

PMC Response to:

Red Line Master Schedule 10.6
EMC Review-Ver 1.0

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Executive summary

The following conclusions were identified by EMC:

Recommendation for approval

EMC view is that Schedule 10.6 is outdated, thus recommends no need to be officially approved by GOI.

Recommendation for action

A revision, or a new Schedule 10.7, should be issued taking into consideration all pending issues, including delays on civil works at stations, under tender processes (SDAG. O&M), future tenders (Turkish Alignment, Fit-Out) and progress of design (Fit-Out strategy, coordination with TBM East, Rolling Stock design, as recently a new stage of detailed design was added).

A civil works delays' mitigation plan should be developed, one that would allow sufficient buffers in the Schedule to cope with future uncertainties. EMC believes that as part of the new schedule, such mitigation plan should be formalized and presented to EMC including “what if” scenarios and risk analysis.

Schedule 10.7 essential milestones should be linked with a Permit to Operate (PTO) process as defined by the regulator (i.e., MoT approval over PTO process and RAMS).

EMC recommends that Schedule 10.7 will be coordinated with SDAG proposal milestones and NTP, while taking into consideration major risks, current delays of civil works in station or any other changes that may affect contractual milestones based on Schedule 10.6 that was the basis of SDAG contractors' proposal.

The PMC disagrees with the statement of Schedule 10.6 being “out dated”. The Master Schedule 10.6 continues to be relevant in determining performance against a given plan particularly with regard to the ongoing civil works. Furthermore, 10.6 is an essential mechanism by which “what-if” models are developed in order to understand the effectiveness of various mitigation scenarios. However, all the pending issues and future mitigation plans that are being investigated at this moment makes GOI approval unnecessary,

NTA has taken steps to implement realistic mitigation measures by issuing instructions to analyze the feasibility of converting all stations from dry/wet excavation to dry. The current outcome indicates that dry excavation methods are feasible. Dry excavation combined with the use of critical chain buffers indicate the October 2021 date remains achievable.

Additional mitigation strategies are being investigated; namely TBM first, increase resource allocation through multiple contracts for MEP / Fit-out and the use of “Framework” contracts for inner box construction in order to increased resource capacity and flexibility to take advantage of work locations as they are made available.

Master Schedule version 10.7 is in process and will reflect the approved mitigation strategies as soon as decisions are made. Critical interface milestones will be preserved and re-synchronized between disciplines.

1. Project Status vs 10.6

The EMC summary below:

Summary

The project has progressed so far mostly with the civil works in the stations and depot. This has been, so far, a difficult stage with a relative long learning curve showing delays to a level that a new constructions strategy called a mitigation plan has been proposed to cope and keep the target timetable. Therefore, most of EMC current review of Schedule 10.6 is related to these works and its associated mitigation strategy. Other Scheduled milestones have been also reviewed with no significant deviation from their schedule.

The critical path of the project's timetable goes through the underground stations. The progress of the works today shows significant delays in the construction of the stations. Since Completion of the D walls in each station is mandatory before beginning of the excavation works, EMC is identifying risk as result of the current delays and deviations of the actual works from its targets set in Schedule 10.6. This risk may be mitigated and the mitigation plan should be reviewed and approved by GOI. It should include buffers for future problems and additional time should be allocated to un-scheduled activities related to the mitigation plan, such as water treatment and reinforcement struts.

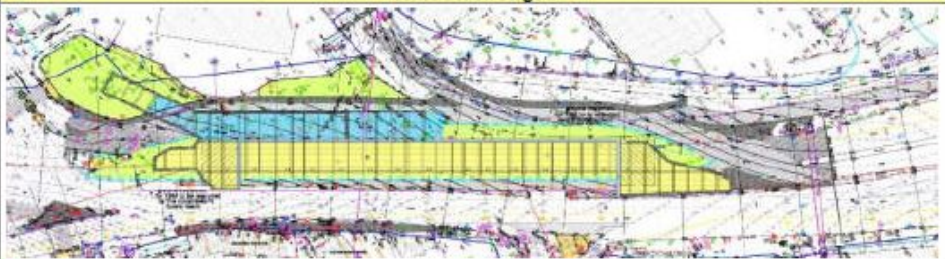
The PMC points out that the dates from the EMC table below taken from Section 1.1.3. are not the 10.6 baseline dates for completion of D-Walls. The PMC is unclear where these dates originated but suspects they may be for the Contractor's baseline.

