DEPARTMENT OF THE ARMY

HEADQUARTERS, NATIONAL TRAINING CENTER & FORT IRWIN

FORT IRWIN, CA 92310-5000

Reply to
Attention of

AFZJ-SPD 29 August 2002

MEMORANDUM FOR G3 National Training Center and Fort Irwin, ATTN: LTC Wallace Fort Irwin, CA 92310-5000

SUBJECT: National Training Center Spectrum Monitoring Studies

1. Purpose. To provide a technical description of proposed measures for monitoring the radio frequency spectrum within the Fort Irwin Expansion area and surrounding communities.

2. Background. The ability of the NTC, NASA-Goldstone and the surrounding area to operate in the frequency spectrum without conflict is critical. Identifying possible conflicts well in advance will allow the NTC to continue training soldiers, and to continue the historic level of cooperation between Fort Irwin and the surrounding community. The development of a spectrum monitoring capability is key to this goal.

3. Equipment Description. The portable monitoring station used by NTC personnel will monitor VHF, UHF and SHF frequency spectrum from 30 kHz to 18 Ghz. This system was designed to be expandable to allow the NTC to monitor frequencies up to 26.5 GHz. The station is portable and provides the capability to be deployed anywhere within the NTC that is accessible by vehicle (The technical description can be found at Appendix 1). The system has three major components: the monitoring equipment, system software, and a vehicle or prime mover.

a. The software (Appendix 2) is the heart of the monitoring system and is responsible for monitoring four essential tasks:

(1) To control a series of remote switches which select the correct RF path from the antenna to the spectrum analyzer.

(2) Remotely control the spectrum analyzer.

(3) Format and record data received from the spectrum analyzer directly to a CD-ROM drive.

(4) Have the ability to store analyzer and switch settings, for later use.

The software will provide the user a series of windows allowing the user to configure the monitoring system for each study. For example, the spectrum analyzer window would allow the user to enter the frequency or frequency ranges, sweep time, bandwidth, and resolution bandwidth, associated with the specific study location. This will allow the user to configure of all of the analyzer functions, and save the configuration for later use.

There is also a measurement window allowing the user to program different types of measurements. For example, the user could set up a timed measurement that would run for a specified amount of time, or a counted measurement that would run for a specified number of times. The measurement window would also allow the user to set up future measurements that would run manually or automatically.

b. The monitoring equipment (Appendix 3) is composed of an analyzer, filters, amplifiers and antennae that have been shock mounted to withstand the harsh environment found at the National Training Center. The equipment is contained within a steel cabinet, and mounted to the bed of a truck or on a trailer. It is a partially automated, computer controlled system, which can run continuously for up to ten hours. Data gathered by the equipment is captured on a removable CD-RW. This data can be exported to the Army's Spectrum Management Division where it will be archived and used to populate an existing SQL database. This database contains information gathered during other studies conducted on the NTC, and is used to identify possible spectrum conflicts.

The equipment has an independent on board battery power source. Alternate power sources can include a 120 VAC system or 24volt vehicle power. Battery power is the preferred power source because of its low probability of inducing electrical noise during the test. Logistically, this power source provides the user with the lowest impact. Batteries can be charged prior to deploying the equipment, and can be recharged using vehicle power, if necessary. Both the 120 VAC system and vehicle power can provide the necessary power to run the system. However, the maintenance requirements involved in keeping the generator or vehicle operational negate any possible advantages in using either of these two options.

c. The equipment is designed so it can be moved by a HMMWV or commercially available pickup truck. The vehicle will have to negotiate all of the various types of terrain found on the NTC, while pulling/carrying the monitoring equipment. Once the monitoring equipment is in place the vehicle can be used as an alternate power source or as a means to recharge the batteries used by the monitoring system.

