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NAVSECGRU SHORE ELECTRONICS CRITERIA

UNITED STATES NAVAL SECURITY GROUP COMMAND

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NAVSECGRU INSTRUCTION 2450.1

Subj: **NAVAL SECURITY GROUP COMMAND (NAVSECGRU) SHORE ELECTRONICS CRITERIA**

Ref: (a) SPAWARINST 2804.1 (NOTAL)
(b) DOD Directive C3222.5 (NOTAL)

Encl: (1) NAVSECGRU Shore Electronics Criteria Manual

1. Purpose. To present criteria and references applicable to the planning, installation, check-out, and performance of Communications Electronics (C-E) systems and equipment at NAVSECGRU shore elements as outlined in enclosure (1). The material in this instruction reflects acceptable practices, guidance, and standardization for system design and installation as set forth in references (a) and (b).

2. Background. The information contained in this instruction was previously published as SPAWAR 0101, 108B with the title NAVAL SHORE ELECTRONICS CRITERIA NAVAL SECURITY GROUP ELEMENTS. This instruction should be used in lieu of SPAWAR 0101,108B. NAVSECGRU shore elements located worldwide operate and maintain a variety of complex and highly automated electronic equipment, systems, and supporting communications in performing cryptologic mission responsibilities to satisfy national and fleet tasking requirements. Specific mission and function statements for NAVSECGRU and each associated shore element are outlined in NAVSECGRUINST 5450 series.

a. Mission and function(s) dictate design criteria to be considered in planning for a new facility or modification of an existing unit. Specific criteria applicable to particular functions are contained in this instruction, or reference is made to appropriate existing document(s) for applicable design/ installation parameters.

b. Criteria is presented for site surveys and performance checks to ensure site protection from Electromagnetic Interference/Radio Frequency Interference (EMI/RFI). Criteria concerning system configuration, interfacing of various elements of NAVSECGRU components, Electromagnetic Compatibility (EMC), site selection, and integration of systems into the shore complex is presented to aid personnel responsible for planning, engineering, installing, inspecting, checking-out, certifying, and accepting NAVSECGRU equipment and systems.

3. Scope. The complexity, variance, and conflicts between mission and support requirements must be accommodated when considering site and system selection for a NAVSECGRU facility. Often, requirements for site habitability or the requirements for an operational site to be as far removed as possible from industrial or housing areas, are in direct conflict with the criteria of this instruction. As such, prudence dictates a delicate balance between acceptable mission performance and support facility "quality of life." The criteria set forth by this instruction may be more stringent than criteria mandated by the Naval Facilities Engineering Command (NAVFAC) and other systems commands, but these additional requirements are necessary to ensure proper operation of a NAVSECGRU operational facility. Should a conflict arise between criteria contained in this instruction and criteria published in other military standards and instructions, the specific criteria contained herein is mandatory and will apply.

4. Action. Commanding Officers and Officers in Charge will ensure Shore Electronics Criteria outlined in this instruction are adhered to.

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ABBREVIATIONS

ANMS	Automated Noise Measurement System
BESEP	Base Electronic System Engineering Plan
BFG	Barrier Filter Ground
BFRL	Basic Facility Requirements List
CCIR	International Radio Consultative Committee
CDAA	Circularly Disposed Antenna Array
COMNAVSECGRU	Commander Naval Security Group
COMNAVCOMTELCOM	Commander Naval Computer and Telecommunications Command
DF	Direction Finding
ECP	Engineering Change Proposal
EFA	Electronic Field Activity
EFD	Engineering Field Division
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
HF	High Frequency
HFDF	High Frequency Direction Finder
HVAC	Heat, Ventilation and Air Conditioning
LFA	Lead Field Activity
LSR	Logistic Support Requirement
MF	Medium Frequency
NAVCOMTELSTA	Naval Computer and Communications Station
NAVFACENGCOM	Naval Facilities Engineering Command
NAVSECGRU	Naval Security Group
NAVSECGRUCOM	Naval Security Group Command
NAVCOMTELCOM	Naval Computer and Telecommunications Command
NCCOSC	Naval Command, Control and Ocean Surveillance Center
NEC	National Electric Code
NFPA	National Fire Prevention Association
NISE EAST	Naval Command, Control and Ocean Surveillance Center, In-Service Engineering, East Coast Division
NRAD	Naval Command, Control and Ocean Surveillance Center, In-Service Engineering, West Coast Division
PET	Performance Evaluation Technique
RF	Radio Frequency
RFI	Radio Frequency Interference
SIP	Standard Installation Plan
SNEP	Signal-to-Noise Enhancement Program
SPAWARSYSCOM	Space and Naval Warfare Systems Command

TIP	Teton Installation Plan
UPS	Uninterruptible Power System

CHAPTER 1
INTRODUCTION

1. General Command Relationships. NSA, SPAWARSYSCOM, NCCOSC, NAVFACENGCOM, and NAVCOMTELCOM are distinct in organization from NAVSECGRU, but each provides support in the design, acquisition, construction, installation and operation of NAVSECGRU elements. Under the NAVSECGRU CLASSIC TETON program implemented in 1995, SPAWAR system and its subordinate elements will play a decreasing role in the planning and installation of electronic systems at NAVSECGRU elements.

2. Basic Planning Procedures. Operational requirements developed by NSA and other operational sponsors will be directed to the appropriate NAVSECGRU element. NAVSECGRU element commanders are responsible for cryptologic site preparation and installation at their respective sites. They will use station resources and/or CLASSIC TETON assets located at certain NAVSECGRU sites to accomplish this responsibility. The CLASSIC TETON program provided NAVSECGRU elements with assets to support equipment/system installations. The CLASSIC TETON program provided a combination of government civilians, contractors and CTM enlisted personnel resident at IMDs and OIMDs located at certain NAVSECGRU sites. The IMD (or OIMD if assigned) will prepare a basic planning document governing the electronic and related phases of the shore electronics project. The task document identifies the shore element, provides a brief description of the requirement, the source of equipment and the operational requirement date. COMNAVSECGRU provides program management and resource sponsorship for CLASSIC TETON.

3. Installation Standardization. Installations at NAVSECGRU sites require a method by which site requirements/peculiarities may be identified and taken into account prior to systems/ equipment installation. To ensure complete and technically adequate system installation and performance, standard installation methodology, as discussed in Chapter V, will be employed.

4. TETON Installation Plan (TIP). The TIP is primarily a technical planning and management document with sufficient installation detail provided to enable evaluation of operational impact on users activities. The TIP translates a sponsor or user's statement of operational need into a technical description of shore electronics systems, equipment and devices to be used, their pertinent parameters, physical characteristics, environmental interface requirements and system performance objectives. It identifies the minimum installation criteria to

be applied. The TIP replaces the BESEP as the basic technical document governing electronics and other affected phases of shore site project planning and implementation at NAVSECGRU sites. The TIP incorporates features of the BESEP and of engineering planning documents used by NSA. The BESEP will continue to be used for those tasks performed by the SPAWAR engineering community. Reference (a) provides greater detail on BESEPs.

5. Standard Installation Plan (SIP). A SIP is an installation plan developed to support multiple-site installations of the same system/equipment. It is used to promote standardization, simplification and elimination of duplication. By using a SIP, logistic support may be improved and simplified and training costs associated with site installation projects/systems may be reduced. NAVSECGRU, the IMD's and, when applicable, the SPAWAR engineering community, jointly participate in the preparation of SIPs applicable to NAVSECGRU shore communications and cryptologic positions for improved configuration management and control. SIPs are developed to use as a tool to accomplish the standardization of shore equipment/system installations, regardless of geographical location. Where the requirements of a particular installation do not permit the practical application of a standard plan, the appropriate SIP can be used for general installation guidance with exceptions appended as required to meet the particular installation. Uniformity and standardization, while not the prime goals in themselves, do contribute to cleaner, more trouble free installations, ease of maintenance and cost effective documentation.

CHAPTER 2
SITE CRITERIA AND SYSTEM EFFECTIVENESS

1. General. This chapter is intended to provide general guidelines to be used in the selection and construction of NAVSECGRU operational sites in order to promote receiving system effectiveness.

2. EMC. System effectiveness or performance is a function of several factors including the following:

- Frequency bands and geographical area to be covered.

- Site selection in an environment which minimizes EMC and EMI problems.

- Site construction and equipment installation procedures which utilize the best available knowledge and criteria to ensure EMC of the diverse functions at a NAVSECGRU site.

- Prevention or reduction of external radio noise and interference encroachment.

In the modification of existing systems or the installation of new systems, an aspect often overlooked is the possibility of EMC problems resulting from the installation. Technical documents and BESEPs should contain positive statements that EMC considerations are part of the overall project. Where EMC problems exist or are anticipated, this instruction and reference (b) should be utilized. Electromagnetic Interference Characteristics Requirements for Equipment, MIL-STD-461D (revised 1992), should be invoked for the acquisition of all equipment and systems to be installed at NAVSECGRU sites.

3. Site Selection Criteria. For maximum system effectiveness, each NAVSECGRU DF and receiving site must be located so that site factors are compatible with mission requirements. Basic site factors include:

- Location providing maximum signal-to-noise ratio for all signals of interest.

- Location in a low radio noise environment, free from man-made noise encroachment and interfering signals.

- Location on flat terrain with good soil conductivity.

- Location suitable for construction at reasonable cost with space for expansion.

- Location with logistic convenience.

Although signal-to-noise ratios and site topography are primary considerations, the choice of a site usually involves engineering judgment based on "tradeoffs" of cost and system performance or effectiveness. Careful planning of the physical arrangement of electronic receive systems and support facilities should minimize electromagnetic compatibility problems and improve system effectiveness.

a. Site Selection Surveys

(1) Site selection surveys are required to determine the relative suitability for the establishment or retention of a site for NAVSECGRU functions. The provisions of USSID 526 and USSID 24 apply in the selection of new site locations and in the evaluation of the suitability of existing sites.

(2) Prior to an on-site evaluation, factors such as wave propagation, economic considerations, hearability results, and studies of topographical maps are considered in an overall site analysis by COMNAVSECGRU and higher authority. To ensure that essential information is provided for determining the technical suitability of a site with regard to mission performance and determining site support factors, the information collected by using the "Site Selection Survey Check List," Appendix A, is required. Site suitability factors discussed in the following paragraphs are especially important to mission performance. Appropriate authorities will determine political ramifications and acceptability of the proposed NAVSECGRU operational site.

b. Suitability of Location

(1) Topography. A visual inspection is necessary to determine topography and terrain conditions. The site must be substantially flat in all directions outward from the antenna field for at least one wavelength at the lowest operating frequency, and must have no more than a slight slope for at least one kilometer in all azimuths. Abrupt terrain irregularities must be avoided. Hills and mountains should not project to a vertical angle of more than three degrees (3°) above the horizontal measured from the base of the outer most antenna element which faces the obstruction.

c. Ground Conductivity

(1) Soil type and ground cover are indicative of ground conductivity. Pastoral or forest land with uniform vegetation and loam or clay soils are usually satisfactory. Dry, sandy, rocky soils are not desirable. Ground conductivity for NAVSECGRU receiving sites should be better than one-tenth of a milliseimen per meter. Soil with conductivity poorer than one-tenth of a milliseimen will result in greater horizontally polarized signal strengths and decreased direction finding accuracy. Table 2-1 lists typical characteristics of soil types.

(2) Any large underground metallic masses within six meters of the earth's surface within the antenna field should be avoided or removed prior to site construction. Large metallic masses buried outside but within 200m of the antenna field should be removed if closer to the earth's surface than 6m minus 0.03 times the object's distance from the antenna field. Underground conductors which are necessary for the operation of the site, such as pipes, cables and wires should be buried to a depth of at least one meter.

d. Re-Radiating Structures and Obstructions. It is necessary to ensure that NAVSECGRU receiving sites are located sufficiently distant from re-radiating sources and obstructions in order to reduce the effects of changes in received signals. Re-radiating structures and obstructions are particularly insidious in close proximity to direction finding antennas where even the slightest distortion, whether by reduction, bending or reinforcement of the incident signal, cause errors to be induced in the apparent bearing. Table 2-2 provides a guide for the citing of NAVSECGRU DF facilities with minimum bearing error. In the category of re-radiating structures and obstructions, all buildings (regardless of type of construction material), other antenna towers and dishes, fences, poles, trees, etc. must be included. Trees and wooden poles should be considered in the same category as buildings and other obstructions. Normally, a wooden pole is not considered to be a good conductor. However, a living tree or wet wooden pole definitely has a measurable conductance and typical ground constants and conductivity values as such should not be introduced into, or allowed to grow into, the antenna field or subtend the vertical clearance zone.

NOTE: The obstruction criteria described in the preceding paragraphs and outlined in Table 2-2 are not intended for prevention of EMI and noise encroachment; they are to minimize wave reflections and refractions. See Chapter 4 for EMI prevention requirements. In Table 2-2, wavelength is based on a frequency of 2 MHz.

4. Construction Criteria. General construction criteria for NAVSECGRU facilities are included in Chapters 2 through 8. The remaining sections of this chapter provide specific site construction criteria for DF antennas/facilities. Procedures, methods, and materials for maintaining AN/FRD-10 structural and mechanical subsystems are contained in SPAWAR 0967-437-9010/NA-VFAC-109A, Maintenance Manual for Antenna Groups OA-3967 (XN-1)/FRD-10 (V) and OA-3967/FRD-10 (V). Electronic maintenance procedures for the AN/FRD-10 System are contained in SPAWAR EE110-SC-MMO-010/W144-FRD-10, CDAA Electronic Maintenance (AN/FRD-10). The following construction criteria must be maintained throughout the operational life of the CDAA. Each requirement was based on extensive research at the Naval Research Lab and the Radio Location Lab, University of Illinois beginning as early as 1947. Over the years various non-compliant deviations occurred even though very few waivers were granted. Most deviations resulted from a lack of understanding of CDAA design capabilities and functions. Deviations and alterations can have an impact on direction finding accuracy and signal reception.

a. A self-supporting DF facility consists of two distinct areas, operations and logistics or support. The support area must be located in such a manner as to eliminate or minimize interference to DF operations. A typical DF operations area requires approximately 180 acres of clear land for an AN/FRD-10 and approximately 20 acres of clear land for an AN/FRD-13. Buffer zones require additional land.

b. AN/FRD-10 DF Sites. Figures 2-1 and 2-2 show a typical plot plan and view of an AN/FRD-10 HFDF site. This is a wide aperture receiving system utilizing the Wullenweber antenna configuration which is commonly referred to as the CDAA. Extreme care must be exercised in planning and constructing or making alterations and modifications to the operations building and antenna structure. Coupling between arrays and nearby metallic objects will affect the antenna patterns; deviations from construction criteria can have a negative impact on site performance and are not acceptable.

NOTE: The location of all buried cables will be marked with permanent signs that contain a warning prohibiting excavating in the area and designate a point of contact for approval to dig. (Note: RG-85 transmission lines can not be replaced; there is only one cable splice kit in existence and the process is cumbersome and expensive).

(1) The cables are made electrically equal (phase-matched) by using the method as described in SPAWAR 0967-437-9010 NAVFAC MO-109A, Maintenance Manual for Antenna Groups OA-3967(XN-1)/FRD-10(V) and OA-3967/FRD-10(V).

(2) Parking Areas. Parking areas inside the antenna array should be located only in those areas where there are no buried antenna transmission lines, such as between antenna quadrants. If parking over buried transmission lines proves to be necessary, care should be taken by installing a barrier which limits parking to passenger vehicles only and by using only NAVFACENGCOM approved methods and materials for parking surfaces that will evenly distribute the vehicular load. Parking facilities outside the array will not be allowed from the high-band antennas to 1000′ outward.

