7 %);
- The average wage used for the economic assessment seems to be the national average wage. The Consultant recalls that, in Tel Aviv region, the average wage is much higher than the other regions. Using national average wage will impact negatively the NPV results and could also have impact on route choice in the TLV transport model. However the Consultant consider that this observation is not significant enough to constitute a recommendation to be rectified since the hourly rates being used for trips are coming from the Transportation Projects Procedure.

The Figure 30 Main study parameters and values used for the economic assessment
(Source: Gush Dan Metro Economic, Social and Urban Impacts, Methodology Report & Results)

Parameter	Estimate	Source	Comments
2019 population	4.0	CBS	Tel Aviv Metropolis
2040 population forecast	5.4-5.8	National Economic Council	
VAT	17%		
Capitalization rate	4%	International review, Transportation Projects Procedure	Sensitivity tests of 7%
Project life span	40 years	Transportation Projects Procedure	
Project start year	2030	NTA	Stage 1 base scenario, sensitivity tests 2035
Full opening year	2035	NTA	Base scenario, sensitivity tests 2040-2045
Forecast years	2030, 2040, 2050	Tel Aviv Model	
Benefit annual growth 2050-2075	2%	National Economic Council	
Average wage in the economy	ILS 10,784	CBS, Average wage 2019	
Hourly rate of work travel in metropolis	100.6	Transportation Projects Procedure, Chief Economist	Calculated according to average wage in the metropolis, work hours per employee, deductions etc.
Hourly rate other journeys	30.2	Transportation Projects Procedure	As percentage of average wage
Realistic annual raise in wages	1-1.5%	Transportation Project Procedures Study, National Economic Council Analysis	
Average land value in metropolis	ILS 15,000 per m²		
Annual cost vehicle capital	ILS 8,377	Depreciation and average vehicle interest less tax	
Cost of parking space	ILS 9,446	Transportation Project Procedures	

4.1.2 Baseline option

In the first version of the economic assessment, the Experts have used two baseline options. On the first one (“A0”) the only LRT red line would be complete (including improvement in bus services). On the second one (“A01”), the LRT purple and green lines would also be complete.

The Experts have considered both “A0” and “A01” as baseline options.

The Consultant disagrees with that. Indeed, in order to properly assess the socio-economic impact of the TLVM project, the baseline option should be the one which is the situation that would prevail in the event that the MRT is not carried out. In the absence of the mass rapid transit project in Tel Aviv, the implementation of the light rail transit red, purple and green lines is mostly probable. The Consultant recommends that the Experts make no confusion between the “A0” (LRT red line only), and the “A01” (LRT red, purple and green lines) scenarios as baseline option.

This issue has been discussed. The Experts have explained that in the “A01” option, the traffic forecast model encounters an overcapacity problem. By 2040 and 2050, the modelled expected traffic on LRT lines is well above there theoretical capacity. Therefore, this option is no more fairly realistic to constitute a good enough baseline option.

As the Consultant consider the “A0” option neither can constitute the baseline option, the Experts and the Consultant have agreed that the “A01” option without application of parking policy is an acceptable compromise.

It should be note that, this traffic forecast and LRT overcapacity issue goes beyond the simple socio-economic assessment. Indeed, this issue shows that the implementation of the only LRT lines would be probably undersized against the mobility needs of the Tel Avivians.

5 TRAFFIC FORECAST

Second opinion on traffic forecast:
(3) The traffic model seems to reach a satisfactory calibration for O-D matrix and travel time, but the Experts should also present the calibration on road links from traffic counting. **Medium impact**
(4) The traffic forecast model was adjusted in a public transport underperforming situation. That might create important bias in public transit estimation. **Medium impact**
(5) In order to facilitate understanding and being more transparent in reporting results, the Experts should lay out the metro lines graph of load for the project scenario by 2030, 2040 and 2050 (S3131, S4111, S5111). **Low impact**
(6) The Experts should explain why several stations does not have any boarding or any alighting on the traffic model and explain the results of expected boardings in Hashalom Station. **Low impact**

5.1 MODEL PARAMETERS AND CALIBRATION

Tel Aviv metropolitan area has a very powerful traffic model, a very advanced activity-based model, which is the best instrument to assess various transport projects at a city scale. The work done, particularly for parking scenarios and car ownership, is very much documented.

The Experts seem to have reached a satisfactory calibration in terms of both origin-destination volume and travel time. However the Consultant note that there is no presentation of road sections traffic, no diagram showing the calibration between traffic counting and traffic forecast, nor any comparison indicators for road traffic such as the coefficient of determination R^2, the RMSE (Root Mean Square Error) or the GEH (from Geoffrey E. Havers).

As a reminder, the coefficient of determination R^2 is an indicator which makes it possible to consider the quality of a linear regression in order to measure the adequacy between the model and the observed data. For each counting point, the GEH indicator takes into account both absolute and relative errors, thus providing a good indicator between flows made and counts observed by section. This indicator is more tolerant with errors on links with low traffic flow.

The other risk that the Consultant has observed is that the Tel Aviv transport model is calibrated in a situation where public transit is underperforming. As a matter of fact, Tel Aviv public transit only operates low capacity bus lines. The calibration of the choice between transport modes (i.e. between cars and rapid transit) can only be based on expectancy and feedbacks from other similar projects. However it is important to note that transport mode choices is mainly unfavourable to the public transport mode.

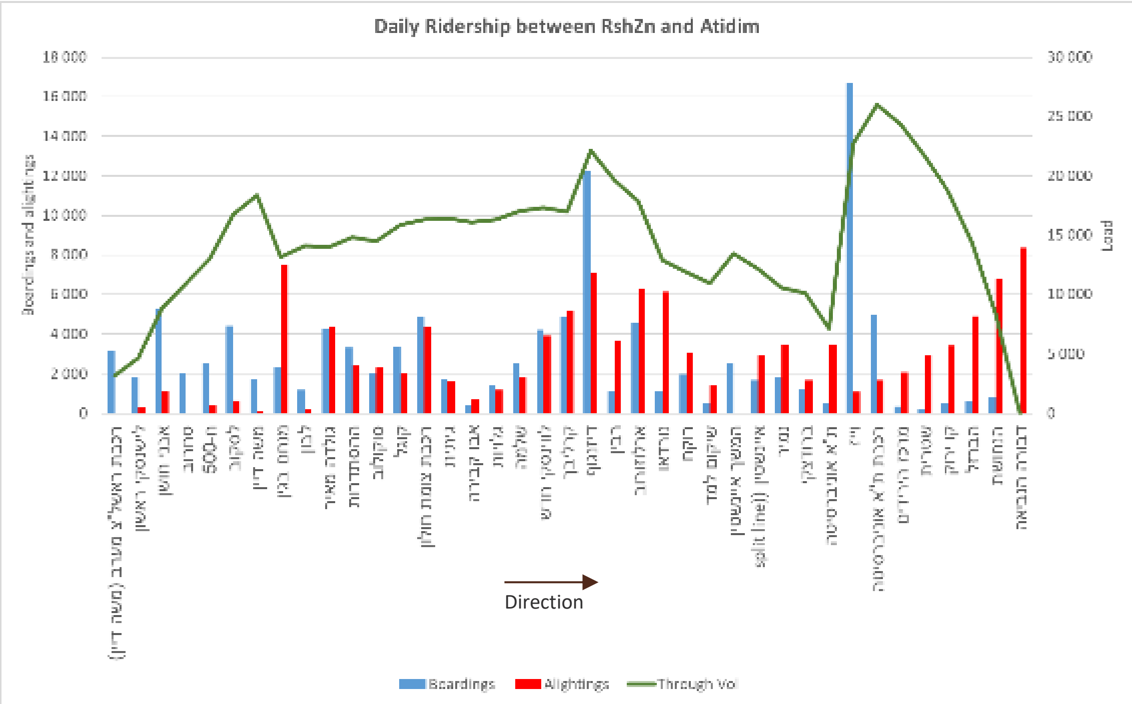
5.2 MRT TRAFFIC FORECAST

The Consultant has analysed traffic forecast for the MRT project main scenarios. The Consultant regrets that there is no clear presentation of traffic forecast on the economic assessment. Due to the complexity to check boardings, aligthings and traffic loads for each scenario and due to lack of time, the Consultant wasn’t able to combine data from the model and specific local data.

The analysis below can only be “macro”, without understandings on local particularities. In order to facilitate understanding of the results, the Experts should lay out the metro lines graph of load for the project scenario by 2030, 2040 and 2050 (S3131, S4111, S5111) and, if possible, produce a GIS or KMZ mapmaking of the metro project with stations location.

An example of graph of load can be found below.

Figure 31 Scenario 3131 daily metro ridership from RshZn to Atidim
(Source: Louis Berger from forecast model Excel report for scenario S3131)



The analysis of ridership on TLV metro lines and stations shows consistent results from the traffic model. The ridership expectations are high but realistic and coherent in front of the city configuration, density, and the implementation of a high-performance metro system.

