RSG

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DOCUMENT 312-77

PRESENTATION OF MISSILE FLIGHT INFORMATION

RANGE SAFETY GROUP
RANGE COMMANDERS COUNCIL

KWAJALEIN MISSILE RANGE
WHITE SANDS MISSILE RANGE
YUMA PROVING GROUND

NAVAL WEAPONS CENTER
PACIFIC MISSILE TEST CENTER
ATLANTIC FLEET WEAPONS TRAINING FACILITY
NAVAL AIR TEST CENTER

AIR FORCE EASTERN TEST RANGE
AIR FORCE FLIGHT TEST CENTER
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AIR FORCE TACTICAL FIGHTER WEAPONS CENTER

PRESENTATION OF MISSILE FLIGHT INFORMATION

RCC/RANGE SAFETY GROUP DOCUMENT

312-77

Completion of RSG Task 13-30, 312-72 Revised

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1.0 INTRODUCTION

1.1 Background

The Flight Safety Data Working Group (FSDWG) was established at the 17th meeting of the Inter-Range Missile Flight Safety Group (IRMFSG) for the purpose of assisting the IRMFSG in the accomplishment of specific tasks of interest to member ranges. At the 30th meeting of the IRMFSG, March 1971, Task 13-30 was assigned to the FSDWG to prepare a report on data that is currently being displayed for real-time decisions by the Range Safety Officer. As a result of a reorganization within the Range Commanders Council, the IRMFSG was renamed the Range Safety Group (RSG) and all responsibilities for tasks relating to Range Safety were placed under its control. At the 31st meeting of this group, September 1971, the FSDWG was disbanded and task accomplishment was transferred to an ad hoc committee under the RSG. The efforts of this ad hoc committee resulted in the publication of RCC Document 312-72 in April 1972. At the request of the RSG, the ad hoc committee reconvened in March 1976 for the purpose of reviewing Document 312-72 in order to determine if the information presented was current enough to be of any benefit. The conclusion of the committee was that there had been sufficient changes in data presentation methods at the various ranges to warrant updating the document. A recommendation to update the document was made to the RSG who assigned the effort to the ad hoc committee.

1.2 Task

1.2.1 Scope and Objective

The scope of this document shall be to identify information, the rationale for the use of the information and the methods of presentation to the RSO's for real-time decisions.

The objective of this document is to promote the exchange of ideas between RCC member ranges, document current practices being employed at these ranges, and detect any future trends which may better be used in presenting data to the Missile Flight Safety Officer. This document is not intended to fulfill a "handbook" or "cookbook" approach to Range Safety, but to merely provide the facts as they presently exist and allow the users of this document to determine which may have merit for their applications. Hopefully, this publication will shed some light on the developments of new presentation systems, and thereby in some indirect way, advance the "state-of-the-art" in data presentation.

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FOREWORD

The goal of Range Safety is the prevention of injury to personnel or damage to property by taking all reasonable precautions consistent with operational requirements. This is dependent not only on precautions taken in the preparation of a missile or vehicle launch but in the ability of the Range Safety Officer (RSO) to maintain surveillance during flight to insure compliance with established safety criteria. To maintain this necessary surveillance, the RSO must have at his disposal information depicting performance of the missile and possible impact locations for comparison against predetermined destruct criteria. In addition he must be sure that the entire safety system is in operational condition at all times.

Presenting this information in a manner that allows clear and quick understanding of significant data will vary due to missile dynamics and test range geometry. Therefore, there is no "one-best display" for all applications.

A survey of seven of the test ranges represented in the Range Safety Group of the Range Commanders Council (RCC) was made to determine the type of display systems currently in use at the various ranges and the data being presented to the RSO. This information is presented in this document as an aid to all ranges in determining which systems may have merit for their application and to provide some insight into future applications of display systems.

1.0 INTRODUCTION

1.1 Background

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1.2.2 Justification

The identification and documentation of the techniques presently available at the RCC member ranges in the area of Range Safety Data Presentation will provide useful information for exchange of ideas. Descriptions of the primary systems currently in use are compiled in one document to provide a convenient vehicle for the dissemination of information to other ranges. This document will facilitate the solution to the common problems of what information should be displayed and how to display it for real-time Range Safety use.

1.2.3 Method of Accomplishment

The ad hoc committee consisting of representatives from Air Force Eastern Test Range (AFETR, SAMTEC-DET-1), Space and Missile Test Center (SAMTEC), Kwajalein Missile Range (KMR), NASA-Wallops, Pacific Missile Test Center (PMTC), Armament Development and Test Center (ADTC), and White Sands Missile Range (WSMR), revised the basic document and added an ADTC section.

1.2.4 Chronology of Significant Events

The significant events leading to the completion of Task 13-30 are as follows:

(a) Task initiated and plans developed at the 12th meeting of the FSDWG in June 1970.

(b) Development of an outline and required definition of data systems were presented to the FSDWG at the 13th meeting in October 1970.

(c) The task was officially assigned the FSDWG by the IRMFSG during their 30th meeting in March 1971.

(d) Specific data systems and data categories were assembled and presented to the FSDWG at the 14th meeting in June 1971.

(e) The FSDWG was dissolved as a result of reorganizing the Range Commanders Council and in September 1971 an ad hoc committee was formed as a result of this reorganization.

(f) The ad hoc assembly committee met in December 1971 for preparation of the draft document, and forwarding to the member Ranges for review.

(g) A combining meeting of the contributors was held in February 1972 with final revisions made.

(h) The final draft was presented to the RSG for publication in March 1972.

(i) The document was revised to include current status and ADTC inputs in August 1976.

2.0 DISCUSSION

The purpose of effective data presentation is to allow man to clearly and quickly understand the significance of data collected. For Range Safety systems, rapid and proper interpretation of data is particularly important because of the potential costs, in life and property, of improper interpretation. Display hardware and software provide the interface between man and data.

The design and employment of an effective system for the display of real-time data requires consideration of the many aspects of both the display system and missile capability as well as human factors. The principles of Human Engineering should be utilized in designing this system to insure that all necessary information is readily discernible. A tradeoff between the display of required and desirable information should be made so that the RSO is able to arrive at a decision in a relatively short period of time. The quality, quantity, format and response time of the display system and the human interface must be compatible. Therefore, prior to selecting a particular display system, an analysis should be performed to determine what data is most indicative of the missile's behavior and the display system optimized to present this data in a manner that permits accurate and rapid determination of the missile's performance. In cases where missile-turn capability is extremely high and incompatible with the concept of manual protection, it may be necessary to have a display serve only as a monitor of the automatic system.

Since the effectiveness of data presentation for Range Safety depends on many factors, there is no "one-best system" for all applications. Missile dynamics and range geometry vary from range to range and certainly affect the data presentation techniques employed.

This section categorizes data presentation systems and data types so that all ranges can take advantage of the work of others. Data presentation systems are broken into three broad caregories. The data presented on these systems is categorized into eight data types. Table 1 presents a brief synopsis of data systems and data types presented at the various ranges. Section 3.0 provides the detailed methods employed by each range.

2.1 Data Presentation Systems

Data presentation systems vary from a simple verbal communication network to a complex computer driven display. All have one thing in common with respect to Range Safety - they serve to better define missile performance to the RSO.

TABLE 1

SUMMARY OF RANGE SAFETY DATA PRESENTATION SYSTEMS

	Analog		Digital			Communications	
Range	Plot boards	Strip Charts	CRT	Alphanumeric	Light Indic	Voice	Video
AFETR		D-E-G	A-B-C-F G-I	G	G	B-D-E-G	E-G
KMR			A-B-C E-G	G	G		
PMTC	A-B-C-E	D-E-G			G	B-C-D E-G	B-E
SAMTEC	A-B-C	D-E-G			G	B-D-E-G	E
Wallops	A-B-C-D-E G-H	D-E-G		A-B-C F-G-H	A-B-G	B-C-D E-G	E
WSMR	A-B-C	D-E-G		B-C-D-G	G	C-E-G	
ADTC	A-B-C-I	G	A-B-C-D-E-G-H-I	A-B-C-D-E-G-H-I	G	B-D-E-G	B-E-G

A - IIP

B - Present Position

C - Velocity

D - Acceleration

E - Attitude

F - Orbital Elements

G - Status Indicators

H - Error Analysis Parameters

I - Flight Control Parameters

Data presentation systems are grouped into three categories: analog, digital, and communications. These are discussed as follows:

2.1.1 Analog Systems

Analog systems are driven by the application of a particular voltage to an electromechanical device. The reaction of the device provides an indication of performance to the RSO, when compared with its "expected reaction." One form of analog data presentation is a plotting board. Horizontal and vertical pen displacements allow the RSO to visualize a two-dimensional display of missile performance with respect to meaningful landmarks - such as latitude/longitude of present position or predicted impact. Often the analog data driving the plotting board has been converted from computer-generated digital information to analog voltages through a digital-to-analog converter. Another form of an analog data presentation is a strip chart. In this case, one dimension (normally time) moves at a constant rate. Other measurable parameters, such as chamber pressure, provide the second dimension. As in the case of plotting boards, strip charts must be interpreted in light of the expected reaction. Plotting boards and strip charts provide a graphic capability at a relatively low cost. The desired resolution and time constraints associated with real-time applications can usually be met. A permanent record for historical purposes is inherently provided by these systems.

