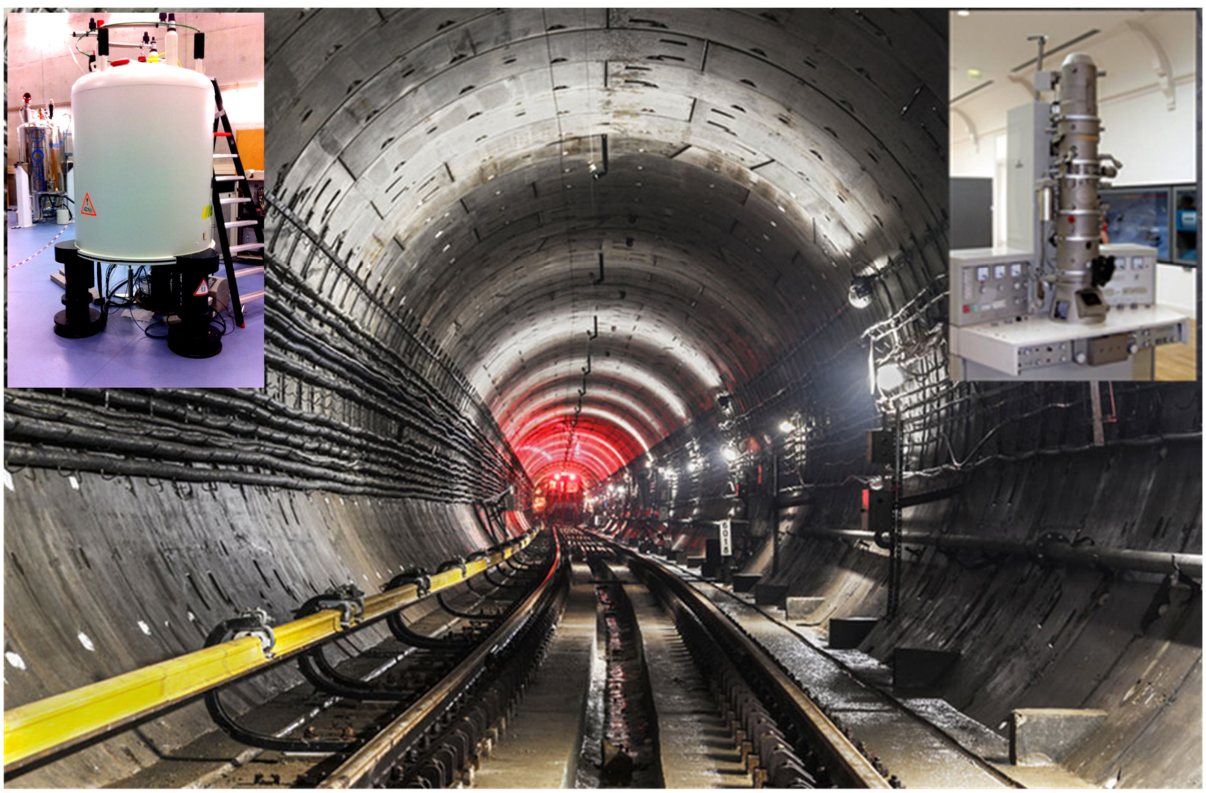
# Bar-Ilan University
# Tel-Aviv metro M2 line Ramat-Gan

## Assessment of NTA's Magnetic Field Measurements



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# Contents

# 0. Assessment Statement

### Magnetic Field Measurements by NTA

The construction of a new metro system will have an environmental impact such as (but not limited to) dust, vibration, noise and so-called electromagnetic emission, both during construction, as well as during operation. New electrical systems cause new electromagnetic phenomena in their environment, and electromagnetic compatibility (EMC) with equipment already present in that environment must be managed.

The M2 is planned to pass the University at close range (northern route) or even beneath the University buildings (southern route). The University uses a variety of scientific instruments in education and research. A new metro system is very well capable of causing electromagnetic fields that disturb the proper operation of the instruments, which would cause certain research to become very difficult or even impossible.