However, the Consultant has two comments that need clarification:

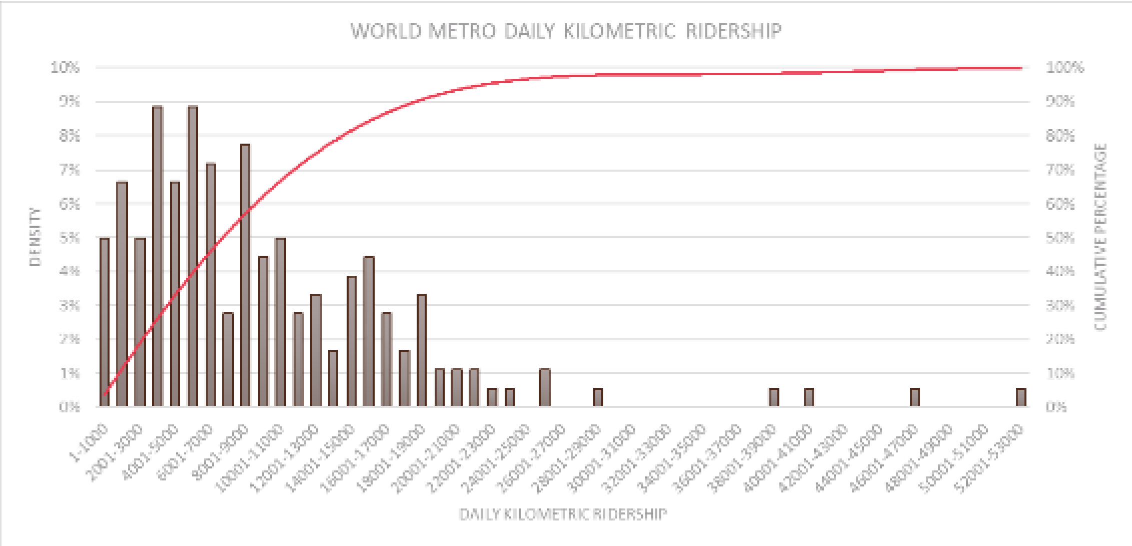
- The Consultant wonders why there is stations with either no boarding or no aligtings (e.g. “Sheba Hospital”, “New Central Station Tel Aviv” or “Continue Einstein”).
- The model boarding expectations at Hashalom Station (almost 70 000 boardings daily) seem to be high. For example in Paris metro, except for huge multimodal train stations such as Gare du Nord, Gare Saint-Lazare, Gare de Lyon, Gare Montparnasse or Gare de l’Est, the most crowed metro stations do not reach 55 000 boardings daily. The Experts should comment that result.

The Expert have explained that the Hashalom station is the most busy and central station in Israel. It will be the biggest multimodal train stations in the country including transfer to the Israeli rail.

The daily ridership divided by the network length is expected to be between 9 000 boardings / km a day by 2030 and 15 000 boardings / km a day by 2040. Note that the ideal unit of measurement and comparison should be the passenger-kilometre divided by the network length, but there is not enough information available on other metro systems. This is why the daily boarding unit measure is used.

Compared to existing metro systems, the TLV metro place himself in 2030 at the same levels as actual performant new and/or European metro networks (Rennes, Milan, Toulouse, Istanbul, Wuhan, Toulouse, Berlin, London, Barcelona, Turin, Stockholm, etc.). The 15 000 boardings / km a day by 2040 correspond to actual metro systems like Rome, Taipei, Beijing, Shanghai or Singapore. These observations shows that the traffic model results are realistic.

Figure 32 World metro systems daily ridership divided by their network length (Source: Louis Berger)



Finally, annual ridership, expected to be 450 million boardings a year by 2030, and 790 million boardings a year by 2040, is close to actual ridership in similar examples in terms of area population and network length (Berlin, Barcelona or Busan).

Figure 33 Similar examples of metro networks compared to Tel Aviv metro (Source: Louis Berger)

City / Country	Opening / Last Expansion	Length / Nb. Stations	Annual ridership / Year
Barcelona / Spain	1924 / 2020	122 km / 133	410 million / 2018
Berlin / Germany	1902 / 2009	152 km / 173	580 million / 2018
Dalian / China	2003 / 2018	153 km / 69	200 million / 2019
Busan / South Korea	1985 / 2017	140 / 135	350 million / 2018
Tel Aviv / Israel	2030 2040	~ 100 km / ~80 143 km / 103	450 million / 2030 790 million / 2040

Figure 34 Metro Ridership and History Data

City / Country	Opening / Last Expansion	Length/Nb. Stations	Annual ridership / Year
Madrid / Spain	1919/2007	293 km / 302	657 million / 2018
Berlin / Germany	1902 / 2009	152 km / 173	553 million / 2017
Milan / Italy	1964 / 2013	96 km / 108	369 million / 2018
Rome / Italy	1955 / 2013	60 km / 73	320 million / 2018
Athens / Greece	1904 / 2013	85 km / 61	494 million / 2013
Budapest / Hungary	1896 / 2014	40 km/ 52	409 million / 2017
Barcelona / Spain	1924 / 2020	122 km / 133	410 million / 2018
Hamburg / Germany	1912 / 1975	106 km / 98	245 million / 2017
Amsterdam / Netherlands	1977 / 2018	52 km / 39	90 million / 2017
Frankfurt / Germany	1968 / 2010	65 km / 86	143 million / 2018
Tel Aviv / Israel	2030 Central 2030 Combined 2035	75 km / 58 85 km / 65 140 km / 103	270 million/ 2030 296 million / 2030 368-470 million/ 2040

6 OPERATIONAL AND CAPITAL EXPENDITURES

Second opinion on operational and capital expenditures:

(7) The Experts should review the level of contingencies applied to the CAPAEX to ensure that this reflects the stage in project's development. **Medium impact**

(8) The CAPEX of the complete project is considered reasonable and to be within the range of costs derived from other similar recent projects. **Medium impact**

(9) The Experts should review the estimate for utility re-location. The Consultant considers that is lower than could be expected in a highly developed urban area. **Low impact**

(10) The Experts should consider whether the cost of land acquisition and any compensation payable should be included in the cost of the Project. **Low impact**

(11) The OPEX of the complete project is considered reasonable and is within the range of costs derived from other similar metro systems and that the 20% contingency that has been added provides enough mitigation for increased costs. **Low impact**

(12) The Experts should ensure that any additional costs arising from the phased delivery of the project are fully considered in the assessment of the development of the complete project. **Medium impact**

(13) The Experts must specify the subsidies and taxes for public works in Israel, in order to be able to convert economic financial costs to economic costs. **Medium impact**

6.1 CAPITAL EXPENDITURE ESTIMATE

6.1.1 SYSTRA 2019

The estimate of Capital Expenditure prepared by SYSTRA in their Feasibility Study Report in 2019 is set out below. This estimate was for each of the 3 metro lines, as modified by the work undertaken as part of the refinement of the routes.

Cost estimate Route M1 - 2019

Item	Measurement units	Rate NIS	Units	CAPEX NIS
Length of the line	km			74
Underground	km			74
Underground stations	Unit			55
Rolling stock	Cars			464
Utilities relocation				**2,574,000,000**
Infrastructure	**NIS/km**			**13,618,161,480**
Underground sections				13,618,161,480
Stations				**19,800,000,000**
Underground stations	NIS/unit	360,000,000	55	19,800,000,000
Systems				**4,998,383,670**
Tracks				982,045,008
Power supply system				957,091,842
Signalling system				909,727,728
Communications / Telecoms and passenger information				541,045,092
Environmental Control System (ECS)	NIS/ underground station	16,800,000	55	924,000,000
Platform Screen Doors (PSD)	NIS/station	10,920,000	55	600,600,000
Fare collection system (AFC)				83,874,000
Equipment and Rolling Stock				**3,423,913,500**
Depots				819,409,500
Control centre building	NIS/unit	12,600,000		12,600,000
Rolling stock	NIS/car			2,591,904,000
Grand Total	**NIS**			**44,414,458,650**
Design				**2,220,722,933**
PMC				**1,554,506,053**
QA				**2,220,722,933**
Contingencies	**Percentage of Grand Total**	**40%**		**20,164,164,227**
Outturn Total	**NIS**			**70,574,574,795**
Outturn Total Inc. VAT				**82,572,252,510**