2.1.2 Digital Systems

The digital presentation can be of various forms. One of the newer forms is the Cathode Ray Tube (CRT). Many CRT's are available on the market today. Both their costs and their capabilities cover a broad spectrum. Some have a vector capability which allows a graphic presentation connecting two discrete points, thus providing a presentation similar to a plotting board. Most have an alphanumeric capability. Only the more costly CRT's provide sufficient resolution for Range Safety plotting applications. A permanent record may be obtained by interfacing a video recording system to the CRT. Most CRT's provide editability in that information can be erased/added as needed. Speed is an attribute of the CRT system. There are no electromechanical dynamics to cope with, and hence no system settling times. Most CRT systems allow man-machine interaction, normally through a keyboard. Image structure selectability (line intensifying, line form, color) varies widely, with extreme flexibility being provided only in the more costly systems. In summary, a wide range of capabilities may be obtained in a CRT system, depending on cost.

Dynamic alphanumeric displays are also common digital presentation devices. A proper pattern of binary bits is formed to represent alphanumeric characters in a display window. Range Safety uses of alphanumeric displays include lift-off time, plus time, event time (such as staging), predicted impact latitude and longitude, and data quality. Alphanumeric displays are normally used only as a supplement to a basic presentation system.

Light indicators form another common digital display system. They range from a simple two-way indicator to a complex multi-level indicator. Some indicators are only two-way presentations. An example is a light that signifies lift-off has occurred (based on a first motion). Others illuminate the proper position of a multi-position indicator. One use of this is a multi-level indicator of data quality (based on computed noise) ranging from excellent to poor. Another type illuminates the proper color of a multi-color light. An example of this use is to provide a quick-look station geometry (based on computed elevation angle) where green indicates favorable geometry, amber means marginal, and red signifies the object is not in view of the station. The prime attribute of light indicators is their ability to be sensed at a lower conscious level. They can be observed while prime attention is being focused on other information. As in the case of alphanumeric displays, light indicators are normally used only as a supplement to a basic data presentation system.

2.1.3 Communication Systems

Communication systems as used in this section include video and audio presentations other than those generated video displays discussed under digital systems. Verbal communication by an observer, such as a sky screen operator, verbal commentary by a data presentation interpreter, and various closed circuit TV pictures are included in this category.

2.2 Data Types

Many different types of data are used to satisfy the composite requirements of all launch vehicles at all ranges. However, they all provide information on where the missile is, where it is going, and how it is performing. Data has been categorized into the following nine types in this document:

2.2.1 Instantaneous Impact Prediction

Instantaneous impact prediction (IIP) provides the Range Safety Officer with a dynamic indication of where the missile would land if thrust were terminated instantaneously. Real-time IIP data is evaluated with respect to predetermined flight termination criteria. Various types of IIP's are displayed at the different ranges. The simplest IIP is a vacuum type which does not account for forces such as drag and wind. Various techniques of drag and wind-corrected IIP are also utilized. Computations may take into account drag, wind, maximum turn rates, explosion velocities, and *a priori* instrumentation uncertainties to display an impact footprint which encloses the area of predetermined debris. The footprint is developed by connecting points generated by a series of worst-case impact computations. Due to the exhaustive amount of computer cycle time required by the computations, the footprint is currently done at a reduced presentation rate. It is often required to compute IIP which takes into consideration the performance of an unignited stage in order to determine if ignition is to be allowed or denied.

2.2.2 Present Position

A multitude of present position parameters are provided by the different ranges for the RSO. Some are driven by computers - others by hardware capable of coordinate transformations through the application of analog trigonometric functions. Included are parameters that represent the three dimensions of distance from a given origin to the missile along a given axis orientation. Additionally, measurement parameters, such as azimuth, elevation, and range from a specified point can be presented.

2.2.3 Velocity

Velocity data in the form of vectors, total, or deviations from nominal, are presented to the RSO. When plotted against expected values, this display often provides an early indication of abnormality. Any thrust anomaly, such as early shut down, failure to stage, or loss of partial thrust, will show up immediately on this display.

2.2.4 Acceleration

Both component and resultant acceleration data may be presented to the RSO. Like velocity, acceleration data provides an early indication of thrust-related problems.

2.2.5 Attitude

Both attitude and attitude-rate data are presented to the Range Safety Officer by many ranges. Pitch, roll, and yaw, or their rates, are the common parameters displayed. A close analysis of attitude data can reveal guidance problems, which may precede an indication of position problems.

2.2.6 Orbital Elements

While real-time presentations of orbital elements are used heavily by range users to assess trajectory characteristics, they are also monitored by Range Safety personnel to confirm that orbit will be achieved. One parameter that is monitored is perigee or the orbital low point. Perigee will be negative, indicating that the orbit of the object intersects the earth (i.e., it has an IIP) until orbit is achieved.

2.2.7 Status Indicators

A variety of status indicators is provided to Range Safety, and grouped together in this category. Included here are times (lift off, GMT, local, event), data-quality indicators, source-status indicators (such as on-track, agreement), computer-status indicators, and others which provide qualitative information about the performance of the complete safety system.

2.2.8 Error Analysis Parameters

While statistical parameters are normally used by the range user, they are also occasionally used by Range Safety personnel as a measure of instrumentation errors, IIP error ellipses, and as data quality indicators. Such information provides quantitative data on the performance of instrumentation supporting the safety system.

2.2.9 Flight Control Parameters

Range Safety control of tactical weapons tests is characterized by rapid decision and response in real time to dynamically changing situations involving multiple aircraft, targets and weapons. To assist the RSO, certain data parameters are computed and presented showing the dynamic relationships of targets, weapons, aircraft, and test area. Such information provides quantitative data on the instantaneous safety of the engagement and gives early indication of trends toward unsafe flight-test conditions.

3.0 INDIVIDUAL RANGE DISPLAY SYSTEMS

The methods used to display information to the Range Safety Officer for real-time decisions vary from range to range. Again, due to the various range geometries and the inflight dynamics of the missiles being flown, there is no "one-best method." The previous sections of this document have identified the general type of information that is available and the display systems that can be used to present this information. In this section, the information displayed at AFETR, KMR, PMTC, SAMTEC, NASA-Wallops, WSMR and ADTC has been documented. The parameters presented, the display systems used, and the rationale for displaying the information have been listed. To aid in simplifying these lists, the data parameters have been categorized into the nine general types discussed in subparagraph 2.2 and the data systems/data categories and rationale have been identified by alphanumeric notation. The legend for data systems/data categories is contained in Table 2 and that for the rationale is contained in Table 3.

This section contains a limited view of the Range Safety Control Centers in addition to the detailed listing of the information displayed at the various ranges. A pictorial of the displays currently in use is also provided.

