APPENDIX A

TWA FLIGHT 800 ELECTROMAGNETIC ENVRONMENT

Report Prepared by

Department of Defense
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TWA FLIGHT 800 ELECTROMAGNETIC ENVIRONMENT

Prepared for

National Transportation Safety Board
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JSC Project Engineer

Richard DeSalvo

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CONSULTING REPORT

Prepared by

Martin Macrae and Douglas Hughes

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This report has been reviewed and is approved for publication.

Reviewed by:

M. Macrae

MARTIN MACRAE
Project Manager, IITRI

Alan W. Fitch

ALAN W. FITCH
Division Manager

Approved by:

RICHARD B. LARSON
Technical Director

ORVILLE A. EARL, JR., Lt Col, USAF
J8 Department Head

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13. ABSTRACT (Maximum 200 words) The National Transportation Safety Board (NTSB) requested the Joint Spectrum Center (JSC) to determine the electromagnetic environment (EME) at the Trans World Airlines (TWA) Flight 800 aircraft location south of Long Island, New York, at approximately 8:30 in the evening on 17 July 1996. Air and sea traffic data from the NTSB accident investigation docket was combined with data from JSC-maintained frequency assignment databases, equipment characteristics file, and engineering models to calculate the accident location EME.			
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EXECUTIVE SUMMARY

The National Transportation Safety Board (NTSB) requested that the Joint Spectrum Center (JSC) calculate the electromagnetic environment (EME) at the Trans World Airlines Flight 800 aircraft accident location. This study defines the peak and average electric field strength levels that could have been present at the TWA Flight 800 airframe due to emitters in the environment at the time of the accident.

The emitters in the TWA 800 environment were categorized as either fixed or mobile. For fixed emitters the JSC examined database selects created over the past two years to identify a select that both included the area of interest and was closest to the time of the accident. The radio frequency (RF) characteristics of the emitters were subsequently collected and used to calculate the strength of the signals these emitters could have generated at the TWA 800 accident location. The identity and locations of the mobile air and sea platforms were provided by the NTSB. Once the mobile platforms were identified, the platform equipment complements and the equipment RF characteristics were determined.

These assumptions with regard to the analysis were made during consultations with the NTSB:

- All fixed and mobile transmitters were assumed to be emitting except commercial airline high frequency communications equipment.
- A conservative electric field strength threshold of 1 V/m at the accident location was to be used to identify emitters-of-interest.
- Maximum values of peak power, duty cycle, and antenna mainbeam gain were to be used to identify emitters-of-interest.
- The electric field strength predictions due to the emitters onboard US Air Flight 217 were assumed to represent the worst case for the EME due to commercial aircraft emitters.
- Refining calculations would be made for emitters identified as emitters-of-interest, taking into account antenna gain in the direction of the accident location, non-line-of-sight propagation conditions and terrain blockage effects.

Once terrain and antenna pattern data were included in the field strength calculations, two ground-based emitters were found to have the potential to generate an average electric field strength greater than 1 V/m at the accident location. Thirty-eight ground-based emitters were found to have the potential to generate peak electric field strengths greater than 1 V/m. Seven mobile emitters were found to have the potential to generate peak electric field strengths above 1 V/m at the accident location. No mobile emitters were capable of generating an average field strength above 1 V/m.

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GLOSSARY

CIWS	-	Close-In Weapon System
COTS	-	Commercial Off-the-shelf
DC	-	Duty Cycle
EIRP	-	Effective Isotropic Radiated Power
EME	-	Electromagnetic Environment
FAA	-	Federal Aviation Administration
FCC	-	Federal Communications Commission
FRRS	-	Frequency Resource Record System
GMF	-	Government Master File
GSORTS	-	Global Command and Control System/Status of Resources and Training System
HF	-	High Frequency
JSC	-	Joint Spectrum Center
LOS	-	Line-of-Sight
NAVSEA	-	Naval Sea Systems Command
NTSB	-	National Transportation Safety Board
RF	-	Radio Frequency
TWA	-	Trans World Airlines
USAF	-	United States Air Force
USCG	-	United States Coast Guard
USN	-	United States Navy
VHF	-	Very High Frequency

SECTION 1 - INTRODUCTION

BACKGROUND

The National Transportation Safety Board (NTSB) requested that the Joint Spectrum Center (JSC) calculate the electromagnetic environment (EME) at the Trans World Airlines (TWA) Flight 800 aircraft accident location south of Long Island, NY, at approximately 8:30 in the evening on 17 July 1996. The latitude and longitude of the TWA Flight 800 aircraft, at the time of the accident, were 40° 39' 52" N and 72° 37' 46" W, respectively.[1-1] The aircraft altitude was approximately 13,750 feet, and the aircraft heading was 69° from True North.