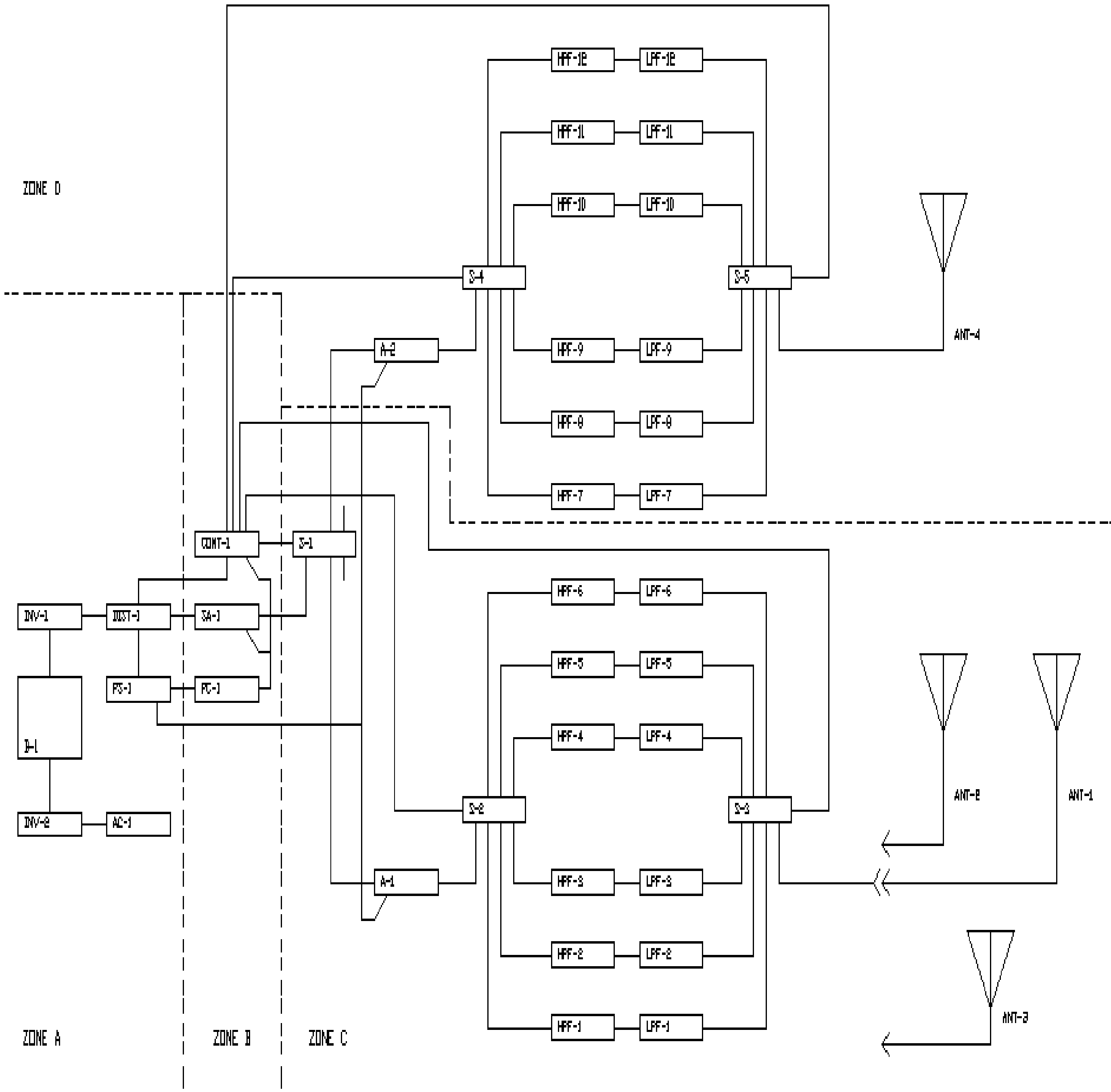
4. The development and utilization of this equipment will provide Fort Irwin with the unique capability to monitor RF spectrum, and identify potential conflicts before they impact training. The system has been designed to be expandable, providing the NTC with the capability to enhance its monitoring capability as requirements change.

SUBJECT: National Training Center Spectrum Studies

5. POC is Mr. David Lloyd, DSN 470-4753, Mr. Greg Swanson, DSN 470-7129 or Mr. Stefan Herzog, DSN 470-6173. Commercial number is (760) 380-XXXX.

Enclosures	RAYMOND H. MARLER
Appendix 1 Monitoring Equipment	Director
Technical Description	Strategic Programs
Appendix 2 Monitoring System	
Software Requirements	
Appendix 3 Monitoring System Component	
Listing	

Appendix 1 – Monitoring Equipment Technical Description



Appendix 1
Block Diagram
Spectrum Monitoring System

Appendix 1 - Monitoring Equipment Technical Description

1. Equipment Description: This system will automatically perform repeated measurements over a programmed range of frequencies at remote spectrum monitoring sites. Each system is mounted in an M105A2 trailer and is light enough to be pulled by HMMWV or other similar vehicle. It has the ability to operate for up to 10 hours with minimal operator support, and has the ability to be upgraded to run autonomously for up to 36 hours. Each measurement is automatically archived for later download to an SQL database for archive and analysis. The time of day that a given sample is measured is asynchronous and results in a random sampling scheme. A stepped measurement plan is utilized rather than a swept method to avoid noise pulses being interpreted as signals. The added dwell time on each frequency also increases the probability of intercept. An analysis of the data can be made using any or a combination of SQL tools, custom programs, or third party analysis engines.

2. Operation

a. The operation of the system is rather straight-forward. The appropriate antenna for the test to be performed is connected to one of the three input ports provided. The first port is used for 30-2000Mhz and would normally support ANT-1, ANT-2, or ANT-3. The second port is used for 1-18Ghz and normally supports ANT-4. A third port which connects to the spectrum analyzer's input directly, by-passing all signal conditioning, is provided to allow for strong signal or out of band measurements.

b. Signals intercepted by the manually selected antenna are routed to the appropriate band-pass filter assembly by computer controlled switches (S-2,S-3 pair or the S-4,S-5 pair). Due to the extreme bandwidths required each band-pass filter consists of a high-pass/low-pass pair. The band-pass filters limit the energy in the amplifier to in-band signals and help prevent amplifier saturation from strong out of band signals such as FM broadcasting.

