MEMORANDUM

To: William E. Holden Date: 30 August 1985

cc: Art O'Connor
Larry Schick

From: Bruce E Walters

Subject: Platoon Early Warning System
Report of Test and Evaluation 9860-0003

....

Due to the recent upsurge in marketing interest in the Platoon Early Warning System (PEWS), more attention has been drawn to the system's performance. You, Art, and I set up the testing and evaluation program for marketing, in order to help in determining whether or not the PEWS can become a viable product. You assigned me the task of testing the PEWS and assisting Art O'Connor in the evaluation of the system.

I have now completed the testing and collaborated on the analysis of the PEWS. In addition, Art and I believe we have defined the fundamental problem of the PEWS: lack of uniformity of detector performance. By analyzing test results and collecting data we hypothesized that by replacing a specific resistor in the AGC section, we could solve the uniformity problem. This hypothesis was validated by an experimental replacement and test program. We have not yet addressed the other, less important problems of the PEWS. These are proposed as follow-on investigations.

This report presents the procedure we used to evaluate, hypothesize and prove the solution to the detector performance problem. Also, this report suggests other programs which would augment the system from both performance and marketing standpoints.

I am confident the PEWS can be made into a salable item. In fact, I believe that the system can perform better than it does at present, but its other problems need to be evaluated in order to do so. It is also possible that many low-cost user options can be added to the current system. These would make PEWS more attractive to potential customers.

REPORT

PLATOON EARLY WARNING SYSTEM
DEVELOPMENT PROGRAM
DETECTOR CONSISTENCY

PREPARED FOR THE
MILITARY ELECTRONICS STRATEGIC BUSINESS UNIT
ISC TECHNOLOGIES INC.

PREPARED BY
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WORK PERFORMED UNDER DEVELOPMENT NUMBER
10-20-2560-7904-9860-0003

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ILLUSTRATIONS

EXECUTIVE SUMMARY

Because of the difficulties encountered with the Platoon Early Warning System (PEWS) due to the lack of repeatable detector performance, the question of whether or not to continue with the system in the ISC Technologies product line has been raised. The difficulties made evident in field tests and demonstrations are in system performance. The systems seem to be erratic. Among the noted problems are target detection, target classification, and false alarm rate.

The fundamental problem was that the ten detectors of any given system failed to perform in a similar manner. Some detectors worked well, others in a mediocre manner, and a few never indicated an intrusion. If this problem could be corrected, then the system would stand a very good chance of becoming a viable product. If this problem could not be solved, then the system might never function properly or predicatably.

The results of specialized tests and other information were tabulated and investigated. A hypothesis was drawn, based on the collected data and a detector circuit examination. The detectors were modified with respect to the hypothesis. Tests identical to the previous ones were performed in order to validate the hypothesis. The modified detector tests upheld the hypothesis and the conclusion was reached. The detector similarity problem could be solved by a simple modification.

The modification involved replacing a resistor whose value was selected by test with one which had a fixed value. This modification will eliminate a step in the production of the detector, while adding no cost to the system.

1.0 INTRODUCTION

1.1 Purpose

The purpose of this report is to convey the results of the detector consistency portion of the PEWS development program. As detector performance was identified as the most frequent cause for PEWS problems, this development program was conducted to aid in determining whether or not to pursue the system as a salable item.

1.2 History

The Platoon Early Warning System (PEWS) is a portable intrusion detection system designed for use by small military units, such as platoons, squads, and patrols. PEWS covers a broad range of applications from offensive to defensive in nature. Other employment may be as part of a fixed security system.

The Platoon Early Warning Device was conceived as a U.S. Army requirement in 1968. The system was redesignated PEWS, in 1972. The original engineering of the system was performed by the Delco Division of General Motors Corporation.

ISC's involvement with PEWS began in 1978, when ISC won the U.S. Government production contract. The system was redesigned under U.S. Government authority to facilitate automatic insertion of components and automatic board testing, which provided for more efficient production. Many other quality improvements were also made in the PEWS (Appendix I).

In 1983, ISC Defense Systems began PEWS production. To date, over 4000 systems have been sold and delivered to the U.S. Army, and the U.S. Air Force. A small number of systems has also been sold abroad (Appendix J).

Field tests and demonstrations have been performed worldwide. During the first demonstrations of the PEWS, system performance problems were discovered. The problems identified were: 1)in most instances, the system did not indicate targets at a distance of ten meters (per system specification) if it detected anything at all; 2)in some cases, the system did not properly classify intrusions; 3)false alarms were too numerous. A few field tests, specifically designed so that the results would be suitable for analysis, have been conducted. These are listed in Appendix L.

2.0 DISCUSSION

2.1 Prior Testing and Observations

Observations for this program began in August of 1984, when field tests were performed to help familiarize marketing personnel with the PEWS. These tests involved George Stickle, Art O'Connor, and the writer. The tests were conducted on the field that is now the ISC Defense Systems parking lot. In the course of the testing, one problem in particular was noted: each detector performed differently, with one or two detectors that performed well, others in a mediocre manner, and others that never gave an indication of detection. A classification problem was also noted; personnel walking past the detectors were classified as vehicles, and distant vehicles were classified as personnel.

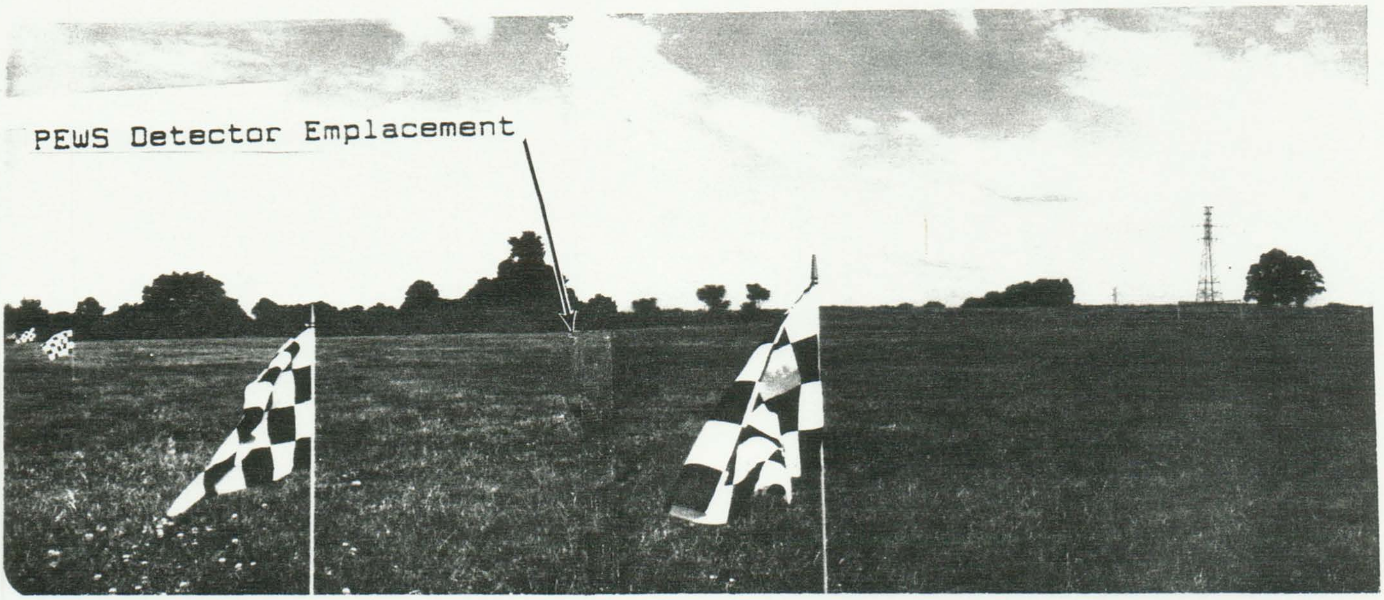
During these tests, the participants took turns walking past the detectors, which were placed on the ground next to one another. At first, wind noise (possibly gusts striking the detector body or vibrating the antenna) was postulated as the problem. In an attempt to shield the detectors from the wind, a box was placed over each detector. Still, all the detectors performed differently. However, they were individually consistent. Detectors that performed well continued to do so; detectors that performed in a mediocre manner continued to do so; and the same few "silent" detectors continued to ignore targets.

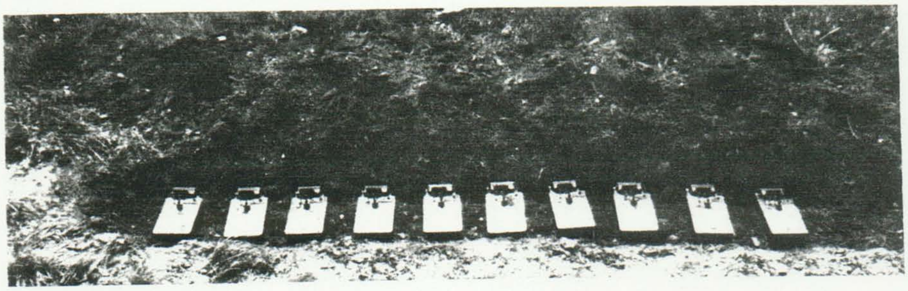
Soil conditions were then postulated as the problem. A new test site was carefully chosen. The new site was formerly a strip mine, with a solid base and a surface of settled top soil. Located on the top of a hill in Lancaster County Park, it is surrounded by distant trees and isolated from most conceivable forms of seismic noise.

The detectors were placed in a long trench and enveloped with soil (Figure 2.1). Care was taken to ensure that all of the detectors were equally emplaced. A number of tests were performed under similar weather conditions and using the same person as a target (Appendices J and K). The detectors were placed in a different order each time, to avoid the possibility of seismic channeling allowing some detectors to receive the seismic wave while preventing the others.

The results of this testing program were similar to the first test. Some of the detectors always worked and some never worked.

Figure 2.1 Field Test Site: Lancaster County Park





PEWS Detector Emplacement

Buried Detectors

2.2 Analysis and Definition of the Problem

All of the test results were tabulated and analyzed. Immediate field fixes and detector ground position had no impact on system performance. In fact, any solution conceived up to this point had failed to show that the system could perform as it is described in various government documents. The new findings were compared with the groundwork and conclusions of testing and analysis performed by A. Stagg, J. Hooper, and C. Opitz. The algorithm used for system operation was well supported by the seismic model described in a series of memos (C. Opitz, 1981). In theory, and on paper, the indications were that the system should work.

It was postulated that the problem was with the electronics, not the local test conditions. All of the testing and analysis had been performed under the assumption that the system functioned as described in various government documents. If, however, the system did not respond consistently to apparently consistent input, then there was reason to suspect that something was wrong with the PEWS system. Obviously, the system electronics were at fault.

The two electronic devices in the system are the detector and the receiver. The receiver accepts data from the detector and displays the intrusion information. No intrusion processing is performed in the receiver. The receiver seemed to be functioning properly. The detectors, however, collect input from the sensors and perform all of the intrusion processing. Field test results showed that targets were not treated the same by all detectors. A few unique detectors always recognized the targets, certain others detected targets some of the time, and a few never idicated an intrusion. Given the same input, the detectors were responding differently. Swapping detector locations did not change the results. Given the same input, the detectors were responding differently. The problem was defined, then, as detector performance similarity. If the detectors could be made to perform in the same manner, then the system could be expected to operate as described by the specifications. As it was, the system algorithm could not work because the system electronics were not operating correctly.

Preparations were made for an investigation of the detector circuitry. After assuring that the proper supply voltages were present, and the other obvious functions (output modes) were intact, analyses began with the geophone. The geophones are the very first step through the detector circuitry; however, they were not expected to be the source of the problem. Each detector was opened, but left assembled so as not to disturb the effects of the case on the geophone. The detector under test was placed on a foam-covered granite gage block, which was supported by a rubber-wheeled table. All connecting cables and wires were run under the gage block. These precautions isolated the detector from seismic noise.

DISCUSSION

A pulse generator was constructed to provide a 5-volt, variable duty cycle, square-wave pulse. The test equipment was configured as in Figure 2.2. A square-wave, from the function generator, was used to trigger the pulse generator. A pulse, one millisecond in duration, was fed to the geophone through an attenuator. The geophone response was monitored by a digital oscilloscope. This response (to the pulse) was then processed (using functions on the digital oscilloscope) to determine the frequency response of the geophone.
The response of all of the geophones was similar, both in signal level and frequency-related properties. The geophones were working exactly as expected; therefore, the geophones could be eliminated from suspicion.

Next, the schematic for the geophone amplifier section was carefully studied. The equipment was configured as in Figure 2.3. The geophones were disconnected and a resistor (330 Ohm) was installed in each of their places. These load resistors emulated geophones that were free of frequency coloration. Again, the function generator provided the triggering square-wave for the pulse generator. The one millisecond pulse was fed to the amplifier through an attenuator. The response of each seismic amplifier at any given Automatic Gain Control (AGC) voltage was different from any other seismic amplifier.

Further investigation showed that the only physical difference between the detector amplifiers was a resistor in the AGC loop. This resistor, selected at test during manufacturing calibration, became the focus of our investigation. The resistor in question affects the gain of the AGC amplifier. The gain should be the same for each detector. If the gain is not the same for each detector, then each detector will perform differently from any other. Changing the value of this resistor has no desirable effects on detector circuit performance. All of the detectors should have the same value for this resistor. The resistor value should be chosen so that the AGC amplifier exhibits a gain that is usable under realistic operating conditions.

The circuits were modified to allow control of the AGC voltage. This simply bypassed the section of the AGC amplifier that is affected by the resistor. Again, the geophone amplifier sections were subjected to the pulse, but with a precisely controlled AGC voltage. The response of each detector then closely resembled that of the others. Bench tests were performed at various AGC voltage levels.
At each level, the detectors operated similarly.