OBJECTIVE

The objective of this study was to define the peak and average field strength levels that could have been present at the TWA Flight 800 airframe due to individual electromagnetic emitters in the environment at the time of the accident.

APPROACH

Overview

The electromagnetic emitters in the TWA 800 environment were categorized as being either fixed or mobile emitters. The JSC-maintained frequency assignment databases were used to identify fixed emitters. The NTSB, US Navy, Air National Guard, and US Coast Guard supplied information identifying the mobile platforms.

Environment Definition

The radio frequency (RF) emitters in the TWA Flight 800 environment were identified as being either fixed or mobile. Ground-based emitters with frequency assignments for the eastern US comprised the

[1-1] *TWA 800 Accident Investigation,* Baltimore, MD: National Transportation Safety Board, 12 December 1997, CD-ROM containing the exhibits presented under Docket Number SA-516.

fixed emitters. The RF equipment onboard air and sea platforms in the vicinity of TWA Flight 800 comprised the mobile emitters.

Fixed Emitters

The JSC maintains a number of frequency assignment databases. These frequency assignment databases provide a record of the ground- and space-based commercial, military, government, and scientific RF equipment that are operated in the US and overseas. Some databases are updated daily, others are updated yearly. Due to the size of the databases and the expense of routinely storing copies of the databases, there are no formal permanent archives. This analysis was requested two years after the accident, and consequently the current fixed emitter frequency assignment databases do not reflect the fixed emitter environment for the time of the accident. The JSC reviewed database selects created over the last two years to identify a fixed US emitter file created closest to the time of the accident.

A frequency assignment database select previously performed in 1997 to identify high-powered emitters in the United States, was located. A comparison between the records in this 1997 select and a similar 1994 database select, prepared for the Federal Aviation Administration (FAA), indicated almost no change in the high-power emitter environment for the Eastern US. Consequently, the 1997 database select was considered the most accurate description of the high-power fixed emitters operating at the time of the accident.

The RF characteristics of the fixed emitters were collected and the electric field strengths these emitters could generate at the accident location were calculated on the basis of their RF characteristics, their separation distances from the accident location, and the propagation path losses associated with the respective separation distances. Those emitters that generated field strengths of interest were identified.

Mobile Emitters

Locations of the air and sea platforms in the vicinity of TWA Flight 800 at the time of the accident were provided by the NTSB. Aircraft near the accident location were identified through the air traffic radar composites prepared for one phase of the accident investigation. US Coast Guard (USCG) and

US Navy (USN) vessels near the accident location were identified through GSORTS [1-2] records provided to the NTSB. While air and sea platform locations were readily extracted from these sources, the specific headings were only partially available.

Once the mobile platforms were identified, the platform equipment complements were identified. Military aircraft avionics suites were extracted from US Air Force (USAF) and USN documentation. The naval shipboard equipment complements were obtained from Naval Sea Systems Command (NAVSEA) documents. The equipment complements of the commercial aircraft and USCG vessel were obtained from the technical literature available at the JSC, NTSB, and direct contact with the USCG. Subsequently, the RF characteristics of the mobile emitters were collected and examined to determine the strength of the signals these emitters could have generated at the accident location.

Terms, Equations, and Units

A two-step approach was employed in calculating the field strengths of interest. The power densities at the accident location generated by each emitter were calculated and then were converted to electric field strength levels. Decibel units were chosen to simplify the power density calculations. Power, gain, and loss values may be stated in terms of decibels (dB), the logarithm of the ratio of two numbers. The general expression for the decibel ratio of two powers, A and B, is as follows:

$$\begin{aligned}\text{The Ratio of Power A/Power B, in dB} &= 10 \log_{10}(\text{Power A/Power B}) \\ &= 10 \log_{10}(\text{Power A}) - 10 \log_{10}(\text{Power B})\end{aligned}$$

In particular, transmitter power is often expressed in terms of decibels relative to a milliwatt (dBm); the decibel ratio of the transmitter power to a reference level of one thousandth of a watt, or:

$$10 \log_{10}(\text{transmitter power in watts/0.001 watts})$$

When antenna gain (a unitless ratio) is expressed in decibels, the units term 'dBi' is employed to indicate the gain of the antenna is referenced to an isotropic (equal gain in all directions) antenna. Decibels are added or subtracted where the original units are multiplied or divided. For instance, effective isotropic radiated power (EIRP), which is defined as the product of transmitter power and

