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FA-TR-74041

AD

EVALUATION TEST OF RADAR CHRONOGRAPH SET, NM87

December 1974

Fire Control Development & Engineering Directorate

U.S. ARMY ARMAMENT COMMAND
FRANKFORD ARSENAL
PHILADELPHIA, PENNSYLVANIA 19137

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER FA-TR-74041	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EVALUATION TEST OF RADAR CHRONOGRAPH SET, NM87		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Filmore Richter		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Frankford Arsenal Attn: SARFA-FCF-E Philadelphia, PA 19137		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS Code: 5210.17/80H DA Proj:67502.12.03900.01
11. CONTROLLING OFFICE NAME AND ADDRESS USA ARMCOM Rock Island, IL 61201		12. REPORT DATE December 1974 13. NUMBER OF PAGES 95
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Radar Chronograph
Muzzle Velocity
Measurements
Velocimeter

20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Norwegian Radar Chronograph Set, NM87 was evaluated by Frankford Arsenal from November 1972 through March 1974 to determine the capability of the NM87 to chronograph standard cannon artillery.

The NM87 was subjected to laboratory, environmental, and firing tests. From the results obtained to date, it is concluded that this chronograph is simple to operate, reliable, requires little maintenance,

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20. Abstract (cont.)

and is capable of the same order of precision as is possible with the M36 Radar Chronograph Set which is the item currently used for muzzle velocity measurements.

Report indicates some limitations and recommends improvements for utilization of the equipment.

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INTRODUCTION

The evaluation of the NM87 Radar Chronograph was authorized under PSTC Project #3-220132. The project was initiated as part of the Foreign Materiel Program to acquire sufficient test data to evaluate the operational performance, reliability, maintainability, and durability of the NM87 Radar Chronograph under actual tactical conditions.

DESCRIPTION OF MATERIEL

The Radar Chronograph Set, Mera Bergen Model NM87, is designed to measure the muzzle velocity of field artillery weapons under actual tactical conditions. The NM87 consists of the following items:

Doppler Radar (Figure 1)
Chronograph (Figure 2)
Cable Reel Assembly (Figure 3)
Mounting Set
Transport Case

The doppler radar unit houses the transmitter/receiver, and is normally mounted directly on the gun carriage. The chronograph unit incorporates the logic circuits, the numeric display, the power distribution circuits, and all operational controls. The cable reel assembly consists of two cables; one cable is used for battery connection and one cable for power and signal transmission to the doppler radar and the chronograph.

The mounting set consists of brackets with necessary supports and screws to mount the doppler radar to the gun/carriage.

The transport case houses all the above mentioned items with the exception of the cable reel assembly.

The doppler radar transmits continuous power on a wavelength of approximately three centimeters. The radar beam is transmitted along the trajectory of the projectile by means of a parabolic antenna. When the projectile leaves the muzzle and enters the radar beam, some of the transmitted power is reflected and detected in the receiver. By counting doppler periods between transmission and reception of reflected radar emissions, the position of the projectile is determined independent of the velocity. After 2176 doppler periods (corresponding to a trajectory of 35 meters), an electronic gate is opened for a duration of 128 doppler periods (corresponding to a base length of 2 meters). During this time, the flight time of the projectile is measured and is presented in 1/4 microsecond units on a 5-digit numeric display. By means of conversion tables, the displayed reading is converted to velocity at the muzzle in meters/second.

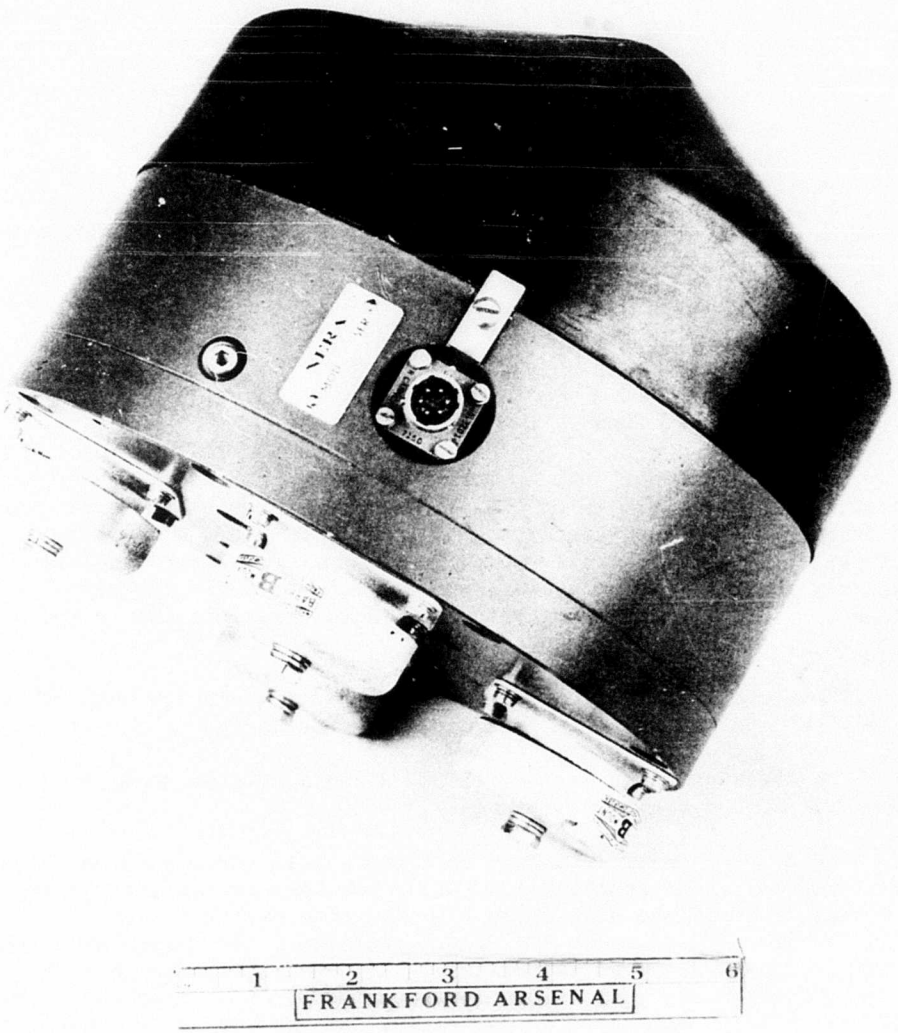

Figure 1. Radar Chronograph NM87, Doppler Radar

Figure 2. Chronograph NM87, Chronograph

Figure 3. Radar Chronograph NM87, Cable Reel Assembly

EVALUATION OBJECTIVES

The objective of the evaluation program described herein was:

a. Evaluation of the electrical and mechanical features of the NM87 Chronograph to determine whether it can be handled, operated, and maintained sefely by operating personnel in a field artillery environment.

b. Eveluation of rel'ability, durability, and mainteinability of the NM87 Chronograph under actual tactical conditions, including exposure to ambient field conditions, the shock of repeated firings, and the ease or difficulty experienced in assembly and disessembly of the test item for firing tests.

c. Comparison with other muzzle velocity meesuring devices in terms of advantages and disadvantages, state-of-the-art, end potentiel for savings in operation.

RESULTS OF EVALUATION TEST PROGRAM

The NM87 is easy to install, simple to operete, rugged, reliable, and requires little maintenance. Its functional performance complies with the specification requirements furnished by the manufacturer.

It was not possible to design a firing test which would demonstrate the accuracy of the NM87. However, a series of firing tests were conducted which constituted an adequate performance demonstration. From the firing test data, inferences were drawn with regards to the precision of measurement, namely, that there is no indication of any statistically significant differences in precision between the NM87 and the other muzzle velocity measurement devices tested with standard weapon projectile combinations. Test data also revealed that the NM87 does not have the capability to reliably measure the muzzle velocity of 8-inch RAP projectiles fired at charge 9.

Our results relative to the precision of the NM87 were confirmed by the U.S. Army Ballistic Research Laboratories. The data gathered by Frankford Arsenal during this test were presented to the BRL for analysis. The data were analyzed in accordance with the methodology adopted by the U.S. and other NATO nations as the most efficient and unbiased means of estimating and comparing relative chronograph performance when two or more instruments are used to make simultaneous measurements of gun muzzle velocities. It must be pointed out that the data reduction process did not include corrections for the recoil velocity of the doppler radar when it was mounted on the weapon.

DETAILS OF EVALUATION TEST

Introduction

The NM87 Radar Chronograph Set was tested in accordance with the evaluation schedule contained in Appendix A. Most of the criteria shown in this report were extracted from the supporting documents furnished by the manufacturer. Where no specific criteria were available, the ones used were based on experience and knowledge in the testing of similar types of items.

Upon receipt of the test item in November 1972, inspection and laboratory performance tests were conducted. At the conclusion of the laboratory tests, trial chronographings were conducted on various weapon ammunition combinations. All major adjustments, repairs, and modifications were performed by Frankford Arsenal personnel.

Most of the environmental tests were conducted at Frankford Arsenal. However, some environmental phases of the test were conducted concurrently with the firing accuracy tests. All testing on this program was completed in March 1974.

Discrepencies observed during the conduct of the evaluation program were reported to Frankford Arsenal by telephone, test reports, and equipment performance reports.

Physical Characteristics

The test item and its accessories were visually inspected for workmanship and mechanical operability.

The test item was measured and weighed. The results were compared with the manufacturer's specified values. The complete weights and measurements are given in Table I.

All markings were visually inspected and found to meet the requirements of Standard MIL-STD 130.

It is possible to interchange component assemblies of the NM87 Chronograph with other radar chronograph sets. This was done during firing tests at Yuma Proving Ground in March 1974.

TABLE I.
Radar Chronograph, NM87
Weights and Measurements

Doppler Radar (Figure 1)

Weight	28.5 pounds
Diameter	8.7 inches
Depth	9.0 inches

Chronograph (Figure 2)

Weight	8.0 pounds
Length	10.6 inches
Width	7.5 inches
Height	4.1 inches

Cable Reel Assembly (Figure 3)

Weight	26.5 pounds
Length	14.4 inches
Width	12.6 inches
Height	15.9 inches

Transport Case W/E

Weight	84.0 pounds
Length	21.0 inches
Width	13.0 inches
Height	15.0 inches

Circuit Description

Refer to Block Diagram Figure 4.

The Gunn Oscillator generates a signal with a nominal frequency of 9525 MH_z and an output power of approximately 20mW. The signal is fed via the circulator and the antenna elements to the antenna. The parabolic antenna directs the transmitter power in a narrow beam into the projectile trajectory.

A small part of the transmitter power is reflected because of mismatch in the antenna element and fed via the circulator to the frequency mixer. The reflected power is thus used as a local oscillator signal. The signal reflected from the projectile has its frequency changed due to the velocity of the projectile. This signal is below that of the transmitted frequency and the frequency difference , fd, is

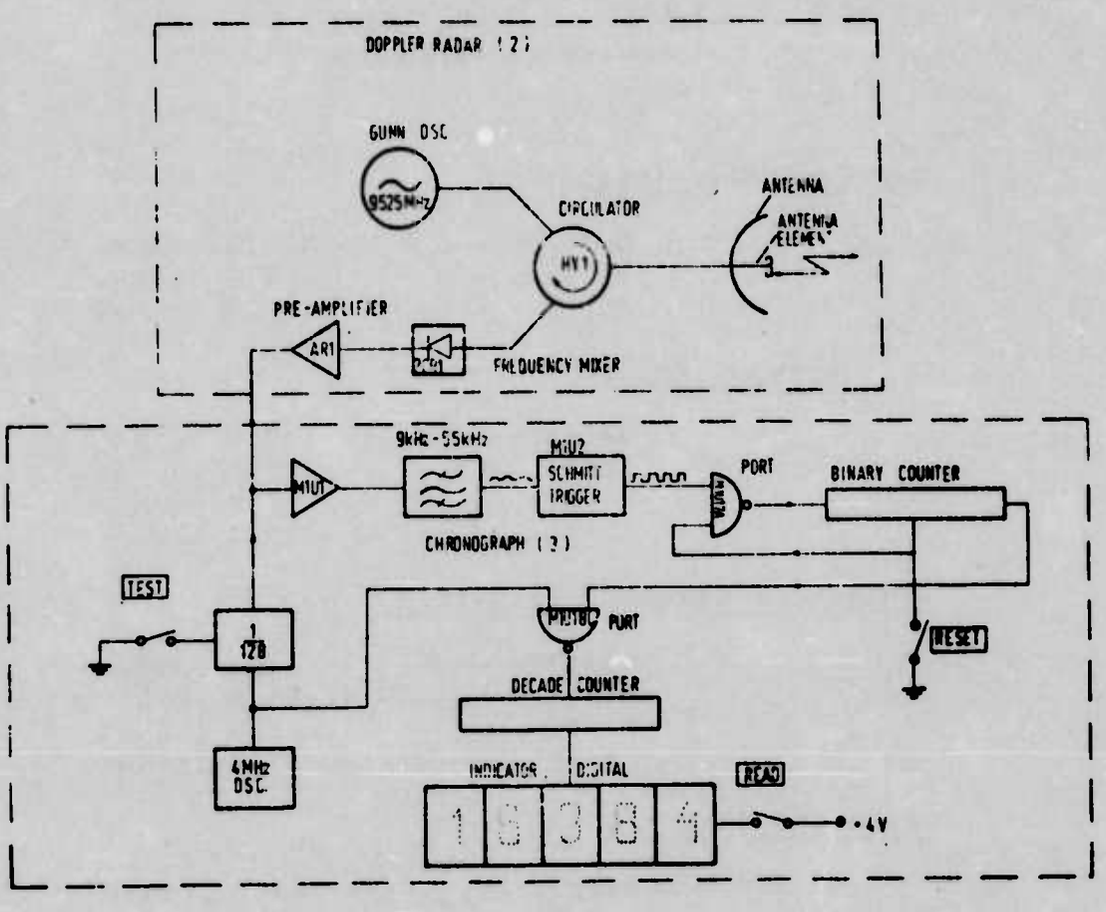

Figure 4. Radar Chronograph NM87, Block Schematic Diagram

given by Doppler's equation:

$$fd = \frac{2V}{\lambda}$$

where V = velocity of projectile
λ = wavelength of transmitted signal

The reflected signal is fed to the frequency mixer via the antenna, the antenna element, and the circulator.

In the frequency mixer, the reflected signal is mixed with the local oscillator signal. The output is a signal with a frequency

equal to the difference between the transmitted frequency and the reflected frequency. This signal is amplified in the preamplifier and then transmitted to the chronograph. Here, the signal is further amplified and fed via a band-pass filter to the Schmitt Trigger. The output of the Schmitt Trigger consists of square wave pulses with constant amplitude.

The square wave pulses are connected to a gate and then to a binary counter. After a preset number of pulses are counted, a gate (MIUI8C), is opened and 1/4 microsecond clock pulses from the 4MHz oscillator are fed to the decade counter.

After a time determined by the duration of a predetermined number of doppler pulses, the gate is closed. The number of 1/4 microsecond pulses fed to the decade counter during this time interval, can be read on the 5-digit numeric indicator when the READ push button is depressed.

A control circuit is incorporated to check the operation of the chronograph. When the TEST push button is depressed, a simulated doppler signal is fed to the input amplifier of the chronograph. If the radar chronograph set is functioning correctly, the control signal generates a reading of 16348 $\pm$ 1 on the numeric indicator.

Operator's Controls and Indicators

The numbers are referred to Figure 5.

a. BATTERY 24V(1). Connector for connection of the power cable.

b. ON-OFF (2). Combined power switch and circuit breaker.

c. DOPPLER RADAR (3). Connector for connection the signal and power cable between the doppler radar and the chronograph units.

d. TEST (4). Push button switch which applies an internal simulated doppler signal to the input of the chronograph.

e. READ indicator (5). Lit when information is stored in the register and is extinguished when the RESET button is pressed.

f. READ (6). When this push button is pressed, the numeric display will display the information stored in the register.

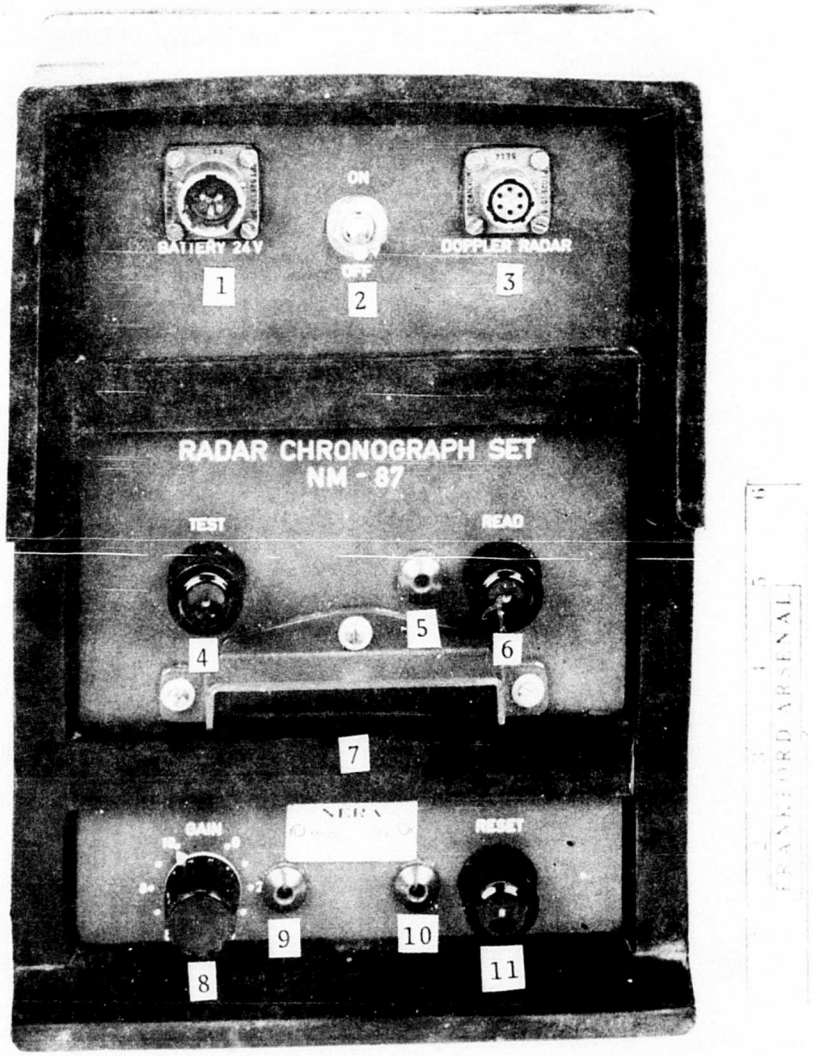

Figure 5. Radar Chronograph NM87, Operator's Controls and Indicators

g. NUMERIC (7). Presents a 5-digit reading of the registered time interval. It is activated when the READ button is pressed.

h. GAIN (8). Potentiometer for adjustment of the gain.

i. NOISE (9). Flashes for each noise or signal pulse which is received.

j. RESET (10). Lit to indicate that the set is ready for operation and is extinguished when a reading is obtained or when one or more noise pulses are received.

k. RESET (11). Push button is pressed to make the set ready for operation. It is pressed just before the shot is fired.

Electrical Characteristics

The electrical performance characteristics of the NM87 were measured in accordance with the test methods and procedures delineated in Military Specification MIL-C-14816. This specification covers the performance requirements of the USA Standard M36 Radar Chronograph Set. The results were compared with the specific characteristics of the manufacturer's (NERA Bergen) documentation furnished with the equipment.

The electrical characteristics are given in Table II.

Continuous Operation Test

The NM87 was set up in the normal operating mode. An operational test, relative power, and frequency test of the system performance was made and the results recorded. The chronograph was operated continuously eight hours a day for a period of five days. Performance tests were conducted periodically and the results compared with the initial test results. No failures, erratic readouts, or degradation of performance were observed during the continuous operation test.

Safety Inspection

As configured, the NM87 presents no electrical or mechanical hazards to operating personnel. However, mounting the doppler radar, Figure 1, on the 155 MM M109, the 8-inch M110, and the 175 MM M107 in

TABLE II.
Radar Chronograph, NM87
Electrical Characteristics

DOPPLER RADAR

Frequency	9525 MHz
Output power	20mW
Antenna gain	22dB
Antenna beamwidth	10°
Antenna polarization	Vertical
Receiver sensitivity	-88dBn

CHRONOGRAPH

Velocity range	150 - 850 meter/second
Clock frequency	4MHz
Display	5-digit (solid state)

POWER

Battery voltage	24 volt
Power consumption	Approximately 20W

accordance with the manufacturer's instructions constitutes a safety hazard to personnel (strain or rupture). This was confirmed by personnel of the Human Factors Engineering Division at Frankford Arsenal.

The doppler radar, which is removed as one unit, weighs 28.5 pounds. Two men are required to grasp and hold the doppler radar unit when mounting and setting up the equipment for operation. This places them in an awkward and unsafe position and is particularly hazardous if footing is unsure.

Firing Tests

Firing tests were conducted at the U.S. Army Artillery Board, Fort Sill, OK during July and August 1973. The primary objective of this firing test program was to determine the capability of the NM87 to chronograph standard cannon artillery.