c. After filtering, the signal is amplified by an LNA (Low Noise Amplifier) which improves the NF (Noise Figure) of the system beyond that typical of spectrum analyzers. Spectrum analyzers typically exhibit a NF 20-30db, the use of an LNA establishes the system NF as that of the LNA at 3-4db. The gain of the LNA also improves the sensitivity of the system beyond the –90dbm of the analyzer alone to approximately –130dbm. This meets the sensitivity of many communication systems in use by the ARMY today.

d. The conditioned signal is then directed to the spectrum analyzer by computer controlled switch (S-1). S-1 is a four-port switch. Port one is connected to the VHF/UHF RF assembly (RFA). Port two is connected to the UHF/SHF RF assembly (RFB). Port three is available for future expansion. Port four is connected to a front panel jack to provide a direct signal feed to the spectrum analyzer.

e. The spectrum analyzer performs the directed measurement under the direction of the computer, which then archives the measurement. The computer then sets up the system for the next measurement and continues the test series. The test series runs until terminated by time, cycle count, or the operator.

f. While ANT-1, ANT-2, and ANT-3 are omni-directional, ANT-4 requires some discussion. Omni-directional antennas at UHF and SHF suffer from the small physical aperture presented by quarter-wave and half-wave dimensions at these frequencies. Greater aperture is readily available using directional antennas. The use of directional antennas in this type of survey would normally be prohibitive. The narrow beam-width of the antenna would require multiple repeater measurement on each bearing to build a composite of the full-circle measurement. Rotary-joint couplings can be used to an advantage but would still be prohibitively slow. The solution is inherited from older radar systems where the rotary joint was eliminated. The primary antenna and beam-forming elements are fixed in position and directed against an angled reflector. The angled reflector is then rotated about the vertical axis at the required search speed. This design would allow faster rotation speeds than can be achieved by rotary couplings. A rotation rate of 400 degrees per measurement period would assure full circle coverage. Another factor is measurement dwell time vs. beam-width. At 18Ghz with a 100msec dwell time and a 2-degree beam-width, a full (400 degree) rotation would require 20 seconds. At 2Ghz with a 20-degree beam-width the same rotation would only require 2 seconds. A four or five speed belt drive system would allow efficient selection of the rotation speed for the band under test. Dwell times as short as 25msec have also been used which would reduce cycle times by a factor of four to 5 and 0.5 seconds, respectively.

g. Power for the system is provided by an array of storage cells providing 24V at 950AH. At an expected average load of 20A (45A, AC running) the battery will provide reliable power throughout the measurement day. Two 1.5KW, 120VAC invertors are used. INV-1 provides power for the instrumentation. INV-2 provides power for the AC unit. The decision to split the load in this fashion was driven by the desire to avoid transients on the instrumentation power when the AC unit cycles. A pair of 12V/75A battery chargers are fixed-mounted and connect in series with an equalization tap to the batteries. During a 14-hour period the battery chargers can provide 1050AH. This assures a full recharge of the system from a 120VAC/15A service overnight.

3. Major Assembly Groups. The four major assemblies consist of the following components:

a. Power

AC-1

B-1

BC-1

BC-2

DIST-1

INV-1

INV-2

Appendix 1 - Monitoring Equipment Technical Description

b. Instrumentation

CONT-1

PC-1

SA-1

c. RFA - Radio Frequency Assembly VHF/SHF

A-1

ANT-1

ANT-2

ANT-3

HPF-1

HPF-2

HPF-3

HPF-4

HPF-5

HPF-6

LPF-1

LPF-2

LPF-3

LPF-4

LPF-5

LPF-6

S-1

S-2

S-3

d. RFB - Radio Frequency Assembly UHF/SHF

A-2

ANT-4

HPF-7

HPF-8

HPF-9

HPF-10

HPF-11

HPF-12

LPF-7

LPF-8

LPF-9

LPF-10

LPF-11

LPF-12

S-4

S-5

4. Component Description

A-1

VHF/UHF Low Noise Amplifier

Used to establish system noise figure and extend sensitivity.

AML0022L3601, 3.5db NF, 36db gain

A-2

UHF/SHF Low Noise Amplifier

Used to establish system noise figure and extend sensitivity.

AML218L4401, 2.8db NF, 42db gain

AC-1

5400BTU air conditioning unit

Low cost, disposable, consumer unit

Refrigerating a small volume of 24 cubic feet.

ANT-1

For VHF measurements a selection of whip antennas are used. The exact choice is dependent upon the frequencies under test for a given measurement.

ANT-2

For low UHF measurements a conical spiral antenna covering 250-1000Mhz. The antenna has a hemispherical pattern and a gain of 0dbi.

ANT-3

For mid to high UHF measurements a conical spiral antenna covering 1-4Ghz. The antenna has a hemispherical pattern and a gain of 0dbi.

ANT-4

For UHF and SHF measurements from 1-18Ghz this antenna provides the aperture and gain of a directional antenna with the radial coverage of an omni-directional antenna. The primary element is a broadband feed firing down, on a vertical axis, into a parabolic secondary reflector. The parabolic's reflection is up to a tertiary reflector. The tertiary reflector is an elliptical plane reflector, centered on the vertical axis, having it's major axis set at a 45 degree tilt to the primary axis. This results in a beam parallel to the ground with 25-45db gain, depending on the frequency being measured. The tertiary element is rotated by a motor resulting in the beam rotating about the vertical axis.