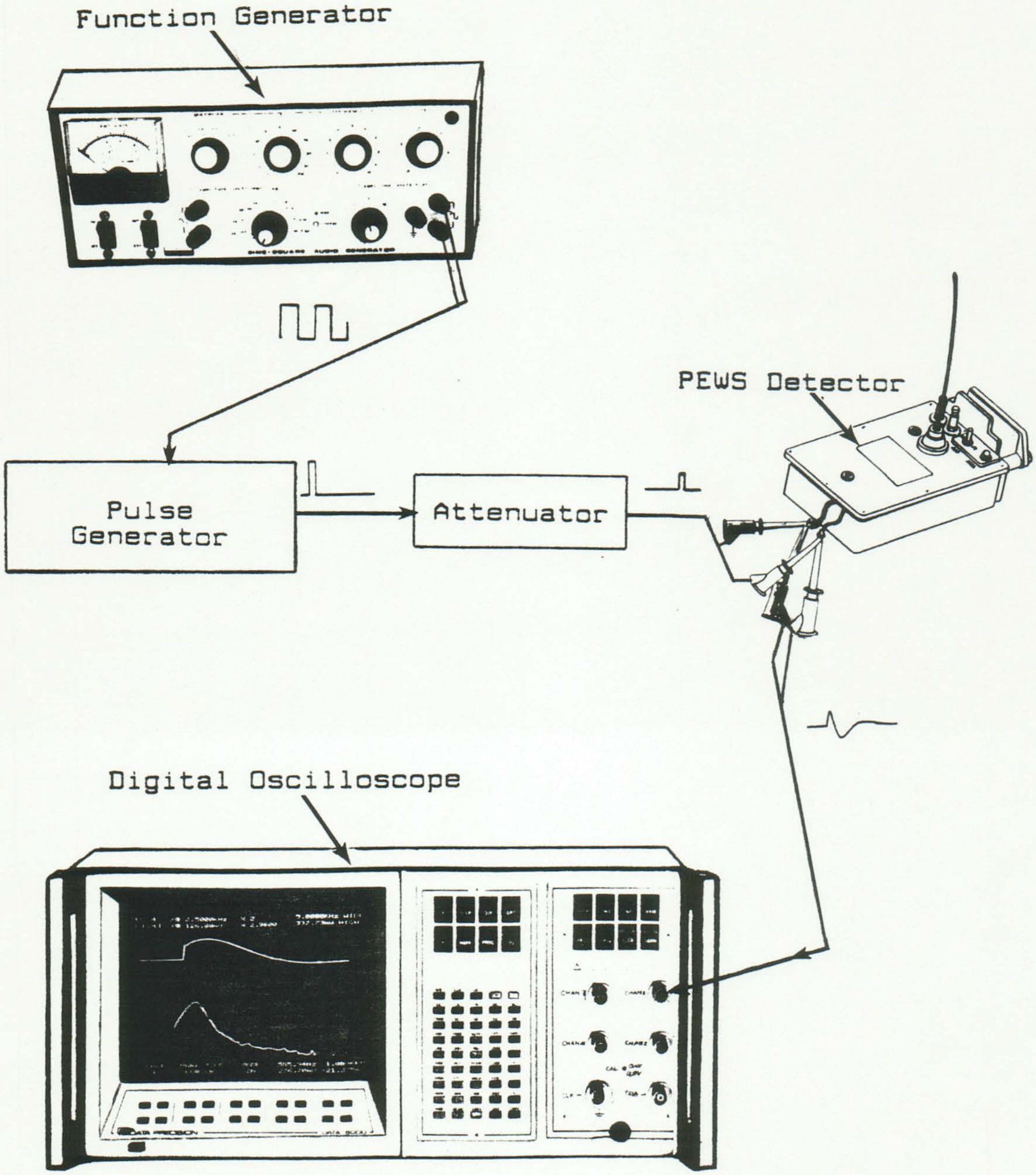


Figure 2.2   Test Equipment Configuration, Geophone

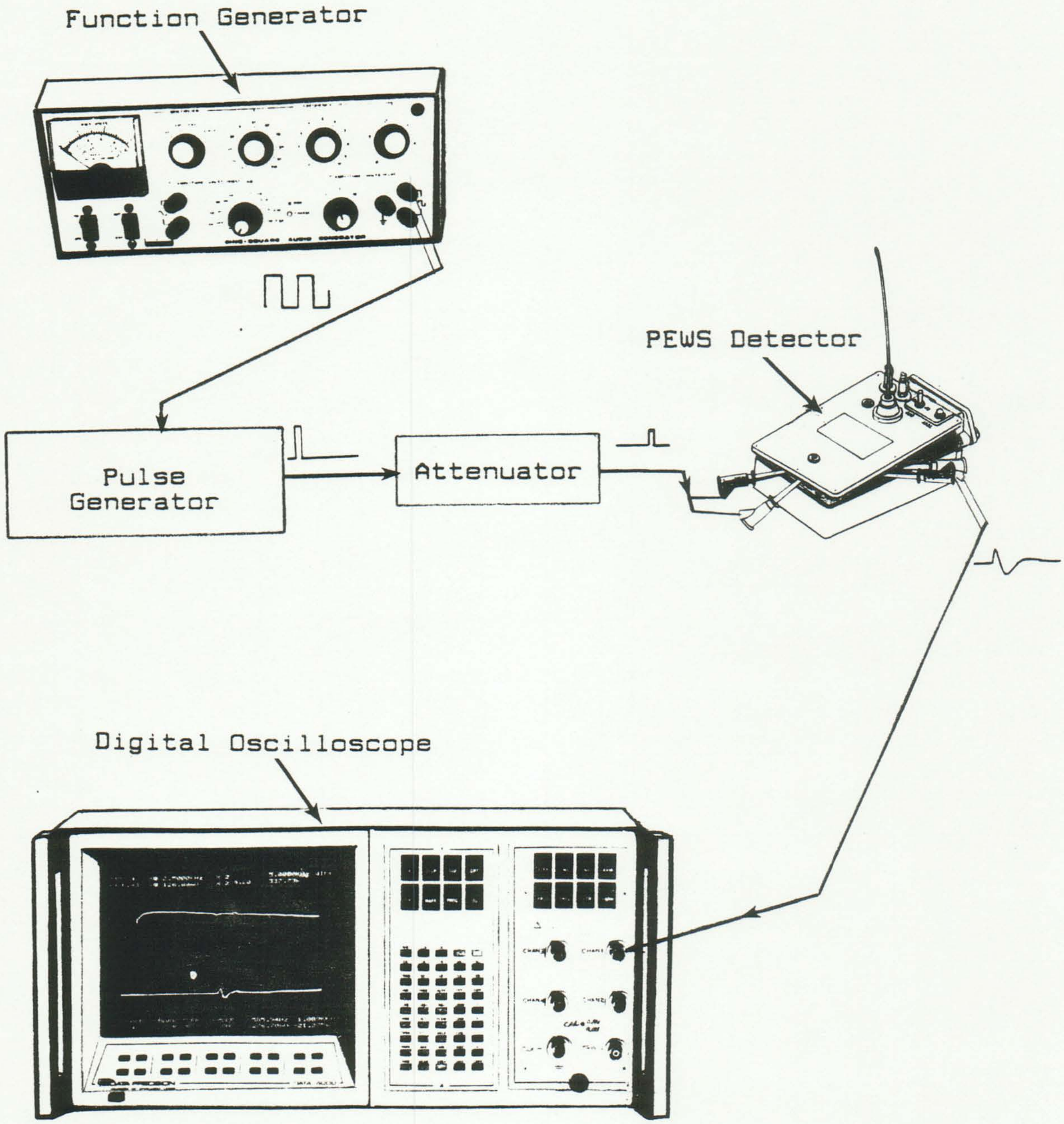


Figure 2.3 Test Equipment Configuration, Geophone Amplifier

2.3 Solution

The hypothesis was deduced. If the value of the "select at test" resistor were made the same for each detector, then all of the detectors should perform similarly. The solution was to choose a fixed resistor value to replace the "select at test" resistor value. In trying to arrive at a suitable resistor value, a pattern was noted. The detectors that operated well had similar values for this resistor. Logically then, the value chosen should be close to the value found in these detectors. The value chosen was 2 megohms.

2.4 Validation

In order to validate the modification, tests were performed again at Lancaster County Park, exactly as described in section 2.1. The detectors were placed in a long trench and enveloped with soil. Care was taken to ensure that all of the detectors were equally emplaced. A number of tests were performed under similar weather conditions and using the same person as a target (Appendices J and K). The detectors were placed in a different order each time, to avoid the possibility of seismic channeling allowing some detectors to receive the pressure wave and preventing others from receiving it.

The results of this testing program revealed a dramatic improvement over the intial tests. All of the detectors performed well, most of them far beyond the specification. The seismic channeling problem, however, did appear to be real. Any detector placed in one of two positions in the emplacement would not detect a target beyond twenty to thirty meters. The detectors that did not function well at these two positions did, however, work very well elsewhere in the emplacement. All of the detectors worked all of the time for targets at a range of ten meters. PEWS assumes that the wave propagation is consistent. In reality, this may not be the case due to buried objects, zones of different materials, variable compaction of materials, rock formations, and other elements that play on the seismic wave model.

Appendix N is a description of the theoretical circuit analysis. This analysis verifies that the demonstrated solution is sound.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

3.1.1 Ramification of the Solution

Test data confirm that the modification is effective in providing detector performance similarity. In addition to detector similarity, the modification also results in greater detection range. Under optimum conditions, detections were consistent at a range of 50 meters, which is five times the system requirement. No negative effects have become evident.

3.1.2 Discussion of Other Problems

Now that the fundamental problem of detector similarity has been solved, we can once again turn our attention to the other problems with system performance. These problems include target classification and false alarm rate, detector jamming, and detector sensitivity.

The next problem to be tackled is target classification. This is the most common complaint by field users; however, it could not be attacked until the detectors performed similarly. The problem is defined as the system's inability to distinguish between personnel and vehicles. This problem is made evident during every field test.

False alarm rate is second most common criticism. The specification for the PEWS false alarm rate is one false alarm per 24 hours of constant operation. At present, the system's false alarm rate is usually much higher. The solution to the classification problem may also help to solve the false alarm rate problem.

It has also been noted that the detectors are easily jammed by background noise, and thus rendered inoperative. This may have been a symptom of the detector similarity problem as none of the modified detectors has exhibited this, even in a rainstorm.

Running or crawling personnel and personnel on bicycles are frequently not detected. This is due to a shortcoming of the detection algorithm. While it is reasonable to expect that the PEWS can be modified to detect running personnel, cycling or crawling personnel may never be detected by this system. This is because high sensitivity is traded off against lowering the false alarm rate. The detectors, as they are now designed, could be made to identify creeping personnel, but the false alarm rate would be excessively high. Cycling personnel may be detected if the magnetometer is used in conjunction with an external sensor.

The possibilities for the solutions to these problems include changes in the AGC time constant, the footstep counter, and the detector logic. The solutions may be complex; it is therefore difficult to estimate the time required to find them.

3.2 Recommendations

The PEWS, as presently modified, is a working security system. The classification and false alarm rate problems may or may not need to be considered in the PEWS marketing decision. If not, then the PEWS is ready. If these problems may have an impact on marketing, then perhaps more testing and analysis are in order. The solutions may be complex, therefore, it is difficult to estimate the time required to find them.

An option development program is suggested to run coincident with the problem-solving program. This would make the most efficient use of available time and funding. The testing program would seek the solutions to the system performance problems, stated above. The development program would define and possibly incorporate user options, as well as identify new applications for the PEWS. Some of the suggested options include:

1) Better strain relief for headset cable (heatshrink)
2) Improve detector antenna (spring-base to avoid breakage)
3) Add-on power units for the detectors (to extend time of operation)
4) Additional sensor option (provide a means of using any of a variety of standard sensors in addition to those currently utilized by the detector)
5) Auxiliary audio amplifier for external loudspeaker
6) Auxiliary display for the receiver (to enable viewing of multiple detections)
7) A higher power or repeater option (for greater distance between detectors and receiver.

CONCLUSIONS AND RECOMENDATIONS

A new name for the PEWS should be chosen. The new name will establish the system as an ISC product, as opposed to a U.S. Army device obtainable through the U.S. Government. It must be recognized however, that the "AN" nomenclature will no longer be available. The "new" system should be described and marketed as "ruggedized". Commercial grade-components can be used in place of military grade devices with little or no performance degradation, allowing less expensive manufacturing.

Appendices

The following is a listing of Army identification numbers for PEWS. This U.S. Army approved nomenclature (Bialo-DRCPM-RBS-L) is dated, by letter, 6 Feb. 1979.

Approved Nomenclature	Gov't DWG. NO.	Assigned Frequency
Platoon Early Warning Systems AN/TRS-2(V)1	DL-C5001250	139.100 MHz
Platoon Early Warning Systems AN/TRS-2(V)1	DL-C5001250	139.250 MHz
Platoon Early Warning Systems AN/TRS-2(V)1	DL-C5001250	141.100 MHz
Platoon Early Warning Systems AN/TRS-2(V)1	DL-C5001250	148.925 MHz
Platoon Early Warning Systems AN/TRS-2(V)1	DL-C5001250	149.600 MHz
Platoon Early Warning Systems AN/TRS-2(V)1	DL-C5001250	150.600 MHz
Case, Platoon Early Warning System, CY-7524/TRS-2(V)	NATICK 2-2-414 &15	N/A
Sensor Interface, Wire Link MX-9738/TRS92(V)	SM-D-783145	N/A
Test Set, Receiver TS-3565/TRS-2(V)	SM-D-783451	N/A

Figure 4.3.1 PEWS SYSTEM

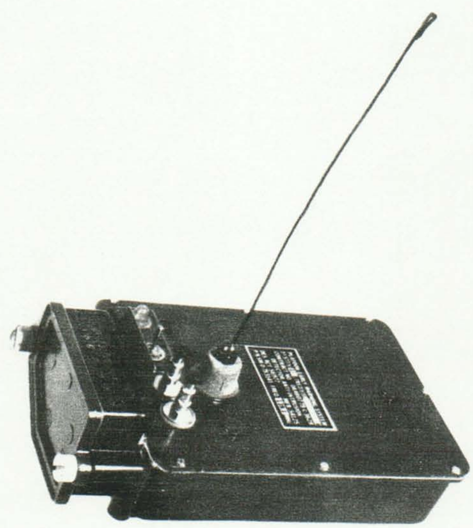


Figure 4.3.2 PEWS Detector

Figure 4.3.3 PEWS Receiver

The requirement for a platoon early warning system was long standing, according to various government publications. The requirement was officially stated in a 1968 Combat Development Center (CDC) letter (CDCMR, 25 Nov 68) "subject: Department of the Army Approved Small Development Requirement for Platoon Early Warning Device (PEWD)". The requirement was defined as "a simple, commpact, lightweight, early warning device utilizing a control unit and sensors capable of detecting the movements of objects on the surface of the earth and/or other sensors not limited to line of site"(sic)"" (U.S. Army Infantry School Handout for PEWS, May 1981, pg 6). The system was redesignated Platoon Early Warning System (PEWS) as a result of an In-Process Review (IPR) conducted on 11 Aug 72, which also approved the Coordinate Test Program (CTP) for PEWS.

PEWS development work was performed by the Delco Division of General Motors Corporation for the United States Army Electronics Command at Fort Monmouth. The PEWS was designed to meet the development standards set forth by the U.S. Army Electronics Command Development Discription, human factor specifications, and cost specifications (design unit to cost $1,206.14 U.S. 1974 Dollars). PEWS must satisfy the requirements of the 1977 Development Acceptance (DEVA) IPR and must meet the requirements for a Small Unit Package (SUP). These are the U.S. Army requirements for PEWS.

The Human Engineering and Design Evaluation (HEDE) Model Review was held at Fort Monmouth and designated changes were made to the detector and receiver control switches. The design was completed and frozen in November of 1974. Prototypes were built and reliability tests were performed from May until July of 1975. The tests revealed the following; 1) Detector Failure: Due to insufficient internal lead spacing in the 2N5086 PNP transistor which allowed ionization to form a conducting path, shorting the collector to the emitter. 2) Receiver Failure: Due to threshold drifting with operating time in the SCL4030AE Integrated Circuit. Both Components were replaced, as a batch, and the testing was reperformed. Re-testing occured from Aug. until Sept. of 1975 and proved successful.

In 1978, government field testing of prototype units was performed at; Fort Huachuca, Arizona; Fort Devens, Massachusetts; Fort Bragg, North Carolina; Fort Greely, Alaska. Deficiencies were found in detection, classification, false alarm rate, durability, leakage, fungus, and publications.

In 1978, ISC won the contract to produce the PEWS. A redesign was performed to facilitate automatic insertion and automatic testing for production. Serious flaws were discovered in the cases of the receiver and detector, and therefore a system redesign was performed in order to improve the cases. Changing the case design demanded changing the printed circuit boards as well. For a list of the changes incured, see Appendix I. In order to support the world market, ISC began looking for a partner to produce and sell the PEWS overseas. Ferranti U.K. was chosen, and Department of State approval was obtained for the license agreement. In 1983, ISC went into production on the PEWS program. To date, over 4000 systems have been sold to the U.S. Army and the U.S. Air Force. A small number of systems have been sold abroad.

PEWS Operation Manuals

(1) TM-11-5895-1047-10
Operator Manual for PEWS AN/TRS-2(V).

(2) U.S. Army Infantry School Student Handout for PEWS.

(3) Tactical Employment of the Platoon Early Warning System (PEWS), by Thomas V. Roberson, 31 March 1977, Fort Benning.

(4) Material Fielding Plan for PEWS, 15 May 1980, Fort Monmouth.

(5) TM-11-5895-1047-23
Organizational and Direct Support Maintenance Manual for PEWS, 8 September 1980, Headquarters, Department of the Army.

(6) TM 11-5895-1047-23P
Organizational and Direct Support Maintenance Repair Parts and Special Tools List for PEWS, 20 October 1980, Headquarters, Department of the Army.

(7) CECOM DMWR 11-5895-1047
Depot Maintenance Work Requirement for PEWS, 31 October 1981, U.S. Army Communications and Electronics Command.

PEWS Development Manuals

(8) Platoon Early Warning System Engineering Program, 1976.

(9) Platoon Early Warning System (PEWS) Development Plan, April 1977, Fort Monmouth.

(10) Coordinated Test Program (CTP) for Platoon Early Warning Device (PEWD), Detection Set AN/TRS-2(V), 16 June 1972, Fort Monmouth.

(11) Coordinated Test Program for the Platoon Early Warning System (PEWS) Production and Development Phase, March 1977, Fort Monmouth.

(12) Operational Test II of AN/TRS-2, Platoon Early Warning System (PEWS) Final Report, February 1977, Fort Bragg.

(13) DT-11 Independent Evaluation Report for the Platoon Early Warning System AN/TRS-2, March 1977, Aberdeen Proving Ground.

(14) Final Report for Initial Production Test of PEWS AN/TRS-2)(V) by Arthur Welander 1980.

PEWS Test Set Manuals

(15) TM-11-6625-2784-14
Operator/Organization/Direct Support Maintenance Manual for T.S., Receiver TS-3565/TRS-2(V), 29 July 1980, Headquarters, Department of the Army.

(16) TM-11-6625-2725-24P
Organizational, Direct Support, and General Support Maintenance for Test Set TS-3565/TRS-2, TM 11-6625-2784-24P, 9 December 1980, Headquarters, Department of the Army.

(17) TM 11-6625-2784-34P
Test Set Receiver.

(18) CECOM DMWR 11-5895-2784
Depot Maintenance Work Requirement for Test Set, Receiver TS-3565/TRS-2(V), CECOM DMWR 11-5895-2784, 31 October 1981, US Army Communications and Electronics Command.

