California High-Speed Train Project

TECHNICAL MEMORANDUM

Measurement Procedure for Assessment of CHSTP Aligment EMI Footprint
TM 3.4.11

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0	03 Mar 10	Initial Release

Note: Signatures apply for the latest technical memorandum revision as noted above.

Prepared by PB

for the California High-Speed Rail Authority

System Level Technical and Integration Reviews

The purpose of the review is to ensure:
- Technical consistency and appropriateness
- Check for integration issues and conflicts

System level reviews are required for all technical memorandums. Technical Leads for each subsystem are responsible for completing the reviews in a timely manner and identifying appropriate senior staff to perform the review. Exemption to the system level technical and integration review by any subsystem must be approved by the Engineering Manager.

System Level Technical Reviews by Subsystem:

Systems: NOT REQUIRED ______________________
Print Name: Date

Infrastructure: NOT REQUIRED ______________________
Print Name: Date

Operations: NOT REQUIRED ______________________
Print Name: Date

Maintenance: NOT REQUIRED ______________________
Print Name: Date

Rolling Stock: NOT REQUIRED ______________________
Print Name: Date

Note: Signatures apply for the technical memorandum revision corresponding to revision number in header and as noted on cover

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ABSTRACT

The California High-Speed Train Project (CHSTP) established the electromagnetic compatibility (EMC) requirement that the CHSTP equipment and facilities must be electromagnetically compatible with themselves, with equipment used on and near CHSTP trains by staff and passengers, and with the equipment and facilities of the neighbors of the CHSTP line. CHSTP equipment and facilities must work with and not interfere with neighbor equipment and facilities, or the CHST project must provide mitigations which control interference with neighbor equipment and facilities to acceptable levels.

CHSTP Section designers need EMC information to prepare the Section impact assessments for the CHST project Environmental Impact Report/Impact Statement (EIR/EIS). For environmental - specific EMC information, the Section Designers must perform Radiated Electric and Magnetic Field measurements for each Section. This Measurement Procedure for Assessment of CHSTP Alignment EMI Footprint (MPE) guides Section Designers so they can identify sensitive equipment and/or medical or research activities that would be affected by the system EMF and measure the back ground levels at these locations. In addition, representative measurements should be taken at locations where EMF generators are present that could affect the CHST systems.

Each Regional Consultant should:

- Prepare a Section-Level Measurement Protocol For EIR/EIS Assessment Of CHST Alignment EMI Footprint (S-MPE) consistent with the MPE.
- Perform the section-level measurements and data collection.
- Provide a report with information needed for the section EIR/EIS and for the project.

The measurement procedures provided in this MPE cover ambient radiated electric and magnetic fields.

1.0 INTRODUCTION

The California High-Speed Train (CHST) will serve the major metropolitan centers of the state, over 800 miles of dedicated high-speed rail track. The route will be at-grade, in open trenches, in tunnels, and on elevated guideways. The CHSTP trains will use electrically powered steel-wheel-on-steel-rail trains operating at up to 220 mph on a fully grade-separated alignment with no highway or street crossings.

The CHST project established the electromagnetic compatibility (EMC) requirement that the CHST equipment and facilities must be electromagnetically compatible with themselves, with equipment used on and near CHSTP trains by staff and passengers, and with the equipment and facilities of the neighbors of the CHSTP line. CHST equipment and facilities must work with and not interfere with neighbor equipment and facilities, or the CHST project must provide mitigations which control interference with neighbor equipment and facilities to acceptable levels.

The CHSTP Project Management Team is responsible for the project-level EMC program. Each CHSTP Section Design team is responsible for EMC engineering for the respective Section.

Project-wide EMC design requirements are provided in the EMC Technical Memorandum 3.4.10, June 2008.

CHSTP Section designers need EMC information to prepare the Section impact assessments for the CHST project Environmental Impact Report/Impact Statement (EIR/EIS). For environmental - specific EMC information, the Section Designers must perform Radiated Electric and Magnetic Field measurements for each Section. This Measurement Procedure For EIR/EIS Assessment Of CHSTP Alignment EMI Footprint (MPE) guides Section Designers so they can identify sensitive equipment and/or medical or research activities that would be affected by the system EMF and measure the back ground levels at these locations. In addition, representative measurements should be taken at locations where EMF generators are present that could affect the HST systems.

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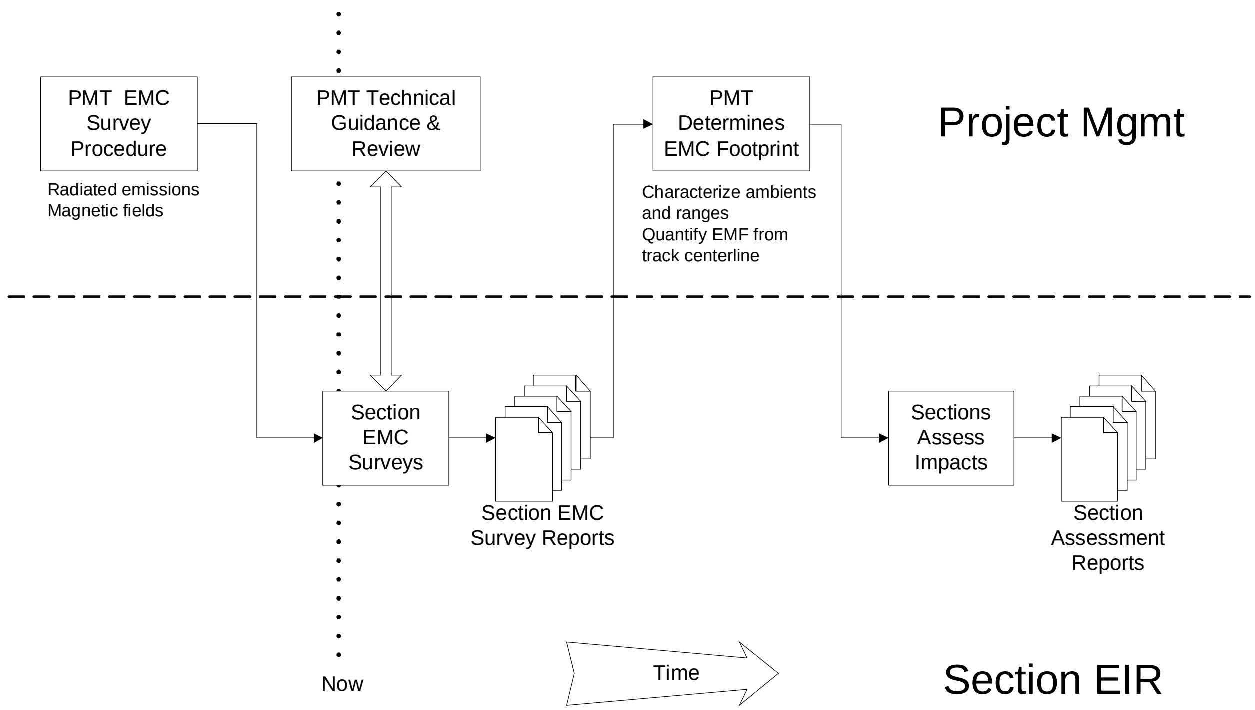
1.1 PROJECT PHASES

Figure 1-1 shows the near-term Project and Section EMC activities.

Figure 1-1
CaHST Near-Term EMC Activities



Next Phase EMC tasks are:

- Task 1: Collect Section EMC data
- Task 2: Determine the areas of EMC influence in each Section.

Task 1 steps to collect Section EMC data are:

- Task 1.1: The CHST Project Management Team (PMT) develops the EMC survey procedure (this MPE)
- Task 1.2: Each Section develops an EMI Footprint Measurement Procedure (S-MPE). Select the Section EMI measurement sites
- Task 1.3: Each section performs the Section EMI measurements. Establish the baseline electromagnetic ambient and identify worst-case wayside emitters and susceptibility victims. Provide a report.