[1-2] *G (Global Command and Control System) SORTS (Status of Resources and Training System)*, Washington, DC: Joint Data Systems Support Center, April 1998.

antenna gain, is expressed in decibels as the sum of the transmitter power, in dBm, and the antenna gain, in dBi, as follows:

$$EIRP = P_T + G_T \quad \textbf{(1-1)}$$

where

EIRP	=	effective isotropic radiated power, in dBm
P_T	=	peak transmitter power, in dBm
G_T	=	gain of the transmit antenna, in dBi.

Power Density

The power density calculation is based upon the expression for the power density flowing outward from a point charge source through a specified area on the surface of an imaginary sphere whose radius is the distance from the point charge. If transmitter power and antenna gain are substituted for the point charge source, the power density generated by an emitter in free space can be expressed as follows:

$$P_d = (10^{EIRP/10})/(4\,\pi r^2) \quad \textbf{(1-2)}$$

where

P_d	=	power density, in milliwatts/m^2
r	=	distance from the emitter, in meters
$4\,\pi\,r^2$	=	surface area of a sphere of radius r, in square meters
π	=	3.14, ratio of the circumference to the diameter of a circle.

When expressed in decibels the power density equation for free space path loss is:

$$PD = EIRP - 20\log_{10} r_m - 10.99 \quad \textbf{(1-3)}$$

where

PD	=	power density, in dBm/m^2
r_m	=	distance from the emitter, in meters.

When the units of distance are changed to nautical miles (nmi), the power density equation in decibels is written as:

$$PD = EIRP - 20\log_{10} r_{nmi} - 76.34 \quad \textbf{(1-4)}$$

where

r_{nmi} = distance from the emitter, in nmi.

The following equation was used to determine radio line of sight (LOS) from the aircraft to emitters in the environment.

$$LOS = \sqrt{2h_1} + \sqrt{2h_2} \quad \textbf{(1-5)}$$

where

LOS = radio LOS distance, in statute miles
h_1 = height of the emitter antenna, in feet
h_2 = altitude of the aircraft, in feet.

Radio LOS was approximately 150 nmi from the TWA Flight 800 altitude of 13,750 ft to ground-based or shipboard emitters with antenna heights of 50 ft. Free space path loss calculations were employed for fixed and mobile emitters within radio LOS of TWA Flight 800. For emitters located beyond radio LOS, either a smooth-earth model, a smooth-earth-over-seawater model, or a terrain-dependent model was used to calculate propagation path loss.

Equation 1-2 applies for the LOS case. For the beyond LOS case:

$$P_d = F^2 \pi \, 10^{(EIRP/10)}/(22{,}500\, \ell_p) \quad \textbf{(1-6)}$$

where

ℓ_p = $10^{Lp/10}$, path loss as a unitless ratio
L_p = path loss predicted using the appropriate path loss model, in dB
F = frequency of transmission, in MHz.

Electric Field Strength

Once the power density is calculated, the electric field strength in free space can be determined. Power density is converted to electric field strength according to the following relationship:

$$FS = (P_d\ 120\pi/1000)^{1/2} \tag{1-7}$$

where

FS	=	electric field strength in volts/m
120π	=	impedance of free space, in ohms.

The conversion from power density in dBm/m^2 to electric field strength becomes:

$$FS = 10^{[(PD - 4.24)/20]} \tag{1-8}$$

Electric fields generated by multiple emitters on the same frequency were not summed in the results.

Peak and Average Power

Unless otherwise stated all calculations refer to peak power and field strength. When it was necessary to determine the power density based upon the average power of an emitter, the duty cycle (DC) of the emitter was factored into the EIRP, as follows:

$$P_{Tave} = P_T\ DC \tag{1-9}$$

where

P_{Tave}	=	average transmitter power, in milliwatts
P_T	=	peak transmitter power, in milliwatts
DC	=	(PW) (PRF), unitless
PW	=	pulsewidth, in seconds
PRF	=	pulse repetition rate, in pulses/second.

The calculation of average EIRP in dBm is simply:

$$EIRP_{avg} = EIRP + 10\ Log_{10}\ (DC) \tag{1-10}$$

Assumptions

The following assumptions were used in calculating the potential electric field strengths at the TWA Flight 800 accident location. These assumptions were developed in consultation with the NTSB.

