# Red Line Master Schedule
# V 10.6
# EMC Report

Nov. 2016

## IDENTIFICATION

| Doc ID | Project | Entity | Line | Package | Doc. Type | Chrono Nb | Version |
|---|---|---|---|---|---|---|---|
| Code : | 8162 | ERA | Red | 234 | 006 | 120303 | B |

| | Written by | Checked by | Approved by |
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| Date | Dec 15th 2016 | Dec 18th 2016 | Dec 19th 2016 |
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# תקציר מנהלים

מטרת הדוח לבחון את התקדמות העבודות בפרויקט הקו האדום ביחס ללוח הזמנים 10.6. לו"ז זה לא שונה בבסיסו מהלו"ז הקודם (וורסיה 10.5). מועד הסיום לעבודת הנדסה אזרחית בתחנות (Station Box) שהן כולן על הנתיב הקריטי לא שונו למרות האיחור בלו"ז עליו דיווחה חברת הבקרה כבר בדוח הקודם בנושא מפברואר 2016. חברת הניהול (PMC) מטעם נת"ע בדעה שלו"ז 10.6 "ממשיך להיות רלוונטי לשם בחינת הביצוע כנגד תוכנית העבודה".

הנתיב הקריטי של הפרויקט עובר בתחנות התת קרקעיות. קצב התקדמות העבודות בתחנות אלו עד היום מצביע גם על בסיס דוחות ה PMC איחור משמעותי לעומת מועד הסיום המתוכנן. חברת הבקרה מוצאת על סמך מדדים הנדסים ופיננסים שמתקבלים מהפרויקט, שעיכובים אלו רק גדלים עם הזמן. בנוסף, רק מעט מהבאפרים שהיו בפרויקט נותרו כדי לתקן את הדברים ולהדביק את הפער. על פי נת"ע עדיין קיימים באפרים בין חבילות הקבלנים בפרויקט, אולם חברת הבקרה לא קיבלה מידע שמאפשר לבחון אם אכן נותרו שכאלה. יחד עם זאת, בהחלט אפשרי שאופטימיזציה של הלו"ז במכרזי המערכות והגמרים יאפשרו לאמוד מחדש את מהות הפער והעיכוב בפרויקט כולו.

תוכנית המיטיגציה שנת"ע מציעה כוללת "חפירה ביבש" שהיא רלוונטית רק ל-7 מתוך 10 התחנות התת קרקעיות ובכל תחנה רק לחלק מעבודות החפירה (אלו שנמצאות מתחת למפלס מי התהום). חברת הבקרה מעריכה שפוטנציאל החסכון בזמן של תוכנית זו הוא בין חודש לחמישה חודשים לעומת חסכון בזמן של בין חודשיים לשבעה שמערכיה חברת ה-PMC. יש לציין שלתוכנית זו עלולות להיות גם השלכות על התקציב. בנוסף, נת"ע שוקלת את הרעיון לשגר את מכונות החפירה (TBM) בטרם הושלמו כל עבודות החפירה בתחנות במטרה להאיץ את התקדמות הפרויקט. רעיון זה טרם הובהר לחברת הבקרה וטרם נתקבל מידע לגביו ולגבי היתרונות שביישומו. מכיוון שפרק הזמן הארוך ביותר שמתוכנן למכונות החפירה הינו של 18 חודש ואילו התחנות נמצאות על הנתיב הקריטי של הלו"ז, כל הפרעה או עיכוב בעבודות בניית התחנות כתוצאה ממעבר ה-TBM עלולה לעכב את הפרויקט כולו.

חברת הבקרה ביצעה אומדן למועד השלמת הפרויקט על בסיס ניתוח כתבי כמויות, תפוקות קבלני הביצוע והנסיון הבינלאומי שצברה חברת אגיס בפרויקטים דומים. במסגרת האומדן לא נכללו באפרים שנדרשים לדעתנו לצורך מיטיגציה של סיכונים עתידיים. ה- PMC מדווח שישנם באפרים שעדיין חבויים בין חבילות העבודה בפרויקט ושניתן לנצל לצורך כך. בנוסף ניתן לבצע אופטימיזציה של הלו"ז על ידי תיאום וביצוע פעולות עבודה של קבלנים במקביל (פעולות חופפות). תוכנית המיטיגציה שכוללת את כל האמור, כולל חפירה ביבש, שיגור ה-TBM לפני גמר התחנות ואופטימיזציה של הלו"ז טרם הובאה לעיון חברת הבקרה.

להערכת חברת הבקרה ביחס ללו"ז 10.5 כל העבודות בכל התחנות נמצאות כרגע בפיגור, כאשר בשש מתוך תשע התחנות שמיועדות להסתיים באוקטובר 2021 נמצא פיגור משמעותי, כאשר בתחנת בן גוריון נמצא הפיגור הגדול ביותר ומועד הסיום של עבודות התחנה להערכתינו יהיה בנובמבר 2022. לפיכך ללא תוכנית מיטיגציה העיכובים והפיגורים בבניית התחנות בשלבי הדיפון (Station Box and D-Wall) מהווים סיכון להשגת היעד של קבלת היתר הפעלה באוקטובר 2021.

מכרז המערכות (SDAG) הוא מרכיב חיוני בפרויקט מכיוון שהוא מאגד את כל חבילות הפרויקט, כולל העבודות הנדסה אזרחית בקטעים העיליים והתת-קרקעיים. יש לו חשיבות גדולה במפתח לאינטגרציה בין כל מרכיבי הפרויקט ולכן מכרז זה בדרך כלל יוצא לדרך בתחילת הפרויקט, אפילו בטרם החלו עבודות ההנדסה האזרחית, אך בוודאי לפני קבלן הקרונות והדפו. במקרה של מכרז תכנון ביצוע (DB), היתרון הגדול של קבלן המערכות ביכולת להשלים את התכנון המפורט מוקדם ככל האפשר כדי לתאם את האינטגרציה בין חלקי הפרויקט ולהימנע מעיכובים ותביעות של קבלני הביצוע.

# EXECUTIVE SUMMARY

The objective of the report is to analyze the progress of the RED Line project per the schedule. The baseline structure of 10.5 and 10.6 has not changed and completion dates for station boxes which are all on the critical path have been basically kept despite already recognized delays appointed in EMC report from February 2016. NTA's project management consultant (PMC) opinion is that Master Schedule 10.6 "continues to be relevant in determining performance against a given work plan.

The critical path of the project's timetable goes through building the underground stations. The progress of the works on these stations today shows also according to PMC monthly report significant delays in completion date. EMC find that the delay is still growing based on the financial and engineering data reported to us. In addition only few time buffers are remaining between packages and EMC opinion is that such buffers need to remain in order to mitigate future risks. As assessed by NTA other buffers exist for all activities but so far EMC were not in position to analyze this assessment. It is possible that schedule optimization of both SDAG and Fit-Out packages would allow determining the potential mitigation float.

NTA mitigation plan is considering dry excavation which is relevant to only 7 of the 10 stations and within each station only part of the work was planned as wet excavation. EMC calculated the potential time saving range between one to five months compared to PMC range from 2 to 7 months. It should be noted that this alternative might have additional cost associated with it. In addition to dry excavation NTA is considering the idea to launch the TBM before the excavation of a station 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), while the stations are on the critical path, each disturbance for the station works if cause by the TBM may affect the overall timetable.

EMC has assessed the project future completion date based on bill of quantity and productivity compiled from PMC, contractors' narrative and EMC international experience. The analysis was not including buffers which EMC believe is required for future uncertainties and risk mitigation. PMC has reported that additional hidden buffers exist in the project that can be utilize for such purpose. In addition, overlapping of activities may also enable to optimize the schedule. The complete mitigation plan prepared by NTA was not yet received for EMC review, including among others the concept of TBM first. It is EMC opinion that such concept should not be part of the mitigation plan.
EMC estimate that compare to schedule 10.5 all stations are in delay, where 6 stations of the 9 underground stations show significant delay compare to the project finishing date in October 2021, of which Ben Gurion station has the longest completion date at November 2022. So far current delay on D Wall and station box activities put at risk achieving October 2021 PTO date.

The SDAG tender is a crucial element as it frames the whole project packages, including civil works of UG and at grade. It has a key role in interface management and final integration, therefore, such tender is usually awarded very early, even before civil packages, but surely before Rolling Stock and Depot. In case of D&B benefit of such early award is to get detailed design as soon as possible, in order to coordinate the interfaces between all packages and avoid claims and delays by the contractors.