NTA performed magnetic field measurements in and around the University buildings above the planned southern route and performed theoretical calculations. In the report made available to the University it is called "*Practical and Theoretical Survey of Magnetic Field Flux Along the Southern Alternative of Metro M2 Route on the Bar Ilan Campus*.

### Assignment

The Bar-Ilan University asked Microsim to perform an assessment on the report and provide a professional opinion on it. Microsim has knowledge of and many years of experience with investigating similar situations and has engineered solutions, both in the Netherlands as well as abroad.

### Scope

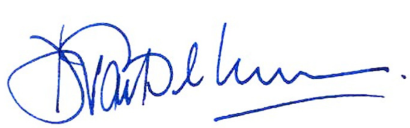
The technical scope of the assessment is the contents of the report in relation to (electro)magnetic interference of scientific instruments of the University by M2 in the low and extremely low frequency bands.

### Assessment

The NTA report was assessed and the assessor's findings are, that the measurements cannot be used in the mitigation of risks, the University faces. The report also uses wrong references and false assumptions relative to elektromagnetic behaviour of metro systems. Measuring the wrong frequencies in the present situation is meaningless.

The findings have been substatiated in the following chapters. The over-all conclusion is, that the report does not at all address the University's concern relative to interference of their instruments by M2. The expected levels of interference by M2 and the errors in NTA's Environmental Impact Assessment as stated in the University's objection are still standing firm.

Leusden, The Netherlands,
May, 20th, 2021
(authorized signature)



Ir. D. van Bekkum,
(managing director)

# 1. Introduction

## 1.1 Scope of the assessment

The assessment concentrates on one of the core issues of the Bar-Ilan University's objections against the alignment of M2 along the (so-called) southern alignment: extremely low frequency (ELF) interference to scientific instruments.
ELF in this context means: frequencies from 0.05 to 5 Hz. Interference to instruments of ELF magnetic fields must be dealt with on a situational specific basis because they are:

- not covered by EMC standards and guidelines;
- harmless for humans according to ICNIRP guidelines;
- very strong because of the high currents involved;
- easily overlooked because it causes interference with "only" specific instruments at special locations.

Therefor this assessment will not apply to (i) electric fields, (ii) high(er) frequencies such as RF.

## 1.2 Original text and translation

The report on NTA's mesurements[1] was written in Hebrew and translated into English or the purpose of an assessment by Microsim. There is (of course) always a certain risk that errors in translation cause confusion or misunderstanding. But from the translation it seems reasonable to assume that no problems with correct understanding have occurred.

## 1.2 Area of interest

Magnetic field flux values were measured on the southern alternative route of the Metro M2 line on the Bar Ilan University campus.


Figure 1: Area of the route of the southern alternative of the Metro M2 line (marked in blue) on the Bar Ilan University campus.

[1] Moshe Netzer, EMC Engineering and Safety, Ltd, March 29th, 2021
Practical and Theoretical Survey of Magnetic Field Flux Along the Southern Alternative of Metro M2 Route on the Bar Ilan Campus

# 2. Assessment of measurements

## 2.1 Basic problem and basis of EM objections

The objection of the University is based on the fact, that scientific instruments are very sensitive to ambient magnetic fields, especially (but not limited to) with extremely low frequencies. Metro and other electrified transportation systems generate extremely strong magnetic fields with frequencies in the range of 0.05 to 5 Hz. The reason is high currents, the behaviour of their high power converters (i.e. the electric drives), the power (and current) related to drive cycles and the movement of the vehicles.

## 2.2 Measurements

Performing measurements in order to investigate future problems, requires a representative situation. Representative means, that a situation should be created which is (more or less) similar to a situation where metro trains are running and where risks occur that will be comparable to risks in a future situation. The assessment has been done with that in mind.