Task 2 steps to determine the areas of EMC influence are:

- Task 2.1: The PMT uses the Section survey data, performs analysis, and develops the project-wide CHSTP EMC footprint - expected emission impact vs. distance from track centerline, vs. frequency.

- Task 2.2: Each Regional Consultant applies the 'footprint' to Section alignments to assess the potential impact of the CHSTP EMC footprint on neighbors and develops the Section EMC Impact Assessment Reports.

1.2 STATEMENT OF TECHNICAL ISSUE

The objective of the EMC program is to ensure that the completed CHST system fulfils the project EMC requirement, so that CHST electromagnetic interference (EMI) does not adversely affect:

- The safety or dependability of the CHST system
- The health of passengers, staff, and neighbors
- The safety or dependability of neighboring equipment and facilities

In addition, the CHST and its systems must work dependably in the electromagnetic environment in which it operates.

To achieve electromagnetic compatibility for the CHST system, the project management consultant team, the system designers, and later, the construction contractors and system and equipment providers, will establish and execute an EMC program which will continue through each project phase from Preliminary Engineering through Operations. The EMC program will provide design criteria and requirements for use by the design team, establish procurement requirements for the project, and ensure completion of tests by the contractor to demonstrate that the requirements are fulfilled.

This Measurement Procedure for Assessment of CHSTP Alignment EMI Footprint Technical Memorandum provides guidance to Section designers for measurement of ambient pre-construction radiated electric and magnetic fields. These measurements are necessary for development of a system-wide EMI footprint and for assessment of EMC impacts.

1.3 GENERAL INFORMATION

1.3.1 Definition of Terms

The following technical terms, acronyms, and abbreviations are used in this document.

A	Amperes
AC	alternating current
APTA	American Public Transportation Association
NASI	American National Standards Institute
APTA	American Public Transportation Association
CHST	California High-Speed Train
CBTC	Communications based train control
CENELEC	European Committee for Electrotechnical Standardization
CHSRA	California High-Speed Rail Authority
CHSTP	California High-Speed Train Project
CMRR	Common Mode Rejection Ratio
COTS	Commercial off the shelf equipment
CRT	Cathode Ray Tube
CSTP	UMTA Conducted Suggested Test Procedures
dB	Decibel
dBuV/m/MH	Decibel Microvolts per Meter per Megahertz
DC	direct current
DOD	Department of Defense
EIA	Electronic Industries Alliance
EIR/EIS	Environmental Impact Report/Statement
EMC	Electromagnetic compatibility
EMCP	EMC Program Plan
EMI	Electromagnetic interference
EMU	Electric multiple unit
EN	Euronorm - European Committee for Electrotechnical Standardization
f	frequency
FFT	Fast Fourier Transform
FTA	U.S. Department of Transportation Federal Transit Administration (FTA) (formerly Urban Mass Transit Administration or UMTA)
GHz	gigahertz
hp	horsepower
HVAC	Heating, ventilation, and air conditioning
Hz	Hertz
IG	Isolated ground

ISM	Industrial, scientific and medical device frequency band
ISTP	UMTA Inductive Suggested Test Procedures
FCC	Federal Communications Commission
FTA	U.S. Department of Transportation Federal Transit Administration (FTA) (formerly Urban Mass Transit Administration or UMTA)
IEEE	Institute of Electrical and Electronic Engineers
kHz	Kilohertz
kV	Kilovolts
LCD	Liquid Crystal Display
m	Meter
mG	Milligauss
MHz	Megahertz
MPE	maximum permissible exposure
MPE (Assessment)	Measurement Procedure For EIR/EIS Assessment Of CHST Alignment EMI Footprint
mph	miles per hour
mT	Millitesla
NEC	National Electrical Code
NFPA	National Fire Protection Association
NTP	Notice to Proceed
OET	Office of Engineering and Technology
PMT	Project Management Team
RF	radio frequency
rms	root mean square
ROW	Right of Way
RSTP	UMTA Radiated Suggested Test Procedures
S-MPE	Section EMI Footprint Measurement Protocol
SCADA	Supervisory control and data acquisition
VA	Volt-amperes
VAC	Volts alternating current
SRS	Signal reference structure ground
STP	Suggested Test Procedure
TIA	Telecommunications Industry Association
UMTA	Urban Mass Transit Administration (now Federal Transit Administration)
UL	Underwriters Laboratories
UPS	Uninterruptible Power Supply
US	United States
V	Volts
VVVF	Variable Voltage Variable Frequency

1.3.2 Units

This document uses U.S. Customary Units, except where technical practice requires use of specialized units.

The California High-Speed Train Project is based on U.S. Customary Units consistent with guidelines prepared by the California Department of Transportation and defined by the National Institute of Standards and Technology (NIST). U.S. Customary Units are officially used in the United States, and are also known in the US as “English” or “Imperial” units. In order to avoid any confusion, all formal references to units of measure should be made in terms of U.S. Customary Units.

2.0 DEFINITION OF TECHNICAL TOPIC

The CHST project established the EMC requirement that the CHST equipment and facilities must be electromagnetically compatible with themselves, with equipment used on and near CHSTP trains by staff and passengers, and with the equipment and facilities of the neighbors of the CHST line. CHST equipment and facilities must work with and not interfere with neighbor equipment and facilities, or the CHST project must provide mitigations which control interference with neighbor equipment and facilities to acceptable levels.

2.1 GENERAL

To achieve the EMC requirement stated above, the CHST project must establish and implement an EMC program that is integrated with the equipment and facility design, procurement, construction, integration, test, commissioning, and operation and maintenance activities which will take place over the life of the project.

The general approach to achieving EMC for the CHST project is:

Establish EMC design criteria. Refer to Technical Memorandum 3.4.10.

Establish and implement an EMC Program Plan (EMCP) at each major phase of the project. The EMCP will specify the activities and deliverables of managers, designers, suppliers, contractors, testers, and maintainers and operators of CHST equipment and facilities. These phases will include, at least, Design, Construction and Procurement, Fabrication and Construction, Test and Integration, and Operations and Maintenance.

The EMCP will incorporate the EMC design criteria identified in Technical Memorandum 3.4.10. It is critical that the procurement contracts for equipment and construction include design specifications which fully integrate and apply these design criteria. The EMC design criteria must specify measures and standards to achieve EMC which are practical, effective, and cost effective.

As the alignment is finalized, the CHST project must determine locations near the alignment where sensitive electronic equipment may be disturbed by CHST operations. Sensitive equipment may include university or industrial research equipment such as for low magnetic field measurements, or special medical equipment. If there are neighbors whose equipment could be disturbed by CHST operations, the EMC program must identify mitigation measures which can be applied to the CHST or to the neighbor equipment or both. This Measurement Procedure for Assessment of CHSTP Alignment EMI Footprint guides the Section Designer task to measure the ambient pre-construction radiated electric and magnetic fields.

In each phase, a CHSTP EMC engineer will have overall responsibility to monitor the EMC activities of all affected participants, and report on the status and accomplishment level of the EMC program.

At the end of the Test and Integration phase, the completed activities of the EMC program will permit the CHSTP EMC engineer to document that the CHSTP has achieved the EMC requirements in section 2.0 above.

2.1.1 CHSTP Design Considerations

The CHSTP will run high-powered electric trains powered from a 25 kV AC traction power system. The CHSTP trains, train control system, communications systems, traction power system, and station equipment will include a broad array of sophisticated special purpose and general purpose electronic equipment, including equipment with safety-critical functions.