# INTRODUCTION

## Background

The objective of the report is to analyze the progress of the RED Line project per the schedule. The report review implemented changes and mitigations measurements embedded in schedule 10.6 regarding schedule 10.5, which is the last officially approved by RL steering committee. The report also measure the progress in the last months since EMC issue its last report on schedule 10.5 in February 2016 and is bringing EMC assessment of the completion date.

**Extract from EMC report on 10.5 (Feb 2016) :**

*For next version (V 10.6) EMC asks NTA to produce, as an addendum of schedule, a formalized mitigation plan (a 3 / 4 pages note) which will give answers to following questions:*

*- Which mitigation measures (acceleration, strategy/sequence changes …) have been undertaken in new version in order to cope with new delays (VS V10.5)?*

*- Are there still buffers, where are they and how long are they?*

*- Are there specific tasks (eg : main utilities diversion, interface design milestones, … ) at a level of risk such higher that they could impact PTO dates.*

Those requests/action items have yet been delivered by NTA or introduced in schedule 10.6, which has been sent as an official version early in September 2016 without further documentation or explanation.

# CHAPTER 1: PROJECT SCHEDULE STATUS

## 1.1 MAIN DIFFERENCES BETWEEN LAST VERSIONS

The baseline structure of 10.5 and 10.6 has not changed and completion dates for station boxes which are all on the critical path have been basically kept despite already recognized delays in EMC report from February 2016, highlighting late starts and lower progress on site for D Walls activity.

No mitigation measures have been integrated in schedule 10.6 despite NTA notice that such measures will be included in the next version of schedule.

Schedule 10.6 shows few differences compare to Schedule 10.5, including:

- At-Grade South : slippage of 5 months for SDAG NTP with as a consequence 2 months of delay for PTO 1
- UG west & East : D walls / excavation / bottom slab durations have been squeezed and delayed in order to cope with current delays and not to change any of other civil milestones : TBM launching/arrival, inner box, hand over TBM W-E to fit out – The Fit Out tender process has been delayed by 6 months – no change shown on T&C / PTO 2 milestones
- At grade North: permit for AG East delayed by 4 month. Works on site delayed by 4 months. - no other major changes no other major changes – no change shown on T&C / PTO 2 milestones
- Depot Access : three month delay for Mekorot utility relocation –no other major changes - no impact on PTO 2
- Axis 8 : 6 month of delay on detailed design process (including approval) - the whole sequence of construction is shifted accordingly –no other major changes - no impact on PTO 2
- Depot : Final commissioning delayed by 3 months + SCC Ready delayed by 7 months. –no other major changes – no change shown on T&C / PTO 2 milestones
- Rolling Stock : First train (LRV 4-5) delayed by 4 months– no change shown on T&C / PTO 2 milestones

In addition, major project structural changes where introduced during 2016 by NTA including:

- new fit out tender strategy,
- new Turkish alignment tender strategy ,
- result of axis 8 detailed design (NTAM VS TBM),
- follow up of O&M tender process,

The above structural changes are not integrated clearly in Schedule 10.6

## 1.2 OFFICIAL STATUS OF 10.6 SCHEDULE

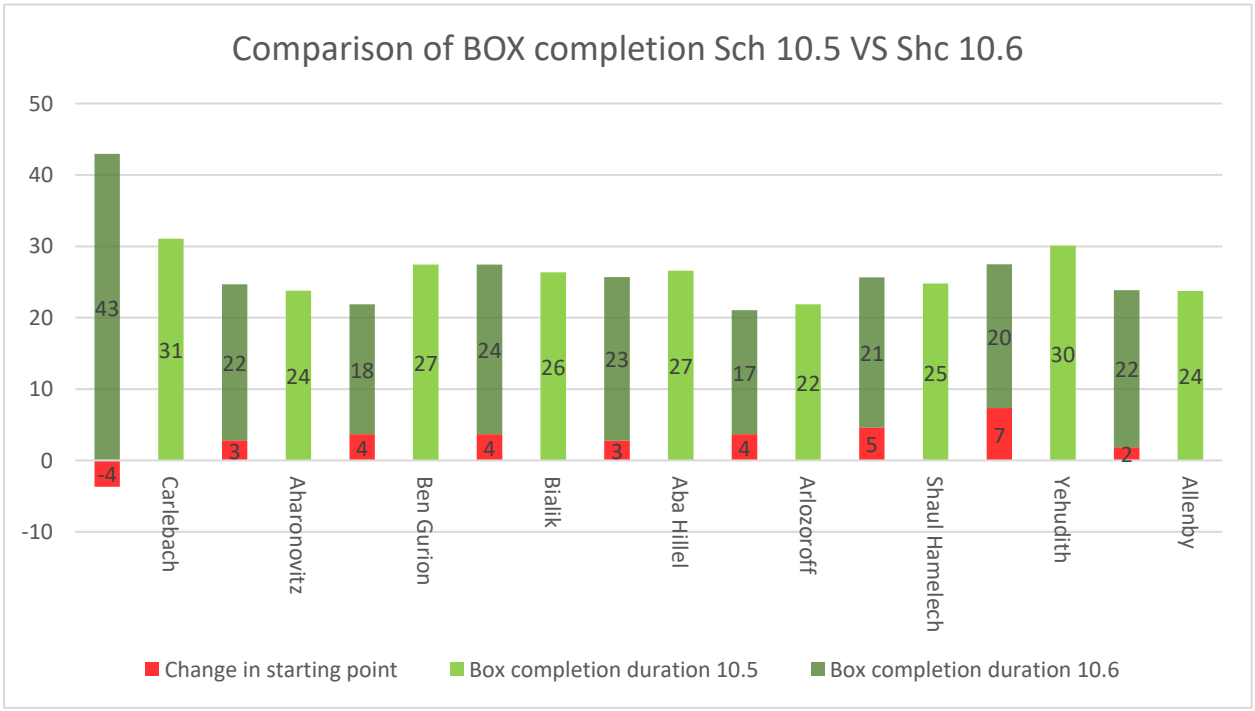
### 1.2.1 NTA (PMC) POSITION REGARDING 10.6

NTA's project management consultant (PMC) opinion is that Master Schedule 10.6 "continues to be relevant in determining performance against a given plan particularly with regard to the ongoing civil works…[and] in order to understand the effectiveness of various mitigation scenarios…[the purpose of] Master Schedule version 10.7…target date for draft submittal end of February…is…[to] reflect the approved mitigation strategies…[including] critical interface milestones…and re-synchronized between disciplines [packages and contractors]" - Extract from NTA answer to EMC after review of the draft version of this report (annex 1.0).

### 1.2.2 EMC POSITION REGARDING 10.6 SCHEDULE

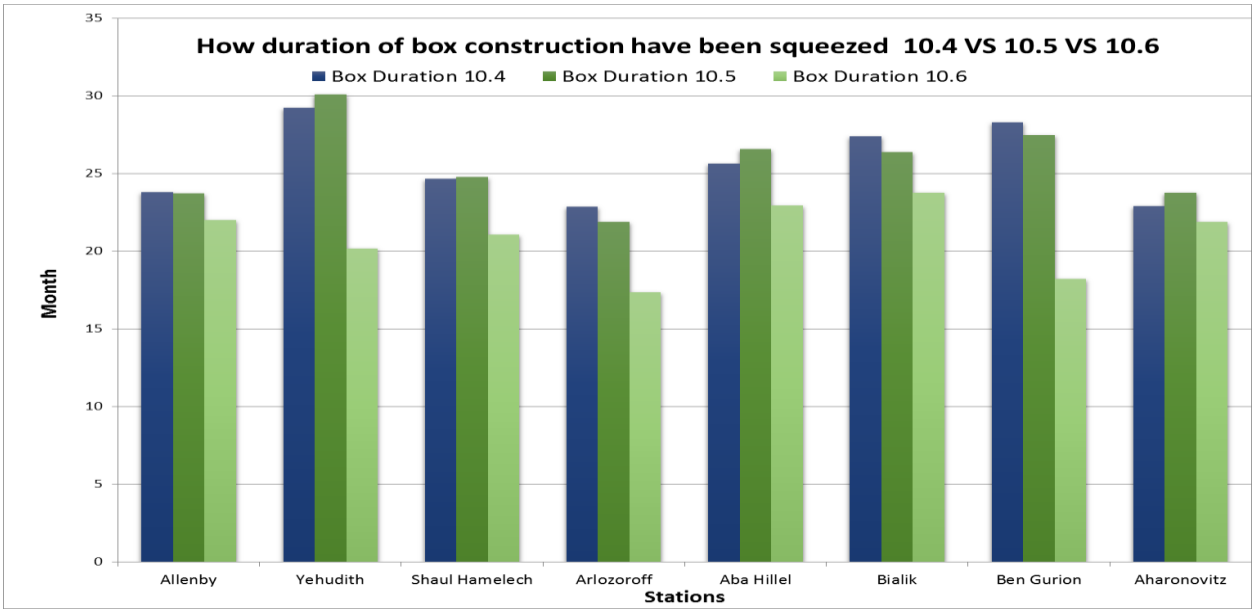
EMC has no information in order evaluate major changes introduced by NTA in 10.6 for ongoing activities, such as box construction. Currently, only about 25-30% of boxes (temporary support) completion is achieved and delays on D Walls are increasing. Duration of box construction has been reduced using, what EMC believe to be quite optimistic rates, allowing to keep the main milestones of project as in scheduled in 10.5. In addition, it is now proposed to have an early start of TBM works "TBM first" designed in Sch 10.6 for mid 2017, an action that may effect all on-going activities, a point we address further in this report.

