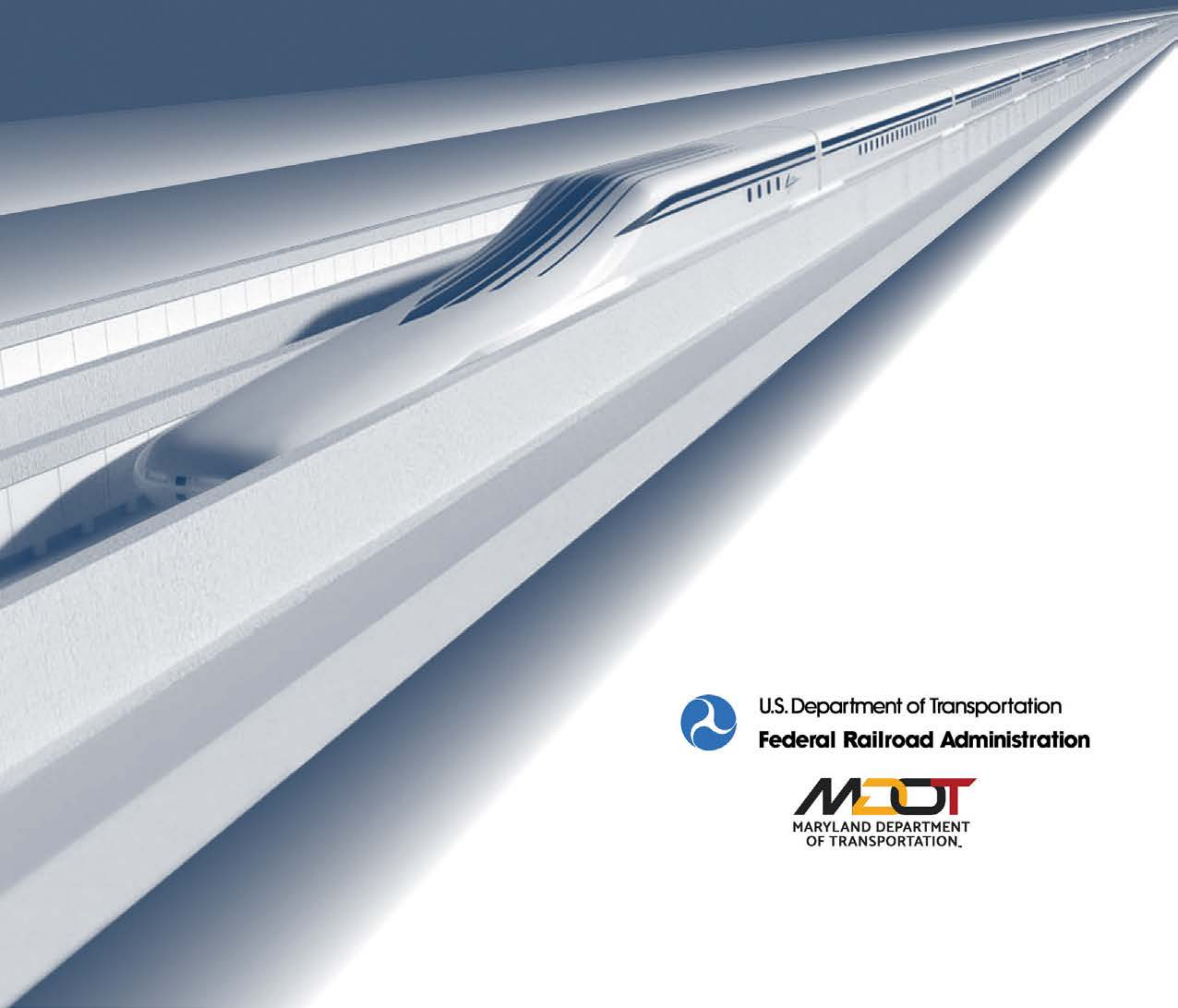
Appendix D.11

Electromagnetic Fields and Interference

BALTIMORE-WASHINGTON
SUPERCONDUCTING MAGLEV PROJECT

DRAFT ENVIRONMENTAL IMPACT STATEMENT AND
SECTION 4(f) EVALUATION



U.S. Department of Transportation
Federal Railroad Administration

MDOT
MARYLAND DEPARTMENT
OF TRANSPORTATION

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Appendix D.11 Electromagnetic Fields and Interference

D.11.1 Introduction

This section provides information about electromagnetic fields (EMFs)—what they are, how they are measured and what government regulations and industry standards have been developed to verify safe use of equipment and devices that intentionally or unintentionally generate EMFs. For this EIS, a review was conducted of published scientific research and the L0 MagLev train technical specifications. Based on this review, EMF levels that are be expected to be generated during operations of the alternatives are identified and compared to national and international standards. This section also analyzes the potential for operation of the alternatives to result in EMI with sensitive electronic equipment used at commercial, industrial, scientific and medical facilities that may occur within the EMF Study Area.

All sources of electricity produce both electric and magnetic fields. Electric fields result from the strength of the electric charge, and magnetic fields are produced from the motion of the charge. Together, the combination of electric and magnetic fields are referred to as “electromagnetic fields.” EMFs are invisible, non-ionizing, low-frequency radiation. EMFs are commonly produced by both natural and man-made sources.