To achieve EMC between trains, CHST equipment, and neighbor equipment, CHST equipment and facilities must incorporate three key sets of provisions:

- All electrical and electronic equipment must conform to a compatible set of criteria which specify electrical and magnetic emissions and immunity. These criteria must of course include applicable laws and regulations such as the FCC Part 15 regulations for intentional and non-intentional radiating devices.
- All electrical and electronic equipment must incorporate EMC design provisions which have been proven effective in similar high-speed electrically powered rail applications.
- For equipment with particular EMC requirements such as train control track circuits or radio communications, the affected equipment on both sides of an interface must implement specific protective provisions and protocols.

The radiated electric and magnetic field measurement procedures provided in section 6 of this Technical Memorandum provide the technical basis for establishing the EMI Footprint for the CHST project.

2.1.2 CHSTP Design Parameters

Key CHSTP EMC design parameters are:

- Evaluation and selection of the standard for limiting human exposure to electric and magnetic fields, both for passengers and for workers.
- Determination of sensitive equipment near the final alignment, and therefore whether any mitigating measures are required.
- Evaluation and selection of the type of train control system, particularly considering track circuits and train-to-wayside communication media.
- Evaluation and selection of a specific standardized set of equipment immunity and emission limits and test methods.
- Determination of the procedure to ensure EMC with commercial off-the-shelf (COTS) equipment. COTS equipment is often available with only limited information about the extent to which it satisfies project-wide EMC criteria.

The CHST project will investigate design alternatives which set or affect these design parameters in the next phases of the project. The decisions made during those design investigations will be monitored by and incorporated into the activities and results of the EMC program.

3.0 ASSESSMENT / ANALYSIS

3.1 GENERAL

The approach used to develop the CHSTP Measurement Procedure for Assessment of CHST Alignment EMI Footprint (MPE) in section 6 consisted of the following steps and considerations:

- Evaluate the CHSTP Basis of Design and other foundation documents.
- Survey and investigate EMC techniques used in other high-speed and high power electric train systems, including for trains, train control, traction power, communications, and station equipment.
- Assess specific technical provisions of potentially applicable laws, regulations, standards, specifications, and guidelines, including those listed in section 5.1.
- Consider overall project plan, construction and procurement plan, and timeline.
- Incorporate provisions as needed to comply with applicable laws and regulations.
- Develop a preliminary EMI footprint measurement procedure, and provide it to the project for review.
- Incorporate feedback from the project and develop this Technical Memorandum.

The results of these steps and considerations are the section 6 MPE.

3.2 ASSESSMENT

Assessments related to this MPE follow:

- Section EMI Footprint Measurement Procedures: Each Regional Consultant is responsible to create a Section-specific EMI Footprint Measurement Procedure (S-MPE) which conforms to this MPE, and which selects specific sites likely to find the highest and lowest ambient conditions in urban, suburban, and rural portions of the section. The MPE describes measurement site selection criteria which will guide the assessment to be performed by the Regional Consultant.

- The MPE provides a radiated electric field measurement method, which lists the test equipment, setup, measurement steps, and conditions for radiated electric field measurements. The assessment performed to develop this MPE considered the frequency range over which to measure ambient, the measurement units to be used, the type of equipment to be used and the data to be recorded, the placement and orientation of antennas with respect to the likely track centerline. The assessment considered typical standards used to characterize ambient and rail-generated fields, and the intended uses for the data.

- The MPE provides a magnetic field measurement method, which lists the test equipment, setup, measurement steps, and conditions for magnetic field measurements. The assessment performed to develop this MPE considered the frequency range over which to measure ambient, the measurement units to be used, the type of equipment to be used and the data to be recorded, the placement of the magnetic field sensor with respect to the likely track centerline. The assessment considered typical standards used to characterize ambient and rail-generated fields, and the intended uses for the data. The assessment noted that perturbations to the static magnetic field may be significant to some particular neighbor facilities, and provides additional measurements to be made if such facilities are found close to the CHST right-of-way.

4.0 SUMMARY AND RECOMMENDATIONS

Section 6 provides the Measurement Procedure for Assessment of CHSTP Alignment EMI Footprint (MPE).

The CHSTP section designers should:

- Use the MPE to develop a Section EMI Footprint Measurement Procedure (S-MPE)
- Measure the pre-construction ambient radiated electric and magnetic fields per the S-MPEs
- Provide a Section EMI Footprint Measurement Report per the S-MPEs
- Assess Section EMC impacts for the EIR/EIS, using the system-wide EMC Footprint developed by the PMT

Following project steps should:

1. Establish a CHST project EMC Plan for the Preliminary Design Phase.
2. Evaluate the EMC design criteria and EMC Footprint data against the emerging designs and EMC standards in use on high-speed trains in successful operation, and update the design criteria so they are ready for use in the design phase of the project.
3. Perform a detailed assessment to determine applicable EMC design standards.
4. Provide necessary reports.

5.0 SOURCE INFORMATION AND REFERENCES

5.1 CODES, STANDARDS, AND SPECIFICATIONS

The following codes, standards and specifications are relevant to the CHSTP EMC program.

1. APTA Standard SS-E-010-98, Standard for the Development of an Electromagnetic Compatibility Plan.
2. EN 50121-3-2, Railway applications - Electromagnetic Compatibility, Part 3-2: Rolling stock - Apparatus, CENELEC European Standard, 2000.
3. EN 50121-1, Railway applications - Electromagnetic Compatibility, Part 1: General, CENELEC European Standard, 2006.
4. EN 50121-2, Railway applications - Electromagnetic Compatibility, Part 2: Emissions of the whole railway system to the outside world, CENELEC European Standard, 2006.
5. En 50121-3-1, Railway applications - Electromagnetic Compatibility, Part 3-1: Rolling stock - Train and complete vehicle, CENELEC European Standard, 2000
6. EN 50121-3-2, Railway applications - Electromagnetic Compatibility, Part 3: Rolling stock - apparatus, CENELEC European Standard, 2006.
7. EN 50121-4, Railway applications - Electromagnetic Compatibility, Part 4: Emission and immunity of signalling and telecommunications apparatus, CENELEC European Standard, 2006.
8. EN-50121-5, Railway applications - Electromagnetic Compatibility, Part 5: Emission and immunity of fixed power supply installations and apparatus, CENELEC European Standard, 2000
9. EN 50155, Railway applications - Electronic equipment used on rolling stock, CENELEC European Standard, 1996-01-12.
10. EN 50207, Electronic Power Converters for Rolling Stock, CENELEC European Standard.
11. EN 50238, Railway applications - Compatibility between rolling stock and train detection systems, CENELEC European Standard, 2006.
12. FCC OET-65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radio frequency Electromagnetic Fields, FCC Office of Engineering and Technology Bulletin 65, Edition 97-10.
13. FCC Part 15, Part 15 of Title 47 of the Code of Federal Regulations.
14. IEEE Std. C2, National Electrical Safety Code, 2007
15. IEEE Std. C95.1, IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 3 kHz - 300 GHz., 2005
16. IEEE Standard C95.6, IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0 - 3 kHz, 2002

17. IEEE Std. 16, IEEE Standard for Electrical and Electronic Control Apparatus on Rail Vehicles, 2004

18. IEEE Std 80, Standard Guide for Safety in AC Substation Grounding, 2000

19. IEEE Std 142-1991, Recommended Practice for Grounding of Industrial and Commercial Power Systems, IEEE, June 27, 19[nas2]91.

20. IEEE Std 518-1982, IEEE Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources, IEEE, 31 May 1990.

21. IEEE Std 519, Recommended Practice and Requirements for Harmonic Control in Electrical Power Systems, 1992

22. IEEE Std 525-1987, IEEE Guide for the Design and Installation of Cable Systems in Substations, IEEE, 1992.

23. IEEE Std 1100-1999, Recommended Practice for Powering and Grounding Electronic Equipment, IEEE, 22 March 1999.

24. IEEE Std 1143-1995, IEEE Guide on Shielding Practice for Low Voltage Cables, IEEE, 13 April 1995.

25. Leland H. Hemming, Architectural Electromagnetic Shielding Handbook, IEEE Press, 1992.

26. MIL-HDBK-237, Electromagnetic Compatibility/Interference Program Requirements, U.S. D.O.D.

27. MIL-HDBK-419A, Grounding Bonding and Shielding for Electronic Equipment and Facilities (Volume I, Basic Theory, 1987). US D.O.D.