The following graph 1.0 highlight the gap between late start of activities and early end of such activities, which result in shortening activity schedule in some cases, for example, in Arlozeroff station, it seems unreasonable to start 4 months late and finish 2 month ahead of time. The following diagram illustrates this situation for all underground stations using comparison between 10 .6 & 10.5 for box construction activities.




*Graph 1.0* - Comparison of BOX completion Sch 10.5 VS Shc 10.6

Despite severe delay between 10.5 and 10.6 for start of box construction, final delay for box completion is very small. [redacted]




*Graph 1.1* - How duration of box construction have been squeezed (10.5 VS 10.6)

Graph 1.1 shows that between 10.5 and 10.6 a [redacted]

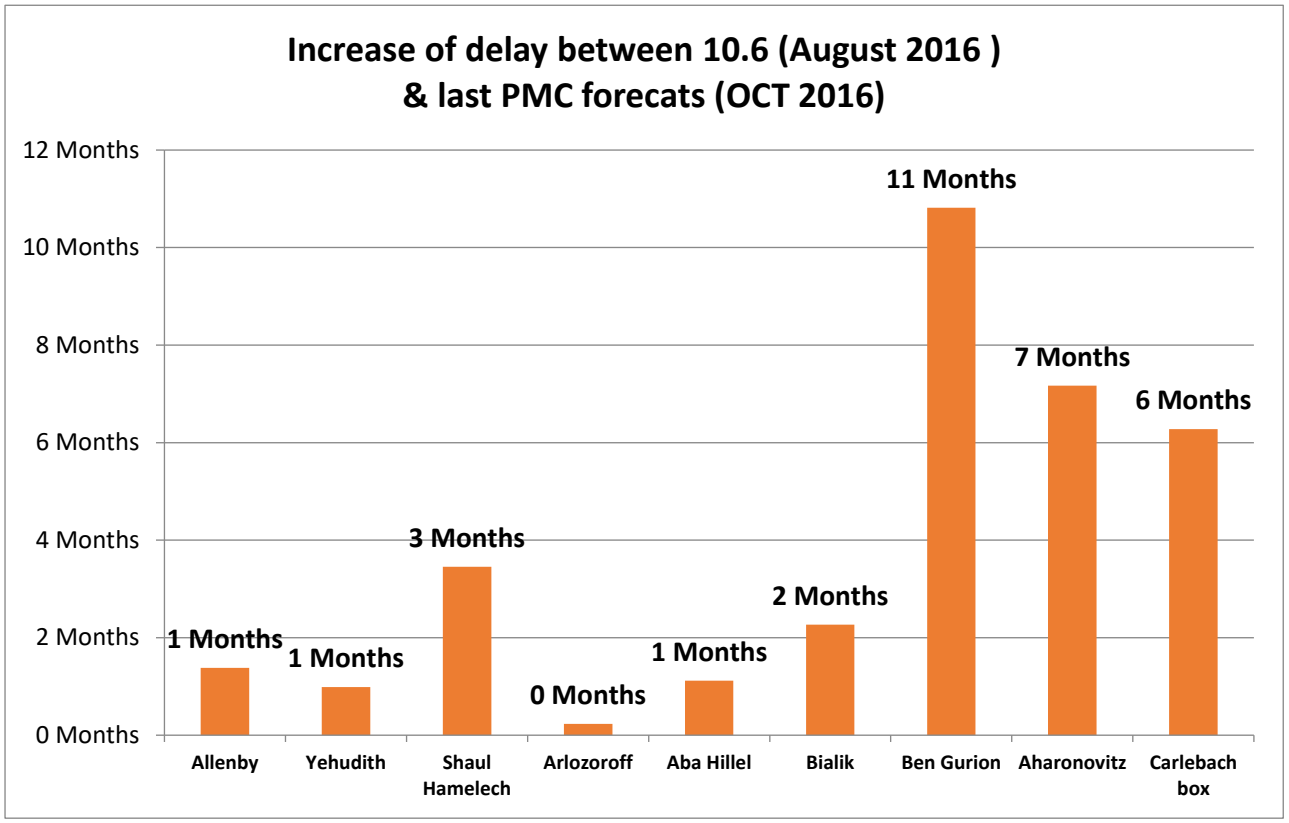
# CHAPTER 2: PROJECT STATUS

## 2.1 STATUS OF CIVIL WORKS

In order to evaluate Schedule 10.6 we also reviewed the project status and its effect on the schedule. The critical path of the project's timetable goes through the underground stations. The progress of the works today shows according to PMC monthly report significant delays in completion date (see Annex 2.0). The allocated timetables for the various activities in the stations, such as excavation, inner box concrete works, fit-out and systems installation

[redacted] (i.e. IEC permits).

Graph 2.0 shows that delay is still growing when comparison between completion dates shown in 10.6 (August data) and latest forecast made by PMC.




*Graph 2.0*– Increase of delay between 10.6 & PMC forecats

### 2.1.1 ON-GOING D-WALLS ACTIVITIES

From data provided by NTA's PMC Red Line monthly report, EMC is following the progress on site, mainly Outer Box and D Walls activities. [redacted].

On going D Walls activities are not yet stabilized at a constant monthly progress rate and delays were increasing for most station during August to October 2016.

The following table 2.0 presents the detailed status of D Walls completion on site at the end of October 2016 with comparison to the schedule. It is clear from the table that there is a significant delay in both MC and EMC forecasts, bringing the completion day to a distance from the schedule, that in Shaul Hamelech, for example, it is accumulating according to EMC forecast up to 13 month.

| Station Name | No. of D Wall Panels | panels Done Oct 30th 2016 (based on Pb monthly report) | Remaining panels to be completed | Remaining In % | Completion date of D WALL | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Schedule 10.5 | PMC forecast (based on PB Oct monthly report) | *EMC forecast* | Delay 10.5 VS PMC |
| **Allenby** | 117 Pannels | 99 Pannels | 18 Pannels | 15% | August-16 | November-16 | *November-16* | 3.0 Months |
| **Yehudith** | 103 Pannels | 39 Pannels | 64 Pannels | 62% | February-17 | September-17 | *September-17* | 7.0 Months |
| **Shaul Hamelech** | 104 Pannels | 38 Pannels | 66 Pannels | 63% | September-16 | October-17 | *October-17* | 13.0 Months |
| **Arlozoroff** | 152 Pannels | 149 Pannels | 3 Pannels | 2% | March-16 | September-16 | *November-16* | 6.0 Months |
| **Aba Hillel** | 114 Pannels | 73 Pannels | 41 Pannels | 36% | September-16 | February-17 | *March-17* | 5.0 Months |
| **Bialik** | 108 Pannels | 55 Pannels | 53 Pannels | 49% | October-16 | April-17 | *April-17* | 6.0 Months |
| **Ben Gurion** | 172 Pannels | 45 Pannels | 127 Pannels | 74% | May-17 | April-18 | *April-18* | 11.0 Months |
| **Aharonovitz** | 143 Pannels | 37 Pannels | 106 Pannels | 74% | March-17 | December-17 | *December-17* | 9.0 Months |
| **Carlebach** | 310 Pannels | 84 Pannels | 226 Pannels | 73% | January-17 | July-17 | *February-18* | 6.0 Months |