TYPE OF TERRAIN	RELATIVE DIELECTRIC CONSTANT	TYPICAL CONDUCTIVITY (Siemens/meter) (S/m)
Sea water	70	5
Fresh water	80	0.003
Wet ground	30	0.01
Pastoral, low hills, rich soil	14 to 20	0.01 to 0.03
Rich, agricultural land with low hills	15	0.001
Medium dry ground	15	0.001
Rocky soil, steep hills	14	0.002
Pastoral land, medium hills/forestation	13	0.005
Pastoral, medium hills, forestation, heavy clay	13	0.004
Marshy, forested, flat land	12	0.008
Dry, sandy, flat coastal areas	10	0.002
Mountains, hills up to 3000′	5	0.001
Cities, residential area	5	0.002
Cities, industrial area (average attenuation)	5	0.001
Cities, industrial area (maximum attenuation)	3	0.001
Very dry ground	3	0.001

Table 2-1
Typical Ground Conductivity Values

	AN/FRD-10	AN/FRD-13
VERTICAL (OR INCLINED) CONDUCTORS	Must not extend above a three degree (3^0) angle measured from the base of the high-band antenna.	Must not extend above a two degree (2^0) angle measured from the base of the low-band antenna.
BURIED HORIZONTAL CONDUCTORS	Bury antenna transmission lines to minimum depth of 1/2 meter between building and the inside edge of ground mat, and minimum depth of 1 meter beyond the inside edge of ground mat. No other conductors within 656' (200 m).	
WIRE FENCES (outside antenna array)	Must be at least 656′ (200 m) from the base of the outer most antenna element and circularly symmetric. Electrical bonding every 5' required. Welded galvanized material must not be used.	
LARGE CONDUCTING SURFACES (all types buildings)	A flat surface one λ long by one λ high should be 25 λ or more from antennas. Distance directly proportional to area. Must not extend into vertical clearance zone.	
TREES AND WOODS	Distance proportional to tree height. Must not extend into vertical clearance zone.	
RAILROAD, STREETCAR OR OTHER METALLIC TRACK SYSTEMS	At least 0.62 mi (1 km) separation from antenna field.	
HILLS AND MOUNTAINS	Hills must be at least 20 times their height away from nearest antenna element. Mountainous country not suitable.	
COASTLINES	Refractions not important.	
ROADS	Must be at least 1500′ (458 m) from antenna field.	
PARKING AREAS	985′ (300 m) from nearest antenna.	492′ (150 m) from nearest antenna.
RUNWAYS, REINFORCED CONCRETE	Minimum distance of one λ at 2 MHz-492′ (150 m). Ignition RFI studied on a case by case basis.	
DITCHES	Deep, straight ditches within 328′ (100 m) of the antenna should be filled or covered with wire netting.	

Table 2-2
Site Selection and Construction Criteria for Minimum Bearing Error

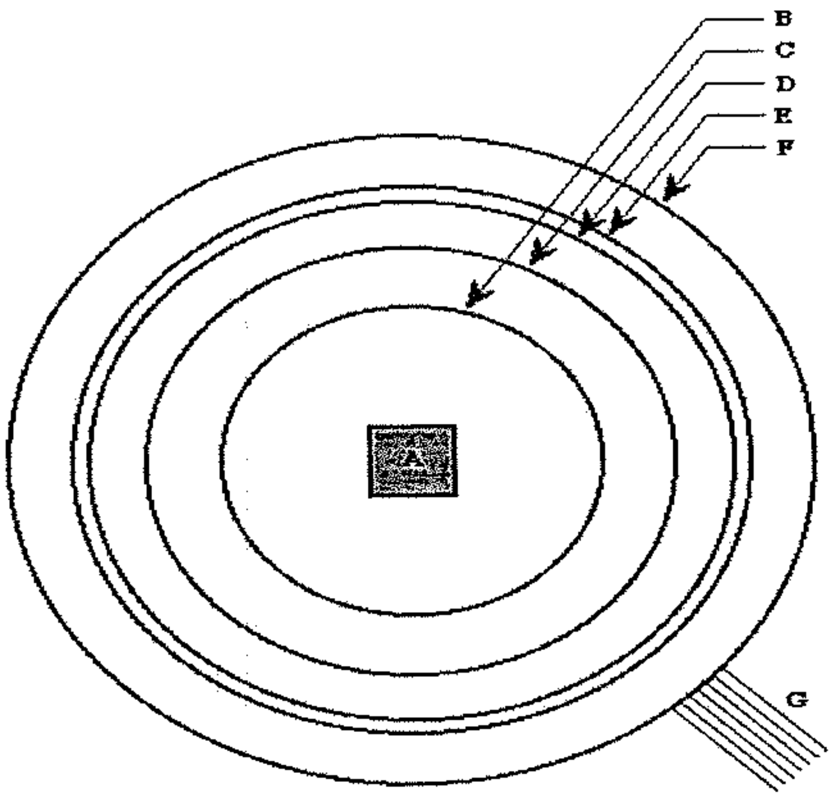
(3) Miscellaneous. Utility or other small buildings are permissible inside the antenna array, given they are not built over buried cables and do not interfere with security fence requirements. Security fences must be a minimum of 30′ (9.14m) from the operations building and at least 20′ (6.09m) from the low-band screen poles (DIAM 50-3, OPNAVINST 5530.14). Microwave towers and antennas should be located on the roof of the operations building as near the center of the array as possible and should not extend above the low-band screen.

c. AN/FRD-13 (V) (PUSHER) DF Sites. Figure 2-3 shows a typical plot plan of an AN/FRD-13 HFDF site. The AN/FRD-13 (V) system is a modified version of the commercial Plessey Type AX-33 Multiple Beam HF receiving antenna and Plessey Type DF-1 HFDF equipment. The antenna system is a small scale CDAA which operates in the HF spectrum. The antenna system consists of high-band and low-band antenna arrays and high-band and low-band omni-directional antennas (search monopoles). As opposed to the configuration of the AN/FRD-10 (V), the operations building associated with the AN/FRD-13 (V) is located outside the main antenna array. The RF Signal Distribution System is located within a center hut located at the center of the antenna array. RF transmission cables from the antenna elements to the center hut will be phase matched.

(1) General Site Construction Criteria AN/FRD-13 (V). The site will be symmetrical over as large an area as possible. Grading will be as follows:

- No specific tolerance is required inside the annular ring circumscribed by the high-and antenna elements. However, symmetrical conditions should prevail, with adequate slope away from the center hut to allow for proper drainage.

- The area from the high-band elements, covered by the radial ground mat, must have a maximum slope of 2° downward, will not have an upward slope and must be level to within plus or minus 4″ (10.16cm).



A. Operations Building.
B. Low-Band Screen (Radius 366 feet [111.55m]). Inner Edge of Ground Mat.
C. Low-Band Antennas (Radius 393.5 feet [119.93m]).
D. High-Band Screen (Radius 423.5 feet [129.08m]).
E. High-Band Antennas (Radius 436.75 feet [133.12m]).
F. Outer Edge of Ground Mat (Extends 127.5 feet [38.86m] from inner edge).
G. Radials (One every degree extending 150 feet [45.72m] in length from outer edge of ground mat.)

Figure 2-1

Typical Plot Plan for AN/FRD-10 HF Direction Finder

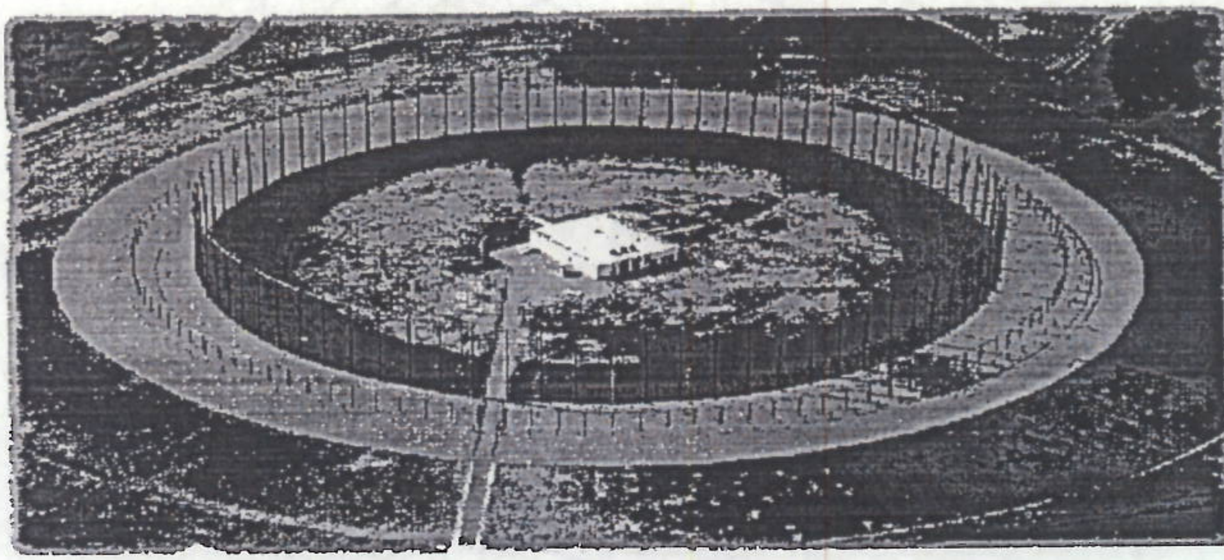


Figure 2-2

AN/FRD-10 Circularly Disposed Antenna Array

- Contours of the area appearing from the center hut wire ring and the end of the ground radials will be concentric circles centered on the vertical axis of the array.

- An overall site tilt of less than one-tenth of one degree must be maintained.

(2) HIGH-BAND Array Criteria (AN/FR-13) Antenna Elements

- Number of elements - 24

- Type of elements: High-fed monopole

- Frequency range: 10 to 30 Mhz

- Element height: 20.6′ (6.27 m)

- Element location: Located on a ring 164′ (50.0m) from the array center and spaced every 15°. Location of the antenna elements will be accurate to within 4″ (100mm).

- Guying: Prestressed, aramid fiber continuous filament rope with extruded protective outer jacket (black olefin copolymer or equal) for abrasion and ultra-violet protection.

(3) LOW-BAND Array Criteria (AN/FRD-13) Antenna Elements

- Number of elements: 24 (doublets)

- Type and configuration: High fed monopole doublet (48 monopole antennas connected in radial pairs as 24 doublets)

- Frequency range: 1.5 to 10 MHz

- Element height: 39.6′ (12.07m)

- Element location: On concentric rings of diameter, (inner) 419.95′ (128m); (outer) 492.13′ (150m) measured from and centered on the vertical axis of the array. Measurements of antenna element locations will be accurate to within 4″ (100 mm).

- Each of the low-band doublet pairs has a combiner network located between the associated elements. The doublet pair combiners are installed on a 473.6 foot (144.3m) diameter circle between the monopole doublets.

- Guying: Prestressed, aramid fiber continuous filament rope with extruded outer jacket (black olefin copolymer or equal) for abrasion and ultra-violet protection.

(4) Omni-Directional Antennas (Search Monopoles). The AN/FRD-13 (V) search monopoles consist of two omni-directional antenna assemblies, one high-band and one low-band, essentially identical to the antenna assemblies used within the main antenna array. The Omni antennas are located a minimum of 300m from the main antenna array and at least 300m from the operations building. In addition, the Omnis must be separated from each other by at least 200′ (60.9m) to avoid mutual coupling effects.

(5) Ground Mat Criteria. The ground mat associated with the AN/FRD-13 main antenna array consists of a grounding ring 30′ (9.14m) in diameter placed symmetrically around the center hut and connected to driven ground rods which are 25′ (7.62m) in length. Connected to the center grounding ring are 120 radial wires placed every three degrees and radiating outward to a nominal radius of 577′ (175.86m). Four additional rings are connected to the radials at each antenna element circle and combiner circle. All radials and rings will be #6 AWG solid copper wire and wherever two wires cross, the junction will be brazed, silver soldered or joined using an exothermic welding process such as CADWELD. A poor electrical bond may cause RF interference, therefore it is important that the process be performed by trained personnel.

(a) The ground mat associated with the search omni-directional monopoles will be a counterpoise system consisting of four 17 foot (5.18m) lengths of PVC insulated #6 AWG copper wire. Each wire is connected at its midpoint to the corner lug on the antenna base plate and laid in the form of eight equally spaced radials (45°). The radials will be connected to individual aluminum T-section ground stakes to provide electrical connection and secure the ends of the radials.

d. AN/FLR-9 DF Sites. Where NAVSECGRU elements are tenants at Army or Air Force commands, the host military command provides for the DF system installation, operation, maintenance and EMI protection. Generally, the AN/FLR-9 DF antenna system is used at Army and Air Force installations. The AN/FLR-9 Antenna Group is a large scale CDAA. It differs from the AN/FRD-10 CDAA structure and layout in that the FLR-9 has three concentric circle antenna arrays rather than two (the HF spectrum is broken into three bands), and the operations building is located outside the CDAA. For additional details refer to Technical Order 31S6-2 FLR-9-122-1.

e. Non-DF General Receiving Sites. Not all NAVSECGRU elements have DF functions; some only have general receiving or communication functions. For Non-DF sites, antennas will be installed per standard installation plans, general guidance of this instruction, and specific manufacturers installation guidelines.

(1) Buffer zones or minimum separation distances from obstructions or re-radiating structures are particularly important to ensure the intended signal of interest is received without distortion. General receiving antennas with similar polarization should be spaced a minimum of two wavelengths from each other based on the lowest design frequency of the antennas.

(2) In order to achieve maximum signal reception, general receiving antennas should be located such that no structure of significant size (e.g., buildings, towers, etc.) protrudes into a vertical clear zone measured from the edge of the antenna field outward at an angle of 5°. For specific receiving antennas such as satellite systems, the vertical clearance zone is 2°.

(3) General receiving antennas (non-DF) should be spaced a minimum of 100m or 2 wavelengths, whichever is greater, from any above ground power line, even a non-operational one.

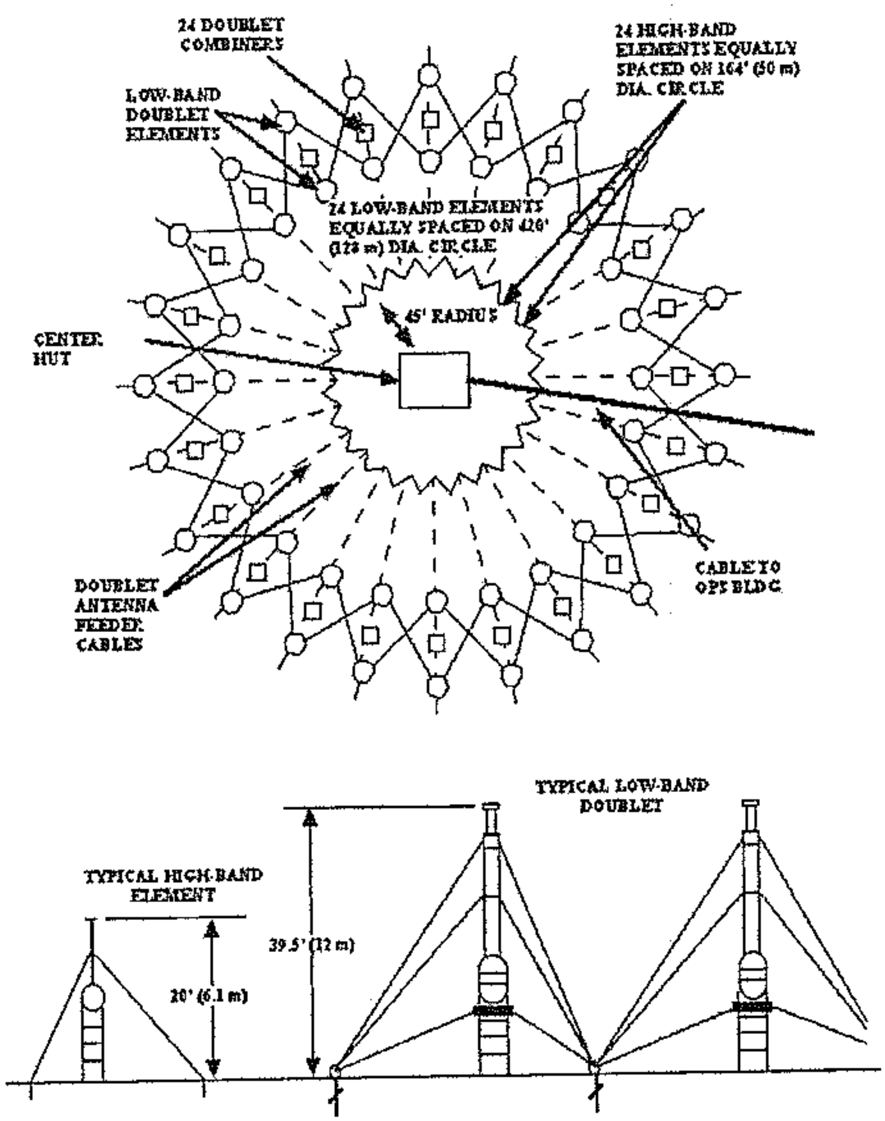


Figure 2-3

AN-FRD-13 (V) System, Typical Installation

CHAPTER 3
BUILDING CRITERIA

1. General. The tasks associated with the construction of new facilities or major modifications of existing facilities are accomplished under the supervision of the NAVFACENGCOM EFD. NAVSECGRU elements are housed in permanent buildings that are designed to promote operational efficiency as well as to provide environmental protection and physical security for equipment and data. Each building is specifically located and tailored for the functions it performs.