28. MIL-STD-461E, Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference. US D.O.D.

29. MIL-STD-462D, Electromagnetic Interference Characteristics, Measurement Of, U.S. D.O.D.

30. NFPA 70, 2007 National Electric Code, NFPA 70, National Fire Protection Association.

31. NFPA 780-2004: Standard for the Installation of Lightning Protection Systems.

32. RaneNote 151: Grounding and Shielding of Audio Devices, Rane Corporation, 2002.

33. TM 3.4.10; EMC Technical Memorandum, TM 3.4.10, CHSTP, June 2008

34. UMTA-MA-06-0153-85-6, Conductive Interference in Rapid Transit Signaling Systems, Volume II: Suggested Test Procedures (CSTP), U.S. Department of Transportation, Federal Transit Administration.

35. UMTA-MA-06-0153-85-8, Inductive Interference in Rapid Transit Signaling Systems - Volume II: Suggested Test Procedures (ISTP), U.S. Department of Transportation, Federal Transit Administration.

36. UMTA-MA-06-0153-85-11, Radiated Interference in Rapid Transit Signaling Systems - Volume II: Suggested Test Procedures (RSTP), U.S. Department of Transportation, Federal Transit Administration.

5.2 APPLICABILITY

All CHSTP measurements of pre-construction ambient radiated electric and magnetic fields shall conform to the final version of the Measurement Procedure for Assessment of CHSTP Alignment EMI Footprint described in Section 6 of this Technical Memorandum.

In case of conflict between the MPE and other CHSTP standards, specifications, and guidelines, this MPE shall apply, unless otherwise determined and approved by the CHSTP Engineer.

6.0 MEASUREMENT PROCEDURE FOR ASSESSMENT OF CHSTP ALIGNMENT EMI FOOTPRINT

6.1 EMI FOOTPRINT MEASUREMENT PROCEDURE INTRODUCTION

6.1.1 EMI Footprint Measurement Objectives and Scope

The objectives of this Measurement Procedure for Assessment of CHSTP Alignment EMI Footprint (MPE) are to guide Section Designers to develop a compatible Section EMI Footprint Measurement Protocol (S-MPE) and perform the EMI measurements, and to achieve consistent field measurements among Sections.

The objectives for the Regional Consultant measurements are to determine actual radiated and magnetic emissions and ambient of Section wayside neighbors, and to find and measure the highest and lowest ambient radiated electric fields and magnetic fields within the Section.

The objectives for the EMI Footprint Measurement activity are to enable setting radiated and magnetic EMI emission limits for use in CHST procurements of trains and other equipment, and to prepare and take mitigation steps as needed to achieve EMC with CHST neighbors.

The scope of the EMI Footprint Measurements is the electromagnetic environment of the planned CHST alignment, in each Section of the line.

6.1.2 Overview of the Measurement Procedure

This MPE guides Section development of a test method, test arrangement, and related technical information for performing the Section EMI Footprint Measurements. This MPE also describes the format of the measurement results documentation.

Each Section EMI Footprint Measurements will consist of:

- Radiated electric field measurements
- Magnetic field measurements

Radiated Electric Field Measurements: Each Section measurement team will perform and document radiated measurements using techniques from the Radiated Interference in Rapid Transit Systems, Volume II: Suggested Test Procedures, UMTA-MA-06-0153-85-11, method RT/RE01A, “Broadband Emissions of Rapid Transit Vehicles - 140 kHz to 400 MHz” (RSTP). Measure from 10 kHz to 6.0 GHz. The measurements will use a RF Spectrum Analyzer and calibrated antennas.

Magnetic Field Measurements: Each Section measurement team will perform and document magnetic field measurements using a sensitive magnetometer. The team will measure from DC to 800 Hz, using an AlphaLab three axis magnetometer and magnetic field probe, or equivalent.

For technical questions about the Measurement Procedure, contact:

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6.1.3 Contents of this Procedure

This MPE consists of the following sections.

Section 6.2, Section EMI Footprint Measurement Procedures

Section 6.3, Radiated Electric and Magnetic Field Measurement Sites: Describes measurement site selection.

Section 6.4, Radiated Electric Field Measurement Method: Lists the test equipment, setup, measurement steps, and conditions for radiated electric field measurements.

Section 6.5, Magnetic Field Measurement Method: Lists the test equipment, setup, measurement steps, and conditions for magnetic field measurements.

Section 6.6, Test Report Format: Outlines the Section EMI Footprint Report.

Section 6.7, EMI Footprint Measurement Data Forms: Example data collection forms for the Section EMI Footprint Measurements.

6.2 CHSTP SECTION EMI FOOTPRINT MEASUREMENT PROTOCOLS

Each CHSTP Section will produce a Section EMI Footprint Measurement Protocol (S-MPE) consistent with this MPE, and submit it for approval by the Project Management Team. The S-MPE will include the following, or equivalent:

- Introduction, including scope, steps, participants, reference information
- Survey sites, map showing sites and the CHST right of way, criteria used for selecting sites, and measurement schedule
- Radiated electric measurement procedures, including equipment configuration, set-up, and calibration; and measurement method
- Magnetic field measurement procedures, including equipment configuration, set-up, and calibration; and measurement method
- Measurement report format
- Measurement data forms

S-MPE requirements are described in following sections.

6.3 RADIATED ELECTRIC AND MAGNETIC FIELD MEASUREMENT SITES

The objectives in selecting CHSTP Section measurement sites are to:

- Find and measure the highest and lowest ambient radiated electric fields and magnetic fields within the Section.
- Locate significant emitters and locations with significant potential susceptibility to high CHST emissions.

6.3.1 Site Selection

Within each Section, measure the highest and lowest ambient radiated electric and magnetic fields.

Measure several cases of potential high emission sources within each Section, including:

- Rail transportation – freight, commuter, LRV, subway
- Airport – aircraft and ground communications and radar
- Technical facilities – hospital, medical center, research facility, university, college, technical institute, high school
- Transmitters – radio and TV broadcasters, police, fire, emergency medical technicians, military
- Power utilities – substation, switching station, high tension cable
- Commercial – business parks, manufacturers, casinos, banks
- Other

In general, denser sites and sites closer to the planned right-of-way (ROW) are good candidates.

Measure several cases of potential low ambient sites within each Section, including Technical facilities – hospital, medical center, research facility, university.

Site measurements should consider and as appropriate measure:

- Variation by time of day: peak, moderate, night
- Intermittent or infrequent emissions
- Intermittent presence of emitters such as trains and aircraft

Section measurement teams can use Table 6-1 to catalog selected sites and summarize their characteristics.

Table 6-1 **CHSTP Section EMI Footprint Measurement Sites**					
High Emission Sites					
Site No.	**Setting:** • Urban • Suburban • Rural	**Emitter:** • Rail • Airport • Tech • Transmit • Power • Commercial • Other	**Site Name, Location, Description**	**Distance from CHST ROW to Emitter**	**Comment**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
Low Emission Sites					
Site No.	**Setting:** • Urban • Suburban • Rural	**Condition:** • Valley • Tech • Residential • Other	**Site Name, Location, Description**	**Distance from CHST ROW to Emitter**	**Comment**
11					
12					
13					
14					
15					

The S-MPE should include a map showing all measurement sites with respect to the CHST right of way.

Following the guidelines shown above, the Regional Consultant should select measurement sites along the ROW, with suitable geographic spread considering the ends and center. The Regional Consultant may choose more measurement sites if there are compelling high emission or high susceptibility candidates. Use the following site selection guidelines:

1] Limit high emission sites to five or less, and low emission sites to three or less, unless there is a compelling reason to choose more.