B-1

A 24V battery bank consisting of two 12V blocks in series. Each 12V block is supported by its own, high capacity, battery charger.

Appendix 1 - Monitoring Equipment Technical Description

BC-1 (not shown on line drawing)

12V, 75A automatic battery charger servicing the "A" block of battery bank assembly B-1. The battery charger is permanently mounted and activated by connecting "shore power" cable to a 120VAC, 7.5A service. The expected daily station time is 14 hours. The 80% efficiency recharge capacity is therefore 840AH.

BC-2 (not shown on line drawing)

12V, 75A automatic battery charger servicing the "B" block of battery bank assembly B-1. The battery charger is permanently mounted and activated by connecting "shore power" cable to a 120VAC, 7.5A service. The expected daily station time is 14 hours. The 80% efficiency recharge capacity is therefore 840AH.

CONT-1

HP87130A switch driver/controller operates S-1, -2, -3, -4, and S-5. There is no provision for manual operation of the switches. All switch commands are processed by the HP87130A and must be received via the IEEE-488 interface.

DIST-1

120VAC power distribution block. While normally supplied by INV-1, "shore power" may also be connected at this point to power the instrumentation.

HPF-1

30Mhz High-Pass Filter.

Used in conjunction with LPF-1 to form a broadband band-pass filter.

The HPF reduces in-band harmonics in the amplifier by reducing sub-harmonic power from out of band signals.

The BPF formed by HPF-1 and LPF-1 also reduces the net power operating in the amplifier by attenuating signals outside the band of interest.

HPF-2

130Mhz High-Pass Filter.

Used in conjunction with LPF-2 to form a broadband band-pass filter.

The HPF reduces in-band harmonics in the amplifier by reducing sub-harmonic power from out of band signals.

The BPF formed by HPF-2 and LPF-2 also reduces the net power operating in the amplifier by attenuating signals outside the band of interest.

HPF-3

160Mhz High-Pass Filter.

Used in conjunction with LPF-3 to form a broadband band-pass filter.

The HPF reduces in-band harmonics in the amplifier by reducing sub-harmonic power from out of band signals.

The BPF formed by HPF-3 and LPF-3 also reduces the net power operating in the amplifier by attenuating signals outside the band of interest.

HPF-4

300Mhz High-Pass Filter.

Used in conjunction with LPF-4 to form a broadband band-pass filter.

The HPF reduces in-band harmonics in the amplifier by reducing sub-harmonic power from out of band signals.

The BPF formed by HPF-4 and LPF-4 also reduces the net power operating in the amplifier by attenuating signals outside the band of interest.

HPF-5

500Mhz High-Pass Filter.

Used in conjunction with LPF-5 to form a broadband band-pass filter.

The HPF reduces in-band harmonics in the amplifier by reducing sub-harmonic power from out of band signals.

The BPF formed by HPF-5 and LPF-5 also reduces the net power operating in the amplifier by attenuating signals outside the band of interest.

HPF-6

1000Mhz High-Pass Filter.

Used in conjunction with LPF-6 to form a broadband band-pass filter.

The HPF reduces in-band harmonics in the amplifier by reducing sub-harmonic power from out of band signals.

The BPF formed by HPF-6 and LPF-6 also reduces the net power operating in the amplifier by attenuating signals outside the band of interest.

HPF-7

1Ghz High-Pass Filter.

Used in conjunction with LPF-7 to form a broadband band-pass filter.

The HPF reduces in-band harmonics in the amplifier by reducing sub-harmonic power from out of band signals.

The BPF formed by HPF-7 and LPF-7 also reduces the net power operating in the amplifier by attenuating signals outside the band of interest.

HPF-8

2Ghz High-Pass Filter.

Used in conjunction with LPF-8 to form a broadband band-pass filter.

The HPF reduces in-band harmonics in the amplifier by reducing sub-harmonic power from out of band signals.

The BPF formed by HPF-8 and LPF-8 also reduces the net power operating in the amplifier by attenuating signals outside the band of interest.

Appendix 1 - Monitoring Equipment Technical Description

HPF-9

3Ghz High-Pass Filter.

Used in conjunction with LPF-9 to form a broadband band-pass filter.

The HPF reduces in-band harmonics in the amplifier by reducing sub-harmonic power from out of band signals.

The BPF formed by HPF-9 and LPF-9 also reduces the net power operating in the amplifier by attenuating signals outside the band of interest.

HPF-10

5Ghz High-Pass Filter.

Used in conjunction with LPF-10 to form a broadband band-pass filter.

The HPF reduces in-band harmonics in the amplifier by reducing sub-harmonic power from out of band signals.

The BPF formed by HPF-10 and LPF-10 also reduces the net power operating in the amplifier by attenuating signals outside the band of interest.

HPF-11

8Ghz High-Pass Filter.

Used in conjunction with LPF-11 to form a broadband band-pass filter.