Unit Definitions and Conversions

Hertz (Hz) – Unit of frequency equal to one cycle per second

Volts per Meter (V/m) – Unit of electric field strength (intensity)
1,000 V/m = 1 kiloVolt/m

Gauss (G) – Unit of magnetic flux density (intensity) (English units)
1 G = 1,000 milligauss (mG)

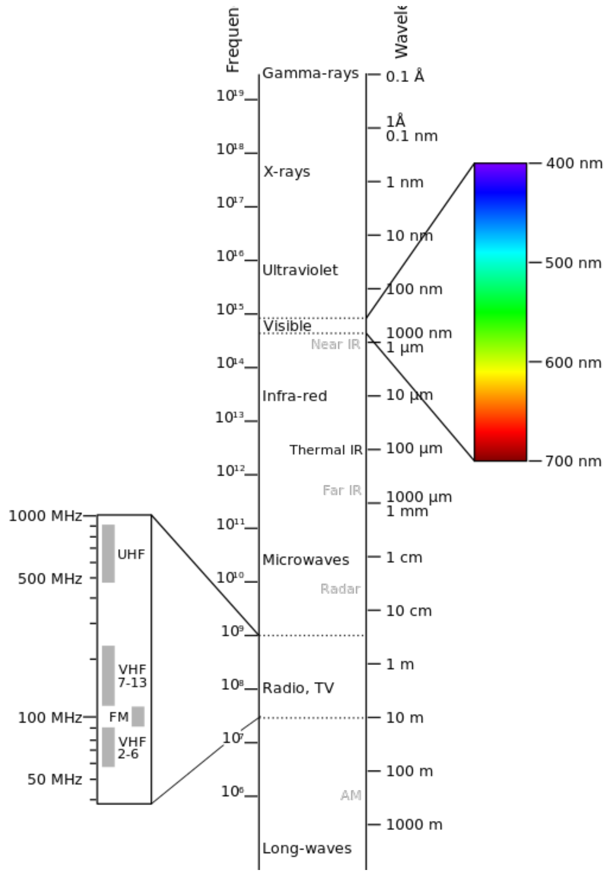
Tesla (T) – Unit of magnetic flux density (intensity) (International units)
1 T = 1 million microTesla (μT)
1 G = 100 μT

milliWatts per square centimeter (mW/cm^2) – Unit of power density (intensity) of EMFs

Electric field strength is measured in units of volts per meter (V/m). Field strength increases as voltage rises. When electrical charges move together (current), they create a magnetic field. Magnetic fields can exert forces on other electric currents. The strength of a magnetic field depends on the current, configuration/size of the source, and distance from the source. Higher currents create higher magnetic fields. The electromagnetic fields grow weaker as the distance from the source increases. Magnetic field strength has several units of measure. The most commonly used are milligauss (mG) and microTesla (μT). Ten mG equals one μT.

EMFs are described in terms of their frequency, which is the number of times the electromagnetic field increases and decreases its intensity each second. In the U.S., electric power operates at a frequency of 60 Hertz (Hz). The electromagnetic (EM) spectrum is illustrated in **Figure D.11-1**.[1] Radio and other communication systems operate at much higher frequencies, often in the range of 500,000 Hz (500 kilohertz [kHz]) to 6,000,000,000 Hz (6 gigahertz [GHz]).

Figure D.11-1: The Electromagnetic Spectrum



Source: Wickimedia Commons, Electromagnetic-Spectrum.svg, https://commons.wikimedia.org/wiki/File:Electromagnetic-Spectrum.svg.

EM radiation is classified based on either the wavelength, measured in meters, or the frequency, measured in Hertz.

Visible light is one part of the entire EM spectrum. Humans also use other forms of EM radiation, such as radio waves for communication, infrared waves for night-vision goggles and microwaves for cooking food.

D.11.1.1 EMF and Health

Reputable authorities on the subject of EMFs include the World Health Organization and the International Commission on Non-Ionizing Radiation Protection. The International Commission on Non-Ionizing Radiation Protection determined that some humans can perceive EMFs in some situations and that perception can be annoying, although not physically harmful. To prevent those acute health effects and annoyance, the International Commission on Non-Ionizing Radiation Protection developed guidelines for human exposure to low-frequency EMFs. The International Commission on Non-Ionizing Radiation Protection states that “adherence to these restrictions protects workers and members of the public from adverse health effects from exposure to low-frequency EMF.” As part of this effort, the International Commission on Non-Ionizing Radiation Protection also reviewed “epidemiological and biological data concerning chronic conditions” (i.e., effects on the neuroendocrine system, neurodegenerative disorders, cardiovascular effects, reproduction and development effects and cancer) and “concluded that there is no compelling evidence

[1] Wikimedia Commons, Electromagnetic-Spectrum.svg, October 2012. Courtesy of Victor Blacus. https://commons.wikimedia.org/wiki/File:Electromagnetic-Spectrum.svg.

that they are causally related to low-frequency EMF exposure."[2] Additionally, the International Commission on Non-Ionizing Radiation Protection concluded that insufficient reliable research exists to determine if a link is possible between the adverse health effects and long-term, elevated EMF exposure. The International Commission on Non-Ionizing Radiation Protection stated that more research is necessary in these areas.[3]

The U.S. National Institutes of Health tasked the National Institute of Environmental Health Sciences with studying and making recommendations on EMF and human health. The National Institute of Environmental Health Sciences published reports outlining their interpretations and recommendations.[4,5,6] The National Institute of Environmental Health Sciences concluded that for most health outcomes, no evidence is present that EMF exposure has adverse health effects.