The NM87 was set to measure projectile velocities at 35 meters from the muzzle. The doppler radar was mounted on the 155 MM Howitzer, M109 as specified by the manufacturer. The rounds from the 105 MM Howitzer, M102 were chronographed with the doppler radar unit mounted on a tripod. To install the doppler radar on the 175 MM Gun M107 and the 8-inch Howitzer M110, a special mounting bracket was fabricated at Frankford Arsenal, see Figure 6. The radar chronograph set was mounted on these weapons as illustrated in Figure 7.

A summary of the firing data for 25 weapon/ammunition combinations fired at Fort Sill is presented in Table III. The displayed readouts obtained from the NUMERIC DISPLAY were converted to velocity (m/s) through the use of the conversion tables furnished with the Operator's Manual, TM 11-5 840 25/200-12.

Based on the number of rounds fired (501), the usage factor and the number of rounds successfully chronographed as shown in Table IV, the overall performance of the set is considered satisfactory.

The evaluation of the NM87 performance was made by comparison among three different muzzle velocity measuring systems (M36, MVR-103, and XMR). The instrumented technical data acquired at the test site were recorded on magnetic tape for use in subsequent analysis and to serve as a permanent record of the test firing.

The data used for analysis was derived from the FADAC computer which had been programmed to compute "normalized" muzzle velocity. This was accomplished by modifying the Cannon FADAC program to accept CHRON DELAY inputs in milliseconds instead of entering the delay gate setting as is normally done for the Radar Chronograph M36 (U.S. Army Standard) muzzle velocity extrapolation routine. All meteorological and ballistic data that affect the trajectory were also entered into the computer. The program scheme uses an automatic successive approximation procedure to adjust the stored muzzle velocity obtained from the test items until the computed quadrant elevation is equal to the input quadrant elevation.

The BRL analysis of the data is presented in Appendix B. A summary of some of the terms found in these data is contained on pages 3 and 4 of Appendix C.

An attempt by Rock Island Arsenal personnel to measure the projectile velocity of 8-inch RAP rounds (XM650E3) when fired at charge 9 utilizing the NM87, was unsuccessful during the week of 18 March 1974 at Yuma Proving Ground. The cause of failure was considered to be the fire ball associated with the XM650E3 projectile when fired at charge 9. The tube used for firing these rounds does not have a muzzle brake. Therefore, the fire ball, instead of being thrown out sideways, is sucked behind the airborne projectile. The fire ball

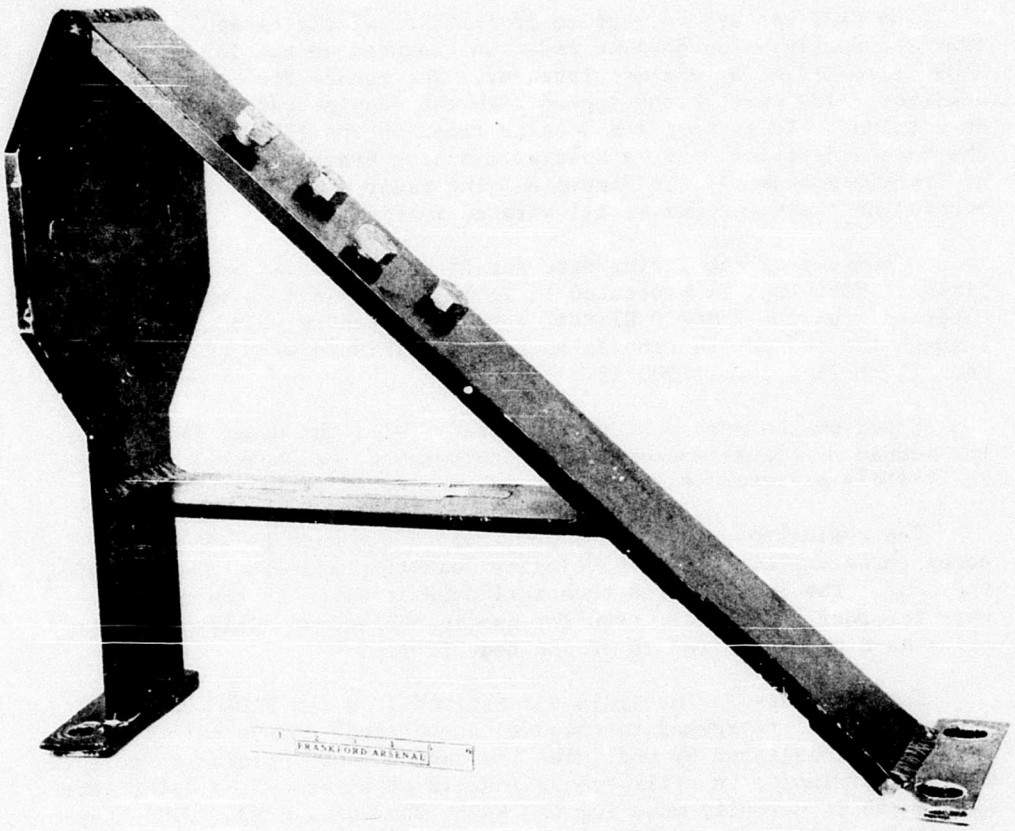

Figure 6. Radar Chronograph NM87, Special Mounting Bracket

appears as an extension to the projectile rear (the radar beam normally reflects off the projectile rear). Therefore, until the fire ball dissipates, the NM87 doppler radar had a very poor reflective target.

In order to investigate this theory, the doppler signal from the NM87 was simultaneously fed to both the signal processing section of the NM87 and to a Frankford Arsenal developed signal processing unit. This was accomplished by sampling the doppler signal from the unit, refer to Figure 4, and feeding it to the Frankford Arsenal processor. Utilizing this configuration, a firing test consisting of 15 rounds of the XM650E3 projectile, fired at charge 9, was conducted on 29 March 1974 at Yuma Proving Ground.

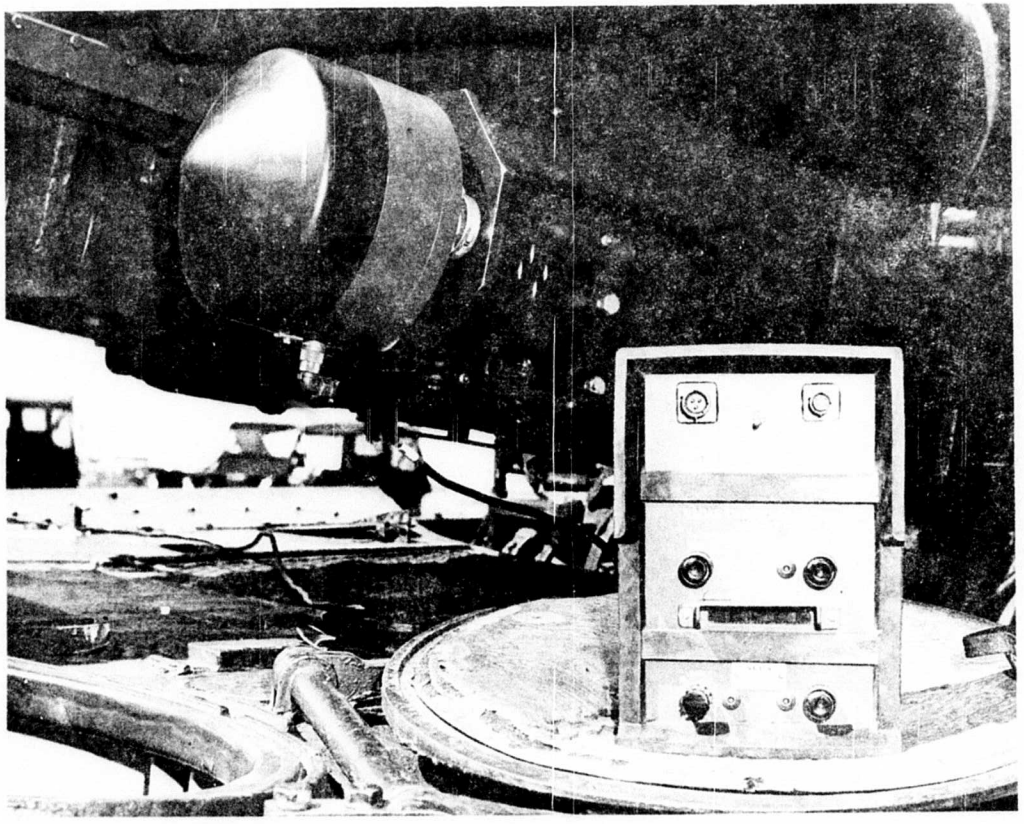

Figure 7. Installation of Radar Chronograph Set, NM87 on the 8-inch Howitzer M110

TABLE III.
Radar Chronograph, NM87
Firing Data Summary Sheet

WEAPON	ZONE	ROUNDS FIRED	ROUNDS RECRD	MEAN VELOCITY (m/s)	NOTE
105MM Howitzer, M102	1	22	22	184.6	
	4	19(1)	19	269.8	
	5	20(2)	20	316.2	
	7	5	5	485.2	
	7(RAP)	9	2	-----	A
155MM Howitzer, M109	1	20	20	200.1	B
	3G	20	20	277.1	
	4G	20	17	316.7	C
	5G	20	20	371.5	
	3W	20	20	281.4	
	4W	20	20	321.9	
	5W	30	30	378.1	
	6W	19(2)	19	463.4	
	7W	19(3)	18	563.6	D
	7(RAP)	4(3)	4	-----	E
175MM Gun, M107	1	25	24	501.7	F
	2	25	25	704.2	G
	3	30	30	915.6	H
8-inch Howitzer, M110	2	20	20	270.5	
	3	20	20	303.9	
	4	19(3)	19	346.3	
	5G	20(1)	20	415.7	I
	5W	20	20	420.5	
	6W	20	20	500.5	
	7W	20	20	594.1	

Notes:

The following comments disregard those rounds which were missed because of operator shortcomings such as:

(1) (.IN control not adjusted before firing .
(2) Equipment not turned on or no input power.
(3) Failure to reset before firing.

Notes - Cont'd

A Only two rounds were acquired during the mission. These readouts were so obviously in error that this mission was deleted for subsequent precision analysis. To date, it has not been determined if the NM87 is capable of chronographing RAP projectiles. It is unlikely that the problem experienced at the test site can be attributed to improper setup of equipment and/or an inexperienced operator.

B Although the NM87 acquired all rounds fired, two of the readouts were deleted through a visual examination of the data. The measurements were found to be in error when compared to measurements of other data points of the same weapon/ammunition combination.

C On three rounds the readout display was approximately twice the expected value (half the velocity) for this charge. The cause of the erroneous readout is unknown. It is definitely not a recording error.

D One round was deleted when it was observed that the measurement was found to be in error when compared to measurements of other data points of the same weapon/ammunition combination.

E The readouts obtained for the four rounds acquired were so inconsistent that this mission was deleted for subsequent precision analysis. To date, it has not been conclusively determined that the NM87 cannot chronograph RAP rounds.

F Operator neglected to record the readout, the readout display before reset.

G Although the NM87 acquired all rounds fired, one round generated a readout display approximately three times the expected value (1/3 the velocity) for this charge. The cause of the erroneous readout could not be determined.

H Although the NM87 acquired all rounds fired during this mission, eight readings were deleted through a visual examination of the data. The measurements were found to be in error when compared to measurements of other data points of the same weapon/ammunition combination. It has been determined that the marginal performance of the equipment (22 out of 30 rounds) is due to operation beyond the design specification. The technical data furnished with the NM87 specifies an effective operating velocity range to 850 meters/second.

I During the first nine rounds, only six readouts were correct. The remaining rounds were deleted because they did not compare with other data points of the same weapon/ammunition combination. Subsequent discussions with the operator revealed that during the first ten rounds, the GAIN control could have been incorrectly set.

TABLE IV.
Radar Chronograph, NM87
Summary of Firing Test Data

Attempts to chronograph	486
Total rounds chronographed	474
Total rounds missed	24*
Chronographing percentage (%)	92.6
Set usage during firing (%)	97.0

NOTES:

Total rounds fired - 501.

Rounds missed because of human error have not been considered in the calculations.

*Includes erroneous readouts determined by comparison of measurements to other data points of the same weapon/ammunition combination.

The round by round data for this date is presented in Appendix D. The results of this firing test are shown in Table V. An examination of this data indicates that the NM87 correctly measured only one round of 15 rounds fired. The Frankford Arsenal signal processor, utilizing the common doppler signal from the NM87, measured eight rounds out of 15. It appears that the NM87 doppler radar is marginal relative to its ability to provide useable doppler signal from this weapon/projectile combination. The probable cause for failure is the fire ball experienced with this projectile when fired at charge 9.

Human Factors Evaluation

Doppler Radar

Because of the weight of the doppler radar (28.5 pounds), two men should be required to install this equipment on the weapon, one man to hold it in position, while a second man secures the mounting

TABLE V.
Radar Chronograph, NM87
Diring Data Summary Sheet for XM650E3 Projectile

Round Number	Charge	Velocity/Range (m/s-m) FA Processor	NM87 Processor
914	9	791.4/28	578.8/35
915	9	000.0/0	794.1/35
916	9	794.9/28	763.8/35
917	9	789.6/140	442.5/35
918	9	000.0/0	746.0/35
919	9	000.0/0	442.5/35
920	9	791.4/126	429.0/35
921	9	793.5/28	438.8/35
922	9	000.0/0	562.5/35
923	9	797.1/28	789.5/35
924	9	791.2/126	502.7/35
925	9	000.0/0	655.5/35
926	9	000.0/0	643.9/35
927	9	795.4/28	770.9/35
928	9	000.0/0	424.5/35

hardware. With two men, installation on the M107, M109, and the M110 was accomplished in approximately five minutes, including cable hookup to the chronograph.

Chronograph

Controls are well placed and clearly labeled. Recepticles are correctly positioned for right-angled cable connectors to route cables over the chronograph so as not to interfere with controls.

The TEST, READ, and RESET push buttons are well positioned for thumb operation when the chronograph is hand held. However, the push buttons should have rubber boots to prevent water entry into the chronograph. This could result in system malfunctions during freezing conditions. Further, the 5/8 inch diameter push buttons do not conform to MIL-STD 1472A which specifies 3/4 inch diameters.

At a weight of eight pounds, the chronograph is too heavy to be hand held for any length of time. It is suggested that a neck strap be used for hand held relief. The lower half of the outside facing edges of the rubber encasement should be rounded for greater palm comfort.

Cable Reel Assembly

This assembly weighs 26.5 pounds and can be carried by one man. However, it is quite awkward and should be carried by two men.

Mounting Set

There appears to be no human engineering problem with regards to the mounting sets, particularly when the swivel head wrench is utilized and since positional accuracy is not critical.

Transport Case

The loaded transport case weighs 83.5 pounds and can be carried by two men if the lifting height does not exceed 4.5 feet.

Technology and Methodology

The system is simple to operate, reliable, and capable of achieving the same order of precission as is possible with other velocity measurement methods. However, the most significant defect in the system is its failure to have indications of possible erroneous displays. The operator has no assurance that the values displayed on the chronograph readout are valid muzzle velocity measurements.

The chronographing range for this system, a maximum of 35 meters, will be inadequate for weapon/projectile combinations in the 1975 - 1985 time frame. Changes in the target reflectivity of projectiles currently being developed will require increased range capabilities in order to capture the projectile in its trajectory.

The component technology utilized in the M87 is slightly behind the current state-of-the-art. The electronics in many areas of the doppler rader and chronograph assemblies, Figures 8 and 9, is such that the size and weight of the M87 can be reduced by replacing discrete and small/medium scale integrated component assemblies with MOS/LSI (Metal oxide semiconductor/large scale intagrated) circuitry.

Reliability and Maintainability

Determination of the reliability of the system existing at the end of the evaluation is considered impractical in this report because no feilures were encountered during the test and evaluation phase. No maintenance difficulties were observed in setup or tear down of the

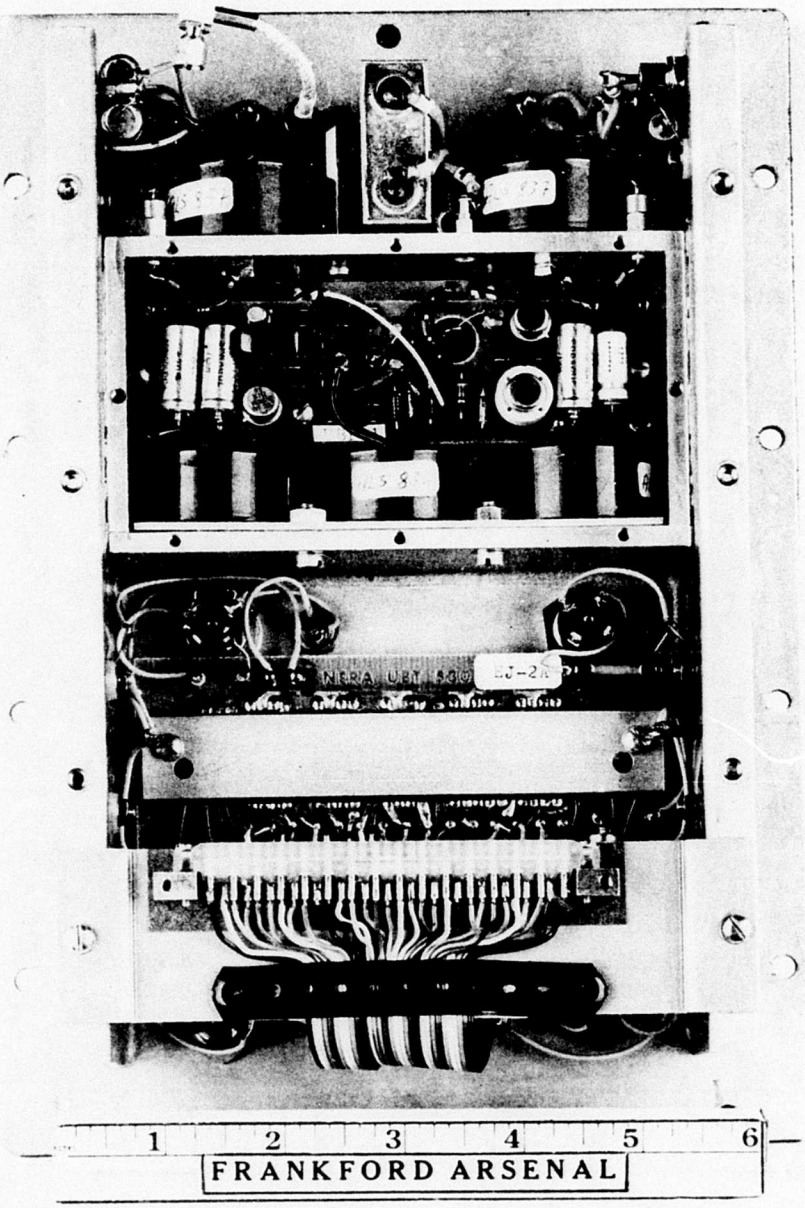

Figure 8. Radar Chronograph Set NM87, Digital Indicator and Voltage Regulator Assembly

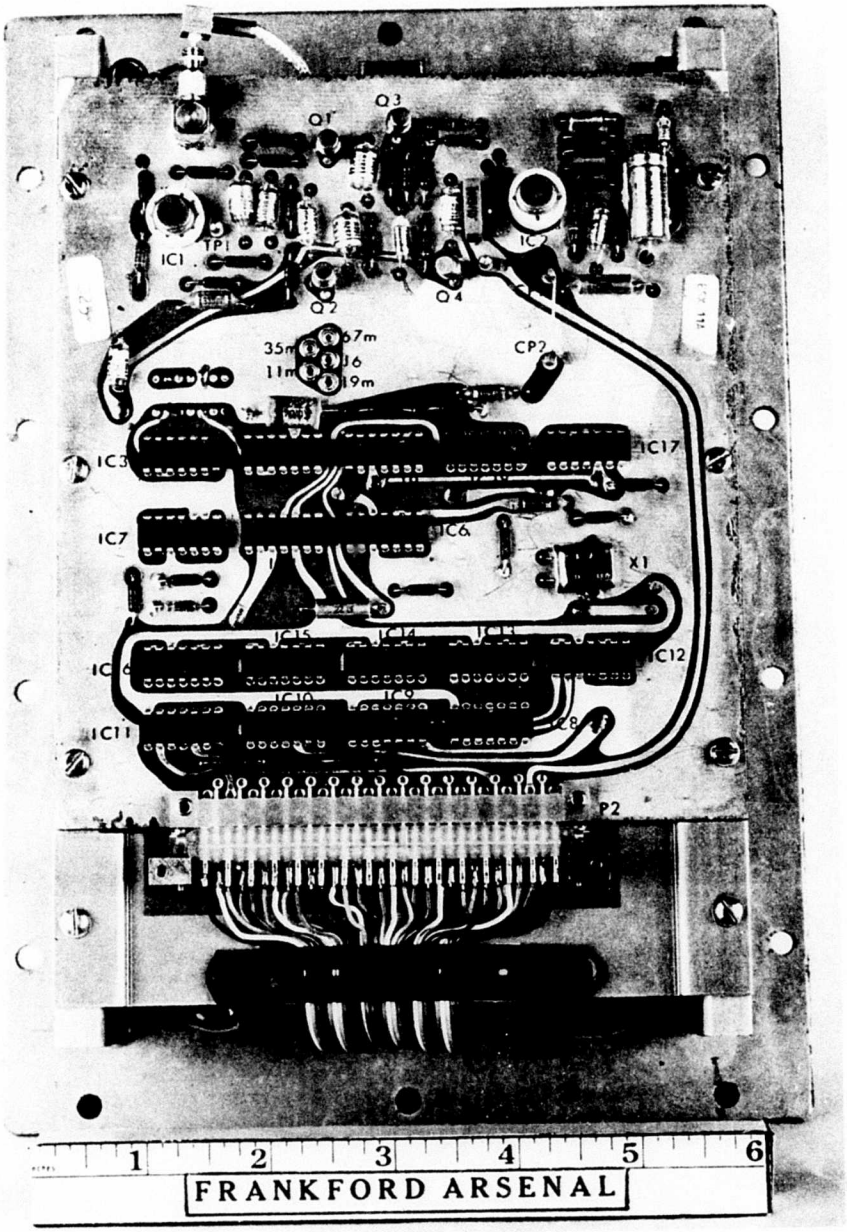

Figure 9. Radar Chronograph Set NM87, Digital Counter Assembly

major assemblies with either the tools or mounting sets provided with the system.