TABLE 2

DATA SYSTEM/DATA CATEGORY LEGEND

<u>Data System</u>

1. Analog
   a. Plot Board
   b. Strip Chart
2. Digital
   a. Cathode Ray Tube
   b. Dynamic Alphanumeric
   c. Light Indicator
3. Communications
4. Television

<u>Data Category</u>

Instantaneous Impact Point
Present Position
Velocity
Acceleration
Attitude
Orbital Elements
Status Indicators
Error Analysis Parameters
Flight Control Parameters

TABLE 3

INFORMATION DISPLAY RATIONALE LEGEND

1. Primary information used for flight termination decisions.

2. Information used for flight termination decisions in the absence of valid primary information.

3. Missile performance information to detect anomalies which have a potential impact on flight termination decisions.

4. Event correlation.

5. Safety system status or quality indicators.

6. Clear-to-fire or release information for weapons test.

3.1 Air Force Eastern Test Range (AFETR, SAMTEC-DET-1)

3.1.1 Summary of Information Presented to Range Safety Officer

PARAMETERS PRESENTED	DATA SYSTEMS	RATIONALE
Instantaneous Impact Point		
Primary Vacuum	2.a	1
Alternate Vacuum	2.a	2
Debris Footprint (Drag)	2.a	1
Present Position		
XY-XZ/SZ-YZ	2.a, 3	2
XY-XZ/XZ-YZ	2.a, 3	2
Velocity		
Time vs. Velocity	2.a	3
Acceleration		
Accelerometer Information	1.b, 3	3
Attitude		
Missile Attitude (pitch, yaw, roll)	1.b, 3	3
Status Indicators		
Missile Fast/Slow Time	2.a	3
Missile High/Low Distance	2.a	3
Missile Right/Left Distance	2.a	3
Missile Engine Chamber Pressures	1.b, 3	3
Event Recordings	1.b, 2.a, 3	4
Command/Destruct Receiver Status	1.b, 3	5
Command/Control Stations Status	2.c, 3	5
Source Track Status	2.a, 2.c, 3	5
Source Track Mode	2.a, 2.c, 3	5
GMT (time)	2.b, 4	4
Plus Time (T-O reference)	2.a, 2.b	4
Flight-line Camera	4	3
Program Camera	4	3
Launch Hold-Fire	2.a, 2.b, 2.c, 3	6

3.1.2 Range Safety Control Center

The following illustrations (Figures 1-5) depict the range safety control center at the Air Force Eastern Test Range.

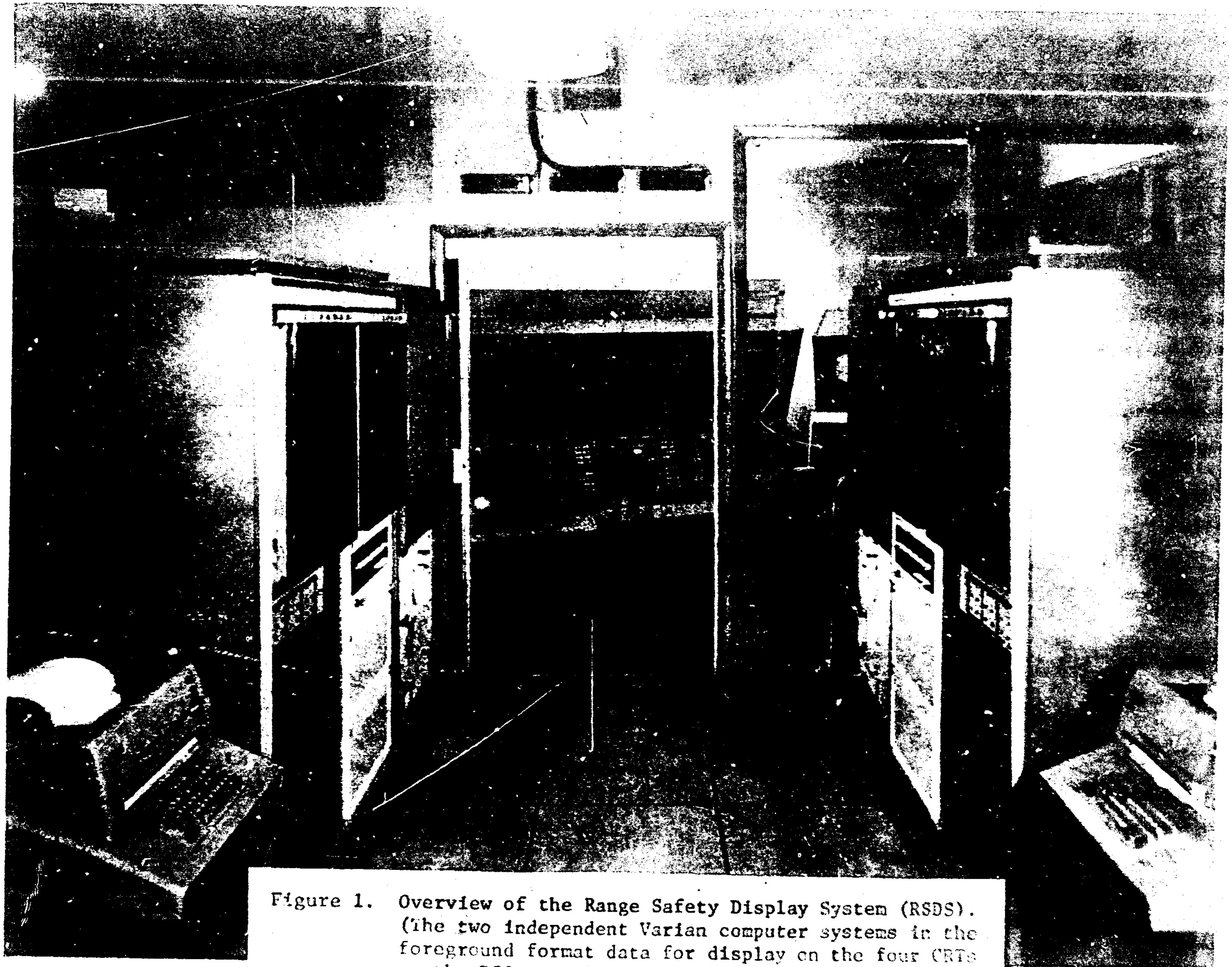


Figure 1. **Overview of the Range Safety Display System (RSDS).** (The two independent Varian computer systems in the foreground format data for display on the four CRTs on the RSO console in the background.)