Many everyday electrical objects emit relatively high EMFs when functioning; however, the International Commission on Non-Ionizing Radiation Protection has determined that these items do not cause health problems.[7] While some of these levels exceed the International Commission on Non-Ionizing Radiation Protection standard, these devices are considered safe. The strength of an EMF rapidly decreases with distance away from its source; thus, EMFs higher than background levels are usually found close to EMF sources. **Table D.11-1** illustrates the magnitude that some common electrical devices are capable of outputting.[8] Note that the values in **Table D.11-1** are instantaneous values, while the International Commission on Non-Ionizing Radiation Protection limit is time averaged over 30 minutes for the public.

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[2] International Commission on Non-Ionizing Radiation Protection, "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields, ICNIRP Guidelines," *Health Physics Society*, April 1998, 74(4), p494-522.

[3] International Commission on Non-Ionizing Radiation Protection, "Review of the Epidemiologic Literature on EMF and Health," *Environmental Health Perspectives*. December 2001, Vol. 109, Issue 6, pp. 911-933.

[4] National Institute of Environmental Health Sciences , "Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields," *NIH Publication* No. 99-4493, May 4, 1999, available at http://www.niehs.nih.gov./health/assets/docs_f_o/niehs_report_on_health_effects_from_exposure_to_powerline_frequency_electric_and_magnetic_fields_508.pdf.

[5] Moulder, J.E., "The Electric and Magnetic Fields Research and Public Information Dissemination (EMF-RAPID) Program," *Radiation Resources*, 2000, 153(5 pt 2), p613-616, available at http://ntp.niehs.nih.gov/about/presscenter/frndocs/ 1997/62fr65814/index.html. .

[6] National Institute of Environmental Health Sciences, "EMF: Electric and Magnetic Fields associated with the Use of Electric Power, Questions & Answers," June, 2002, available at https://www.niehs.nih.gov/health/materials/electric_and_magnetic_fields_associated_with_the_use_of_electric_power_questions_and_answers_english_508.pdf.

[7] International Commission on Non-Ionizing Radiation Protection, "Review of the Epidemiologic Literature on EMF and Health," *Environmental Health Perspectives*. December 2001, Vol. 109, Issue 6, pp. 911-933.

[8] National Institute of Environmental Health Sciences, "EMF: Electric and Magnetic Fields associated with the Use of Electric Power, Questions & Answers," June, 2002, available at https://www.niehs.nih.gov/health/materials/electric_and_magnetic_fields_associated_with_the_use_of_electric_power_questions_and_answers_english_508.pdf.

Table D.11-1: Example EMF Sources

Source	Magnetic Field 6 Inches Away	
	µT	mG
ICNIRP Limit (60 Hz)	200	2,000
Microwave Oven	30	300
Mixer	60	600
Hair Dryer	70	700
Vacuum Cleaner	70	700
Electric Can Opener	150	1,500

Source: National Institute of Environmental Health Sciences, 2002
µT = microTesla
mG = milliGauss

D.11.1.2 Regulatory Context

From a regulatory standpoint, the Federal Communications Commission (FCC) and the Occupational Safety and Health Administration (OSHA) have developed standards for EMF exposure in occupational settings. Neither the federal government nor the State of Maryland has standards for residential EMF exposure.

D.11.1.2.1 Federal

FRA regulations within 49 C.F.R. Parts 236.8, 238.225 and 236 Appendix C provide safety standards for passenger equipment and rules, standards and instructions regarding operating characteristics of electromagnetic, electronic or electrical apparatus.

- 49 C.F.R. 236.8 defines the operating characteristics of electromagnetic apparatus and provides for maintenance of the electronic equipment.
- 49 C.F.R. 238.225 requires that the train equipment not produce “electrical noise” that affects the safe performance of the train’s control, signaling or communications equipment; and that train equipment suppress electromagnetic transients whenever possible.
- 49 C.F.R. 236 Appendix C requires that the train must operate safely when subjected to external sources of EMF or EMI.

Under 47 C.F.R. Part 15, the FCC provides rules and regulations for licensed and unlicensed radio frequency transmissions. Most telecommunications devices sold in the U.S., whether they radiate intentionally or unintentionally, must comply with Part 15. However, Part 15 does not govern any device used exclusively in a vehicle, including on SCMAGLEV.

The FCC provides guidance for evaluating whether proposed or existing transmitting facilities, operations or devices comply with limits for human exposure to radio frequency fields.[9] The FCC limits are partially based on the Institute of Electrical and Electronics Engineers C95.1 standard.[10]

OSHA 29 C.F.R., Sub Part G, §1910.97[11] contains safety standards for occupational exposure to non-ionizing electromagnetic radiation. **Table D.11-2** summarizes OSHA standards.