All fixed and mobile transmitters were assumed to be emitting except commercial airline high frequency (HF) communications (comm) equipment. Commercial airline HF comm equipment are typically not employed when very high frequency (VHF) air traffic control is available. Military HF comm transmitters were assumed to be active at the time of the accident.

In calculating the peak and average electric field strengths generated at TWA Flight 800, maximum values of peak power, duty cycle, and antenna mainbeam gain were assumed. Where the duty cycles of pulsed emitters were unavailable, the JSC compared combinations of pulsewidths and pulse repetition rates to determine the highest duty cycle. Where mainbeam illumination of the TWA Flight 800 aircraft by fixed or mobile emitter antennas was determined not to have occurred, sidelobe antenna gain values were used to calculate electric field strength.

The avionics onboard US Air Flight 217 were assumed to be representative of the commercial aircraft in the vicinity of TWA Flight 800. Since US Air Flight 217 was the closest commercial aircraft to TWA Flight 800, the electric field strength predictions due to the emitters onboard US Air Flight 217 were assumed to represent the worst case for the EME due to commercial aircraft emitters.

An electric field strength of 1 V/m at the accident location was selected as a conservative threshold of interest. Fixed emitters that did not exceed the 1 V/m threshold were not identified. Mobile emitters that did not exceed the 1 V/m threshold were not identified in Section 3 but were reported in Section 2.

SECTION 2 - ANALYSIS

OVERVIEW

The electric field strength calculations for each emitter were performed using a commercial-off-the-shelf (COTS) software spreadsheet. The decibel versions of the power density and electric field strength equations, described in Section 1, were used in the spreadsheets. Various JSC automated programs were employed to calculate smooth earth and terrain losses where free space LOS propagation paths did not exist.

GROUND-BASED EMITTERS

The fixed ground-based emitters in the accident environment were identified through the frequency assignment records in the JSC-maintained databases. The Frequency Resource Record System (FRRS), the Government Master File (GMF), and the Federal Communications Commission (FCC) databases were the sources for the emitter records that were analyzed. The FRRS database is the repository for all military equipment frequency assignments. The GMF database contains non-military government frequency assignments. The FCC database is comprised of the frequency assignments provided to commercial and public frequency spectrum users.

Map inspection indicates a 10-nmi slant range between TWA Flight 800 and the closest point on the Long Island shore. An EIRP of 100.6 dBm is the minimum effective isotropic radiated power level required by a ground-based emitter, at the closest point to the accident location, to generate an electric field strength of 1 V/m at the accident location. In selecting records for further analysis, a conservative EIRP cull level of 88 dBm was employed. Of the emitter records in the 1997 database select, 3,403 had EIRPs greater than 88 dBm. This number of emitter records was considered too large to list in this report.

Power density values were calculated for the separation distance between the accident location and each of the emitters identified. After converting power density to electric field strength (see Section 1), 144 ground-based emitter records indicated the associated emitter had the potential to generate field strengths above 1 V/m at the accident location. Table 2-1 lists the equipment types found in the 144 emitter records.

Table 2-1. TWA Flight 800 High Power Ground-Based Emitter Environment

Emitter Type
Airport Surveillance Radar
Air Route Surveillance Radar
Airport Surface Detection Equipment
Military Navigation Radar
Weather Radar
Terminal Doppler Weather Radar
Long Range Tracking Radar
Navy Radar Shore Installations
Space Object Tracking Radar
Over-The-Horizon Radar
Research and Development Emitters

Propagation path losses were calculated for the signal paths associated with the 144 culled emitter records. All the ground-based emitters beyond radio LOS (see Section 1) from the accident location were found to lack the EIRP required to generate peak electric field strengths greater than 1 V/m at the accident location, once terrain effects were factored into the path loss. When antenna pattern information was available, the elevation and horizontal scan patterns of the remaining ground emitters were also investigated. In many cases minimum antenna elevation angles precluded mainbeam illumination of the accident location. Once terrain and antenna pattern data was included in the field strength calculations, only 40 emitter records indicated the associated emitter had the potential to generate peak electric field strengths above 1 V/m at the accident location.

Through a similar procedure, only two ground-based emitters were found to generate an average electric field strength greater than 1 V/m. The 40 emitter records that describe the 38 emitters capable of generating peak or average electric field strengths above 1 V/m are identified in Table 2-2. One of the 38 emitters, the tracking radar at Westford, has three emitter records due to variations in emission type. The Westford tracking radar was also one of the two ground-based emitters capable of generating an average electric field strength greater than 1 V/m. The other ground-based emitter found to be capable of generating average electric field strengths above 1 V/m at the accident location was the weather radar at Brookhaven.