*Table 2.0– D wall current delay – except EMC forecast all data provided by NTA*

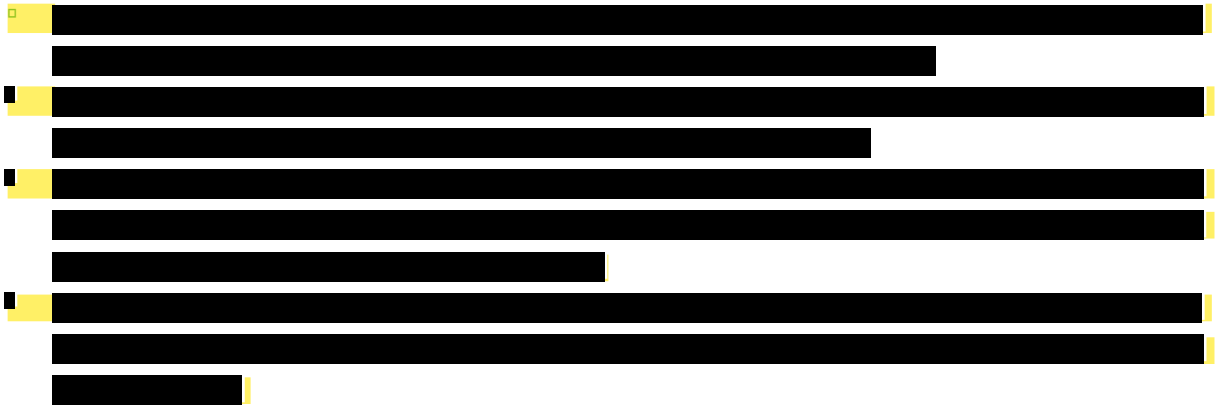
On the basis of the latest PMC forecast the table 2.0 shows significant deviations for all of 10 underground stations, noted delays at Shaul Hamelech of 13 months, Ben Gurion 11 Months, Aharonowitz 9 months and Carlebach 6 months.

Those delays are based on current work progress and do not account for additional unforeseen problems such as, equipment malfunctions, deficiencies in the quality of execution or the need for more works to relocate of utilities.

Completion of the D walls in each station is mandatory before beginning of the excavation works and de-watering. Therefore, the NTA mitigation plan, to be further discussed herewith, should minimize risk of further delays in the execution of the D walls in the stations. If NTA choose partial station excavation strategy, it may be implemented, but will require adjustment to the temporary support system design and to the construction sequence.

### 2.1.2 EXCAVATIONS

The PMC assumptions are that the average excavation productivity refers to a fixed monthly performance rate. [redacted]



### 2.1.3 CONCRETE SLAB (FLOOR + WALLS OF THE STATION)

The unique context of constructing an underground station in the center of town account for many issues: limited access, working with small foot-print (ground area of 3,000 square meters at depth of 25-30 meters), safety requirements of crane working over roads, protection of houses and public spaces near-by, traffic arrangements, as well as the difficulty to work and move equipment between the horizontal support (struts).

Common practice benchmarked data from other projects enables to analyze productivity. As can be seen from the narrative of contractors (Annex 2.1) at each station they will operate only one crane that can serve simultaneously and efficiently an expert climbing team and Iron workers of 50-60 employees.

[redacted]

### 2.1.4 CASH FLOW INDICATORS

The current delay in the schedule is also manifesting in the current accounts. For this report, we have analyzed the accounts which have thus far accumulated in 2016 in the TBM-WEST project. It is important to note that the gap in the TBM EAST package is wider.

#### 2.1.4.1 MONTHLY EXPENDITURE PER STATION AS AN INDICATOR

The analysis is focusing on the work carried out in the six underground stations which are located in TBM-WEST area. The contract cost of civil works in the 6 stations is 3.1 billion NIS and the schedule 10.6 shows a duration of about 50 months. Hence, the average monthly expenses per station could be considered approximately 5.9 million NIS.

One should consider for the first months (3 to 6 months) a learning curve according to the expected expenditure could be 50% of the average. In the first 6 month from June to December 2015 the average was MNIS1142 which is 20% of the expected average, as presented in table 2.1.

| Month | Execution payments for six stations in TBM west | Average per station per month |
|---|---|---|
| 2015 Learning Curve Period | | |
| August-15 | ₪ 7,100 | ₪ 1,183 |
| September-15 | ₪ 8,900 | ₪ 1,483 |
| October-15 | ₪ 11,700 | ₪ 283 |
| Advanced paiment Oct-2015 | ₪ -10,000 | |
| November-15 | ₪ 11,500 | ₪ 1,917 |
| December-15 | ₪ 5,066 | ₪ 844 |
| Average for learning curve | | ₪ 1,142 |

*Table 2.1 – 2015 expenditure*

18 months later one would expect that the monthly expenditure would be above the average and unfortunately the best month performance was in June 2016 were total expenditure has reached 6.233 (see table 2.2) which is only 5.6 % above the average.

| Month | Execution payments for six stations in TBM west | Average per station per month |
|---|---|---|
| 2016 Regular Period | | |
| January-16 | ₪ 10,243 | ₪ 1,707 |
| February-16 | ₪ 22,439 | ₪ 3,739 |
| March-16 | ₪ 30,400 | ₪ 5,067 |
| April-16 | ₪ 20,145 | ₪ 3,357 |
| May-16 | ₪ 35,038 | ₪ 5,839 |
| June-16 | ₪ 37,400 | ₪ 6,233 |
| July-16 | ₪ 24,700 | ₪ 4,117 |
| August-16 | ₪ 20,200 | ₪ 3,367 |
| September-16 | ₪ 20,000 | ₪ 3,333 |
| October-16 | ₪ 13,000 | ₪ 2,166 |
| Average for last 6 months | | ₪ 4,176 |

*Table 2.2 – 2016 expenditures*

Table 2.3 is presenting the lates data we have (May to October 2016) for the average expenditure rate which was MNIS 4 176 per month, which is 29 % below the expected average.

| | |
|---|---|
| Average for last 6 months | ₪ 4,176 |
| Expected Averag | ₪ 5,900 |
| Difference Last 6 months VS Expected % | -29% |

*Table 2.3 – "Comparison of result for last 6 months"*

[redacted]

### 2.1.4.2 FORECAST EXPENDITURE FOR 2016

In light of the above, and while assuming same execution rate for the coming months of 2016, the accumulating execution projection for the TBM-WEST package will be approximately 280 million NIS. Compared to the cash flow projection made in end 2015, which was MNIS 432 we find a gap of 35%. Such gap is the second indicator of potential delay in the project

### 2.1.4.3 TBM BUDGET UTILISATION IN Q2 & Q3

Table 2.4 shows the aggregate payments for both projects (TBM-EAST and TBM-WEST) during Q2 & Q3 2016. The table shows low utilization of budget in Q3 where comparing Q2, indeed Q3 is only 43 % of Q2 2016. Such decreasing utilization is the third indicator of potential delay in the project

| Packages | Q2/2016 | Q3/2016 |
|---|---|---|
| **TBM west** | ₪ 201 687 344 | ₪ 120 734 982 |
| **TBM east** | ₪ 153 531 840 | ₪ 32 950 617 |
| Total | ₪ 355 219 184 | ₪ 153 685 599 |

*Table 2.4 – TBM E & W Cash Flow Q2 & Q3 2016*

### 2.1.4.4 POTENTIAL DELAY EFFECT ON BUDGET

Potential implication of project delay on budget includes:

1. Postponement of the 2016 flow to following years (2017 and forward)
2. [redacted]
4. Discrepancies between equipment arrivals and the completion of the project, which may lead to storage costs, unnecessary maintenance insurance etc.
5. [redacted]

In order to minimize possible damages, NTA should consider taking cost reducing actions, and updating the flow as following:

1. Preparing of an updated cash flow for the TBM works while updating the schedule.
2. To evaluate the risk of potential delay and update the risk matrix.
3. [redacted]

#### 2.1.4.5 PMC COMMENTS ON BUDGET INDICATORS

PMC response to these budget indicator as presented for its review in Ver1.0 of this report included the following comments:

- PMC rejects the use of Cost and Schedule performance relationships as one-to-one indicators of true cost/time relationship.
- Expenditure in projects such as the Red Line cannot be expected to be linear, even after applying a learning curve. Production rates are expected to increase after sites are cleared from utility obstacles.
- PMC dismisses EMC's calculations of the expected average monthly expenses. PMC traces the discrepancy to EMC's calculation of the total cost for civil works in the 6 stations.