# 3. Assessment of NTA's report paragraph by paragraph

## 3.1 Chapter 1: Administrative Data and Executive Summary

**Report text**

*1.1 Survey Objective*

*Mapping the magnetic field flux at a frequency of 50 Hz, which exists along the southern alternative route of the Metro M2 line on the Bar Ilan University campus. The measurements were compared to an estimate made for the Metro M2 line (Reference 3).*

**Assessment**

A frequency of 50 Hz is hardly a worry for the University's instruments. It is the basic frequency of their own power supply and manufacturers are very capable of designing instruments that do not suffer from interference by their own power supplies.
Also the fact that the NTA is only looking at 50 Hz interference from their M2 (caused by the rectifier ripple), shows a fundamental lack of understanding.

**Report text**

*1.1 Safety Criterion and Electromagnetic Compatibility*
*Safety of exposure to magnetic field flux – see Chapter 2*
*Electromagnetic compatibility – see the table below from Reference 5*

| *Building* | *Distance from the Metro* | *Bar Ilan Data* | *Results of Theoretical Estimate (References 3, 5)* | |
|---|---|---|---|---|
| | | *Sensitivity of scientific equipment to electromagnetic fields* | *Static magnetic field flux from normal driving current* | *Static magnetic field flux from short current or maximum load* |
| | *Meters* | *mG* | *mG* | *mG* |
| *202* | *123* | *1-10mG AC*<br>*No DC data* | *0.28* | *0.82* |
| *204* | *123* | *Low sensitivity* | *-* | *-* |
| *205* | *111* | *No data* | *0.075* | *0.35* |
| *206* | *49* | *10µG AC* | *1.0* | *3.7* |
| *207* | *82* | *Moderate sensitivity* | *0.14* | *0.46* |
| *208* | *72* | *Not given* | *0.17* | *0.6* |
| *209* | *43* | *High sensitivity* | *0.5* | *1.7* |
| *211* | *42* | *1-10mG AC*<br>*No DC data* | *0.52* | *1.8* |
| *212* | *5* | *Low sensitivity* | *-* | *-* |

**Assessment**
The reference data under column "*Static magnetic field flux from normal driving current"* makes very clear, that the nature of electrified transport systems has been overlooked completely. Though the power supply of these kind of systems always refer to DC, the currents are far from DC, especially in the ELF range. That will be elaborated further in paragraphs 3.5 and 3.6.

**Report text**
*1.6 Measurement Method and Equipment*
*Direct measurement of magnetic field flux using wide band measuring equipment -- Tenmars TM-192D S.N 120600218 Triaxle ELF Magnetic Field Meter, calibration validity September 2021*

**Assessment**
The measurements were carried out with an instrument that can measure magnetic flux densities in the frequency range of 30-2000 Hz. That means that no measurements were carried out in the frequency range of interest. Even worse: most if not all scientific instruments are well designed to operate in a 50 Hz or 60 Hz environment because those are the frequencies of their power supplies. The measurements were carried out with an instrument that can measure flux densities in the range of 20/200/2000 mG (2/20/200 µT). But the University's instruments have sensitivities in range of 0.5-0.01 mG. The instrument cannot measure what could be interfering.

Measurements of this kind with this instrument does not serve any purpose relative to the expected problems with M2 ELF EM emission.

## 3.2 Chapter 2: The Safety Criterion

**Report text**
*Limiting Exposure to a Magnetic Field as a Function of the Exposure Duration (March 2020 update) and remainder of the paragraph.*

**Assessment**
The entire chapter has been dedicated to long term exposure and exposure intensity. Relative to scientific instruments, the major mishaps with that approach are:

- the approach and these methods deal with human safety and health. In fact, all ICNIRP Guidelines do not address equipment and instruments at all. So this type of assessment is useless because scientific instruments are quite different from humans;
- the text uses longer term exposure as something to consider. But the time scale for instrument interference is in the order of milliseconds and a long term duration means seconds or minutes. Within that time frame, interference from external sources can ruin an instruments performance.