Cost estimate Route M2 - 2019

Item	Measurement units	Rate NIS	Units	CAPEX NIS
Length of the line	km			29
Underground	km			29
Underground stations	Unit			26
Rolling stock	Cars			304
Utilities relocation				**1,216,800,000**
Infrastructure	**NIS/km**			**5,274,360,840**
Underground sections				5,274,360,840
Stations				**9,360,000,000**
Underground stations	NIS/unit	360,000,000	26	9,360,000,000
Systems				**2,426,159,400**
Tracks				398,832,000
Power supply system				388,143,000
Signalling system				603,489,600
Communications / Telecoms and passenger information				274,638,000
Environmental Control System (ECS)	NIS/ underground station	16,800,000	26	436,800,000
Platform Screen Doors (PSD)	NIS/station	10,920,000	26	283,920,000
Fare collection system (AFC)				40,336,800
Equipment and Rolling Stock				**2,037,703,500**
Depot				326,959,500
Control centre building	NIS/unit	12,600,000		12,600,000
Rolling stock	NIS/car			1,698,144,000
Grand Total	**NIS**			**20,315,023,740**
Design				**1,015,751,187**
PMC				**711,025,831**
QA				**1,015,751,187**
Contingencies	**Percentage of Grand Total**	**40%**		**9,223,020,778**
Outturn Total	**NIS**			**32,280,572,723**
Outturn Total Inc. VAT				**37,768,270,086**

Cost estimate Route M3 - 2019

Item	Measurement units	Rate NIS	Units	CAPEX NIS
Length of the line	km			36
Underground	km			36
Underground stations	Unit			27
Rolling stock	Cars			164
Utilities relocation				**1,263,600,000**
Infrastructure				**6,502,244,280**
Underground sections				6,502,244,280
Stations				**9,720,000,000**
Underground stations	NIS/unit	360,000,000	27	9,720,000,000
Systems				**2,746,129,050**
Tracks				488,720,400
Power supply system				502,558,350
Signalling system				649,059,600
Communications / Telecoms and passenger information				313,427,100
Environmental Control System (ECS)	NIS/ underground station	16,800,000	27	453,600,000
Platform Screen Doors (PSD)	NIS/station	10,920,000	27	294,840,000
Fare collection system (AFC)				43,923,600
Equipment and Rolling Stock				**1,224,153,000**
Depot				295,449,000
Control centre building	NIS/unit	12,600,000		12,600,000
Rolling stock	NIS/car			916,104,000
Grand Total	**NIS**			**21,456,126,330**
Design				**1,072,806,317**
PMC				**750,964,422**
QA				**1,072,806,317**
Contingencies	**Percentage of Grand Total**	**40%**		**9,741,081,354**
Outturn Total	**NIS**			**34,093,784,738**
Outturn Total Inc. VAT				**39,889,728,144**

Cost estimate Total - 2019

The total Capital Cost of the complete Metro system including depots and rolling stock is estimated as follows:

Line	Length	Cost per km w/o contingencies		Cost per km w/ contingencies	
	Km	Ex. VAT	Inc. VAT	Ex. VAT	Inc. VAT
M1	74	681	797	954	1,116
M2	29	795	930	1,113	1,302
M3	36	676	791	947	1,108
Total	**139**	**704**	**823**	**985**	**1,153**

It will be noticed that Line M2 has the highest cost per km this line has stations that are on average more closely spaced than the other lines, increasing the cost per km.

The estimated cost of the infrastructure in the SYSTRA Feasibility Study are based on several projects that SYSTRA have knowledge of and data from the Red Line Project. The Consultants will compare these costs to other similar projects that have been recently constructed.

6.1.2 SYSTRA 2020

The Methodology Report & Results issued on 23rd April 2020 included a revised estimate, based on the rates used in the previous estimate but with further adjustments to the route. This estimate recognised that part of Line 2 was not underground with a reduced price per unit length, it also revised the number of stations.

Discipline	Units	Quantity	Price per Unit	Estimate (M)
Infra 1				**66,226**
Utilities relocation				3,708
Civil works (without stations)	km	137.6	183	25,174
At Grade section	km	2.9	91.5	264
Stations	Stations	103.0	360.0	37,080
Infra 2				**16,741**
Track	km	140.4	13.5	1,896
Systems	km	140.4	58.0	8,146
4 Depots	Cars			1,480
Rolling stock	Cars	932.0	5.6	5,219
Construction				**82,967**
Additional costs (13.5%)				11,201
Sub sum				**94,167**
Contingencies (40%)				37,667
Total				**131,834**
Total with VAT				***154,246***

The total of revised estimate is 4% lower, this is due to reduction in the number of stations to be constructed and a significant reduction (27%) in the cost of utility relocation. The cost of the project per km is set out below:

Element	Cost per km w/o contingencies		Cost per km w/ contingencies	
	Ex. VAT	Inc. VAT	Ex. VAT	Inc. VAT
Infrastructure and systems	629	735	880	1,030
Rolling stock	42	49	59	69
Total all elements	**671**	**785**	**939**	**1,099**

6.2 Infrastructure

6.2.1 Construction of the route

The estimated cost of the infrastructure, not in stations, in the SYSTRA Feasibility Study is 30% of the total cost of the project. The infrastructure element is the cost of constructing the routes and the original estimated costs were based on all sections being in tunnels underground. The revised estimate identified a small at grade with a reduced rate, however, this represents a very small part of the total project and therefore the infrastructure cost remains very similar.

The study identifies several methods of tunnel construction and identified that some sections of the routes are likely to be constructed through more difficult ground conditions. This being a factor in the Multi Criteria Analysis that was conducted to refine the routes. The alignment of the tunnels largely follows the line of existing streets and highways to reduce the amount of property to be acquired.

The method of construction for the tunnelled part of the route is most likely to by Tunnel Boring Machines (TBM), as used for the construction the Red Line LRT. This is because of the difficult and variable geological conditions that are likely to be encountered. The alternative is cut and cover and this is likely to cause considerable disruption to users of properties adjacent to the street through noise, dust and reduction in access to properties. It would also disrupt traffic flows over a wide area as long lengths of street would be unavailable. Considerable disruption to utilities would also occur, needing the relocation of plant either temporarily or permanently, potentially extending the disruption to traffic.

Provided that the ground condition encountered on this project are similar to those on the Red Line Project and SYSTRA have full knowledge of any issues encountered on that project then the estimated cost will be the best that it is possible to obtain.

6.2.2 Stations

Stations account for about 50% of the cost of the project. It is suggested that the stations would be constructed using a cut and cover method by excavating in the street, reducing land acquisition but incurring the cost of utility relocation. A unit rate has been applied for each station on each line, irrespective of whether is underground, at grade or possibly on viaduct. Not all stations will be the same size because more passengers boarding and alighting at a station, particularly in the central area of Tel Aviv, may require stations with wider platforms, passageways and circulating areas.

Interchange stations have been assumed to cost twice as much as an ordinary station on a single line as the cost of the station is included in the estimate of each line. There will be additional costs because of the need to provide interchange passages for potentially large numbers of passengers and one of the lines will be constructed at a deeper level to allow the lines to cross. Interchange station with the LRT system use the same cost rate as all other stations. However, the total cost is reasonable at this stage in the project's development.

6.3 Systems, rolling stock and depots

6.3.1 Systems

The systems cost head accounts for 12% of the total estimated cost of the project in the SYSTRA estimate. Included in this cost head are the track, power supply, signalling, safety, communication and environmental control systems needed for the operation of the metro. This can vary considerably between metro projects depending on the systems that are provided, the value that has been suggested by SYSTRA is reasonable.

6.3.2 Rolling stock and depots

SYSTRA have identified that operate the metro system a total of 932 cars operating either as 4-car or 8-car trains will be required to provide a 3-minute headway on the common part of Line 1 and on Lines 2 and 3. A 6-minute headway is proposed for the branches of Line 1. A 4-car metro unit of 65m with a capacity for 625 is proposed with two units operating together on Lines 1 and 2. This frequency and train capacity meet the maximum demand forecast by the model of 24,000 passengers/hour.

The cost for each car included in the SYSTRA estimate is at the lower end of the range of costs contained in the Consultant's data.

It is proposed to have 2 depots on Line 1 and 1 each of Lines 2 and 3. The depots proposed of a similar scale. It is assumed that all lines will be self-sufficient, the depots serving Lines 2 and 3will have the same facilities whereas in the Line 1 depots some facilities will only be available at one of the depots. The estimate takes the same cost for each depot which is enough at his stage of development.

6.4 Contingencies, utility relocation and excluded capital costs

6.4.1 Contingencies

It should be noted that tunnelling projects are one of the most difficult civil engineering projects to estimate the cost, because, even with extensive site investigation, the ground conditions can vary considerably from those expected. Therefore, it is necessary to include a significant contingency to allow for this. SYSTRA have added 40% to their estimates to allow for these uncertainties. The Consultant notes that the estimates are based on data from the Red Line Project, this will aid the accuracy of the estimate but whilst this Project is located close to the Red Line Project in some areas the geological condition could offer other challenges for construction. The contingency must should reflect the stage in the development of the project and level that of uncertainty that has been removed and the level of contingency reduced as more information is obtained through the design process.

The Consultant recommends at this stage when no detailed examination and design of the project has been conducted that the Contingencies should be re-examined to ensure that this reflects the stage in project development.