Ruggedness

The NM87 is capable of withstanding exposure to the shock of repeated firings and transportation over cross country without adverse effects on operational performance. Further, it was not sensitive to weather and ambient light conditions.

Adaptability

The NM87 is adaptable to all standard cannon artillery. It can be mounted on carriage to follow the azimuth and elevation of the tube with the mounting set surnished with the system; or other mounting brackets, see Figure 6, for special applications.

The system can also be mounted on a tripod with no adverse affect on performance. This permits greater versatility in deployment and reduces the initial set up time without any sacrifice of the required stability.

Because of the system's low power consumption, it is capable of being operated directly from vehicle power systems.

CONCLUSIONS

There is no indication of any statistically significant differences in precision between the NM87 and other muzzle velocity measurement devices tested with standard weapon/projectile combinations.

Preliminary test data indicated that the NM87 does not have the capability to reliably measure the muzzle velocity of the XM650E3 projectile fired at charge 9 (8-inch RAP).

The NM87 is easy to install, simple to operate, rugged, relisble, and capable of achieving the same order of precision as is possible with other doppler radar velocity measurement devices.

RECOMMENDATIONS

Error detecting features should be incorporated into the design to assure the operator that the values displayed on the chronograph readout are valid muzzle velocity measurements.

The chronographing range capability should be increased from the present maximum of 67 meters to 300 meters. Increased range capabilities will be required to chronograph projectiles under current development.

APPENDIX A
Radar Chronograph Set NM87
Evaluation Schedule - 18 September 1972

	M/DAYS
Physical Inspection and Inventory	4
Conformance of Physical Characteristics with Test Item Specifications	5
Safety Inspection	5
Electrical Characteristics	
Receiver Sensitivity	20
Doppler Frequency Response	20
Transmitter Frequency	5
Transmitter Output	5
Calibration	5
Antenna Beamwidth	3
Antenna Gain	4
Boresighting	8
Monitor Circuits	6
Power Source	2
Power Consumption	5
Continuous Operation Test	4
Firing Accuracy Test	
Howitzer, 105MM	15
Howitzer, 8-inch	15
Howitzer, 155MM	15
Gun, 175MM	15
Ruggedness Test	
Shock	4
Vibration	10
Transport	24
Electromagnetic Inteference Tests	10
Environmental Characteristics	
Low Temperature Test	5
High Temperature Test	5
Rain Test	2
Sand and Dust Test	4
Reliability Assessment	20
Maintainability Assesssment	15
Human Factors Assessment	20
Physical Teardown	25
Determination of Special Features, Technology, and Methodology Utilized in Test Item	20

APPENDIX B
BRL Analysis - Customer Service Test
Fort Sill, Oklahoma, 8 - 23 August 1973

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL ORRYON
NORMALIZED DATA 105MM HOWITZER M102,ZONE 1 , ROUNDS 200-221 QE = 350 MILS

DATA POINT		M36-1 A	M36-2 B	QE-1 C	QE-2 D	NM-87 E	XMR F	MEAN
DELETED	1	0.00	181.90	181.10	181.60	181.70	0.00	0.00
DELETED	2	0.00	179.30	179.10	179.10	179.40	0.00	0.00
DELETED	3	0.00	178.60	179.10	178.60	178.50	178.30	0.00
	4	178.30	178.50	177.60	177.60	177.90	177.70	177.93
	5	177.30	177.20	177.10	176.60	177.90	176.30	177.07
	6	178.30	178.50	179.10P	178.10	178.40	178.20	178.43
	7	179.00	179.00	179.10	178.60	179.40	178.60	178.95
	8	181.10	181.00	181.10	180.10	180.40	180.40	180.68
	9	179.60	179.60	181.60	181.10	181.00	181.20	180.68
	10	184.40	184.00	183.10	183.60	183.60	183.80	183.75
	11	183.70	184.00	183.10	183.10	183.20	183.50	183.43
	12	185.40	185.30	185.60	184.60	184.80	184.40	185.02
	13	193.40	193.00	193.60	192.60	192.70	192.60	192.98
	14	190.70	190.30	189.60	189.60	189.90	189.60	189.95
	15	188.70	188.30	187.60	187.60	187.90	188.00	188.02
	16	188.70	188.30	187.60	188.10	187.90	188.00	188.10
	17	187.40	187.00	187.10	186.60	186.50	186.20	186.80
	18	186.70	186.60	185.60	186.10	186.20	186.00	186.20
	19	187.70	187.30	187.60	187.10	187.00	185.70P	187.07
	20	188.10	187.60	187.10	187.10	187.20	185.90	187.17
	21	188.70	188.60	187.60	188.10	188.00	187.70	188.12
	22	188.70	188.60	187.60	188.10	188.20	188.00	188.20
MEAN		185.05	184.88	184.65	184.44	184.64	184.31	
VARIANCE		23.054	21.484	19.830	21.113	19.307	20.201	
STND DEV		4.801	4.635	4.453	4.595	4.394	4.494	
PROB ERR		3.239	3.126	3.004	3.099	2.964	3.032	

GRAND MEAN= 184.661 AVERAGE VARIANCE= 20.8314 STND DEV= 4.5641 PROB ERR= 3.0785

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY 1 OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

6 INSTRUMENTS WITH 19 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 105MM HOWITZER M102,ZONE 1 , ROUNDS 200-221 GE = 350 MILS

COVARIANCE MATRIX

	M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E	XMR F
M36-1	0.0000	22.2394	21.0890	21.9273	20.9943	21.3325
M36-2	22.2394	0.0000	20.3484	21.1659	20.2558	20.6223
GE-1	21.0890	20.3484	0.0000	20.3143	19.4091	19.7469
GE-2	21.9273	21.1659	20.3143	0.0000	20.1478	20.5453
NM-87	20.9943	20.2558	19.4091	20.1478	0.0000	19.6070
XMR	21.3325	20.6223	19.7469	20.5453	19.6070	0.0000
COV INCLD INST	107.5825	104.6319	100.9077	104.1007	100.4140	101.8541
COV EXCLD INST	202.1630	205.1136	208.8377	205.6448	209.3315	207.8914
EST ($SIGMA E1)$^2	0.2370	0.1426	0.3511	0.0368	0.0745	0.2480
EST (SIGMA E1)	0.48685	0.37761	0.59252	0.19172	0.27288	0.49801
PRECISION RANK	4	3	6	1	2	5

TOTAL COVARIANCE= 309.7455 PARAMETER VARIANCE = 20.650 PARAM STD DEV. = 4.5442

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL ORRYON
NORMALIZED DATA 105MM HOWITZER M102,ZONE 3 , ROUNDS 243-263 QE = 1250 MILS

	DATA POINT	M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E DELETED	XMR F	MEAN
DELETED	1	240.20	240.10	239.30	239.30	0.00	0.00	0.00
DELETED	2	243.10	242.60	241.80	242.30	0.00	241.70	0.00
	3	241.10 I	239.60	239.80	239.30	0.00	238.60	239.68
	4	238.10	237.60	237.30	237.30	0.00	236.80	237.42
	5	234.70	234.60	233.80	234.30	0.00	233.50	234.18
	6	234.10	233.60	233.30	233.30	0.00	232.90	233.44
	7	234.70	234.30	233.80	234.30	0.00	233.50	234.12
	8	234.70	234.30	233.30	233.30	0.00	232.80	233.68
	9	233.70	233.30	233.80	233.30	0.00	232.50	233.32
	10	235.10	235.00	235.30	234.30	0.00	234.00	234.74
	11	235.70	234.60	235.80	235.30	0.00	234.70	235.22
	12	234.10	234.00	233.30	233.30	0.00	233.50	233.64
	13	238.40	235.00	237.30	237.80	0.00	235.40	236.78
	14	237.10	236.60	237.30	236.30	0.00	235.00	236.46
	15	237.40	237.30	237.80	236.80	0.00	236.40	237.14
	16	235.40	235.30	235.80	234.80	0.00	234.50	235.16
	17	235.40	235.30	235.80	234.80	0.00	234.50	235.16
	18	235.40	235.30	235.80	234.80	0.00	234.30	235.12
	19	238.10	237.60	237.30	237.30	0.00	236.70	237.40
	20	237.10	236.60	237.30	236.30	0.00	235.90	236.64
	21	236.40	236.30	235.80	235.80	0.00	235.30	235.92
	22	237.70	237.30	237.80	237.80	0.00	236.50	237.42
	MEAN	236.22	235.68	235.88	235.53	0.00	234.86	
	VARIANCE	3.506	2.651	3.481	3.144	0.000	2.543	
	STND DEV	1.872	1.628	1.866	1.773	0.000	1.595	
	PROB ERR	1.263	1.098	1.258	1.196	0.000	1.076	

GRAND MEAN= 235.632 AVERAGE VARIANCE= 3.0652 STND DEV= 1.7508 PROB ERR= 1.1809

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
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* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

5 INSTRUMENTS WITH 20 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 105MM HOWITZER M102,ZONE 3 , ROUNDS 243-263 QE = 1250 MILS

COVARIANCE MATRIX

		M38-1 A	M38-2 B	GE-1 C	QE-2 D	NM-87 E DELETED	XMR F
	M38-1	0.0000	2.7879	3.2879	3.2505	0.0000	2.8549
	M38-2	2.7879	0.0000	2.7651	2.5822	0.0000	2.4986
	GE-1	3.2879	2.7851	0.0000	3.1533	0.0000	2.8212
	QE-2	3.2505	2.5822	3.1533	0.0000	0.0000	2.7030
DELETED	NM-87	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	XMR	2.8549	2.4986	2.8212	2.7030	0.0000	0.0000
COV INCLD INST		12.1813	10.6338	12.0275	11.8891	0.0000	10.8777
COV EXCLD INST		16.5234	18.0709	16.6772	17.0158	0.0000	17.8270
EST (SIGMA E1)^2		0.1692	0.3464	0.2487	0.1355	0.0000	0.0758
EST (SIGMA E1)		0.41130	0.58852	0.49869	0.36807	0.00000	0.27524
PRECISION RANK		3	5	4	2	0	1

TOTAL COVARIANCE= 28.7047 PARAMETER VARIANCE = 2.870 PARAM STD DEV. = 1.0942

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,8RL OBRYON
NORMALIZED DATA 105MM HOWITZER M102,ZONE 4 , ROUNDS 222-241 QE= 180 MILS

	DATA POINT	M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E	XMR F	MEAN
DELETED	1	269.40	269.30	269.60	268.60	0.00	268.70	0.00
	2	271.10	271.00	271.60	270.60	270.40	269.90	270.77
	3	270.40	270.60	271.10	270.10	269.80	269.40	270.23
	4	270.10	270.00	269.60	269.60	269.80	269.10	269.70
	5	269.10	269.30	269.60	269.10	268.50	268.60	269.03
	6	268.70	269.00	269.10	268.10	268.00	267.40	268.38
	7	270.70	270.30	271.10	270.10	270.00	269.80	270.33
	8	270.40	271.00	271.60	270.60	270.40	270.50	270.75
	9	270.40	270.30	269.60	270.10	269.50	269.70	269.93
	10	272.10	271.60	271.10	271.10	271.00	270.50	271.23
	11	274.70 I	275.00 I	275.60 I	274.60 I	274.30 I	274.30 I	274.75
	12	270.70	270.60	271.10	270.10	270.00	270.00	270.42
	13	270.70	270.60	271.10	270.10	270.00	270.00	270.42
	14	271.40	271.00	271.10	271.10	270.60	270.70	270.98
	15	269.40	269.30	269.60	269.10	268.50	268.50	269.07
	16	269.40	269.30	269.60	269.10	268.50	268.70	269.10
	17	270.10	270.20	269.60	269.60	269.20	268.50	269.53
	18	270.10	270.20	269.60	269.60	269.30	268.60	269.57
	19	270.10	269.60	269.60	269.60	269.30	268.80	269.50
	20	270.70	270.60	271.10	270.60	270.00	269.90	270.48
	MEAN	270.54	270.50	270.65	270.15	269.85	269.63	
	VARIANCE	1.655	1.674	2.164	1.719	1.802	2.025	
	STND DEV	1.286	1.294	1.471	1.311	1.342	1.423	
	PROB ERR	0.868	0.873	0.992	0.884	0.905	0.960	

GRAND MEAN= 270.220 AVERAGE VARIANCE= 1.8399 STND DEV= 1.3564 PROB ERR= 0.9149

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

6 INSTRUMENTS WITH 19 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL DORYON
NORMALIZED DATA 105MM HOWITZER M102,ZONE 4 , ROUNDS 222-241 SE= 180 MILS

COVARIANCE MATRIX

	M38-1 A	M38-2 B	SE-1 C	SE-2 D	MM-87 E	XMR F
M38-1	0.0000	1.6228	1.7254	1.6504	1.6973	1.7461
M38-2	1.6228	0.0000	1.8028	1.6667	1.7117	1.7678
SE-1	1.7254	1.8028	0.0000	1.8165	1.0640	1.9902
SE-2	1.6504	1.6667	1.8165	0.0000	1.7335	1.8319
MM-87	1.8973	1.7117	1.8640	1.7335	0.0000	1.8587
XMR	1.7461	1.7678	1.9902	1.8319	1.8587	0.0000
COV INCLD INST	8.4420	8.5717	9.1990	8.6990	8.0652	9.1946
COV EXCLD INST	18.0437	17.9141	17.2868	17.7868	17.6205	17.2911
EST (σ^2 E1)	0.0023	0.0372	0.2128	0.0184	0.0175	0.0787
EST (σ E1)	0.28898	0.19283	0.46133	0.13558	0.13225	0.27667
PRECISION RANK	5	3	6	2	1	4

TOTAL COVARIANCE= 26.4857 PARAMETER VARIANCE = 1.766 PARAM STD DEV. = 1.3288

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,SRL OBRYON
NORMALIZED DATA 105MM HOWITZER M102,ZONE 5 , ROUNDS 266-284 SE = 208 - 200 MILS

	DATA POINT	M36-1 A	M36-2 B	SE-1 C	SE-2 D	NN-87 E	XNR F	MEAN
		DELETED						
DELETED	1	314.80	0.00	317.60	317.60	0.00	316.60	0.00
	2	0.00	317.30	317.60	316.10	316.10	316.40	316.70
	3	0.00	319.40	318.60	319.10	318.10	317.70	318.58
	4	0.00	318.80	317.60	316.10	317.10	317.20	317.76
DELETED	5	0.00	0.00	316.10	316.60	315.40	315.50	0.00
	6	0.00	318.30	317.60	317.60	317.00	316.40	317.38
	7	0.00	316.80	316.18	316.10	315.40	315.40	315.96
	8	0.00	316.30	315.60	316.10	315.20	315.30	315.70
	9	0.00	317.10	316.60	316.60	315.90	316.20	316.48
	10	0.00	315.30	314.60	315.10	314.10	313.60	314.54
	11	0.00	316.30	315.60	315.60	314.90	314.30	315.34
	12	0.00	317.30	317.80	318.60	316.00	315.80	317.06
	13	0.00	318.00	317.60	317.60	316.80	315.90	317.18
	14	317.10	318.90	317.10	316.60	315.70	315.70	316.40
	15	316.10	316.00	315.60	315.60	314.90	314.60	315.34
	16	319.30	319.10	319.60	318.60	317.90	317.70	318.58
	17	320.70	320.50	319.60	320.20	319.30	319.70	319.86
	18	317.50	317.30	317.60	316.10	316.20	316.20	317.08
	19	316.20	318.30	317.80	316.60	316.90	317.20	317.32
	20	317.20	317.30	317.60	316.60	316.00	315.30	316.86
	21	316.10	316.00	315.10	315.60	314.80	313.80	315.06
	MEAN	0.00	317.49	317.10	317.06	316.23	316.02	
	VARIANCE	0.000	1.765	1.944	1.964	1.679	2.204	
	STND DEV	0.000	1.329	1.394	1.401	1.296	1.485	
	PROB ERR	0.000	0.896	0.941	0.945	0.874	1.001	

GRAND MEAN= 316.783 AVERAGE VARIANCE= 1.9113 STND DEV= 1.3825 PROB ERR= 0.9328

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

5 INSTRUMENTS WITH 19 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYOM
NORMALIZED DATA 105MM HOWITZER M102,ZONE 5 , ROUNDS 266-284 QE = 208 - 200 MILS

COVARIANCE MATRIX

		M36-1 A DELETED	M36-2 B	QE-1 C	QE-2 D	MM-87 E	XMR F
DELETED	M36-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	M36-2	0.0000	0.0000	1.7167	1.6637	1.7120	1.8880
	QE-1	0.0000	1.7167	0.0000	1.7222	1.6944	1.8806
	QE-2	0.0000	1.6637	1.7222	0.0000	1.6400	1.7849
	MM-87	0.0000	1.7120	1.6944	1.6400	0.0000	1.8511
	XMR	0.0000	1.8880	1.8806	1.7849	1.8511	0.0000
COV INCLD INST		0.0000	6.9803	7.0139	6.8108	6.8975	7.4046
COV EXCLD INST		0.0000	10.5732	10.5396	10.7427	10.6560	10.1490
EST (SIGMA E1)^2		0.0000	0.0375	0.1941	0.3490	0.0060	0.1932
EST (SIGMA E1)		0.00000	0.19365	0.44058	0.59078	0.07720	0.43954
PRECISION RANK		0	2	4	5	1	3

TOTAL COVARIANCE= 17.5535 PARAMETER VARIANCE = 1.755 PARAM STD DEV. = 1.3249

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,SRL OGRYON
NORMALIZED DATA 155MM HOWITZER M102,ZONE 7 , ROUNDS 301-310, BE = 1093

DATA POINT	M36-1 A DELETED	M36-2 B DELETED	BE-1 C	BE-2 D	NH-67 E DELETED	XMR F	MEAN
1	489.30	0.00	488.00 I	489.00 I	0.00	488.50 I	488.50
2	480.60	0.00	486.00	487.00	0.00	488.80	486.53
3	477.80	0.00	485.50P	486.50	0.00	488.50	486.17
4	485.00	0.00	486.00	487.00	0.00	486.70	486.57
5	480.60	0.00	485.50	486.50	0.00	486.30	488.10
6	480.20	0.00	485.50	485.50	0.00	485.40P	485.47
7	485.70	0.00	486.00	486.00	0.00	485.70P	485.90
8	442.20	0.00	485.50	485.50	0.00	485.80P	485.53
9	477.80	0.00	484.00	485.00	0.00	485.20	484.73
10	474.40	0.00	485.50	485.50	0.00	485.80P	485.58
MEAN	0.00	0.00	485.75	486.35	0.00	486.21	
VARIANCE	0.000	0.000	0.958	1.336	0.000	0.934	
STND DEV	0.000	0.000	0.979	1.156	0.000	0.967	
PROB ERR	0.000	0.000	0.660	0.780	0.000	0.652	

GRAND MEAN= 486.103 AVERAGE VARIANCE= 1.0763 STND DEV= 1.0374 PROB ERR= 0.6997

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
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* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

5 INSTRUMENTS WITH 10 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

COVARIANCE MATRIX

		M36-1 A DELETES	M36-2 B DELETED	BE-1 C	BE-2 D	NH-67 E DELETED	XMR F
DELETED	M36-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DELETED	M36-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	BE-1	0.0000	0.0000	0.0000	1.0139	0.0000	0.8250
	BE-2	0.0000	0.0000	1.0139	0.0000	0.0000	1.1072
DELETED	NH-67	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	XMR	0.0000	0.0000	0.8250	1.1072	0.0000	0.0000
COV INCLD INST		0.0000	0.0000	1.8389	2.1211	0.0000	1.9322
COV EXCLD INST		0.0000	0.0000	1.1072	0.8250	0.0000	1.0139
	2						
EST (SIGMA E1)		0.0000	0.0000	0.2267	0.0400	0.0000	0.0160
EST (SIGMA E1)		0.00000	0.00000	0.47610	0.20000	0.00000	0.12849
PRECISION RANK		0	0	3	P	0	1