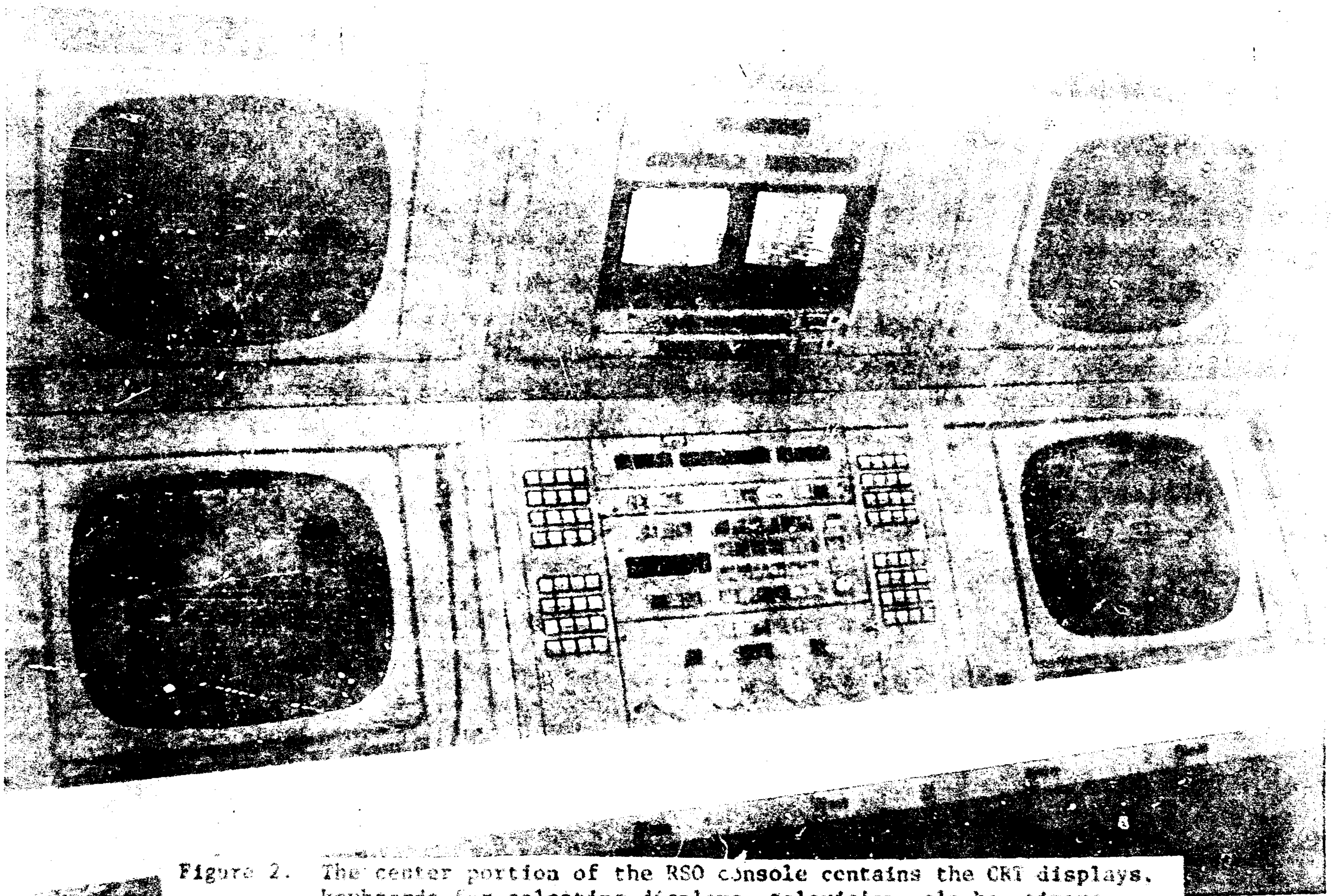


Figure 2. The center portion of the RSO console contains the CRT displays, keyboards for selecting displays, television, clocks, timers, and command system indicators and control switches. The upper CRTs are showing vertical plane projections for the early portion of flight, while the lower CRTS are displaying impact prediction and present position information.

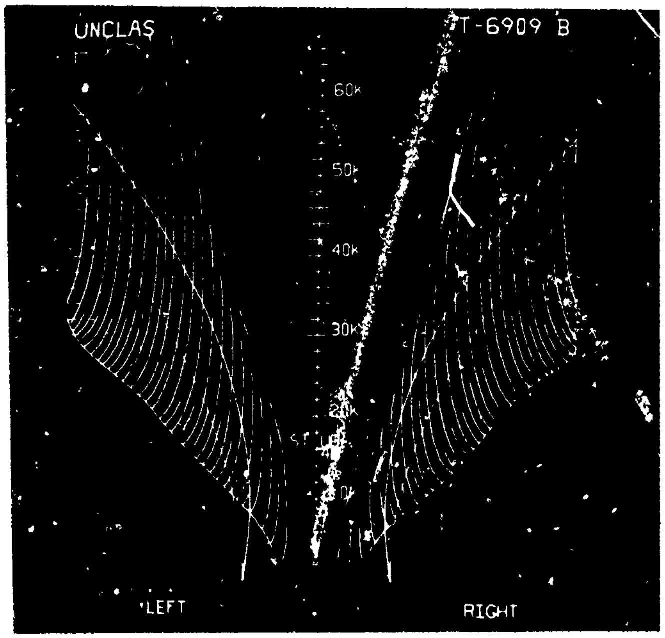


Figure 3a. The RSDS Vertical Plane presentation shows nominal and three sigma high present position trajectories plotted on families of destruct lines. When plotting, primary and/or alternate source data may be selected along with alphanumeric information about the data sources and missile performance.

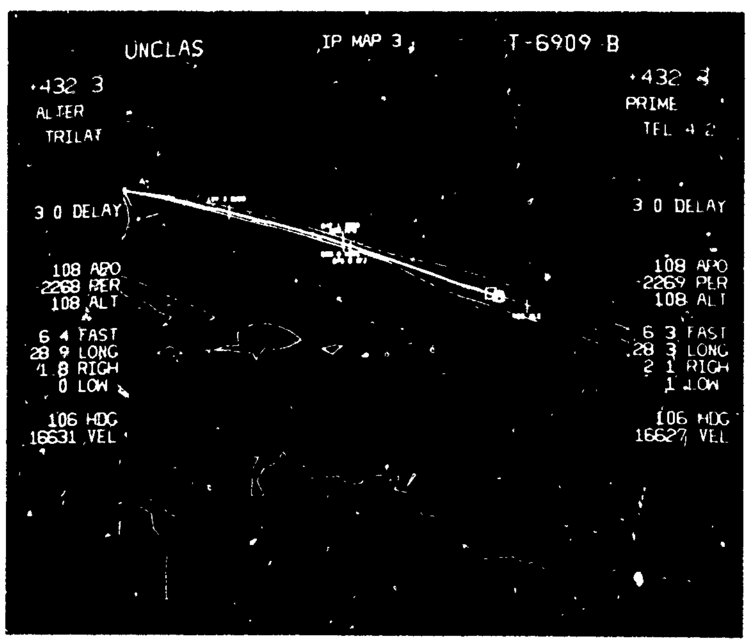


Figure 3b. The Impact Prediction (IP) Map 3 is typical of IP maps available to the RSO and contains destruct lines, nominal missile performance lines, and an outline of land masses, along with alphanumeric information about the data source and missile performance. Present position and velocity vs time plots may be selected to overlay the IP map.

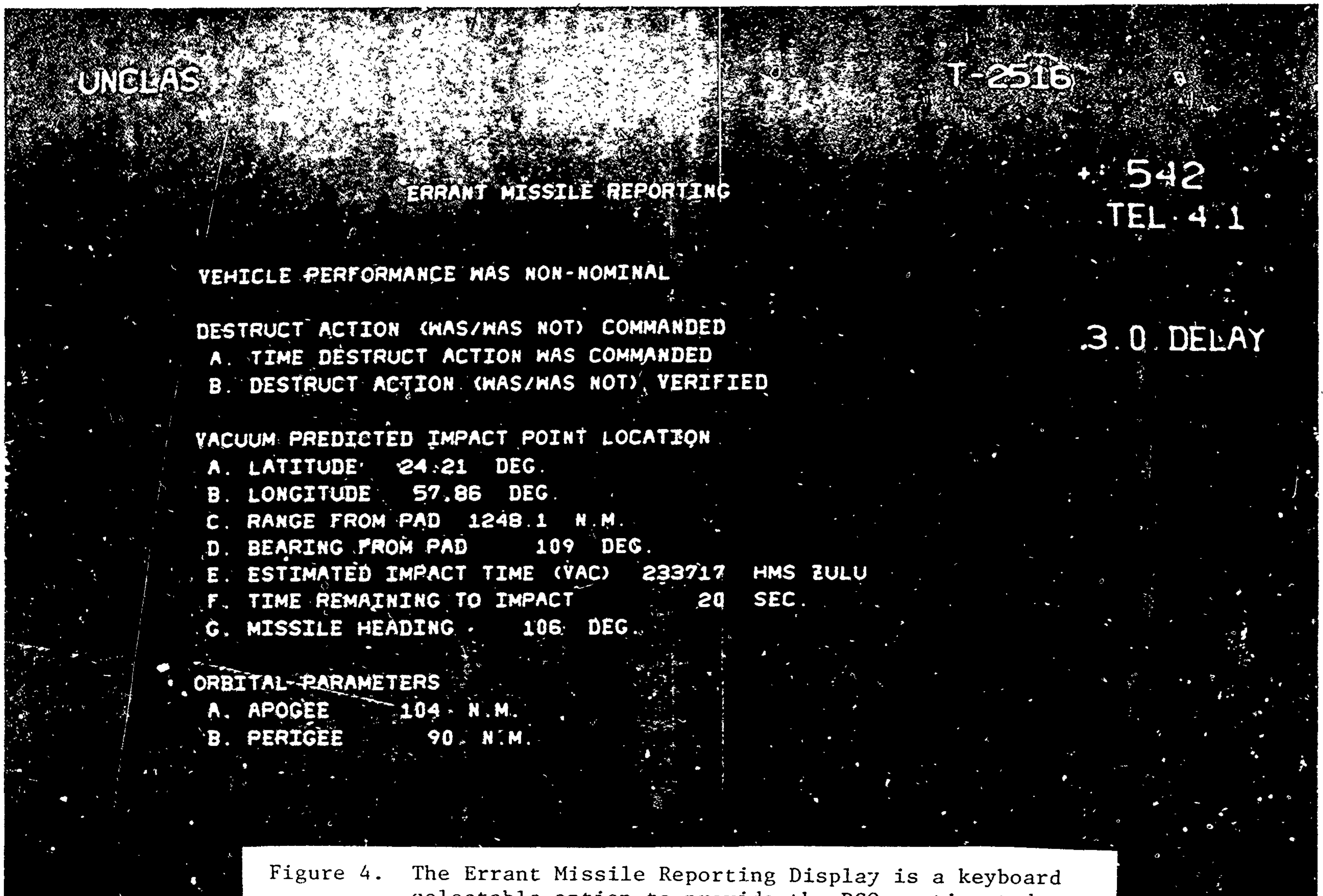


Figure 4. The Errant Missile Reporting Display is a keyboard selectable option to provide the RSO pertinent data to be verbally relayed to the Air Defense Command Launch Correlation Unit and the National Military Command Center.