2] Make all measurements on publicly accessible land. Section 6.3.2 bullet 2 notes that alternative distances to the track are acceptable.

3] Use low emission measurement data from one section to augment the limited measurements of later sections. This can be done once there is a useful summary available characterizing the high and low emissions in the first measured sections with the approval of the Program Management Team

6.3.2 Site Requirements

Unless otherwise constrained or guided, the measurement point at each site should be at or near the centerline of a planned CHST track.

As alternatives, the measurement point can be:

- 100 ft (30 m) or 50 ft (15 m) from the planned CHST track centerline. These distances are broadly used for transit radiated electric field measurements, and permit easy comparisons.
- At another suitable location close to a point of interest such as an emitter or potential victim. Note the distance to the planned CHST track centerline and to the point of interest.
- For sites along an existing rail right of way, the antenna may be positioned 100 ft (30 m) or 50 ft (15 m) from the operating track centerline. Measure background with no train present, and measure several trains passing.
- For airports, the measuring antenna can face airport antennas. Measure background with no planes active, and measure several plane take-offs and landings.

The antenna should point toward the CHST track. The antenna should be mounted 6 ft (2 m) above ground level. If the terrain requires a different height above the ground, record it.

If possible, there should be no fence or other significant metal structure above rail level between the measurement point and the antenna, or immediately behind or to the sides of the measurement point. For obstructed or tunnel locations, the in-situ construction materials, such as cut-and-cover or bored tunnel, should be noted.

There should be a safe area for the test crew and test equipment to park a test van.

The test equipment needs 110 vac power, which may be provided by connection to a utility or gasoline generator.

The S-MPE should identify any local requirements for the Section Measurement Team such as access restrictions, safety requirements, security issues, etc.

Include a detailed site diagram and photographs of each measurement site in the Measurement Report, and a map showing all measurement sites with respect to the CHST right of way. An example site diagram is shown in section 6.7.

6.4 RADIATED ELECTRIC FIELD MEASUREMENTS

This section lists and describes the test equipment, test steps, setup, measurement methods, and data evaluation the Section Measurement Team should use to measure ambient radiated electric field along the CHSTP planned alignment.

6.4.1 Radiated Electric Field Measurement Equipment Configuration and Calibration

6.4.1.1 Setup

Figure 6-1 shows the recommended test equipment setup for the Radiated Electric Field Measurements. Table 6-2 lists recommended Radiated Electric Field Measurement equipment. Equivalent equipment may be used. Generally, follow the approach of UMTA-MA-06-0153-85-11, Radiated Interference in Rapid Transit Signaling Systems - Volume II: Suggested Test Procedures (RSTP), U.S. Department of Transportation, Federal Transit Administration, method RT/RE01A, "Broadband Emissions of Rapid Transit Vehicles".

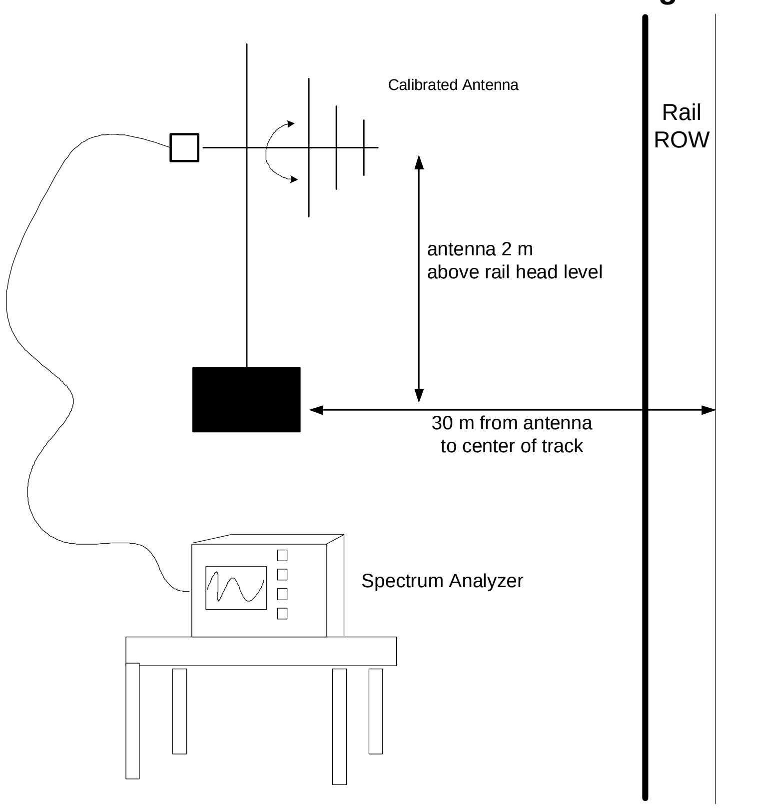
To the extent possible, place the measurement antenna 50 or 100 ft (15 m or 30 m) from the centerline of the track under test and 2 m above the rail head, as specified in the RSTP.

Table 6-2
Radiated Electric Field Measurement Equipment List

#	Item	Comment
1	RF Spectrum Analyzer, Agilent E4404B, 9kHz to 6.5GHz Spectrum Analyzer w/GPIB, or equivalent	For measuring EMI field intensity between 9 kHz and 6.5 GHz.
2	Laptop computer	For control of printer and storage of test data results
3	PC Software, HP HPE4444A Benchlink Software, or equivalent	For transfer of data from Spectrum Analyzer to PC
4	HP 930 Deskjet Printer, or equivalent	For plotting emission spectra. Compatible with spectrum analyzer.
5	A.H Systems SAS-550-1: Active Monopole Antenna or equivalent, 10 kHz to 60 MHz	Calibrated antenna for Bands 1 – 4
6	A.H. Systems SAS-521-7: Bilogical Antenna or equivalent, 25 MHz to 7 GHz	Calibrated antenna for Bands 5 – 7
7	Adjustable Antenna Tripod, non-metallic	To support antennas
8	AC Power Source	AC line, generator, or car battery inverter.

The following subsections describe the major test equipment items.

Figure 6-1
Radiated Electric Field Measurement Configuration



6.4.1.2 RF Spectrum Analyzer

The Agilent Technologies Model E4044B Spectrum Analyzer, or equivalent, measures intensity of the RF field over a frequency range of 9 kHz to 6.0 GHz. It:

- Measures and documents the field intensity received from calibrated antennas.
- Converts received signals from calibrated antennas into standard dBμV/m units.
- Applies conversion factors to convert measurements into dBμV/m/MHz units.
- Stores system configuration including antenna factors and cable losses.
- Has amplitude accuracy better than ±1.7 dB, adequate for the task
- Displays Limit Lines or to indicate ETS specification limits.

The spectrum analyzer is connected to a laptop or PC by a data link for data acquisition, storage, and printing.

6.4.1.3 Antennas

Mount antennas on a non-metallic tripod with the antenna base plate 6.6 ft (2 m) above rail head level. The measurements will orient the antennas as follows:

- **Active Monopole Antenna:** The Active Monopole Antenna covers the frequency range of 10 kHz to 60 MHz. Measurements are taken with this antenna oriented vertically.
- **Bilogical Antenna:** The Bilogical Antenna is a wide operating range antenna which covers the frequency range of 25 MHz to 7,000 MHz. The name "bilogical" indicates that the antenna combines the characteristics and response of a biconical and log periodic antenna. Measurements are taken with this antenna oriented vertically, with its axis perpendicular to the ground, and with the antenna oriented horizontally, with the antenna axis parallel to the train's path.

Calibrated antennas receive and convert RF field intensities into electrical signals with a known conversion antenna factor. These antenna factors are provided by the antenna supplier, and are entered into the spectrum analyzer so the spectrum analyzer can display received signals in units of the corresponding electrical field intensity.