6.4.2 Utility relocation

About 4% of the cost of the project has been set aside for Utility relocation. This has been reduced by 27% from the earlier estimate, it is assumed that this is based upon the costs that been incurred on the Red Line LRT project. With many of the stations to be constructed by cut and cover in areas where there are likely to be many utilities this cost appears low compared to other similar projects. The Consultant suggests that this estimate is re-examined ensuring the larger size of these stations is considered.

6.4.3 Excluded capital costs

Several areas of cost have been specifically excluded from the estimates including costs of property acquisition and compensation, sunk costs and the costs of providing the High Voltage electricity to the project by the Israel Electric Corporation.

The compensation paid for sequestration of land or reduction of its value can be significant element of public construction projects in urban areas, particularly in city centres where land values are at their highest. This cost has not been included and can be very difficult to quantify. Although this cost has been considered in the planning of the routes to reduce the area of land that is adversely affected but the cost should be included in the cost of the project.

6.5 Comparison of CAPEX to other similar projects

The Consultant has produced a comparable estimate based on data from several similar metro projects in Europe, with adjustments to allow for the stage reached for projects not completed. The construction costs per km (excluding contingency) of the comparable projects ranged between ILS 470 Million and ILS 860 Million with an average of ILS 599 Million per km excluding VAT. This compares with the current estimated cost of ILS 629 Million per km produced by SYSTRA, both values excluding contingencies.

The cost of the rolling stock as noted above is at the lower end of the range contained in the Consultant's data. Using the average cost of suitable rolling stock in our data suggests a cost of NIS 6.3 Million per car rather than NIS 5.6 Million per car.

The total cost of the project, without contingency, produced by the Consultant is NIS 89,972 Million 4.4% less than the latest SYSTRA estimate of NIS 94,167 Million. There is some variation in the pricing of the components, but the Consultant considers that the estimate prepared for construction cost of the metro has been prepared on a reasonable basis and that the total estimated cost is within the expected range of costs for projects such as this. The allowances made for design, project management and quality assurance are also reasonable and in line with normal practice.

6.6 Operational expenditure (OPEX)

6.6.1 OPEX, SYSTRA

SYSTRA have identified the operational costs of the project these are set out below:

Item	Ex. Estimate NIS (M)
Renewal cost	374
Maintenance cost	611
Staff	242
Consumption	882
Operation cost	1,124
Contingencies (20%)	422
Total	**2,531**
Total with VAT	*2,961*

6.6.2 Comparison of OPEX of other similar projects

The Consultant compared this with data from 12 European metro systems and made an estimate of the renewals cost.

Item	Ex. Estimate NIS (M)
Renewal cost	366
Rolling Stock	254
Infrastructure	227
Stations	180
Maintenance cost	661
Operation cost	1,167
Total	2,194
Total with VAT	2,567

The Consultant considers that the OPEX that has been assumed is reasonable and notes that a 20% contingency has been applied in addition. The Consultant considers that, when compared to the range of OPEX costs in the sample of Metro operators, this contingency is enough to cover the costs of 75% of the sampled operators.

6.7 Phased Development Costs

The Methodology Report & Results issued on 23rd April 2020 included 3 alternative phased approaches to the delivery of the complete project:

- Cross alternative which includes:
    - Trunk of route M1 and Rehovot branch – from branch split in Ramat HaSharon to Kaplan Station in Rehovot.
    - Route M2 from end station in Wolfson to Sirkin Station (inclusive).
- Central alternative which includes:
    - Trunk of route M1 and small part of Rehovot branch – from branch split in Ramat HaSharon to HaRishonim Station.
    - Route M2 from end station in Wolfson to Sirkin Station (inclusive).
    - Route M3 from end station in Bat Yam to the Red Line's Beilinson Station in Jabotinsky.
- Combined alternative which includes:
    - Trunk of route M1 and Rehovot branch – from branch split in Ramat HaSharon to Kaplan Station in Rehovot.
    - Route M2 from end station in Wolfson to Sirkin Station (inclusive).
    - Route M3 from end station in Bat Yam to the Red Line's Beilinson Station in Jabotinsky.

None of these alternatives include the north-west branch of Line 1 and the main depot for Line 1 at Ra'anana. Line 1 is connected to the other depot at HaRishonim, but this depot does not include all the facilities to service trains on Line 1 or infrastructure maintenance on all lines. The size of the depot at HaRishonim must be checked to see if the facilities can be provided there and that the site is bigger enough. The cost of providing the additional facilities should be included in the Financial Analysis of the Phases.

6.8 Financial Versus Economic Costs

The price schedule above, give financial costs for the Tel Aviv Metro project. These costs are excluding VAT but including subsidies and other taxes. For a socio-economic evaluation however, we must use the economic costs of the project that exclude VAT and all subsidies and taxes. In order to know the economic cost of production, the prices of all taxes paid by companies and corporations should be deducted from the financial costs (but the eventual public subsidies should be added).

In the absence of detailed analysis of subsidies and taxes on public works, it is common to consider that the economic cost of an infrastructure project is around 85% of its financial cost.

The Experts must specify the subsidies and taxes for public works in Israel, in order to be able to convert economic financial costs to economic costs.

7 SOCIO-ECONOMIC ASSESSMENT

Second opinion on economic model:

(14) The Excel-based economic model is not fully compliant with FAST modelling standard. It means that the TLV economic model is not designed to be easily intelligible or usable by a third-party. However this modelling standard, highly recommended for financial models, is not an obligation for economic models. **Low impact**

(15) The economic cost of the project is not clearly detailed. Indeed corporate tax, income tax or any kind of tax as well as subsidies must be exclude from the socio-economic assessment. In the model, the economic cost represents only 97% of the financial cost. That must be clarified. **Medium impact**

(16) The economic model does not apply any CAPEX inflation rate over an investment period of nearly 20 years. The Experts have to explain why. **Medium impact**

(17) The Consultant recommends to apply an annual growth rate on pollutant unit costs. **Medium impact**

(18) The Consultant recommends to review and reconfirm environmental benefits that seems abnormally low with regards to other metro projects. **High impact**

(19) The Government has recently updated the discount rate for urban transport projects (from 7% to 4%). Decision-makers must take into account the discount rate used for any other public investment project before making any comparison. The Consultant suggests that every communication on socio-economic results should be featured with both 7% and 4% discount rates. **Low impact**

(20) The Consultant has previously recommended to use the "A01" scenario as the only baseline option. If this recommendation is implemented, the Experts might have to review the sensitivity tests with this baseline option. **Medium impact**

7.1 ECONOMIC MODEL

7.1.1 FAST modelling standard

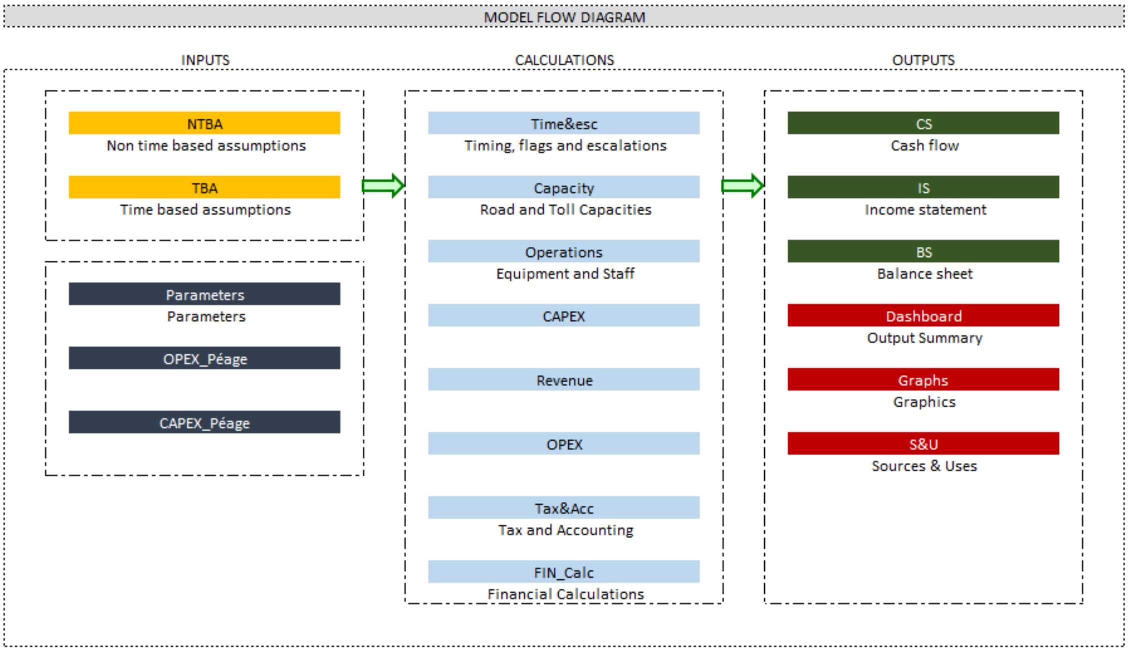
The FAST Modelling Standard is a set of rules providing guidance on the structure and design of efficient spreadsheets. Adopting this standard increases productivity, reduces errors, and makes models easier to understand and review.