The HPF reduces in-band harmonics in the amplifier by reducing sub-harmonic power from out of band signals.

The BPF formed by HPF-11 and LPF-11 also reduces the net power operating in the amplifier by attenuating signals outside the band of interest.

HPF-12

12Ghz High-Pass Filter.

Used in conjunction with LPF-12 to form a broadband band-pass filter.

The HPF reduces in-band harmonics in the amplifier by reducing sub-harmonic power from out of band signals.

The BPF formed by HPF-12 and LPF-12 also reduces the net power operating in the amplifier by attenuating signals outside the band of interest.

INV-1

1500W continuous duty inverter, 24VDC input power.

Supplies 120VAC for instrumentation.

Rated to start 3/4HP, antenna rotor motor is rated at 1/3HP.

INV-2

1500W continuous duty inverter, 24VDC input power.

Supplies 120VAC for air-conditioner.

Rated to start 3/4HP, AC is rated at less than 1/2HP (12,000BTU/HP).

Separate inverter is used to prevent transients from disturbing the instrumentation.

Appendix 1 - Monitoring Equipment Technical Description

LPF-1

90Mhz Low-Pass Filter.

Used in conjunction with HPF-1 to form a broadband band-pass filter.

See HPF-1 for details.

LPF-2

160Mhz Low-Pass Filter.

Used in conjunction with HPF-2 to form a broadband band-pass filter.

See HPF-2 for details.

LPF-3

300Mhz Low-Pass Filter.

Used in conjunction with HPF-3 to form a broadband band-pass filter.

See HPF-3 for details.

LPF-4

500Mhz Low-Pass Filter.

Used in conjunction with HPF-4 to form a broadband band-pass filter.

See HPF-4 for details.

LPF-5

1000Mhz Low-Pass Filter.

Used in conjunction with HPF-5 to form a broadband band-pass filter.

See HPF-5 for details.

LPF-6

2000Mhz Low-Pass Filter.

Used in conjunction with HPF-6 to form a broadband band-pass filter.

See HPF-6 for details.

LPF-7

2Ghz Low-Pass Filter.

Used in conjunction with HPF-7 to form a broadband band-pass filter.

See HPF-7 for details.

LPF-8

3Ghz Low-Pass Filter.

Used in conjunction with HPF-8 to form a broadband band-pass filter.

See HPF-8 for details.

LPF-9

5Ghz Low-Pass Filter.

Used in conjunction with HPF-9 to form a broadband band-pass filter.

See HPF-9 for details.

Appendix 1 - Monitoring Equipment Technical Description

LPF-10

8Ghz Low-Pass Filter.

Used in conjunction with HPF-10 to form a broadband band-pass filter.

See HPF-10 for details.

LPF-11

12Ghz Low-Pass Filter.

Used in conjunction with HPF-11 to form a broadband band-pass filter.

See HPF-11 for details.

LPF-12

18Ghz Low-Pass Filter.

Used in conjunction with HPF-12 to form a broadband band-pass filter.

See HPF-12 for details.

PC-1

PC/controller, a 500Mhz P3 computer with an IEEE-488 interface. This unit is physically hardened and includes a CD writer for archiving the collected data.

PS-1

12V/10A power supply supporting the pre-amplifiers and the PC/controller.

S-1

A 4 position rotary switch compatible with the HP87130A controller. This switch selects the output of the pre-selector/pre-amplifier assemblies. The third position is available for expansion. The fourth position is available on the front panel for direct feed to the spectrum analyzer.

S-2

A 6 position rotary switch compatible with the HP87130A controller. This switch selects the output of the band-pass filter array for VHF/UHF bands. The operation of this switch must be synchronized with S-3.

S-3

A 6 position rotary switch compatible with the HP87130A controller. This switch selects the input of the band-pass filter array for VHF/UHF bands. The operation of this switch must be synchronized with S-2.

S-4

A 6 position rotary switch compatible with the HP87130A controller. This switch selects the output of the band-pass filter array for UHF/SHF bands. The operation of this switch must be synchronized with S-5

Appendix 1 - Monitoring Equipment Technical Description

S-5

A 6 position rotary switch compatible with the HP87130A controller. This switch selects the input of the band-pass filter array for UHF/SHF bands. The operation of this switch must be synchronized with S-4.

SA-1

HP E4407B/290/A4H Spectrum Analyzer

A 33Ghz spectrum analyzer capable of “zero-span” measurements.

Controlled by IEEE-488 interface or manually via front panel controls.

Appendix 2 - Monitoring System Software Requirements

1. Overview. The monitoring system software will be required to perform 4 main tasks.

- To control a series of remote switches which select the correct RF path from the antenna to the spectrum analyzer.
- Remotely control the spectrum analyzer.
- Format and record data received from the spectrum analyzer directly to a CD-ROM drive.
- Have the ability to store analyzer and switch settings, for later use.

2. The following is a description of the computer, peripherals, and conceptual design for the monitoring system.

a. The Computer System. The system platform is Windows 2000. The CPU is a Pentium class 550Mhz processor with 512Mbs of cache. The storage devices include a 20Gb hard drive and an 8x4x32 CDRW drive.