2. Facility Design. The prime consideration of NAVSECGRU building design is to facilitate the installation, operation, and maintenance of the electronic equipment used in the accomplishment of the NAVSECGRU element mission. Administrative areas, personnel support requirements, and physical security separation requirements must also be met. The possibility of storm, earthquake, and other natural or man-made acts should be taken into account in the facility structural design. During the design phase, not only should current requirements be addressed, but also reasonable future mission expectations and installation requirements. The initial design and location of the operational facility should provide for additional expansion by addition to the existing structure.

a. Operational Facility Structure. NAVSECGRU buildings should be permanent structures of masonry, metal or concrete. Recent technical developments indicate that for CDAA sites, metallic exterior surfaced structures (situated inside the HFDF array) provide a better operational environment with regard to both internal and external RF interference rejection.

NOTE: In order to reduce electromagnetic noise generation and the resultant impact on mission performance, all masonry or concrete structures will be constructed using welded joint rebar or non-conductive fibrous polymer resin reinforcing bars.

b. Operational Facility Features. Architectural and engineering planning for NAVSECGRU facilities must address the following special considerations:

(1) Structural and interior walls

(2) Roofs

(3) Ceilings and ceiling treatments

(4) Floors and flooring systems

(5) Lighting requirements, both internal and external

(6) Environmental control

(7) Acoustics

(8) Facility grounding and bonding

(9) Fire protection

(10) Physical security (buildings and perimeter)

3. Facility Design Criteria. The basic criteria governing the design and construction of NAVSECGRU facilities is contained in the following publications, except as specifically modified herein:

NOTE: Unless specifically listed, the following referenced DM indicate the DM number series.

- MIL-HDBK-1190. A manual written for facility commanders as a guide for new construction, repair, and renovation of existing permanent and temporary facilities.

- MIL-HDBK-1002. This manual is the basis for determining the loading factors and structural strength of proposed structures.

- MIL-HDBK-1003

- MIL-HDBK-1004. This manual provides the design considerations for facility electrical power distribution systems, lighting systems, emergency power and lightning protection.

NOTE: MIL-HDBK-1004 should only be consulted for electrical safety purposes and other matters that do not conflict with this instruction. Power distribution, bonding and grounding requires special consideration at modern signal processing sites. Treatment of RFI/EMI problems is beyond the scope of most military instructions traditionally applied to communications facilities.

- NAVFAC DM-5. This design manual provides considerations for surveys, drainage, roads, walks, fencing, water supply and pollution control.

- MIL-HDBK-1012/1. This series presents design criteria and guidance for communications facilities, antennas, transmission lines, and High Altitude Electromagnetic Protection techniques.

NOTE: MIL-HDBK-1012/1 should only be consulted for subject matter that does not conflict with Chapters 5-8. Electrical/electronic requirements to mitigate electromagnetic interference require an engineering approach that deviates from traditional military documents that were prepared when communications facilities used teletype equipment rather computers.

- DCID 1/21

- DCA Circular 1A, 1B, 2 and 3

- OPNAVINST 11010.20E. This manual not only provides detailed guidance for the administration of facilities at Naval Shore Activities, but also outlines the Special Project Step I and Step II and MILCON process.

NOTE: For facility construction or modification at NAVSECGRU sites, application of the above referenced design manuals and criteria will be accomplished in coordination with the CNSG (N44).

CHAPTER 4
ELECTROMAGNETIC COMPATIBILITY

1. General. This chapter presents planning criteria and judgment factors for engineers, system sponsors and site personnel involved in the planning process for facilities and equipment installations at NAVSECGRU receiving facilities. The factors presented, if judiciously applied throughout all phases of the planning process, will readily address concerns dealing with site encroachment, EMI/RFI and the overall operational compatibility.

2. Primary Requirements. The primary considerations in the selection of any NAVSECGRU shore receiver site is the suitability and technical adequacy of the site for meeting the mission performance objectives. Generally, the main objective when choosing a receiver site is to obtain maximum signal-to-noise ratio by the sites receiving equipment. This applies not only to new sites but to existing ones where a compatible operational relationship between current and proposed installations must be considered.

NOTE: Technical adequacy encompasses site topography and EMI/RFI.

All aspects leading to the initial selection and proper follow-on development of a NAVSECGRU receiver site must be understood and applied to the site development plan (area master plan). These considerations must be taken into account in arriving at the basic requirements for a project and should be cited in all project planning documents. These planning documents should contain detailed resource requirements for the proposed receiving facility and set forth technical details concerning system installation and site selection.

3. Site Performance and the Electromagnetic Environment. The effective performance of a NAVSECGRU receiving or DF system is dependent on several factors. Two factors of particular significance are equipment design parameters and the nature of the electromagnetic environment in which the system is intended to operate. Since an established NAVSECGRU receiver site represents a substantial investment, system degradation from man-made radio noise must not be allowed. In order to fully understand the effects of EMI/RFI on operational systems a basic knowledge of the nature of radio interference (noise) and the resultant impact on operational receive systems is necessary.

a. Electromagnetic Definitions

(1) EMC. The ability of equipment and systems to function as designed without degradation or malfunction in their intended operational environment.

(2) EMI/RFI. Internally or externally generated noise, man-made or natural, that masks or otherwise interferes with a system's ability to receive or process signals of interest.

4. Noise. In every receiving system strong signals and noise are the limiting factors that determines whether the desired signals are usable. Two of the most significant categories of noise with which RF signals must compete are atmospheric and man-made.

a. Atmospheric Noise. Earth-bound or terrestrial noise generated by natural phenomena. The largest portion of this noise is generated by electrical discharges in the atmosphere (lightning strikes, etc.).

b. Man-Made Noise. Man-made radio noise is generated by transmitters, power lines, electrical devices, such as switches and relays, diathermy devices, RF-stabilized arc welders, ignition systems of gasoline engines and digital devices and equipment (including electronic switching devices, computers and data processing equipment). Harmful levels of man-made noise can originate from sources that are both internal and external to a site. Man-made noise is typically higher in areas that use overhead distribution power lines than areas that employ underground power lines.

(1) Man-made noise is frequently the performance limiting factor at radio receiving sites where urban or suburban encroachment has become a problem. Extensive field experience has shown that overhead power lines are the primary source of RFI/EMI encroachment regardless of the type of area-urban, suburban or rural. Areas that employ underground power are rarely a source of external RFI/EMI. In the absence of man-made noise, atmospheric noise is usually the factor that determines the minimum usable signal. The tremendous energy released by electrical discharges in the atmosphere is transmitted over considerable distances by the same propagating mechanism as a HF radio signal. Thus, the intensity of atmospheric noise or static follows the propagation conditions, high when conditions are favorable for long distance propagation, and low when conditions are such that the only static to reach the receiver is that which is generated locally.

c. Noise, An Assessment of the Problem. Extensive field investigations by the NAVSECGRU SNEP teams have shown that the operational performance of most NAVSECGRU receiving sites is being degraded by strong signals and noise from a combination of internal and external sources. Figure 4-1 depicts the source to victim model. A convenient way to assess the impact of man-made noise on site performance is to examine both the desired signals and the undesired man-made noise levels present at the input to each receiving system. In most sites this can be accomplished by observing and measuring noise and signals at the output of the site's RFD system.

(1) External noise can be divided into the following two categories:

NOTE: Any nearby external noise source within line of sight of the highest point of the receiving antenna has the potential to degrade site performance categories.

(a) Noise from distant sources:

- Jamming signals
- Sounder signals
- Out-of-band ISM Signals
- Unauthorized transmissions and signals from faulty transmitters

(b) Noise from nearby sources:

- Power-line hardware noise
- Out-of-band ISM signals
- Gasoline engine ignition systems
- Industrial processes

(2) Noise sources internal to the receiver site must also be considered and are divided into noise located within the RFD system, and noise sources external to the RFD system but emanating from sources within the facility. Inside noise source emanations can be conducted or radiated outside the facility and re-enter the facility and the RFD system by way of the receive antennas. Therefore, an internally generated noise source can also be included in the external source category. This is shown in Figure 4-1 by the dotted vertical line. Typical examples of noise generated within the RFD system are:

- Intermodulation products created by overloading active devices
- Intermodulation products caused by loose connectors or improper connections in the RFD system
- Switching transients

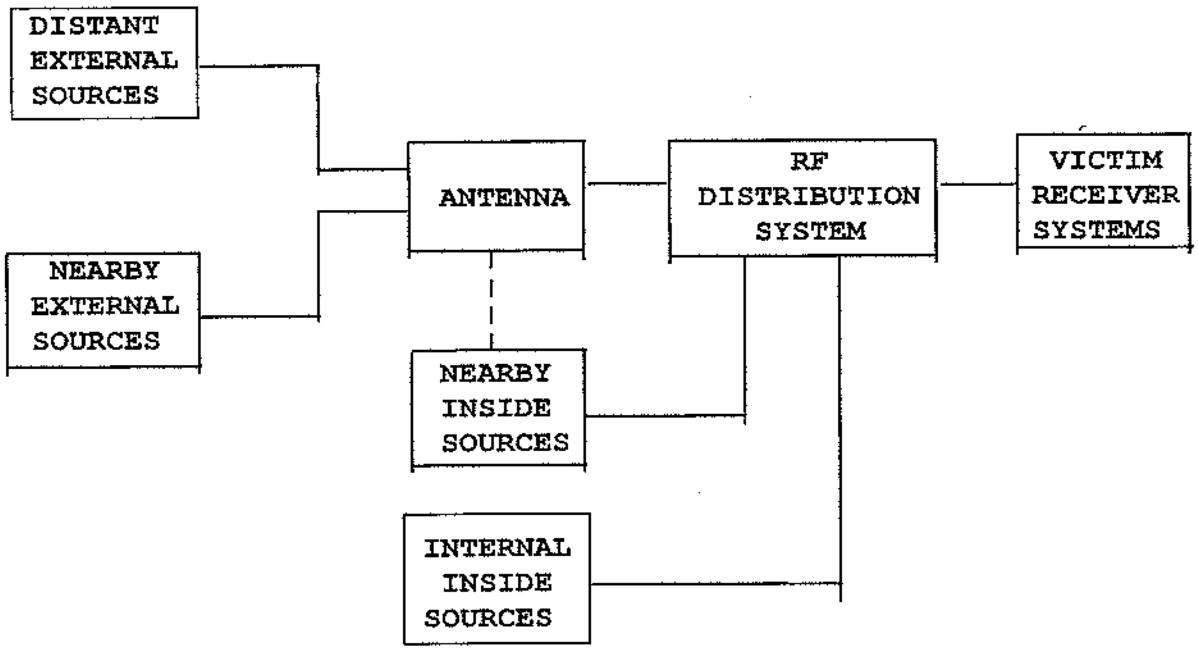


FIGURE 4-1
SOURCE TO VICTIM MODEL

- Parasitic oscillations caused by unstable active devices
- Undesired signals and noise that are fed back into the RFD via the receiving system

(3) Examples of noise injected into the RFD system by sources outside the RFD, but within the facility:

- Coupling of electromagnetic fields into coaxial cables (especially prevalent into single shielded cable), components and systems

- Inductive and capacitive coupling of extraneous signals and noise from one conductor (or cable) to another conductor (or cable)

- Direct conduction of extraneous signals and noise from their source(s) into the RFD system over grounds, power conductors, and coaxial cable shields

(4) A combination of any of the above interference sources may exist thus constituting multiple paths from the noise source to the victim receiving system.

d. Noise, Impact on Site Performance. The proliferation of digital systems, commercial long haul transmitters and the increase in active system components employed within NAVSECGRU receive sites, has increased the site's susceptibility to RF spectral pollution. Since extraneous signals and noise from both internal and external sources appear in the output of the site's RFD System, a method of differentiating between the various kinds/sources of signals and noise is needed. The SNEP team, employing a wide-band measurement system, has been able to display the temporal and spectral details of each signal/noise source. This wide-band system is able to cope with both stationary and nonstationary noise conditions. When substituted for the victim site receiver, the composite collection of normal signals, extraneous signals, and noise can be examined, categorized and evaluated. Using the measurement system, the spectral and temporal characteristics of extraneous signals and noise can be related to that of signals of interest. By establishing a relationship between the desired signals and the extraneous signals/noise, the impact of noise on the site's ability to perform its mission may be approximated, as depicted in figure 4-2.

(1) Since receiver sites must handle a variety of signal formats, multiple sets of relationships are needed to completely

evaluate a site's overall performance. Given a single dominant type of receiving system, sometimes a single performance criteria can be applied. Figure 4-2 is based on the measured average population of signals in the HF spectrum (including large complexes of high-powered HF broadcast stations) at sites located within one ionospheric hop of target signal sources. Because performance rating is subject to a number of variables (ionospheric conditions, activity of multiple noise sources, frequency, equipment adjustments, RFD losses, etc.), a precise single rating for a site is not feasible. However, deriving a rating curve similar to the illustrative curve in Figure 4-2 will give an approximation of a sites ability to receive and process desired signals. Figure 4-3 provides a similar means to evaluate the impact of man-made noise on the performance of receiving sites located two ionospheric hops from the target signal source.

(2) The PET is useful:

- to evaluate the impact of EMI and other site factors on the ability of a site to detect SOI.

- to quantify the amount of degradation from each factor that affects performance of a site.

- to provide site managers with the information needed to place meaningful priorities on mitigation actions.

For information on how to derive and interpret these curves, known as the PET, contact the SNEP Program Manager at CNSG (N44).

5. Noise and Interference Measurement. Experience has shown that EMI/RFI problems constantly arise where receiver sites are in close proximity to transmitters or other emitting devices (power lines, industrial complexes, etc.). To adequately assess and correct the situation where NAVSECGRU receiving facilities have been degraded by man-made RF noise, various research/mitigation programs have been initiated. NAVSECGRU has established a comprehensive EMI/RFI Engineering-Navy program to answer questions concerning instrumentation, measurement parameters, test procedures, noise characteristics, correlation of noise vs. system performance and education/training. This program is supported by the SNEP and the ANMS. Noise and EMI surveys at various NAVSECGRU receiver sites substantiate the need for periodic noise surveys and a standardized measurement approach. The noise standards and survey/monitoring program discussed in the following sections and Appendix A are intended to provide awareness and a means to make meaningful analyses of noise levels at NAVSECGRU field stations.