TOTAL COVARIANCE= 2.9461 PARAMETER VARIANCE = 0.982 PARAM STD DEV. = 0.9910

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON

NORMALIZED DATA 105MM HOWITZER M102,ZONE 7 , ROUNDS 311-320, BE = 1077

	DATA POINT	M36-1 A	M36-2 B	BE-1 C	BE-2 D	NM-87 E DELETED	XMR F		MEAN
	1	483.20	486.10	486.00	486.00	I 0.00	484.30	I	485.12
DELETED	2	481.20	485.10	484.00	485.50	0.00	485.10		0.00
DELETED	3	0.00	485.10	484.00	485.00	0.00	485.00		0.00
DELETED	4	0.00	484.70	483.50	484.50	0.00	484.80		0.00
DELETED	5	0.00	85.10	483.50	485.00	0.00	484.60		0.00
	6	482.20	485.50	484.00	485.00	0.00	485.20		484.38
	7	484.60	485.50	484.00	485.00	0.00	484.90		484.80
	8	484.60	485.10	484.00	485.00	0.00	485.00		484.74
	9	484.60	485.10	484.00	484.50	0.00	484.90		484.62
	10	485.00	485.80	485.60	485.00	0.00	485.20		485.32
	MEAN	484.03	485.52	484.60	485.08	0.00	484.92		
	VARIANCE	1.191	0.154	0.880	0.242	0.000	0.110		
	STND DEV	1.091	0.392	0.938	0.492	0.000	0.331		
	PROB ERR	0.736	0.264	0.633	0.332	0.000	0.223		

GRAND MEAN= 484.830 AVERAGE VARIANCE= 0.5151 STND DEV= 0.7177 PROB ERR= 0.4841

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT,
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

5 INSTRUMENTS WITH 6 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

COVARIANCE MATRIX

		M36-1 A	M36-2 B	BE-1 C	BE-2 D	NM-87 E DELETED	XMR F
	M36-1	0.0000	-0.1327	-0.0240	-0.2233	0.0000	0.0593
	M36-2	-0.1327	0.0000	0.3240	0.1583	0.0000	-0.0623
	BE-1	-0.0240	0.3240	0.0000	0.3400	0.0000	-0.1560
	BE-2	-0.2233	0.1583	0.3400	0.0000	0.0000	-0.1217
DELETED	NM-87	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	XMR	0.0593	-0.0623	-0.1560	-0.1217	0.0000	0.0000
COV INCLD INST		-0.3207	0.2873	0.4840	0.1533	0.0000	-0.2807
COV EXCLD INST 2		0.4823	-0.1257	-0.3223	0.0083	0.0000	0.4423
EST (SIGMA E1)		1.4314	-0.0109	0.5843	0.1664	0.0000	0.3237
EST (SIGMA E1)		1.19641	0.00000	0.76438	0.40791	0.00000	0.56897
PRECISION RANK		5	1	4	2	0	3

TOTAL COVARIANCE= 0.1617 PARAMETER VARIANCE = 0.016 PARAM STD DEV. = 0.1271

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 105MM HOWITZER M102,ZONE 7 , ROUNDS 322-326, SE= 405 MILS

DATA POINT	M36-1 A	M36-2 B	SE-1 C	SE-2 D	NM-87 E	XMR F	MEAN
1	489.40	469.20	488.00	488.50	486.90	488.60	488.43
2	487.60	487.70	487.60	487.50	485.50P	487.30	487.20
3	488.00	487.70	487.50	487.50	485.50P	487.60	487.30
4	485.90	486.40	486.10	485.90	484.30P	486.20	485.80
5	485.90	486.10	486.10	485.90	464.00P	486.00	485.67
MEAN	487.36	487.42	487.06	487.06	485.24	487.14	
VARIANCE	2.223	1.527	0.803	1.288	1.328	1.138	
STND DEV	1.491	1.236	0.896	1.135	1.152	1.067	
PROB ERR	1.006	0.833	0.604	0.765	0.777	0.720	

GRAND MEAN= 486.660 AVERAGE VARIANCE= 1.3645 STND DEV= 1.1766 PROB ERR= 0.7936

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

6 INSTRUMENTS WITH 5 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

COVARIANCE MATRIX

	M36-1 A	M36-2 B	SE-1 C	SE-2 D	NM-87 E	XMR F
M36-1	0.0000	1.8235	1.2830	1.6760	1.6995	1.5870
M36-2	1.8235	0.0000	1.0485	1.3810	1.4240	1.3090
SE-1	1.2830	1.0465	0.0000	1.0030	0.9770	0.9145
SE-2	1.6780	1.3810	1.0030	0.0000	1.2870	1.1970
NM-87	1.6995	1.4240	0.9770	1.2870	0.0000	1.2205
XMR	1.5870	1.3090	0.9145	1.1970	1.2205	0.0000
COV INCLD INST	6.0710	6.9660	5.2260	6.5460	6.6060	6.2280
COV EXCLD INST	11.7615	12.8465	14.6065	13.2865	13.2245	13.6045
EST ($SIGMA^2$ E1)	0.1708	0.0172	0.1733	-0.0016	0.0073	0.0072
EST (SIGMA E1)	0.41322	0.13134	0.41623	0.00000	0.08515	0.08515
PRECISION RANK	5	4	6	1	3	2

TOTAL COVARIANCE= 19.8325 PARAMETER VARIANCE = 1.322 PARAM STD DEV. = 1.1499

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 105MM HOWITZER M102,ZONE 7. (RAP), ROUNDS 327-345, QE = 405 MILS

	DATA POINT	M36-1 A DELETED	M36-2 B	QE-1 C	QE-2 D	NM-87 E DELETED	XMR F DELETED	MEAN
	1	0.00	542.80P	542.00	542.00	0.00	0.00	542.27
	2	0.00	543.10	542.00	543.00	538.20	0.00	542.70
	3	0.00	539.00	544.00	545.00	0.00	0.00	542.67
DELETED	4	0.00	544.90	0.00	544.50	554.30	0.00	0.00
	5	0.00	547.30	545.50	548.50	0.00	0.00	546.43
	6	0.00	540.10	542.00	542.30	0.00	0.00	541.47
	7	0.00	546.20P	545.50	545.50	0.00	0.00	545.73
	8	0.00	547.00	548.00P	547.00	0.00	0.00	546.67
	9	0.00	543.90P	544.00	544.00	0.00	540.10	543.97
	10	0.00	546.60	545.00	545.50	0.00	544.80	545.70
	11	0.00	548.00P	547.50	547.50	0.00	543.80	547.87
	12	0.00	548.30P	547.50	547.50	0.00	544.10	547.77
	13	0.00	548.00	545.50	546.50	0.00	0.00	546.67
	14	0.00	545.90P	545.50	545.50	0.00	0.00	545.63
DELETED	15	0.00	546.20	526.00	547.00	0.00	0.00	0.00
	16	0.00	548.00	548.00	548.00	0.00	0.00	548.00
	17	0.00	541.50	545.50	546.50	0.00	0.00	544.50
	18	0.00	547.70	545.50	546.50	0.00	0.00	546.57
	19	0.00	547.70	547.50	548.50	0.00	0.00	547.90
	MEAN	0.00	545.36	545.21	545.72	0.00	0.00	
	VARIANCE	0.000	9.144	3.658	3.743	0.000	0.000	
	STND DEV	0.000	3.024	1.913	1.935	0.000	0.000	
	PROB ERR	0.000	2.040	1.290	1.305	0.000	0.000	

GRAND MEAN= 545.429 AVERABE VARIANCE= 5.5150 STND DEV= 2.3484 PROB ERR= 1.5840

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

• INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

3 INSTRUMENTS WITH 17 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,8RL OBRYON
NORMALIZED DATA 105MM HOWITZER M102,ZONE 7. (RAP), ROUNDS 327-345, DE = 405 MILS

COVARIANCE MATRIX

		M36-1 A	M36-2 B	DE-1 C	DE-2 D	NM-87 E	XMR F
		DELETED				DELETED	DELETED
DELETED	M36-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	M36-2	0.0000	0.0000	4.3528	4.1948	0.0000	0.0000
	DE-1	0.0000	4.3528	0.0000	3.5824	0.0000	0.0000
	DE-2	0.0000	4.1948	3.5824	0.0000	0.0000	0.0000
DELETED	NM-87	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DELETED	XMR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
COV INCLD INST		0.0000	8.5475	7.9351	7.7771	0.0000	0.0000
COV EXCLD INST		0.0000	3.5824	4.1948	4.3528	0.0000	0.0000
EST (SIGMA E1)2		0.0000	4.1786	-0.0822	0.3188	0.0000	0.0000
EST (SIGMA E1)		0.00000	2.04417	0.00000	0.56461	0.00000	0.00000
PRECISION RANK		0	3	1	2	0	0

TOTAL COVARIANCE= 12.1299 PARAMETER VARIANCE = 4.043 PARAM STD DEV. = 2.0108

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUSY 73,8RL OBRYON

NORMALIZED DATA 155MM HOWITZER, M109, ZONE I, ROUNDS 401-420, QE = 460 MILS

	DATA POINT	M36-1 A	M36-2 B	QE-1 C	QE-2 D	NM-87 E	XMR F	MEAN
			DELETED					
	1	199.60	199.20	199.30	199.20	199.20	197.00P	198.86
DELETED	2	202.30	202.20	201.80	202.20	0.00	198.30	0.00
	3	202.30 I	200.80	201.80	201.70	201.30	199.30P	201.28
	4	200.60	0.00	201.30	200.20	199.90	198.10	200.02
	5	200.60	196.20	201.30	200.20	199.80	198.40	200.06
DELETED	6	200.60	198.20	201.30	200.20	0.00	198.70	0.00
	7	199.60	196.20	199.80	199.20	198.80	196.50P	198.78
	8	199.90	0.00	199.30	199.70	199.30	196.90P	199.02
	9	199.60	0.00	199.30	199.20	198.90	196.80P	198.76
	10	199.90	0.00	199.80	199.70	199.30	198.00P	199.34
DELETED	11	198.90	0.00	199.80	198.70	199.40	0.00	0.00
	12	200.30	0.00	199.80	199.70	200.40	197.50P	199.54
	13	199.90	0.00	199.30	199.70	200.10	197.00P	199.20
	14	200.60	0.00	201.30	200.70	200.90	198.10P	200.32
	15	199.90	0.00	199.80	199.70	200.40	197.60P	199.48
	16	201.30	201.20	201.80	201.20	201.50	198.60P	200.88
	17	200.60	199.50	201.30	200.20	200.80	198.60	200.30
DELETED	18	199.90	193.80	199.80	200.20	200.70	0.00	0.00
	19	200.60	0.00	201.30	200.20	200.70	200.30	200.62
	20	200.60	200.20	201.30	200.20	200.70	198.70	200.30
	MEAN	200.37	0.00	200.49	200.04	200.12	197.96	
	VARIANCE	0.505	0.000	0.996	0.491	0.718	1.044	
	STND DEV	0.711	0.000	0.998	0.700	0.847	1.022	
	PROB ERR	0.479	0.000	0.673	0.472	0.572	0.689	

GRAND MEAN= 199.798 AVERAGE VARIANCE= 0.7506 STND DEV= 0.8664 PROB ERR= 0.5844

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

5 INSTRUMENTS WITH 16 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,8RL OBRYON
NORMALIZED DATA 155MM HOWITZER, M109, ZONE 1, ROUNDS 401-420, QE = 460 MILS

COVARIANCE MATRIX

		M36-1 A	M36-2 B	QE-1 C	QE-2 D	NM-87 E	XMR F
			DELETED				
	M36-1	0.0000	0.0000	0.6029	0.4815	0.4688	0.5394
DELETED	M36-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	QE-1	0.6029	0.0000	0.0000	0.5979	0.6450	0.8442
	QE-2	0.4815	0.0000	0.5979	0.0000	0.5042	0.5138
	NM-87	0.4688	0.0000	0.6450	0.5042	0.0000	0.6317
	XMR	0.5394	0.0000	0.8442	0.5138	0.6317	0.0000
COV INCLD INST		2.1126	0.0000	2.6900	2.0973	2.2697	2.5290
COV EXCLD INST		3.7367	0.0000	3.1593	3.7520	3.5796	3.3203
EST (SIGMA E1)^2		0.0714	0.0000	0.1774	0.0673	0.1798	0.3327
EST (SIGMA E1)		0.26725	0.00000	0.42117	0.25945	0.42399	0.57681
PRECISION RANK		2	0	3	1	4	5

TOTAL COVARIANCE= 5.8493 PARAMETER VARIANCE = 0.585 PARAM STD DEV. = 0.7648

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 155MM HOWITZER, M109, ZONE 3B ROUNDS 481-500, QE = 1219 MILS

	DATA POINT	M36-1 A	M36-2 B	QE-1 C	QE-2 D	NM-87 E	XMR F	MEAN
		DELETED	DELETED					
DELETED	1	0.00	0.00	0.00	0.00	272.70	271.10	0.00
	2	0.00	0.00	275.30	275.40	276.00	274.80	275.37
	3	0.00	0.00	277.80	276.90	277.40	276.10	277.05
	4	0.00	0.00	277.80	276.90	277.60	275.10	276.85
	5	0.00	0.00	277.30	276.90	277.10	275.50P	276.70
	6	0.00	0.00	277.80	276.90	277.40	276.10	277.05
	7	0.00	0.00	277.80	277.40	277.70	276.10P	277.25
DELETED	8	0.00	0.00	0.00	0.00	278.00	276.50	0.00
	9	0.00	0.00	277.30	276.40	277.00	275.50	276.55
	10	0.00	0.00	277.80	277.90	278.60	277.30 I	277.90
	11	0.00	0.00	277.80	276.90	277.50	275.70	276.98
	12	0.00	0.00	277.30	276.40	277.00	275.30	276.50
	13	0.00	0.00	277.30	276.90	277.10	275.70	276.75
	14	0.00	0.00	277.30	276.90	277.40	275.90	276.88
	15	0.00	0.00	277.30	276.40	277.50	275.50	276.68
	16	0.00	0.00	275.30	275.40	276.10	274.70	275.37
	17	0.00	0.00	275.30	275.90	276.30	274.60	275.53
	18	0.00	0.00	277.30	276.40	277.00	275.70	276.60
	19	0.00	0.00	277.80	276.90	277.50	275.90	277.02
	20	0.00	0.00	275.30	275.40	275.80	274.30	275.20
	MEAN	0.00	0.00	277.05	276.57	277.11	275.54	
	VARIANCE	0.000	0.000	0.978	0.471	0.481	0.488	
	STND DEV	0.000	0.000	0.989	0.686	0.694	0.699	
	PROB ERR	0.000	0.000	0.667	0.463	0.468	0.471	

GRAND MEAN= 276.568 AVERAGE VARIANCE= 0.6045 STND DEV= 0.7775 PROB ERR= 0.5244

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
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• INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

4 INSTRUMENTS WITH 18 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 155MM HOWITZER, M109, ZONE 30 ROUNDS 481-500, QE = 1219 MILS

COVARIANCE MATRIX

	M36-1 A	M36-2 B	QE-1 C	QE-2 D	NM-87 E	XMR F
	DELETED	DELETED				
DELETED M36-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DELETED M36-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
QE-1	0.0000	0.0000	0.0000	0.6029	0.6147	0.5471
QE-2	0.0000	0.0000	0.6029	0.0000	0.4539	0.4304
NM-87	0.0000	0.0000	0.6147	0.4539	0.0000	0.4365
XMR	0.0000	0.0000	0.5471	0.4304	0.4365	0.0000
COV INCLD INST	0.0000	0.0000	1.7647	1.4873	1.5052	1.4140
COV EXCLD INST	0.0000	0.0000	1.3208	1.5983	1.5804	1.6716
EST (SIGMA E1) 2	0.0000	0.0000	0.2418	0.0119	0.0044	0.1030
EST (SIGMA E1)	0.00000	0.00000	0.49168	0.10887	0.06634	0.32098
PRECISION RANK	0	0	4	2	1	3

TOTAL COVARIANCE= 3.0856 PARAMETER VARIANCE = 0.514 PARAM STD DEV. = 0.7171

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,8RL OBRYON

NORMALIZED DATA 155MM HOWITZER, M109, ZONE 4B ROUNDS 421-440, QE = 237 MILS

	DATA POINT	M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E	XMR F	MEAN
		DELETED						
DELETED	1	0.00	0.00	315.70	315.20	315.80	313.60	0.00
	2	0.00	316.40	315.70	316.20	316.70	314.40	315.88
	3	0.00	316.40	317.20	316.70	317.30	315.50	316.62
	4	239.50	315.90	315.70	316.20	316.60	314.20	315.72
DELETED	5	0.00	314.30	315.20	314.20	0.00	0.00	0.00
DELETED	6	0.00	313.60	313.20	313.70	0.00	311.80	0.00
	7	0.00	314.90	315.70	315.20	318.10	314.10	315.60
	8	0.00	314.30	313.70	314.20	314.60	313.10	313.98
	9	315.00	314.90	315.70	314.70	315.50	313.90	314.94
	10	310.60	314.90	315.70	314.70	315.40	312.80P	314.70
DELETED	11	289.50	314.60	313.70	314.20	0.00	312.60	0.00
	12	251.50	316.40	315.70	316.20	316.40	314.30P	315.80
	13	260.00	315.90	315.70	316.20	316.60	314.20	315.72
	14	0.00	317.00	317.70	316.70	317.30	315.20	316.78
	15	0.00	316.70	317.20	316.70	317.00	314.70P	316.46
	16	0.00	314.30	313.70	314.20	317.30	312.40	314.38
	17	316.80	316.70	317.20	316.70	317.10	314.80P	316.50
	18	315.40	315.40	315.70	315.20	316.90	313.60	315.36
	19	316.50	316.50	315.70	316.20	316.80	314.70	315.98
	20	317.10	317.10	317.70	317.20	317.40	315.30P	316.94
	MEAN	0.00	315.86	315.98	315.82	316.69	314.20	
	VARIANCE	0.000	0.892	1.432	0.950	0.765	0.779	
	STND DEV	0.000	0.944	1.197	0.975	0.875	0.882	
	PROB ERR	0.000	0.637	0.807	0.657	0.590	0.595	

GRAND MEAN= 315.710 AVERAGE VARIANCE= 0.9636 STND DEV= 0.9816 PROB ERR= 0.6621

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
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* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

5 INSTRUMENTS WITH 16 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OPRTON
NORMALIZED DATA 155MM HOWITZER, M109, ZONE 4B ROUNDS 421-440, QE = 237 MILS

COVARIANCE MATRIX

	M36-1 A DELETED	M36-2 B	QE-1 C	QE-2 D	NM-87 E	XMR F
DELETED M36-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
M36-2	0.0000	0.0000	0.9565	0.8958	0.3774	0.7427
QE-1	0.0000	0.9565	0.0000	0.9958	0.5071	0.9067
QE-2	0.0000	0.8958	0.9958	0.0000	0.4483	0.7900
NM-87	0.0000	0.3774	0.5071	0.4483	0.0000	0.3807
XMR	0.0000	0.7427	0.9067	0.7900	0.3807	0.0000
COV INCLD INST	0.0000	2.0724	3.3660	3.1300	1.7135	2.8200
COV EXCLD INST	0.0000	4.0286	3.6349	3.8710	5.2875	4.1810
EST (SIGMA E1) 2	0.0000	0.0772	0.3551	0.0302	0.7897	0.0685
EST (SIGMA E1)	0.00000	0.27785	0.59589	0.17367	0.88863	0.25592
PRECISION RANK	0	3	4	1	5	2

TOTAL COVARIANCE= 7.0010 PARAMETER VARIANCE = 0.700 PARAM STD DEV. = 0.8367

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 155MM HOWITZER, M109, ZONE 5G ROUNDS 701-720, QE = 680 MILS

DATA POINT	M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-67 E	XMR F	MEAN
		DELETED					
1	372.30	371.10	371.60	372.00	372.00	370.20P	371.62
2	369.50	369.40	369.60	369.00	369.40	367.30P	368.96
3	368.80	368.10	368.60	368.00	369.00	367.20	368.32
4	370.80	370.70	370.60	370.00	370.90	369.00	370.26
5	370.20	370.00	369.60	369.50	370.20	368.00	369.50
6	369.80	369.40	369.60	370.00	370.20	368.20P	369.56
7	369.80	0.00	371.10	372.00	370.70	370.40	370.80
8	370.80	0.00	370.60	370.00	370.90	369.00	370.26
9	372.60	0.00	372.10	371.50	372.40	371.00	371.92
10	371.60	0.00	371.60	372.00	371.80	369.00P	371.20
11	370.50	370.00	369.60	370.00	370.50	369.10	369.94
12	371.90	371.80	371.10	371.50	371.90	369.90	371.26
13	371.60	371.50	372.10	371.00	371.70	370.20	371.32
14	372.30	371.80	372.10	371.50	372.10	370.10P	371.62
15	373.30	0.00	373.60	373.00	373.30	371.80P	373.00
16	373.80	373.50	373.60	373.00	373.60	371.80	373.16
17	371.60	0.00	371.60	371.00	371.50	369.60P	371.06
18	372.60	0.00	371.60	372.00	372.60	371.10	371.98
19	371.90	371.50	372.10	371.50	372.10	370.00P	371.52
20	372.90	372.50	372.10	372.50	372.90	371.60	372.40
MEAN	371.43	0.00	371.23	371.05	371.49	369.73	
VARIANCE	1.852	0.000	1.786	1.813	1.541	1.912	
STND DEV	1.361	0.000	1.336	1.347	1.242	1.383	
PROB ERR	0.918	0.000	0.901	0.908	0.837	0.933	