The peripheral I/O is a National Instruments PCI-GPIB 488.2 card.

b. The peripheral devices

(1) Agilent E4407B Spectrum analyzer.

(2) Agilent 87130B Attenuator/Switch driver.

c. Physical system. The physical system consists of a computer (Lunchbox), a switch driver, 5 switches, and a spectrum analyzer. The Computer will connect to the peripheral devices using a GPIB interface. All of the peripheral devices conform to the IEEE 488.2 standard, and are capable of using the SCPI expansion to the common command set.

d. The Conceptual Design. The software controls the two main sub systems of the monitoring system: the peripheral control and data recording.

(1) The Peripheral Device Software. The software would provide the user a series of windows allowing the user to configure the peripheral devices. For example, the spectrum analyzer window would allow the user to configure the spectrum analyzer. The user would be able to enter the frequency or frequency ranges, sweep time, bandwidth, resolution bandwidth, etc. Basically allowing the user to configure of all of the analyzer functions, and once configured allow the user to save the configuration for later use. There would also be a measurement window allowing the user to program different types of measurements. For example, the user could set up a timed measurement that would run for a specified amount of time, or a counted measurement that would run for a specified number of times. The measurement window would also allow the user to set up future measurements that would run automatically, or allow the user to control the measurement manually.

(2) The last peripheral device for software control is the switch driver. The switch driver controls all of the switches in the RF circuit. There are two methods for controlling the switches, a manual method and, an automatic method. The manual method would provide the user with a window for selecting each switch or combination of switches for the required RF path. The automatic control would automatically select the correct switch or combination of switches required based on the frequency or frequency range programmed into the spectrum analyzer.

(3) The Data Recording Software. The data recording software will allow the user to select and format the output data from the analyzer into a comma or space delimited ASCII text file. The computer would write the data to the CDRW drive in real time. The purpose of writing to the CDRW in real time is so that in the event of a system crash or equipment failure the data burned into the CDRW would still be retrievable.

3. Software flow. The monitoring system software was built to make program set up and execution as easy as possible with the use of click and drag technology. The following steps were developed to create a monitoring plan:

a. Program start up. A monitoring plan can be reopened or created from either the start menu or desktop icon. Once a monitoring plan is created it can be named and saved. The plan can be used later at another site, but cannot be altered. This insures that monitoring plans remain consistent at numerous locations, providing the user with the best data possible.

(1) The first window would prompt the user to either select a previously executed plan, or build a new monitoring plan. A monitoring plan consists of a frequency or band of frequencies linked to a measurement type. If the user chooses to build a monitoring plan the user is then prompted to select or build a frequency or frequency band.

(2) If the user chooses to build a frequency band, a spectrum analyzer window appears allowing the user to enter a frequency band, set up the spectrum analyzer for taking measurements in that band, and name the band for use in the monitoring plan.

(3) The user can now select or build a measurement type. This is used for measuring the band. The monitoring plan window would then allow the user to select a frequency band or bands, associate them with a measurement type, then name and save the plan.

(4) The monitoring plan will control the analyzer set up, switch configuration, and prompt the user for a file name and location for data collection. Upon entering the requested information, the monitoring plan is now ready for execution.

b. Program execution. The monitoring plan has been created and stored in the computer and is ready for deployment to a field site. Once at the site the user sets the system up for operation by mounting antennae to the system, and insuring the power source to the system is on line. After these tasks are completed the monitoring system can be turned on and left to run for a pre-determined amount of time (as specified in the monitoring plan). At the end of the monitoring period the data can be removed (via CD-RW), and the equipment prepared for movement to another site.

DEPARTMENT OF THE ARMY

HEADQUARTERS, NATIONAL TRAINING CENTER & FORT IRWIN

FORT IRWIN, CA 92310-5000

Reply to
Attention of

AFZJ-SPD 12 September 2002

MEMORANDUM FOR G3 National Training Center and Fort Irwin, ATTN: LTC Wallace Fort Irwin, CA 92310-5000

SUBJECT: National Training Center Spectrum Test Facility

1. Purpose. To provide a technical description of proposed measures for testing radio systems utilized at the NTC to insure they will not interfere with the Goldstone mission.

2. Background. The increased RF spectrum requirements for units training at the NTC necessitate expanding the capabilities of the current Spectrum Management Division's (SMD) Spectrum Test Facility. The test facility, as it is today, is not capable of reaching the level of sensitivity required to ensure that the emissions generated by the Army will not interfere with the NASA-Goldstone Deep Space Communications Complex. This requirement became more important with the onset of land expansion, as training will now occur closer to NASA facilities.

3. Equipment Description. To meet these new requirements several hardware changes need to be made to the existing facility (Appendix 1). The addition of a directional coupler, amplifier, and dummy load will enhance the current capability and allow the SMD to identify any potential emissions within the NASA bands of concern. The test facility equipment will automatically perform qualification measurements against an acceptance mask, as defined by NASA/ JPL and the NTC SMD. The acceptance mask defines frequency bands and acceptable emission limits for operation at distances greater than or equal to one kilometer from DSN (Deep Space Network) systems.