The Federal Aviation Administration (FAA) does require that airplanes used by commercial aircraft carrier "demonstrate that aircraft electrical and electronic systems are not adversely affected by electromagnetic emissions from other electrical and electronic systems onboard the aircraft."[12] FAA regulations are contained within 14 CFR 77 and include requirements for evaluating the effects of electromagnetic fields on new or existing structures. Specifically, 14 CFR 77.29 requires that the FAA "conduct an aeronautical study to determine the impact of a proposed structure, an existing structure that has not yet been studied by the FAA, or an alteration of an existing structure on aeronautical operations, procedures, and the safety of flight," that includes evaluating "the potential effect on ATC radar, direction finders, ATC tower line-of-sight visibility, and physical or electromagnetic effects on air navigation, communication facilities, and other surveillance systems." 14 CFR 77.31 also requires that the FAA identify "the extent of the physical and/or electromagnetic effect on the operation of existing or proposed air navigation facilities, communication aids, or surveillance systems."

The FCC 47 C.F.R. 1.1310 is based on the 1992 version of the American National Standards Institute/Institute of Electrical and Electronics Engineers C95.1 safety standard.[13] **Table D.11-2** shows Maximum Permissible Exposures contained in the American National Standards Institute/Institute of Electrical and Electronics Engineers C95.1 and FCC standards at frequencies of 450, 900 and 5,000 MHz, which covers the range of frequencies that may be used by SCMAGLEV radio systems. FCC Maximum Permissible Exposures are based on an average time of 30 minutes for exposure of the general public and 30 minutes for occupational exposure. As shown in **Table D.11-2**,

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[9] FCC Office of Engineering and Technology Bulletin 65, "*Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields,"* Edition 97-01, August, 1999, available at https://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf.

[10] IEEE C95.1-2005, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," April 19, 2006.

[11] OSHA, Occupational and Environmental control: Non-Ionizing Radiation, 29 C.F.R. 1910.97, 2013, https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9745.

[12] U.S. Department of Transportation, Federal Aviation Administration, AC 20-190, "Aircraft Electromagnetic Compatibility Certification," June 1, 2018.

[13] IEEE C95.1-2005, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," April 19, 2006.

the differences between the American National Standards Institute/Institute of Electrical and Electronics Engineers C95.1 and FCC MPEs are negligible.[14]

Table D.11-2: Radio Frequency Emission Safety Levels Expressed as Maximum Permissible Exposures

Frequency	ANSI/IEEE C95.1 MPE (mW/cm²)		FCC MPE (mW/cm²)		OSHA MPE (mW/cm²)	
	General Public	Occupational	General Public	Occupational	General Public	Occupational
450 MHz	0.225	1.5	1.5	0.3	NA	10
900 MHz	0.45	3.0	3.0	0.6	NA	10
5,000 MHz	1.0	10	5.0	1.0	NA	10

Source: IEEE, 2002; FCC, 2010; OSHA, 2010
Notes: ANSI/IEEE = American National Standards Institute/Institute of Electrical and Electronics Engineers
FCC = Federal Communications Commission
mW/cm2 = milliwatts per square centimeter
MPE = Maximum Permissible Exposure
MHz = Megahertz
OSHA = Occupational Safety and Health Administration

D.11.1.2.2 Regional and Local

EMF ordinances exist within the County of Baltimore. Articles 2 § 210.2(C) and 210.5(A)[15] state that no property use within a Service Employment zone may create a nuisance to other properties outside the zone, including in the form of electromagnetic disturbances.

The Council of the District of Columbia has issued a "Moratorium on the Construction of Certain Telecommunications Towers…," which mentions that inconclusive health effects are associated with EMF exposure.[16] The Council established the "Comprehensive Plan Amendment Act of 2006," which included a "prudent avoidance" policy regarding EMFs.[17] The policy states that equipment that could generate EMFs should be designed "to mitigate involuntary public exposure to potential adverse effects."

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[14] FCC Office of Engineering & Technology, "Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields," OET Bulletin 56, 4th Edition, August 1999.

[15] Baltimore County Government, Code of Ordinances, Available at https://library.municode.com/md/baltimore_county/codes/code_of_ordinances.