The FAST acronym stands for Flexible, Appropriate, Structured and Transparent models:

- **Flexible** – The structure and style of models require flexibility for both immediate usage and the long term. They should allow multiple users to run scenarios and sensitivities and to make modifications over an extended period as new information becomes available. This level of flexibility is achieved through **maintaining the simplicity of the model**, rather than attempting to **incorporate complex devices** with an option for every eventuality.
- **Appropriate** – Models must reflect key assumptions directly and faithfully without being cluttered in unnecessary detail.
- **Structured** – Rigorous consistency in layout and organisation is essential in retaining the model's logical integrity over time, particularly as a model's author may change. A consistent approach to structuring workbooks, worksheets, and formulas saves time when building, learning, or maintaining the model.

- **Transparent** - Effective models are founded upon simple, clear formulas that can be understood by other modellers and non-modellers alike. Confidence in a financial model's integrity can only be assured through the clarity of a logical structure and layout. Many of the recommendations that enhance transparency also increase the flexibility of the model: if they can be reviewed easily this facilitates any future adaptation that may be required.

Figure 35 : Example of a FAST model structure



The Excel-based TLVM economic model is not fully compliant with FAST modelling standard. It means that this model is not designed to be easily intelligible or usable by a third-party. However this modelling standard, highly recommended for financial models, is not an obligation for economic models.

A non-regulatory modelling structure could involve high risk for an economic assessment, furthermore in the case of a long term investment infrastructure such as a rapid transit system. Nevertheless, the TLVM economic model structure respects some FAST modelling standards, it is not fully flexible or transparent but is appropriate and has good structure. Moreover, the Consultant has got answers in all his interrogations and has got full access to all files on the TLVM economic model.

7.1.2 Questioning and inquiry on the economic model

The Consultant has checked several links and inputs, calculation formulas and results of the TLVM economic model. The work done by the Experts is both well-documented and rich in content. The main benefits come from time savings (conventional benefits) and agglomeration employment benefits (non-conventional benefits). These results are very similar to similar mass transit and urban projects such as the Grand Paris Express in France for example.

However, the Consultant has few questioning and inquiries with regard to the economic model and methodology.

Tax on investment costs

In Israel, a sales tax rate (value-added tax) is applied to most goods and services with a rate of 17%, but in the economic model, the Experts have used a 20% rate from taxes on investment costs.

The Consultant believes that this rate may include other taxes in order to obtain an economic cost (instead of a financial cost), but this does not appear to be a sufficient ratio between financial and economic costs in view of tax rates in Israel.

In that case, the economic costs would constitute 97.5% of the financial cost while it is common to consider that the economic cost of an infrastructure project is around 85% of its financial cost (cf. section 5.2 "Financial versus economic costs").

The Experts must clarify the financial/economic cost ratio used in the model, or replace it by a more realistic ratio (i.e. economic costs equal 80% up to 90% of financial costs).

Figure 36 Israel taxes
(Source: Trading Economics)

Israel Taxes	Last	Previous	Highest	Lowest	Unit	
Corporate Tax Rate	23.00	23.00	36.00	23.00	percent	[+]
Personal Income Tax Rate	50.00	50.00	50.00	45.00	percent	[+]
Sales Tax Rate	17.00	17.00	18.00	15.50	percent	[+]
Social Security Rate	19.60	20.00	20.00	9.70	percent	[+]
Social Security Rate For Companies	7.60	8.00	8.00	5.40	percent	[+]
Social Security Rate For Employees	12.00	12.00	12.00	9.70	percent	[+]

Inflation on investment costs

The Consultant observed that the in the TLVM economic model, the Experts did not apply any inflation on construction costs even though the metro plan carry out a series of works over a period of nearly 20 years. For operational and maintenance costs, the Experts applied a 1.5% annual inflation. For investment costs, there is no apparent reason not to use an equivalent rate. The Experts are invited to give the reason of the absence of CAPEX inflation rate.

Overall, the Consultant suspects that the costs used in the model are 2018 equivalent (with regards to the 4.2 ₪/€ conversation rate used), but this is only an assumption. The Experts must clarify that point.

Environment benefits

In comparison to other similar projects, the impact of the Tel Aviv Metro on the environment seems very much undervalued. Indeed, the environment benefits represents only 1 % of actual benefits while it should usually represent around 10 % of total benefits.

The Consultant checked the economic model, and found that there is no increase in pollutant average costs. In France for example, the carbon price in constant euros increases by 6 % per year between 2010 and 2030, and by 9 % between 2030 and 2040. That will have an impact on environment benefits, but this is not sufficient to explain the gap of environment benefits in the TLVM project and other metro projects.

The Consultant wasn't able to find any other mistake nor error on the model and recommends that the Experts review and reconfirm environmental benefits from the economic and traffic model.

7.1.3 Discount rate

For the Tel Aviv metro project economic assessment, the Experts have considered to discount rate options:

- A first option with a 4 % discount rate based on literature review and reference values applied for transport infrastructure projects in occidental countries. This discount rate is included in the new Israeli "Transportation Project Procedures" released in mid-2020.
- A second option with a 7 % discount rate in accordance with the Israeli "Transportation Project Procedures".

According to the information that he has, The Consultant considers that the first option is more realistic and a 4 % discount rate is more suitable for the economic assessment.

However, since the Israeli discount rate reference value for transport infrastructure projects has changed very recently, the Consultant recommends that the socio-economic outcomes should be outlined with both 4 % and 7 % discount rate.

Indeed, due to the scarcity of public resources, the authorities are obliged to arbitrate between all public investment projects. In order to choose fairly between these projects, decisions-makers have to see the whole picture.

7.1.4 Sensitivity analyses

The Experts have carried out several sensitivity analyses. The methodology and parameters overlooked seem consistent with the nature of the TLVM project.

7.2 COST-BENEFITS ANALYSIS

7.2.1 CBA from the economic assessment with "A0" as baseline option

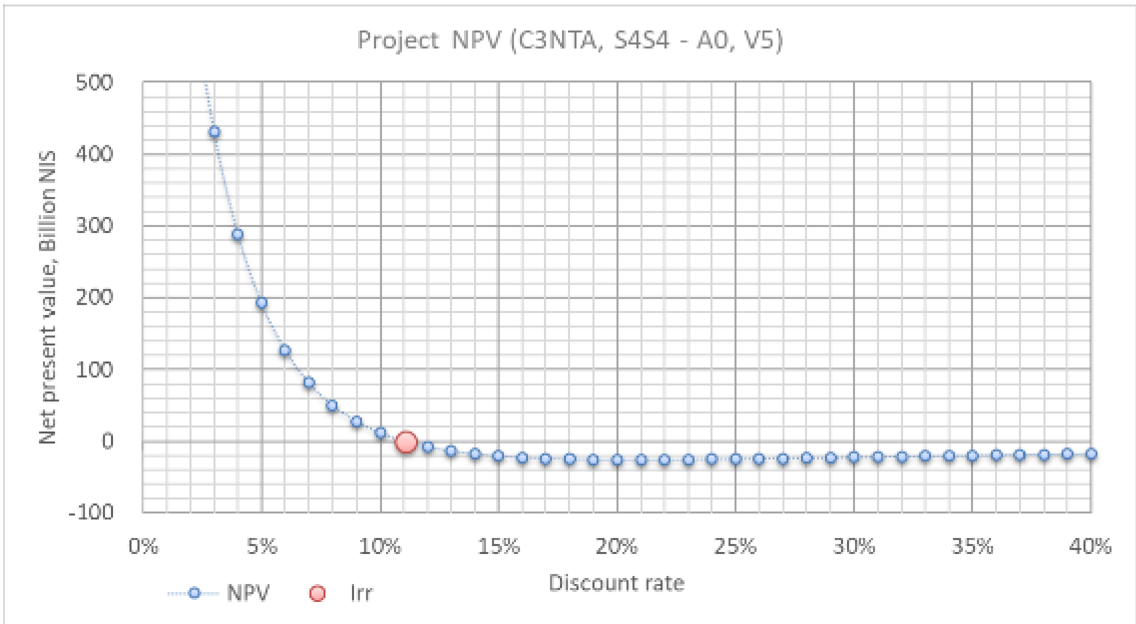
Figure 37 Economic assessment "A0" base scenario results
(Source: Gush Dan Metro, Economic, Social and Urban Impacts, Methodology Report & Results, Draft 23-04-20)