Figure 1 – Table form EMC report Section 1.13.3

Stations	Total of D Wall Panels	PB Data from Monthly report				Egis calculation			
		No of panels Done Oct 30th 2016 (Pb monthly report)	No of panels remaining to completion		Completion date for "D walls" activities		Completion date for "D walls" activities EMC point of view	Current Delay based on PB forecast VS 10.6	
			In units	In %	Schedule 10.6	PB forecast (monthly report)			
Allenby	117 Pannels	99 Pannels	18 Pannels	15%	8/16	11/16	11/16	3 Months	
Yehudith	103 Pannels	39 Pannels	64 Pannels	62%	5/17	9/17	9/17	4 Months	
Shaul Hamelech	104 Pannels	38 Pannels	66 Pannels	63%	1/17	10/17	10/17	9 Months	
Arlozoroff	152 Pannels	149 Pannels	3 Pannels	2%	8/16	9/16	11/16	1 Months	
Aba Hillel	114 Pannels	73 Pannels	41 Pannels	36%	10/16	2/17	3/17	4 Months	
Bialik	108 Pannels	55 Pannels	53 Pannels	49%	2/17	4/17	4/17	2 Months	
Ben Gurion	172 Pannels	45 Pannels	127 Pannels	74%	8/17	4/18	4/18	8 Months	
Aharonovitz	143 Pannels	37 Pannels	106 Pannels	74%	6/17	12/17	12/17	6 Months	
Carlebach box	310 Pannels	84 Pannels	226 Pannels	73%	2/17	7/17	2/18	5 Months	

For example referring to Yehudit station, the image below is taken from the September monthly report. Note the 10.6 baseline date for completion of D-Walls is Aug-2017 not May-2017. The PMC has found other inconsistencies in the above table e.g. Shaul Hamelach station D-Wall completion EMC - Jan-2017 vs. PMC September monthly - June-2017.

Figure 2 – Yehudit Station – September Monthly report

TBM + Boxes West		PMC:	DANA Engineering		Contractor:	CRTG - Soel Boneh JV			
YEHUDIT STATION					Stages				
					Traffic :	1.6	Construction :	2	
Safety		Construction Stage 1							
Unsafe Acts / Conditions									
Detection	Closure							Open	
26	9							17	
Incident (Injury < 3 days leave)									
0									
No incidents or accidents.									
Master Schedule				Contractual Schedule 2016					
Activity	Finish date		Variation in Months	Contractual Baseline		Actual / Forecast		Variation in Months	
	10.6	Actual/ Forecast		Start	Finish	Start	Finish	Start	Finish
D-Walls	Aug-17	Sep-17	1	Mar-16	Aug-16	Mar-16	Dec-16	0	4
Wet Excavation	Jun-18	Jun-18	0	Mar-16	Jun-16	Mar-16	Jun-16	0	0
Casting Slab	Aug-18	Aug-18	0	Feb-16	Mar-16	Apr-16	Sep-16	2	6
TBM 5 Through	Jan-19	Jan-19	0	Mar-16	Apr-16	Jun-16	Nov-16	3	7
TBM 6 Through	Feb-19	Feb-19	0	Apr-16	Apr-16	Aug-16	Sep-16	4	5
Inner Box	Apr-20	Apr-20	0	Apr-16	May-16	Nov-16	Dec-16	7	7
HO to Fit-Out	Jun-20	Jun-20	0	May-16	May-16	Dec-16	Dec-16	7	7
HO to SDAG	Aug-19	Aug-19	0						

- High voltage tunnel of IEC in Yehudit station, which is expected to take about 3 months.
- Temporary traffic arrangements and construction of ramps to detour traffic.
- Most of the production is based on "Top Down" which should benefit traffic on Main Street above, but causes difficulty to the progress of the works underground.
- Making horizontal support (rows of horizontal reinforcement - Struts) about every 6.0 m deep. These metal support bars may require slowdown of the works.
- There is not enough reference to the pumping system installation (Including pumping wells) and implementation of groundwater extraction and infiltration into the aquifer bottom (or removal to another drainage system). Using as an example of the excavation works at the Yehudit station as a representative station, if the excavation work will begin in September.2017) We expect it will be completed only In February 2019 - presenting 9 months of delay for 10.6 timetable (compare to May 2018)."

The PMC offers the following:

Bullet 1 – duration for supporting the IEC tunnel at Yehudit will be evaluated during development of 10.7

Bullet 2 – durations for this activity has been included in 10.6

Bullet 3 – it is unclear what this statement is referring to. Inner box construction for all underground stations is designed for "bottom-up" construction.