Regarding PMC response to EMC Review of 10.6 Master Schedule, expected average monthly expenses per station was calculated in the following method as presented in the updated version of table 2.5:

| | |
|---|---|
| Average for last 6 months | 4.176 million NIS |
| Expected average | 5.900 million NIS |
| Difference last 6 months vs Expected % | -29% |
| Expected average – including only half of the provisional sums | 5.505 million NIS |
| Difference last 6 months' vs Expected % | -24% |
| Expected average – not including any of the provisional sums | 5.113 million NIS |
| Difference last 6 months' vs Expected % | -18% |

*Updated Table 2.5 – "Comparison on result for last 6 months"*

As shown on the table, even without including any part of the provisional sums in the expected expenditure per station per month, as PMC suggested, there is an 18% gap between expected expenditure and real expenditure. However, EMC believes that it is probable that at least 50% of the provisional sums are allocated to works on the stations, and therefore the gap between expected expenditure and real expenditure stands on at least 24%. [redacted]

Low expenditure during Q3 compared to Q2: PMC did not respond to EMC's comments regarding this issue. PMC has explained that increase in expenditure should be expected once utilities evacuation has finished is not consistent with the actual database.

Low expenditure during 2016 - According to PMC, there is not a "one to one" connection between the real works and expenses. Nonetheless, EMC is still concerned by the 35% gap between 2016's estimation and the updated expenditure.

## 2.2 MITIGATION PLAN

### 2.2.1 DRY EXCAVATION

NTA is considering instead of excavating and casting at some stations under the water table, an alternative by which de-watering is creating a dry area, which will enable 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 of those stations, only part of the excavation works relates to wet excavation method that is proposed to be replaced now with dry excavation method.

The following Table 2.6 Show % of wet excavation VS total for each station

| Station | Total Volume to be excavated (revised BOQ) | "DRY" Volume to be excavated | "WET" Volume to be excavated | % WET VS DRY |
|---|---|---|---|---|
| **Allenby station - main box - Excavation** | 98,653 m3 | 88,788 m3 | 9865 m3 | 10% |
| **Yehudit station - main box - Excavation** | 118,164 m3 | 86,351 m3 | 31813 m3 | 27% |
| **Shaul Hamelech station - main box -** | 96,293 m3 | 73,366 m3 | 22927 m3 | 24% |
| **Arlosoroff station - main box - Excavation** | 110,051 m3 | 78,101 m3 | 31950 m3 | 29% |
| **Abba Hillel station - main box - Excavation** | 97,770 m3 | 77,401 m3 | 20369 m3 | 21% |
| **Bialik station - main box - Excavation** | 84,354 m3 | 69,684 m3 | 14670 m3 | 17% |
| **Ben Gurion station - main box - Excavation** | 134,860 m3 | 80,916 m3 | 53944 m3 | 40% |
| **Aharonovitz station - main box -** | 89,139 m3 | 53,484 m3 | 35655 m3 | 40% |
| **Carlebach station - main box - Excavation** | 129,372 m3 | 129,372 m3 | 0 m3 | 0% |
| **Carlebach intersection - Excavation** | 118,019 m3 | 118,019 m3 | 0 m3 | 0% |
| **Carlebach South Retrieval Shaft -** | 21,825 m3 | 21,825 m3 | 0 m3 | 0% |

*Table 2.6– Wet **VS** Dry*

In general, the alternative of dry excavation is effective to less than 1/3 of the total excavation volume, thus its effect may shorten the excavation period accordingly by 3 months on average per station.

### 2.2.2 TIME SAVING RELATED TO DRY EXCAVATION OPTION

From data transmitted by NTA/PMC (see annex 2.3), EMC calculated the total potential time saving of dry excavation option in table 2.7 The table shows potential time saving from 0.9 to 5.1 months (EMC calculation) or from 1.5 to 6.7 (PMC assessment) in all station concerned by wet excavation issues.

Calculation of potential benefit has been made by (presented in table 2.7):

- applying the rate per working day for dry excavation used for 10.6 (data provided by NTA/PMC) to the whole volume to be excavated
- duration of excavation activity in a what if scenario "dry excavation" only
- difference between the duration shown on 10.6 and this "what if scenario" duration calculating potential time savings in working days (WD) converted in "working month".

In document "SubmissionRed_Line_Master_Schedule_10 6EMC ReviewVer02PMC" (annex 1.0) NTA assess different duration in matter of time saving expected from dry excavation. This different approach has not been detailed yet by PMC/PMC.

| | PB Data (see annex 11) BOQ (Revised) | PB Data (see annex 11) "Dry + Wet" Daily Rate | PB Data (see annex 11) Duration "Dry + Wet" | Calculated "Dry only" Daily Rate | Calculated Duration "Dry Only" | Calculated Benefit of dry excavation with no consideration to any extra time associated to Dry Only | | PB last assessment (See Annex 12) |
|---|---|---|---|---|---|---|---|---|
| **Allenby station - main box - Excavation** | 98 653 m3 | | 278 WD | 386 m3 | 256 WD | 22 WD | 0.9 Months | 2.0 Months |
| *ST1310 Excavate to water table (+24 till 0) & deck* | 88 788 m3 | 386 m3 | 230 WD | | | | | |
| *ST1320 Excavate below water table - Allenby* | 9 865 m3 | 206 m3 | 48 WD | | | | | |
| **Yehudit station - main box - Excavation** | 118 164 m3 | | 240 WD | 675 m3 | 175 WD | 65 WD | 2.7 Months | 2.0 Months |
| *ST1610 Excavate to water table struts 2 3 & 4 -* | 86 351 m3 | 675 m3 | 128 WD | | | | | |
| *ST1620 Excavate below water table to -9.20 -* | 31 813 m3 | 284 m3 | 112 WD | | | | | |
| **Shaul Hamelech station - main box - Excavation** | 96 293 m3 | | 189 WD | 863 m3 | 112 WD | 77 WD | 3.2 Months | 1.5 Months |
| *ST1910 Excavate to water table struts 1 & 2 -* | 73 366 m3 | 863 m3 | 85 WD | | | | | |
| *ST1920 Excavate below water table to -14.70* | 22 927 m3 | 220 m3 | 104 WD | | | | | |
| **Arlosoroff station - main box - Excavation** | 110 051 m3 | | 202 WD | 1420 m3 | 78 WD | 124 WD | 5.2 Months | 2.5 Months |
| *ST2210 Excavate to water table struts 2 & 3 -* | 78 101 m3 | 1 420 m3 | 55 WD | | | | | |
| *ST2220 Excavate below water table to -19.05* | 31 950 m3 | 217 m3 | 147 WD | | | | | |
| **Abba Hillel station - main box - Excavation** | 97 770 m3 | | 221 WD | 790 m3 | 124 WD | 97 WD | 4.1 Months | 3.0 Months |
| *ST2510 Excavate to water table - Abba Hillel* | 77 401 m3 | 790 m3 | 98 WD | | | | | |
| *ST2520 Excavate below water table - Abba Hillel* | 20 369 m3 | 166 m3 | 123 WD | | | | | |
| **Bialik station - main box - Excavation** | 84 354 m3 | | 271 WD | 505 m3 | 167 WD | 104 WD | 4.4 Months | 6.7 Months |
| *ST2810 Excavate to water table from +14.75* | 69 684 m3 | 505 m3 | 138 WD | | | | | |
| *ST2820 Excavate below water table to -10.20* | 14 670 m3 | 110 m3 | 133 WD | | | | | |
| **Ben Gurion station - main box - Excavation** | 134 860 m3 | | 286 WD | 817 m3 | 165 WD | 121 WD | 5.1 Months | 5.5 Months |
| ST3410 Excavate to water table - Ben Gurion | 80 916 m3 | 817 m3 | 99 WD | | | | | |
| ST3420 Excavate below water table - Ben Gurion | 53 944 m3 | 288 m3 | 187 WD | | | | | |
| **Aharonovitz station - main box - Excavation** | 89 139 m3 | | 242 WD | Mistake in daily rate data provided by PB (Wet > Dry) | | | | 5.2 Months |
| *ST3110 Excavate to water table - Aharonovitz* | 53 484 m3 | **347 m3** | 154 WD | | | | | |
| *ST3120 Excavate below water table -* | 35 655 m3 | **405 m3** | 88 WD | | | | | |
| **Carlebach station - main box - Excavation** | 129 372 m3 | | 264 WD | 490 m3 | 264 WD | 0 WD | NA | NA |
| Excavate to water table | 129 372 m3 | 490 m3 | 264 WD | | | | | |
| **Carlebach intersection - Excavation** | 118 019 m3 | | 151 WD | 782 m3 | 151 WD | 0 WD | NA | NA |
| *Excavate to water table* | 118 019 m3 | 782 m3 | 151 WD | | | | | |
| *Excavate below water table* | | | | | | | | |
| **Carlebach South Retrieval Shaft - Excavation** | 21 825 m3 | | 129 WD | 169 m3 | 129 WD | 0 WD | NA | NA |
| *Excavate to water table* | 21 825 m3 | 169 m3 | 129 WD | | | | | |
| *Excavate below water table* | | | | | | | | |