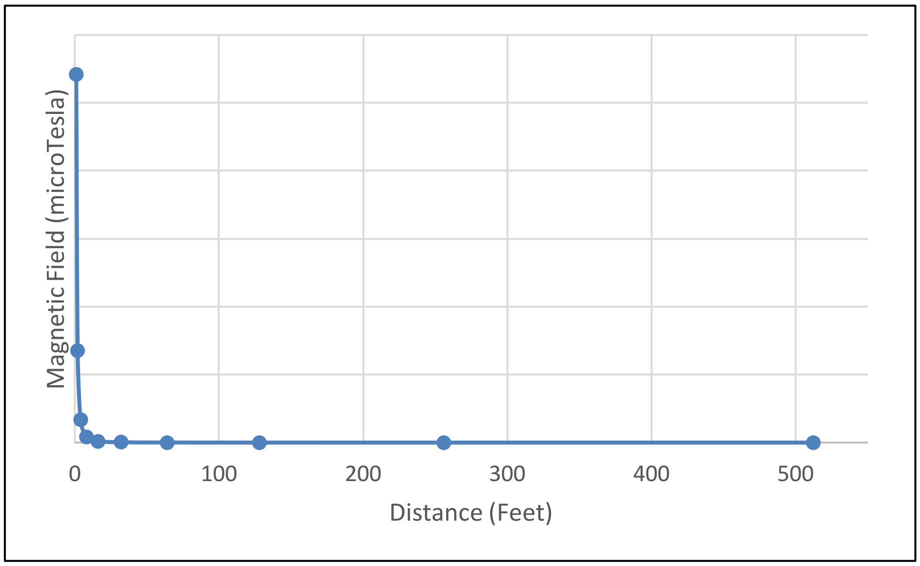
[16] Council of the District of Columbia, Moratorium on the Construction of Certain Telecommunications Towers Temporary Amendment Act of 2000, Available at https://code.dccouncil.us/dc/council/laws/docs/13-218.pdf.

[17] Council of the District of Columbia, Comprehensive Plan Amendment Act of 2006, Section E-4.7, p. 172. Available at https://code.dccouncil.us/dc/council/laws/docs/16-300.pdf.

D.11.1.3 EMF and Distance

The inverse square law applies to EMF. The inverse-square law means that EMF levels would substantially decrease with increased distance from the source. Therefore, for the purposes of this analysis, the EMF Study Area is defined as 500 feet from the centerline of the SCMAGLEV track, unless potential sensitive receptors outside of this area expressed concerns based on sensitive electromagnetic equipment. Beyond the 500-foot distance, the EMF would be below background levels. Assuming a worst-case magnetic field of 2,710 μT, which is the Institute of Electrical and Electronics Engineers occupational exposure limit, the magnetic field would drop off following the inverse-square law to below 1 μT within 60 feet, as illustrated in **Figure D.11-2.**

Figure D.11-2: Magnetic field strength as a function of distance



Source: AECOM 2016

Maps, surveys, photographs and databases were reviewed to identify sensitive receptors within the EMF Study Area that could be susceptible to EMFs produced by the Build Alternatives. Sensitive receptors include universities, medical institutions, high-tech businesses, airports and governmental facilities (i.e., police and fire) that may use equipment that could be affected by new sources of EMFs. For completeness, the review of potentially impacted sensitive receptors was expanded to include schools, which may have wireless networks for tablets and laptops. EMF calculations on the SCMAGLEV Project were not completed as part of this analysis.

D.11.1.4 EMF Guidance Documents

A variety of organizations have published recommendations for EMFs. These recommendations are not regulations but are frequently cited by organizations as a means of demonstrating low EMF levels. For example, published reports state that the

L0 Series train complies with the International Commission on Non-Ionizing Radiation Protection EMF exposure levels for the general public.[18]

The International Commission on Non-Ionizing Radiation Protection has adopted EMF exposure guidelines and standards in the extremely low frequency and radiofrequency bands of the EM spectrum. The International Commission on Non-Ionizing Radiation Protection standards address EMF exposure by the general public and workers in an occupational setting, and are widely used within the U.S. and abroad. The International Commission on Non-Ionizing Radiation Protection recommendations are based on the epidemiological data available from verifiable research studies.[19] Based on the International Commission on Non-Ionizing Radiation Protection's work, the European Union has adopted these same standards for EMF exposure.[20] **Table D.11-3** summarizes these standards. While the guidelines are voluntary, the levels are designed to prevent potential health risks associated with EMF exposure.

Table D.11-3: International Commission on Non-Ionizing Radiation Protection Electric Field Exposure Limits

Frequency	Electric Field Strength (V/m)		Magnetic Field (μT)	
	Public	Occupational	Public	Occupational
1-8 Hz	5,000	20,000	$40{,}000/f^2$*	$20{,}000/f^2$**
60 Hz	5,000	10,000	200 (2,000 mG)	100 (1,000 mG)

Notes: f = frequency (in Hz); Hz = Hertz, V/ = volts per meter, μT = microTesla
*For 6 Hz, the public Magnetic Field limit would be 1,111 μT.
**For 6 Hz, the occupational Magnetic Field limit would be 5,555 μT.

The Institute of Electrical and Electronics Engineers Standard C95.6, Institute of Electrical and Electronics Engineers *Standard for Safety Levels With Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz*, is often referenced within the U.S. and has been formally adopted by the American National Standards Institute. The Institute of Electrical and Electronics Engineers standard specifies Maximum Potential Exposures for the general public and for occupational exposure to extremely low frequency EMFs, which have frequencies of 0 to 3 kHz. **Tables D.11-4** and **D.11-5** present Institute of Electrical and Electronics Engineers Standard C95.6 exposure

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[18] Ohsaki, H. "Review and Update on Maglev." European Cryogenics Days 2017, Karlsruhe, Germany, Sept. 13, 2017. Available at https://publikationen.bibliothek.kit.edu/1000075557/4402937.