	CF simulation								
	Billion NIS		Capex	Opex	Disruption	Benefit	CF	ACC NPV, 4	ACC NPV, 7
Assumptions	index	year	C3NTA	C3NTA	C3NTA	C3NTA	C3NTA	C3NTA	C3NTA
C3NTA	0	2018							
	0	2019	0	0		0	0	0	0
	1	2020	-5.0	0.0	-0.3	0.0	-5.3	-5.1	-4.9
	2	2021	-5.3	0.0	-0.3	0.0	-5.6	-10.3	-9.8
open red, start metro	3	2022	-8.4	0.0	-0.3	0.0	-8.7	-18.0	-16.9
	4	2023	-9.7	0.0	-0.3	0.0	-10.0	-26.5	-24.5
	5	2024	-12.0	0.0	-0.3	0.0	-12.3	-36.6	-33.3
open green & purple	6	2025	-9.7	-0.6	-0.4	3.8	-6.9	-42.1	-37.9
	7	2026	-12.1	-0.6	-0.4	4.0	-9.1	-49.0	-43.6
	8	2027	-13.5	-0.6	-0.5	4.3	-10.4	-56.6	-49.6
	9	2028	-14.2	-0.6	-0.6	4.5	-10.8	-64.1	-55.5
	10	2029	-12.8	-0.6	-0.6	4.8	-9.3	-70.4	-60.2
open metro phase A	11	2030	-10.6	-2.1	-0.7	13.6	0.1	-70.3	-60.1
	12	2031	-10.1	-2.3	-0.7	14.5	1.4	-69.4	-59.5
	13	2032	-8.0	-2.5	-0.7	15.5	4.3	-66.9	-57.7
	14	2033	-7.7	-2.7	-0.7	16.6	5.5	-63.6	-55.6
	15	2034	-5.8	-2.9	-0.6	17.7	8.3	-59.0	-52.5
open metro full	16	2035	-3.7	-3.1	-0.6	18.9	11.4	-52.9	-48.7
	17	2036	-2.5	-3.2		20.1	14.4	-45.5	-44.1
	18	2037	-1.5	-3.2		21.5	16.7	-37.3	-39.1
	19	2038	-1.0	-3.3		23.0	18.7	-28.4	-34.0
	20	2039	0.0	-3.3		24.5	21.2	-18.7	-28.5
	21	2040	**0.0**	**-3.4**		**26.2**	**22.8**	**-8.7**	**-23.0**
	22	2041	0.0	-3.4		27.0	23.6	1.3	-17.7
	23	2042	0.0	-3.5		27.9	24.4	11.2	-12.5
	24	2043	0.0	-3.5		28.8	25.3	21.0	-7.5
	25	2044	0.0	-3.6		29.7	26.2	30.8	-2.7
	26	2045	0.0	-3.6		30.7	27.1	40.6	2.0
	27	2046	0.0	-3.7		31.7	28.0	50.3	6.5
	28	2047	0.0	-3.7		32.7	29.0	60.0	10.8
	29	2048	0.0	-3.8		33.8	30.0	69.6	15.0
	30	2049	0.0	-3.8		34.9	31.0	79.2	19.1
	31	2050	0.0	-3.9		36.0	32.1	88.7	23.1
	32	2051	0.0	-4.0		36.7	32.8	98.0	26.8
	33	2052	0.0	-4.0		37.5	33.4	107.2	30.4
	34	2053	0.0	-4.1		38.2	34.1	116.2	33.8
	35	2054	0.0	-4.1		39.0	34.8	125.0	37.1
	36	2055	0.0	-4.2		39.8	35.6	133.7	40.2
	37	2056	0.0	-4.3		40.6	36.3	142.2	43.2
	38	2057	0.0	-4.3		41.4	37.0	150.5	46.0
	39	2058	0.0	-4.4		42.2	37.8	158.7	48.7
	40	2059	0.0	-4.5		43.0	38.6	166.8	51.3
	41	2060	0.0	-4.5		43.9	39.4	**174.6**	**53.7**
	42	2061	0.0	-4.6		44.8	40.2	182.4	56.1
	43	2062	0.0	-4.7		45.7	41.0	190.0	58.3
	44	2063	0.0	-4.7		46.6	41.8	197.4	60.4
	45	2064	0.0	-4.8		47.5	42.7	204.7	62.5
	46	2065	0.0	-4.9		48.5	43.6	211.9	64.4
	47	2066	0.0	-5.0		49.4	44.5	219.0	66.3
	48	2067	0.0	-5.0		50.4	45.4	225.9	68.0
	49	2068	0.0	-5.1		51.4	46.3	232.6	69.7
	50	2069	0.0	-5.2		52.5	47.3	239.3	71.3
	51	2070	0.0	-5.3		53.5	48.3	245.8	72.8
	52	2071	0.0	-5.3		54.6	49.2	252.2	74.3
	53	2072	0.0	-5.4		55.7	50.3	258.5	75.7
	54	2073	0.0	-5.5		56.8	51.3	264.7	77.0
	55	2074	0.0	-5.6		57.9	52.3	270.7	78.3
End of Life cycle	56	2075	**109.4**	**-5.7**		59.1	162.8	288.8	82.0

Figure 38 Cost-benefits main figures from Economic assessment "A0" base scenario, in billions (Source: Louis Berger from Excel sheet BC Summary V5)

Capex	Opex	Disruption	Benefit	ACC NPV, 4%
-₪ 98.7 -23.5 €	-₪ 53.5 -12.7 €	-₪ 5.5 -1.3 €	₪ 446.5 106.3 €	₪ 288.8 68.8 €

Figure 39 Net present value based on discount rate from Economic assessment "A0" base scenario (Source: Louis Berger from Excel sheet BC Summary V5)



From the economic assessment, the baseline scenario weights the 3131, 4111 and 5111 scenarios with the "A0" option (as baseline option), with a discount rate of 4 % until year 2075. This scenario gives the economic impact of the whole transit system (including the LRT lines).

The total actual benefits on this scenario are estimated 446.5 billion shekels (approximatively 106.0 billion euros). Total costs (including CAPEX, OPEX and disruption) are estimated 157.7 billion shekels (approx. 37.5 billion euros).

In this scenario, the socio-economic net present value (SE-NPV) of 288.8 billion shekels (approx. 68.8 billion euros) is very important.

With such an outcome, there is no doubt that the metro project would be worth the investment. However, the Consultant believes that this scenario is not appropriate in order to assess the TLV metro project. In order to do so, the Consultant believes the only baseline option should be the "A01" scenario (see section 4.1.2 "Baseline option").

7.2.2 CBA with "A01" without parking policy as baseline option)

Figure 40 Cost-benefits main figures with "A01" without parking policy as baseline option, in billions (Source: Louis Berger from Excel sheet BC Summary V5 to A01)

Capex	Opex	Disruption	Benefit	ACC NPV, 7%
-₪ 66.0 Bn -15.7 Bn €	-₪ 19.0 Bn -4.5 Bn €	-₪ 3.0 Bn -0.7 Bn €	₪ 188.9 Bn 45.0 Bn €	₪ 100.9 Bn 24.0 Bn €

Capex	Opex	Disruption	Benefit	ACC NPV, 4%
-₪ 76.5 Bn -18.2 Bn €	-₪ 41.7 Bn -9.9 Bn €	-₪ 4.2 Bn -1.0 Bn €	₪ 440.4 Bn 104.9 Bn €	₪ 318.1 Bn 75.7 Bn €

Figure 41 Net present value based on discount rate from Consultant point of view
(Source: Louis Berger from Excel sheet BC Summary V5 to A01)

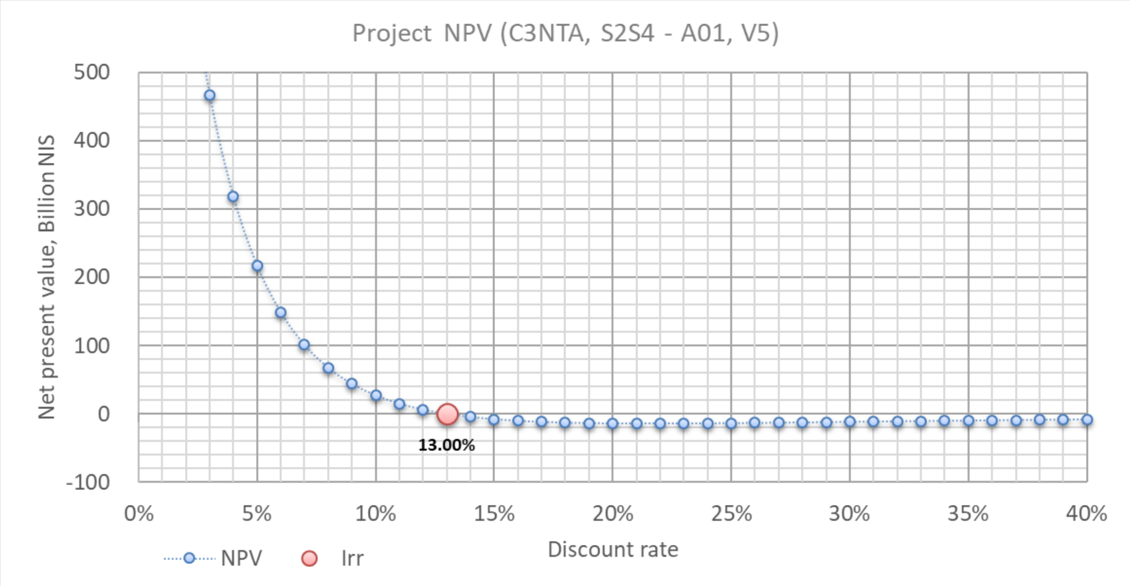


Figure 42 Socio-economic key points
(By 2075, full light rail without parking policy as baseline option, BC V5 to A01 S2S4, comparison 3131.4111.5111 to 3100.4100.5100)