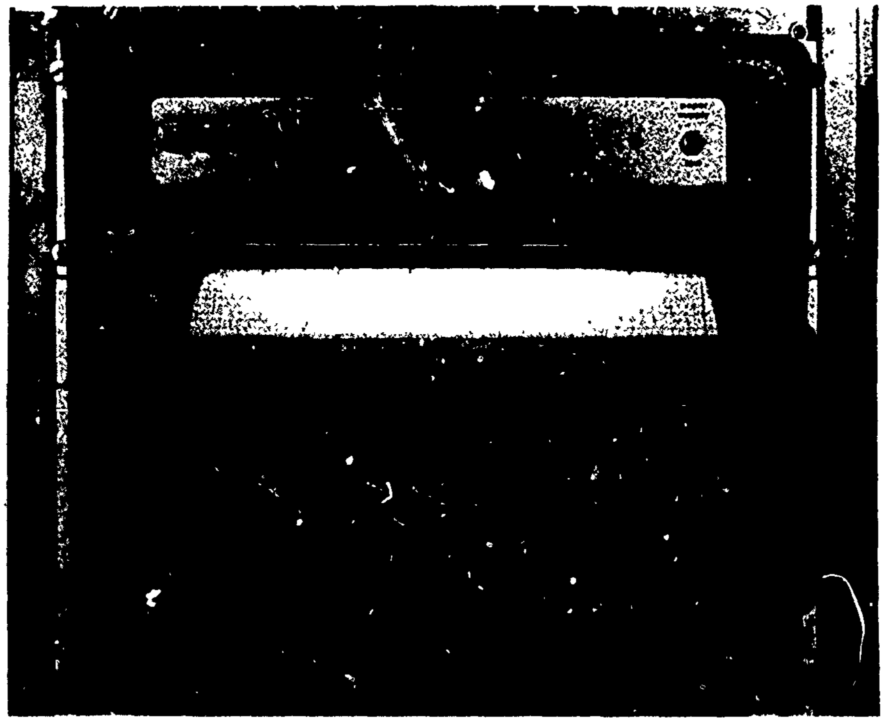


Figure 5. Close-up view of 8-channel telemetry recorder monitored by an assistant RSO.

3.2 Kwajalein Missile Range (KMR)

3.2.1 Summary of Information Presented to Range Safety Officer.

PARAMETERS PRESENTED	DATA SYSTEMS	RATIONALE
Instantaneous Impact Point		
Whole Body	2.a	1
Debris Footprint	2.a	1
Largest Piece of Debris	2.a	1
Present Position		
X vs. Y	2.a	2
Altitude vs. Range	2.a	2
Attitude		
Flight Path Angle vs. Altitude	2.a	2, 3
Velocity		
Time vs. Velocity	2.a	3
Velocity vs. Altitude	2.a	3
Status Indicators		
Predicted Intercept Point	2.a	3
Time Since Launch	2.a	4
Time to Intercept	2.a	4
Missile Stages Ignition and Burnout Condition	2.a	4
Liftoff, Flight Terminated	2.c	4
Automatic/Manual Inhibit of Flight Safety System	2.a	5
Automatic/Manual Destruct	2.a	5
Radar Track	2.c	5
Command Control Transmitter	2.c	5
Automatic/Manual Radar Data Select	2.c	4, 5

3.2.2 Kwajalein Range Safety Data Presentation

Real-time flight safety support at the Kwajalein Missile Range (KMR) is provided by the Kwajalein Range Safety System (KRSS). A block diagram of the KRSS is shown in Figure 6. With the exception of the Cathode Ray Tube (CRT) display system and the Command Control Transmitter (CCT), other

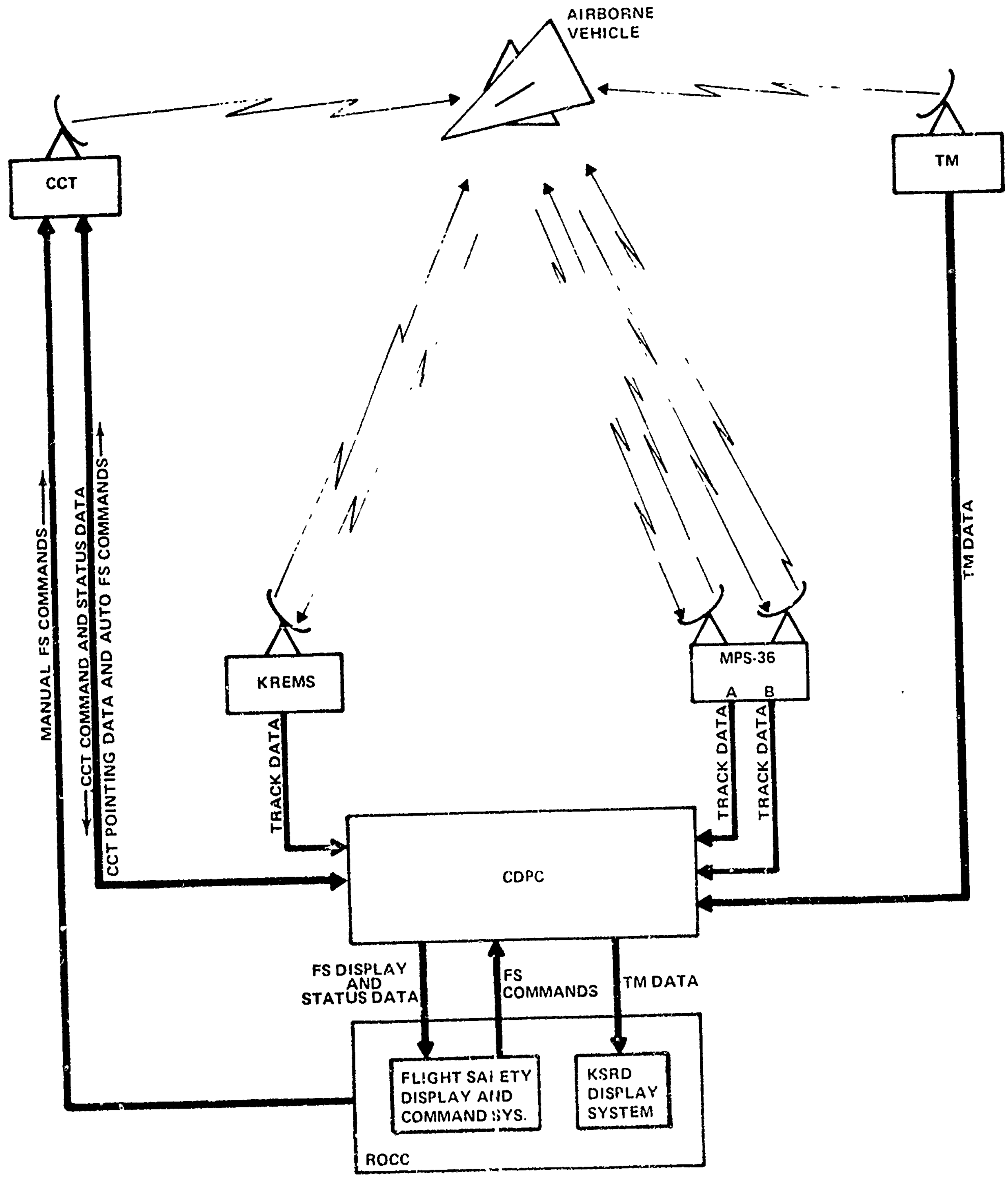


Figure 6. Kwajalein Range Safety System (KRSS) block diagram.

system elements are shared during real-time operations with other range activities. As shown in the block diagram, the system currently employs two AN/MPS-36 radars and the ALCOR radar for tracking data. This data is passed to a CDC-7600 computer for processing and automated safety decisions. The CDC-7600 also passes data to the CRT display system located in the Range Operations Control Center (ROCC) for presentation to the Flight Safety Officer.