*Table 2.7– benefits of dry excavation -All data source provided by NTA*

Nevertheless, we have consider that in this "what if" scenario potential time saving should be balanced by extra duration linked to preparation works which needs to be carry out before implementing the dry excavation method and which is at this stage under design by IBI, but also duration of permitting process linked to water pumping/treatment.

[redacted]

### 2.2.3 COST IMPACT

This alternative might have additional costs associated with it that affect the project:

a. The contract rate for underwater casting based on the current contractors' price is around 700NIS/M3, while dry excavation the costs are approximately 1,110NIS/M3 – 40% higher.
b. In addition, there is need to pump and inject back the dewatered.

It is EMC opinion that NTA should present a risk analysis and then get an agreement from GOI before implementing the mitigation plan.

### 2.2.4 TBM FIRST

The idea to launch the TBM before the excavation of a station is intended to expedite the works. NTA did not 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), while the stations are on the critical path, each disturbance for the station works if caused by the TBM may affect the overall timetable.

Indeed TBM first option has to be tightly coordinated station works in order not to delay it taking into consideration that this option could have a negative impact on duration of works within station with as main risks :

- Preparation works could have to be done in some stations to allow TBM to go first (eg : Extra ground reinforcement works, making D Wall deeper to cope with water pressure issues, …)
- Ongoing excavation works could have to be stopped at a certain level before TBM go through station excavation and which could create idle period for excavation activities.
- After TBM go through the station, even if volume of soil will subsequently lowered, excavation works will be more complicated and longer due to presence of section of tunnel underneath.

Other important technical issues have also to be taken into consideration such as TBM heavy maintenance which has to be done during stops at each stations. As a result TBM FIRST can be considered only for very few and non-adjacent stations for each TBM drive not for all.

EMC expects to get from NTA detailed explanation of this concept, including the sequence of works at each station, and the timing of the TBM passing through.

It is EMC opinion that NTA should present a risk analysis and then get an agreement from GOI before implementing TBM FIRST.

### 2.2.5 ADDITIONAL MITIGATION MEASURES TO BE CONSIDERED

EMC believes that additional mitigation measures can be developed including, among other, working with Local Authorities'/ Municipalities to achieve better flexibility in working hours (increasing 5.5 working days a week), temporary traffic arrangement (to allow better flow of equipment and trucks in and out of the working sites) and additional area to enlarge the worksites (to allow installation of additional equipment such as cranes).

## 2.3 MARGINS

### 2.3.1 OVERALL BUFFERS

Because 5 years remains to completion we can consider that a sufficient buffer has to be integrated within the Master Schedule for all remaining activities in all packages.

So far EMC has no information from NTA regarding what were the initial buffers, how they have been spread within the schedule and how long they were. In spite of specific request in 10.5 report, we didn't receive yet any information regarding buffer strategy by NTA.

The only information we got from NTA so far are related to station works and buffers between the two packages Civil and Fit Out contractor for each station[redacted]

### 2.3.2 REMAINING BUFFER FOR STATION BOXES

When EMC reviewed 10.5 schedule early in 2016, NTA reassured than margins were embedded within 10.5 schedule and especially for the station works. The margins were not clearly identified but supposed to be located between packages and specially for station works between civil works activities and fit out activities.

On 10.6 completion dates for boxes are more or less still shown as they were on 10.5 in spite of several late starts or current low progress of D Wall activities in many stations (see preamble). Currently, NTA is showing confidence that buffers are still embedded within 10.6 schedules and especially between Fit Out package and civil work packages.

Those margins were initially estimated by NTA from 2 to 4 months except for Yehudit & Shaul Hamelech stations for which margin is now 0 (see Annex 2.4) but in last answer from PMC different status of buffer is shown with any further demonstration (see table 2.8).

| | | D-Wall Activities | | | | | |
|---|---|---|---|---|---|---|---|
| # | Station | v10.6 Base Line | PMC November Report | Variance (Months) | Benefit of Dry Excavation (Months) | Remaining delay (Months) | Remaining Buffers (Months) |
| 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 2.8 - Extract from PMC document "Red_Line_Master_Schedule_10 6-EMC Review-Ver02-PMC Response.pdf"*

EMC opinion is that situation of buffer seems not stabilized if you take into consideration data from schedules, data from PMC regarding buffers and current delay.

Table 2.9 shows discrepancy between information by PMC and schedule status ; indeed following PMC it could remain 11.2 months of buffer for Aharonovitz station while initial duration of this box was 23.8 months in 10.5 This duration has been reduced by almost 2 months in 10.6 and that D.walls accumulated delay for completion is presently 9 months VS 10.5. Such situation is not clear and does not reflect correctly the status of the real buffer, if any exists.

| Station Name | First information given by PMC about remaining buffers | Last information given by PMC about remaining<br>Current buffer without dry excavantion (as per 10.5) | Dwalls delay 10.6 VS 10.5 | Boxes Duration 10.5 | Boxes Duration 10.6 |
|---|---|---|---|---|---|
| **Allenby** | 2 to 4 months | 4 Months | 3 Months | 24 Months | 22 Months |
| **Yehudith** | 0.0 Months | 2 Months | 7 Months | 30 Months | 20 Months |
| **Shaul Hamelech** | 0.0 Months | 4 Months | 13 Months | 25 Months | 21 Months |
| **Arlozoroff** | 2 to 4 months | 4 Months | 6 Months | 22 Months | 17 Months |
| **Aba Hillel** | 2 to 4 months | 5 Months | 5 Months | 27 Months | 23 Months |
| **Bialik** | 2 to 4 months | 7 Months | 6 Months | 26 Months | 24 Months |
| **Ben Gurion** | 2 to 4 months | 7 Months | 11 Months | 27 Months | 18 Months |
| **Aharonovitz** | 2 to 4 months | 11 Months | 9 Months | 24 Months | 22 Months |
| **Carlebach** | 2 to 4 months | 7 Months | 6 Months | 31 Months | 43 Months |

*Table 2.9 – Differences between duration period*

### 2.3.3 HIDDEN OR OTHER MARGIN

At this stage of the project, with 5 years ahead up to PTO schedule for Oct 2021, some "hidden margins" within the master schedule would remain. Part of those margins could be embedded in overall duration of “macro” tasks, that have not been detailed to construction level. Further schedule optimization of both SDAG and Fit-Out packages should allow determining the potential mitigation float by detailed scheduling work.

As assessed by NTA other buffers exist for all activities but so far EMC were not in position to analyze this assessment.

## 2.4 OTHER PACKAGES STATUS

### 2.4.1 TBM

NTA intend to launch in an early schedule the first TBM in Feb 2017 with the argument of securing Ayalon corridor crossing. Such intention by NTA has not yet received the mandatory agreement from GOI. [redacted]

[redacted]

### 2.4.2 FIT OUT

We confirm our previous conclusion: No Objection to the proposed change from "Construction Only" to Design and Build. IBI full design (100%) for the inner-box is undergoing. NTA preserve the alternative to tender the fit-out package as several sub-packages (mechanical, finishing, furniture, etc'). This option shall be implemented as DB with 100% design by IBI. The schedule of this alternative is yet finalized.

### 2.4.3 TURKISH ALIGNMENT

EMC has shared the tender readiness report with NTA. [redacted].