Table 2-2. Dominant Ground-Based Emitters

FRQ	FRU	XSC	LOC	BRG	FS VM
420	435	CT	MELVILLE	69	1.7
1294.6	0	NY	RIVERHEAD	348	17.9
1295	0	MA	WESTFORD	24	11.6 (2.0)
1295	0	MA	WESTFORD	24	11.6 (2.0)
1295	0	MA	WESTFORD	24	11.6 (2.0)
1326.92	0	NY	RIVERHEAD	348	3.5
2715	0	NJ	NEWARK	270	2.4
2715	0	NJ	NEWARK	271	1.5
2730	0	NJ	MCGUIRE	247	1.1
2745	0	NY	ISLIP	290	7.6
2745	0	NY	ISLIP	292	7.4
2755	0	NY	JAMAICA	268	3.1
2765	0	NY	NEWBURGH	306	2.3
2780	0	CT	WINDSOR LOCKS	358	2.2
2795	0	NY	WHITE PLAINS	295	3.3
2800	0	NJ	MCGUIRE	246	1.0
2830	0	RI	COVENTRY	37	2.2
2865	0	CT	BLOOMFIELD	356	7.1
2865	0	NY	ALBANY	330	3.8
2870	0	PA	PHILADELPHIA	242	5.3
2875	0	NY	BROOKHAVEN	321	32.6 (1.2)
2890	0	MA	BOSTON	42	5.0
2895	0	CT	BLOOMFIELD	356	7.1
2900	3100	CT	ORANGE	335	7.9
2900	3100	RI	NORTH SMITHFIELD	32	3.8
2900	3100	MA	WORCESTER	22	3.0
3100	3500	NJ	MOORESTOWN	248	8.2
3100	3500	NJ	MOORESTOWN	248	4.1
5603	0	NY	LA GUARDIA	280	10.1
5610	0	MA	BOSTON	41	4.0
5610	0	NJ	PENNSAUKEN	248	3.9
5620	0	NJ	WOODBRIDGE	266	6.2
5640	0	NJ	ATLANTIC CITY	230	4.1
5647	0	NY	NEW YORK JFK	272	11.4
9100	0	NY	CALVERTON	334	13.7
9410	0	NY	GOVERNORS I.	271	1.0
9475	0	NJ	SANDY HOOK	259	1.0
23600	24470	NJ	NEWARK	271	1.7
34512	35208	MA	OTIS	60	3.8
34512	35208	MA	HANSCOM	30	3.3

FRQ – Lower Frequency of emitter, in MHz
FRU – Upper frequency of emitter, in MHz. Value of '0' indicates the emitter operates at the discrete frequency of 'FRQ'
XSC – State in which emitter is located
LOC – Location of emitter
BRG – Bearing from the TWA 800 aircraft to the ground-based emitter, in degrees
FS VM – Peak electric field strength, in V/m. Where the emitter average electric field strength exceeded 1 V/m, the value for average electric field strength is reported in parentheses after the peak value.