MIL-P-49115A(EL)	Military Specification PEWS AN/TRS-2(V).
MIL-STD-252B(EL)	Classification of Visual and Mechanical Defects for Equipment, Electronic, Wired and other Devices.
MIL-STD-454D	Standard General Requirements for Electronic Equipment.
MIL-C-45662A	Calibration System Requirements.
DL-SM-783140	Detector, Anti-intrusion DT-577(V)/TRS-s(V).
DL-SM-B-783138	Receiver, Radio R-1808(V)/TRS-2(V).
DL-SM-B-783144	Sensor Interface Assy, Wire Link.
SM-D-783184	Schematic Diagram, Display A1.
SM-D-783185	Schematic Diagram, Decoder A2.
SM-D-783186	Schematic Diagram, Receiver, RF, A3.
SM-D-783215	Schematic Diagram, Sensor Interface, Wire Link, (3A1).
SM-A-783424	Test Specification for Decoder (2A2) Circuit Card Assembly.
SM-A-783425	Test Specification for Display (2A1) Circuit Card Assembly.
SM-A-783426	Test Selected and Alignment Procedure for Receiver RF Circuit Card Assembly.
SM-A-783438	Acceptance Test Procedure, MX-9738/TRS-2(V).
SM-A-783420	Test and Alignment Specifications for Detector Circuit Card Assembly SM-D-783209.
SM-A-783435	Acceptance Test Procedure DT 577(V)TRS-2(V).

Physical:

Dimensions (Inches):
Length 6.6
Width 3.8
Height 2.5

Weight (Pounds): 1.14 (with battery)

Volume (Cubic Inches): 29.6

Operation:

Power/Mode Switch: toggle RF/OFF/WIRE
Test Switch: Push to Test
Code Plug (Programmable):
Identification Number: 1 to 16
Area Number: 1 to 8
Parity: On or Off

Operating Temperature Range:

-31 to +71 Degrees Centigrade
-25 to +160 Degrees Fahrenheit

Power Consumption:
1.0 mA in Standby Mode
200 mA in Transmit Mode

Stabilization Time:

5 Minutes after turn on

Detector Range:

10 Meters

Detection Capability:

Detect and Classify Personnel and Vehicles

Sensor Type:

Seismic: Geophone
Magnetic: Magnetometer

Data Transmission:

- Baud Rate: 30-40 Bits per Second
- Error Detection: Odd Parity
- Digital Word Length: 10 bits:
  - Start bit: 1 bit
  - Classify: 1 bit
  - ID: 3 bits
  - Area: 4 bits
  - Parity: 1 bit
- Range: 1500 Meters (.9 miles)
- Wire Link:
  - Differential Output Driver (Internal)
  - Field Wire: WD-36
- Radio Link:
  - Radio Frequency Transmitter (Internal)
  - Power: 250 mW nominal (100-450mW @ 9 VDC)
  - Output Power: 100 mW (@ 5.5 VDC)
  - Frequency Bandwidth: 20 KHz
  - Fixed Frequency (set to be same as Receiver)
  - Frequency Band: 139-153 MHz
    - Developmental Units:
      - 145.350 MHz
      - 148.925 MHz
      - 152.500 MHz
  - Carrier Frequency Stability (RF): 40 ppm
  - Modulation Deviation:
    - F1 > 8 KHz
    - F2 < 14 KHz
  - Modulation: Pulse Code Modulation
    - Frequency Shift Keying
      - F1 = 1500 30 Hz
      - F2 = 1800 45 Hz

Ancillary Component Requirements:

- Seismic Ground Stakes: 2 ea.
- 9 Volt Battery (Lithium Prefered): 1 ea.
- Antenna (for Radio Link Mode): 1 ea.
- WD-36 Field Wire (for Wire Link Mode): 1 ea.

Physical:

Dimensions (Inches):
- Length 7.8
- Width 4.7
- Height 1.9

Weight (Pounds): 1.86 (with battery)

Volume (Cubic Inches): 52.5

Operation:

Power Switch: toggle OFF/AUD.TONE/AUD.TONE and DISPLAY
Mode Switch: toggle RF/WIRE
Area Select Switch: rotary 1 to 8

Display:
- Self Test/Retest
- Low Battery indicator at 5.5 VDC
- New Detection
- Area: 1 to 8
- ID: 1 to 16
- Classification:
  - P = Personnel
  - C = Carrier (Vehicle)

Wire Link Module (Wire Link Mode):
- Area Select/Test Switch: rotary 1 to 9 and Test
- 9 Input Pair Terminals
- Grounding Terminal
- Test LED (for Test Mode):
  - Normal, Steady On
  - Open/Short, Blinking

Operating Temperature Range:

-31 to +71 Degrees Centigrade
-25 to +160 Degrees Fahrenheit

Power Consumption:
6 mA max. with Display Off (@ 9 VDC battery voltage)
25 mA max. with Display ON (@ 9 VDC battery voltage)

Data Reception:

Baud Rate: 30-40 Bits per Second
Error Detection: Odd Parity
Digital Word Length: 10 bits:
Start bit: 1 bit
Classify: 1 bit
ID: 3 bits
Area: 4 bits
Parity: 1 bit
Wire Link:
WD-36 Field Wire
Radio Link:
Radio Frequency Receiver (Internal)
Sensitivity: 0.4 uV min. @ 40 KHz Bandwidth max.
Local Oscillator Frequency Stability: 30 ppm of Oscillator Frequency
Spurious Response:
0 Spurious Response Signals < +35 dB above 1.0 uV
1 Spurious Response Signal < +40 dB above 1.0 uV
Desensitization: @ 1.0 uV signal-operate properly with undesired signal allowed: frequency with spurious response @ 20 mV @ > ±10 % of Oscillator Frequency
Rejection Ratio:
IF @ > 50 dB
Image @ > 45 dB
Local Oscillator Radiation:
100 uV max. across 50 ohmLoad
Fixed Frequency (Set same as Detector)
Frequency Bandwidth: 20 KHz
Frequency Band: 139-153 MHz
Developmental Units:
145.350 MHz
148.925 MHz
152.500 MHz
Demodulation: Pulse Code Modulation, Frequency Shift Keying

Ancillary Component Requirements:

9 Volt Battery (Lithium Prefered): 2 ea.
Carry Strap: 1 ea.
Antenna (Radio Link Mode): 1 ea.
Antenna Adapter (Radio Link Mode): 1 ea.
Wire Link Module (Wire Link Mode): 1 ea.
Grounding Rod (Wire Link Mode): 1 ea.

List of PEWS Equipment Redesign Changes

Receiver:

* Redesign housing (Aluminum Die Cast)
* Relayout Printed Circuit Board for Auto-insertion
* Redesign Printed Circuit Board support structure
* Redesign receiver front end to eliminate oscillation
* Environmentally sealed

Detector:

* Redesign housing (Aluminum Die Cast)
* Relayout Printed Circuit board for auto-insertion
* Redesign Printed Circuit Board support structure
* Redesign antenna loading coil for broadband use
* Redesign antenna for single length use
* Incorporate self test feature
* Redesign transmitter for proper power output and temperature compensation
* Incorporate field programmable code plug
* Environmentaly sealed

Wire Link adapter:

* Redesign housing (Molded Plastic Assembly)
* Relayout Printed Circuit Board for auto-insertion
* Redesign Printed Circuit Board location and test switch

Carrying Case:

* Heavy-Duty Duck carrying case

PEWS Demos:

1980

Belgium, 21 Nov.
Federal Republic of Germany, 21 Nov.
Netherlands, 21 Nov.

1981

Australia, 24 Jun.
Egypt, 30 Sep.
Greece, 16 Jun.
Indonesia, 30 Jun.
Japan, 24 Jun.
Korea, 24 Jun.
Malaysia, 30 Jun.
New Zealand, 24 Jun.
Philippines, 30 Jun.
Singapore, 30 Jun.
Spain, 3 Dec.
Switzerland, 3 Dec.
Taiwan, 22 Jun.
Thialand, 30 Jun.

1982

Abu Dhabi, 7 Sep.
Egypt, 30 Jun.
Kuwait, 1 Mar.
Pakistan, 7 May.

PEWS Sales:

1980

Norway, 3 Oct.
P.O. 86632, 2 ea. (V)2

Sweden, 12 Aug., 150.6 MHz
P.O. 86333, 3 ea. (V)4 (V)5, 4 ea. (V)6

1981

United Kingdom, 13 Aug., 139.25 MHz
P.O. 86322, 3 ea. (V)3
P.O. 86321, 1 ea. (V)3 kit

1982

Portugal, 16 Jun. (139.1 MHz)

PEWS Repairs:

1981

Norway, one system returned for repair, 3 Sep.
Sweden, one system returned for repair, 20 Aug.

1982

Sweden, one system returned for repair, 7 Jun.
two detectors returned for repair, 27 Aug.
Portugal, two detectors returned for repair, 30 Jul.

The following pages contain the field test procedure for the PEWS, as intended to be used by ISC Technologies marketing, quality assurance, and other demonstration personnel. For the specialized field tests conducted in this report, the following alterations were made;

1) The test field (controlled area) was approximately 130 meters square.
2) The Base line was extended to 50 meters on either side of the emplacement.
3) The target lines were extended to 110 meters from one end to the other.
4) The target line distances (from the baseline) were increased:
   - 5 meter line to 10 meters
   - 10 meter line to 20 meters
   - 15 meter line to 30 meters
   - 20 meter line to 40 meters
   - 30 meter line to 50 meters

These changes were made in order to determine the target detection range of the system. Under optimum conditions, modified detectors are not expected to indicate personnel intrusions beyond 50 meters.

SEISMIC FIELD TEST PROCEDURE

Platoon Early Warning System (PEWS)

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Equipment Description

The Platoon Early Warning System (PEWS) is a lightweight, weatherproof, battery-powered, compact, tactical intrusion detection system designed for use by small units such as platoons, squads, and patrols. The PEWS consists of ten seismic/magnetic detectors, two receiver/monitors, two wire link modules, and ancillary components packaged in two canvas carrying bags (see Figure 1).

The PEWS detectors (see Figure 2) are easily concealed, remote, hand-emplaced ground sensors. The detector will adjust itself to its surroundings electronically, and indicate the presence of intruders within a range of ten meters. Detector settling time is approximately five minutes. The intrusion signature, both seismic and magnetic, is validated, analyzed, and classified as either personnel or carrier (vehicle). The classified message is digitally encoded and added to the programmable "area," "ID," and "parity" codes. The message, a digital word, is then transmitted to the receiver/monitor by one of two transmission mediums: the Radio Frequency (RF) link, and the Wire link. When the RF link mode is selected, the digital word modulates the radio Frequency Modulated (FM) transmitter. When the Wire Link mode is selected, the digital word modulates the differential line driver.

The PEWS receiver/monitor (see Figure 3) acquires the message through a) the Wire Link Module (via field wire), which would be attached to the receiver when the Wire mode is selected, or b) the radio receiver section (via radiated (RF) energy and antenna) when the RF mode is selected. Intrusion detection is indicated by an audible tone and the light emmiting diode (LED) display. The LED display registers the detector identification number and the type of detection for each originating detector in the network. Updated intrusions are also indicated and will be held in memory until the receiver/monitor is reset by personnel.

1.2 Purpose of Test Procedure

This test procedure shall be used to test the Platoon Early Warning System (PEWS) in an environment emulating the expected operating environment. PEWS units that do not pass the requirements of this performance test shall be classified as rejects, and labeled as such.

This procedure can be used to perform system demonstrations, to screen systems for demonstrations and sales, and to aid personnel in becoming more familiar with the PEWS. This procedure assumes the operator has read and/or will refer to the applicable documents mentioned in 2.1 below.

2.0 TESTING SUPPORT REQUIREMENTS

2.1 Applicable Documents

2.1.1 Operators Manual, Headquarters Department of the Army, TMII-5895-1047-10

2.1.2 Organizational and Direct Support Maintenance Manual for PEWS, Headquarters Department of the Army, TMII-5895-1047-23

2.2 Test Equipment and tools

2.2.1 Shovel.

2.2.2 Pick.

2.2.3 Hand Spade.

2.2.4 Rake.

2.2.5 Tape Rule (30 meter, metric preferred).

2.2.6 Field Marker Flags (small).

2.2.7 Thermometer (hand held).

2.2.8 Chronometer (portable or wristwatch).

2.2.9 Compass.

2.2.10 Voltmeter, Simpson model 260 or equivalent (battery operated), for optional AGC measurements.

2.2.11 Chart Recorder, Astro-Med or equivalent (battery operated), for optional seismic measurements.

2.2.12 Log Sheets and writing implements, such as clip board, pencils, scratch paper, labels (self-adhesive), etc.

2.3 Frequency Verification

The PEWS is presently configured to operate on a number of different factory set frequencies. Please verify that the character(s) following the "(V)" on the serial tag (AN/TRS-2(V)N) is the same for all of the units in the system. This is the frequency identification character. All of the units must be on the same frequency in order for the system to operate as a whole.

3.0 FIELD TEST SET UP

3.1 Location Selection

Testing should be performed on a moist (not wet or muddy), fairly level, and smooth surface. These parameters take personnel safety into consideration, and are not necessary for the operation of the PEWS. The testing area should be large enough to provide reasonable isolation from possible forms of interference, and to allow ample room for participants and observers to be clear of the target range on all four sides (approximately 70 meters wide by 70 meters long is suggested) (see Figure 6).

The test site location should be far from heavy traffic (main roads, highways, bicycle paths, etc). The site should likewise be situated such that PEWS testing does not become a public spectator sport.

3.2 Deployment

The PEWS detector is a ground sensor and must be placed in the ground, with ground stakes attached, for proper seismic coupling (see Figure 4). For convenience, the RF mode will be employed for field testing and demonstrations unless otherwise specifically requested.

3.2.1 Dig a shallow trench (approximately 4 inches deep) in the middle of the testing area (see Figure 6).

3.2.2 Insert the seismic ground stakes snugly (by careful rotation) into their threaded mounting holes, located on the bottom of the detector. Repeat for each detector (see 2.1.1 and Figure 2).

3.2.3 Install the antenna firmly on the threaded antenna post, located on the top of the detector. Repeat for each detector (see 2.1.1 and Figure 2).

3.2.4 Program the code plug as per 2.1.1 above, if not previously performed (note: each plug should have a unique detector identity (ID) number, but the same area number. Cut the parity (red) wire on code plugs which have an odd number of wires. It is helpful to identify the detectors 1 through 10 for our purposes). Write the ID and area numbers on a label and affix the label to the top of the detector. Insert the identity plug into the keyed connector, located in the battery compartment on the front side of the detector. Repeat for each detector remembering to give each detector a separate identity number (see Figure 2).

3.2.5 Connect and install a fresh 9 volt battery in the battery compartment, located on the front side of the detector. Repeat for each detector (see 2.1.1 and Figure 2).

3.2.6 Connect and install fresh 9 volt batteries (2 ea.) in the battery compartment of the receiver, located on the bottom of the receiver. Repeat for each receiver (see 2.1.1 and Figure 2).

3.2.7 Place each detector firmly in the ground (trench), starting with the lowest identity number and working in ascending order toward the highest. The detectors should be evenly spaced, four to eighteen inches apart, and facing the same direction: fronts toward the test side of the field (see Figure 5).

3.2.8 Install the receiver antenna adapter securely in the antenna socket, located on the top of the receiver. Install the receiver whip antenna stably in the antenna adapter, located on the top of the receiver. Repeat for each receiver (see 2.1.1 and Figure 3).

3.2.9 Turn all of the detectors and receivers on, selecting the RF mode of operation unless otherwise requested (see 2.1.1, Figure 2, and Figure 3).

3.2.10 Set all of the receivers to the same area code as the detectors (see 2.1.1 and Figure 3).

3.2.11 Push the TEST button on the detector, wait a few seconds, and observe the proper ID number on the receiver display. The number displayed should be the same as the ID number on the detector label. If you do not read the proper ID number on the receiver, check the ID plug for the correct ID code (corresponding to the label), check the 9 volt battery, or discard the detector as reject, subject to later intensified testing. Repeat for each detector and receiver (can be performed simultaneously on receivers) (see 2.1.1, Figure 2, and Figure 3).

3.2.12 In the case of Optional Testing, modified (spare) detectors should be deployed in the same manner as the others mentioned above (see 3.2.2, 3.2.3, 3.2.4 3.2.5, and 3.2.11). The recording, transmitting, and/or other related devices should be connected to the predetermined detector output leads and placed behind the detector ground emplacement (see Figure 5 and Figure 6). For convenience and detector isolation, an RF data link is recommended between the detector and the associated equipment (see 4.4).

3.2.13 Fill in the open trench around the detectors, lightly covering the top of each detector with soil.

3.3 Field Markers

Field markers (flags) will be used as an aid to the personnel performing the test. Set up field markers at the beginning and end of each target path (see Figure 6).