The ROCC at KMR is the center for all range safety activities associated with launches either into or from the KMR. Communications and appropriate displays are provided for the Range Safety Officer (RSO) and/or the Flight Safety Officer (FSO) to accomplish clearance of hazard areas, sheltering and evacuation of nonessential personnel and necessary in-flight safety control. In addition to the safety function, the ROCC is the control center for all range instrumentation to include optics, radars and telemetry. Inter- and intra-range coordination is also performed in this center by the Range Control Officer (RCO). A photograph of the ROCC is contained in Figure 7. The Flight Safety Console (FSC) is located on the front row just beneath the countdown clocks and range status indicators.

The FSC(Figure 8) contains two CRT displays, a Command and Status Panel (CSP) and a communications panel. Primary data (e.g., background map of the Kwajalein area, missile present position, instantaneous impact prediction, debris footprint, abort boundaries, various alphanumeric information, etc.) is presented on the right CRT. Secondary data (e.g., range-altitude plot, velocity-time plot, present-position plot and varius alphanumeric status messages) are displayed at the left CRT. The information displayed on the CRT's allows the FSO to monitor the operation of the system during any automatic phase and provides him with all the information necessary to assess missile performance, so that if necessary, a manual destruct action can be taken. During real-time operations, the FSO has the capability of selecting up to four different background scales on the primary display and up to three different scales on the secondary display. During preflight operations, the configuration of these scales with regard to range, altitude and time is selected so that during flight, only the selection of a scale button is required in order to present the particular display desired. In addition, the FSO has the capability to reverse the presentations so that the primary data is shifted to the left CRT and the secondary data to the right CRT.

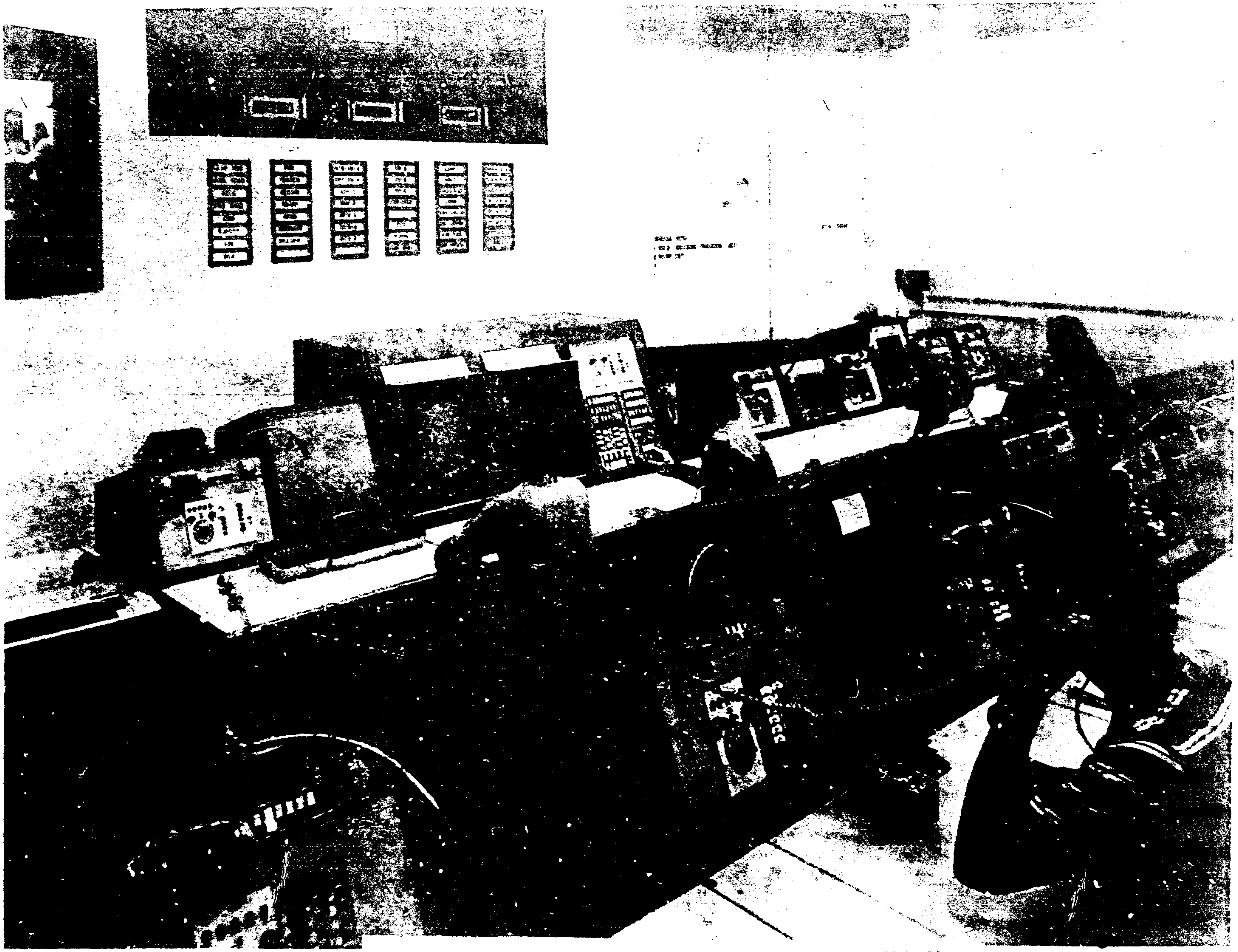


Figure 7. Range Operations Control Center (ROCC).

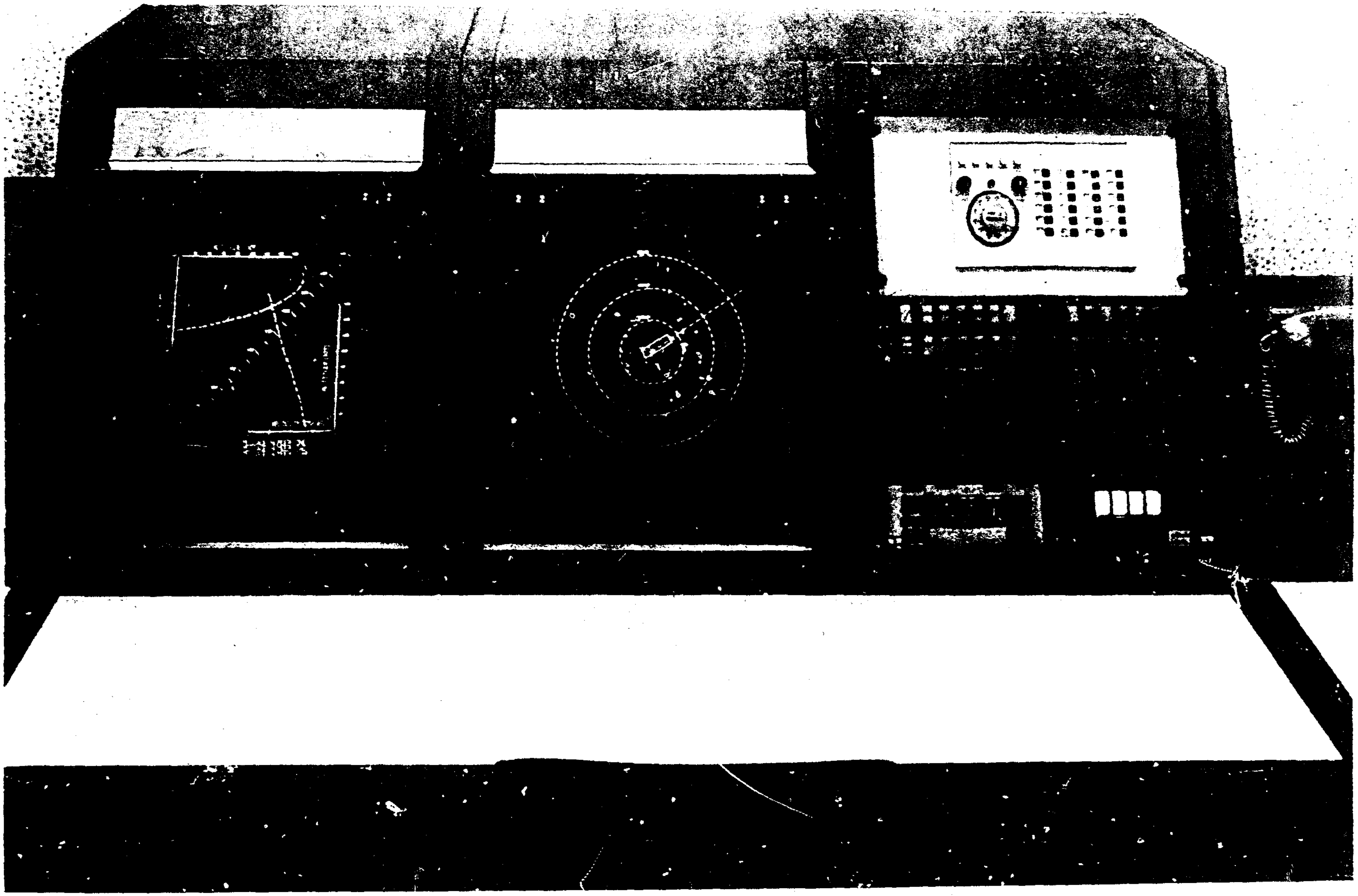


Figure 8. Flight Safety Console (FSC).