GRAND MEAN= 370.983 AVERAGE VARIANCE= 1.7810 STND DEV= 1.3345 PROB ERR= 0.9001

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

5 INSTRUMENTS WITH 20 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 155MM HOWITZER, M109, ZONE 58 ROUNDS 701-720, DE = 680 MILS

COVARIANCE MATRIX

		M36-1 A	M36-2 B	SE-1 C	SE-2 D	NM-87 E	XMR F
			DELETED				
	M36-1	0.0000	0.0000	1.6697	1.5879	1.6626	1.6771
DELETED	M36-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	SE-1	1.6697	0.0000	0.0000	1.6382	1.5704	1.6651
	SE-2	1.5879	0.0000	1.6382	0.0000	1.5482	1.7145
	NM-87	1.6626	0.0000	1.5704	1.5482	0.0000	1.6072
	XMR	1.6771	0.0000	1.6651	1.7145	1.6072	0.0000
COV INCLD INST		6.5973	0.0000	6.5434	6.4887	6.3884	6.6639
COV EXCLD INST		9.7436	0.0000	9.7974	9.6522	9.9525	9.6769
EST (SIGMA E1)^2		0.1770	0.0000	0.1474	0.2108	0.0059	0.1933
EST (SIGMA E1)		0.42066	0.00000	0.38390	0.45918	0.07686	0.43971
PRECISION RANK		3	0	2	5	1	4

TOTAL COVARIANCE= 16.3409 PARAMETER VARIANCE = 1.634 PARAM STD DEV. = 1.2783

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 155MM HOWITZER, M109, ZONE 3W ROUNDS 441-460, QE = 300 MILS

	DATA POINT	M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E	XMR F	MEAN
		DELETED						
DELETED	1	276.80	278.10	277.20	277.70	266.00	277.00	0.00
	2	255.40	278.50	277.70	278.20	278.90	277.40	278.14
DELETED	3	270.20	279.50	0.00	279.20	279.80	278.60	0.00
DELETED	4	248.40	248.00	279.20	278.20	278.90	277.60	0.00
	5	235.00	282.20	281.70	281.70	282.30	281.00	281.78
	6	268.80	279.50	279.20	279.20	279.80	278.40	279.22
	7	275.20	283.20	283.20	282.70	283.40	281.90	282.88
	8	222.60	283.20	283.70	282.70	283.40	281.80	282.96
	9	300.70	279.80	279.20	279.20	279.90	278.40	279.30
	10	236.00	282.50	283.20	282.70	283.30	281.60	282.66
DELETED	11	244.40	254.60	275.60	276.20	276.40	275.10	0.00
	12	299.00	280.80	281.10	280.70	281.10	279.40P	280.62
	13	220.60	283.50	283.70	283.20	283.60	282.10P	283.22
DELETED	14	340.30	282.50	0.00	0.00	282.60	281.30	0.00
	15	259.20	282.20	281.60	281.70	282.40	280.70	281.72
	16	312.80	281.50	281.60	280.70	281.30	280.10	281.04
	17	252.40	280.80	281.60	280.70	281.30	280.10	280.90
	18	206.20	276.70	277.60	277.70	278.20	276.50	277.34
DELETED	19	0.00	272.10	283.70	283.70	284.30	282.50	0.00
	20	0.00	279.20	279.10	279.20	280.10	278.40	279.20
	MEAN	0.00	280.97	281.01	280.74	281.36	279.84	
	VARIANCE	0.000	4.081	4.491	3.249	3.180	3.233	
	STND DEV	0.000	2.020	2.119	1.802	1.783	1.798	
	PROB ERR	0.000	1.363	1.429	1.216	1.203	1.213	

GRAND MEAN= 280.784 AVERAGE VARIANCE= 3.6466 STND DEV= 1.9096 PROB ERR= 1.2880

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
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* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

5 INSTRUMENTS WITH 14 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 155MM HOWITZER, M109, ZONE 3W ROUNDS 441-460, QE = 300 MILS

COVARIANCE MATRIX

	M36-1 A DELETED	M36-2 B	8E-1 C	8E-2 D	NM-87 E	XMR F
DELETED M36-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
M36-2	0.0000	0.0000	4.1312	3.5665	3.5379	3.5898
8E-1	0.0000	4.1312	0.0000	3.7648	3.7068	3.7478
8E-2	0.0000	3.5665	3.7648	0.0000	3.2055	3.2176
NM-87	0.0000	3.5379	3.7068	3.2055	0.0000	3.1897
XMR	0.0000	3.5898	3.7478	3.2176	3.1897	0.0000
COV INCLD INST	0.0000	14.8254	15.3507	13.7544	13.6399	13.7448
COV EXCLD INST	0.0000	20.8322	20.3069	21.9032	22.0177	21.9127
EST ($SIGMA_{E1}^2$)	0.0000	0.1400	0.1997	0.0220	0.0292	0.0131
EST ($SIGMA_{E1}$)	0.00000	0.37417	0.44689	0.14819	0.17097	0.11451
PRECISION RANK	0	4	5	2	3	1

TOTAL COVARIANCE= 35.6576 PARAMETER VARIANCE = 3.566 PARAM STD DEV. = 1.8883

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON

NORMALIZED DATA 155MM HOWITZER, M109, ZONE 4W ROUNDS 461-480, QE = 229 MILS

DATA POINT	M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E	XMR F	MEAN
	DELETED	DELETED					
1	299.50	306.40	321.60	321.20	321.70	320.10	321.15
2	295.20	324.70	323.70	324.30	322.70	323.10	323.45
3	276.70	323.20	323.70	322.70	323.50	322.00	322.98
4	329.20	321.80	321.20	321.20	319.40	320.40	320.55
5	309.30	321.20	321.70	320.70	321.60	319.50	320.87
6	284.10	322.10	321.70	322.70	320.20	321.00	321.40
7	298.50	321.50	321.20	321.20	321.70	320.50	321.15
8	334.70	322.10	325.20	324.30	327.60 I	322.90	325.00
9	0.00	323.60	323.70	322.70	323.50	322.40	323.07
10	277.60	321.80	321.20	321.20	322.10	320.30	321.20
11	317.50	317.30	317.70 I	317.20 I	317.50	316.20 I	317.15
12	0.00	0.00	321.20	320.20	320.70	319.40	320.38
13	0.00	0.00	323.20	322.20	322.80	321.10	322.33
14	0.00	0.00	321.20	320.20	320.80	319.30	320.38
15	0.00	0.00	321.20	321.20	322.10	319.80	321.07
16	0.00	0.00	321.20	321.70	322.20	320.80	321.48
17	230.40	0.00	321.20	321.70	322.30	320.30	321.38
18	0.00	320.00	321.70	322.20	322.60	320.50	321.75
DELETED 19	0.00	320.40	0.00	320.20	320.80	318.70	0.00
20	0.00	0.00	321.20	320.70	321.20	319.50	320.65
MEAN	0.00	0.00	321.83	321.55	321.91	320.48	
VARIANCE	0.000	0.000	2.470	2.478	3.983	2.386	
STND DEV	0.000	0.000	1.572	1.574	1.996	1.545	
PROB ERR	0.000	0.000	1.060	1.062	1.346	1.042	

GRAND MEAN= 321.441 AVERAGE VARIANCE= 2.8292 STND DEV= 1.6820 PROB ERR= 1.1345

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
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• INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

4 INSTRUMENTS WITH 19 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 155MM HOWITZER, M109, ZONE 4W ROUNDS 461-480, CE = 229 MILS

COVARIANCE MATRIX

	M36-1 A DELETED	M38-2 B DELETED	CE-1 C	CE-2 D	NM-87 E	XMR F
DELETED M36-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DELETED M38-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CE-1	0.0000	0.0000	0.0000	2.2474	2.7337	2.2606
CE-2	0.0000	0.0000	2.2474	0.0000	2.4842	2.3889
NM-87	0.0000	0.0000	2.7337	2.4842	0.0000	2.4229
XMR	0.0000	0.0000	2.2806	2.3889	2.4229	0.0000
COV INCLD INST	0.0000	0.0000	7.2414	7.1005	7.6408	7.0524
COV EXCLD INST	0.0000	0.0000	7.2760	7.4172	6.8770	7.4653
EST (SIGMA E1)^2	0.0000	0.0000	0.0873	0.2169	1.1812	0.1730
EST (SIGMA E1)	0.00000	0.00000	0.25946	0.46574	1.08683	0.41596
PRECISION RANK	0	0	1	3	4	2

TOTAL COVARIANCE= 14.5177 PARAMETER VARIANCE = 2.420 PARAM STD DEV. = 1.5555

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 155MM HOW.,M109,5W ROUNDS 721-40,786-795,QE-666-680 MILS

	DATA POINT	M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E	XMR F	MEAN
			DELETED	DELETED				
DELETED	1	375.90	375.80	376.10	375.50	379.60	374.60	0.00
	2	381.40	381.20	381.60	381.00	381.50	379.90	380.95
	3	380.00	379.60	380.10	379.50	380.10	378.70	379.57
	4	378.70	0.00	374.10	378.50	378.70	377.30P	378.30
	5	378.40	378.20	0.00	378.00	378.30	377.10	377.95
	6	379.70	0.00	353.60	379.00	379.40	378.10	379.05
	7	379.00	0.00	0.00	379.00	379.20	377.70P	378.73
	8	379.00	0.00	354.20	378.50	379.00	377.90	378.60
	9	375.90	0.00	349.60	378.50	376.20	374.80	376.35
	10	378.00	0.00	376.10	377.50	376.20	377.00	377.18
	11	377.50	0.00	0.00	376.50	377.20	375.70	376.73
	12	376.90	0.00	0.00	376.50	377.20	375.70	376.57
	13	374.60	0.00	0.00	374.50	374.90	373.50	374.37
	14	376.60	0.00	0.00	376.50	376.90	375.00P	376.25
	15	377.40	0.00	0.00	377.00	377.50	376.00	376.98
	16	379.70	0.00	0.00	379.00	380.30	378.40	379.35
	17	378.40	0.00	0.00	378.00	378.60	376.80	377.95
	18	377.70	0.00	0.00	377.50	377.60	375.90P	377.18
	19	377.40	0.00	0.00	378.00	378.30	376.90	377.65
	20	376.70	0.00	0.00	377.00	377.70	376.10	376.88
DELETED	21	377.40	269.40	0.00	369.50	377.60	376.30	0.00
	22	379.70	340.60	0.00	379.00	378.80	377.30	378.70
	23	380.40	372.80	0.00	380.50	380.90	379.40	380.30
	24	380.00	305.60	0.00	379.50	380.10	378.50	379.53
	25	378.40	0.00	0.00	378.00	378.10	376.90	377.85
	26	379.00	0.00	0.00	378.50	379.00	377.80	378.57
	27	379.00	0.00	0.00	379.50	378.30	378.00	378.70
	28	378.70	0.00	0.00	378.00	378.80	377.30	378.20
	29	374.60	0.00	0.00	374.00	374.80	373.40	374.20
	30	373.90	0.00	0.00	374.00	374.30	372.50P	373.68
	MEAN	378.10	0.00	0.00	377.89	378.14	376.77	
	VARIANCE	3.313	0.000	0.000	2.970	3.150	3.148	
	STND DEV	1.820	0.000	0.000	1.723	1.775	1.774	
	PROB ERR	1.228	0.000	0.000	1.162	1.197	1.197	

GRAND MEAN= 377.725 AVERAGE VARIANCE= 3.1451 STND DEV= 1.7734 PROB ERR= 1.1962

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
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* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

4 INSTRUMENTS WITH 28 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 155MM HOW.,M109,5W ROUNDS 721-40,786-795,0E=666-680 MILS

COVARIANCE MATRIX

	M36-1 A	M36-2 B DELETED	0E-1 C DELETED	0E-2 D	NM-87 E	XMR F
M36-1	0.0000	0.0000	0.0000	2.9200	3.0853	3.1625
DELETED M36-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DELETED 0E-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0E-2	2.9200	0.0000	0.0000	0.0000	2.7951	2.8783
NM-87	3.0853	0.0000	0.0000	2.7951	0.0000	3.0130
XMR	3.1625	0.0000	0.0000	2.8783	3.0130	0.0000
COV INCLD INST	9.1678	0.0000	0.0000	8.5934	8.8935	9.0538
COV EXCLD INST	8.6864	0.0000	0.0000	9.2408	8.9608	8.8004
EST ($SIGMA E1)$^2	0.0966	0.0000	0.0000	0.3276	0.2078	0.0456
EST (SIGMA E1)	0.31075	0.00000	0.00000	0.57236	0.45589	0.21363
PRECISION RANK	2	0	0	4	3	1

1 TOTAL COVARIANCE= 17.8542 PARAMETER VARIANCE = 2.976 PARAM STD DEV. = 1.7250

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 155MM HOWITZER, M109, ZONE 6W ROUNDS 741-760, QE = 1111 MILS

DATA POINT	M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E	XMR F	MEAN
		DELETED	DELETED				
1	461.70	0.00	0.00	461.10	461.60	460.30	461.18
2	464.00	0.00	0.00	464.10	464.10	462.30P	463.62
3	462.70	0.00	0.00	463.60	463.30	461.60	462.80
4	462.00	0.00	0.00	462.10	462.00	460.20P	461.57
5	464.00	0.00	0.00	463.60	464.10	462.20	463.48
6	465.00	0.00	0.00	464.60	464.90	463.10P	464.40
7	465.00	0.00	0.00	465.10	465.00	463.30P	464.60
8	464.70	0.00	0.00	464.60	464.60	463.20P	464.28
9	464.30	0.00	0.00	464.10	464.10	462.40P	463.73
10	462.30	0.00	0.00	462.60	462.40	460.80P	462.03
11	463.70	0.00	0.00	463.60	463.60	462.10P	463.25
12	462.70	0.00	0.00	462.60	462.60	461.60P	462.38
13	463.70	0.00	0.00	463.60	463.60	462.10P	463.25
14	463.00	0.00	0.00	462.60	463.00	461.40	462.50
15	463.00	0.00	0.00	462.60	462.70	461.70	462.50
16	463.30	462.20	0.00	463.10	463.10	461.60P	462.78
DELETED 17	0.00	0.00	0.00	463.60	462.60	461.10	0.00
18	463.70	461.90	0.00	463.60	464.00	461.40P	463.18
19	463.00	0.00	0.00	462.60	463.00	461.30	462.48
DELETED 20	465.70	0.00	0.00	465.60	0.00	0.00	0.00
MEAN	463.43	0.00	0.00	463.32	463.43	461.81	
VARIANCE	0.948	0.000	0.000	1.007	0.935	0.786	
STND DEV	0.974	0.000	0.000	1.003	0.967	0.886	
PROB ERR	0.657	0.000	0.000	0.677	0.652	0.598	

GRAND MEAN= 462.999 AVERAGE VARIANCE= 0.9189 STND DEV= 0.9586 PROB ERR= 0.6466

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

4 INSTRUMENTS WITH 18 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 155MM HOWITZER, M109, ZONE 6W ROUNDS 741-760, QE = 1111 MILS

COVARIANCE MATRIX

	M36-1 A	M36-2 B	QE-1 C	QE-2 D	NM-87 E	XMR F
	DELETED	DELETED	DELETED			
M36-1	0.0000	0.0000	0.0000	0.9186	0.9208	0.8249
DELETED M36-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DELETED QE-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
QE-2	0.9186	0.0000	0.0000	0.0000	0.9405	0.8239
NM-87	0.9208	0.0000	0.0000	0.9405	0.0000	0.7979
XMR	0.8249	0.0000	0.0000	0.8239	0.7979	0.0000
COV INCLD INST	2.6643	0.0000	0.0000	2.6830	2.6592	2.4467
COV EXCLD INST	2.5623	0.0000	0.0000	2.5436	2.5674	2.7799
	2					
EST (SIGMA E1)	0.0261	0.0000	0.0000	0.0657	0.0181	0.0813
EST (SIGMA E1)	0.16162	0.00000	0.00000	0.25638	0.13435	0.28511
PRECISION RANK	2	0	0	3	1	4

TOTAL COVARIANCE= 5.2266 PARAMETER VARIANCE = 0.871 PARAM STD DEV. = 0.9333

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON

NORMALIZED DATA 155MM HOWITZER, M109, ZONE 7W, ROUNDS 761 - 780, QE = 319 MILS

DATA POINT		M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E	XMR F	MEAN
		DELETED	DELETED	DELETED				
DELETED	1	0.00	0.00	0.00	551.70	0.00	560.00	0.00
	2	0.00	0.00	0.00	563.00 I	563.50	562.60	563.03
DELETED	3	0.00	0.00	0.00	566.50	566.50	559.90	0.00
DELETED	4	0.00	0.00	0.00	535.10	566.00	564.90	0.00
DELETED	5	0.00	0.00	0.00	564.00	555.60	563.50	0.00
	6	0.00	0.00	0.00	565.00	565.60	564.60	565.07
	7	0.00	0.00	0.00	566.10	560.90	565.00	564.00
	8	0.00	0.00	0.00	564.20	559.00	563.50	562.23
DELETED	9	0.00	0.00	0.00	545.00	566.40	565.50	0.00
DELETED	10	0.00	0.00	0.00	553.00	564.10	563.50	0.00
	11	566.90	0.00	0.00	566.00	566.30	565.30	565.87
DELETED	12	564.40	0.00	0.00	547.40	0.00	562.50	0.00
	13	565.40	0.00	0.00	565.50	565.60	564.90	565.33
DELETED	14	436.90	0.00	0.00	560.20	565.50	565.20	0.00
	15	0.00	0.00	0.00	566.00	566.50	565.50	566.00
DELETED	16	0.00	0.00	0.00	566.80	540.40	0.00	0.00
DELETED	17	0.00	0.00	0.00	565.00	552.40	564.50	0.00
	18	0.00	0.00	0.00	565.00	565.40	564.00	564.80
	19	545.00	0.00	0.00	565.50	557.10	565.00	562.53
	20	500.00	0.00	0.00	566.00	566.20	565.70	565.97
	MEAN	0.00	0.00	0.00	565.23	563.61	564.61	
	VARIANCE	0.000	0.000	0.000	0.980	11.601	0.943	
	STND DEV	0.000	0.000	0.000	0.990	3.406	0.971	
	PROB ERR	0.000	0.000	0.000	0.668	2.297	0.655	

GRAND MEAN= 564.483 AVERAGE VARIANCE= 4.5081 STND DEV= 2.1232 PROB ERR= 1.4321

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

3 INSTRUMENTS WITH 10 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 155MM HOWITZER, M109, ZONE 74, ROUNDS 761 - 780, QE = 319 MILS

COVARIANCE MATRIX

	M36-1 A DELETED	M36-2 B DELETED	QE-1 C DELETED	QE-2 D	NM-87 E	XMR F
DELETED M36-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DELETED M36-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DELETED QE-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
QE-2	0.0000	0.0000	0.0000	0.0000	0.7597	0.9274
NM-87	0.0000	0.0000	0.0000	0.7597	0.0000	0.9399
XMR	0.0000	0.0000	0.0000	0.9274	0.9399	0.0000
COV INCLD INST	0.0000	0.0000	0.0000	1.6871	1.6996	1.8673
COV EXCLD INST	0.0000	0.0000	0.0000	0.9399	0.9274	0.7597
EST (SIGMA E1)	0.0000	0.0000	0.0000	0.2329	10.8289	-0.1644
EST (SIGMA E1)	0.00000	0.00000	0.00000	0.48259	3.29073	0.00000
PRECISION RANK	0	0	0	2	3	1

TOTAL COVARIANCE= 2.6270 PARAMETER VARIANCE = 0.876 PARAM STD DEV. = 0.9358

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 175MM GUN, M107,ZONE I, ROUNDS 971-995, QE = 306 MILS