3.3.1 Target paths run parallel with the reference base line (see Figure 6).

3.3.2 The base line is an imaginary line which runs through the front of each detector (see Figure 5). Each detector is perpendicular to the base line. The base line is the line of target travel of the detectors. The base line extends 30 meters on each side of the detector array (see Figure 6).

3.3.3 The target lines run parallel to the base line, at specified distances from the base line. The distances are; 5 meters, 10 meters, 15 meters, 20 meters, and 30 meters. Persons who will act as targets will proceed along the target line from one end to the other (see Figure 6).

4.0 TEST PROCEDURE

4.1 Settling Time

Allow sufficient settling time (at least five minutes) before beginning each part of the test. It is during this time that the AGC amplifier is adjusting the system gain for proper target detection. Seismic disturbances of any nature will be acknowledged, averaged, and adapted for by the AGC amplifier.

4.2 Field Test Log Sheets

The field test log sheets will be used to record the results of each part of the test. Initial entries should also be made, such as, date, time (beginning and ending), temperature, approximate wind speed and direction, direction of target travel, detector indications and false alarms, etc. (see Figure 7).

4.3 Testing (Target Detection)

4.3.1 The person acting as the target should walk the length of each target line, beginning with the 5 meter target line, and ending with the 30 meter target line. Again, appropriate time (five minutes) should be allowed between target line walks. The person(s) acting as the observer should record any receiver indications and notes, such as; "detectors 2,5,6, and 7 picked up passing helicopter" (see Figure 6 and Figure 7).

4.3.2 The persons (two) acting as the target should walk the length of each target line, beginning with the 5 meter target line, and ending with the 30 meter target line. Again, appropriate time (five minutes) should be allowed between target line walks. The person(s) acting as the observer should record any receiver indications and notes (see Figure 6, Figure 7, and 4.3.1).

4.3.3 Repeat 4.3.2 with three people acting as the target. (optional).

4.3.4 The PEWS performance should be an 85% detection rate, for personnel targets of nominal weight and speed, at the 10 meter target line. This is a minimum requirement, and the properly operating PEWS will perform in excess of this requirement.

Other requirements are called out in 2.1.1 and 2.1.2 above and may be of a cosmetic nature, however, the requirement stated above is our primary concern for this test.

4.4 Optional Testing

Optional testing is performed for circuit evaluation. The optional testing may include, but is not limited to; seismic signal recording (both "raw" and amplified), and AGC reference voltage. For our purposes, the optional testing, if performed, will be seismic- and AGC-related and will be performed on specifically modified detectors (spares). These tests may help our evaluation of background seismic noise versus AGC voltage (performance). The use of an RF data link between the modified detector(s) and the associated equipment and/or devices is advised (Refer to 3.2.12). The procedures below are a supplement to section 3.2 above.

4.4.1 Seismic Information Recording

(a) Output from the detector can be from either the geophone or an amplifier stage. During modification, coded wires should have been attached to the appropriate places inside the detector and run through an opening in the detector case. The code plug should have been programmed and the detector labeled. Again be careful not to use the same ID number on two separate detectors, but maintain the same area code.

(b) Assemble the detector(s). (see 3.2.2, 3.2.3, 3.2.5, and Figure 2).

(c) After emplacing the detector(s) (see 3.2.7), connect the relative detector output to either the recording device(s) or the RF data link transmitter(s). Connect the RF data link receiver(s) to the relative recording device(s) if the RF data link is utilized. Adjust the gain and record speed controls on the recorder as required.

(d) Turn on the detector(s) (see 3.2.9 and Figure 2).

(e) Turn on the RF data link, if used.

4.4.2 AGC Voltage Recording

(a) Detector(s) should have been modified (see 4.4.1.(a)) for the desired test. The needed connecting wires should protrude through the detector case.

(b) Assemble the detector(s) (see 3.2.2, 3.2.3, 3.2.5, and Figure 2).

(c) After emplacing the detector(s) (see 3.2.7), connect the relative detector(s) output to either the recording device(s) and/or voltmeter(s) or the RF data link transmitter(s). Connect the RF data link receiver(s) to the relative recording/reading device(s) if the RF data link is utilized. Adjust the gain and record speed controls on the recorder and the range on the voltmeter (if used) as required.

(d) Turn on the detector(s) (see 3.2.9 and Figure 2).

(e) Turn on the RF data link if used.

(f) If using the voltmeter, periodic (every five minutes) readings should be recorded. Personnel recording this information may use scratch paper or the field test log sheet (see Figure 7).

4.5 Clean Up

In order to prevent damage or loss of the equipment and tools, the test site should be taken down shortly after the test or demonstration. This will also encourage a favorable attitude with the property owners toward future testing.

4.5.1 Turn off and remove the batteries from the detectors and receivers (see 2.1.1 , Figure 2 and Figure 3).

4.5.2 Turn off the RF data link and optional test equipment, if utilized. Disconnect the RF data link transmitter from the detector and the RF data link receiver from the recording/reading equipment if employed. Prepare all test-related equipment and ancillaries for transportation (see 4.4).

4.5.3 Remove the detector antenna from the detector, and store the antenna in one of the canvas carry bags. Repeat for all detectors (see 2.1.1 and Figure 2).

4.5.4 Remove the detector seismic ground stakes from the detector, and store them in one of the canvas carry bags. Repeat for all detectors (see 2.1.1 and Figure 2).

4.5.5 Store all detectors in the canvas carry bags. The code plugs and labels may remain on the detectors if designated a demonstration or evaluation PEWS.

4.5.6 Remove the receiver antenna from the receiver/monitor, and store it in one of the canvas carry bags. The antenna adapter may remain on the receiver/monitor. Repeat for all receivers (see 2.1.1 and Figure 3).

4.5.7 Fill in the trench and firm up the soil on the surface.

4.5.8 Collect the field markers.

4.5.9 Place the field test log sheets and other test data, if any, in the log book for future reference and tabulation.

4.5.10 Police the testing field.

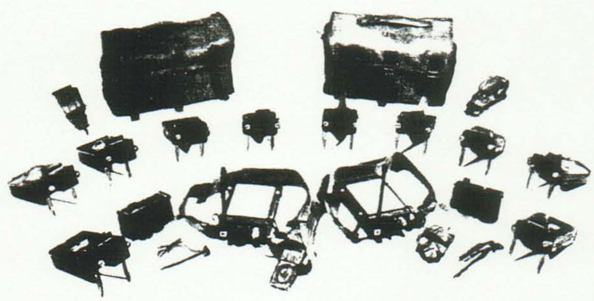
4.5.11 Collect all tools, equipment and other company property for tranportation, pack up and go home.

5.0 Figures

The following figures will act as an aid in following the test procedure. The figures are fairly accurate and should be applied to assembly and emplacement. The Field Diagram (Figure 6) is to be used as a guide, but may differ from location to location (for example: the unused area to the rear of the detector array is not used and therefore may be geologically different from location to location).

5.1 Figure 1 Platoon Early Warning System (PEWS),

AN/TRS-2(V)N (N=1-6)



COMPONENTS:

(two bags, each containing)

A. (1) Canvas Carrying Case
B. (1) Receiver
C. (1) Headset
D. (1) Receiver Antenna Adapter
E. (1) Receiver Antenna
F. (1) Wire Link Adapter
G. (1) Grounding Stake
H. (5) Detector
I. (5) Detector Antenna
J. (10) Seismic Coupling Stakes

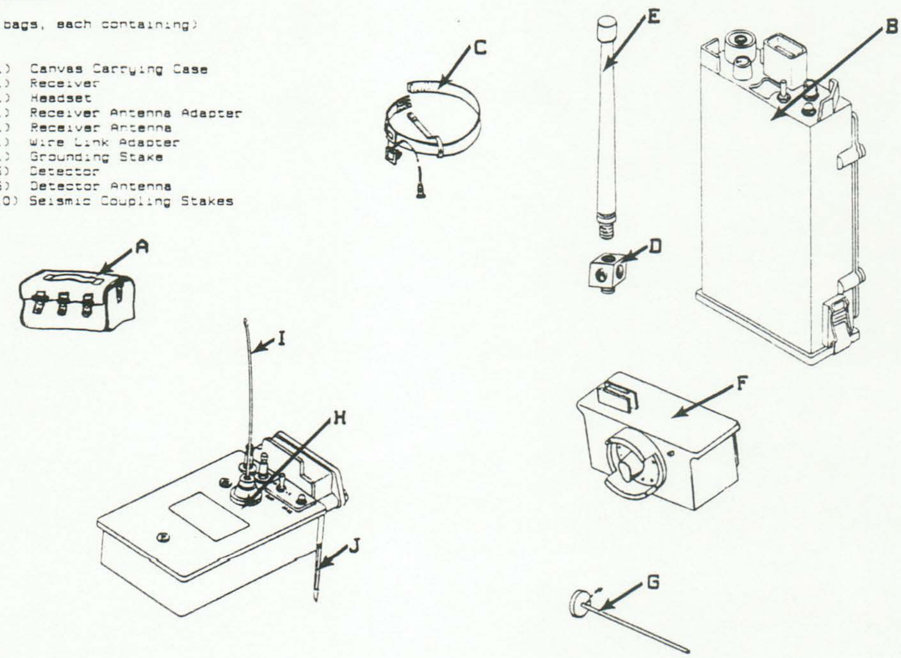


Figure 4.11.1 Platoon Early Warning System (PEWS)

5.2 Figure 2 PEWS Detector (ground sensor),

DT-577(V)/TRS-2(V)

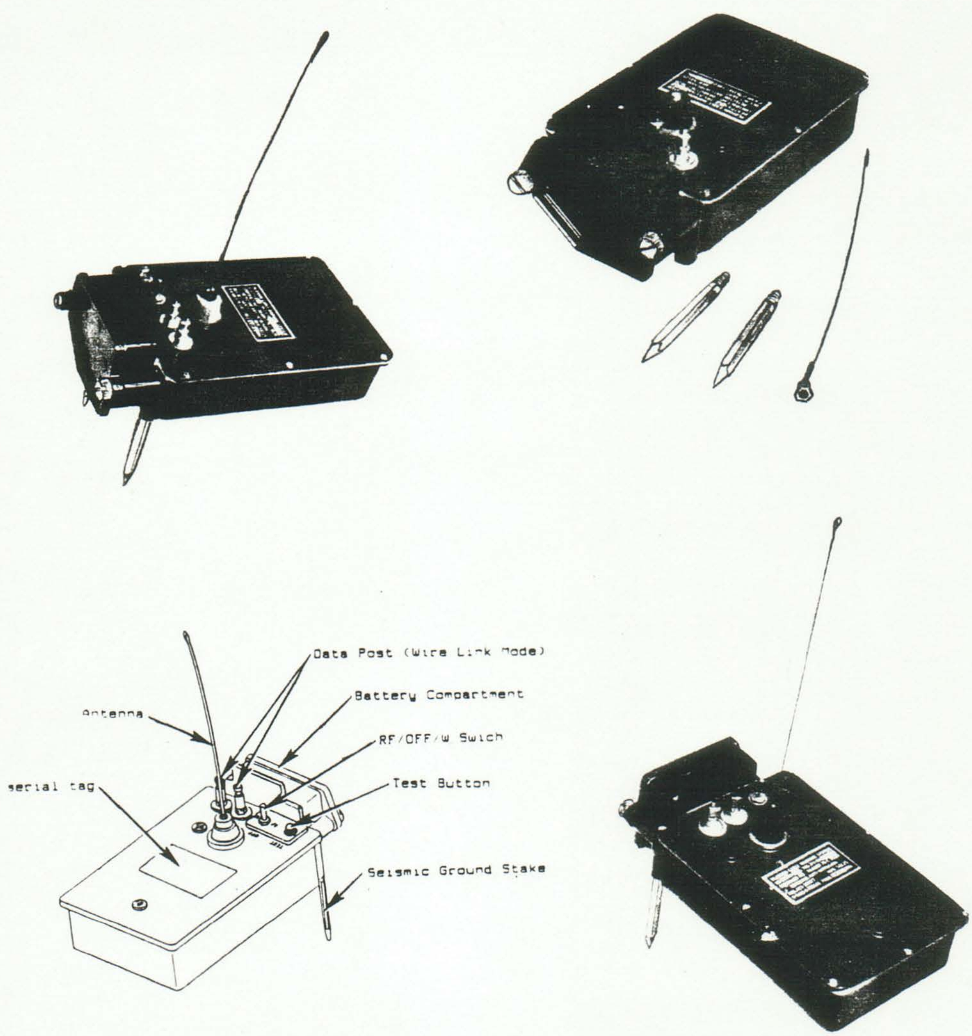


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Figure 4.11.2 PEWS Detector (ground sensor)

5.3 Figure 3 PEWS Receiver (receiver/monitor),

R-1808(V)/TRS-2(V)

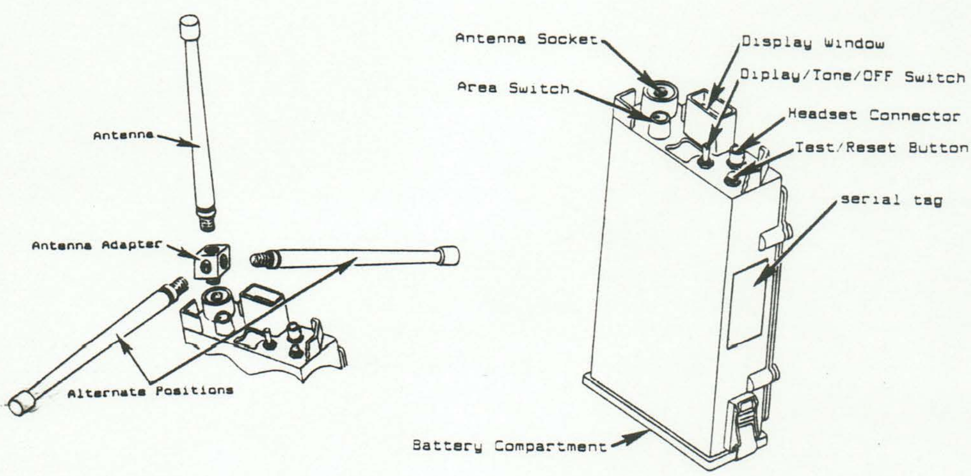

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Figure 4.11.3 PEWS Receiver (receiver/monitor)