### 2.4.4 DEPOT

DEPOT FACILITIES works are progressing according to 10.5 schedule with the various building delivery expected between Dec 2017 and June 2018. Most of the works are in the phase of structure and beginning of finishing. KYRIAT ARIE STATION design has not been completed and is excluded from Depot contactor scope of work.

### 2.4.5 ROLLING STOCK

CNR is progressing as schedule with completion of preliminary design, management and safety plans, initial hazard analysis and finalizing systems suppliers list. It has been noted that final design is subject to detailed coordination with SDAG contractor, which makes SDAG NTP an important and urgent milestone for RS final design.

### 2.4.6 SDAG/SYSTEM

[redacted]

### 2.4.7 O&M

NTA and EMC had a working session on Sept 8th to review the status of the O&M tender and the changes proposed to the tender documents as result of:

- Bidders Conference held on 29th June 2016
- Face-to-Face Meetings held on 1st & 2nd Aug. 2016

NTA proposed several changes which were accepted by EMC in its written report to the steering committee date September 15. It is EMC recommendation to amend the contract accordingly without pending anti-trust commissioner decision regarding the competitive effect of [redacted].

### 2.4.8 PTO PROCESS

In February 2015 MoT and NTA have concluded the PTO process chronological order and milestones along the project completion that requires MOT approval (see annex 2.5). It has been agreed that the list of milestones can be changed following the project needs, MOT requirements or other updated circumstances. The process is designed in such a way that the SISA (nominated as TuvRheinland) issues a formal report prior to each MOT approval. Parallel to the SISA assesement, MOT can check and analyze similar issues as MOT decided to including EMC comments.

# CHAPTER 3: **EMC ASSESSMENT**

## 3.1 Benchmarking

The Red Line project is designed such that the TBM machines and at the stations are executed in parallel. Considering the relatively short TBM drives and the duration of tunnel and station construction, the critical path of the project goes through the underground stations. Therefore, the completion of the stations is the most critical element and its completion has a direct effect on the expected date of opening the line to service. Execution of each station includes: relocation of utilities and temporary traffic arrangements, mounting D- walls, excavation, concrete and waterproofing works, Earthing system works, soil resistivity measurements, trenching and cable laying, mat installation, protection, fit-out, station systems, railway systems (SDAG) and landscaping and in addition the timetable should include test running and trial running by the operator. Some of the scheduled activities are not finalized as it is still under tendering or design phase (SDAG, Fit-Out, Turkish Alignment).

EMC has assessed the local conditions and made a comparison with other international metro projects of similar construction methodologies. To maintain confidentiality over disclosure of third party information, names of the projects are not explicitly stated. Instead a numbering reference system is used in this report, related to a unique internal index of relevant EGIS RAIL experience in previous projects.

### 3.1.1 Box Diaphragm wall construction

D-wall excavation comparison is made to experience with project ID# 'E' constructed in ground conditions of comparable quality and productivity, excavated with one hydrofraise of similar dimensions. Average construction progress rate was 2 days per D-wall bite excavation & panel reinforcement installation and concreting. Experience in in other projects (ID's 'A', 'B' & 'F') were also considered in soft rocks utilizing similar or smaller hydrofraise machines. Average construction progress rate was 3 days for bite excavation, reinforcement and panel concreting. Construction works were executed on a 6-day week working basis.

In order to take into account equipment break-downs & maintenance an average of 3-days' minimum per D-wall panel is considered feasible. D-walls progress has been assumed to proceed in two concurrent panels (one being excavated and the other being reinforced/concreted. Furthermore, progress can be expedited in specific critical stations, in order to safely complete D-walls prior to TBM arrival at the station. This can be achieved by bringing to site more hydrofraise machines (new or from less critical stations) on the condition that the bentonite suspension desanding plant capacity can cope with the excavated material treatment.

### 3.1.2 Box Station Excavation

**Station** box excavation progress rate is compared to project 'E' utilizing D-walls in 'bottom-up' construction method. An average rate of excavation rate of 250 to 300 m3 per day was possible for this method (averaged over a 7-month construction duration). Project 'A' excavations within D-walls are also considered, which are not exactly considered a close fit for D-walls construction comparison, as D-walls were only utilized in one occasion, rock breakers being always necessary, and due to the presence of a ramp enabling truck loading both at surface and at

the excavation level and a large plan station dimensions and available site occupation allowing for a large equipment operating at multiple locations (rock breakers, earth movers, tower cranes, trucks). Thus a spoil volume of 500-1500m3 per day on a week average basis was possible which for these reasons in snot considered feasible in the present project.

For the evaluation, an average excavation rate of 350m3 per day (400m3/day for dry excavation and 200m3/day for wet excavation) on a 6-day working week excavation and spoil removal average has been considered in general, on the condition that the station area and town logistics and carefully planned and implemented. In particular for Ben Gurion and Carlebach stations a higher average rate was considered (2 to 3 times up respectively), due to the larger footprint of the construction area, excavation can take place simultaneously at several locations. In view of the struts installation time, monitoring works, D-wall integrity checks and repairs and various other obstructions, this rate is thought to be rather onerous but achievable for the present project. Station excavation is also considered to be performed in staged sections, due to traffic diversions phases etc) and need to be considered the program.

### 3.1.3 Permanent Structure Concreting

For the concreting works progress reference is made to rates from projects 'C' and 'E', as structural type, concrete delivery and site restrictions appear to be similar. An average of 40-80m3 per day (6-days' week) for reinforcement and concreting works was achieved. For project 'A', in many occasions a concurrent concrete supply for 2 dedicated batching plants & 7 concrete pumps was possible that increased the level of delivery [upto 480m3 per hour capacity, which is not considered likely in this project].
For the purpose of the TBM 1st mitigation comparison, only the raft slab (waterproofing system installation, testing & repairs / reinforcement / kicker formworks installation / casting) has been considered at an average rate of 70m3 per day, to assess station preparedness for the TBM break-in. This considers waterproofing system, reinforcement works and concreting occurring concurrently at 2 parts of the station. In particular, for Carlebach station a 3-times higher average rate was considered, as works can be simultaneously executed at several parts of the station area.

## 3.2 Assessment of Duration

EMC assessment of project duration and completion date was calculated based on project bill of quantity and productivity compiled from PMC, contractors' narrative and EMC local and international experience. The detailed calculation and methodology are presented in Annex 3.0 and can be referred to the following:

- D-Wall data are according to PMC report from October 2016 and PMC forecast.
- Excavation data are based TBM launching excavation rate of Galie Gil, contractors narrative and EMC international experience.
- Concrete works were based on TBM West contractor's narrative, similar data from local building projects and EMC international experience.
- Finishing works were based on data from similar data from local building projects and EMC international experience.

The analysis does not include buffers which EMC believe is required for other construction activities (such as jet grouting, earthing works, temporary traffic diversion decks, utility diversions, construction of dewatering wells, waterproofing system installation etc) and future uncertainties and risk mitigation. PMC has reported that

additional hidden buffers exist in the project that can be utilized for such purpose, which shall be demonstrated by the PMC. However, potential overlapping of construction activities may be feasible and have not been considered in this analysis, that could enable to optimize the schedule and shall also be demonstrated by the PMC.

The complete mitigation plan prepared by NTA was yet received for EMC review, including among others the concept of TBM first. It is EMC opinion that such concept should not be part of the mitigation plan. Further, the analysis do not take into consideration mitigation action, such as dry excavation which is not part of the "wet volume" we analyzed for each station.