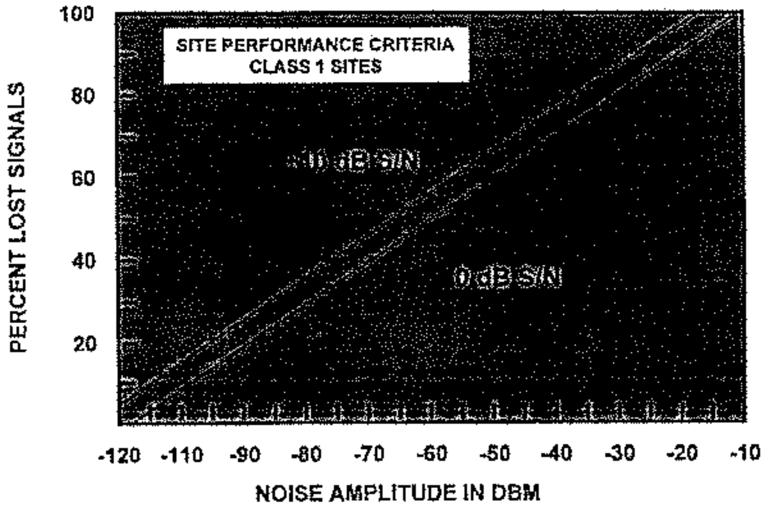


Figure 4-2

Site Performance Criteria for 1-Hop Conditions

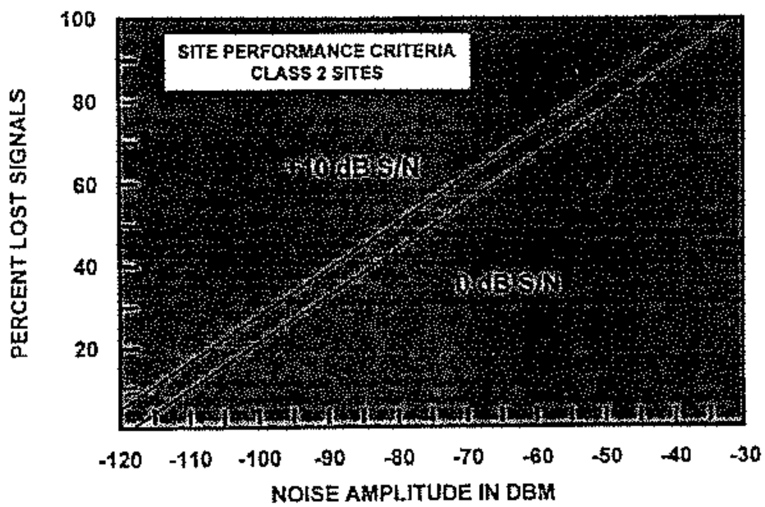


Figure 4-3

Site Performance Criteria for 2-Hop Conditions

a. SNEP. The SNEP was formed to fulfill the need for a source of HF RF engineering expertise directed toward the preservation of operations at NAVSECGRU sites. SNEP is a cadre of professionals and technicians formed primarily to investigate specific site interference problems, develop noise measurement procedures and applications, and enact interference mitigation techniques. Specific program objectives:

- Determine measurement procedures and specifications for survey instrumentation that will adequately predict system performance.

- Establish procedures for the identification, understanding and mitigation of specific interference problems at NAVSECGRU sites.

b. ANMS. The ANMS is a system developed by NRAD Activity, Hawaii. The ANMS was incorporated into the AN/FRM-19 Test System and measures the minimum RMS noise power and voltage deviation ratio on all monitor and omni beams at NAVSECGRU CDAA sites as a function of:

(1) Frequency: 2 to 32 MHz

(2) Azimuth: Determine the direction of noise sources

(3) Time: Determine daily noise fluctuations

(4) Day-of-the-week: Determine changes due to the weather or local industrial conditions (weekday vs. weekend)

The ANMS records the time-domain waveform of highly impulsive noise automatically during a seven day period for later analysis (FFT, APD, etc.). The system also measures the strong signal levels from 2 - 32 MHz used to baseline the highest levels. Specific objectives of the ANMS:

- Document changes to the ANMS measured site noise baseline over time or after mitigation procedures are performed.

- Automatically measure strong signal levels at NAVSECGRU CDAA sites to determine if they may cause intermodulation products in the system.

- Develop a standard measurement technique which can be used to establish a database and compare measurements between NAVSECGRU sites.

c. Noise Mitigation. The SNEP teams have shown that it is possible to make large-scale improvements in the performance of HF receiving sites with relatively modest efforts. But, these efforts must be specifically directed toward the mitigation of those specific sources of man-made noise that have proven to cause degraded system performance. Generalized noise isolation and mitigation approaches that apply to all sites are costly and usually will not provide sufficient information to locate and correct sources of noise.

(1) Guidance to enable site commanders/operators to control or mitigate RFI/EMI is still evolving. The PEACS courses have provided on-site awareness training to NAVSECGRU personnel. DoD Directive C3222.5 provides guidance for assessing, reporting, managing and controlling harmful interference at SCE sites. Several mitigation instructions, such as, Power Line Mitigation and Mitigation of EMI from Internal Sources are under development. For information on the availability of noise mitigation instructions, contact the EMC Program Manager at CNSG (N44).

6. Electromagnetic Interference Protection Criteria. The effective performance of NAVSECGRU receiving systems is dependent on the nature of the electromagnetic environment in which they operate. NAVSECGRU site mission performance is limited by the signals they are able to receive or by noise from sources other than the natural noise of the receivers themselves. Since these sites and their respective performance are extremely sensitive to increased noise levels, it is imperative that noise generated within a station, and in the vicinity of its receiving antennas, be kept at the lowest possible level. In the case of locally generated noise (internal to the operations area), however, it is possible to eliminate or mitigate the noise source.

a. Encroachment Zone Criteria. Encroachment zones are required around NAVSECGRU receiver sites to ensure adequate protection from electromagnetic noise and interference sources. Within these zones, noise producing activity must be prohibited or restricted otherwise controlled. The encroachment zones are concentric circles centering on the antenna system or field. Figure 4-4 shows the site plan and encroachment zones in effect since 1972 for EMI/RFI protection. These zones, Prohibited and Restricted, are described in the following paragraphs.

b. Prohibited Area. The first circular zone, beginning at the outer periphery of the antenna field and extending outward for one mile. Only essential construction required to carry on the site's mission is permitted within this zone. All conductors not associated with the receiving antenna or its supporting structure should be buried. All structures (fences, lighting poles, etc.) within this zone must not extend above the vertical clearance zone (measured from the base of the receiving antenna) prescribed for particular antenna systems. See Figure 4-4. The vertical clearance angle is measured from the base of the receiver antenna closest to potential obstruction.

(1) Within the prohibited area, no overhead powerlines will be permitted. Every effort must be made to keep the prohibited area clear of high trees and bushes which could induce bearing errors into the receive system due to re-radiation/ reflection. Roads and trails must be kept to a minimum.

c. Restricted Area. A second circular zone beginning at the outer edge of the prohibited area and extending outward for one mile. Within the restricted area only limited domestic housing may be permitted (not to exceed five individual family units per acre). Command support facilities may be permitted within the restricted area if care is taken to ensure the functions of these facilities does not produce EMI/RFI or in any way change or degrade the NAVSECGRU mission. No radio transmitters of any type may be permitted within this area unless mission essential (i.e. security patrol or fire department radio communications).

(1) In theory, a zone with limitless radius should exist where national (e.g., FCC, IRAC) and international (e.g., ITU, CCIR) frequency management procedures, standards, rules and regulations apply and if enforced, offer some degree of protection from civic and industrial encroachment. New zone definitions are being developed as part of the revision to DOD Directive C3222.5. The new zones will be based on separation-distance criteria for noise thresholds for devices that were not designed to radiate electromagnetic energy, e.g., household devices, business and manufacturing tools, etc.

d. EMI Protection Criteria from Radiating Sources. The area beyond the Restricted Area also requires monitoring and reporting with respect to radio noise. Often the area is beyond the confines of the site and under other than military control or agreement. In cooperation with all parties concerned, action must be taken to ensure that any source or potential source(s) of interference producing activities are fully analyzed and agreements or controls enacted which will eliminate the possibility of interference with desired signal reception. In cases of intentional radiators, the appropriate military frequency manager or the DoD Joint Spectrum Center, should be consulted.

(1) In order to protect the mission viability of the NAVSECGRU receiver site, minimum separation distance are required between common sources of radio energy and the site. Table 4-1, in consonance with the criteria contained in USSID 24 and DOD Directive C3222.5 lists separation criteria for typical sources of potential interference. Table 4-1 is not all inclusive. Determination of the actual impact from proposed or existing sources will be made after investigations by a SNEP team. Table 4-1 is based on specific separation criteria in effect when AN/FRD-10 sites were built in the mid 1960s and was based on the response of tube-type multicouplers.

NOTE: The distances listed in Table 4-1 refer to separation distances from transmitters with omnidirectional antennas. For transmission sources with directional antennas, the transmitter power upon which the separation criteria is based should be adjusted for the antenna gain in the direction of the NAVSECGRU receiver site. Transmitters installed as a group are to be treated according to the combined power level which results when all transmitters are on the air simultaneously, at full power.

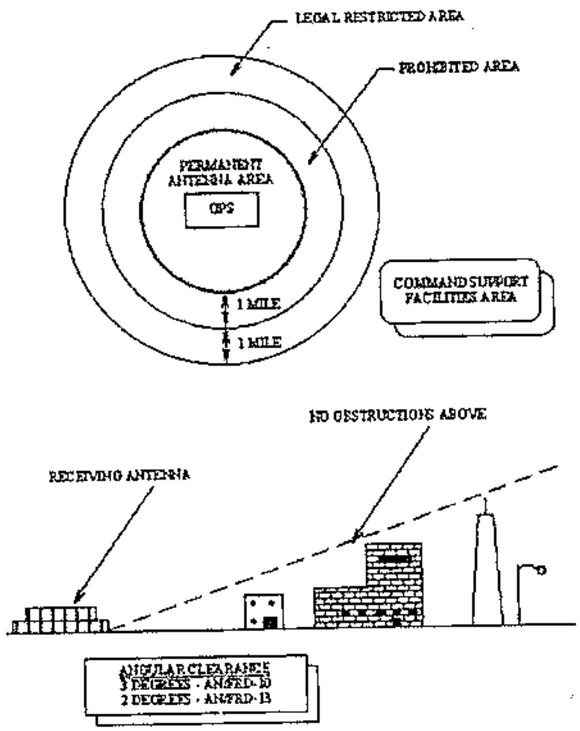


Figure 4-4

Buffer/Vertical Clearance Zones

Potential Interference Source	Distance from Antenna Field Boundary	
	Miles	Kilometers
VLF Transmitters (3KHz-30KHz)	25	40.0
LF-HF Transmitters (30KHz-30MHz)	15	24.0
Other Transmitters (>30MHz)	5	8.0
Above Ground Power Lines	No nearer than line-of-sight from top of low band screen or 2 miles; whichever is greater.	
Main Highways, Expressways, commuter routes	1	1.6
Secondary Roads	.5	0.8
Housing Areas		
Single story detached units	0.6	1
Attached and detached units with 2 stories or greater	1	1.6
Industrialized/Commercial Areas		
Light commercial - business and research parks, warehouses, etc.	4	6.4
Heavy Industry - manufacturing, refineries, ports, staging areas	6	9.6
Any Industry Using RF Heating or rf-stabilized arc welding	15.5	25.0
Power plants	5	8.0
Railroads (Electrified)	1	1.6
Ionospheric Sounders	25	40.0
Over-the-Horizon HF Backscatter Radar	100	160.9

Table 4-1
Minimum Receiver Site Separation Distances for EMI Protection

CHAPTER 5
ELECTRONIC SYSTEM DESIGN AND INSTALLATION

1. General. This chapter provides guidance regarding specific system design concepts, installation materials and techniques to be used at NAVSECGRU sites.

2. Installation Standardization. The majority of equipment system projects are intended for multi-station installation. At any given time, at NAVSECGRU sites, there are a diverse and varied number of electronic equipment projects being installed or modified to meet system operational requirements. In order to ensure complete and technically adequate system installation and performance, standard installation methodology will be used.

3. Antennas. The NAVSECGRU uses the Wullenweber or CDAA for basic DF applications. Non-DF sites use various general purpose and application specific antennas in the performance of their missions.

a. Wullenweber. The Wullenweber (CDAA) is the primary type of array used by the U.S. Navy in its HFDF Network. Figure 5-1 depicts a segment of a typical AN/FRD-10 (HFDF) CDAA. This antenna group OA-3967/FRD-10 consists of two circular concentric arrays. The inner array (low-band) consists of 40 folded monopole elements (Figure 5-2) arranged in a circle with a 90′ (27.4m) reflector back screen. The outer array (high-band) consists of 120 sleeve monopole elements (Figure 5-3) with a 24′ (7.31m) reflector back screen. A reflecting ground mat in the shape of an annular ring lies under each array and extends approximately 200′ (72.9m) outward beyond the high band elements. Each element of both the high and low band arrays are connected to the operations building by electrically equal (phase matched) lengths of either lead-sheathed armored coaxial or HELIAX type transmission cable buried beneath the ground mat. See Figure 5-4.

b. CDAA Principles of Operation. The reflector back screens associated with the CDAA system (Figure 5-5) reflect the vertically polarized incident waves. These waves generate currents in the screen wires which in turn re-radiate at an angle equal to the incident angle. The total current generated in the antenna element is the vector sum of the direct and reflected waves. Mathematically, it is convenient to consider the wave reflected from the screen as inducing currents in an image antenna element located the same distance behind the screen as the actual antenna element is in front of the screen. The induced signals are then summed together. In like manner, the ground mat reflects high angle of arrival vertically polarized signals (Figure 5-6). The term array as applied to antennas is an arrangement of antenna elements spaced and phased so that the vector sum of their individual contributions forms a directional beam (Figure 5-7). Rotating beams are formed in the goniometer (Figure 5-8) by the individual element outputs passing through coupling capacitors to beam formers in the goniometer. As this beam rotates through the direction of the maximum signal strength, the bearing of the signal source can be determined. The number and size of elements necessary to provide high resolution (directivity) in the HF band prohibits mechanical rotation of the array. Thus, each element in the array is connected to a goniometer which provides an electrical representation of a rotating array (Figure 5-9).

(1) In addition to the goniometer beams used for DF, fixed beams are used for processing signals from various known azimuths without the requirement to locate the signal source. These fixed, non-DF beams consist of monitor, sector and omnidirectional beams (Figures 5-10 and 5-11). In the AN/FRD-10 system the low and high bands each contain 30 monitor beams, that provide very directive, high gain signals compared to other beams. The AN/FRD-10 system has six sector beams and two types of omnidirectional antennas--eight elements combined in the low and high bands or a combiner consisting of 120 high-band elements. Selected AN/FRD-10 sites also have a separate conical monopole antenna for omnidirectional coverage. The signal gain of the fixed beams is very complex, varying with azimuth, elevation angle and number of elements making up the beam. For more detailed information on antenna patterns and signal gain, see figure 5-9.

c. AN/FRD-13 (V) (PUSHER) DF Antennas. The AN/FRD-13 (V) antenna system is a modified version of the commercial Plessey Type AX-33 Multiple Beam HF receiving antenna. The antenna system is a small scale CDAA which operates in the HF spectrum. Because the AN/FRD-13 System has fewer elements than the AN/FRD-10 and no reflecting screens, its signal-to-noise ratio is less than the AN/FRD-10 System and the gonio pattern does not have the same high resolution as the AN/FRD-10.