6.4.1.4 Broadband Measurements

The RSTP specifies that measurements be made in a broadband mode, which is appropriate when the source of the electric field emission is an impulse or burst of energy. If the source of the electric field emission is a narrowband source like a radio transmitter, narrowband mode is more appropriate.

Consistent with the RSTP, this procedure uses the broadband mode. To do so, modify the antenna factors to include a broadband correction factor for the specified spectrum analyzer resolution bandwidth. The correction factors are 36.5 dB for a 10 kHz resolution bandwidth, 16.5 dB for a 100 kHz resolution bandwidth, and 7.0 dB for a 300 kHz resolution bandwidth.

Since the spectrum analyzer does not permit modification of the units it displays on its plots, plot units are labeled dBuV/m, although the actual units are dBuV/m/MHz.

6.4.1.5 Test Bands

Perform broadband emission measurements in the range 10 kHz to 6 GHz using active monopole and bilogical antennas for horizontal and vertical electric fields as appropriate.

Divide the measurement band into smaller test bands, such as listed in Table 4-2. Use the active monopole antenna to cover the range from 10 kHz - 30 MHz, in five measurement subbands.

Measure with the active monopole oriented vertically. Use the bilogical antenna to cover the range from 25 MHz to 6 GHz, with both horizontal and vertical orientation.

Table 6-3
Radiated Emissions Measurement Bands

ID	Frequency Range	Antenna	Ant Orientation	Resolution Bandwidth
B0	10 kHz – 50 kHz	Active Monopole	Vertical	1 or 3 kHz
B1	50 kHz – 550 kHz	Active Monopole	Vertical	10 kHz
B2	500 kHz – 3 MHz	Active Monopole	Vertical	10 kHz
B3	2.5 MHz – 7.5 MHz	Active Monopole	Vertical	10 kHz
B4	5 MHz – 30 MHz	Active Monopole	Vertical	100 kHz
B5h	25 MHz – 225 MHz	Bilogical	Horizontal	100 kHz
B5v	25 MHz – 225 MHz	Bilogical	Vertical	100 kHz
B6h	200 MHz – 2.2 GHz	Bilogical	Horizontal	300 kHz
B6v	200 MHz – 2.2 GHz	Bilogical	Vertical	300 kHz
B7h	2 GHz – 6 GHz	Bilogical	Horizontal	300 kHz
B7v	2 GHz – 6 GHz	Bilogical	Vertical	300 kHz

6.4.1.6 Spectrum Analyzer Calibration

Verify proper operation of the Radiated Electric Field Measurement equipment:

- Turn on spectrum analyzer and let it warm up for 30 minutes.
- After warm-up, calibrate the spectrum analyzer as described in the user's manual. This calibration procedure should be followed after transport or after a long time period.
- Adjust the receiver sensitivity following the manufacturer’s adjustment procedure, using the built-in calibration signal of the spectrum analyzer.
- Attach a matched termination to the spectrum analyzer antenna input terminal. Observe and record the spectrum analyzer output levels across the entire frequency range. Label data “With Antenna Terminal Terminated.” Note any spurious receiver response.
- Verify cable loss matches calibration record. The internal calibrator can be used to make this measurement.
- Verify antennas are operating properly.

6.4.1.7 Spectrum Analyzer Setup

Measure using the peak hold averaging mode on the spectrum analyzer while ambient measurements are being made or when transient emitters such as trains are present. Use a typical peak hold measurement time of 5 seconds, unless otherwise noted. Record the duration of data acquisition.

Use two traces, one set for Max Hold and the other set for Min Hold, to distinguish between broadband and narrowband emissions and between continuous and discontinuous emissions.

6.4.1.8 Site Diagram

Make a detailed diagram of the measurement site, showing location, measurement point, nearby structures, emitters, CHSTP right-of-way and other significant objects. Include the measurement site GPS coordinates. Provide photographs of the measurement site. Provide a map showing all measurement sites with respect to the CHST right of way. An example site diagram is shown in section 6.7.

6.4.2 Radiated Measurement Planning

Select radiated electric field test sites per section 3 above.

Arrange measurements to measure worst-case (maximum and minimum) radiated emissions, considering time-of-day, intermittent events, and local actions. Ambient radiated electric field conditions change frequently because neighbor radio and energy sources continually vary their operating conditions.

Perform sufficient repeated measurements to identify worst-case conditions and characterize their amplitude, frequency, duration, and repetition at the CHST alignment location. If high emissions are measured, reorient the antenna and record the direction in which the highest emission level is measured.

For each measurement, maintain a test log of measurement type and band, test equipment configuration, measurement duration, external event or condition description, comments, summary of measured data, and other relevant information. If the measurement includes a train, motor vehicle or airplane, note it.

6.4.3 Radiated Electric Field Measurement Method

6.4.3.1 Broadband Emission Evaluation

To identify a broadband emission observed at a particular frequency and polarization as a distinct wayside emission, the emission level must exceed the corresponding observed ambient broadband level by 10 dB or more. The frequency in question must be at least twice the impulse bandwidth from any ambient narrowband signal producing receiver output greater than the observed broadband emission levels.

If a questionable signal is found that would be excluded under these criteria, re-measure it later under similar conditions to determine whether the emission is an ambient variation or an actual wayside emission.

A set of regular peaks displayed on the spectrum analyzer screen could either are a set of harmonics emissions or the record of a periodic sequence of impulses. If such a set is found:

- Note the peaks in the log
- Make another measurement with all setting the same but with a different spectrum analyzer sweep speed. If the peaks change spacing on the screen, they are a sequence of impulses. If the peaks maintain a constant spacing, they are a set of harmonics.
- Record the results in the log.

6.4.3.2 Field Reduction of Data

Set up the spectrum analyzer to account for antenna factors, calibration factors, gain, and conversion units so that the emission amplitudes are recorded in dBμV/m/MHz. Plot or print the spectrum analyzer data on completion of each frequency test run, annotating the test results as appropriate.

Make a printout and save the data for each valid test run.

Characterize the measurement. Note:

- Key emissions in the measurement
- The extent to which the minimum and maximum traces differ, reflecting the broadband noise present.
- Changes between the measurement and recent similar measurements
- Similarities or differences to other measurements in the same band at other locations
- Whether there is a set periodic impulses or a set of harmonics
- Whether the measurement is an apparent worst case.

6.4.3.3 Test Data Collection

Collect data, including for test equipment calibration and each ambient site measurement. Section 6.7 provides example Radiated Electric Field Measurement forms.

Equipment Calibration: Record calibration data for each major test equipment item. Calibration data will include Test Equipment Item, Manufacturer, Model, Serial Number, Calibration Date, Calibration Source and Reference Number, Notes.

Measurement Log: Maintain a measurement run log, recording the following for each measurement: Date, Time, Performed By, Location, Site Conditions, Event, Run #, Identification # for plot, Measurement Type, Frequency Band, Test Configuration Data such attenuation settings, Summary Results, Notes.

See the Measurement Log and Directory of Measurement forms in Section 6.7.

6.5 MAGNETIC FIELD MEASUREMENTS

This section lists and describes the test equipment, test steps, setup, measurement methods, and data evaluation the Section Measurement Team should use to measure the ambient low frequency magnetic field along the CHSTP planned alignment.

6.5.1 Magnetic Field test Equipment Configuration and Calibration

6.5.1.1 Setup

Figure 6-2 shows the test equipment setup for the magnetic field measurements. Table 6-4 lists the magnetic field measurement equipment.