Bullet 4 – Strut installation durations have been considered in 10.6

Bullet 5 – Details regarding dewatering activities are contained in the Contractor's schedule. Dewatering activity is scheduled as concurrent with excavation activities therefore is not expected to increase or decrease the overall excavation durations. Dewatering well installation and discharging system is done in advance and in parallel with ancillary d-wall activities such as capping beam and final traffic deck

installations. The current forecast for completion of excavation (in dry conditions) for Yehudit Station is June-2018 (from Figure not Feb-2109).

2. Mitigation Plan

The EMC summary below:

Summary

NTA is considering a mitigation plan comprised of several elements. The first, is that instead of excavating and casting at some stations underwater table an alternative by which de-watering is creating a dry area, which is enabling an accelerated excavation. In addition, under such alternative it is easier and faster to cast the base slab. This alternative is relevant to only 7 of the 10 stations and within each station only part of the work was planned as wet excavation. As result the mitigation plan proposed under this strategy, the current delays can be partially mitigated. EMC analysis show that further delays remain in the magnitude of one to six months for Shaul Hamelech Ben Gurion Aharonovitch and Carlebach stations.

The second mitigation strategy is to launch the TBM before the excavation of a station, which is intended to expedite the works. NTA yet presented the benefit of such change. Since the TBM has a long "free flow" duration the longest drive expected to have about 18 months, each disturbance for the station works if cause by the TBM may affect the overall timetable.

Detailed construction strategy, presentation of "hidden buffers" between packages and optimization of the under tendering packages (SDAG and Fit-Out) are necessary in order to complete EMC review.

The PMC is in the process of developing Master Schedule version 10.7 which will officially incorporate the proposed mitigations. Target date for draft 10.7 submittal is the end of February, by which time key decisions regarding dry/wet excavation, TBM first scenarios and SDAG procurement strategies will be quantified.

The PMC notes that dry excavation partly mitigates the overall delay depending on the station. As stated above in the Executive Summary, additional mitigations such use of buffers are available to off-set residual delay durations that remain after dry excavation is implemented.

Table 1 below shows the current D-Wall variances between 10.6 baseline and the PMC November Monthly Report. Remaining delay after the benefit dry excavation is applied and available buffers to off-set residual delay are also shown.

Table 1: D-Wall variances and remaining buffers

#	Station	D-Wall Activities		Variance (Months)	Benefit of Dry Excavation (Months)	Remaining delay (Months)	Remaining Buffers (Months)
		v10.6 Base Line	PMC November Report				
1	Allenby	9/16	12/16	3	2	1	1.5
2	Yehudit	8/17	9/17	1	2	-1	0
3	Shaul Hamelech	6/17	9/17	3	1.5	1.5	2.5
4	Arlosoroff	8/16	11/16	3	2.5	0.5	1.5
5	Abba Hillel	12/16	4/17	4	3	1	1.5
6	Bialik	1/17	5/17	4	6.7	-2.7	n/a
7	Ben Gurion	5/17	1/18	8	5.5	2.5	1.5
8	Aharonovitz	4/17	2/18	10	5.2	4.8	6
9	Carlebach	5/17	10/17	5	N/A	5	6.5

Table 2 below shows the specific buffers used in conjunction with the reduced excavation durations to overcome the remaining delay. Note activity **B2037** “Handover entrance structure to Fit-out – Shaul Hamelach” had an original duration of 55 working days (2.5. months) of which 50 days (2.2 months) will be used, leaving a balance 5 days (one week). Ben Gurion on the other hand is running a 1 month deficit in available buffer, therefore further mitigation measures must be applied. This includes improved D-wall production, revised traffic arrangements to allow more efficient production and cooperation from IEC to accelerate the overhead powerline.

Furthermore, it must be noted that for buffers to be effective in mitigating delays, they must be on the critical path.

Buffers are continuously monitored to ensure there remains sufficient margin for future use if necessary. The current situation indicates this margin is becoming too thin and therefore additional mitigations are being evaluated.

One such option currently being evaluated is the TBM First methodology, meaning passing the TBM through each station in advance of box excavation. As pointed out earlier, NTA has issued a directive to IBI (the designer) to confirm dry excavation is feasible. Early results indicate that station design can be modified at all locations in order to facilitate dry excavation.

Another option being evaluated is to change TBM 1 and 2 launch sequence. The TBM will be launched from the Depot Portal towards Chamber 1/5/2/6. The TBM will be then retrieved and launched from Shenkar Portal towards Aharonovitch. This option will mitigate the risk that the TBM might have to wait for the completion of Aharonovitch Box.

Additional mitigation measures have been put in place at Carlebach station by increasing the number of D-wall machines from 2 to 3.