Socio-economic indicators	Discount rate: 4 %		Discount rate: 7 %	
	Shekel2018 (₪)	Euro2018 (€)	Shekel2018 (₪)	Euro2018 (€)
Actual costs:	**122.3 bn**	**29.1 bn**	**88.0 bn**	**21.0 bn**
Actual capital expenditure (including residual value)	*76.5 bn*	*18.2 bn*	*66.0 bn*	*15.7 bn*
Actual operational expenditure	*41.7 bn*	*9.9 bn*	*19.0 bn*	*4.5 bn*
Disruption	*4.2 bn*	*1.0 bn*	*3.0 bn*	*0.7 bn*
Actual conventional effects:	**294.8 bn**	**70.2 bn**	**125.4 bn**	**29.9 bn**
Vehicles operating costs	*31.8 bn*	*7.6 bn*	*13.2 bn*	*3.1 bn*
Time savings	*165.0 bn*	*39.3 bn*	*70.7 bn*	*16.8 bn*
Freight time savings	*29.5 bn*	*7.0 bn*	*13.2 bn*	*3.1 bn*
Parking cost savings	*21.5 bn*	*5.1 bn*	*8.7 bn*	*2.1 bn*
Vehicle capital savings	*11.4 bn*	*2.7 bn*	*4.6 bn*	*1.1 bn*
Reliability	*34.7 bn*	*8.3 bn*	*14.5 bn*	*3.5 bn*
Actual non-conventional effects:	**145.4 bn**	**34.6 bn**	**63.4 bn**	**15.1 bn**
Environment	*8.8 bn*	*2.1 bn*	*4.2 bn*	*1.0 bn*
Safety	*5.4 bn*	*1.3 bn*	*2.4 bn*	*0.6 bn*
Agglomeration	*114.4 bn*	*27.2 bn*	*49.3 bn*	*11.7 bn*
Landuse savings	*14.2 bn*	*3.4 bn*	*6.3 bn*	*1.5 bn*
Health, comfort and stress	*2.3 bn*	*0.6 bn*	*1.1 bn*	*0.3 bn*
Socio-economic net present value	**318.1 bn**	**75.7 bn**	**100.0 bn**	**24.0 bn**

From the Consultant point of view, the only suitable baseline option should be the "A01" scenario and the results should be displayed with both previous and new discount rate (7 % and 4 % respectively).

As agreed with the Experts, since the traffic forecasts exceed LRT lines full capacity in the traffic modelling, the baseline option is set with "A01" (all LRT lines) and without parking policy. This scenario is known as S2S4 scenario.

By using the model results with project life cycle until 2075, full light rail and no parking policy as baseline option, and comparison of scenarios "3131", "4111" and "5111" to "A01", the Consultant found that:

- The total actual direct benefits would be 294.8 billion shekels (approx. 70.2 billion euros) with a 4% discount rate, and 125.4 billion shekels (approx. 29.9 billion euros) with a 7% discount rate. While the total indirect benefits would be 145.4 billion shekels (approx. 34.6 billion euros) with a 4% discount rate, and 63.4 billion shekels (approx. 15.1 billion euros) with a 7% discount rate;
- The total actual costs would be, for a discount rate of 4% and 7%, 122.3 billion shekels (approx. 29.1 billion euros) and 88.0 billion shekels (approx. 21.0 billion euros) respectively;
- The SE-NPV would be 318.1 billion shekels (approx. 75.7 billion euros) with a 4% discount rate and 100.0 billion shekels (approx. 24.0 billion euros) with a 7% discount rate;
- The SE-NPV excluding non-conventional benefits would be 170 billion shekels (approx. 40 billion euros) with a 4% discount rate, and only 37 billion shekels (approx. 9 billion euros) with a discount rate of 7%.

With these specifications, the metro project is still very profitable and the metro project would still be worth the investment with the old 7% discount rate. Even with significant variations in costs or construction planning, the project would still be worth the investment. Furthermore, the second opinion revelled potential inaccuracies or uncertainties which could lead to increase the Tel Aviv metro project socio-economic net present value (and comfort the results).

7.3 Comparison with the Grand Paris Express project

As with the Tel Aviv Transport Master Plan, the Grand Paris Express project is not only a simple public transport project. It is a landmark project for urban development and regional planning, and a genuine economic growth accelerator for the whole country.

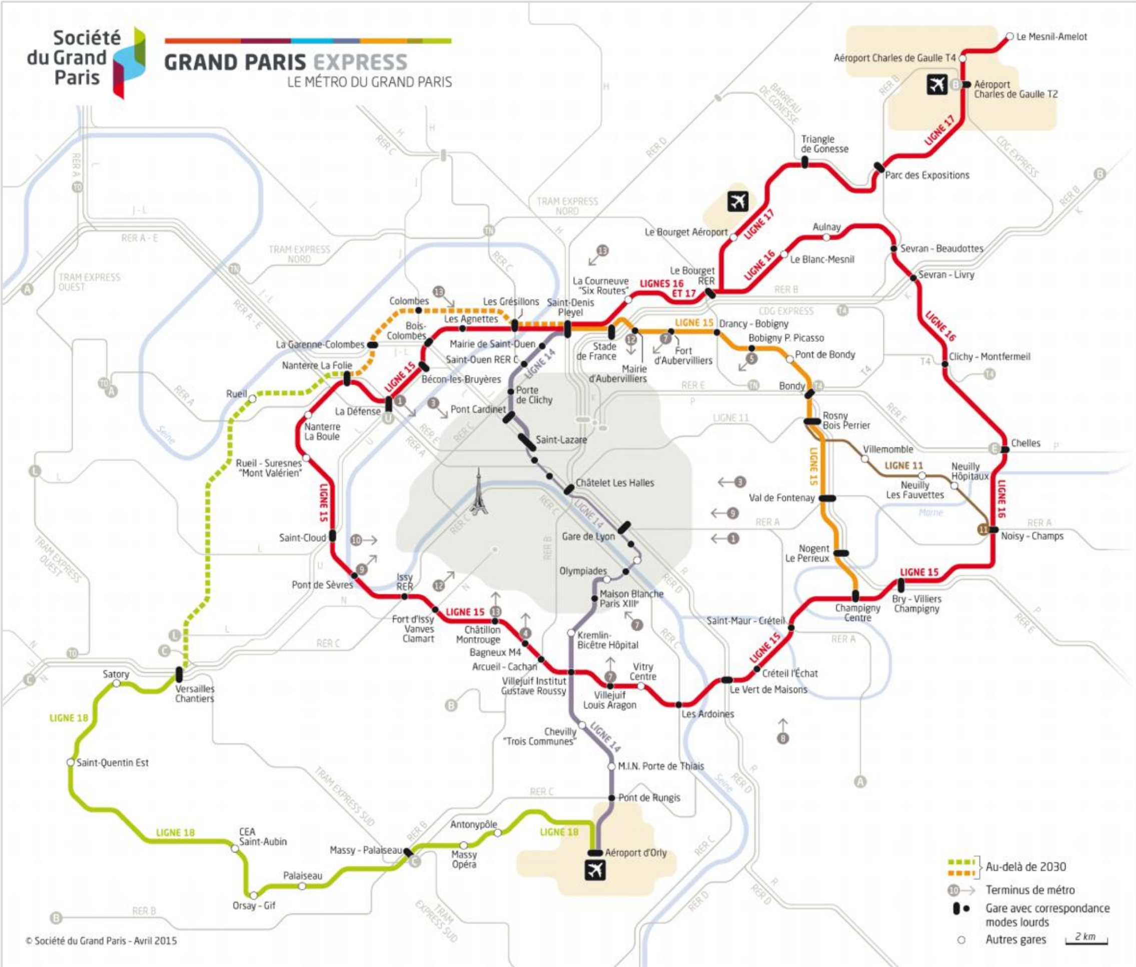
This is the largest infrastructure project in Europe. The Grand Paris Express will therefore double the actual length of the Paris Metro with 200 km of new metro lines, mostly between suburb cities around Paris.

The project involves the development of 4 new metro lines around Paris (lines 15, 16, 17 and 18), the extension of the line 14 on south and north (see figure below). It also involves the extension of several other lines from their actual terminus to the Grand Paris Express new stations.