So the contents of this chapter is of no use at all when having to mitigate the risks of instrument interference by M2.

## 3.3 Chapter 3: Measurements

**Report text**
*Magnetic field flux density is measured in milligauss (mG). The values presented are the vector weighting of the magnetic field flux on the x, y, and z axes.*
*Measurements were performed at a height of 1 meter.*

**Assessment**
As mentioned before, the measurement range of the instrument is inadequate. The measurements do not serve any purpose relative to the University's risks from M2.

**Report text**
***Interim summary**: Table 1 shows the reference measurements of the magnetic field flux density in open space and buildings on the BIU campus, in the areas adjacent to the Metro M2 route. In addition, magnetic field flux was measured in laboratories that may house equipment sensitive to magnetic field flux. The tests were performed during hours when the university was active during the coronavirus period.*
*During the testing, building current consumption data came from the control room. The data readings are of phase currents.*

*At all the points tested, the magnetic phase flux level was low and did not exceed 1 mG, except at Point 4, where magnetic field flux density was measured as high as 20 mG. The high level resulted from performing the measurement underneath a concealed electrical cable ladder.*

**Assessment**

Measurements were carried out in the present situation, without any source similar to M2. The outcome is (of course) the ambient magnetic field of the present University environment. But that does not provide any information on a situation where metro trains would run below the University buildings. In order to do such a thing, it would take a completely other approach and other types of measuring equipment.

## 3.4 Chapter 4: Summary and Conclusions

**Report text**

*This report presents the practical reference measurements of magnetic field flux density in the open space and buildings of the Bar Ilan University campus, in the area of the southern route alternative of Metro M2. In addition, measurements were performed in areas where there are laboratories operating that might house scientific equipment sensitive to magnetic field flux. The tests were carried out at hours when the university was active during the coronavirus period. At the time of the tests, building current consumption data was provided from the control room. Data readings are of the current intensity. According to the guidelines of the Environmental Protection Ministry, magnetic field flux measurements were performed 1 meter above ground.*

**Assessment**

In short: these type of measurements are totally inadequate to get a reasonable feel for the risks of M2 to the University's scientific instruments. M2 will cause a totally different magnetic environment, which will cause the University's instruments to disfunction.

**Report text**

*At all points surveyed besides Point 4, the magnetic field flux density was between 1 mG and 4 mG. At Point 4, magnetic field flux density was measured at 20 mG. The high reading is evidence that the measurement was performed under a concealed electrical cable ladder. This level is not representative of the background magnetic field flux on the university campus. It can be seen from the results of the prediction in Appendix A that the background level of magnetic field flux on the Bar Ilan campus is similar or higher than that expected at ground level from the Metro infrastructure with a third-rail or fourth-rail feed system.*

**Assessment**

These kind of data may be interesting, but not adequate for the solution of the problem.

## 3.5 Appendix A-1: Metro System with Third Rail

**Report text**

*Figure A-1 shows the daily average magnetic field flux, with a ripple current of 13.8 amps for two trains traveling in opposite directions, with a current of 1500 amps in a third-rail system. The illustration shows the following findings regarding the magnetic field flux on ground above the tunnel:*

**Assessment**

The text of the report shows some serious misunderstandings on how electrified rail systems function and what their environmental impact is.

First: a daily average is a useless figure, because scientific instruments suffer from instantaneous changes of the M2's flux density. Changes that happen in a matter of seconds make them disfunction. And the instantaneous current in a train system has that kind of changes, due to acceleration, braking and movement.

Second: a ripple of 13.8 Amps is not the cause of the trouble. The changes of the main current are.

Third: the direction of travel of the vehicles may have some impact, but much more important is the direction of current flows. And trains travelling in opposite directions may well have their feeder and return currents flow in the same directions.

Fourth: a current of 1500 Amps for a single train seems a rather low figure. NTA intends to run trains with a maximum of 7 carriages absorbing many thousends of Amps.