	DATA POINT	M36-1 A DELETED	M36-2 B	GE-1 C	GE-2 D	NM-67 E	XMR F DELETED	MEAN
	1	500.00	500.60	499.80	500.20	500.40	0.00	500.25
	2	501.40	500.60	501.30	500.20	500.40	0.00	500.63
	3	503.40	504.60	503.30	502.20	502.50	0.00	503.15
	4	501.10	500.60	501.80P	500.70	500.80	0.00	500.98
	5	503.10	501.70	501.80	502.20	502.20	0.00	501.98
DELETED	6	0.00	503.60	503.30	502.20	0.00	0.00	0.00
	7	0.00	501.60	501.30	501.20	501.40	500.00	501.37
	8	0.00	502.60	501.80	502.20	503.40	0.00	502.50
	9	0.00	503.30	503.30	503.20	502.50P	0.00	503.07
	10	0.00	504.60	505.30	500.20P	504.30	0.00	503.60
	11	0.00	502.30	501.70	501.70	501.90	0.00	501.90
DELETED	12	0.00	0.00	503.30	503.20	503.30	0.00	0.00
	13	0.00	500.40	500.30	500.20	500.50	0.00	500.35
DELETED	14	0.00	0.00	500.30	500.70	500.60	0.00	0.00
DELETED	15	0.00	375.60	503.30	503.20	503.20	0.00	0.00
	16	0.00	497.50	496.70 1	496.30 I	496.70 1	0.00	496.80
	17	0.00	503.60	503.30	502.70	503.20	0.00	503.20
	18	0.00	498.60	498.20	497.30	498.00	0.00	498.03
	19	0.00	502.90	502.30	501.70	502.20	0.00	502.27
	20	0.00	502.60	502.30	501.70	502.10	0.00	502.18
	21	0.00	503.30	503.20	503.20	502.80P	0.00	503.13
	22	0.00	502.90	501.70	502.70	502.30	0.00	502.40
	23	0.00	504.90	503.70	504.70	504.30	0.00	504.40
	24	0.00	502.30	501.70	501.70	501.40	0.00	501.77
	25	0.00	505.30P	503.20	502.70	502.80	0.00	503.50
	MEAN	0.00	502.23	501.81	501.38	501.72	0.00	
	VARIANCE	0.000	4.034	3.639	3.691	3.396	0.000	
	STND DEV	0.000	2.009	1.908	1.921	1.843	0.000	
	PROB ERR	0.000	1.355	1.287	1.296	1.243	0.000	

GRAND MEAN= 501.783 AVERAGE VARIANCE= 3.6899 STND DEV= 1.9209 PROB ERR= 1.2957

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
1 INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

• INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

4 INSTRUMENTS WITH 21 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL ORRYON
NORMALIZED DATA 175MM GUN, M107,ZONE 1, ROUNDS 971-995, 9E = 306 MILS

COVARIANCE MATRIX

		M36-1 A DELETED	M36-2 B	9E-1 C	9E-2 D	NM-87 E	XMR F DELETED
DELETED	M36-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	M36-2	0.0000	0.0000	3.5572	3.2482	3.4439	0.0000
	9E-1	0.0000	3.5572	0.0000	2.9022	3.3093	0.0000
	9E-2	0.0000	3.2482	2.9022	0.0000	3.0805	0.0000
	NM-87	0.0000	3.4439	3.3093	3.0805	0.0000	0.0000
DELETED	XMR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
COV INCLD INST		0.0000	10.2494	9.7688	9.2309	9.8337	0.0000
COV EXCLD INST		0.0000	9.2920	9.7726	10.3105	9.7077	0.0000
EST (SIGMA E1)^2		0.0000	0.2986	0.3839	0.9738	0.0757	0.0000
EST (SIGMA E1)		0.00000	0.54642	0.61963	0.98680	0.27513	0.00000
PRECISION RANK		0	2	3	4	1	0

TOTAL COVARIANCE= 19.5414 PARAMETER VARIANCE = 3.257 PARAM STD DEV. = 1.8047

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 175MM GUN, M107,ZONE 2, ROUNDS 941-96[illegible], SF = 325 MILS

DATA POINT		M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E	XMR F DELETED	MEAN
DELETED	1	710.70	709.40	100.50	109.50	710.60	0.00	0.00
DELETED	2	703.60	0.00	702.80	103.00	704.40	701.20	0.00
DELETED	3	707.10	0.00	706.30	706.80	707.10	704.70	0.00
DELETED	4	701.60	650.10	700.80	707.30	701.40	699.00	0.00
DELETED	5	707.10	0.00	706.30	706.30	706.50	704.30	0.00
DELETED	6	698.90	682.30	700.30	700.30	700.50	0.00	0.00
	7	704.00	704.60	703.30	703.30	703.80	701.50	703.80
	8	704.60	704.90	703.80	703.80	704.00	0.00	704.22
	9	706.00	706.70	705.80	706.30	699.20P	704.50	704.80
	10	701.30	701.90	700.80	701.30	696.40PI	0.00	700.34
	11	707.40	707.40	707.30	706.80	706.70	0.00	707.12
	12	704.00	704.60P	703.80	703.80	703.80	0.00	704.00
	13	705.30	704.00P	705.30	705.80	705.40	0.00	705.16
	14	705.00	705.60	705.30	704.80	704.90	0.00	705.12
	15	707.40	707.40	707.30	706.80	706.90	0.00	707.16
	16	703.60	704.00	703.80	703.30	703.40	0.00	703.62
	17	703.60	703.60	703.80	703.30	703.40	0.00	703.54
	18	705.60	706.30	705.30	705.80	705.60	0.00	705.72
	19	705.30	705.60	705.80	704.80	705.00	0.00	705.30
DELETED	20	708.00	708.70	707.80	707.3[illegible]	273.80	0.00	0.00
	21	707.70	708.40	706.80	707.30	707.40	0.00	707.52
	22	701.60	703.30	702.80	702.80	702.40	0.00	702.58
	23	707.40	708.00	706.80	707.30	707.50	0.00	707.40
	24	704.00	704.30	703.30	703.80	703.80	0.00	703.84
	25	706.30	707.40	706.30	706.30	706.70	0.00	706.60
MEAN		705.01	705.44	704.86	704.86	704.24	0.00	
VARIANCE		3.537	3.345	3.173	3.114	8.018	0.000	
STND DEV		1.881	1.829	1.781	1.765	2.832	0.000	
PROB ERR		1.269	1.234	1.202	1.190	1.910	0.000	

GRAND MEAN= 704.880 AVERAGE VARIANCE= 4.2375 STND DEV= 2.0585 PROB ERR= 1.3885

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

5 INSTRUMENTS WITH 18 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 175MM GUN, M107,ZONE 2, ROUNDS 941-965, QE = 325 MILS

COVARIANCE MATRIX

		M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E	XMR F
							DELETED
	M36-1	0.0000	3.2639	3.2173	3.2085	3.9545	0.0000
	M36-2	3.2639	0.0000	3.0033	3.0150	3.6323	0.0000
	GE-1	3.2173	3.0033	0.0000	3.0261	3.8448	0.0000
	GE-2	3.2085	3.0150	3.0261	0.0000	3.5507	0.0000
	NM-87	3.9545	3.6323	3.8448	3.5507	0.0000	0.0000
DELETED	XMR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
COV INCLD INST		13.6442	12.9144	13.0915	12.8003	14.9822	0.0000
COV EXCLD INST		20.0722	20.8019	20.6248	20.9160	18.7341	0.0000
	2						
EST (SIGMA E1)		0.0603	0.3547	0.0649	0.2002	3.6491	0.0000
EST (SIGMA F1)		0.24558	0.59559	0.25479	0.44745	1.91025	0.00000
PRECISION RANK		1	4	2	3	5	0

TOTAL COVARIANCE= 33.7163 PARAMETER VARIANCE = 3.372 PARAM STD DEV. = 1.8362

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON

NORMALIZED DATA 175MM GUN, M107,ZONE 3, ROUNDS 901-930, QE = 500 MILS

	DATA POINT	M36-1 A	M36-2 B	QE-1 C	QE-2 D	NM-87 E	XMR F	MEAN
						DELETED	DELETED	
DELETED	1	0.00	914.50	1000.50	914.90	915.60	0.00	0.00
	2	915.10	914.50	915.90	914.90	914.60	0.00	915.10
	3	917.90	917.90	917.40	917.40	910.40	0.00	917.65
DELETED	4	917.90	0.00	917.90	917.40	917.40	914.90	0.00
	5	916.10	915.20	915.40	915.40	915.80	913.00	915.52
	6	916.50	916.90	917.90	917.90	918.20	915.60	917.30
	7	916.10	916.90	917.90	916.90	917.20	914.80	916.95
	8	913.40	914.80	915.40	914.40	914.80	912.20	914.50
	9	916.10	915.20	915.90	914.90	0.00	0.00	915.52
	10	918.50	917.60	917.90	917.40	917.80	915.00	917.85
DELETED	11	914.80	901.10	914.40	0.00	914.80	912.10	0.00
DELETED	12	905.00	0.00	1000.50	915.40	915.00	913.40	0.00
DELETED	13	914.40	0.00	915.40	914.40	0.00	911.90	0.00
	14	916.90P	915.80	915.90	915.90	916.20	913.60	916.12
	15	915.40	914.80	915.90	914.90	915.00	912.60	915.25
	16	915.10	914.20	914.40	914.40	914.00	912.10	914.52
	17	918.50	919.30	916.90	917.40	917.20	0.00	918.02
DELETED	18	918.90	665.80	913.90	914.40	562.00	911.70	0.00
	19	917.20	917.90	915.90	916.40	916.00	914.00	916.85
	20	914.80	915.80	914.90	915.40	915.00	912.80	915.23
	21	902.90 I	901.30 I	911.40 I	911.90	904.60	909.40	906.88
DELETED	22	860.20	847.40	913.90	914.40	873.00	912.10	0.00
	23	915.80	916.90	914.40	914.90	297.10	912.30	915.50
DELETED	24	895.10	886.00	913.90	914.40	288.60	0.00	0.00
	25	908.30	915.50	913.90	913.90	913.80	911.40	912.90
DELETED	26	836.50	541.00	916.90	916.90	869.00	0.00	0.00
DELETED	27	909.00	923.80	910.40	910.90	911.00	908.40	0.00
	28	916.80	915.50	915.90	916.40	915.80	913.80	916.15
	29	906.30	908.40	914.40	914.90	914.60	912.60	911.00
DELETED	30	913.40	695.70	913.40	913.90	913.60	911.30	0.00
	MEAN	914.62	914.97	915.66	915.56	0.00	0.00	
	VARIANCE	17.671	15.942	2.594	2.224	0.000	0.000	
	STND DEV	4.204	3.993	1.610	1.491	0.000	0.000	
	PROB ERR	2.835	2.693	1.086	1.006	0.000	0.000	

GRAND MEAN= 915.201 AVERAGE VARIANCE= 9.6077 STND DEV= 3.0996 PROB ERR= 2.0907

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

4 INSTRUMENTS WITH 19 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 175MM GUN, M107,ZONE 3, ROUNDS 901-930, QE = 500 MILS

COVARIANCE MATRIX

		M36-1 A	M36-2 B	QE-1 C	QE-2 D	NM-87 E	XMR F
						DELETED	DELETED
	M36-1	0.0000	14.8789	5.4623	4.9085	0.0000	0.0000
	M36-2	14.8789	0.0000	4.9671	4.5497	0.0000	0.0000
	QE-1	5.4623	4.9671	0.0000	2.2200	0.0000	0.0000
	QE-2	4.9085	4.5497	2.2200	0.0000	0.0000	0.0000
DELETED	NM-87	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DELETED	XMR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
COV INCLD INST		25.2496	24.3957	12.6494	11.6782	0.0000	0.0000
COV EXCLD INST		11.7368	12.5908	24.3370	25.3082	0.0000	0.0000
EST (SIGMA E1) 2		4.7506	3.8754	2.2730	2.8743	0.0000	0.0000
EST (SIGMA E1)		2.17950	1.96861	1.50764	1.69537	0.00000	0.00000
PRECISION RANK		4	3	1	2	0	0

TOTAL COVARIANCE= 36.9865 PARAMETER VARIANCE = 6.164 PARAM STD DEV. = 2.4828

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON

NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 2, ROUNDS 601-620, DE = 598 MILS

DATA POINT	M36-1 A	M36-2 B	BE-1 C	BE-2 D	NM-87 E	XMR F	MEAN
		DELETED					
1	273.80 I	233.30	273.40	272.70 I	273.60 I	272.30 I	273.16
2	269.10	269.50	269.90	268.70	269.50	268.70	269.18
3	269.40	269.20	269.90	268.70	269.50	268.60	269.22
4	271.10	271.20	271.40	270.20	270.90	270.30	270.78
5	270.40	0.00	269.90	269.70	270.40	269.20	269.92
6	270.40	0.00	269.40	269.20	270.00	269.40	269.68
7	268.80	0.00	269.40	268.20	268.90	268.30	268.72
8	270.40	263.40	269.40	269.20	270.00	269.00	269.60
9	270.10	0.00	269.40	269.20	269.90	269.30	269.58
10	271.10	0.00	271.40	270.20	271.10	270.50	270.86
11	269.80	0.00	269.70	268.70	269.70	268.70	269.32
12	269.80	0.00	269.70	268.70	269.20	267.80	269.04
13	271.10	270.90	271.20	270.20	270.90	270.10	270.70
14	270.80	270.50	271.20	270.20	270.60	269.60	270.48
15	270.40	270.20	269.70	269.70	270.40	269.60	269.96
16	270.10	268.50	269.40	269.20	269.90	268.80	269.48
17	271.80	271.50	271.70	270.70	271.40	270.60	271.24
18	271.40	0.00	271.70	270.70	271.40	270.20	271.08
19	271.80	0.00	271.70	270.70	271.40	270.50	271.22
20	271.80	0.00	271.70	270.70	271.40	270.40	271.20
MEAN	270.67	0.00	270.56	269.77	270.50	269.59	
VARIANCE	1.303	0.000	1.355	1.113	1.141	1.078	
STND DEV	1.142	0.000	1.164	1.055	1.068	1.038	
PROB ERR	0.770	0.000	0.785	0.711	0.720	0.700	

GRAND MEAN= 270.221 AVERAGE VARIANCE= 1.1980 STND DEV= 1.0945 PROB ERR= 0.7383

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

• INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

5 INSTRUMENTS WITH 20 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 2, ROUNDS 601-620, GE = 598 MILS

COVARIANCE MATRIX

		M36-1 A	M36-2 B DELETED	GE-1 C	GE-2 D	NM-87 E	XMR F
	M36-1	0.0000	0.0000	1.1877	1.1813	1.1944	1.1188
DELETED	M36-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	GE-1	1.1877	0.0000	0.0000	1.1400	1.1449	1.0866
	GE-2	1.1813	0.0000	1.1400	0.0000	1.1180	1.0504
	NM-87	1.1944	0.0000	1.1449	1.1180	0.0000	1.0790
	XMR	1.1188	0.0000	1.0866	1.0504	1.0790	0.0000
COV INCLD INST		4.6822	0.0000	4.5593	4.4897	4.5363	4.3348
COV EXCLD INST		6.6190	0.0000	6.7419	6.8114	6.7648	6.9663
EST (SIGMA E1)	2	0.0653	0.0000	0.1992	0.0029	-0.0002	0.0721
EST (SIGMA E1)		0.25563	0.00000	0.44629	0.05352	0.00000	0.26843
PRECISION RANK		3	0	5	2	1	4

TOTAL COVARIANCE= 11.3011 PARAMETER VARIANCE = 1.130 PARAM STD DEV. = 1.0631

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,8RL OBRYON

NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 3, ROUNDS 641-660, QE = 1130 MILS

	DATA POINT	M36-1 A	M36-2 B	QE-1 C	QE-2 D	NM-87 E	XMR F	MEAN
	1	302.80	302.30	303.20	301.70	302.50	301.50	302.33
	2	303.40	303.00	303.70	302.70	303.20	302.30	303.05
	3	304.40	304.40	303.70	303.70	304.40	303.70	304.05
	4	303.40	303.00	303.70	302.20	303.10	302.10	302.92
DELETED	5	309.20	308.10	287.20	303.70	309.20	308.60	0.00
	6	303.80	303.30	303.70	302.70	303.40	302.50	303.23
DELETED	7	0.00	0.00	303.20	303.20	304.10	303.00	0.00
	8	304.80	304.70	305.20	303.70	304.90	304.20	304.58
	9	303.80	303.30	303.20	302.70	303.50	302.50	303.17
	10	304.20	304.00	303.20	303.20	304.00	306.50P	304.18
	11	303.90	303.60	303.20	302.70	303.70	302.40	303.25
DELETED	12	304.60	238.30	303.70	303.20	304.20	302.90	0.00
	13	305.00	302.00	305.20	303.70	304.60	305.60	304.35
	14	304.30	304.10	303.20	303.20	304.00	302.90	303.62
	15	305.30	305.10	305.20	303.70	304.90	303.50	304.62
	16	304.30	304.10	303.20	303.20	304.00	304.80	303.93
DELETED	17	303.90	278.20	303.20	302.70	303.60	302.50	0.00
	18	304.30	304.10	303.20	303.20	303.90	302.70	303.57
DELETED	19	303.90	303.60	303.20	303.20	303.80	0.00	0.00
	20	305.00	304.50	305.20	303.70	304.60	303.40	304.40
	MEAN	304.18	303.70	303.87	303.07	303.91	303.37	
	VARIANCE	0.469	0.773	0.738	0.374	0.486	1.929	
	STND DEV	0.685	0.879	0.859	0.611	0.697	1.389	
	PROB ERR	0.462	0.593	0.579	0.412	0.470	0.937	

GRAND MEAN= 303.683 AVERAGE VARIANCE= 0.7947 STND DEV= 0.8915 PROB ERR= 0.6013

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY 1 OR P.
1 INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

6 INSTRUMENTS WITH 15 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER BERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 3, ROUNDS 641-660, QE = 1130 MILB

COVARIANCE MATRIX

	M36-1 A	M36-2 B	QE-1 C	QE-2 D	MM-87 E	XMR F
M36-1	0.0000	0.3650	0.4214	0.3971	0.4660	0.5730
M36-2	0.3650	0.0000	0.1750	0.3357	0.4014	0.2557
QE-1	0.4214	0.1750	0.0000	0.3274	0.4226	0.3548
QE-2	0.3971	0.3357	0.3274	0.0000	0.4126	0.5533
MM-87	0.4660	0.4014	0.4226	0.4126	0.0000	0.6054
XMR	0.5730	0.2557	0.3548	0.5533	0.6054	0.0000
COV INCLD INST	2.2226	1.5329	1.7012	2.0262	2.3080	2.3422
COV EXCLD INST	3.8440	4.5337	4.3653	4.0403	3.7585	3.7243
EST (SIGMA E1) 2	-0.0358	0.6131	0.4942	-0.0326	-0.0618	1.3648
EST (SIGMA E1)	0.00000	0.78299	0.70296	0.00000	0.00000	1.16824
PRECISION RANK	2	5	4	3	1	6

TOTAL COVARIANCE= 6.0665 PARAMETER VARIANCE = 0.404 PARAM STD DEV. = 0.6360

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 4, ROUNDS 621-640, QE = 335 MILS

	DATA POINT	M36-1 A	M36-2 B	QE-1 C	QE-2 D	NM-87 E	XMR F	MEAN
			DELETED					
	1	347.40	0.00	345.20	345.20	346.40	345.60	345.96
	2	346.40	0.00	345.20	344.20	345.40	343.90	345.02
	3	346.00	0.00	345.20	343.70	345.30	343.90	344.82
	4	346.70	0.00	345.70	344.70	345.80	344.50	345.48
	5	347.40	0.00	345.20	344.70	346.30	345.60	345.84
	6	347.40	0.00	345.20	345.20	346.40	345.40	345.92
	7	348.10	0.00	347.20	345.70	347.10	346.10	346.84
	8	347.40	0.00	345.20	344.70	346.10	345.10	345.70
	9	346.40	0.00	345.20	343.70	345.30	344.00	344.92
	10	347.00	0.00	345.20	344.70	346.10	345.10	345.62
DELETED	11	347.60	300.00	345.70	345.20	0.00	348.00	0.00
	12	348.60	348.10	347.70	346.70	347.80	346.30	347.42
DELETED	13	348.60	348.10	347.70	346.20	347.70	0.00	0.00
	14	346.20	346.40	345.20	343.70	345.10	344.70	344.98
	15	348.60	348.50	347.20	346.70	348.00	351.30 I	348.36
	16	347.20	347.20	345.70	345.20	346.40	345.40	345.98
DELETED	17	347.60	347.40	0.00	0.00	347.10	350.40	0.00
	18	346.80	346.00	345.20	344.70	346.10	345.00	345.56
	19	347.90	350.90	347.20	345.70	347.20	346.10	346.82
	20	347.60	321.10	345.70	345.70	346.40	345.40	346.16
	MEAN	347.24	0.00	345.79	344.99	346.31	345.49	
	VARIANCE	0.605	0.000	0.820	0.846	0.703	2.789	
	STND DEV	0.778	0.000	0.905	0.920	0.839	1.670	
	PROB ERR	0.525	0.000	0.611	0.620	0.566	1.127	

GRAND MEAN= 345.965 AVERAGE VARIANCE= 1.1526 STND DEV= 1.0736 PROB ERR= 0.7241

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

5 INSTRUMENTS WITH 17 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 4, ROUNDS 621-640, DE = 335 MILS

COVARIANCE MATRIX

		M36-1 A	M36-2 B	DE-1 C	DE-2 D	HM-87 E	XMR F
			DELETED				
	M36-1	0.0000	0.0000	0.5649	0.6871	0.6347	1.0053
DELETED	M36-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	DE-1	0.5649	0.0000	0.0000	0.6756	0.6463	0.9662
	DE-2	0.6871	0.0000	0.6756	0.0000	0.7482	1.1862
	HM-87	0.6347	0.0000	0.6463	0.7482	0.0000	1.1450
	XMR	1.0053	0.0000	0.9662	1.1862	1.1450	0.0000
COV INCLD INST		2.8920	0.0000	2.8529	3.2971	3.1743	4.3027
COV EXCLD INST		5.3675	0.0000	5.4065	4.9624	5.0852	3.9568
EST ($SIGMA E1)^2		0.0536	0.0000	0.2945	0.0241	-0.0365	1.2975
EST (SIGMA E1)		0.23160	0.00000	0.54265	0.15534	0.00000	1.13906
PRECISION RANK		3	0	4	2	1	5