5.4 Figure 4 PEWS Detector In Ground

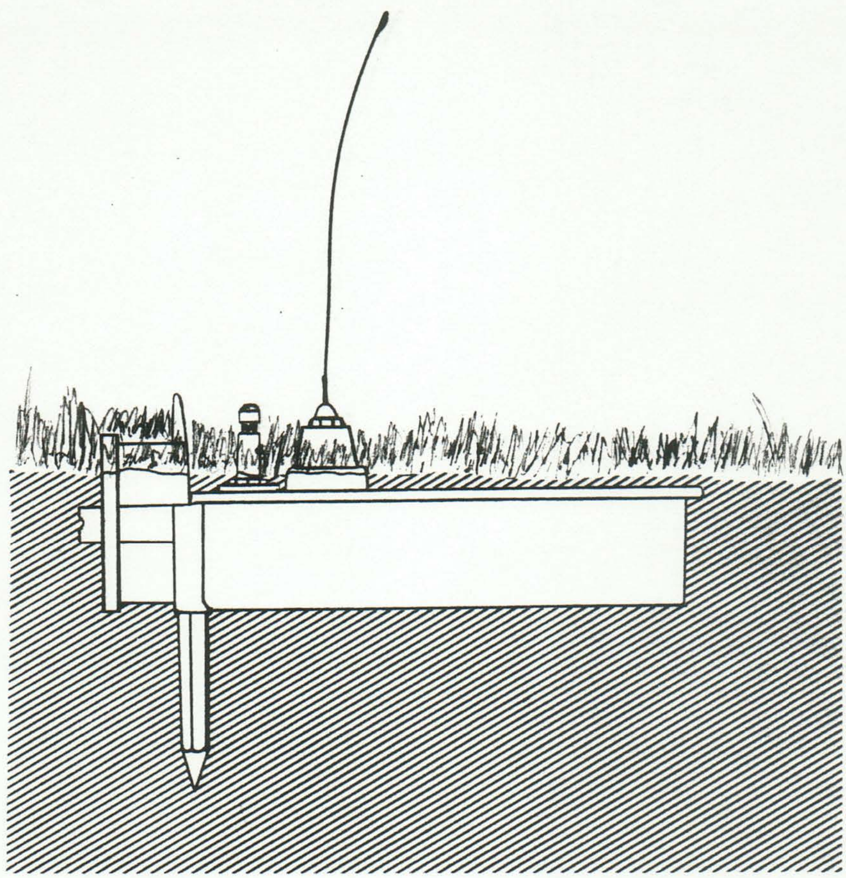

Figure 4.11.4 PEWS Detector In Ground

5.5 Figure 5 PEWS Detector Ground Emplacement

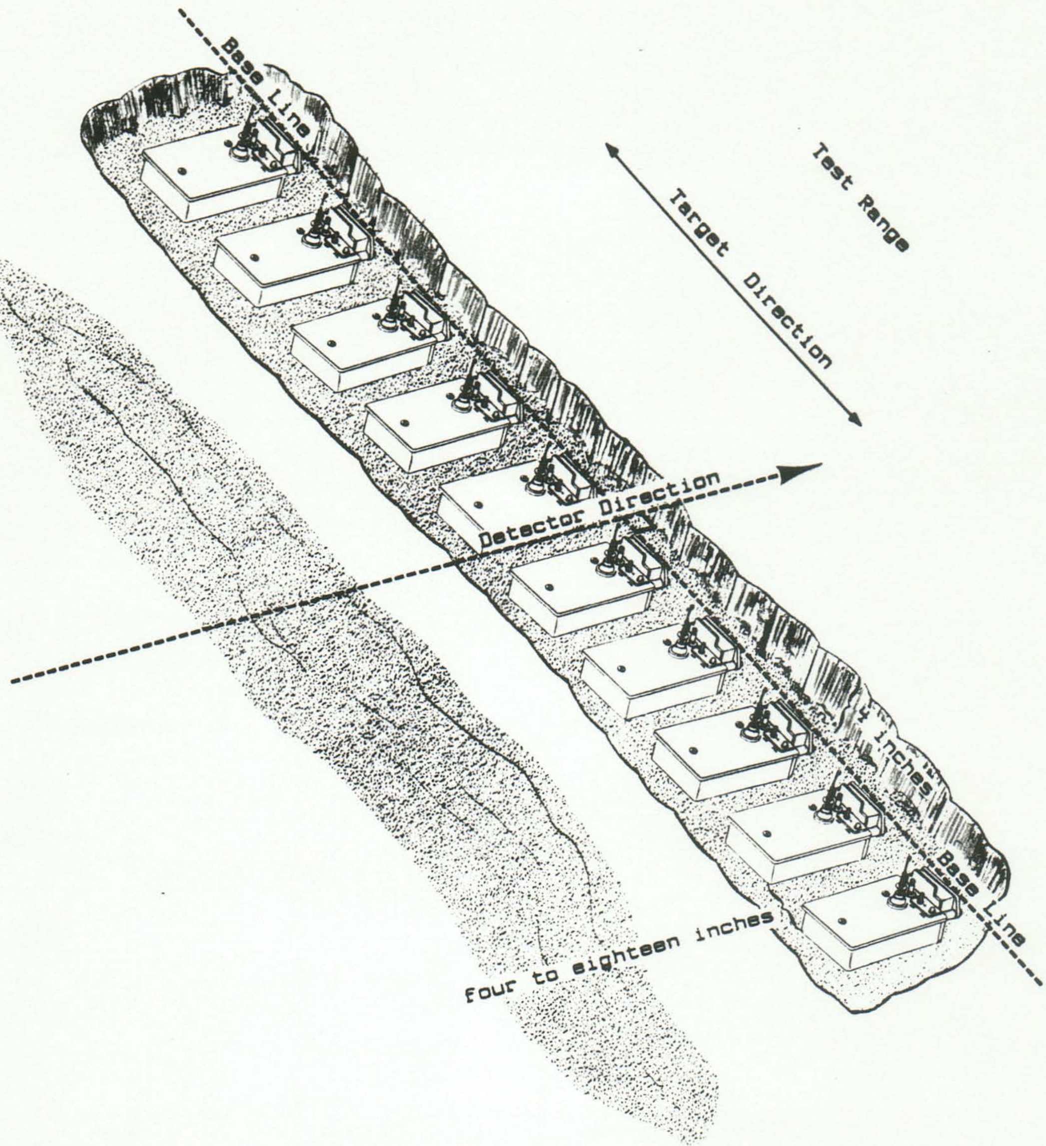

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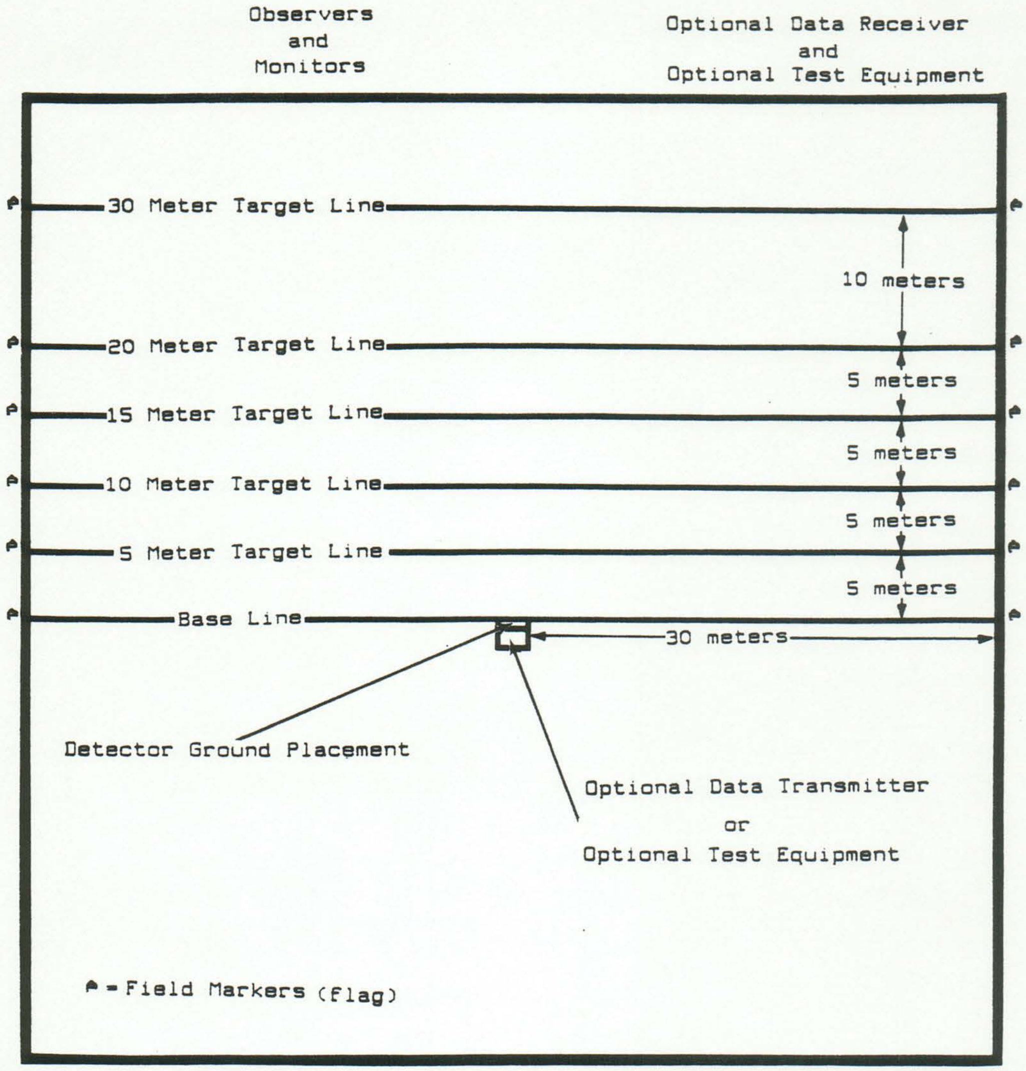
Figure 4.11.5 PEWS Detector Ground Emplacement

5.6 Figure 6 Field Diagram



70 meters by 70 meters

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Figure 4.11.6 Field Diagram

5.7 Figure 7 Field Test Log Sheets

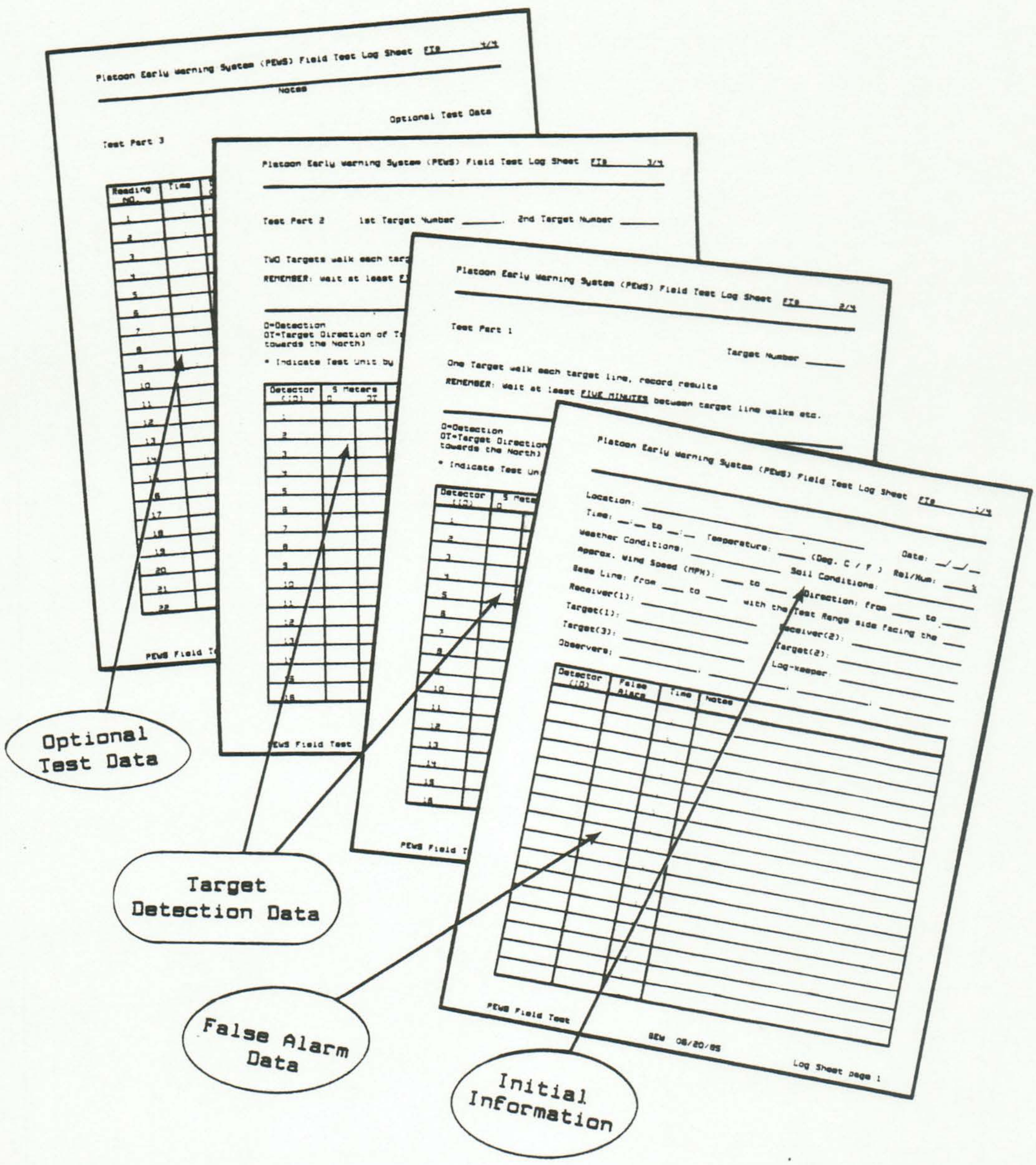

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Figure 4.11.7 Field Test Log Sheets

United Kingdom

A number of tests were conducted, using both personnel and vehicles in a variety of scenarios. These tests intended to simulate different types of targets the PEWS might encounter in actual field use.

Tests were performed in two sets. The first set revealed problems with the PEWS. The second set was performed similar to the first, while seismic conditions were monitored.

In both sets, detection was said to be poor. Speculated reasons for poor system performance were seismic characteristics of the soil and AGC desensitization by rain.

Date: January to March 1981

Conducted by: Surveillance Target Aquisition and Night Observation Center (STANOC)

Location: United Kingdom: Northern Ireland
Essex
New Forrest
Nottingham
Salisbury Plain

Attendees:
Lt. Colonel Bolton Clark - British Army
Major John O'Brien - British Army
Sergeant John Cox - British Army
Keith Proctor - Ferranti/Cheadle Heath
Ian Miller - Ferranti/Cheadle Heath
John Hartley - ESIL
Larry Schick - ESI

Date: 7 to 10 July 1981

Conducted by: Surveillance Target Aquisition and Night Observation Center (STANOC)

Location: United Kingdom: Salisbury Plain

Attendees:
Major John O'Brien - British Army
Sergeant John Cox - British Army
Sergeant Tony Kavanagh - British Army
Keith Proctor - Ferranti
Ian Miller - Ferranti
Larry Schick - ESI
Al Jodzio - ESI

Sweden

The results of these tests show that personnel and ski-troop intrusions were not properly classified when detected. Distant aircraft were classified as personnel.

Date: 17 February 1982

Conducted by: Swedish Army

Location: Sweden

Attendees: Un-named members of the Swedish Army
Un-named representatives of Ferranti

Lancaster County Park

Tabulation of 10 meter Target Line Results

Det. ID#	R 14 value (ohms)	Test #1	Test #2	Test #3	Test #4	Test #5	Test #6	Test #7
						Modified Detectors R 14 = 2 megohms		
1	2.0 M	C	C		P C	P	P	P
2	2.4 M	C	C	P	C	C	P C	P C
3	3.3 M			P	P C	P C	C	C
4	5.6 M		C	P	P	P C	P C	C
5	4.7 M	P	C	P	P	P C	P C	P C
6	3.0 M	P		P		C	P C	P C
7	3.3 M					C	P C	P C
8	3.9 M	C		P		P C	P C	P
9	2.7 M	C		P	C	C	C	C
10	2.4 M			P	P C	P	P	P

Lancaster County Park

Tabulation of 50 meter Target Line Results

Det. ID#	R 14 value (ohms)	Test #1	Test #2	Test #3	Test #4	Modified Detectors R 14 = 2 megohms Test #5	Test #6	Test #7
1	2.0 M	C	C		P C	P	P	P
3	3.3 M	N/A	N/A					P
4	5.6 M	N/A	N/A				P	P
5	4.7 M	N/A	N/A			P	P	
6	3.0 M	N/A	N/A				P	
7	3.3 M	N/A	N/A			P	P	
8	3.9 M	N/A	N/A				P	P
9	2.7 M	N/A	N/A			P	C	
10	2.4 M	N/A	N/A				P	

The following is a technical analysis of the PEWS detector circuit, written by Arther O'Connor.

The purpose of this analysis, is to show that the solution to the detector performance problem is sound.

PEWS Automatic Gain Control (AGC) Circuit Analysis

Simplifying Assumptions:

See Figures 4.14.1 and 4.14.2 for schematic diagram representations of the argument.

1. Q_4 , Q_5 , and Q_6 all have a Beta greater than 10 at their respective operating collector currents (this is reasonable, since low noise, small signal NPN Silicon transistors generally have minimum Betas of 50 and typically 100 at I_C = 5 uAmp).

2. Q_6 will switch very rapidly (as Q_5 switches) therefore only switching conditions for Q_5 will be considered.

3. For analysis purposes (we are going to determine the relative impact of changing R_{SAT}, the Select At Test resistor, not absolute switching voltages) R_{13} will be ignored.

4. Cascaded gain of preceding stages, and Automatic Gain Control (AGC) are sufficiently high so that with the AGC loop closed, the output noise level will be determined only by the AGC detector in action.