[19] International Commission on Non-Ionizing Radiation Protection (ICNIRP), "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields," *ICNIRP Guidelines, Health Physics Society*, April 1998, 74(4), p494-522.

[20] Council Recommendation (1999/519/EC), "On the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)," *Official Journal of the European Communities*, July 12, 1999.

levels, with the 60 Hz levels highlighted for comparison.[21] Note that the Institute of Electrical and Electronics Engineers exposure levels are guidelines only, not regulations.

Table D.11-4: IEEE C95.6 Magnetic Field Maximum Potential Exposure Levels for the General Public

Body Part	Frequency Range (Hz)	Magnetic-Field (mG)
Head and Torso	0.153 – 20	181/f
	20 – 759	9,040
	759 – 3,000	6,870,000/f
	60	9,040 (904 μT)
Arms or Legs	< 10.7	3,530,000
	10.7 – 3,000	37,900,000/f
	60	632,000 (63,200 μT)

Source: IEEE, 2002
Notes: /f = divide by the frequency; Hz = Hertz, IEEE = Institute of Electrical and Electronics Engineers; mG = milligauss; μT = microTesla

Table D.11-5: IEEE C95.6 Magnetic Field Maximum Potential Exposure Levels for the General Public

Body Part	Frequency Range (Hz)	Electric Field (V/m)
Whole Body	1 – 368	5,000
	368 – 3,000	$1.84 \times 10^6/f$
	60	5,000

Source: IEEE, 2002
Notes: /f = divide by the frequency; Hz = Hertz; IEEE = Institute of Electrical and Electronics Engineers; MPE = maximum permissible exposure; V/m = volts per meter

In 2006, the American National Standards Institute adopted Institute of Electrical and Electronics Engineers Standard C95.1, as its standard for safe human exposure to EMF in the radio frequency portion of the EM spectrum.[22] The SCMAGLEV control and communications systems would use radio signals within the range covered by this standard. The C95.1 Standard specifies Maximum Potential Exposure levels for whole and partial body exposure to electromagnetic energy.

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22 IEEE C95.1-2005, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," April 19, 2006.

Both the Institute of Electrical and Electronics Engineers C95.6 and C95.1 standards specify safety levels for occupational and general public exposure. For each, the exposure levels are frequency dependent. The general public exposure safety levels are stricter because workers are assumed to have knowledge of occupational risks and are better equipped to protect themselves (e.g., through use of personal safety equipment). The general public safety levels are intended to protect all members of the public, including pregnant women, infants, the unborn and the infirm, from short-term and long-term exposure to EMFs. The safety levels are set at 10 to 50 times below the levels at which scientific research shows harmful health effects may occur, thus incorporating a large safety factor.[23]

The American Conference of Governmental Industrial Hygienists recommends that occupational EMF exposure levels should not exceed 10 Gauss (10,000 mG or 1 μT). The American Conference of Governmental Industrial Hygienists also recommends that workers with pacemakers should not exceed 1 Gauss (1,000 mG or 0.1 μT). The American Conference of Governmental Industrial Hygienists guidelines are for occupational exposure only. Note that occupational EMF exposure is reasonably anticipated exposure to EMFs that may result from performance of an employee's duties.

D.11.1.5 EMF and Maglev

D.11.1.5.1 Background

Magnetic levitation (maglev) trains are used in other countries, where studies have been performed on the amount of EMFs that human beings are subjected to. Superconducting maglev trains have been implemented in Japan and reportedly exhibit EMF levels below ICNIRP limits.[24] **Table D.11-6** summarizes the published reports of EMF levels associated with maglev trains around the world. The ICNIRP guidance level and the IEEE regulatory level are provided in the table for context. All reported values are lower than the Institute of Electrical and Electronics Engineers standards.

All forms of transportation are associated with EMF exposure. **Table D.11-7** compares the EMF expected in the extremely low frequency range from various modes of transport.

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[23] IEEE C95.1-2005, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," April 19, 2006..

[24] Ohsaki, H. "Review and Update on Maglev." European Cryogenics Days 2017, Karlsruhe, Germany, Sept. 13, 2017. Available at https://publikationen.bibliothek.kit.edu/1000075557/4402937.

Table D.11-6: Reported EMFs Associated with Maglev Trains

Source	Magnetic Field mG	Notes	Reference
IEEE Public Standard (U.S.)	9,040	Regulatory limit	IEEE, 2002
ICNIRP Public Limit (Europe)	2,000	Guideline	ICNIRP, 1998
Transrapid Maglev System, Shanghai, China	981	In car	ICNIRP, 2008[25]
Japanese Yamanashi SCMaglev	2,680 0.9	7.5 meters from the train In car	ICNIRP, 2008[24] Fukuta, 2005[26]
German Maglev TR07	200 1,000	On platform In car	Halgamuge, 2010[27]
German Maglev TR08	1,000 34	On floor of train In car	Brecher, 2002[28] DEIS, 2003[29]
Chuo Shinkasen	122	From magnets	Nishijima[30]

Table D.11-7: ELF EMF Associated with Transportation

Transport Type	Magnetic Field (mG)
Moving Walkway	4
Cars and Light Trucks	6
Airplane	14
Electric Shuttle Tram	14
Conventional Bus	17
Electric Commuter Train	50
Maglev TR08	34

Source: Baltimore-Washington DEIS, Chapter 3, page 3-391, Table 3.106.