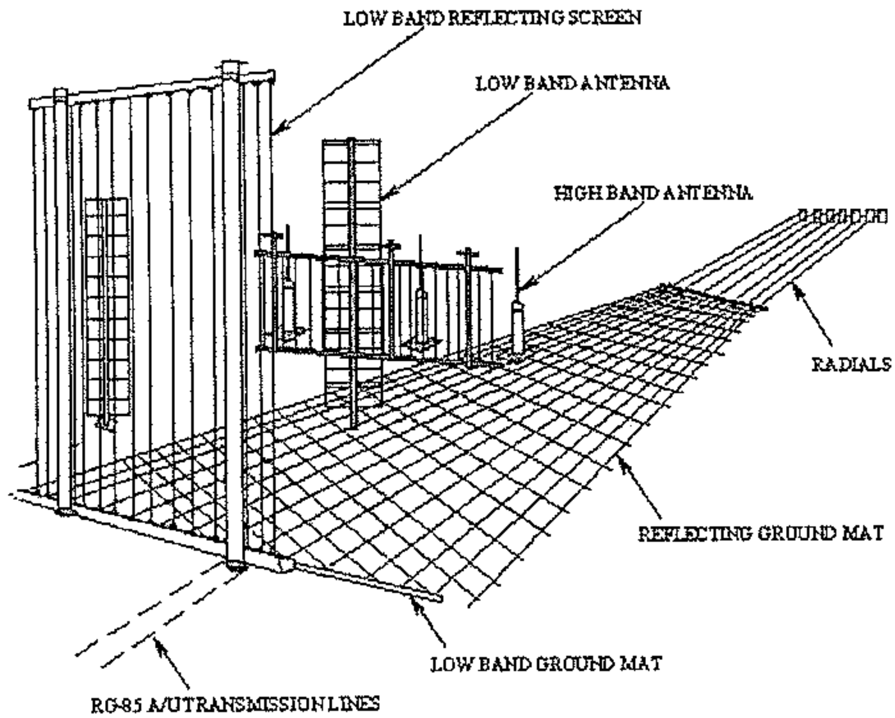


Figure 5-1

AN/FRD-10 Major Components

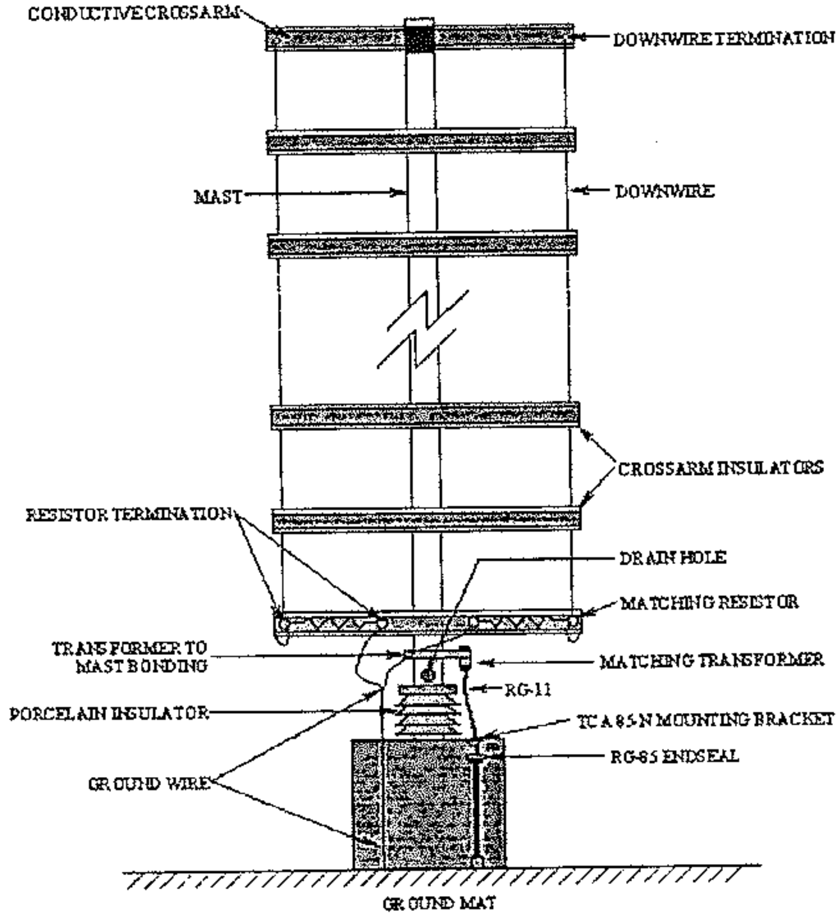


Figure 5-2

Components of a Low Band Antenna

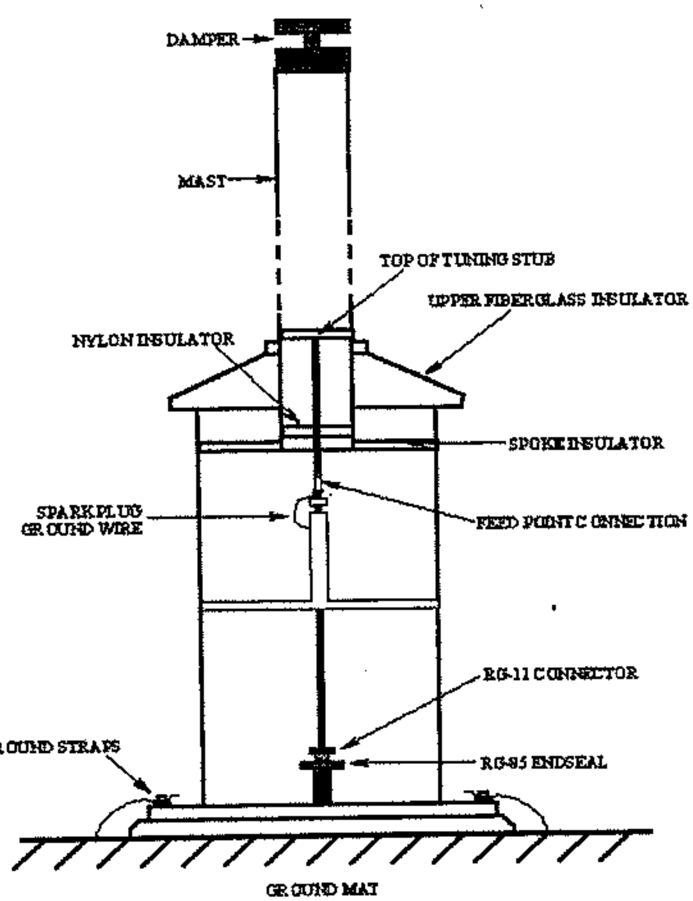


Figure 5-3

Components of a High Band Antenna

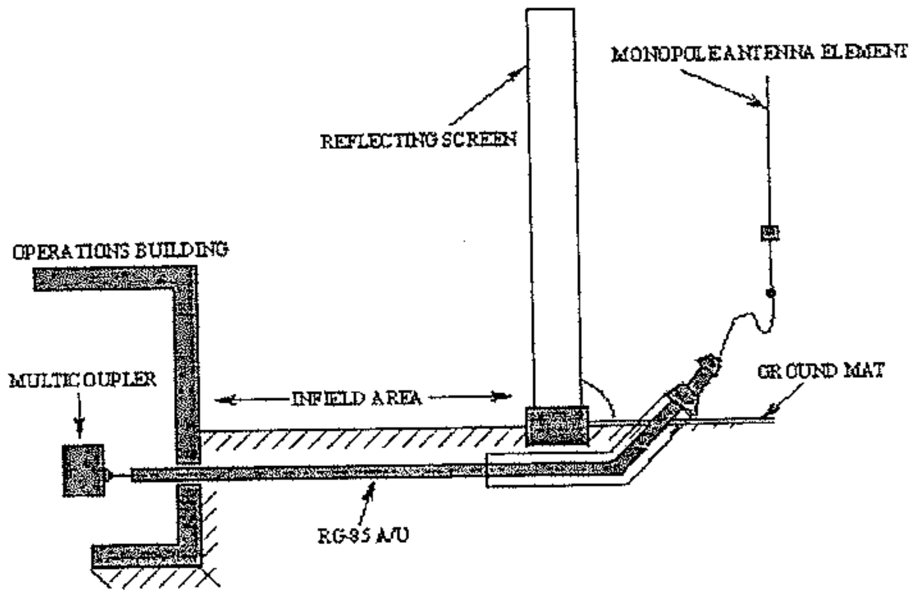


Figure 5-4

Typical Transmission Line Configuration

4. CDAA RF Distribution. The one common factor in all CDAA systems is "system complexity." The CDAA system uses many antenna elements for reception of incoming signals. Combination of these signals (by various methods and devices) provides the operational system with the required directivity. Typical devices used to combine the incoming signals and which are common to many HFDF systems include multicouplers, beamformers, adders, goniometers, RF switches, and patch panels. See Figures 5-10 and 5-11.

a. Multicoupler. Preamplifier with a single input and multiple outputs which distributes RF signals to a group of receivers. The characteristics of a typical multicoupler are:

- Broad-band device with limited dynamic range
- Linear amplifier with fixed phase shift
- Unity gain
- Not subject to strong signal overload and generation of intermodulation products

Note: Multicouplers will not be cascaded.

The model CU-1382 (8 output) and model CU-2289 (16 output) multicouplers are used in most applications by NAVSECGRU elements. When replacing existing multicouplers or adding new ones, choose a multicoupler type that is not susceptible to the generation of intermodulation products.

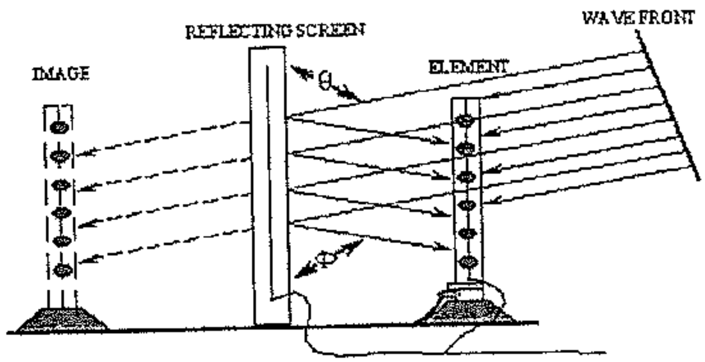
b. Beamformer. Device into which RF signals (more than one) are injected and combined using precise phase shifts to make the selected antenna elements form a directive array. Figure 5-7 presents an example of a 5-element CDAA and the methodology by which signals are received. The received wavefront induces a current first in element 3 then later in elements 2 and 4 and still later in elements 1 and 5. Thus the signal at element 3 is out of phase with that of 2 and 4 which in turn is out of phase with 1 and 5. Assuming the transmission lines from the antenna elements to the beam-forming network provide equal delay (i.e. phase matched), the signals will be out of phase by amounts D1 and D2. The addition of delays equivalent to D1 and D2 by the beam forming network produces signals that are in-phase. These in-phase signals are then summed in the adder circuit and the resultant signal delivered to the receiver.

c. Adder. Circuit that takes the in-phase signals produced by the beamformer and combines (sums) them together and produces a resultant signal which is delivered to the receiver.

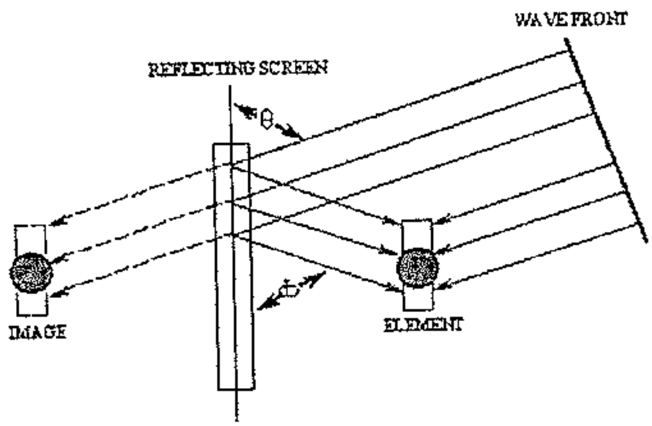
d. Goniometer. Device that takes signals from many or all antenna elements and provides at its output a "rotating" beam. Figure 5-8 depicts a wave front which arrives first at element 1 then at elements 2 and 12 and finally at 3 and 11. The signal generated at element 1 is out of phase with the signal generated at 2 and 12 which in turn is out of phase with that generated in 3 and 11. These signals when delivered through phase matched transmission lines to the goniometer stator will be out of phase by amounts D1 and D2. The goniometer rotor delays the signals an appropriate amount to produce signals which are all in phase. These signals are then delivered to a summing network which adds the signals together and delivers the resultant output to the receiver. If the rotor is permitted to rotate through a small angle, the signals will no longer be coupled to the appropriate delay line which produces all of the signals in-phase at the input to the summing network. This results in signals which are out-of-phase and at a reduced signal strength when the summing network adds the signals together. As the rotor is permitted to turn through a larger angle, the signals become even more out-of-phase and a large reduction in signal strength occurs. If the goniometer is permitted to rotate through the full 360°, a signal strength pattern will be generated. By rotating the goniometer to the spot on the pattern where the maximum signal strength is obtained, the direction from which the signal is arriving may be determined.

e. RF Switches and Patch Panels. Automatic or manual means of routing the signals from the goniometer, the formed beams, or other antennas to the various receiving systems within the operational site.

(1) The ENLARGER RF distribution system is used at all but two of the AN/FRD-10 sites. Figure 5-12 is a simplified block diagram of ENLARGER and represents the integration of the ENLARGER switching system with site antennas and receivers. The number of RF inputs provided to ENLARGER varies and is site specific. ENLARGER provides automated control of the RF path selection process. Control software provides the necessary algorithms to select an RF path and to find alternate paths if the operator's primary selection is blocked. Bypassing the ENLARGER system may be necessary for sensitive or critical collection systems because of the variable RF path losses inherent in the design of ENLARGER. Further in-depth discussion of the CDAA RF distribution system, with the exception of ENLARGER, may be found in SPAWAR EE110-SC-MMO-010/W144-FRD-10.