4. Software Description (Appendix 2). The computer's software program will utilize "click and drag" technology to assist the user in designing and conducting a test. These test configurations can be saved and used at a later date to allow the user to duplicate the test while using a new piece of equipment. The software will develop a pass/fail response based on the acceptance mask and provide the user with a description of any failures.

5. The development and utilization of this equipment provides Fort Irwin with the unique capability to test radio equipment, and identify potential conflicts, with Goldstone before they impact training or Goldstone Operations. The system has been designed to be expandable, providing the NTC with the capability to enhance its testing capability as requirements change.

6. POC is Mr. David Lloyd, DSN 470-4753, Mr. Greg Swanson, DSN 470-7129 or Mr. Stefan Herzog, DSN 470-6173. Commercial number is (760) 380-XXXX.

Enclosures	RAYMOND H. MARLER
Appendix 1 Test Facility	Director
Technical Description	Strategic Programs
Appendix 2 Test Facility	
Software Requirements	

Appendix 1 Test Facility Technical Description

1. Test Facility Operation. The operation of the test facility is prompted by a computer program. An initial "cold" test is performed with the input terminated to measure base values. The computer will then prompt the operator to connect the DUT (Device Under Test) and energize the transmitter.

a. The computer will direct the spectrum analyzer and switch driver to perform the "L-band" measurement:

1628Mhz-1708Mhz NTE –94.2dbm/Hz

b. Upon completion of the "L-band" measurement the computer will proceed to the

"S-band" measurements:

Measurement 1: 2200Mhz-2290Mhz NTE –86.5dbm/Hz

Measurement 2: 2290Mhz-2300Mhz NTE –103.1dbm/Hz

c. Upon completion of the "S-band" measurements the computer will proceed to the

"X-band" measurements:

Measurement 1: 8400Mhz-8450Mhz NTE –91.2dbm/Hz

Measurement 2: 8450Mhz-8500Mhz NTE –74.9dbm/Hz

d. Upon completion of the "X-band" measurements the computer will proceed to the

"Ku-band" measurements.

Measurement 1: 12750Mhz-13250Mhz NTE –75.7dbm/Hz

Measurement 2: 14800Mhz-15350Mhz NTE –69.9dbm/Hz

e. At completion of the "Ku-band 2" measurements the computer will proceed to the

"Ka-band" measurements

Measurement 1: 31800Mhz-32300Mhz NTE –77.3dbm/Hz

Measurement 2: 37000Mhz-38000Mhz NTE –63dbm/Hz

f. Each test is performed through a band-pass filter. The filter is designed to reject the power developed by the transmitter operating on its designed frequencies. No test will be performed by this system on a radio designed to emit power within a GDSCC (Goldstone Deep Space Communications Complex) band. All transmitters will be terminated by a broadband, resistive termination. The potential exists that a 6db correction will be required by the filter design. If the filters can only be realized with a low input impedance, the measured signal will be "double terminated." The test is designed measure unintended or spurious emissions occurring within the DSN bands.

g. Emission limits, to this point, have been specified as a power level per hertz. Direct measurement of spurious emissions from NTC transmitters on a per hertz basis would be prohibitively slow and misleading. Spectrum analyzer sweep speeds are calibrated in conjunction with the IF filter and video filter response times. Narrow filters are very slow to respond to signal changes and require extremely slow sweep speeds. In addition, the slow response time will lower the measured signal values of spurious emissions which are rapidly changing their amplitude. This will be particularly evident on FM and N-QUAM transmitters. The error will be approximately on the order of:

10log(transmitter modulation / filter band-width)

h. For voice FM modulation of 10Khz deviation the spurious signal could be as high as 40db over the measured value. If the spurious signal were measured with a filter similar to the transmitter's emission the measured values would be more accurate but the pass/fail standard would have to be adjusted to compensate for the bandwidth and the power level per hertz inferred. Recommended IF bandwidths for voice FM or digital single channel voice transmitters would be 30Khz (+45db). For digital multiplex, or HI-CAP trunk transmitters, the IF bandwidth would be 300Khz (+55db). Radars would require a 1Mhz IF bandwidth (+60db).

2. Component Description

a. DUT (Device Under Test)

Transmitting equipment being certified

b. Termination

Broad-Band

50-ohm

resistive

100 Watt

Dummy load

c. Computer

Lap-top or PC

Capable of RS-488 control

Alternatively use in conjunction with and RS-488/ethernet interface.

d. Switch Driver

An HP87130A switch driver/controller operates switches S-1 and S-2. There is no provision for manual operation of the switches. All switch commands are

processed by the HP87130A and must be received via the IEEE-488 interface.

e. S-1, S-2

4-position rotary switches, the exact vendor's solution may not use this architecture.

PIN microwave switches are a distinct possibility, but will still be driven by the HP87130A.

f. Coupler / Band Pass Filter (BPF) ASSEMBLY

An assembly of directional couplers and Hi-Q Band-pass filters. The assembly may also take the form of a multi-coupler. Shape factors for the filters will need to be sharper than 1.01:1.