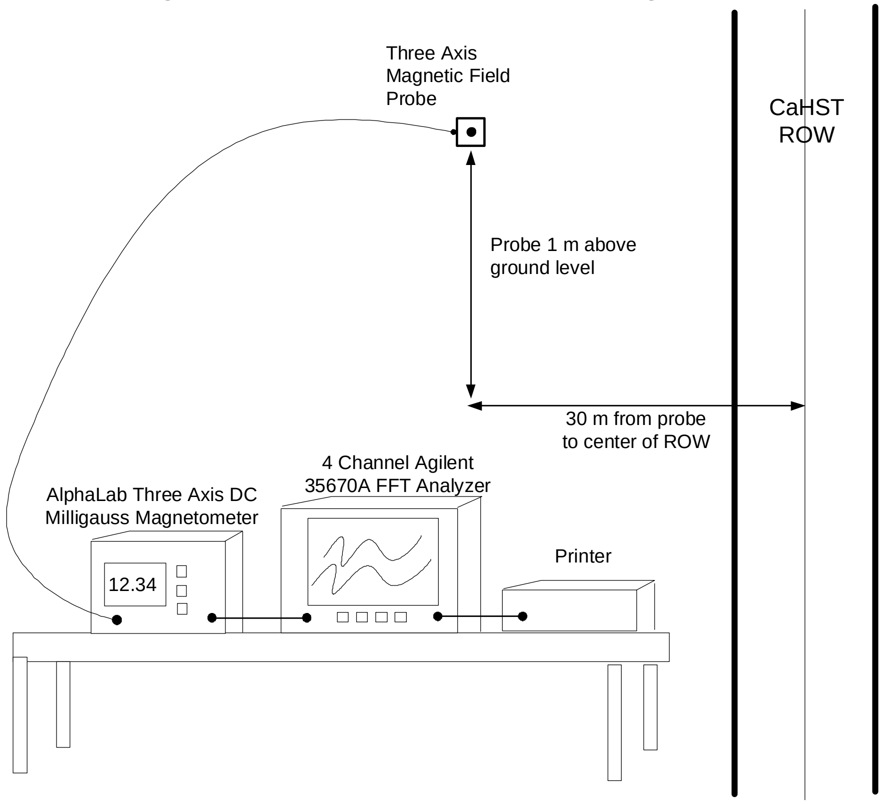
Measure the AC magnetic field in the frequency range from DC to 800 Hz, in three axes, at a height of 3.3 ft (1 m) above the ground. The purpose is to find and record the strongest magnetic field strengths vectors and magnitudes and changes related to ambient conditions.

Table 6-4
Magnetic Field Test Equipment List

#	Item	Comment
1	Agilent Technologies AT35670A Four Channel FFT Dynamic Signal Analyzer, or equivalent	For measuring frequency components of magnetic field signals
2	AlphaLab Inc. Three Axis DC Milligauss Magnetometer with Analog Outputs, or equivalent	For measuring magnetic field
5	HP 6L LaserJet Printer, or equivalent	For plotting emission spectra. Compatible with 35670A Analyzer
6	Adjustable Antenna Tripod, non-metallic	To support magnetic field probe
7	AC Power Source	AC line, generator, or car battery inverter.

The following subsections describe the major test equipment items.

Figure 6-2
Magnetic Field Measurement Configuration



The equipment measures, processes, and records low frequency AC magnetic fields, in three axes.

The earth's static (or DC) total magnetic field in San Diego is about 471mG, and about 497 mG in Sacramento. The static magnetic field at any measurement point is significantly affected by nearby composition of the earth, by the presence of large steel objects nearby (bridges, steel buildings). Fluctuations in the magnetic field with durations of 1 to 10 s are caused by passing steel vehicles (cars, LRVs, buses, trucks, and trains), and by the presence of fluctuating DC currents in nearby cables such as LRV overhead contact wires and return rails.

The AC field at a measurement location is typically due to AC currents in nearby cables.

6.5.1.2 Three-Axis DC Milligauss Magnetometer and Three-Axis Probe

An AlphaLab Three Axis DC Milligauss Magnetometer and Three Axis Probe (or equivalent) measures and displays the amplitude of the magnetic field in each of three axes in the frequency range of DC to 900 Hz (@ -3 dB), for fields of amplitude from 0.01 mG to 2,000 mG. The magnetometer includes for each axis digital displays, offset controls, zero controls, and range controls.

The magnetometer has an analog output for each of three axes, each of which is proportional to the magnetic field. The three analog outputs will be connected to the Dynamic Signal Analyzer, so the AC frequency components of the magnetic field can be measured and processed.

The three-axis probe is a one-inch cube which mounts three sensors, and is sensitive to magnetic fields transverse to each flat surface.

6.5.1.3 Dynamic Signal Analyzer

An Agilent Technologies four-channel Dynamic Signal Analyzer Model AT35670A or equivalent performs the following tasks:

- Measures the magnetometer outputs.
- Converts from measured voltages into engineering units of Gauss or Tesla.
- Processes measured data to determine and display frequency components over the selected range.
- Measures time sequence (waterfalls) or peak hold amplitudes.
- Records to floppy or PC and prints out results on connected printer.

6.5.1.4 Narrowband Measurements

The expected magnetic field components will be the earth's DC magnetic field and AC magnetic fields due to nearby 60 Hz utility power cables, and other AC magnetic fields due to other frequency currents in nearby cables.

Since all these expected components are narrowband in nature, make these measurements with a narrowband mode and calibration.

6.5.1.5 Test Bands

Perform narrowband emission measurements in the range DC to 800 Hz, using the magnetometer, probe, and Dynamic Signal Analyzer. Measure and process in three axes to determine the orientation with the highest field.

If a measurement shows high levels of magnetic field at a specific frequency, make a following measurement to zoom in on that frequency.

6.5.1.6 Perturbations in Static Magnetic Field

Some sensitive research and medical facilities are sensitive to perturbations in the static magnetic field. Examples are sensitive magnetic field laboratories and unshielded MRI machines. If the measurement survey reveals that a facility that is sensitive to magnetic field perturbations is close to the CHSTP alignment, more detailed measurements of variations in the static magnetic field should be performed. The following procedures only apply if a specific sensitive facility has been found close to the planned alignment.

To observe perturbations in the static magnetic field, including ones that occur with a duration of 1 to 10 seconds, the measurement setup should record the magnetometer outputs in the time domain and making time-domain plots of the results. The magnetometer, chart recorder, or post-processor should apply low-pass filtering to the magnetometer readings. The filtered results should be plotted vs. time for all three axes.

To accurately measure magnetic field fluctuations over times in the range of minutes or longer, it is necessary to check and compensate for magnetometer thermal drift. Thermal drift characteristics of the magnetometer's response to changing temperature are typically available from the manufacturer, or they can be measured. Then magnetometer temperature can be measured over the duration of each measurement, and the temperature-dependent correction factors can be applied.

In addition, to measure variations with a duration in the range of minutes or longer, it is necessary to also measure and control for naturally occurring fluctuations in the geomagnetic field.

If the sensitive facility is only sensitive to pulse- or step-shaped fluctuations with time scales of seconds, then it is not necessary to measure and compensate for thermal and geomagnetic effects.

6.5.1.7 Magnetometer Calibration

Perform the following steps to verify proper operation of the magnetometer.

- Turn on the magnetometer and let it warm up for 10 minutes.
- After warm up, check the DC magnetic field offset of each axis. Flip the probe cube over. If the magnetometer is properly zeroed, the axis reading should go from +xyz to –xyz. Check the zero and adjust as necessary.
- Check that the magnitude DC field measured by the magnetometer is close to the expected value of 0.5 G in California.

6.5.1.8 Site Diagram

Make a detailed diagram of the measurement site, showing location, measurement point, nearby structures, emitters, CHSTP right-of-way and other significant objects. Include the measurement site GPS coordinates. Provide site photographs.

6.5.2 Magnetic Field Measurement Planning

Select magnetic field test sites per section 3 above.