SIDE
VIEW



TOP VIEW

Figure 5-5

Principle of CDAA Reflecting Screen

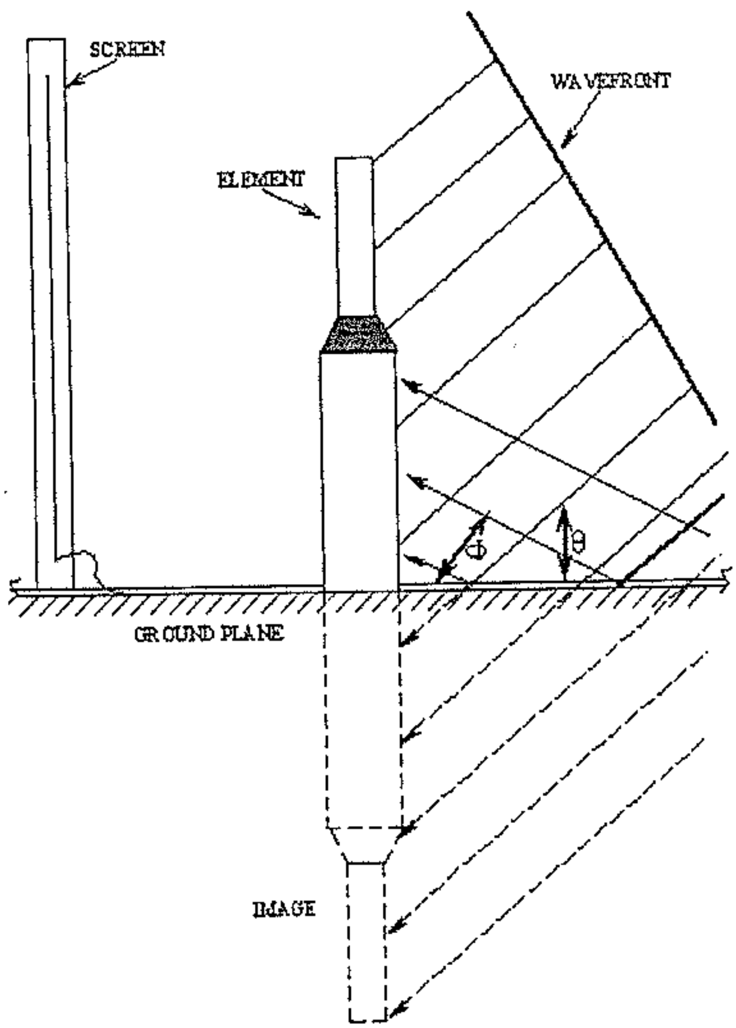


Figure 5-6

Principle of CDAA Reflecting Ground Plane

5. RF Cables. Selection of RF cables and connectors for any application at NAVSECGRU sites must carefully consider such factors as system impedance, frequency, length of cable, acceptable attenuation, isolation, cost, ease of installation and availability. Since several of the critical characteristics of cable performance are constant for most NAVSECGRU installations, it is possible to specify certain cable types as being standard for generic applications. This enables NAVSECGRU stations to maintain an inventory of replacement cable/connectors and reduces the burden on the supply system to stock many different cable types. For those systems having unique cable requirements, the cable type will generally be specified and documented in the system tech manual, installation BESEP, and SIP.

a. The impedance of coaxial cable in the majority of NAVSECGRU RF distribution and mission equipment is 50 ohms. Consequently, to minimize impedance mismatches, 50 ohm impedance cable will be used for all RF distribution (non phase-matched) applications. Adapters for transition of cable types (even if both types are 50 ohms) will be avoided. The only time a cable adapter will be used is when the female equipment connectors are dissimilar. This practice will pose the least number of impedance mismatches within the RF distribution.

NOTE: Where impedance mismatches occur within the RF distribution system, impedance matching devices will not be used to correct the mismatch. Signal loss through the matching device is as great as that caused by the impedance mismatch itself (at HF).

b. RF Cable Selection. Signal cables are available in a variety of types and configurations, the most common being single-shielded coax. Other cable configurations include: double-shielded coax, in which two coaxial shields are in contact with each other; triax, in which two coaxial shields are insulated from each other; and quadrax, which has three mutually insulated shields. Single-shielded cable, such as RG-58/59U, is highly susceptible to coupling or induced interference. Therefore, the less expensive single-shielded type cable is unacceptable for use in highly complex C-E facilities such as NAVSECGRU sites.

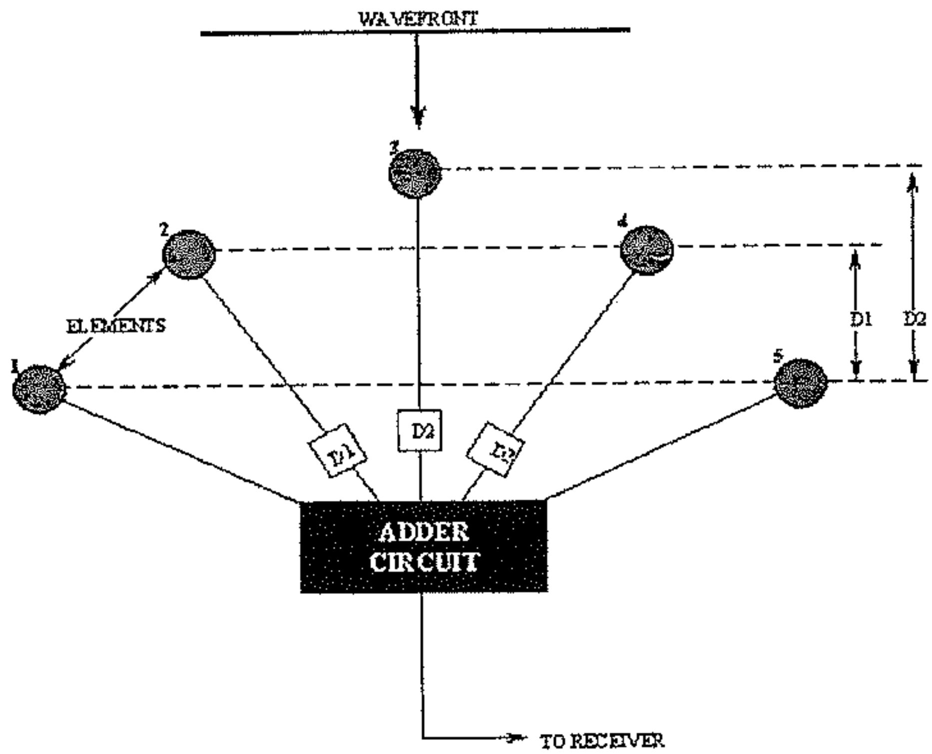


Figure 5-7

Beam Forming Network

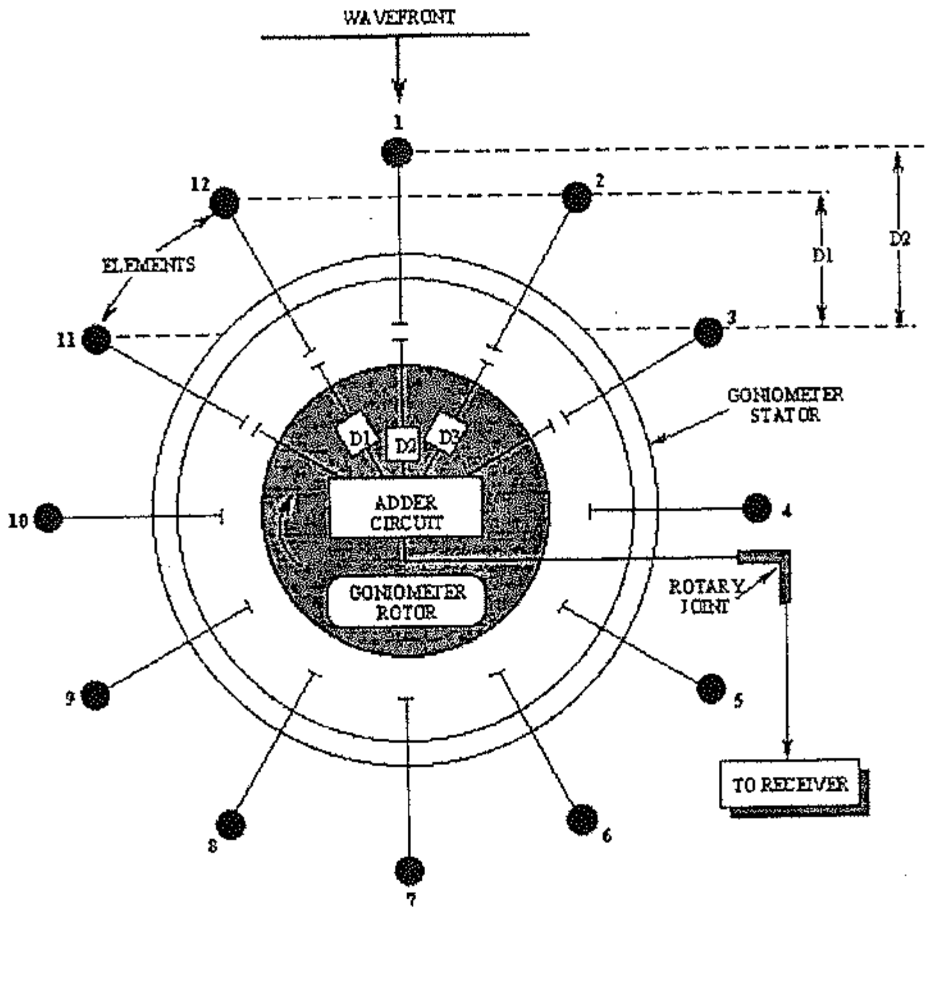


Figure 5-8

Goniometer

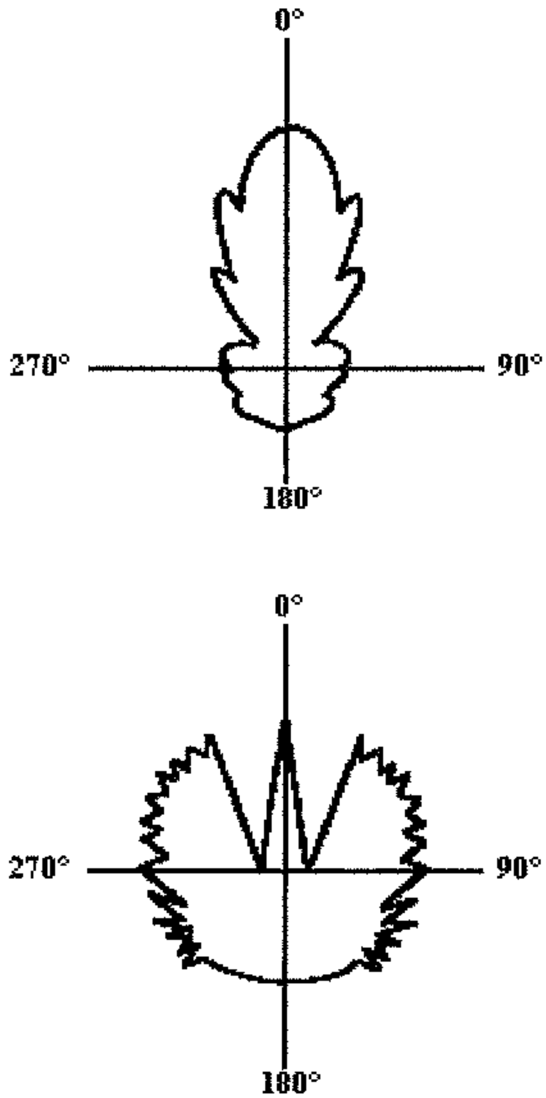


Figure 5-9

1 **Sum and Difference Mode Output Patterns of CDAA Goniometer**

NOTE: All RF cables within a NAVSECGRU facility must be of a double shielded coaxial type.

c. RF applications requiring short runs (less than 20') of 50 ohm impedance cable may be satisfied utilizing RG-223/U double-shielded coax. For longer cable runs use larger cable (such as RG-214/U) with less signal attenuation. For some 75 ohm requirements, RG-307/U triax may be used. However, RG-307/U is extremely expensive and difficult to use in standard double-shielded coax applications. This cable is a triaxial design but is routinely terminated in a coaxial mode (the inner shield is tied to the outer shield).

(1) Double-shielded cable such as Belden YR21946 or Storm Products 30-070 may be used for 75 ohm RF applications. RG-307/U cable is an acceptable substitute, however the much higher cost of this cable makes its routine use prohibitive. These cables have outstanding shielding effectiveness making them suitable for phase match applications. In addition, the sturdy construction of these cables enable them to better withstand the static loading of numerous other cables, as often found in the bottom of a cable trough, without undergoing significant deformation.

d. RF Cable Attenuation. Cable attenuation is another important aspect of total system performance. Attenuation is a description of the amount of RF energy decreased as a signal propagates down a length of cable. As a cable run increases in length, so will its attenuation. The maximum attenuation in the longest RFD path (e.g., beamformer output to a receiver) must not exceed 1.5 dB. In order to assure this standard is met, attenuation must be considered in the cable selection process. Cable characteristic data will include attenuation factors to aide in the selection process. Table 5-1 lists cable data for commonly used cable in NAVSECGRU receiving systems.

(1) To determine if a cable will meet the 1.5dB loss standard for a specific length, use the attenuation factor (dB/100'), divide by 100ft, and multiply by the length (ft). This will be the calculated attenuation of that cable. If it does not meet the 1.5dB standard, select another type of cable with lower loss and recalculate.

NOTE: To ascertain if existing cabling systems meet attenuation requirements, electronically test existing cables and newly installed cables to ensure they meet the 1.5dB standard. In addition to attenuation from cable length, allow 0.10dB attenuation for each connector.