Table 2 – Mitigations to off-set remaining delay after dry excavation

BUFFERS USED in MITIGATION		Original	Mitigated	
Activity ID	Activity Name	Duration	Duration	Delta
B2037	Handover entrance structure to Fit out - Shaul Hamelech station box	55	5	-50
B6760	Handover Depot portal site till Em Hamoshavot inc. Cross over	44	0	-44
B1437	Handover entrance structure to Fit out - Allenby station box	88	50	-38
B6600	Handover Civils to Fit-out - Carlbach station	132	100	-32
B3215	Access Box to Fit out - Aharonovitz station box	66	44	-22
B7955	Handover Stations to Testing - Abba Hillel station	44	33	-11
B7935	Handover Stations to Testing - Arlosoroff station	44	33	-11
B8015	Handover Stations to Testing - Aharonovitz station	44	33	-11
B7995	Handover Stations to Testing - Ben Gurion station	44	33	-11
B7875	Handover Stations to Testing - Allenby station	44	33	-11
B7850	Handover Tunnels to Static Testing - Allenby to Aharonovitz - Systems	10	7	-3

The EMC further points out that additional mitigations can (and should) be implemented,

These are:

- Additional working hours e.g. 24 / 5.5;
- Optimization of traffic arrangements to open more work fronts; and
- Greater working foot print to improve site logistics.

With regard to the second bullet above, such measures have been implemented at several locations and are currently being investigated at Ben Gurion and Aharonovitch.

3. Cash Flow Indicators

The EMC Summary below:

Summary
<p>EMC has used three financial indicators to observe the project status in term of budget and cash flow. The conclusion is that the three indicators confirm current delay. Detailed as follows:</p> <p>Average monthly expenditure per station is -29% VS expected average Expenditure for 2016 will be -35% VS forecast made end of 2015 Low budget utilization in Q3 2016 compare to Q2 of -43%</p> <p>All the above may have budget implications which has to be analyzed and evaluated by NTA and update the risk analysis matrix accordingly.</p>

Cost and Schedule performance relationships for the Red Line Project are not one-to-one. A true cost/time relationship and indices are only relevant when applied to physical progress as in Earned Value management techniques. Furthermore, expenditure in this type of project cannot be expected to be linear, even when applying a learning curve, since in the first period of construction there are utilities to be relocated, causing the production rates to be lower compared to average rates. After the site is cleared from utility obstacles, the production rates

are expected to increase. Evidence to that can be found when comparing the average duration of the diaphragm wall activity to the average cost. We find that the activity's duration is approximately 25% of the total duration while the costs (including applied overheads) is approximately 22%. Therefore, EMC's methodology would cause an exceeded expected average payment of approximately 13%.

It should also be noted, that EMC's calculations as per the expected average monthly expenses are not accurate. The total cost for civil works in the 6 stations of this contract is 1.5 billion NIS, and therefore, according to the EMC's methodology, we should have expected a monthly average expenditure of 5.1 million NIS per station and not 5.9 million NIS. Therefore, according to the EMC's methodology, the average monthly expenditure per station is -18% VS expected average instead of -29%.

4. EMC Assessment vs 10.6

The table below is taken from the EMC report referenced as "Table 6".

The EMC has used Yehudit station as an indicative example to present a worst / best case scenario.

Yehudit Station as an example - EMC Assessment					
Main Activities / milestones	Sch10.6	Worst Case Scenario		Best Case Scenario	
		Mitigation/delay	Cummulative Delay	Mitigation/delay	Cummulative Delay
D Wall Completion	02/17	7 months	7 months	7 months	7 months
Excavation Completion	05/18	2 months	9 months	-2 months	5 months
Bottom Slab completion	07/18	0 months	9 months	0 months	5 months
TBM Going through Station	10/18	2 months	11 months	-2 months	3 months
Inner Box Completion	03/20	0 months	11 months	0 months	3 months
Fit - out Completion	06/21	0 months	11 months	-1 months	2 months
Commissioning/integration	08/21	0 months	11 months	0 months	2 months

The PMC disagrees with the EMC findings that the current magnitude of delay on Yehudit D-wall completion to be approximately 7 months. On the contrary the actual delay is shown in Table 1 above, currently forecast at 1 month.

Additional quotes;

"One should consider that Sch10.6 already consume all the buffers that existed for the general project works (some buffers as we already mentioned and called "hidden buffers" may still exist). Therefore, we believe that to the above analysis, additional buffers of 3-4 months should be added (3 to be added to the best-case and 4 to be added to the worst-case scenarios). "

The PMC disagrees with above quote. There are still additional 3 to 6 months of buffers and floats to the Red Line Schedule (in addition to the buffers indicated in table 1) depending on the critical path at the time on which the implementation is applied.