All these factors contribute to a much higher fluxdensity around the metro system than is shown in the graphs.

**Report text**
*The magnetic field flux reduces to an average daily current of 4 mG within the Metro tunnel, about 8 meters below the ground. Above ground, the magnetic field flux (0.4 mG) is similar to the background levels that exist even without the Metro, as shown in this report in Table 1.*

**Assessment**
Figures of 4 mG within the tunnel and 0.4 mG above ground at 8 m higher are way too low. The calculations may be right but the input figures, especially of currents, are way too low. Especially here the truth is: erronous figures in, result in erronous figures out. Therefore we did some simulations to determine the real values.

If we assume two trains that consume 1500 Amps each, then a third rail system generates a flux density of
- 24.8 mG at track level
- 9.5 mG at 9 m above track level (tunnel ceiling)
- 5.1 mG at 17 m above track level (ground level)

If we assume a more realistic situation of two trains that consume 3500 Amps each, then a third rail system generates a flux density of
- 57.8 mG at track level
- 22.2 mG at 9 m above track level (tunnel ceiling)
- 11.8 mG at 17 m above track level (ground level)

## 3.6 Appendix A-2: Metro System with Fourth Rail

**Report text**
*Figure A-2 shows the daily average magnetic field flux, with a ripple current of 13.8 amps for two trains traveling in opposite directions, with current of 1500 amps in a fourth-rail system. The illustration shows the following findings regarding the magnetic field flux on ground above the tunnel:*

**Assessment**
As is the case for a third rail systems, also for the fourth rail system, the figures on currents are erroneous.
Whether a fourth rail system will cause a (much) lower environmental flux density, remains to be seen. Two currents of half the total through two running rails will differ not much from the total current through a fourth rail at running rail level.
It is also a strange phenomenon that the fluxdensities of both trains differ. The cross section pattern of the leftmost train differs substatially from the pattern of the rightmost train. That is weird, given the currents and the physical properties and lay-out are the same. That makes the figures hard to believe.

**Report text**
*Magnetic field flux above the ground: The magnetic field flux reduces to 4 mG above the track platform, 8 meters under ground. Above ground level, the magnetic field flux is very low (0.5 mG), lower than the typical background levels. The Metro train would be in motion at a maximum load of 1500 A in the tunnel.*

**Assessment**
Figures of 4 mG above track platform and 0.5 mG above ground at 8 m higher are way too low. The calculations may be right but the input figures, especially of currents, are way too low. Especially here the truth is: erronous figures in, result in erronous figures out.
Also, it is weird that figures within the tunnel are lower for a fourth rail system, while the figure above ground level is higher for a fourth rail system than it is for a third rail system. Why would that be? Or are we talking about different heights of ground level above the tunnel?

## 4. Conclusions

It seems that the NTA measurements completely overlooked the nature of the phenomena caused by M2. It misjudges the risks for the University. The NTA report is missing out the essentials of metro systems at four major aspects.

First, the report refers to ICNIRP recommendations and documents. Those are intended for the protection of humans. But scientific instruments are far from human. It is important to know that scientific instruments can be very sensitive to phenomena that do not have impact on humans.

Second, the report measures the present ambient magnetic fields in buildings of the University. That is a situation which is totally not representative for the environment of a metro system. Magnetic fields in the present situation (also the ones generated by scientific instruments themselves) are very much different from the ones that will be generated by the metro.

Third, the measurements were carried out with an instrument that measures magnetic fields above 30 Hz. But that is far above the frequencies generated by metro systems that make instruments disfunction.

Fourth, currents in metro systems can reach many thousands of Amps, generating very strong magnetic fields. The fact that those are considered in the report as DC, misunderstands the electrical behaviour of metros. The voltage of metros may be (more or less) constant, but currents are far from constant. And the variations are much more than a little 50 Hz ripple from the substation rectifiers.

Just remember: when looking at a small mountain lake, do not expect to be able to accurately predict a tsunami in the Pacific Ocean.

DvB/-