The following table 3.0 presents the completion dates of the different packages until end of construction, but not including the time for integration test, commissioning, and trial running, which are needed before receiving PTO. The table present the base line status of D-walls activity, on which EMC accepts PMC forecast for work completion. The EMC estimate that compare to schedule 10.5 all stations are in delay, where 6 stations (marked in red) show significant delay compare to the project finishing date in October 2021, of which Ben Gurion station is the most significant to the project, where the delay is over a year. Carlibach is not on the critical path of the Red Line as its finishing date is aligned with the completion of the Green Line (not yet under construction).

| Activity | Station | Allenby | Yehudit | Shaul Hamelech | Arlozorof | Abba Hillel | Bialik | Ben Gurion | Aharonovitz | Carlibach |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Date and Durations (in working days) | | | | | | | | |
| D-walls | 10.5 end date | Aug-16 | Feb-17 | Sep-16 | Mar-16 | Sep-16 | Oct-16 | May-17 | Mar-17 | Jan-17 |
| | PB Report date | Jan-17 | Sep-17 | Oct-17 | Dec-16 | Mar-17 | Apr-17 | Apr-18 | Dec-17 | Dec-17 |
| Box Excavation | 10.5 duration | 239 | 282 | 305 | 348 | 305 | 283 | 284 | 240 | 305 |
| | EMC estimate | 271 | 375 | 298 | 355 | 295 | 248 | 315 | 312 | 673 |
| Base slab Concreting | 10.5 duration | 88 | 87 | 67 | 44 | 67 | 86 | 67 | 66 | 131 |
| | EMC estimate | 86 | 90 | 86 | 86 | 86 | 86 | 86 | 86 | 86 |
| Remaining Station Concreting | 10.5 duration | 240 | 284 | 370 | 348 | 414 | 349 | 262 | 349 | 565 |
| | EMC estimate | 438 | 482 | 450 | 510 | 430 | 417 | 449 | 449 | 561 |
| Station Fit-out | 10.5 finish date | May-20 | Jan-21 | Dec-20 | Jun-20 | Jan-21 | Dec-20 | Jan-21 | Feb-21 | Oct-21 |
| | EMC estimate | Jun-21 | Aug-22 | Apr-22 | Nov-21 | Aug-21 | Jul-21 | Nov-22 | Jul-22 | Mar-24 |

*Table 3.0 – EMC Assessment of Project Duration and Completion date*

## 3.3 Critical Path

### 3.3.1 Stations

All 10 underground stations (UG) final commissioning dates can be considered as crucial milestones for PTO. Accordingly, main part of UG stations activities are on the critical path and completion of activities by one contractor plus handover to the following one are crucial milestones. Among those key milestone, we can emphasize:

- Completion of station box which allow TBM to go through the station (see above)
- TBM going out the station which allow inner box start
- Completion of inner box which give access to:
    - SDAG contractor for implementation of all equipment related to system: power supply transformer, signaling, telecom, SCADA, PSD, AFC … in various technical rooms, platforms and at each concourse.

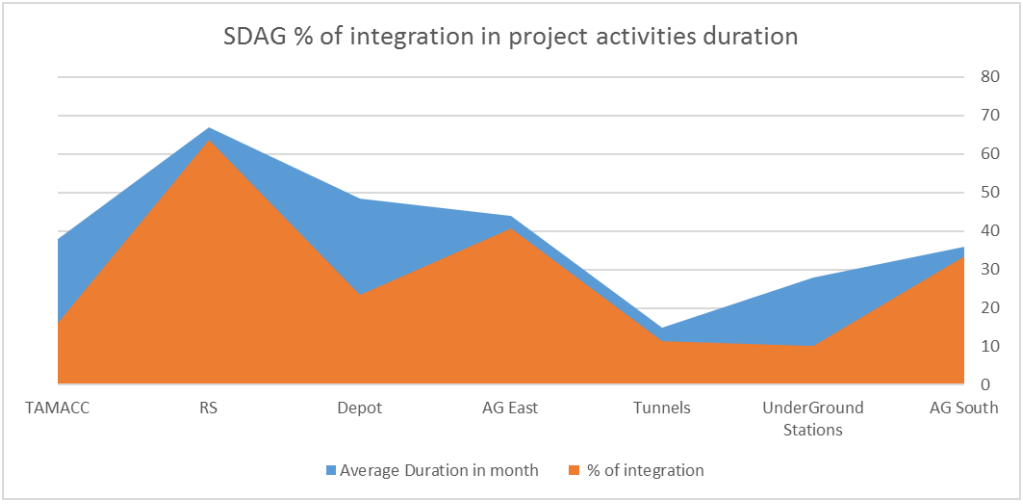
- Fit out contractor (s) for M&E equipment's such as elevator, escalators, doors, security and defense equipment, ventilation system, lighting, fire system, and all architectural works.

- T&C at individual level of all equipment related to system but also to safety within the stations which allow integration of the overall UG system (e.g.: ATO ATP) and safety equipment such as ventilation or fire detection.
- Completion of integration processes (System & safety) which will allow approval of PTO(s) by authorities.

So far current delay on D Wall/box activities put at risk achieving October 2021 PTO date.

### 3.3.2 SDAG TENDER

Systems tender (systems, Depot and At-Grade – SDAG) is a crucial process for all LRT/MRT project because it frames the whole project including civil works on UG and at grade sections. Due to its key role in each package activity and duration (see graph 3.1) and its importance to interface management and final integration such tender is usually awarded very early in the project meaning in parallel or even before civil packages (if they are not merged in a single package) but before Rolling Stock (if they are not merged in a single package) and before Depot (if they are not merged in a single package). In case of D&B benefit of such early award is to get detailed design as soon as possible in order to coordinate design of interfaces between all packages and avoid claims and delays by the contractors.




*Graph 3.1 – SDAG integration share of Project Packages*

In addition, SDAG contractor will be responsible of interface management and final integration for the whole project including Rolling Stock, UG structures (Tunnels & UG station see above), TAMAC, Depot, [redacted] e to this situation SDAG tender is on critical path of the project.

First critical milestone is the delivery of the detailed design for interfaces with the Rolling Stock and the depot to complete their own design with as a first consequence some activities already stopped/delayed for the Depot and very soon completion of detailed design will be impacted. [redacted].

Another milestone is linked to permitting process required to start at grade civil works; indeed such permitting process is supposed to be completed by SDAG contractor and current delay in SDAG tender already reduce to almost 0 the early operation of south bound (VS 10 months of early operation in 10.5)

Other milestones are linked to all system equipment to be implemented in technical rooms or in station or on site (including UG station) and which will require few month of manufacturing abroad before shipping in ISL and delivery/installation on site. Impact of current delay of SDAG tender on installation on site of system equipment is not yet evaluated but it could be considered that two to three months of delay is already there.

So far the current delay on SDAG tender clearly put at risk 2021 PTO date and has already prohibited early operation of at grade south bound.

# RECOMMENDATIONS

**<u>להכין לוח זמנים חדש</u> <u>10.7</u>** או לעדכן את לו"ז 10.6, כך שייקח בחשבון את כל הנקודות הפתוחות, שכוללות :עיכובים בעבודות הנדסה אזרחית בתחנות, מכרזים בתהליך (SDAG) ו (O&M -מכרזים בהכנה) מסילה טורקית (Fit-Out, התקדמות התכנון ואסטרטגיית הביצוע של מכרז ה Fit-Out - והתיאום עם עבודות TBM East ותכנון הקרונות) לאחרונה הוצע שלב ביניים טרום גמר תכנון מפורט.(

**<u>להציג תוכנית ביצוע חלופית</u>** שנועדת להקטין סיכונים ללוח הזמנים (mitigation plan), ושתכלול באפר מספיק לאי ודאות עתידית .תוכנית זו יש להביא לעיון והערות חברת הבקרה תוך כדי שיוצגו תרחישים וניתוח סיכונים.

**<u>לתאם את אבני הדרך בלו"ז 10.7 לתהליך קבלת היתר ההפעלה (PTO)</u>** כפי שמאשר משרד התחבורה באמצעות אגף רכבות – הרגולטור - וכולל את תוכנית הבטיחות.

**<u>לתאם את לו"ז 10.7 עם ההצעה הזוכה במכרז ה</u> <u>SDAG</u>** ומועד מתן אישור תחילת עבודה לזכיין, כולל בחינה מחדש של הסיכונים כתוצאה מהעיכוב בעבודות ההנדסה האזרחית בתחנות או כל סיכון אחר כתוצאה משינויים לעומת לו"ז 10.6 שעמד בבסיס ההצעה הזוכה ושיש בהם בכדי להשפיע על אבני הדרך העיקריות בתוכנית העבודה של הזכיין.

**<u>לקבל אישור המדינה לשיגור מוקדם של עבודת ה-TBM</u>** לכיוון תחנת ארלוזרוב כפוף לבחינה של מצב הפרויקט והסיכון שכרוך בכך שהמכונה "תתקע" למספר חודשים לאחר מעבר האיילון בטרם יושלמו עבודות התחנה.

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.

NTA should receive GOI approval for an early launch of the first TBM in Feb 2017 in order to evaluate the risk the TBM may be stuck for several month in front of Arlozeroff station due to possible delay in box completion.