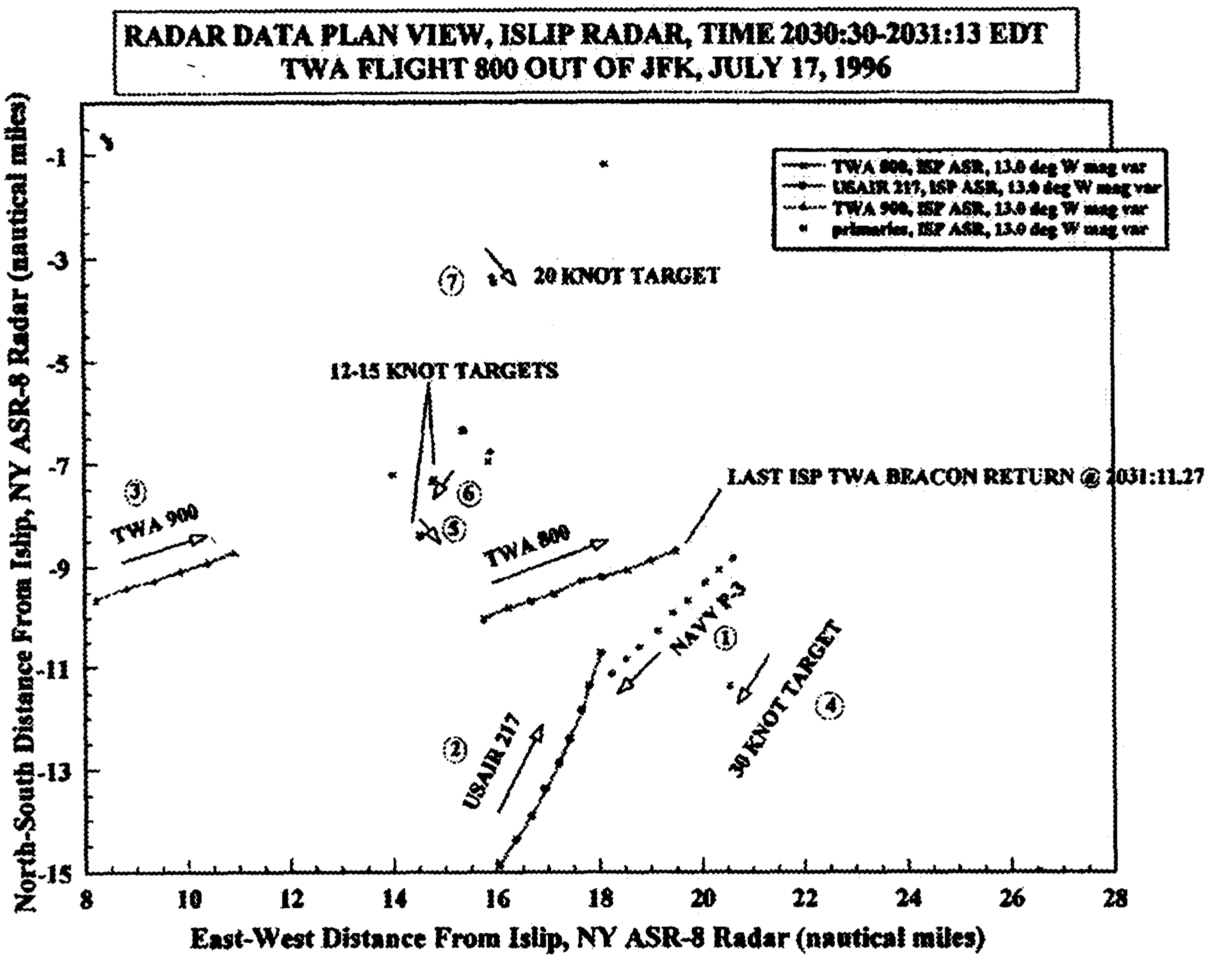

Figure 2-1. Composite Radar Data Plot (Reference 1-1)

AIRBORNE EMITTERS

Aircraft in the immediate vicinity of TWA Flight 800 at the time of the accident were identified by primary (skin reflection) and secondary (transponder) radar return plots presented at the accident investigation public hearing (Exhibit 13A, Reference 1-1) and through NTSB discussions with the USAF and USN. Figure 2-1, taken from Exhibit 13A, identifies the craft that were tracked between 8:28 and 8:32 p.m. on 17 July 1996. The aircraft identified from Figure 2-1, and other aircraft identified by the NTSB staff, are listed in Table 2-3.

The actual number and the operating frequencies of the navigation and communication equipments in the vicinity of the accident location are identified in Table 2-4 and 2-5, respectively. The number and operating frequencies of the airborne transponders and interrogators, altimeters, and radars, in the vicinity of the accident location, are identified in Tables 2-6, 2-7, and 2-8, respectively.

Table 2-3. TWA Flight 800 Aircraft Environment

Flight	Aircraft	From TWA 800		Altitude (ft)
		Distance (nmi)	Bearing (degrees true)	
US Air 217	B-737-400 (4B7)	2.5	218	17,000
AT 450	P-3C	2.9	207	20,000
TWA 900	B-747	8.7	270	19,000
AMTRANS 493	L-1011	9	340	30,000
JOLLY 14	HH-60G	10.5	359	300
KING 74	HC-130P	13	57	1,000
N1182J	AC-12	17	UNKNOWN	8,000
VIR 009	B-747	20.5	UNKNOWN	17,500
PDE 3112	MD-80	21.5	UNKNOWN	11,000
BBE 507	UNKNOWN	22	UNKNOWN	18,000
AZ 609	UNKNOWN	25	UNKNOWN	18,500
GRA 507	UNKNOWN	51.5	UNKNOWN	24,000
USAF	KC-10A	25*	UNKNOWN	UNKNOWN
USAF	C-141B	25*	UNKNOWN	UNKNOWN
* Note: Assumed distance separation				