5. Frequency of interest is 15Hz.

6. AGC action starts when the incoming signal is just large enough to turn Q_5 off.

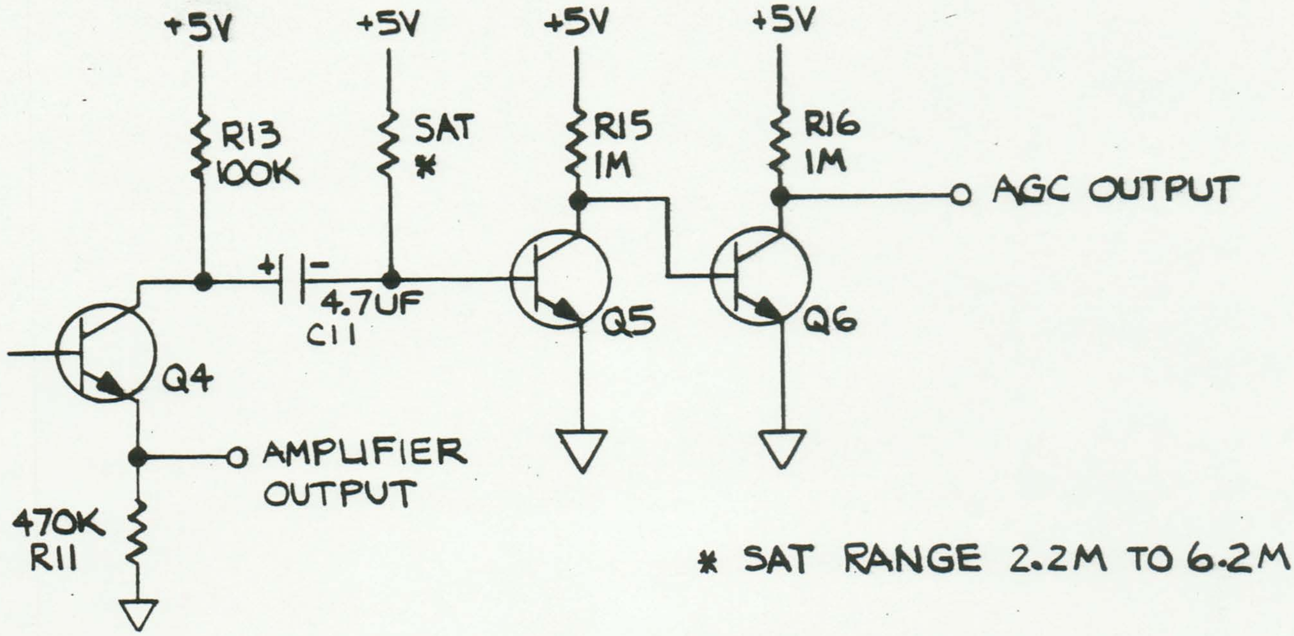


Figure 4.14.1 Detector AGC Schematic

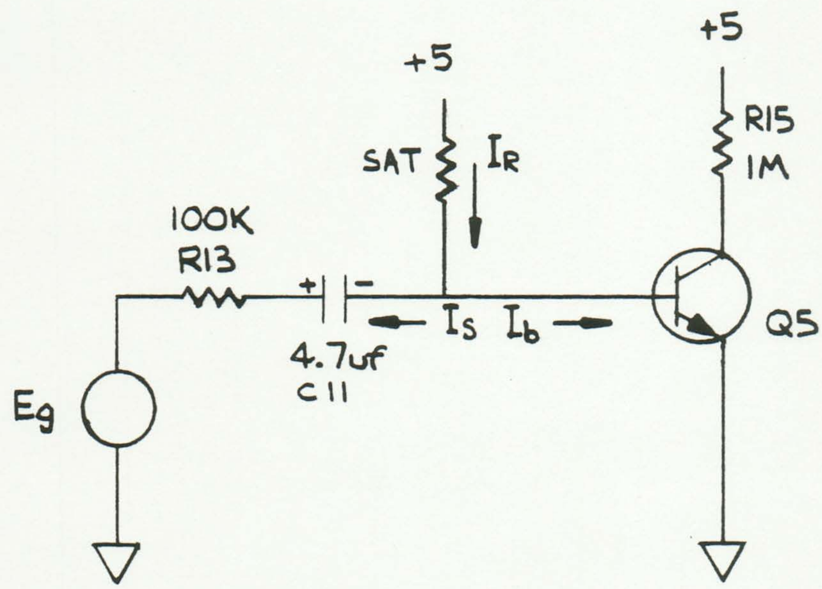


Figure 4.14.2 Simplified Circuit Used for Analysis

ANALYSIS

Q_5 is off when $I_B = 0$, $V_{BE} = 0$

Conditions at Q_5 are:

$$I_R = \frac{5V}{R_{SAT}}$$

$$I_S = C \frac{dE_g}{dt}$$

If $E_g = A \sin (wt)$

Then $\frac{dE_g}{dt} = A\ w \sin (wt)$

For $I_B = 0$

$$I_R = I_{S\ peak}$$

$$\frac{5}{R_{SAT}} = C_{11} (A\ w \cos (WT))_{wt=0}$$

$$\frac{5}{R_{SAT}} = C_{11}\ A\ w$$

At 15 Hz, $w = 2\ pi\ f = 6.28(15)$

$$A = \frac{5}{4.7 \times 10^{-6}(6.28)(15)R_{SAT}}$$

$$A = \frac{5 \times 10^6}{(442.74)R_{SAT}} = \frac{1.13 \times 10^4}{R_{SAT}}$$

For R_{SAT} = 2.2 megohms

A = 5.1 mV (peak)

For R_{SAT} = 6.2 megohms

A = 1.8 mV (peak)

This represents a 9 dB (20 log 5.1/1.8) possible spread in the threshold sensitivity of the AGC detector! The impact of this difference is quite dramatic and explains the appearent total disabling of some PEWS units in high noise environments (no detector output even at distances as close as 1 meter). See Figure 4.14.3.

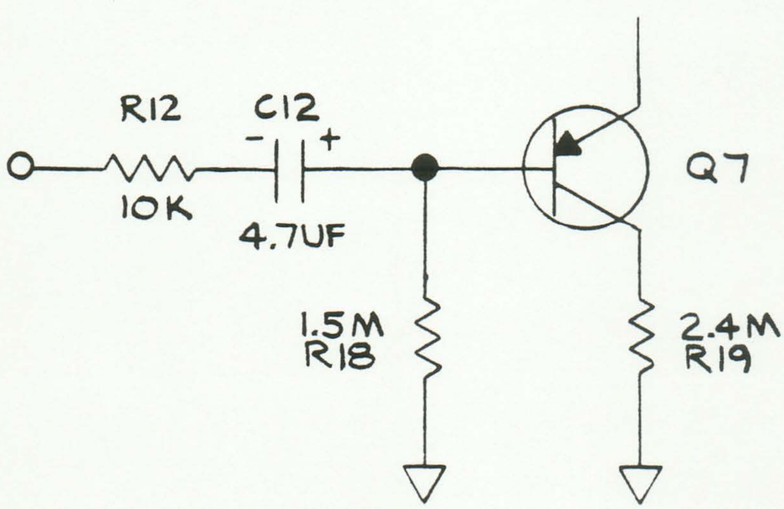


Figure 4.14.3 Event Detector

The AGC amplifier output (Emitter of Q_4) is 4.7 times the AGC voltage calculated above.

2.2 megohms A = 24 mV

6.2 megohms A = 8.46 mV

Q_7's switching voltage is:

$$V_S = (I_S)(R) + A_S$$

$$I_S = C_{12} \frac{dV}{dt}$$

$$\frac{5}{1.5 \times 10^6} = (4.7 \times 10^{-6})(6.28)(15)(A_S)$$

$$A_S = \frac{5}{(1.5)(4.7)(6.28)(15)}$$

$$A_S = 7.53 \times 10^{-3}$$

$$V_S = \frac{5 \times (10 \times 10^3)}{1.5 \times 10^6} + 7.53 \times 10^{-3}$$

$$V_S = 40 \text{ mV}$$

From prior testing:

Amplifier open loop gain is about 73 dB = 4.45×10^3

Seismic sensitivity is 146 mV/.32 in./sec. or about 180 uV/.001 cm/sec.

The zero noise system detection sensitivity can be calculated.

$$S = \frac{V_S}{G} = \frac{40 \times 10^{-3}}{4.45 \times 10^3} = 9 \text{ uV}$$

$$S_{dB} = 20 \log \frac{9}{180} = -26 \text{ dB} \quad \text{RE .001 cm/sec.}$$

System detection sensitivity for noise = -20 dB RE .001 cm/sec. is highly dependent on R_{SAT}.

For R_{SAT} = 2.2 megohms

Amplifier output noise = 24 mV

Input noise = 180 uV - 20 dB

$$= \frac{180}{10} = 18 \text{ uV}$$

$$\text{Gain} = \frac{\text{Output}}{\text{Input}} = \frac{24 \times 10^{-3}}{18 \times 10^{-6}} = 1.33 \times 10^{3}$$

V_S = G(S + N)

$S = 40 \times 10^{-3} = (1.33 \times 10^{3})(S + 18 \times 10^{-6})$

$S = 18 \times 10^{-6} = 30 \times 10^{-6}$

$S = 12 \times 10^{-6}$

S dB = 20 log 12/180 = -23.5 dB RE .001 cm/sec.

For R_{SAT} = 6.2 megohms

Amplifier output noise = 8.46 mV

Input noise = 18 uV

$$\text{Gain} = \frac{8.46 \times 10^{-7}}{18 \times 10^{-6}}$$

G(S + N) = 40 mV

$(S + 18 \times 10^{-6})(.47 \times 10^{3}) = 40 \times 10^{-3}$

$S + 18 \times 10^{-6} = 85 \times 10^{-6}$

$S = 67 \times 10^{-6}$

S dB = 20 log 67/180 = -8.6 dB RE .001 cm/sec.

For Noise = -10 dB RE .001 cm/sec. the respective sensitivities are:

2.2 megohms : S dB = -13.5 dB RE .001 cm/sec.

6.2 megohms : S dB = +1.33 dB RE .001 cm/sec.

The noise level at which there is no difference in performance is that at which input noise amplified by the open loop gain is equal to the AGC detector threshold voltage.

$$V_{IN} \times G_{OPEN\ LOOP} = V_{THRESH}$$

$$(V_{IN})(4.45 \times 10^{3}) = 8.46 \times 10^{-3}\ V$$

$$V_{IN} = 1.90\ uV$$

$$V_{IN} = \text{(approximately) } -40 \text{ dB RE .001 cm/sec.}$$

This noise level is a very quiet seismic environment. At all noise levels higher than this, PEWS detectors with 2.2 megohm R_{SAT} will have a substantial advantage over those with higher values of R_{SAT}. Figure 4.14.4 illustrates the difference in range caused by R_{SAT} for a target of 1 man walking on various soil types.

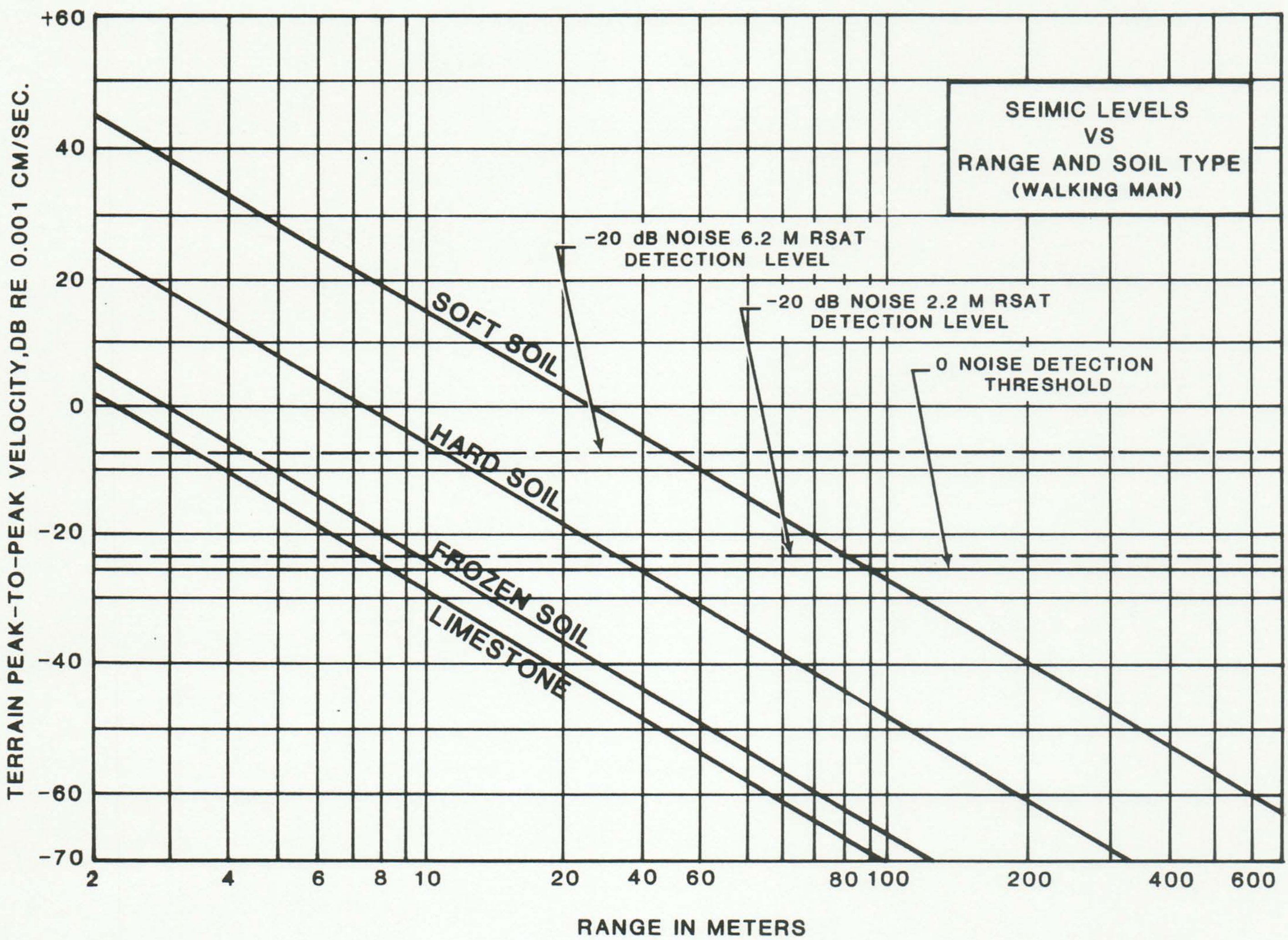


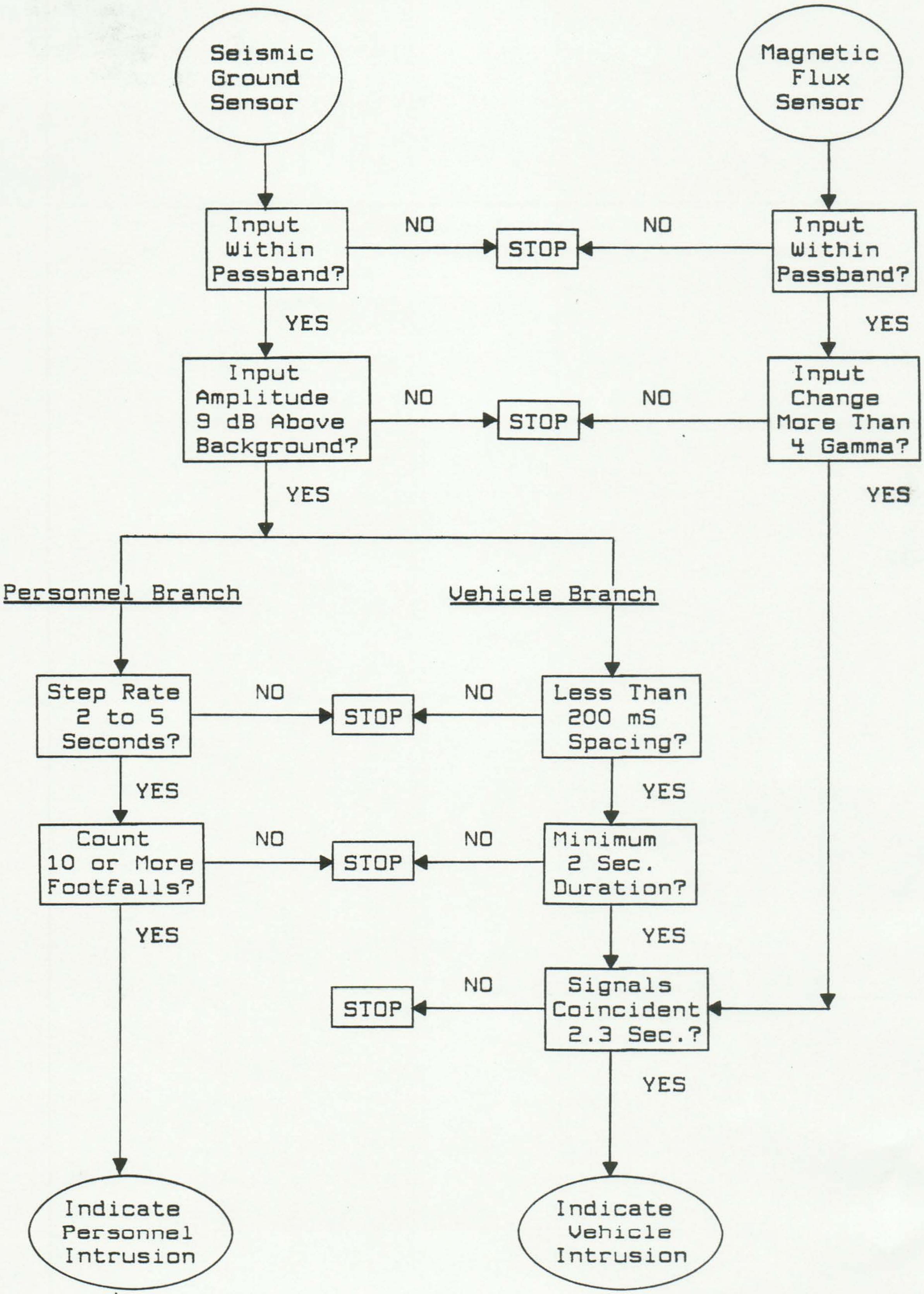
Figure 4.14.4 Seismic Levels vs Range and Soil Type