In addition to the CRT displays, the CSP on the FSC provides the FSO with control switches and status indicators which interface with the other elements of the KRSS. The layout of the CSP is shown in Figure 9. Status indicators provided include radar track status, CCT status, and missile prelaunch-event sequence. Control switches are available for manual radar-source select, scale select, safety commands, interface with the KRSS software in the CDC-7600, and CCT transmitter radiation control. A typical primary display format for an incoming ICBM launched from Vandenberg Air Force Base is shown in Figure 10. Since the KRSS was designed as a general purpose system to support any conceivable type of mission, considerable emphasis was placed on providing flexibility in the display software design to minimize the effort required to implement display format changes.

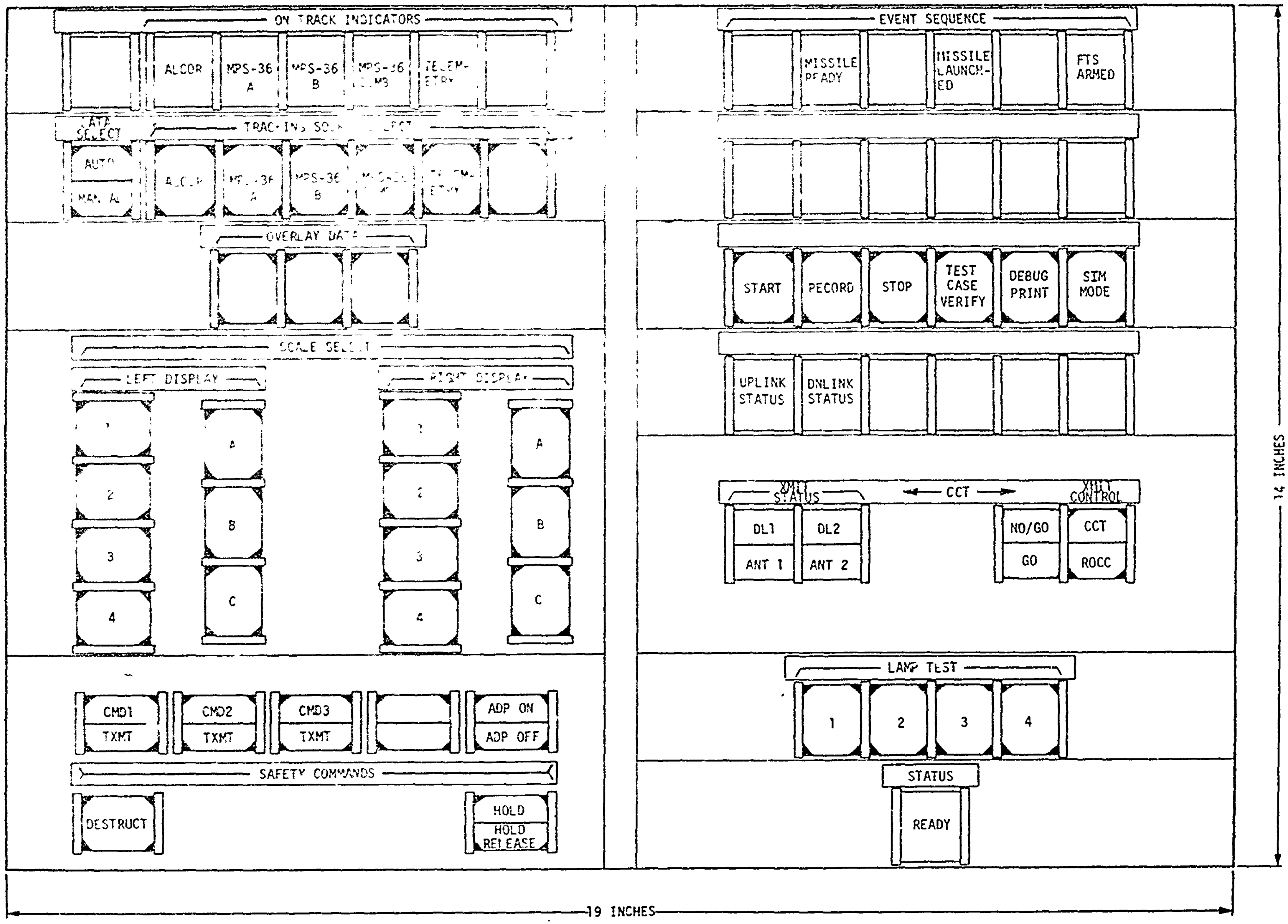
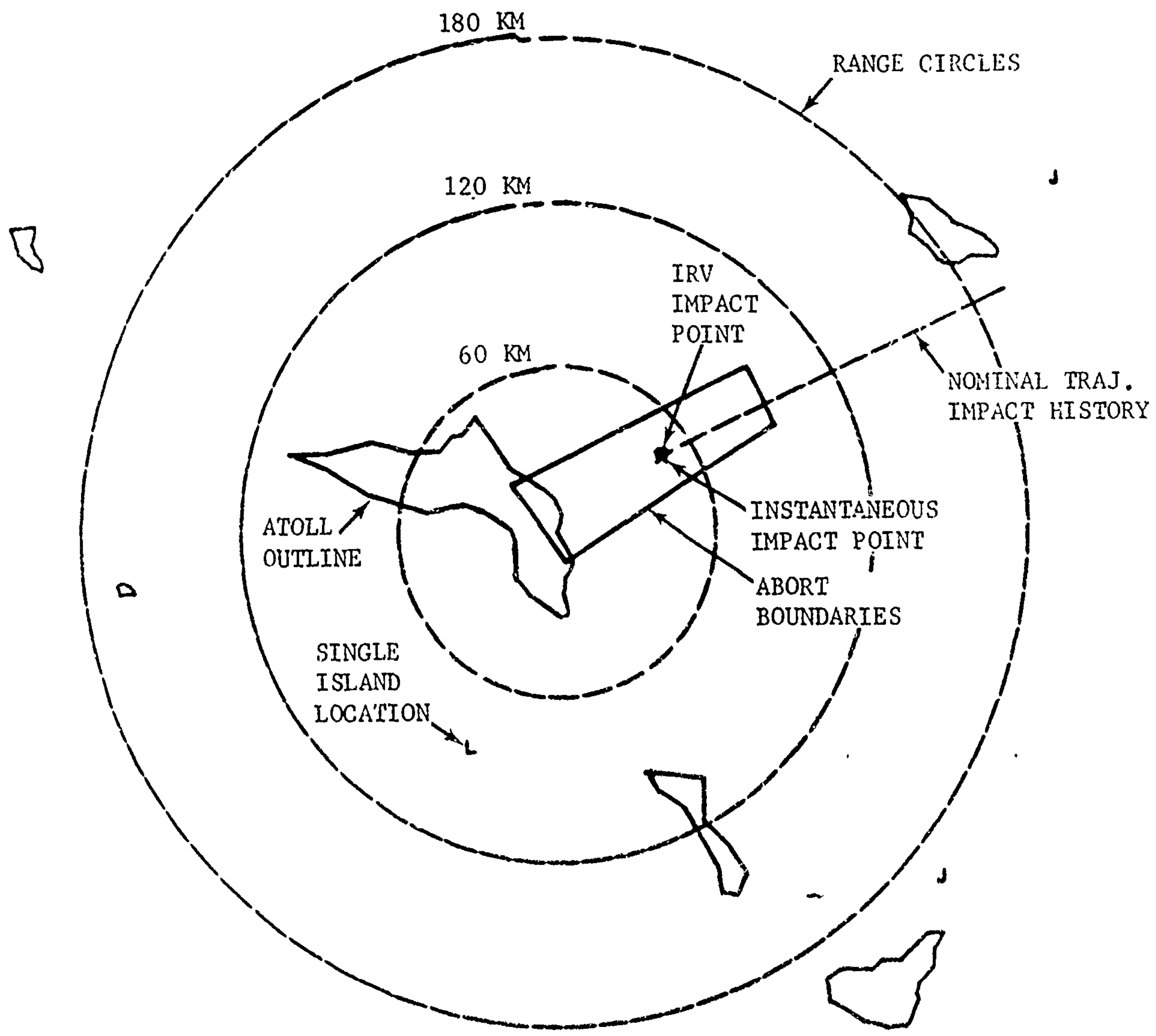


Figure 9. Command and Status Panel (CSP).