Table 2-4. Number and Frequencies of Airborne Navigation Emitters

Number in Environment	Frequency (MHz)	
	Low	High
5	1025	1150
1	3390	3510
1	13320	13330
1	13325	13325

Table 2-5. Number and Frequencies of Airborne Communication Emitters

Number in Environment	Frequency (MHz)	
	Low	High
5	2	30
4	30	88
2	116	149
2	116	152
1	118	136
1	118	155.975
1	150	173
1	156	173.975
7	225	399.975
3	294.2	317.21
1	1626.5	1661

Table 2-6. Number and Frequencies of Airborne Transponders and Interrogators

Number in Environment	Frequency (MHz)	
	Low	High
2	1030	1030
6	1090	1090
1	8800	9500

Table 2-7. Number and Frequencies of Altimeters

Number in Environment	Frequency (MHz)	
	Low	High
5	4200	4400

Table 2-8. Number and Frequencies of Airborne Radars

Number in Environment	Frequency (MHz)	
	Low	High
2	8500	9600
1	9315	9375
1	9335	9415
2	9374	9376
1	9375	9375

SHIPBOARD EMITTERS

USCG and USN ships reported to NTSB staff as being in the accident area are listed in Table 2-9. Exact location (latitude and longitude) details are available for only the USCG ship. The mobile emitter slant ranges and bearing were determined from the NTSB accident investigation reports (Exhibit No. 13A, Reference 1-1) and the GSORTS file data (Reference 1-2). For those cases where bearings were provided as compass directions, the compass directions were converted into degrees for this report (i.e. NE, E, S, and SW were presented as 45, 90, 180, and 225 degrees, respectively).

The shipboard navigation emitters are identified by function and operating frequency in Table 2-10. Tables 2-11 and 2-12 provide the number and operating frequencies of the shipboard environment communications emitters and transponders/interrogators, respectively. The three shipboard systems with classified RF characteristics are identified in Table 2-13. The emissions of the three classified systems did not result in electric field strengths above 1 V/m at the TWA 800 accident location. The number and operating frequencies of the shipboard radars are identified in Table 2-14.

Table 2-9. Ship Platforms Considered for EME Determination

Military Service	Ship Number	Ship Name	From TWA 800 Distance (nmi)	From TWA 800 Bearing (degrees true)
USCG	WPB-1333	ADAK	5.4	12
USN	AOE-3	SEATTLE	43.4	270
USN	SSN-706	ALBUQUERQUE	121.5	90
USN	FFG-40	HALYBURTON	130.2	68
USN	CG-60	NORMANDY	156.3	180
USN	SSN-764	BOISE	217*	203
USN	TAO-189	JOHN LENTHALL	243*	158
USN	SSBN-742	WYOMING	252*	180
USN	SSN-649	SUNFISH	260*	180
USN	DDG-61	RAMAGE	269*	180
USN	FFG-47	NICHOLAS	278*	203
USN	CG-72	VELLA GULF	304*	180
USN	CG-66	HUE CITY	347*	135

* Note: Beyond 4/3 Earth Radius Radio Line of Sight

Table 2-10. Number and Frequencies of Shipboard Navigation Emitters

Number in Environment	Frequency (MHz) Low	Frequency (MHz) High
2	962	1213
2	9050	10000
1	9345	9427
1	9380	9440

Table 2-11. Number and Frequencies of Shipboard Communication Emitters

Number in Environment	Frequency (MHz)	
	Low	High
5	2	30
1	30	75.95
1	30	87.975
1	116	149
2	116	152
2	156.025	157.425
4	225	400
2	824	894
2	1636.5	1644.9
1	4945	4960
7	43500	45500

Table 2-12. Number and Frequencies of Shipboard Transponders and Interrogators

Number in Environment	Frequency (MHz)	
	Low	High
2	1030	1030
3	1090	1090

Table 2-13. Shipboard Electronic Warfare Emitters

Emitter Function	Frequency (MHz)	
	Low	High
Electronic Warfare System	Classified	Classified
Illuminator	Classified	Classified
Close In Weapon System (CIWS)	Classified	Classified

Table 2-14. Number and Frequencies of Shipboard Radars

Number in Environment	Frequency (MHz)	
	Low	High
2	850	942
1	3100	3500
1	5450	5825
1	8795	8855
2	9345	9427

SECTION 3 - RESULTS

The emitters that were predicted to have the potential to generate peak and average electric field strengths above 1 V/m are identified in the following tables. No mobile emitters, shipboard or airborne, could generate average electric field strengths above 1 V/m. Only two fixed emitters generated an average field strength above 1 V/m. Although many classified emitters were identified in the environment, none of them were close enough or powerful enough to generate peak or average electric field strengths above 1 V/m.