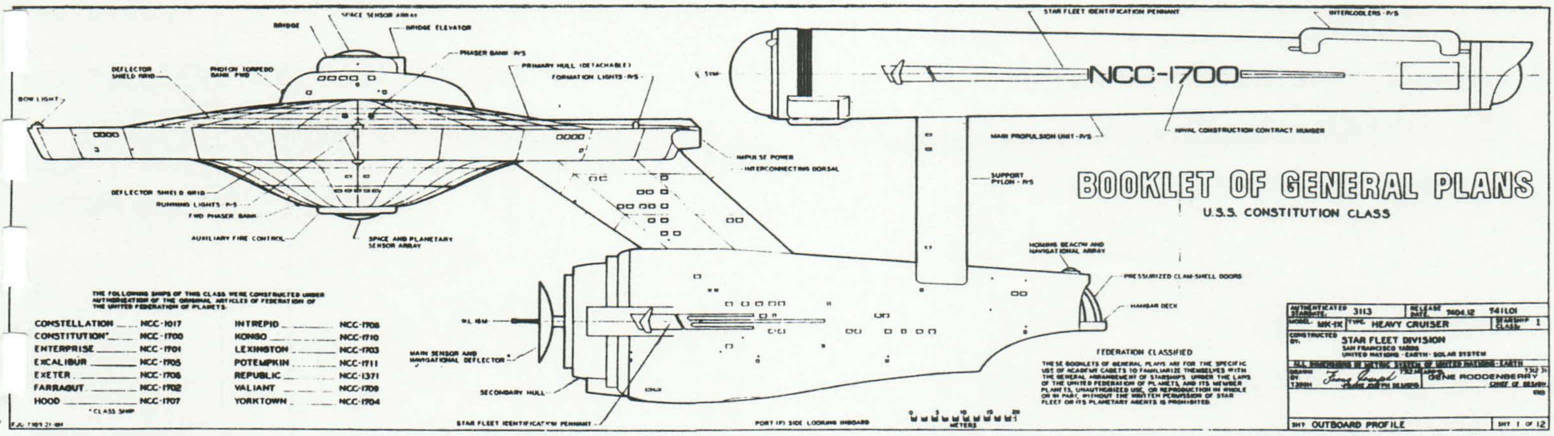
RECOMMENDATIONS

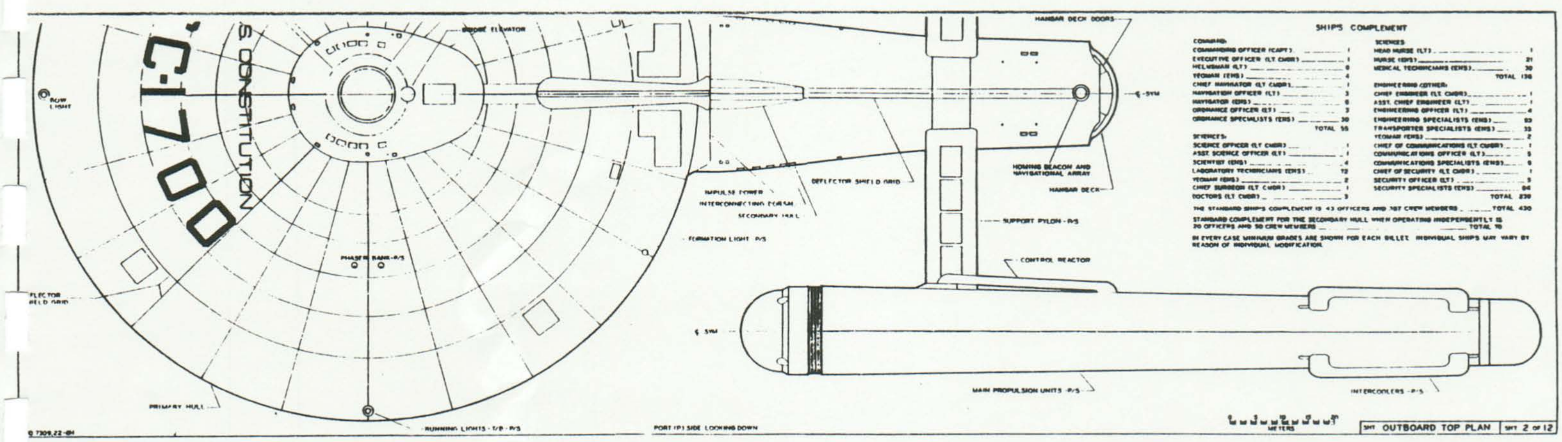
1. Use a fixed value of 2.2 megohm for R_{14} (R_{SAT}) in all PEWS detector AGC amplifiers.

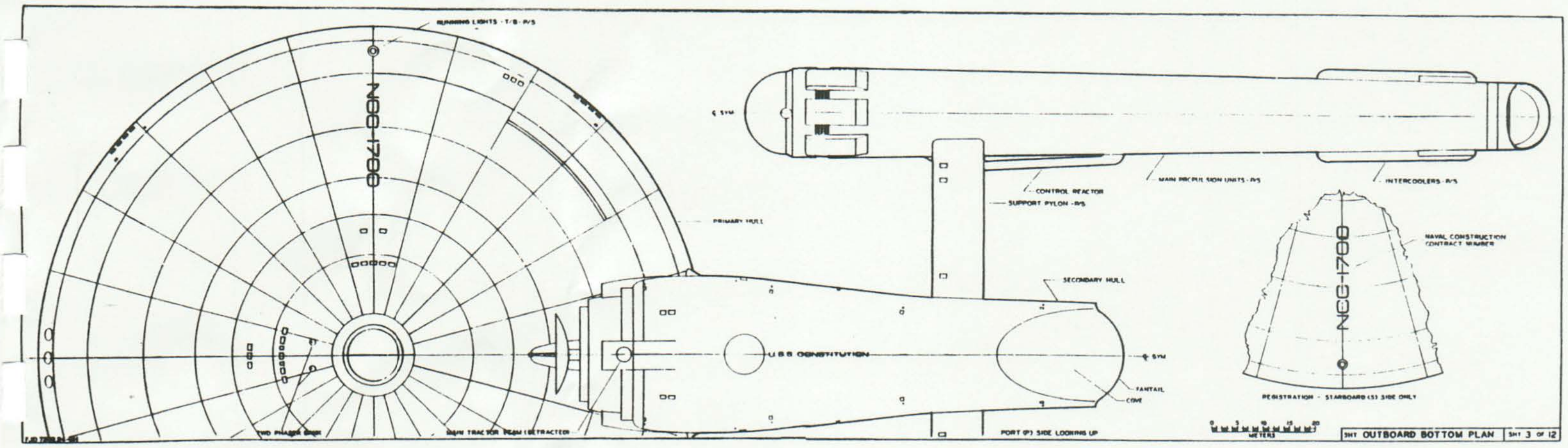
2. Eliminate all of step 6.1 of Test procedure drawing No. SM-A-783420.

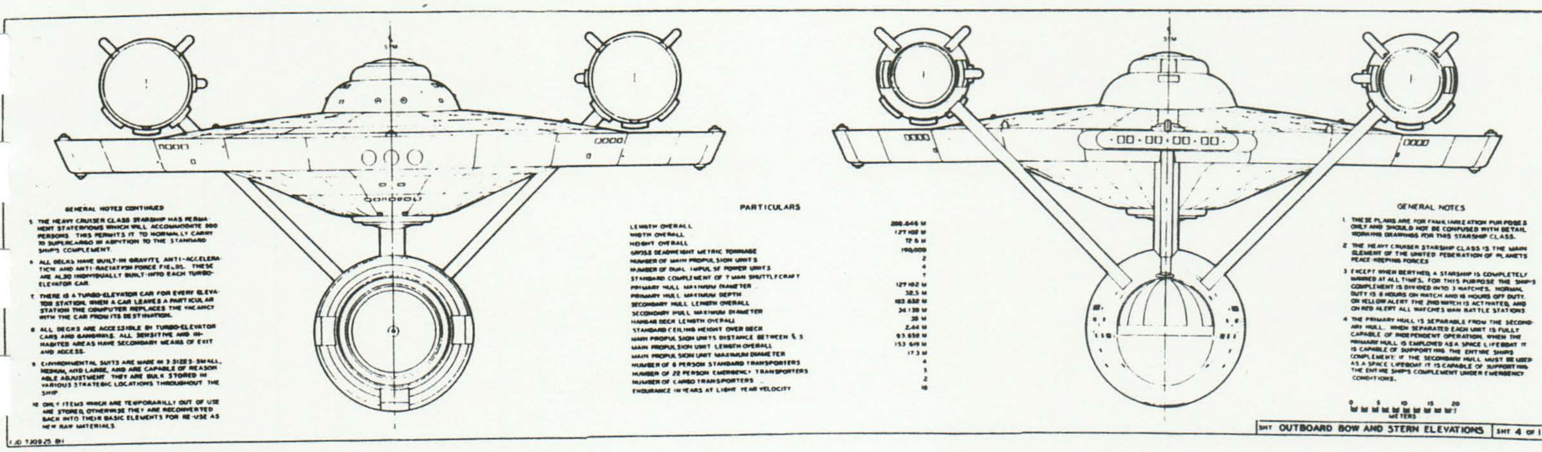
3. Capacitors C_{11}, and C_{12} should be ultra low leakage types. They should be 100% tested for leakage of less than .1 uA DC at 5 VDC and 20 C. They should be sample tested for the same electrical characteristics over the full PEWS operating temperature range. These capacitors should be $\pm$ 5% (or better) tolerance units.

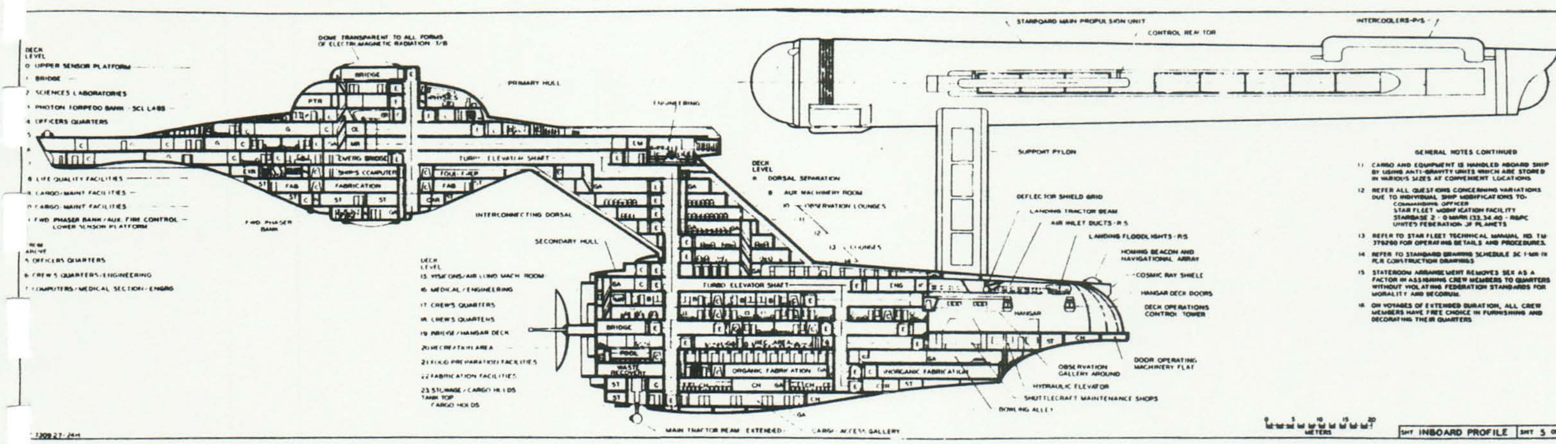

Seismic Ground Sensor
Magnetic Flux Sensor
Input Within Passband?
NO
STOP
NO
Input Within Passband?
YES
YES
Input Amplitude 9 dB Above Background?
NO
STOP
NO
Input Change More Than 4 Gamma?
YES
YES
Personnel Branch
Vehicle Branch
Step Rate 2 to 5 Seconds?
NO
STOP
NO
Less Than 200 mS Spacing?
YES
YES
Count 10 or More Footfalls?
NO
STOP
NO
Minimum 2 Sec. Duration?
YES
YES
STOP
NO
Signals Coincident 2.3 Sec.?
YES
Indicate Personnel Intrusion
Indicate Vehicle Intrusion

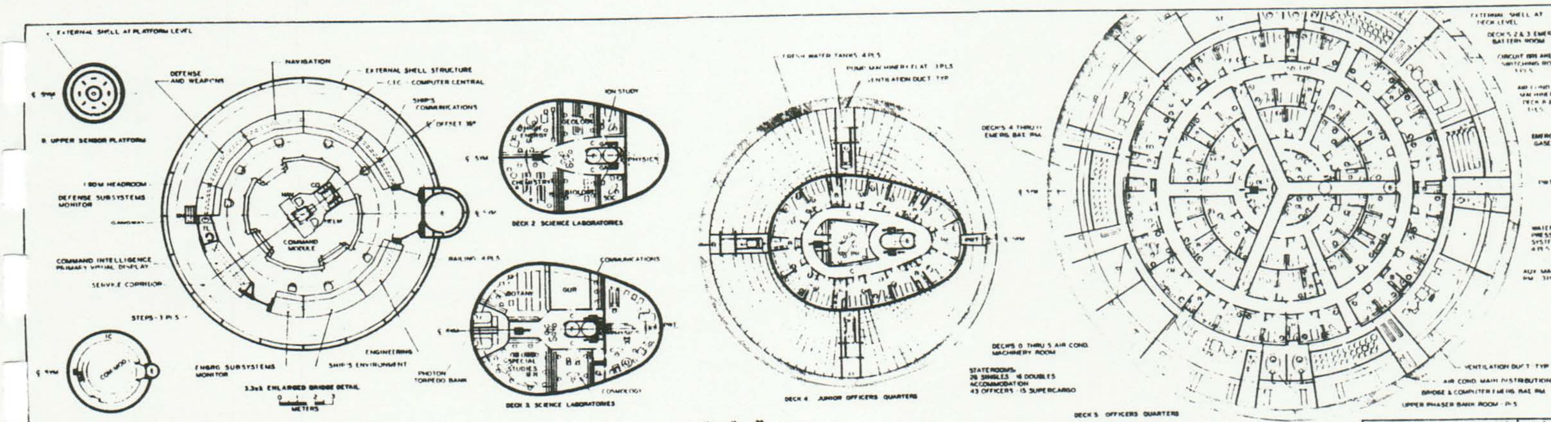

NCC-1700
BOOKLET OF GENERAL PLANS
U.S.S. CONSTITUTION CLASS
THE FOLLOWING SHIPS OF THIS CLASS WERE CONSTRUCTED UNDER AUTHORIZATION OF THE ORIGINAL ARTICLES OF FEDERATION OF THE UNITED FEDERATION OF PLANETS.
CONSTELLATION NCC-1017
CONSTITUTION* NCC-1700
ENTERPRISE NCC-1701
EXCALIBUR NCC-1705
EXETER NCC-1706
FARRAGUT NCC-1702
HOOD NCC-1707
INTREPID NCC-1708
KONGO NCC-1710
LEXINGTON NCC-1703
POTEMPKIN NCC-1711
REPUBLIC NCC-1371
VALIANT NCC-1709
YORKTOWN NCC-1704
*CLASS SHIP
FEDERATION CLASSIFIED
HEAVY CRUISER
STAR FLEET DIVISION
OUTBOARD PROFILE