Finally, in few figures the project implies:

- 600,000 m² of urban projects (7 000 housing, 200,000 m² of offices and shops);
- 28 million tonnes of CO² emissions saved by 2050;
- 250,000 up to 400,000 new housing build thanks to urban transformation of station districts;
- Between 10 and 20 billion additional GDP per year for the Ile-de-France region after the Grand Paris Express implementation;
- 115,000 jobs created thanks to the economic growth following the project implementation.

Figure 43 Grand Paris Express network
(Source: Société du Grand Paris)



Because of the project peculiarities (implementation, systems, start date, characteristics, etc.), the socio-economic assessment of the project was done by sections:

1. Line 14 South extension – Between Olympiades and Aéroport d'Orly;
2. Line 15 South – Between Noisy-Champs and Pont de Sèvres;
3. Line 15 West – Between Pont de Sèvres and Saint-Denis Pleyel;
4. Line 15 East – Between Saint-Denis Pleyel and Champigny Centre;
5. Lines 16, 17 and 14 North extension – Between Saint-Denis Pleyel and Noisy-Champs for the line 16, between Saint-Denis Pleyel and Le Bourget RER for the line 17 and extensions from Mairie de Saint-Ouen to Saint-Denis Pleyel for line 14;
6. Line 17 North – Between Le Bourget RER and Le Mesnil-Amelot;
7. Line 18 – Between Aéroport d'Orly and Versailles Chantiers.

The socio-economic key points for these lines are coming from the Public Enquiries prior to issuing the Declaration of Public Utility of the project.

Figure 44 Socio-economic key points of the Grand Paris Express (per line)
(Sources: Economic Assessments of the Grand Paris Express metro lines, Société du Grand Paris)

Actual socio-economic indicators in Euro$_{2010}$ (€), for the central scenario, excluding opportunity cost of public capital (set at 1.2 of costs)	**Line 14 South**	**Line 15 West**	**Line 15 South**	**Line 15 East**	**Lines 16, 17 and 14 North**	**Line 17 North**	**Line 18**
Length:	**14 km**	**20 km**	**33 km**	**23 km**	**29 km**	**20 km**	**35 km**
Wellbeing of commuters:	**3.8 bn**	**3.6 bn**	**5.7 bn**	**2.1 bn**	**4.1 bn**	**1.4 bn**	**1.1 bn**
Transport effects	*2.3 bn*	*2.4 bn*	*5.2 bn*	*1.6 bn*	*3.3 bn*	*1.4 bn*	*0.6 bn*
Regularity	*1.2 bn*	*0.8 bn*	*0.3 bn*	*0.5 bn*	*0.3 bn*	*0.0 bn*	*0.5 bn*
Comfort	*0.3 bn*	*0.4 bn*	*0.2 bn*	*0.0 bn*	*0.5 bn*	*0.0 bn*	*0.0 bn*
Urban and environmental effects:	**1.2 bn**	**2.1 bn**	**1.1 bn**	**0.9 bn**	**1.9 bn**	**0.7 bn**	**0.7 bn**
Urban and environmental effects	*1.2 bn*	*2.1 bn*	*1.1 bn*	*0.9 bn*	*1.9 bn*	*0.7 bn*	*0.7 bn*
Economic effects:	**3.5 bn**	**5.1 bn**	**6.0 bn**	**2.9 bn**	**3.4 bn**	**0.9 bn**	**1.4 bn**
Spatial reallocation	*1.3 bn*	*1.8 bn*	*1.4 bn*	*1.0 bn*	*0.8 bn*	*0.3 bn*	*0.5 bn*
Agglomeration effects	*0.8 bn*	*1.2 bn*	*1.6 bn*	*0.7 bn*	*0.9 bn*	*0.2 bn*	*0.3 bn*
New employments	*1.4 bn*	*2.1 bn*	*3.0 bn*	*1.2 bn*	*1.7 bn*	*0.4 bn*	*0.6 bn*
Actual Costs:	**2.9 bn**	**3.3 bn**	**5.7 bn**	**3.3 bn**	**3.6 bn**	**1.7 bn**	**2.3 bn**
Socio-economic net present value:	**5.6 bn**	**7.5 bn**	**6.9 bn**	**2.7 bn**	**5.8 bn**	**1.3 bn**	**1.0 bn**
Economic rate of return:	**11.9 %**	**11.9 %**	**8.4 %**	**8.0 %**	**10.0 %**	**7.0 %**	**6.2 %**

These results shows that the economic rate of return of each line (apart and without taking into account the network effects between these lines) is between 6 % for the lines crossing the less dense and attractive cities and 12 % for the lines crossing the most dense and attractive cities.

The economic rates of return of the Grand Paris Express lines are therefore of the same order of magnitude as the economic rate of return of the TLVM project (see Figure 41 "*Net present value based on discount rate from Consultant point of view*").

We can also see that the environmental effects (which are actually around 50 % of the “urban and environmental effects” of the table beside) represent around 10 % of the benefits of the project unless for line 15 South were it is around 4 %.

The figure below shows the inputs used for the socio-economic assessment. We can see that the basic discount rate including risk is 4.5 %.

We can also see that the carbon price increase within time (32 €$_{2010}$/t in 2010 to 241 €$_{2010}$/t in 2050).

Figure 45 Inputs for the Grand Paris Express socio-economic assessment
(Sources: Economic Assessments of the Grand Paris Express metro lines, Société du Grand Paris)

Année d'actualisation	***2010***		
Taux d'actualisation	Calcul sans prise en compte du risque		***4,0%***
	Avec prise en compte des risques	Calcul élémentaire	***4,5%***
		Calcul paramétré	***Avantages : 4,7% jusqu'à 2070 puis 4,8% (β = 1,1)*** ***CO_2 : 4,5% (β = 1)*** ***Investissements : 3,5% (β = 1,1)***
		Calcul probabilisé	***Taux d'actualisation = 4% + 2 x (PIB-1,5%)***
Durée du bilan	*Jusqu'à 2070, puis calcul de la valeur résiduelle de 2070 à 2140 avec avantages maintenus constants, sauf pour le CO_2 qui croît comme le taux d'actualisation*		
Taux de croissance PIB	Jusqu'à 2030	***1,5%***	
	Après 2030	***1,5%***	
Taux de croissance Trafic	0,5% par an à partir de 2035		
COFP et PFRFP	COFP	***1,20***	
	PFRFP	***0,05 si distinction du risque*** ***0,07 si taux d'actualisation constant à 4,5%***	
TVA	Taux normal	***20,0%***	
	Taux réduit (billets TC)	***10,0%***	
Valeur du temps	Professionnels	***22,3***	***€2010 / h en 2010***
	Domicile-travail	***12,6***	***€2010 / h en 2010***
	Autres	***8,7***	***€2010 / h en 2010***
Taux de croissance Valeur du temps	Jusqu'à 2030	***0,7%***	
	Après 2030	***0,7%***	
Coût d'exploitation des véhicules particuliers	***0,21 €/véh.km***		
Prix de la tonne de CO2	en 2010	***32 €2010 / t***	
	en 2030	***100 €2010 / t***	
	en 2050	***241 €2010 / t***	

8 CONCLUSION

The Consultant has concluded that the type of solution that has been proposed for Tel Aviv is in line with the solution that has been adopted for most large metropolitan areas of the same scale. It is considered that the inclusion of a network of 3 metro lines in the proposal is appropriate for Tel Aviv and the size and extent of the metro solution is like the kind of solution that has been adopted or is being implemented in other metropolitan areas.

The cost of the metro solution suggested by the Experts has been examined and the Consultant finds that the costs are generally in line with the cost of other metro projects. There are some areas where the Consultant considers the Experts should check that sufficient design and investigation information is available to justify the proposed level of contingency or the estimated cost.

As a Conclusion, the second opinion focused on understanding and questioning the mechanisms and calculations used by the Experts to carry out this socio-economic assessment of the Tel Aviv Metro project. The Consultant has questioned several assumptions made by the Experts in order to carry out the socio-economic study for the Tel Aviv metro project.

It should be note that the work done by the Experts is very substantial and well documented. The economic assessment of a program like the TLVM project is a real challenge. Unlike more modest and classical transport projects, the TLVM project will generate huge public transit flows between a very dense centre and its periphery.

It will involve network effects, interacting with other transport infrastructures and will affect the economic environment of the project area, where there is not any feedback of other mass transit investment in the past.

In spite of this degree of complexity, the Consultant has made only few concerns and observations, mainly about methodological assumptions.

These are not of a nature that would undermine the socio-economic profitability of the TLV metro project. In the CBA made with the scenario “A01” without parking policy as baseline option, the TLVM project is very profitable. The economic rate of return of the investment is around 13 % which seems reasonable according to the project characteristics.

The Consultant's second opinion is therefore favourable to the implementation of the project. However, the Experts are invited to check, comment and correct the TLVM economic assessment.