The functions, locations, and field strength values of the fixed emitters capable of generating peak and average electric field strengths above 1 V/m are provided in Table 3-1 and Table 3-2, respectively. The mobile emitters capable of generating electric field strengths above 1 V/m are provided in Table 3-3.

Table 3-1. Functions and Locations of Fixed Emitters Generating Peak Field Strengths >1 V/m

FUNC	FRQ	FRU	LOC	XSC	FS VM
Navail	420	435	MELVILLE	CT	1.7
Search	1294.6	0	RIVERHEAD	NY	17.9
Track	1295	0	WESTFORD	MA	11.6
Search	1326.92	0	RIVERHEAD	NY	3.5
GCA	2715	0	NEWARK	NJ	2.4
Search	2715	0	NEWARK	NJ	1.5
Search	2730	0	MCGUIRE	NJ	1.1
Search	2745	0	ISLIP	NY	7.6
GCA	2745	0	ISLIP	NY	7.4
GCA	2755	0	JAMAICA	NY	3.1
GCA	2765	0	NEWBURGH	NY	2.3
GCA	2780	0	WINDSOR LOCKS	CT	2.2
Search	2795	0	WHITE PLAINS	NY	3.3
ATC	2800	0	MCGUIRE	NJ	1.0
GCA	2830	0	COVENTRY	RI	2.2
Weather	2865	0	BLOOMFIELD	CT	7.1
Weather	2865	0	ALBANY	NY	3.8
Weather	2870	0	PHILADELPHIA	PA	5.3
Weather	2875	0	BROOKHAVEN	NY	32.6
Weather	2890	0	BOSTON	MA	5.0
Weather	2895	0	BLOOMFIELD	CT	7.1
Search	2900	3100	ORANGE	CT	7.9
Search	2900	3100	NORTH SMITHFIELD	RI	3.8
Search	2900	3100	WORCESTER	MA	3.0
Search	3100	3500	MOORESTOWN	NJ	8.2
Navail	3100	3500	MOORESTOWN	NJ	4.1
Weather	5603	0	LA GUARDIA	NY	10.1
Weather	5610	0	BOSTON	MA	4.0
Weather	5610	0	PENNSAUKEN	NJ	3.9
Weather	5620	0	WOODBRIDGE	NJ	6.2
Weather	5640	0	ATLANTIC CITY	NJ	4.1
Weather	5647	0	NEW YORK JFK	NY	11.4
Track	9100	0	CALVERTON	NY	13.7
Navail	9410	0	GOVERNORS ISLAND	NY	1.0
Navail	9475	0	SANDY HOOK	NJ	1.0
Search	23600	24470	NEWARK	NJ	1.7
Weather	34512	35208	OTIS	MA	3.8
Weather	34512	35208	HANSCOM	MA	3.8

FUNC – Function; GCA – Ground Control Approach; ATC – Air Traffic Control
FRQ – Lower Emitter Operating Frequency, in MHz
FRU – Upper Frequency of Emitter, in MHz. Value of '0' indicates the emitter opeates at the discrete frequency of 'FRQ'
LOC – City
XSC – State
FS VM – Peak Electric Field Strength, in volts per meter

Table 3-2. Functions and Locations of Fixed Emitters Generating Average Field Strengths > 1 V/m

FUNC	FRQ	FRU	LOC	XSC	AVG FS
Track	1295	0	WESTFORD	MA	2.0
Weather	2875	0	BROOKHAVEN	NY	1.2
AVG FS – Average Electric Field Strength, in volts per meter					

Table 3-3. Functions of Mobile Emitters Generating Peak Electric Field Strengths > 1 V/m

FUNC	FRQ	FRU	FS VM
Shipboard Radar	3100	3500	3.8
Shipboard Radar	5450	5825	1.2
Airborne Radar	8500	9600	23.8
Airborne Radar	9335	9415	1.7
Shipboard Radar	9345	9427	2.1
Airborne Radar	9374	9376	1.4
Airborne Radar	9374	9376	1.4

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