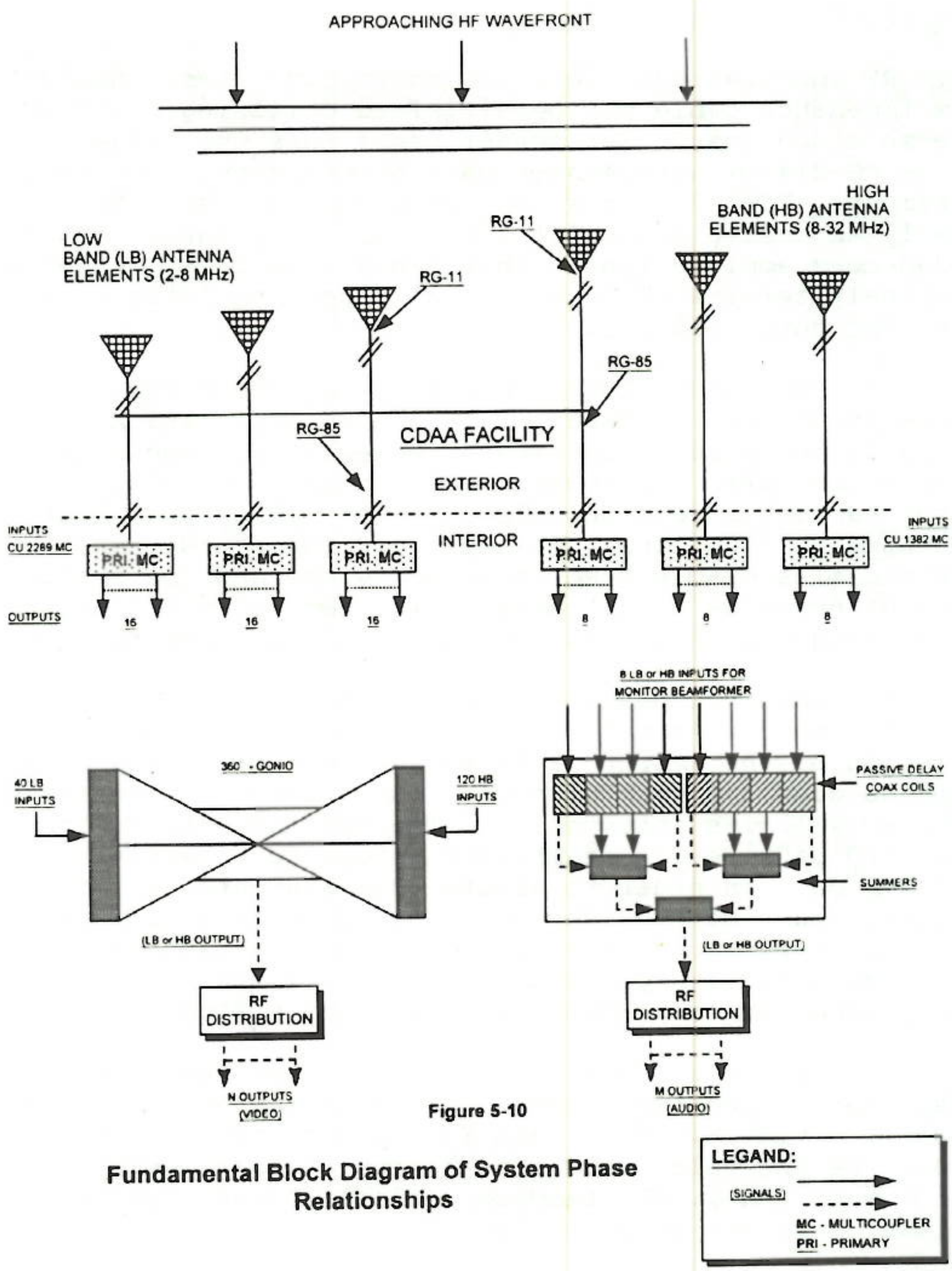


Figure 5-10

Fundamental Block Diagram of System Phase Relationships

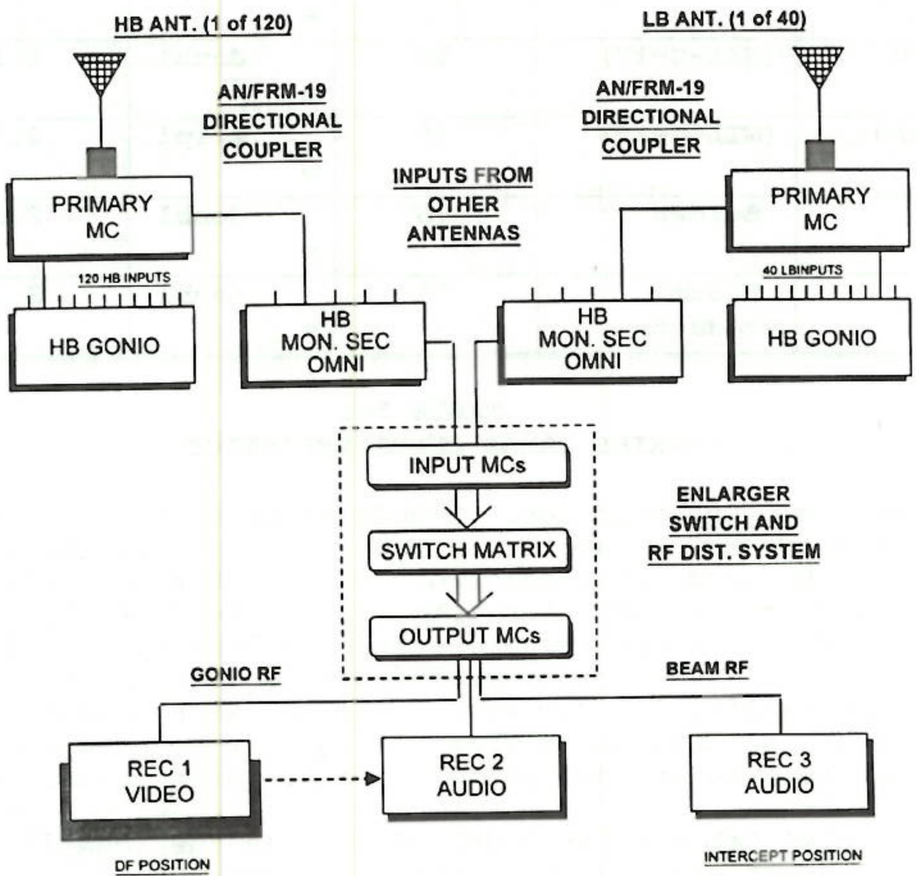


Figure 5-11

RF Signal Path of One Antenna Element to Various Receivers

PART NO.	**MANUFACTURE**	**IMPEDANCE (W)**	**SHIELDING**	**ATTENUATION (dB/100') 50 MHZ**
RG-223/U	**(MIL-C-17)**	**50**	**double**	**3.00**
RG-214/U	**(MIL-C-17)**	**50**	**double**	**1.50**
RG-307A/U	**(MIL-C-17)**	**75**	**triple**	**2.70**
YR21946	**Belden**	**75**	**double**	**2.30**
30-070	**Storm Products**	**75**	**double**	**2.30**

TABLE 5-1
COAXIAL CABLE CHARACTERISTICS

e. RF Cable Construction. Double shielded coaxial cable will be used for all RF applications. Under no circumstances will single shielded cable be used. Double shielded coax offers many desirable characteristics with respect to TEMPEST, isolation, EMC, flexibility, and ease of assembly. A solid center conductor is generally preferable as it simplifies connector installation. However, RF cables with stranded center conductors are slightly more flexible and may be used where cables require frequent manipulation (e.g. patch cords, etc.).

f. Coaxial Cable Color Code. To aid in the identification of RF cable functions and help maintain proper separation between cable types at all points in a cable run, the following color coding scheme will be utilized:

50 ohm RF distribution	-	Black
75 ohm RF distribution	-	Magenta
BT/NP distribution	-	White
Reference frequency distribution	-	Yellow
Time Code distribution stripe	-	Yellow/black helical
Digital Communication	-	Orange or Blue

g. Cable Labeling. Each end of an RF cable will be labeled to indicate the terminating equipment and jack. Additionally, cables should be sequentially numbered to allow correlation to a cabling diagram. Phase-matched cables will have an additional label on each end stating "PHASEMATCHED CABLE, DO NOT CUT."

h. RF Cable Splicing. RF cables run within a NAVSECGRU facility will not be spliced. The cumulative signal loss resulting from multiple mechanical connections in an RF signal path can have a detrimental affect on system performance.

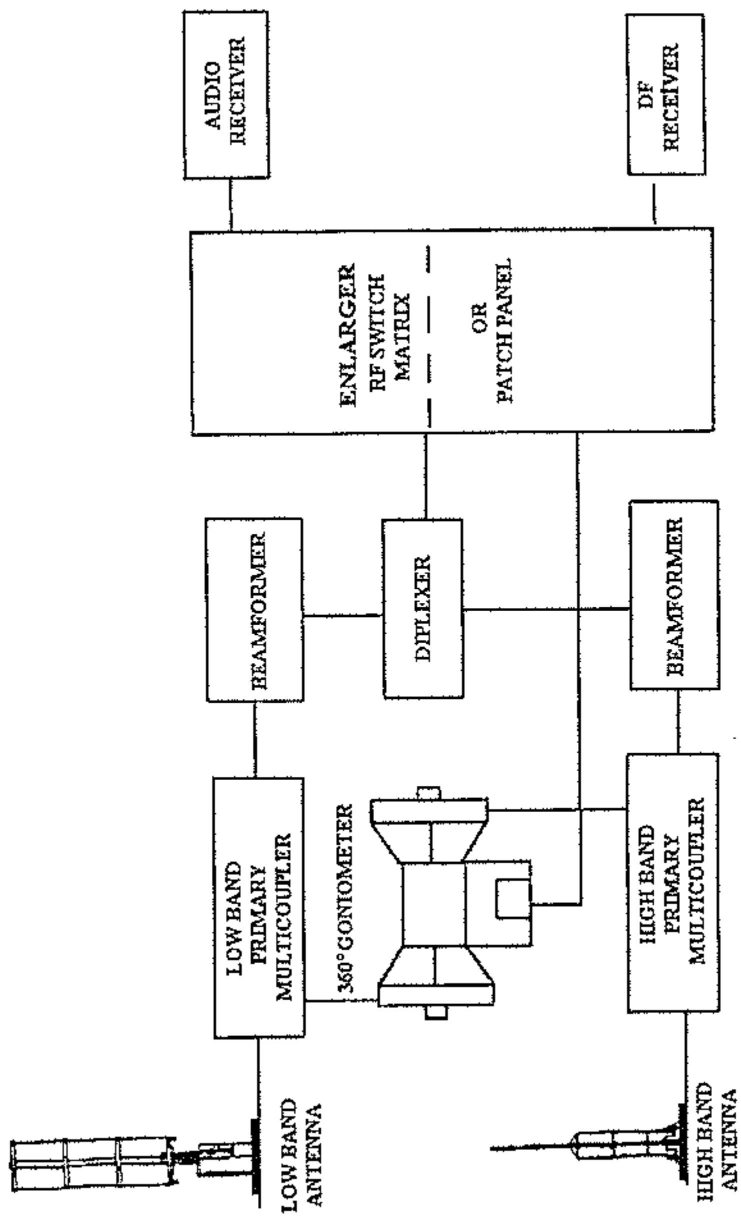


FIGURE 5-12
ENLARGER RF DISTRIBUTION SYSTEM

Consequently, the only practical approach is to replace the entire cable when it is in need of repair. Splices to cables that run outside the facility are permitted because these cable runs can be extremely long. However, these splices have the additional problem of weather-proofing.

(1) Standard flexible coaxial cable can be spliced by cutting the cable at the damaged point, terminating both ends, and inserting a barrel connector. When splicing in this manner, TNC vice BNC will be used. Weather proofing will be accomplished by wrapping the connection with black tape, then overlapping the black tape with coax seal. The coax seal should extend beyond the edge of the black tape to bond securely to the cable jacket. The black tape covering the connectors keeps coax seal from seeping into the connectors. For special cable types, such as the RG-85 used in CDAA's, special chemical repair kits must be obtained from NISE EAST.

i. Cable Dressing. Cables will not be allowed to dangle their entire length within equipment cabinets. Sufficient slack must be left in the cable to allow equipment to be extended on slides without the necessity of disconnecting the cables. Timing/control cables should be secured to one side of the cabinet and RF cables secured to the opposite side. RF, control, and timing cables may not enter the cabinet through the same duct. Induced interference can be lessened by maintaining physical separation and shielding of timing and control cables.

(1) Cables should be tied so that cable labels can be easily seen. Cable ties are preferred for securing cables as they can be easily removed and replaced if it becomes necessary to work with the cables. A tie wrap tool should be used to secure the cable ties. The tie wrap tool provides uniform tension to the ties and neatly trims the excess cable tie without leaving a sharp edge.

6. Connectors. It is essential that RF cables be terminated with the proper connector designed for the specific type of cable on which it is to be used (e.g. connectors with the correct impedance characteristics). Selection of an improper connector can cause a variety of problems, from poor physical/electrical connection to damaged mating connectors. Beyond its suitability for a given cable application, some connectors have features that provide other advantages. Two features required for NAVSECGRU installations are solder type captive center pins (not crimp-on)

and a sleeve bearing in the gland nut. The connector must be secured to the cable with a gland nut instead of a crimp-on

ferrule. These two features result in more consistent performance and easier installation. The captive center pin results in the pin consistently extending the same distance from the connector, even if the cable center conductor is not trimmed perfectly. The sleeve bearing in the gland nut prevents the shield braid from becoming twisted and/or bunched during assembly. The rotating sleeve allows the nut to turn while the sleeve, which is the only part of the nut contacting the shield, remains stationary with the connector body. The result is a uniform pressure on the shield without the twisting motion.

7. Power and Signal Cable Distribution Systems

a. Power Cable Distribution. The NEC, provides the minimum requirements for the distribution of A/C power. Power distribution configurations which do not meet the minimum requirements outlined in the NEC are unacceptable. Power distribution ducting, conduit, and/or raceway will never be used as the sole equipment grounding conductor. A green wire equipment grounding conductor will always be run with the phase and return conductors (See Chapter 7). The power cables will be run in flexible metallic tubing or metal conduit from the box inside the bay to the A/C strip or other termination point. Conduits will not be filled in excess of 40 percent. Liquid tight flexible metal conduit is not preferred because the outer jacket may emit noxious gases if exposed to extreme heat or fire. As these power runs will frequently be installed under a raised floor which also serves as an air plenum, the noxious gases would exacerbate fire hazards. Power distribution should also comply with the requirement of paragraph 8b(6) for cable penetration of equipment cabinets.

b. Signal Cable Distribution. Signal cable duct/tray(s) will not be filled in excess of 80 percent of its capacity. This will not only lessen the potential for cable distortion due to the excessive weight of other cables above it, but will also facilitate the easy removal of cables no longer required or that require replacement. All multi-conductor cables used to interconnect systems or system components will be shielded. Ribbon cables will not be used.

(1) Black Signal Cable. The RED/BLACK demarcation point for all processing systems (i.e., ENLARGER) is considered to be the RF receiver. The RF input to the receiver is considered to be BLACK, all outputs (i.e., IF, audio, digital, video) are

considered to be RED. Exceptions to this policy must be obtained in writing from CNSG. RF receivers installed as part of a

processing system will be connected to RED ground. RF receivers installed for maintenance/testing purposes only, i.e., AN/FRM-19, or located in RFD spaces are considered to be BLACK for installation purposes. BLACK signal cables (those cables from equipment which originate or terminate unclassified signals) will be distributed in non-metallic trays or ladders on new systems/installations. If no raised flooring is installed, the cable tray must be suspended from overhead. When installed horizontally under the floor, a solid bottom tray is preferred. Ladder type cable tray should be used for vertical runs and overhead installation. Using ladder tray for vertical runs makes it possible to tie-wrap the cables to the "rungs". All BLACK cables will have, as a minimum, one overall nonferrous metallic shield and outer sheath. Cable shields should be low impedance and continuous. The shield should not be connected to the A.C. protective ground.

(2) Historically, all cable shields have been terminated to the ground system at one end only to meet "TEMPEST" or "RED/BLACK" criteria (see MIL-HDBK-232A). The termination of the shield at one end results in the flow of EMI/RFI current on the outside of the shield. If the source of the signal within the cable has spectral components that are higher than a cable length of about 1/50 wavelength, these components will appear on the outer shield. The practice of not terminating one end of the cable shield was generated in the days of teletype. Modern digital devices now operate at faster bit rates. For new installations or major modifications, terminate both ends of cable shields. Correction of existing unterminated shields should be undertaken, if an internal noise problem develops.

(3) RED Signal Cable. RED signal cables (those cables from equipment which originate or terminate classified signals or all outputs from receivers) will be distributed in duct vice tray systems. The duct system may consist of square ducting, electrical metallic tubing, flexible metallic tubing, flexible metal conduit, or combinations thereof as appropriate for the specific installation. These will be clearly marked with red tape or paint at intervals of approximately 1.5m. All RED cable will have, as a minimum, one overall nonferrous metallic shield and outer insulating sheath. Neither cable shields nor ground conductors will be used as a return path for RED signal and/or clocking control signals. Additional cable pair shielding for the purpose of added isolation will be a matter of system engineering design requirements or TEMPEST tests.

(4) Cable Separation. All RF cables will be run in a

dedicated RF cable duct system. Placing RF cables and control/timing cables in the same ducting system can result in noise/interference being induced into the RF lines. A separate ducting system will be installed for control/timing cables. Control and timing signals should be treated as RED signals. All multiconductor cables fall into the control/timing cable category and should be handled accordingly. RF cables within an equipment cabinet will be routed such that they are separated from equipment power supplies by a minimum of six inches.

(5) Phase-Matched Cable Distribution. Solid bottom non-conductive cable trays are required for the distribution of phase-matched cables. In ladder cable trays, the weight of a cable is concentrated on the rungs and can result in sufficient distortion of the cable dielectric to cause changes in cable impedance. The problem is exacerbated as more cables are laid in the tray, concentrating the weight on the bottom cables where they lie on the rungs.

(6) The impedance of a cable is a function of the ratio of the inner diameter of the shield to the outer diameter of the center conductor, and the dielectric value of the insulating material (dielectric). Since the impedance of a cable is a prime factor in determining its electrical length, distortion of the cable dielectric will change the effective electrical length of the cable and thus bring it out of phase-match tolerance with respect to the other cables. Sharp bends or coiling can have similar effects. Distribution systems for phase-matched cables must be carefully designed to avoid the aforementioned pitfalls. Placement of equipment requiring phase-matched cables must be carefully planned so that the equipment is centrally located with respect to signal sources. This will reduce the requirement to coil or loop cables within the tray system to take up the excess cable lengths.

(7) Fiber Optic Cables. All fiber optic cables will be installed in a dedicated fiber optic duct system. Fiber optic cable duct may be PVC/plastic except when installed in a plenum system, in which case, metal or plenum rated PVC/plastic must be used in accordance with the NEC. RED and BLACK signals may not be run in the same fiber optic cable. However, RED and BLACK fiber optic cables may be run in common fiber optic duct system as long as the cables break-out into separate RED and BLACK cable access facilities. Fiber optic cable will not have a metal strain relief or shield. See NFPA Article 770 when developing

and/or using optical fiber technology in conjunction with electrical conductors for communication, signaling and control

circuits in lieu of metallic conductors.