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25 ICNIRP, "ICNIRP Statement on EMF-Emitting New Technologies," Health Physics, 94(4), p 376-392, April 2008. Available at https://journals.lww.com/health-physics/Fulltext/2008/04000/ICNIRP_STATEMENT_ON_EMF_EMITTING_NEW_TECHNOLOGIES.11.aspx

26 Fukuta, M. et. al. "Influence of electromagnetic interference on implanted cardiac arrhythmia devices in and around a magnetically levitated linear motor car." 2005. Available at https://slideheaven.com/influence-of-electromagnetic-interference-on-implanted-cardiac-arrhythmia-device.html.

27 Halgamuge, M.; Abeyrathne, C. D.; Mendis, P., "Measurement and Analysis of Electromagnetic Fields from Trams, Trains and Hybrid Cars," *Radiation Protection Dosimetry*, 2010, Vol. 141 Issue 3, p. 255-268.

28 Brecher, A. et. al. "Electromagnetic Field characteristics of the Transrapid TR08 Maglev System." 2002. Available at http://www.fra.dot.gov/Elib/Document/1179.

29 Baltimore-Washington DEIS, Chapter 3, page 3-391, Table 3.108.

30 Nishijima, S., et. al. "Superconductivy and the Environment: A Roadmap." Superconductor Science and Technology, 26(11):113001, September 2013. Available at https://www.researchgate.net/figure/Superconducting-Maglev_fig5_258289351.

A series of EMF studies was conducted on the Chuo-Shinkasen superconducting magnetic levitation train within Japan in 2015. The study both calculated EMF levels and measured actual EMF levels relative to the operating train. **Table D.11-8** summarizes the results of these studies and compares the values to the IEEE and ICNIRP values.

Table D.11-8: Reported Magnetic Field Values for Chuo-Shinkasen SCMAGLEV Train

Description	Magnetic Field (mG)
IEEE Public Standard (U.S.) - Regulatory	9,040
ICNIRP Public Limit (Europe) - Guideline	2,000
On a platform: 20 feet from train, horizontally	1,900
At ground level, from a train on a viaduct (6.7 feet from the train horizontally, 26 feet from the train vertically)	200

Source: Final environmental impact statement, Chuo-Shinkasen SCMagLev Project, August 2014, Kanagawa, Japan. Available from https://company.jr-central.co.jp/chuoshinkansen/assessment/document1408/kanagawa/
Notes: mG = milliGauss

The Central Japan Railway Company (JR) states, "The magnetic field generated by the Superconducting Maglev has no impact on health, as it is controlled with various measures to keep it below the standards established in international guidelines (ICNIRP Guidelines). The standards are set at approx. 1/5 to 1/10 the level that could affect the human body."[31]

D.11.1.5.2 EMF Comparison

EMFs are emitted from natural and man-made sources. Natural sources include the earth, the sun, and the ionosphere. The earth has a natural magnetic field to which human beings are constantly exposed. In Washington DC and the surrounding area, for example, the total magnetic field is approximately 51 μT (0.51 Gauss or 470 mG).[32]

EMFs are also generated by man-made sources. **Table D.11-9** compares some common sources of EMF. Note that a similar Maglev system, built by the same company, was used in **Table D.11-8** for comparison, as detailed information on the L0 model is not readily available. However, values for the TR08 and L0 are expected to be similar. Man-made sources within the Study Area include telecommunication transmitters that broadcast over a large area, electrical substations, AM and FM radio stations, time signal transmitters, maritime and land mobile radio transmitters, air-to-

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[31] Central Japan Railway Company website, SCMagLev project, https://scmaglev.jr-central-global.com/about/magnetic/

[32] National Geophysical Data Center (NGDC), "Estimated Values of Magnetic Field Properties," http://www.ngdc.noaa.gov/geomag-web/#igrfgrid, 2018.

ground transceivers, cellular telephone antennas and television station transmission antennas.

Table D.11-9: Man-Made Sources of EMF

.	Distance (ft)	Magnetic Field (mG)
Microwave oven	1	40-80
Electric Range	0.1 (1 inch)	60-2,000
Hair Dryer	0.1 (1 inch)	60-20,000
Television	1	0.1-2
Maglev (TR08) Passenger Compartment	Waist Level	30 (avg) – 150 (max)
Maglev (TR08) Guideway	Under or at 16.4	10-120
Maglev (TR08) Power Equipment	Less than 16.4	4-20

Source: Baltimore-Washington DEIS, Chapter 3, page 3-391, Table 3.107.

D.11.1.5.3 Frequency Ranges

Information on the L0 indicates that superconducting magnets will be located along the track as well as on board. The magnets will not be active all of the time, but rather will be turned on as the train approaches to propel the train forward. For example, a 16-car SCMaglev train would be comprised of 34 total superconducting magnets and 136 superconducting coils. The magnets use Bi2223 superconducting wires, each with a maximum flux density of 5.2 T.[33]

The train will use different frequencies for different aspects during use. **Table D.11-10** summarizes the types of EMF that the train is expected to use.