TOTAL COVARIANCE= 8.2595 PARAMETER VARIANCE = 0.826 PARAM STD DEV. = 0.9088

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,8RL OBRYON

NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 5G, ROUNDS 801-820, QE = 1110 MILS

	DATA POINT	M34-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E	XMR F	MEAN
DELETED	1	0.00	415.50	417.80	416.30	0.00	415.70	0.00
	2	416.30	415.80	415.80	415.30	416.00	414.80	415.67
	3	415.80	415.10	415.80	414.30	415.40	414.80	415.17
DELETED	4	415.30	414.80	415.30	414.80	0.00	413.80	0.00
	5	415.60	415.10	415.80	414.30	415.10	413.90	414.97
	6	416.10	415.50	415.80	414.30	415.40	414.70	415.30
	7	415.60	415.50	415.80	414.30	415.40	414.20	415.13
DELETED	8	415.60	415.10	415.30	414.80	0.00	414.10	0.00
DELETED	9	415.60	415.50	415.80	414.30	0.00	414.00	0.00
	10	415.60	415.10	415.80	414.30	415.40	414.00	415.03
	11	415.90	415.80	415.80	414.80	415.50	414.30	415.35
	12	415.60	415.10	415.30 I	414.30	414.90	413.80	414.83
	13	415.90	415.50	415.80	414.80	415.60	414.90	415.42
	14	416.60	416.50	415.80	415.80	416.50	415.40	416.10
	15	416.30	415.80	415.80	415.30	416.00	414.70	415.65
DELETED	16	0.00	415.50	415.80	414.30	415.20	414.00	0.00
DELETED	17	0.00	415.50	415.80	414.80	415.60	414.20	0.00
DELETED	18	0.00	416.10	415.80	417.80	416.30	415.70	0.00
	19	416.90	416.50	415.80	415.80	416.50	415.60	416.18
	20	416.60	416.10	415.80	414.30	416.10	414.80	415.62
	MEAN	416.05	415.65	415.76	414.76	415.68	414.61	
	VARIANCE	0.209	0.249	0.019	0.353	0.252	0.301	
	STND DEV	0.458	0.499	0.139	0.594	0.502	0.548	
	PROB ERR	0.309	0.337	0.094	0.400	0.339	0.370	

GRAND MEAN= 415.417 AVERAGE VARIANCE= 0.2305 STND DEV= 0.4801 PROB ERR= 0.3239

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

4 INSTRUMENTS WITH 13 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 5G, ROUNDS 801-820, QE = 1110 MILS

COVARIANCE MATRIX

	M36-1 A	M36-2 B	QE-1 C	QE-2 D	NM-87 E	XMR F
M36-1	0.0000	0.2135	0.0186	0.2061	0.2128	0.2096
M36-2	0.2135	0.0000	0.0228	0.2394	0.2337	0.2221
QE-1	0.0186	0.0228	0.0000	0.0192	0.0324	0.0337
QE-2	0.2061	0.2394	0.0192	0.0000	0.2490	0.2462
NM-87	0.2128	0.2337	0.0324	0.2490	0.0000	0.2427
XMR	0.2096	0.2221	0.0337	0.2462	0.2427	0.0000
COV INCLD INST	0.8606	0.9315	0.1266	0.9599	0.9706	0.9542
COV EXCLD INST	1.5411	1.4703	2.2751	1.4418	1.4312	1.4475
EST (SIGMA E1)^2	0.0192	0.0238	0.1961	0.1128	0.0068	0.0638
EST (SIGMA E1)	0.13861	0.15426	0.44283	0.33581	0.08251	0.25264
PRECISION RANK	2	3	6	5	1	4

TOTAL COVARIANCE= 2.4017 PARAMETER VARIANCE = 0.160 PARAM STD DEV. = 0.4001

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 5W, ROUNDS 821-840, QE = 518 MILS

	DATA POINT	M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 F	XMR F	MEAN
				DELETED	DELETED			
DELETED	1	421.50	421.40	417.80	0.00	420.20	0.00	0.00
	2	422.80	422.40	289.70	0.00	421.50	422.50	422.30
	3	421.50	421.00	0.00	0.00	420.50	420.60	420.90
	4	421.20	421.00	0.00	0.00	420.50	421.00	420.93
	5	420.80	420.70	398.00	475.10	419.60P	420.80	420.48
	6	421.80	421.40	0.00	363.10	420.20	420.10	420.87
DELETED	7	422.80	422.70	0.00	0.00	421.80	426.50	0.00
	8	421.50	421.00	486.00	386.10	420.20	422.80	421.38
	9	421.20	421.40	0.00	395.10	421.00	421.00	421.15
	10	417.40 I	420.40	468.00	535.90	420.10	421.10	419.75
	11	423.20	422.70	462.00	0.00	421.90	422.80	422.65
DELETED	12	0.00	421.00	0.00	0.00	419.80	420.90	0.00
	13	421.20	421.00	0.00	0.00	420.10P	421.00	420.82
DELETED	14	421.20	419.00	380.10	0.00	419.60	0.00	0.00
	15	421.50	421.00	0.00	0.00	420.00	420.60	420.78
DELETED	16	0.00	420.40	418.00	461.10	419.40	420.80	0.00
	17	421.50	421.40	443.50	0.00	420.20P	421.60	421.18
	18	423.20	422.70	490.00	391.20	421.60	421.90	422.35
	19	420.20	420.00	402.10	355.00	419.50	419.80	419.87
	20	421.80	422.00	407.60	402.10	421.10	421.70	421.65
	MEAN	421.39	421.34	0.00	0.00	420.53	421.29	
	VARIANCE	1.908	0.638	0.000	0.000	0.528	0.917	
	STND DEV	1.381	0.799	0.000	0.000	0.728	0.957	
	PROB ERR	0.932	0.539	0.000	0.000	0.491	0.619	

GRAND MEAN= 421.137 AVERAGE VARIANCE= 0.9704 STND DEV= 0.9896 PROB ERR= 0.6675

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

4 INSTRUMENTS WITH 15 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73.BRL DARRYON
NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 5W, ROUNDS 821-840, QE = 518 MILS

COVARIANCE MATRIX

	M36-1 A	M36-2 B	QE-1 C DELETED	QE-2 D DELETED	NM-87 E	XMR F
M36-1	0.0000	0.8891	0.0000	0.0000	0.6598	0.5898
M36-2	0.8891	0.0000	0.0000	0.0000	0.5393	0.5006
DELETED QE-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DELETED QE-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NM-87	0.6598	0.5393	0.0000	0.0000	0.4555	0.0000
XMR	0.5898	0.5006	0.0000	0.0000	0.4555	0.0000
COV INCLD INST	2.1387	1.9290	0.0000	0.0000	1.6545	1.5459
COV EXCLD INST	1.4953	1.7050	0.0000	0.0000	1.9795	2.0882
EST (SIGMA F1)^2	0.9810	-0.0794	0.0000	0.0000	0.0863	0.5067
EST (SIGMA F1)	0.99046	0.00000	0.00000	0.10000	0.29385	0.71185
PRECISION RANK	4	1	0	0	2	3

TOTAL COVARIANCE= 3.6340 PARAMETER VARIANCE = 0.606 PARAM STD DEV. = 0.7783

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 5W, ROUNDS 881-890 QF = 518 MILS

DATA POINT		M36-1 A	M36-2 B	GE-1 C DELETED	GE-2 D DELETED	NM-87 E DELETED	XMR F	MEAN
DELETED	1	423.80	423.40	0.00	0.00	0.00	0.00	0.00
DELETED	2	423.20	422.70	0.00	0.00	0.00	0.00	0.00
DELETED	3	423.50	423.70	333.90	379.10	421.83	0.00	0.00
	4	422.50	421.40	458.00	430.20	0.00	422.20	422.03
	5	422.20	422.40	407.40	407.10	0.00	422.30	422.30
	6	424.20	424.00	429.30	473.80	0.00	423.50	423.90
	7	423.80	423.30	0.00	0.00	0.00	423.70	423.60
	8	423.20	422.70P	0.00	0.00	0.00	423.20	423.03
	9	420.20	421.70	389.80	419.30	0.00	421.40	421.10
	10	422.80	423.00	0.00	0.00	0.00	422.50	422.77
MEAN		422.70	422.64	0.00	0.00	0.00	422.69	
VARIANCE		1.710	0.816	0.000	0.000	0.000	0.671	
STND DEV		1.308	0.903	0.000	0.000	0.000	0.819	
PROB ERR		0.882	0.609	0.000	0.000	0.000	0.553	

GRAND MEAN= 422.676 AVERAGE VARIANCE= 1.0659 STND DEV= 1.0324 PROB ERR= 0.6964

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

3 INSTRUMENTS WITH 7 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

COVARIANCE MATRIX

	M36-1 A	M36-2 B	GE-1 C DELETED	GE-2 D DELETED	NM-87 E DELETED	XMR F
M36-1	0.0000	0.9250	0.0000	0.0000	0.0000	1.0133
M36-2	0.9250	0.0000	0.0000	0.0000	0.0000	0.6074
DELETED GE-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DELETED GE-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DELETED NM-87	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
XMR	1.0133	0.6074	0.0000	0.0000	0.0000	0.0000
COV INCLD INST	1.9383	1.5324	0.0000	0.0000	0.0000	1.6207
COV EXCLD INST	0.6074	1.0133	0.0000	0.0000	0.0000	0.9250
EST (SIGMA FI) 2	0.3790	0.2971	0.0000	0.0000	0.0000	-0.0243
EST (SIGMA FI)	0.61567	0.54511	0.00000	0.00000	0.00000	0.00000
PRECISION RANK	3	2	0	0	0	1

TOTAL COVARIANCE= 2.5457 PARAMETER VARIANCE = 0.849 PARAM STD DEV. = 0.9212

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 6W, ROUNDS 841-860, QE = 382 MILS

	DATA POINT	M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E	XMR F	MEAN
DELETED	1	505.90	0.00	499.80	499.80	500.30	500.20	0.00
	2	501.80	500.60	501.80	500.30	501.10	501.10	501.12
	3	500.70	500.30	499.80	499.80	500.10	499.90	500.10
	4	501.70	501.60	501.30	500.80	501.30	500.20	501.15
	5	502.10	501.30	501.30	501.30	501.80	500.30	501.35
	6	500.70	500.30	501.30	499.80	500.40	499.40	500.32
	7	500.40	497.90P	499.80	499.30	500.00	499.70	499.52
	8	500.10	499.90	499.30	498.80	499.60	499.50	499.53
	9	501.40	500.90	501.80	500.30	500.90	499.90	500.87
	10	500.70	500.30	499.80	499.30	500.20	500.10	500.07
	11	500.70	500.30	503.30	499.80	500.40	498.50	500.50
	12	501.70	501.30	501.80	500.30	501.10	499.70	500.98
	13	500.10	499.10	499.80	499.30	499.90	498.20	499.40
	14	499.10	498.90	499.30	498.30	498.90	497.20P	498.62
	15	499.70	499.60	499.30	498.80	499.60	497.50P	499.08
	16	503.50 I	503.40 I	503.80	502.30 I	503.00 I	501.10	502.85
	17	501.10	500.60	501.30	500.30	500.70	498.60P	500.43
	18	500.70	500.60	499.80	499.30	500.20	498.30	499.82
	19	501.10	500.90	501.30	499.80	500.60	498.70	500.40
	20	500.10	499.90	499.30	498.80	499.50	497.40	499.17
	MEAN	500.92	500.41	500.80	499.83	500.49	499.23	
	VARIANCE	0.981	1.336	1.861	0.930	0.870	1.382	
	STND DEV	0.991	1.156	1.364	0.964	0.933	1.176	
	PROB ERR	0.668	0.780	0.920	0.650	0.629	0.793	

GRAND MEAN= 500.277 AVERAGE VARIANCE= 1.2267 STND DEV= 1.1076 PROB ERR= 0.7471

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
I INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF OTHER DATA POINTS BY THE SAME INSTRUMENT.
P INDICATES THE MEASUREMENT WAS FOUND TO BE AN OUTLIER WHEN COMPARED TO MEASUREMENTS OF THE SAME DATA POINT BY OTHER INSTRUMENTS.

* INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

6 INSTRUMENTS WITH 19 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 6W, ROUNDS 841-860, QE = 382 MILS

COVARIANCE MATRIX

	M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E	XMR F
M36-1	0.0000	0.9955	1.0778	0.9246	0.9130	0.9246
M36-2	0.9955	0.0000	1.1361	0.9360	0.9284	0.7537
GE-1	1.0778	1.1361	0.0000	1.0694	1.0389	0.8472
GE-2	0.9246	0.9360	1.0694	0.0000	0.8864	0.8382
NM-87	0.9130	0.9284	1.0389	0.8864	0.0000	0.8286
XMR	0.9246	0.7537	0.8472	0.8382	0.8286	0.0000
COV INCLD INST	4.8353	4.7497	5.1694	4.6545	4.5953	4.1923
COV EXCLD INST	9.2630	9.3486	8.9288	9.4437	9.5030	9.9060
EST ($SIGMA^2$ FI)	-0.0264	0.3711	0.6862	0.0124	-0.0179	0.6957
EST (SIGMA FI)	0.00000	0.60916	0.82838	0.11129	0.00000	0.83410
PRECISION RANK	1	4	5	3	2	6

TOTAL COVARIANCE= 14.0983 PARAMETER VARIANCE = 0.940 PARAM STD DEV. = 0.9695

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 7W, ROUNDS 861-880, QE = 277 MILS

	DATA POINT	M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 F	XMR F	MEAN
	1	594.90	594.60	593.80	593.80	594.30	592.10P	593.92
	2	592.60	593.90	593.80	593.30	593.90	591.80	593.22
	3	598.40	597.70	597.30	596.80	597.70	595.60	597.25
DELETED	4	593.30	0.00	593.30	592.30	592.80	590.10	0.00
	5	596.00	596.00	595.80	594.80	595.60	592.90P	595.18
DELETED	6	594.60	594.20	593.80	593.80	594.30	0.00	0.00
	7	596.00	596.00	595.30	594.80	595.60	593.60	595.22
	8	593.20	592.90	593.30	591.80	592.80	590.70	592.45
	9	596.30	596.30	595.30	595.30	595.90	593.80	595.48
	10	592.20	596.70	591.80	590.80	591.60	588.60	591.95
	11	590.90	590.90	589.80	589.80	590.40	586.10P	589.65
	12	596.40	596.00	595.30	595.30	595.90	590.90P	594.97
	13	596.00	595.70	595.30	595.30	596.50	592.70P	595.25
	14	594.60	594.20	593.80	593.30	594.10	590.90P	593.48
	15	592.60	592.60	591.80	591.30	592.20	589.20P	591.62
	16	594.90	594.90	595.30	593.80	594.60	591.60P	594.18
	17	595.40	593.60	595.30	593.80	594.70	590.90P	593.95
	18	593.30	593.20	593.30	592.30	592.70	589.60P	592.40
	19	591.60	585.10 I	591.30	590.38	592.50	587.90	589.78
	20	593.30	592.60	591.80	591.80	592.50	588.50P	591.75
	MEAN	594.37	594.05	593.86	593.24	594.08	590.97	
	VARIANCE	4.005	8.064	3.791	3.908	3.689	5.612	
	STND DEV	2.001	2.840	1.947	1.977	1.921	2.369	
	PROB ERR	1.350	1.915	1.313	1.333	1.295	1.598	

GRAND MEAN= 593.428 AVERAGE VARIANCE= 4.8447 STND DEV= 2.2011 PROB ERR= 1.4846

MEASUREMENTS FOUND TO BE OUTLIERS AT A 95% CONFIDENCE LEVEL ARE FOLLOWED BY I OR P.
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• INDICATES AN OUTLIER WHEN CONSIDERING THE DIFFERENCE BETWEEN INSTRUMENTS. (TWO INSTRUMENT CASE ONLY)

6 INSTRUMENTS WITH 18 DATA POINTS EACH WERE USED IN THIS ANALYSIS.

CUSTOMER SERVICE TEST AT FORT SILL, CONDUCTED BY F.A., JULY-AUGUST 73,BRL OBRYON
NORMALIZED DATA 8-INCH HOWITZER,M110,ZONE 7W, ROUNDS 851-880, QE = 277 MILS

COVARIANCE MATRIX

	M36-1 A	M36-2 B	GE-1 C	GE-2 D	NM-87 E	XMR F
M36-1	0.0000	4.0576	3.6755	3.8275	3.6806	4.2182
M36-2	4.0576	0.0000	3.8500	4.1000	3.4068	4.7112
GE-1	3.6755	3.8500	0.0000	3.6944	3.5686	4.2814
GE-2	3.8275	4.1000	3.6944	0.0000	3.7225	4.3569
NM-87	3.6806	3.4068	3.5686	3.7225	0.0000	4.2000
XMR	4.2182	4.7112	4.2814	4.3569	4.2000	0.0000
COV INCLD INST	19.4594	20.1256	19.0699	19.7013	18.5785	21.7676
COV EXCLD INST	39.8918	39.2256	40.2813	39.6499	40.7727	37.5836
EST (SIGMA E1)^2	0.2101	3.9362	0.1910	-0.0070	0.3344	0.6631
EST (SIGMA E1)	0.45839	1.98397	0.43704	0.00000	0.57826	0.81429
PRECISION RANK	3	6	2	1	4	5

TOTAL COVARIANCE= 59.3512 PARAMETER VARIANCE = 3.957 PARAM STD DEV. = 1.9892

Customer Service Test, at Fort Sill by Frankford Arsenal July-Aug 73

105MM HOWITZER M102

EST ISIGMA E_{11}^{2} SUMMARY

INST	POINTS	MEAN	M3A-1	M3A-2	GE-1	GE-2	NM-87	XMR	ROUNDS	ZONE	QE
6	19	184.66053	0.23702	0.14259	0.35108	0.03674	0.07446	0.24401	200-220	1	350
5	20	235.63200	0.16917	0.34635	0.24670	0.13547	0.00000	0.07575	243-263	3	1250
6	19	270.22018	0.09235	0.03716	0.21283	0.31838	0.01749	0.07666	221-241	4	130
5	19	316.78316	0.00000	0.03750	0.19411	0.34902	0.00596	0.19319	266-284	5	200
7	10	484.10333	0.00000	0.00000	0.22667	0.24000	0.00000	0.01600	301-310	7	1093
5	6	464.83000	1.43139	-0.01094	0.58428	0.16639	0.00000	0.32372	311-320	7	1077
6	5	486.86000	0.17075	0.01725	0.17325	-0.00175	0.00725	0.00725	322-326	7	405
7	17	545.42941	0.00000	4.17464	-0.08224	0.51879	0.00000	0.00000	327-345	7	405 (RAP)

Customer Service Test, at Fort Sill by Frankford Arsenal July-Aug 73

155MM HOWITZER M109

EST ISIGMA E_{11}^{2} SUMMARY

INST	POINTS	MEAN	M3A-1	M3A-2	GE-1	GE-2	NM-87	XMR	ROUNDS	ZONE	QE
5	16	199.79750	0.07142	0.00000	0.17739	0.06731	0.17977	0.33272	401-420	1	460
4	18	276.56606	0.00000	0.00000	0.24175	0.01185	0.00440	0.10303	481-500	3G	1219
5	16	315.71000	0.00000	0.07720	0.35509	0.03016	0.28966	0.06549	421-440	4G	237
5	20	373.66300	0.17495	0.00000	0.14739	0.21085	0.00591	0.19335	701-720	5G	680
5	14	280.78429	0.00000	0.14000	0.19971	0.02196	0.02923	0.01311	441-460	3W	300
4	19	321.44079	0.00000	0.00000	0.06732	0.21691	1.14121	0.17302	461-480	4W	229
4	20	377.72500	0.09457	0.00000	0.00000	0.32760	0.20784	0.04564	{721-740 781-795	5W	675
4	18	462.99861	0.02612	0.00000	0.00000	0.06573	0.01805	0.08129	741-760	6W	1111
3	10	564.48333	0.00000	0.00000	0.00000	0.23289	10.82489	-0.16444	761-780	7W	319

Customer Service Test, at Fort Sill by Frankford Arsenal July-Aug 73

175MM GUN, M107

EST ISIGMA E_{11}^{2} SUMMARY

INST	POINTS	MEAN	M3A-1	M3A-2	GE-1	GE-2	NM-87	XMR	ROUNDS	ZONE	QE
4	21	501.78333	0.00000	0.29858	0.38394	0.97377	0.07570	0.00000	971-995	1	306
5	18	704.66000	0.06031	0.35472	0.06492	0.20021	3.64907	0.00000	941-965	2	325
4	19	915.20132	4.75060	3.87543	2.27297	2.47429	0.00000	0.00000	901-930	3	500