8. Equipment Cabinets and Racks

a. Equipment Cabinet Selection. SIPs dictate the type of equipment cabinet/rack utilized for given installations. Whenever possible, RF processing equipment will be installed in separate cabinets from digital processing equipment. All equipment cabinets will be constructed of either steel or aluminum with side panels. The cabinet walls establish an EM barrier which isolates the EM environment inside the cabinet from the environment outside the cabinet. Necessary hardware (such as bay blowers, A/C power strips, ground bus bar, etc.) must be provided with the cabinet/rack. A/C power strips must comply with MIL-HDBK-232A. Specifically, conductors must be secured to each outlet with terminal screws. Outlets with serrated blades that contact the conductor by cutting through the insulation do not comply and will not be used.

b. Equipment Cabinet Installation

(1) Sleepers. All equipment cabinets and racks installed in NAVSECGRU facilities on non-computer floors are to be installed on 4"x4" or 4"x6" wooden foundations (sleepers) treated with fire retardant and meeting requirements of MIL-L-19140E. Sleepers should not be treated with wood preservative as it may negate the effect of the fire retardant. Sleepers are not required on raised flooring (computer decks). The function of sleepers is to isolate the equipment cabinets from the floor, evenly distribute the weight of the cabinets, provide a cableway between adjacent cabinets, and protect the bottom of the cabinet from abrasion. Sleepers will be secured to the true floor with bolts or continuously threaded rod into anchors in the floor. The bolt head, or nut and washer for all-thread, will be counter-sunk into the sleeper to prevent contact with the cabinet/rack. Additionally, the bolts or threaded rod must be positioned in the sleeper in a manner such that there will be no metal-to-metal contact between the lag bolts securing the racks/cabinets to the sleepers and the bolts/all-thread securing the sleepers to the floor. The end cabinets/racks in rows will have lag bolts in all four corners. Cabinets/racks in the middle of a row require only two lag bolts (one in the front and one in the rear).

(2) Side Panels. All cabinets, whether individual or in multiple bay systems will have side panels. This practice completes a barrier, protecting against EMI/RFI.

(3) Blank Panels. Cabinets will have blank metal panels installed in all spaces not occupied by equipment. This practice facilitates proper cooling, ensuring that airflow reaches all equipment, and facilitates the completion of the barrier, protecting against EMI/RFI contamination.

(4) Adjacent Cabinets. Adjacent cabinets will be bolted together with two bolts, one at each top corner. Precautions must be observed when bolting RFI enclosures together to ensure that enclosure integrity is maintained.

(5) Cabinet/Rack Positioning. Cabinets/racks must be positioned with respect to other equipment, walls, columns, etc. to allow access to the front, rear and side if appropriate for maintenance and safety purposes.

(6) Cable Penetrations. All coaxial, twisted pair and multi-conductor cables will penetrate equipment cabinets via a feed through connector. This requirement only applies to cabinets that contain a source of EMI or some special item of equipment that is susceptible to RFI/EMI. It is not necessary to do this for cabinets with inert equipment, such as, patch panels, linear amplifiers with linear power supplies, multicouplers beamformers, etc. The use of the feed-through connector prevents the harmful injection of RFI/EMI current onto cable shields. However, this action will be completely negated if other penetrating conductors are not treated to limit the flow of harmful EMI current. When used, the feed through connector will be of the type that makes good electrical contact between the cabinet surface, the cable shield and the outer surface of the connector. The exception to this rule occurs when several cabinets are used together to make an EMI/RFI barrier. In this case, the feed through connector will be used for all penetrations of the electromagnetic barrier boundary established by the combination of cabinets.

9. LAN. Excessive noise currents found on fortuitous conductors in CDAA sites have been linked to LANs. LAN cables act like a receive antenna for signals in the ambient environment. Fiber optic cable with metallic armor may pose the same problems as coax cable. Compliance with existing guidelines for grounding, EMC and TEMPEST does not guarantee that a LAN will not interfere with sensitive systems. Depending on the sensitivity of

potential victim systems, implementation of integrated barrier, filter and ground may be necessary. In severe cases individual enclosures may be required for each personal computer (PC) on the LAN. The enclosure for LAN hardware does not have to be a

cabinet. Small metal boxes only large enough to house the computer terminal and monitor, with a window for viewing the monitor screen, are available and acceptable. The application of this method may not be needed in all cases; a determination should be made on a site by site basis.

10. Lighting. Lighting systems used within NAVSECGRU facilities will be designed and have lighting intensities that meet the requirements of MIL-HDBK-1190 and the Illumination Engineering Society of North America Lighting Instruction. When fluorescent lighting is used, the following requirements apply:

- Four tube fluorescent fixtures (luminescent) with RF suppressed standard magnetic ballasts will be used.

- Flush recessed type fixtures with either translucent or "egg crate" diffusers. These types of diffusers evenly distribute the lighting while affording protection from falling light tubes.

- Fluorescent lights with electronic ballasts will not be used without prior approval from CNSG (N44). (Limited lab testing of one model of the new electronic ballast revealed radiated and conducted noise at levels higher than from magnetic ballasts.)

a. Visibility and Visual Comfort. Lamp placement and candlepower distribution will be selected to minimize ceiling reflections and minimize discomfort glare. Ceiling reflections reduce the contrast of the components of the task thus make seeing the task more difficult. Light coming over the workers' shoulders or from the sides generally produces better visibility than light coming from the front of the worker (offending zone). Luminescent lighting is recommended for those areas in which CRTs are used for extensive periods. This type of lighting helps reduce eye fatigue common to CRT users.

b. Lighting Switching. SCR type dimmers are not permissible. Installation of the lighting system in individually switched zones within a room will enable a degree of light intensity control without the need for RFI producing dimmers (variacs may be used).

c. Emergency Lighting. Emergency lighting can be accommodated aesthetically through the use of ballasts which contain an integral battery backup unit. Replacement of standard

ballasts with these battery backup units at strategic locations within the facility will provide a low cost, maintenance free alternative to independent emergency lighting units.

11. Raised Flooring. NAVSECGRU C-E facilities require raised flooring systems within the operational spaces. These flooring systems will conform to the requirements of NFPA 75, MIL-F-29046. New raised floors will be compatible with existing raised flooring systems within the same facility (if the existing floor meets the requirements of this section). Compatibility will simplify the logistics of obtaining replacement components. For new or replacement floor systems, 10 percent additional floor tiles will be purchased to provided spare tiles which will facilitate replacement as required.

a. Raised Floor Structure. Raised flooring systems installed in NAVSECGRU facilities must be supported by an appropriate arrangement of pedestals, adjustable in height to facilitate leveling, and must be inter-locked by a grid of connecting stringers. These connecting stringers will be of the bolted-in type (not clipped in), removable in both directions. From a safety perspective, the bolted-in stringer raised floor retains the greatest resistance to lateral movement because the stringers remain firmly in place when a number of floor tiles are removed. The system will be such that the access panel rests on each pedestal as well as the stringer. The floor will be of the free access type that will allow for pipes, cables, conduit, etc., to run in any direction beneath the floor. To provide complete flexibility in arrangement and quick and easy access to the under floor services, all parts of the floor system will be easily removed and replaced; easily disassembled, rearranged, interchanged, and reassembled; and easily cut for cable outlets, air distribution and other services. The floor panels will be removable without disturbing adjacent panels and interchangeable without modification. The flooring system will be designed to retain its lateral stability with 50 percent of the adjacent floor panels removed. The weight of the panel will be evenly distributed over 360° of the panel edge. Systems that use only the lip of the floor panel on the stringer system for support and do not have any support of the panel resting on the top plate pedestal assembly are not acceptable. The elevation of the flooring will be approximately 18"-30" (45.7 cm-76.2 cm) above the base (structural) floor, unless limited by structural ceiling height. If lower floor height is necessary due to existing building design limitations, adequate under the floor air flow must be accomplished. See MIL-HDBK-419A VOL II and MIL-HDBK-1012/1 for additional specifications.

b. Panel Size and Construction. The panels will be approximately 2′ by 2′ (60 cm x 60 cm) and constructed of reinforced metal. The covering will be conductive plastic laminate/vinyl. Carpeted floor tiles should be avoided.

c. Raised Floor Loading. The entire floor system will be designed and constructed to support a live load of 250 pounds per square foot uniformly distributed over the entire area, and a concentrated caster load of 1000 pounds per square or round area of one square inch at any point on the removable panels. Maximum panel or system deflection for either loading will not exceed 0.080″. The entire floor system will be designed to support a rolling live load of 1000 pounds along any path over the panel. Maximum permanent deformation or set under these loading conditions will not exceed 0.010″ after 1000 applications of the 1000 pound moving load. The finished floor system will be level to within +/- 0.062″ in 10′ and +/- 0.10″ for the entire floor. The finished assembly will be square, rigid, free of vibration and provide jam-free removal or replacement of access panels.

d. Structural Floor Preparation. Prior to installing equipment on a raised floor, the building structural floor must be totally cleaned and sealed with lightcolored, chalk-free paint/sealant to inhibit dust and dirt accumulation/circulation. This will include underfloor walls/stanchion up to the height of the raised floor. Sealing agents mixed with the concrete is a not suitable method of sealing. When pedestals are glued (in addition to being bolted) to the true floor, the sealant must be applied to the surface of the floor after the pedestals are installed and glued in place. This will ensure that the strength of the bond is not weakened by adhering the pedestal to the sealant vice the true floor. When pedestals are bolted to the true floor, the sealant may be applied either before or after installation of the pedestals.

12. <u>Steps and Ramps</u>. Steps, rather than ramps, are preferred between raised and non-raised floor due to the amount of floor space permanently committed to a ramp. Steps will be of the same construction as the raised floor panels, covered with matching vinyl/laminate. Portable ramps should be provided to ease movement of equipment over the steps. Considering space restrictions, portable ramps will have approximately a 10-15° incline. If the volume of equipment movement through the area

makes use of a portable ramp unacceptable, a permanent ramp may be installed. Permanent ramps will have six inches run for one inch rise (9.5° incline) and will be at least the full width of

the servicing door opening. If installed in a passageway, ramps must be the full width of the servicing passageway. Handrails must be provided.

13. HVAC. Adequate environmental conditions are essential to proper operation of electronic systems. HVAC systems must be capable of maintaining proper temperature/humidity for the systems installed in a NAVSECGRU C-E facility. Environmental control requirements for NAVSECGRU electronic equipment spaces are discussed below:

a. Computer rooms. These areas generally should be maintained at 72 +/- 2° F (22 +/- 1° C), 45 +/- 5 percent RH on a year-round basis.

b. Receiver rooms/buildings and similar areas. Electronic equipment in receiver rooms/buildings, telephone switchgear rooms, RDF facilities, and similar areas generally require a year round environmental control of 75 +/- 5° F (22 +/- 2° C), 50 +/- 5 percent RH.

c. Transmitter buildings/rooms. The inside design condition for heating and cooling is 90° F (32° C), which will prevent equipment damage by moisture in the most humid climate. The waste heat generated by the transmitters can be used to maintain an elevated room temperature year-round. Air conditioning is provided only if excessive salt spray, sand, or dust makes it impractical to remove waste heat by ventilation practices, or if outside design conditions exceed the equipment rating more than one percent of the time. When air conditioning is required to meet the stated criteria, year-round levels less than 90° F (32° C) are acceptable provided a relative humidity of 50 +/- 10 percent can be maintained without significant reheat.

d. UPS. Spaces with UPS equipment will be maintained as indicated for transmitter rooms/buildings.

e. Further in-depth specific environmental control guidance may be found in MIL-HDBK-411A, MIL-HDBK-1003 (Series), and American Society of Heating, Refrigeration, and Air Conditioning Engineers Guide and Data Books, 4 volumes (Fundamentals, Applications, Systems, and Equipment). In all cases, the project BESEP should be consulted for manufacturers' equipment requirements or specific project requirements. Proper planning will result in adequate HVAC always being available.

f. HVAC Balancing. Any significant change in the quantity or type of equipment installed in a room may result in a heating load which exceeds the capacity of the HVAC system for that room or that area of the room. New heat loading requirements (new systems/equipment) are not always resolved by making changes to the opening of an air register or changing a thermostat setting.

g. Planning for the installation or deinstallation of any system should always be accompanied by a study of the heat loading for that system. Technical manuals provide information which can be the basis for determining the significance of the heating change. In some cases, an HVAC survey should be conducted by air conditioning personnel to determine if the existing HVAC system can provide the required volume of air and meet other equipment specifications for minimum temperature and humidity control.

14. Underfloor Air Plenum. Electronic equipment systems designed to use an underfloor air plenum are preferable to systems using ambient air for cooling. This methodology allows for a more comfortable ambient room temperature (personnel concerns) while significantly reducing the room noise level by eliminating the need for bay blowers. Generally, the space beneath the raised floor is used as a supply air plenum with an overhead ducted return or ceiling plenum return. A positive static pressure of 62.2 pascals (0.25" of water) gauge must be maintained in the underfloor plenum. Fans mounted atop the equipment cabinets may be required to help draw the conditioned air through. Systems requiring cooling by ambient room air, installed in a room with an underfloor plenum, will have floor tiles with floor registers installed directly in front of the cabinet air intake. The practice of using "home made" register panels (regular panel in which large holes have been cut for the purpose of air flow) in lieu of specific manufacturer provided register panels should be avoided since cutting holes of any significant size inherently weakens the tile. Total underfloor/overhead air plenum will be considered as one zone with zone transfer apertures kept to a minimum. Dust systems across zones will have baffles installed to restrict air flow from one zone to another in order to maintain zone static pressure.

NOTE: Disposable cardboard framed air filters will not be used in air handlers at NAVSECGRU operational sites.

15. Underfloor Fire Suppression Systems and Alarms. Raised computer floors used as air plenums require special types of

heat/smoke detectors because of the moving air. Compatibility with an existing fire alarm system should be considered in selecting components for an expansion. Underfloor alarm cabling should be installed in conduit and routed as close to the raised floor surface as possible to facilitate placement of duct work, piping, etc.

16. Installation Criteria at Air Force Host Sites

Electronic systems installed for Navy use at AF host sites are classed as either "common" or "Navy unique" equipment. It is the responsibility of the host to install and maintain common equipment. Navy unique systems (e.g. HFDF) will be installed as authorized by COMNAVSECGRU. However, some exceptions to typical Navy installation criteria are required to be consistent with other installations in the facility. All Navy installations will be coordinated through HQ AIA and the AF field unit. Copies of installation documents will be provided to HQ AIA and the field unit for review. HQ AIA will provide comments to NAVSECGRU. HQ AIA is responsible for ensuring their field site's comments are included with their own. The following paragraphs detail specific practices to be employed at AF host sites when systems are installed by Navy personnel. AIA Equipment Installation Standard, EIS 2-1 and 2-2 details standard AF installation practices and to the maximum extent practicable these should be adapted to Navy systems installed at AF sites.

a. RF Cables. The host activity will run all required RF cables from the RF distribution room to the vicinity of the equipment requiring it. The host activity will provide the cable and connectors for termination. In the case of AF host sites, this will be RG-214 cable and female "N" type connectors. Cable tray systems will not be installed in AF facilities. In areas with raised flooring, cables will be run in accordance with Air Force host requirements. Cables will not be routed diagonally across a space. Although cable trays are not employed, cables will be run in specific routes which are approved by the cognizant site office. RF cable runs for systems having dedicated antennas will be run by the EFA via a path specified by the local AF unit. Coordination with HQ AFIC and the local AF unit is required to determine a suitable location for antenna placement and manner in which it will be installed.