Arrange measurements to measure worst-case (maximum and minimum) magnetic field conditions, considering time-of-day, intermittent events, and local actions. Ambient magnetic field conditions change frequently because neighbor energy sources continually vary their operating conditions.

Perform sufficient repeated measurements to identify worst-case conditions and characterize their amplitude, frequency, duration, and repetition at the CHSTP alignment location.

For each measurement, maintain a test log of measurement type, test equipment configuration, external event or condition description, comments, summary of measured data, and other relevant information. If the measurement includes a train, motor vehicle or airplane, note it.

Record the magnetometer probe axis which detects the peak level.

6.5.3 Magnetic Field Measurement Method

6.5.3.1 Narrowband Emission Evaluation

Measure magnetic field emissions and record narrowband levels.

6.5.3.2 Field Reduction of Data

Set up the Dynamic Signal Analyzer to display measurements in units of gauss (G).

Make a printout and save the data for each valid test run.

Characterize the measurement. Note:

- Key emissions in the measurement
- Changes between the measurement and recent similar measurements
- Similarities or differences to other measurements in the same band at other locations
- Whether the measurement is an apparent worst case.

6.5.3.3 Test Data Collection

Collect data, including for test equipment calibration and each ambient site measurement. Section 6.7 provides example Magnetic Field Measurement forms.

Equipment Calibration: Record calibration data for each major test equipment item. Calibration data will include Test Equipment Item, Manufacturer, Model, Serial Number, Calibration Date, Calibration Source and Reference Number, Notes.

Measurement Log: Maintain a measurement run log, recording the following for each measurement: Date, Time, Performed By, Location, Site Conditions, Event, Run #, Identification # for plot, Measurement Type, Test Configuration Data such attenuation settings, Summary Results, Notes.

See the Measurement Log and Directory of Measurement forms in Section 6.7.

6.6 SECTION EMI FOOTPRINT MEASUREMENT REPORT FORMAT

Document the measurements in a Section EMI Footprint Measurement Report compatible with this procedure. Provide it to the PMT for system-level evaluation.

The Report will consist of sections including or equivalent to the following:

Section 1, Introduction: The Introduction section provides the purpose, scope, applicable requirements, participants, reference documents including CHSTP alignment section under survey, test procedure overview, and organization for the rest of the report.

Section 2, Measurement Results and Conclusions: In the Measurement Results and Conclusions section, provide tables:

- Radiated electric field:
  - For each frequency band, worst-case emitters, including amplitude and frequency of emission, location, conditions, and preliminary assessment of impact.
  - For each frequency band, most quiet condition
  - Notes on potential victim locations in the section.
- Magnetic field:
  - Identify worst-case fields, including amplitude and frequency of emission, location, conditions, and preliminary assessment of impact.
  - Identify most quiet condition
  - Notes on potential victim locations in the section.

Summarize the test schedule and scope; provide a top level index of all measurements; identify, reference, and describe the most important results; and state conclusions.

Section 3, CHSTP Section and Measurement Sites: The CHSTP Section portion of the report describes the as-measured CHSTP alignment and measurement locations. Provide maps showing the site and the CHST right of way. Provide a detailed diagram and photographs for each site.

Section 4, Test Equipment Configuration: The Test Equipment Configuration section describes the as-performed test equipment configuration, including a test equipment connection diagram, and the list of test equipment with model numbers, and instrument calibration dates and calibration certificates.

The Test Equipment Configuration section provides complete information on the scale or conversion factors which apply to all test data, including Antenna or Probe outputs, data-time series charts, and Analyzer plots.

The Test Equipment Configuration section provides initial setup calibration data which demonstrate that the Antennas, the RF Spectrum Analyzer, Magnetometer, Dynamic Signal Analyzer, transducers, and external instruments give correct, accurate, and repeatable results.

Section 5, Test Procedure: The Test Procedure section summarizes the test steps, and describes any differences between the "as-performed" test steps and the S-MPE.

Section 6, Measurements and Data: The Measurements and Data section describes significant test results, conclusions, or considerations. This section summarizes all data collected during the measurements. It includes a list, log, or index of all measurements, print outs, and spectral plots. It includes the Date, Performed by, Location, and notes for all measurements. For each measurement it provides the Measurement Number, Measurement Type, Time, IDs of computer print out; measurement description; test configuration data such as gain settings; summary result; and notes. The Measurements and Data section provides all appropriate test data, such as RF Spectrum Analyzer print outs, plots, logs, and other information supporting the test results and conclusions.

6.7 EMI FOOTPRINT MEASUREMENT FORMS

The following emissions measurement forms are provided below:

- CHSTP EMI Footprint Equipment Calibration Record
- CHSTP EMI Footprint Measurement Log
- CHSTP EMI Footprint Radiated Electric Field Measurement Directory
- CHSTP EMI Footprint Magnetic Field Measurement Directory
- Measurement Site Plan, with example diagram

Recorded by: ________________________________ **Date:** ______________________________

CHSTP EMI Footprint Measurement Equipment Calibration Record

#	Item	Manufacturer	Model/Serial Number	Calibration / Date
1	RF Spectrum Analyzer	Agilent Technologies	E4404B, or equivalent	
2	Four Channel FFT Dynamic Signal Analyzer	Agilent Technologies	35670A, or equivalent	
3	Benchlink PC Software	Agilent Technologies	E4444A, or equivalent	
4	Deskjet Printer	Hewlett Packard	HP 930, or equivalent	
5	Active Monopole Antenna 10 kHz to 60 MHz	A.H Systems	SAS-550-1, or equivalent	
6	Bilogical Antenna 25 MHz to 2000 MHz	A.H. Systems	SAS-521F-2, or equivalent	
8	Laptop computer	Toshiba	2805-S302, or equivalent	

CHSTP EMI Footprint Measurement Log

Date: ____________________ **Time:** ________________ **Weather:** ________________________ **Performed By:** ____

Section: ________________________ **Location:** ____________________________________ **Notes:**____

Measurement ID	Time	Type	Frequency Band	Location	Conditions	Results

Date: ____________________ **Time:** ________________ **Weather:** _________________ **Performed By:** ____

Section: ________________________ **Location:** ____________________________________ **Notes:**____

CHSTP Section Radiated Electric Field Measurement Directory									
		Frequency Band							
Site		**B0: 10 to 50 kHz** Monopole Vertical 1 or 3 kHz res bw	**B1: 50 to 550 kHz** Monopole Vertical 10 kHz res bw	**B2: 500 kHz to 3 MHz** Monopole Vertical 10 kHz res bw	**B3: 2.5 to 7.5 MHz** Monopole Vertical 10 kHz res bw	**B4: 5 to 30 MHz** Monopole Vertical 100 kHz res bw	**B5: 25 to 225 MHz (Note V or H polarity)** Bilogical, 100 kHz res bw	**B6: 200 to 2200 MHz (Note V or H polarity) Bilogical**, 300 kHz rbw	**B7: 2 GHz to 6 GHz (Note V or H polarity) Bilogical**, 300 kHz rbw
1									
2									
3									
4									
5									
6									
	Worst Cases								

Date: ____________________ **Time:** ________________ **Weather:** _________________ **Performed By:** ____

Section: ________________________ **Location:** ____________________________________ **Notes:**____

CHSTP EMI Footprint Magnetic Field Measurement Directory

Site						
1						
2						
3						
4						
5						
6						
	Worst Cases					

Date: Feb 23. 2010 **Time:** 10:26 am **Weather:** Sunny, 70 deg C **Performed By:** Jane Smith, John Doe, Jim Engineer

Section: Los Angeles – Anaheim **Location:** Fullerton Police Dept., 237 W. Commonwealth Ave., Fullerton CA 33º 52' 11.80" N 117º 55' 43.60" W **Notes:** Strongest emissions near Police Dept transmitter

CHSTP Section EMI Footprint Measurement Site Plan