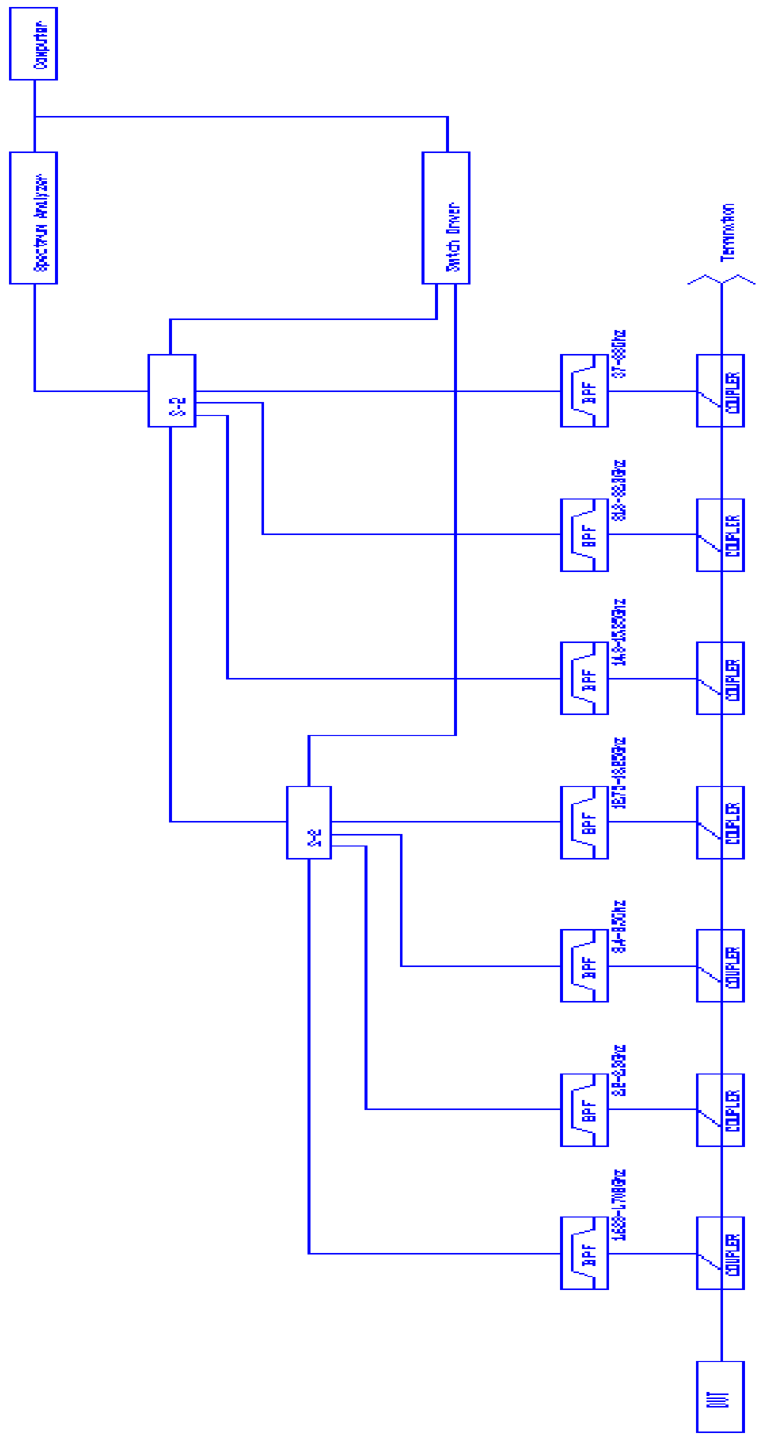
g. Spectrum Analyzer

HP E4446A Spectrum Analyzer

A 44Ghz spectrum analyzer.

Controlled by IEEE-488 interface or manually via front panel controls.

Appendix 1 Test Facility Technical Description



Appendix 2 Test Facility Software Requirements

1. Software requirements. The Test Facility software will be required to perform the following tasks:

a. Control a series of remote switches, which select the correct RF path from the tap on the directional coupler to the spectrum analyzer.

b. Remotely control the spectrum analyzer.

c. Record measurement data from the spectrum analyzer.

d. Perform interference testing

e. Provide a pass or fail report showing the results of the test.

2. Conceptual design. The software is responsible for controlling the entire interference test. The software responsibilities include the set up of all of the test equipment, recording measurement data, and performing interference testing.

3. Test equipment set up. The software will provide the user a series of windows controlling the setup of the test equipment (peripheral devices). The peripheral devices include, a spectrum analyzer, a switch controller, and a printer. The software would also allow the user to name, and save the configuration of the test equipment, allowing for duplicate testing in the future.

4. Recording Measurements. The software would allow the user to format and save the measurement data received from the analyzer. The measurement data would also be compared against a measurement mask to determine the possibility for interference.

5. Interference testing. Interference would be determined by comparing the measurement data from the spectrum analyzer against a pre-programmed measurement mask.

The measurement mask would be composed of a series of frequencies, and or frequency bands, and the maximum allowable signal levels in those bands. The results of the comparison would be put into a pass or fail report and formatted for print or electronic media.