Customer Service Test, at Fort Sill by Frankford Arsenal July-Aug 73

8 INCH HOWITZER, M110

EST ISIGMA E_{11}^{2} SUMMARY

INST	POINTS	MEAN	M3A-1	M3A-2	GE-1	GE-2	NM-87	XMR	ROUNDS	ZONE	QE
5	20	270.22100	0.06535	0.00000	0.19917	0.00286	-0.00019	0.07206	601-620	2	598
6	15	303.68333	-0.03579	0.61308	0.49415	-0.03263	-0.06185	1.36480	641-660	3	1130
5	17	345.96471	0.05364	0.00000	0.29447	0.02413	-0.03651	1.29746	621-640	4	355
6	13	415.41667	0.01921	0.02379	0.19610	0.11277	0.00681	0.06363	801-820	5G	1110
4	15	421.13667	0.08102	-0.07937	0.00000	0.00000	0.08635	0.50673	821-840	5W	518
3	7	422.67619	0.37905	0.29714	0.00000	0.00000	0.00000	-0.02429	881-890	5W	518
6	19	500.27719	-0.02643	0.37107	0.68622	0.01239	-0.01792	0.69572	841-860	6	382
5	18	593.42778	0.21012	3.93615	0.19100	-0.00704	0.33439	0.66306	861-880	7	277

Customer Service Test, at Fort Sill by Frankford Arsenal July-Aug 73

105MM HOWITZER M102

EST (SIGMA E11 SUMMARY)^2

INST	POINTS	MEAN	M36-1	M36-2	GE-1	GE-2	NM-87	XMR	ROUNDS	ZONE	QE
6	19	184.66053	0.23782	0.34259	0.35108	0.03674	0.07446	0.24801	200-220	1	350
5	20	235.63200	0.16917	0.34635	0.24670	0.13547	0.00000	0.07575	243-263	3	1250
6	19	278.22018	0.08235	0.04714	0.21283	0.31838	0.01749	0.07666	221-241	4	130
5	19	316.78316	0.00000	0.03750	0.19411	0.34902	0.00596	0.10419	266-284	5	200
3	18	484.19333	0.00000	0.00000	0.22667	0.34000	0.00000	0.01600	301-310	7	1093
5	6	484.83600	1.43133	-0.01094	0.58428	0.16659	0.00000	0.32372	311-320	7	1077
6	5	486.88000	0.17975	0.01725	0.17325	-0.00175	0.00725	0.00725	322-326	7	405
3	17	545.42941	0.00000	4.17464	-0.08224	0.51879	0.00000	0.00000	327-345	7	405 (RAP)

Customer Service Test, at Fort Sill by Frankford Arsenal July-Aug 73

155MM HOWITZER M109

EST (SIGMA E11 SUMMARY)^2

INST	POINTS	MEAN	M36-1	M36-2	GE-1	GE-2	NM-87	XMR	ROUNDS	ZONE	QE
5	16	199.79750	0.07142	0.00000	0.17745	0.06731	0.17977	0.33272	401-420	1	460
4	18	276.55806	0.00000	0.00000	0.24175	0.41185	0.00440	0.10403	481-500	3G	1219
5	16	315.71000	0.00000	0.07720	0.35509	0.03016	0.78966	0.06549	421-440	4G	237
5	20	370.98300	0.17495	0.00000	0.14739	0.21085	0.00591	0.19335	701-720	5G	680
5	14	280.78429	0.00000	0.14600	0.19971	0.02196	0.02923	0.01411	441-460	3W	300
4	19	321.48079	0.00000	0.00000	0.06732	0.21691	1.18121	0.17302	461-480	4W	229
4	28	377.72500	0.09457	0.00000	0.00000	0.32760	0.20784	0.04564	{721-740 / 781-795	5W	675
4	18	462.99861	0.02612	0.00000	0.00000	0.06573	0.01805	0.08129	741-760	6W	1111
3	10	564.48333	0.00000	0.00000	0.00000	0.23289	10.82889	-0.16444	761-780	7W	319

Customer Service Test, at Fort Sill by Frankford Arsenal July-Aug 73

175MM GUN, M107

EST (SIGMA E11 SUMMARY)^2

INST	POINTS	MEAN	M36-1	M36-2	GE-1	GE-2	NM-87	XMR	ROUNDS	ZONE	QE
4	21	501.78333	0.00000	0.29859	0.38394	0.07377	0.07570	0.00000	971-995	1	306
5	18	704.88000	0.06031	0.35472	0.06492	0.20021	3.64907	0.00000	941-965	2	325
4	19	915.20132	4.75060	3.87543	2.27297	2.37429	0.00000	0.00000	901-930	3	500

Customer Service Test, at Fort Sill by Frankford Arsenal July-Aug 73

8 INCH HOWITZER, M110

EST (SIGMA E11 SUMMARY)^2

INST	POINTS	MEAN	M36-1	M36-2	GE-1	GE-2	NM-87	XMR	ROUNDS	ZONE	QE
5	20	270.22100	0.06535	0.00000	0.19917	0.00286	-0.00019	0.07206	601-620	2	508
4	15	303.68333	-0.03578	0.61308	0.49415	-0.03263	-0.06185	1.36480	641-660	3	1130
5	17	345.06471	0.05164	0.00000	0.29447	0.02413	-0.03451	1.29746	621-640	4	335
4	13	415.41667	0.01921	0.02379	0.19510	0.11277	0.00681	0.06383	801-820	5G	1110
4	15	421.13667	0.96102	-0.07937	0.00000	0.00000	0.08635	0.50673	821-840	5W	518
3	7	422.67619	0.37905	0.29714	0.00000	0.00000	0.00000	-0.02429	881-890	5W	518
4	19	500.27719	-0.02643	0.37107	0.68622	0.01239	-0.01792	0.69572	841-860	6	382
6	18	593.42778	0.21012	3.93615	0.19100	-0.00704	0.33439	0.66306	861-880	7	277

APPENDIX C
Correspondence - BRL to FA, AMXBR-EB-FT, 11 January 1974

DEPARTMENT OF THE ARMY Mr.O'Bryon/jm/4227
U.S. ARMY BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND 21005

AMXBR-EB-FT 11 January 1974

SUBJECT: Customer Service Test Results of Chronographs, Fort Sill, Oklahoma, July-August 1973

Commander
Frankford Arsenal
ATTN: SARFA-FCF-E
Bridge & Tacony Streets
Philadelphia, PA 19137

1. References:

a. Frankford Arsenal (FA) Customer Service Test conducted at Fort Sill, July-August 1973.

b. Telecons with Mr. F. Richter, FA, during period June-December 1973.

c. Letter from FA dated 19 July 1973, to BRL, subject: Customer Service Test of Chronographs, Fort Sill, Oklahoma.

d. Letter to ARMCOM dated 3 July 1973, subject: Customer Service Test of Chronographs, Fort Sill, Oklahoma

2. As requested by reference 1.c., BRL has analyzed the data of the referenced customer service test using methodology adopted by the U.S. and other NATO nations as the most efficient and unbiased means of estimating and comparing relative chronograph performance when two or more instruments are used to make simultaneous measurements of gun muzzle velocities. STANAG 4114 and ARDC TN 12 (AD732428) provide the rationale for the discussion and results that follow.

3. The data gathered at Fort Sill during this test were presented to the BRL in three different forms. First, the raw velocity observations were given. These velocities simply reflect what numbers were found on the display

readouts directly from the chronographs themselves. From this set of data, a second set which was corrected for frequency was generated. The third and final set of data that was given to the BRL was a set of "normalized" data. These data were obtained by feeding the chronograph readings corrected for frequency into the FADAC computer and letting the FADAC program routine compute muzzle velocity. This last set of data was ued as the basis for all of the performance estimates to follow. It must be pointed out here that one very vital part of the data reduction process was omitted from the test results and this was correction for parallax. Unlike magnetic coils and most sky screens, doppler chronographs typically must be offset from the trajectory to avoid destruction by the shot and also, as in the case where several chronographs are being used at one time, the logistics of chronograph placement caused some to be farther away from the trajectory line than others. The importance of these parallax corrections has already been discussed with FA as well as the vital bearing that they have on our data analysis, however, due to lack of time and complexity in re-reducing all data tapes, BRL was asked to make chronograph estimates based on the normalized data provided. Four different models of chronographs were used in the test. There were two M36 doppler radars (M36-1, M36-2), two General Electric doppler radars (GE-1, GE-2), a Norwegian doppler radar (NM-87) and a Frankford Arsenal doppler radar prototype (XMR).

4. Missing data, maverick readings, and outliers had to be considered in this data analysis since a matrix with entries in every cell was necessary to obtain performance estimates properly.

a. Where a chronograph was turned off, intentionally or unintentionally, and failed to obtain a reading, either the data from all chronographs for that specific round were deleted or consideration of other readings from that same chronograph for that specific weapon/zone/QE were also deleted, thereby maintaining a full matrix of observations.

b. Where maverick readings (obviously extremely far from true) were encountered, these were treated as missing data.

c. The computer program contains an outlier test which is designed to detect values which are statistically not part of the same population in which they are found. Two different

analyses were performed. The first looked at possible outlying observations within each round fired (i.e., did one chronograph record a significantly different reading than all other chronographs simultaneously looking at the same round). This test was performed on every round from every weapon contained in the service test. The second outlier test looked at possible outliers for each chronograph over each group of projectiles fixed at every initial condition (weapon/zone/QE combination). These tests were performed at the 99 percent level of confidence and data points were deleted only when they were detected as outliers by both tests.

5. Detecting a small constant bias in velocity measurement has always been a problem in chronograph tests. It is for this reason that the BRL, in its letter to ARMCOM on 3 July 1973 suggested that methods independent of doppler radar be used to observe velocity. Methods such as sky screens (optical) or coils (electromagnetic) were suggested as techniques which should also be used in this test since independent detection modes not dependent on doppler radar techniques would minimize the possibility of bias errors remaining undetected. This suggestion was not acted upon due to a number of reasons, and, hence, only the doppler method of velocity observation is common to all six devices. With no independent measurement being available, we must, therefore, assume that the real (unbiased true), velocity falls somewhere midway between all observations of the doppler radars.

6. The measurement related to successive shots, but produced by the same instrument, differs not only by the value of the instrumental error of the chronograph but, also, and often to a considerably greater degree, by the value of the random deviation of the velocity of each successive shell. Hence, traditional analysis of variance techniques could not be applied effectively to determine the accuracy and precision of the instrumentation since projectile velocity is not, in itself, a repeatable phenomenon. The methodology used by BRL takes into account these problems and computes unbiased estimates of random errors of measurement for each chronograph. These estimates are contained in Inclosure 1. Below is a brief summary of some of the terms found in these data.

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SUBJECT: Customer Service Test Results of Chronographs, Fort Sill, Oklahoma, July-August 1973

"Mean" - simple arithmetic mean

"Variance" - variance of all observations in column appearing immediately above (except deleted data)

"stnd dev" - standard deviation (square root of variance)

"prob err" - .6745 of standard deviation

"grand mean" - mean of all data considered

"average variance" - arithmetic average of variances from all instruments considered

"covariance matrix" - included simply as computational information

"cov incld inst" - included simply as computational information

"cov excld inst" - included simply as computational information

*"est (sigma$^2_{e_1}$)" - unbiased estimate of variance in random precision error (est $\sigma^2_{e_1}$)

*"est (sigma $_{e_1}$)" - (est σ_{e_1})

"precision rank" - a simple numerical ranking of size of each precision estimate with smallest being ranked 1

"total covariance" - included simply for computational information

"parameter variance" - estimate of the real round-to-round muzzle velocity variance due to propellant and tube influences but free of chronograph precision errors

The quantities marked with an asterisk (*) above occasionally are negative due to the statistical approach used. There is no reason for alarm when these estimates become negative since (a) they are best estimates of precision and because, in some cases, the precisions are very small numerically, the estimates do occasionally fall into the negative region and, (b) these negative numbers are only slightly negative and can be treated as zero. If more information on this is desired, volume 43, pp 243-264 of the June 1948 edition of the journal of the American Statistical Association gives a comprehensive explanation.

7. Chronograph performance is dependent upon many factors including

a. velocity level being measured,

b. quadrant elevation (QE) of weapon,

c. shell cross-sectional area and surface irregularities,

d. baseline length,

e. blast and muzzle flash,

f. weather conditions,

g. skill of chronograph operators.

Looking at the test in light of each of these factors, we can make the following observations.

a. Although the test encompassed a velocity span of approximate 730 m/s (185 m/s to 915 m/s), a linear least squares fit of precision versus velocity showed significance in the first order term only for the 175mm gun over zones 1, 2 and 3. Other systems generally showed little degradation in precision due to changing velocity levels.

b. Since only one true replication is included (shell, weapon, and zone identical with only QE altered), that being the 105mm howitzer, zone 7, firing both at 1077 and 1093 mils, no conclusive statement can be made. Past studies have shown that doppler radar chronographs are much less affected by elevation change than instruments dependent on optical techniques.

c. Caliber size did not seem to affect the ability of any chronograph to lock on and measure. The RAP shell which possess a very irregular base which fosters poor reflectivity did cause problems for some of the systems, the 105mm RAP caused erratic behavior patterns for the M36-1 as well as the XMR system. Unfortunately NM87 was turned off during the 105 RAP firing, but the reason for this has not been noted on the data sheets submitted to BRL. Only five (5) 155mm RAP projectiles were fired and of these five shell, no chronograph obtained a reading for every shot. The GE-2 unit and the NM87 obtained readings for four out of these five however, there is no way of determining which unit, if either, was reading precisely. As the result of studying the test plan drawn up by Frankford Arsenal in June, which included a small number of RAP shell to be fired, BRL recommended shortly before the test that "these hollow base shell be part of the test plan since recent tests have shown that radar tracking of these shell is more difficult due to irregularities of reflection from shell base." Since these types of shell will be encountered in the field in increasing numbers in the years just ahead, it is unfortunate that only 24 out of the approximately 800 shell expended in the subject test were from the RAP family.

d. None of the chronograph systems possessed a particularly long or short baseline so no discussion will be made of the effects of baselength.

e. The influence of blast and muzzle flash was a major factor in this test. The 8-inch howitzer, zone 5, white bag, because of its internal ballistic burning behavior, produces a large muzzle flash pattern. Looking at the results of the two occasions fired at this zone, it is immediately obvious that the flash caused serious degradation in the performance of both GE units. Not only were 50 percent of the data lost completely but the other data gathered for the most part were erroneous. The M36 units did not seem to encounter a significant data loss, but their precision errors did increase and were significantly higher than the lower zones measured. The NM87 performance and precision was good for the first data set (rounds 821-840), however, later, under identical conditions with the second set (rounds 881-890), the same unit became erratic. This is not consistent with past performance of the unit and it is suspected that the data omissions in the second data set do not reflect the instrument's true ability and typical behavior. The XMR unit was quite consistent in obtaining readings but,

in this case, was not as precise as the NM87 ($\sigma^2_{e_{NM87}}$ = .08635 vs $\sigma^2_{e_{XMR}}$ = .50673). Although the 175mm gun did not exhibit the muzzle flash that the 8-inch howitzer, zone 5W, displayed, the blast (shock or overpressure) from the 175mm gun zone 3 was the maximum encountered during the test. The effects of muzzle flash caused sizeable data loss for some chronographs. Blast overpressure, on the other hand, although it caused some random data loss, caused precision to degrade also. The pooled variance in precision error for the M36 and GE systems (the only systems in the 175mm matrix) was approximately 3.4 m/s. The XMR experienced a cracked wave guide as a result of this overpressure.

f. Weather conditions are often a consideration in chronograph operation. No data on prevailing weather was submitted to BRL as part of the data package and since normalization (extrapolation thru prevailing weather) was performed on the data by means of a FADAC computer by Frankford Arsenal, no meaningful comment on weather influences can be made.

g. Operators familiar with their equipment were present at the test site. A total of five trained soldiers were operating the two M36 systems. General Electric had an instrumentation van with two skilled operators highly trained in the usage of their systems. Frankford Arsenal had an instrumentation van which was manned by people familiar with the XMR from its inception. The only system which did not have its own trained crew was the NM87 which is foreign made. This system was mounted on top of an excess M36 tripod. Past results of the NM87 with trained crews and developers operating it showed highly of the NM87 with trained crews and developers operating it showed highly successful and reliable results. ($\sigma_{e_1} \simeq .05\% \bar{V}$). Hence, the results shown in this test for the NM87, although not bad, are not necessarily representative of the system's capabilities given a crew with the equivalent familiarity as the other systems used in this test.

8. Inclosure 2 is a summary sheet displaying the precision estimates of all of the systems tested. Two sets of data, 155mm howitzer, zone 7 RAP (rounds 781-785) and the 8-inch

howitzer, zone 5W (881-890), were not computed since data omissions prevented a large enough data matrix to determine meaningful precision estimates. Overall, no single system possessed a significantly better or worse precision than the others. On the basis of the test data alone, all that can be said concerning precision is that the pooled precision error of all systems for all conditions was held at approximately .15 percent of average velocity. It is unfortunate that the data given to BRL for analyses was not corrected for parallax since, for example, a projectile which is being tracked in a 50 foot gate beginning 25 feet from the gun by a chronograph located four feet laterally from the muzzle could experience velocity errors of the order of .4 percent. If all gating were over the same distance and triggering dependent only on distance for on-off, the errors would only be bias errors which would not affect precision estimates, however, since baselengths vary between chronographs and some have fixed gates in time (M36 and XMR), the precision estimates made are affected by parallax.

9. The summary to accompany this data analysis which will be prepared by Frankford Arsenal will hopefully elaborate on the specific reasons for data omissions throughout the test. The conclusions of the BRL regarding this test is that the data gap problem, i.e., lack of obtaining a reading, was a more serious problem than the precision of the reading itself. In the field application, consistent readings are of vital importance and data gaps regardless of the reason are intolerable.

FOR THE DIRECTOR:

Charles H. Lebegern, Jr.

CHARLES H. LEBEGERN, JR.
Chief, Firing Tables Branch
Exterior Ballistics Laboratory

2 Incls
as

CF (w/o Incl 1)

RIA, Attn: Dr. K. Moore
OCRD, Attn: LTC Ganahl
NWL, Attn: Code EPE, Mr. L. Raymond
RIA, Attn: AMSAR-RDT, Dr. E. J. Haug

APPENDIX D
Test Data - Yuma Proving Ground, Yuma, Arizona - 29 March 1974

8 inch HOWITZER			PROCESSOR			DATA REDUCTION				
RD NO	PROJ	CHARGE	NM87	FA		NM87		FA		
912	M106	7	12976	564.2	2	621.5	35	621.9	22	
913	M106	9	19294	000.0	99	418.0		—		
914	XM650E3	9	13932	717.9	8	573.8		791.4	28	
915			10155	000.0	99	794.1		—		
916			10558	721.1	2	763.8		794.9	28	
917			18225	716.3	10	442.5		789.6	140	
918			10810	000.0	99	746.0		—		
919			18222	000.0	99	442.5		—		
920			18796	717.9	9	429.0		791.4	126	
921			18377	719.8	2	438.8		793.5	28	
922			14337	000.0	99	562.5		—		
923			10214	723.1	2	789.5		797.1	28	
924			16042	717.7	9	502.7		791.2	126	
925			12303	000.0	99	655.5		—		
926			12524	000.0	99	643.9		—		
927			10461	721.5	2	770.9		795.4	28	
928	↓	↓	18995	000.0	99	424.5	↓	—		
			(A)	(B)	(C)	(D)	(E)	(F)	(G)	740329 (YPG)

AMUPA Form 1047, Rev 3 Jul 68 (Supersedes edition of 17 Mar 66)

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DATA REDUCTION METHODOLOGY

1. Legend

A = NM87 Chronograph Readout (.25 X 10^{-6} seconds)

B = FA Processor Readout (meters/second)

C = FA Processor Gate Number

D = NM87 calculated velocity (meters/second)

E = NM87 Range (35 meters - fixed)

F = FA Processor calculated velocity (meters/second)

G = FA Processor Range (meters)

2. Sample Calculation: Round Number 912

a. NM87

$$\text{Velocity} = \frac{\text{Base length}}{\text{Chronograph readout}}$$

$$= \frac{2.016*4.0*10^{-6}}{\text{Chronograph readout (A)}}$$

$$= \frac{8.064*10^{-6}}{12976}$$

$$= 621.5 \text{ meters/second}$$

b. FA Processor

Velocity = K*FA Processor Readout (B)

where K is the correction factor for the transmitter frequency difference between the NM87 Radar Chronograph Set and the FA Processor[1]

$$K = \frac{10.500}{9525} = 1.10236$$

Velocity = 1.1024*564.2

= 621.9 meters/second

Range = Velocity (F)*Gate Number (C)*GW

where GW is gate width of FA Processor = .0178 seconds.

= 621.9*2*.0178

= 22 meters

---

1 The FA Processor was developed by the Systems Development Division at Frankford Arsenal.

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Yuma, AZ 85364

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Ft. Sill, OK 73503

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Date Printed: 10 February 1975