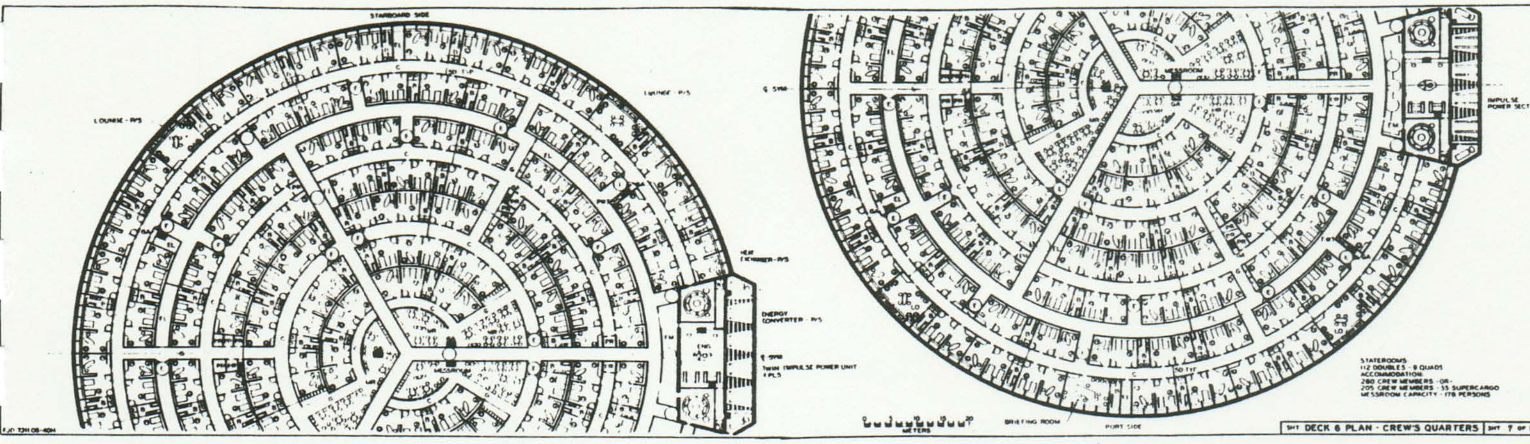

C-1700
SHIPS COMPLEMENT
OUTBOARD TOP PLAN

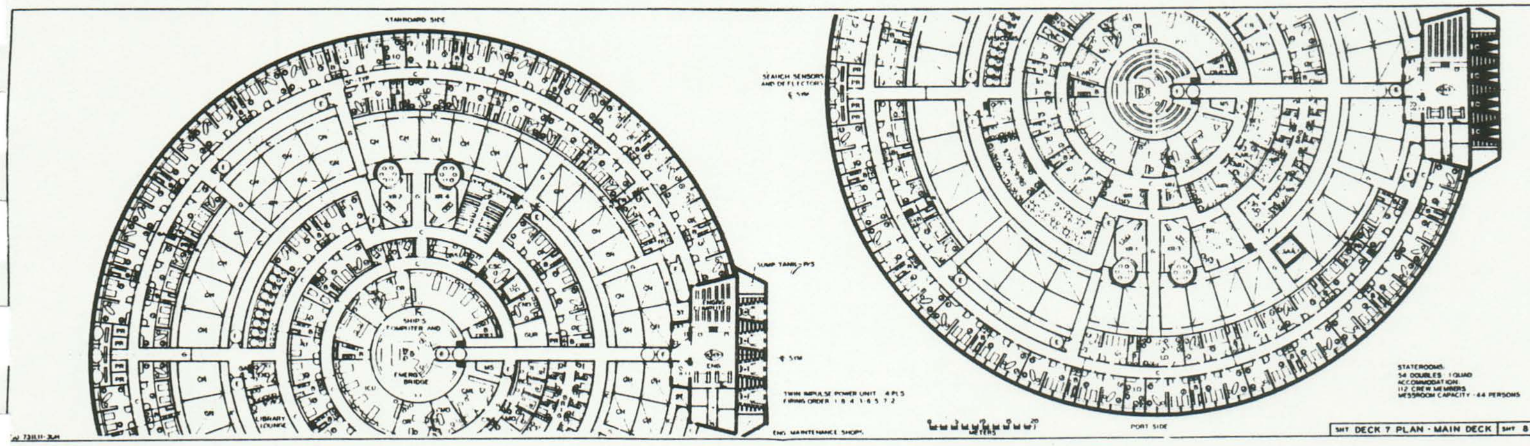

NCC-1700
U.S.S. CONSTITUTION
OUTBOARD BOTTOM PLAN

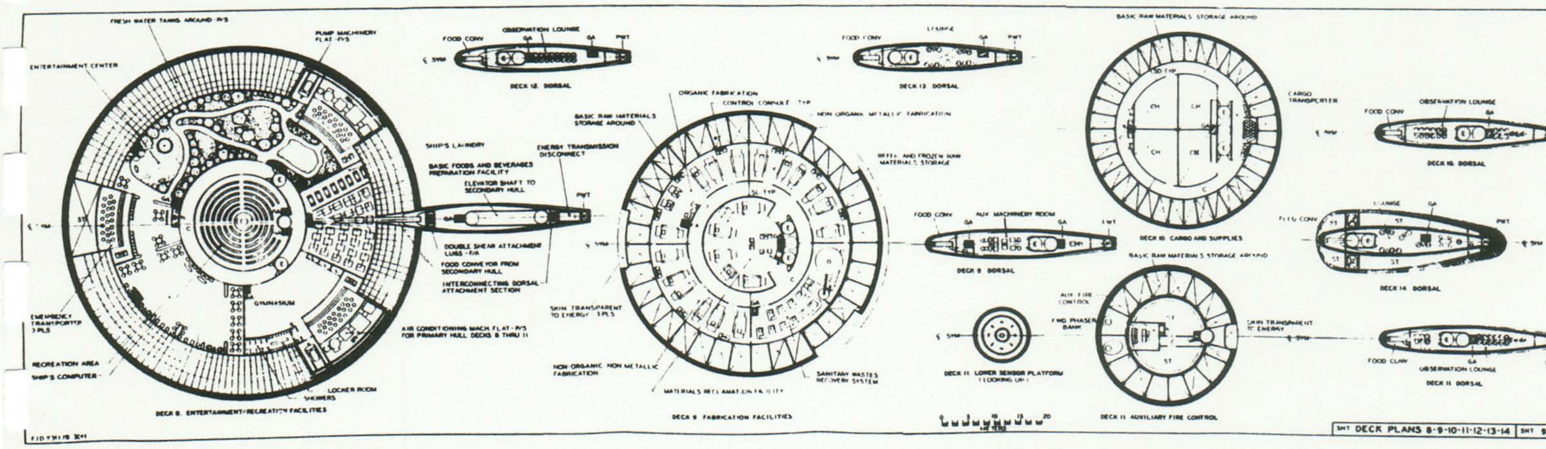

GENERAL NOTES CONTINUED
PARTICULARS
GENERAL NOTES
SHT OUTBOARD BOW AND STERN ELEVATIONS SHT 4 OF 12

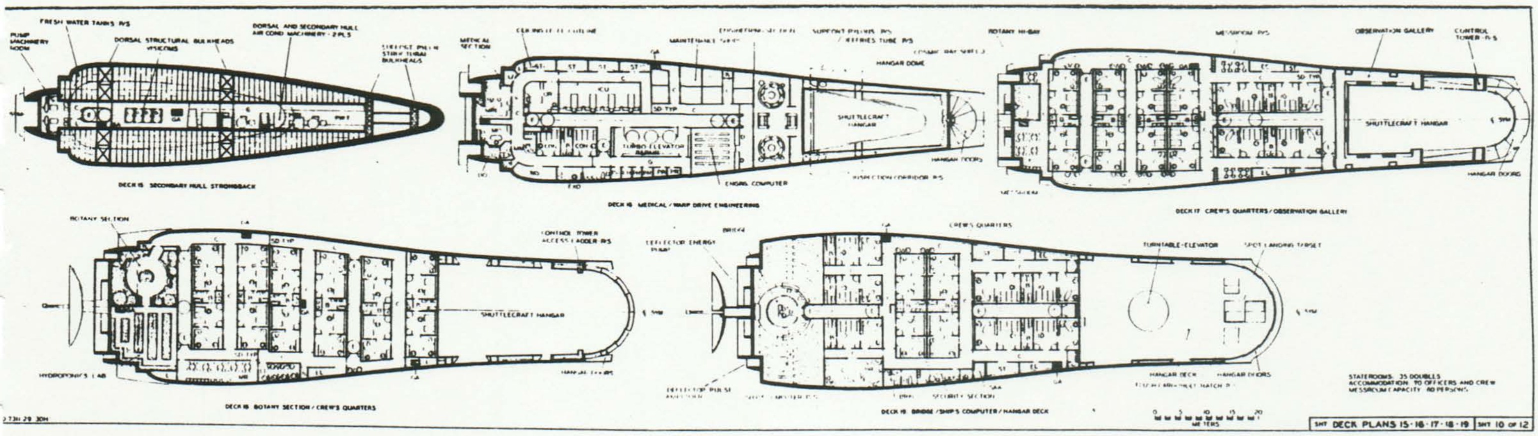

PRIMARY HULL
SECONDARY HULL
SUPPORT PYLON
GENERAL NOTES CONTINUED
SHT INBOARD PROFILE SHT 5 OF 12

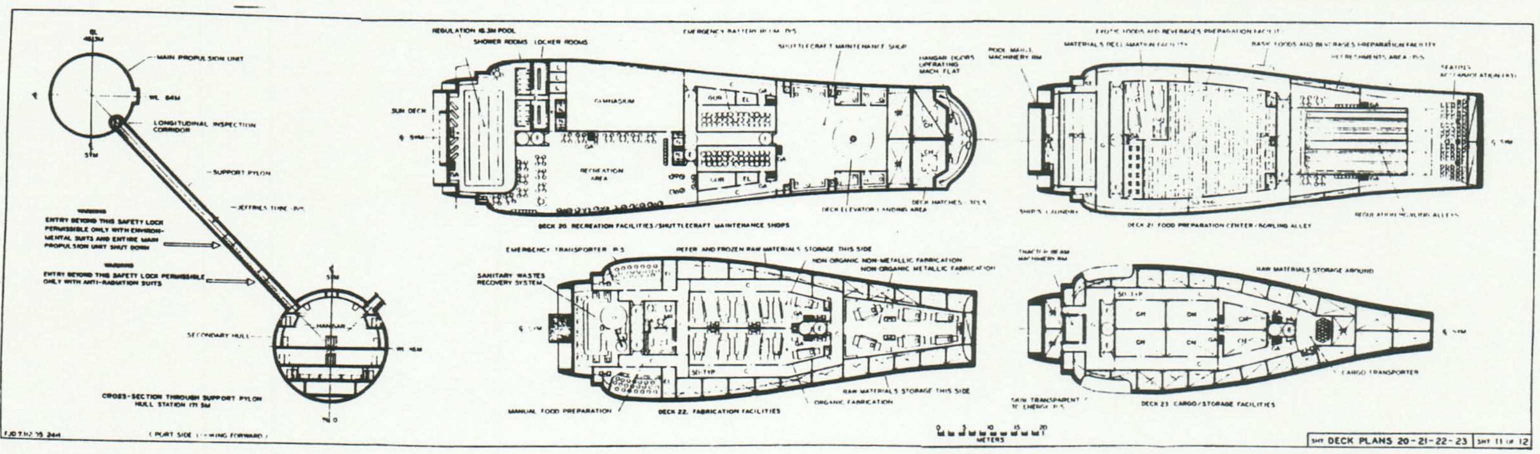

DECK 2 SCIENCE LABORATORIES
DECK 3 SCIENCE LABORATORIES
DECK 4 JUNIOR OFFICERS QUARTERS
DECK 5 OFFICERS QUARTERS
SHT DECK PLANS 0·1·2·3·4·5 SHT 6 OF 12

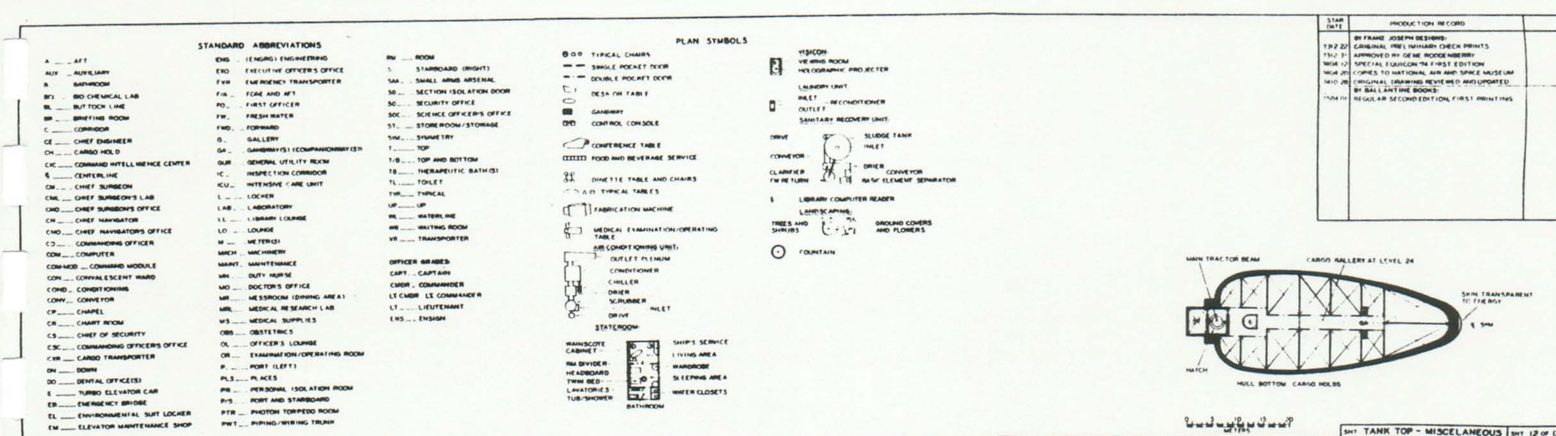

STARBOARD SIDE
LOUNGE - P/S
ENERGY CONVERTER - P/S
TWIN IMPULSE POWER UNIT
IMPULSE POWER SECT
STATEROOMS:
112 DOUBLES - 8 QUADS
ACCOMMODATION:
280 CREW MEMBERS - OR -
205 CREW MEMBERS - 35 SUPERCARGO
MESSROOM CAPACITY - 178 PERSONS
METERS
BRIEFING ROOM
PORT SIDE
SHT DECK 6 PLAN - CREW'S QUARTERS SHT 7 OF 12


STARBOARD SIDE
SEARCH SENSORS AND DEFLECTORS
SUMP TANKS - P/S
TWIN IMPULSE POWER UNIT - 4 PLS
LIBRARY LOUNGE
EMERG. BRIDGE
ENG. MAINTENANCE SHOPS
STATEROOMS:
54 DOUBLES - 1 QUAD
ACCOMMODATION:
112 CREW MEMBERS
MESSROOM CAPACITY - 44 PERSONS
PORT SIDE
SHT DECK 7 PLAN - MAIN DECK SHT 8 OF 12


FRESH WATER TANKS AROUND P/S
PUMP MACHINERY FLAT - P/S
ENTERTAINMENT CENTER
SHIP'S LAUNDRY
BASIC FOODS AND BEVERAGES PREPARATION FACILITY
ELEVATOR SHAFT TO SECONDARY HULL
DOUBLE SHEAR ATTACHMENT LUGS
FOOD CONVEYOR FROM SECONDARY HULL
INTERCONNECTING DORSAL ATTACHMENT SECTION
GYMNASIUM
EMERGENCY TRANSPORTER
RECREATION AREA
SHIP'S COMPUTER
LOCKER ROOM
SHOWERS
DECK 8 ENTERTAINMENT/RECREATION FACILITIES
FOOD CONV
OBSERVATION LOUNGE
DECK 12 DORSAL
ORGANIC FABRICATION
BASIC RAW MATERIALS STORAGE AROUND
ENERGY TRANSMISSION DISCONNECT
NON ORGANIC NON METALLIC FABRICATION
MATERIALS RECLAMATION FACILITY
SANITARY WASTES RECOVERY SYSTEM
DECK 9 FABRICATION FACILITIES
DECK 13 DORSAL
AUX MACHINERY ROOM
DECK 9 DORSAL
DECK 11 LOWER SENSOR PLATFORM
BASIC RAW MATERIALS STORAGE AROUND
CARGO TRANSPORTER
DECK 10 CARGO AND SUPPLIES
DECK 11 AUXILIARY FIRE CONTROL
DECK 16 DORSAL
DECK 14 DORSAL
DECK 11 DORSAL
SHT DECK PLANS 8-9-10-11-12-13-14 SHT 9 OF 12


DECK 15 SECONDARY HULL STRONGBACK
DECK 16 MEDICAL / WARP DRIVE ENGINEERING
DECK 17 CREW'S QUARTERS / OBSERVATION GALLERY
DECK 18 BOTANY SECTION / CREW'S QUARTERS
DECK 19 BRIDGE / SHIP'S COMPUTER / HANGAR DECK
SHUTTLECRAFT HANGAR
SHT DECK PLANS 15-16-17-18-19 SHT 10 OF 12


DECK 20 RECREATION FACILITIES / SHUTTLECRAFT MAINTENANCE SHOPS
DECK 21 FOOD PREPARATION CENTER / BOWLING ALLEY
DECK 22 FABRICATION FACILITIES
DECK 23 CARGO / STORAGE FACILITIES
SHT DECK PLANS 20-21-22-23 SHT 11 OF 12


STANDARD ABBREVIATIONS
PLAN SYMBOLS
PRODUCTION RECORD
HULL BOTTOM CARGO HOLDS
SHT TANK TOP - MISCELLANEOUS SHT 12 OF 12

"BEAM ME UP SCOTTY...

THERE'S NO INTELLIGENT LIFE HERE"