Table D.11-10: SCMAGLEV Frequency

Frequency	EMF Region	Use	Notes
6 Hz	Extremely Low Frequency	Train Propulsion	EMF only present when train passing.
60 Hz	Super Low Frequency	Power supply source	In use at VMFs to power equipment. In use on trains to power electronic devices.
300-3,000 MHz	Ultra-High Frequency	GPS, communication	EMF possibly present only when train passing.

[33] Ohsake, H. “Review and Update on MAGLEV.” European Cryogenics Days 2017, Karlsruhe, Germany, Sept. 13, 2017.

D.11.1.6 Environmental Consequences

D.11.1.6.1 No Build Alternative

Under the No Build Alternative, the SCMAGLEV Project would not be constructed or operated; therefore, ambient EMF conditions would remain the same as existing conditions. Sensitive receptors would not be subject to potential EMF or EMI from the construction or implementation of the SCMAGLEV Project.

D.11.1.6.2 Build Alternatives

Construction Impacts

Construction of the Build Alternatives would be limited to within the LOD. These areas would be periodically subjected to increased EMF during the use of electric and electronic construction equipment, such as two-way communication radios and power equipment. This standard equipment is regulated by the FCC and associated EMFs would be within the FCC regulatory limits. Typical construction equipment would not interfere with the operation of other nearby electric and electronic equipment; therefore, the impacts from construction activities of the Build Alternatives would not be significant.

Operational Impacts

During operation, the Build Alternatives would generate EMF/EMI between 1 and 10 Hz caused by the propulsion magnets, 60 Hz and harmonics for power, and radiofrequencies for SCMAGLEV signaling and communication equipment. EMF exposure levels within and outside the existing L0 MagLev trainsets are reported by Shinkansen to be below International Commission on Non-Ionizing Radiation Protection guidelines;[34] therefore, passengers on the train, passengers waiting at the platform, or people beyond the external security fencing of the SCMAGLEV ROW, such as passers-by, would not be exposed to EMF levels above the International Commission on Non-Ionizing Radiation Protection guidelines. Additionally, SCMAGLEV equipment would comply with FCC requirements and not adversely interfere with other electric or electronic equipment.

No sensitive receptors within the 500-foot study area were identified that may be impacted from EMI. Depending on the type and location of equipment housed within the NSA, Ft. Meade, the NASA Goddard Space Center, or the Rowley Training Center, the facilities may be impacted by operation of the L0 MagLev system.

Radio and Television Interference

No impact would be expected, as the SCMAGLEV project would operate on different frequency bands. The FCC allocates different bands of the electromagnetic spectrum

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[34] Central Japan Railway Company, "Environmental Report. 2010," *Global Environmental Committee*, http://jr-central.co.jp.

for different uses: cellular phones, radio control equipment and other communication devices have dedicated bands so that EMI cannot occur.

Induced Currents and Shock Hazards

The generation of EMF from the SCMAGLEV Project could result in induced currents in nearby metal structures. These currents could lead to shock hazards to humans and animals if the metal is ungrounded and touched. These induced currents and shock hazards can be minimized by grounding all metallic structures. Therefore, all metal equipment surrounding the SCMAGLEV (i.e., metal fencing) would be grounded to minimize induced currents and shock hazards and maintained to prevent corrosion.

Cardiac pacemakers

The electric fields associated with the SCMAGLEV may be of sufficient magnitude to impact operation of a few older-model pacemakers; in such cases, the older-model pacemakers may revert to an asynchronous pacing while in the presence of the SCMAGLEV Project. Cardiovascular specialists do not consider prolonged asynchronous pacing to be a problem. Cardiovascular specialists commonly use asynchronous pacing to check pacemaker operation; therefore, while the SCMAGLEV project's electric field may impact operation of some older-model pace-makers while in the presence of the SCMAGLEV, the result of the interference would be of short duration and not considered harmful. Pacemakers revert to their normal mode of operation once out of the immediate area of the SCMAGLEV Project.

Unlike high voltage transmission lines, EMF exposure from the SCMAGLEV project would not be constant. EMF exposure would only occur as the train passes by. Additionally, the exposure level would be lower than a high-voltage transmission line, as the Shinkansen website states that the train reportedly complies with the International Commission on Non-Ionizing Radiation Protection standards. As previously stated, The EMF inside the train and along the tracks is approximately one third of the International Commission on Non-Ionizing Radiation Protection guidelines and is safe for persons with medical pacemakers.

D.11.1.7 Avoidance, Minimization and Mitigation

Project design features, such as high-performance magnetic shields on the trainsets, would be implemented to avoid and minimize impacts to the social and physical environment. The following Compliance Measures (CM) for EMF would be required for the Build Alternatives.

EMF-CM#1: Fencing and Metal Grounding. As part of the general operation and maintenance of the SCMAGLEV, the external fencing and any other grounded metallic objects would be routinely inspected and replaced as necessary. This would avoid or minimize any corrosion. If, for example, the external metal fencing corrodes, it would no longer be effectively grounded and electric shock could become an issue of concern for people or animals.