CRT PRIMARY MAP DISPLAY (SCALE #2 - 1 IN. ≈ 60 KM)

Figure 10. Typical primary display format for an incoming ICBM launched from VAFB.

3.3 Pacific Missile Test Center (PMTC)

3.3.1 Summary of Information Presented to Range Safety Officer.

PARAMETERS PRESENTED	DATA SYSTEMS	RATIONALE
Instantaneous Impact Point (IIP)		
Vacuum IIP	1.a	1
Drag and Wind Corrected IIP	1.a	1
Present Position	1.a	2
Velocity		
Total	1.a	3
Component (Radar Data)	1.a, 3-1b	3
Component Velocity to be Gained from Guidance T/M	1.a	3
Acceleration	3-1b	3
Attitude		
Yaw Rate	1.a, 3-1b	3
Status Indicators	2.b, 2.c	4, 5
(Status of instrumentation system, program option selected, time)		
Radar Boresight TV Picture	4	3, 5
Fixed TV	4	3
Narrative from Observer at Sky-screen	3	2

3.3.2 Range Safety Control Center

The Pacific Missile Tester Center currently operates Range Safety Control Centers at Point Mugu and in the Range ship USNS WHEELING. This section discusses only the WHEELING system.

3.3.3 The Range Safety Control Center in the USNS WHEELING

Figure 11 shows the Range Safety Control Center in the USNS WHEELING. Five-30" x 30" vertical plotting boards are used to display IIP information and missile present position. At the right foreground may be seen the console which contains two-11" x 17" plotting boards and the Missile Flight Safety

Figure 11. Range Safety Control Center in the USNS WHEELING.

Officer's panel. The plotting boards are normally configured as follows: the first board on the left will contain the long range IIP based on data from radar, showing the entire IIP trace from launch point to impact point. The middle three boards contain two IIP presentations, one based on radar and one based on telemetry (the radar/telemetry composite IIP). The second board shows the launch area and the first portion of flight. The third board shows the middle portion of the flight, particularly a blown up area through the most hazardous portion of flight. The fourth board is the terminal IIP chart with the final portion of the flight out to final stage impact. The fifth board on the far right is used to display missile present position in an XY plot and an altitude versus range plot. The two small boards in the console are used as secondary sources. Both boards are equipped with a single arm and two pens. The board on the right, nearest to the Missile Flight Safety Officer's position, is used to plot total missile velocity from radar data and missile telemetered guidance velocity-to-be-gained downrange versus time of flight. On the second small plotting board, missile cross range velocity-to-be-gained from guidance telemetry and missile yaw rate from analog to telemetry are displayed versus time of flight.

3.3.4 Missile Flight Safety Officer's Console

Figure 12 shows a close-up of the Missile Flight Safety Officer's console showing the two plotting boards described earlier and the Missile Flight Safety Officer's communications panel, on the right, which includes circuit select buttons for the various circuits both within the ship and the outside radio circuits. It includes buttons which are used to change the mode of operation of the radar telemetry composite IIP system (a re-initialize button and one to rule out radar data to allow IIP to go on the basis of telemetry alone). It also includes status lights to indicate the red or green status of the radars and telemetry and other components of the instrumentation system. The missile destruct panel is located in the horizontal portion of the console on the right-hand side and includes the transmitter control functions, the manual arm and destruct buttons, the control-over-computer automatic-abort system and key CDT system monitor lights.

3.3.5 A Typical PMTC Instantaneous Impact Point (IIP) Presentation

Figure 13 is a representation of a typical IIP chart where the radar IIP is on one side and the telemetry composite IIP on the other side. The nominal trajectory is shown going

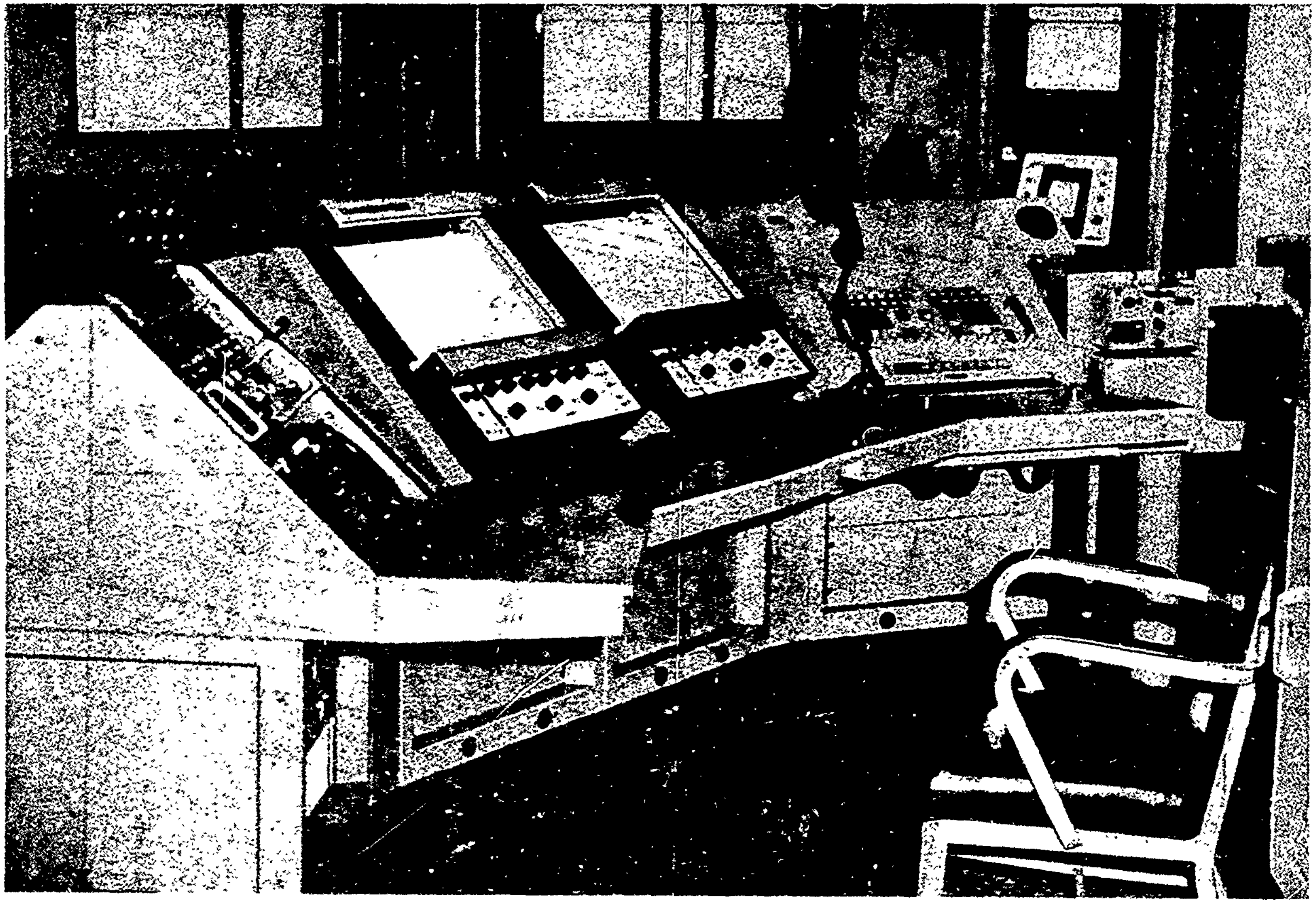


Figure 12. Missile Flight Safety Officer's console.

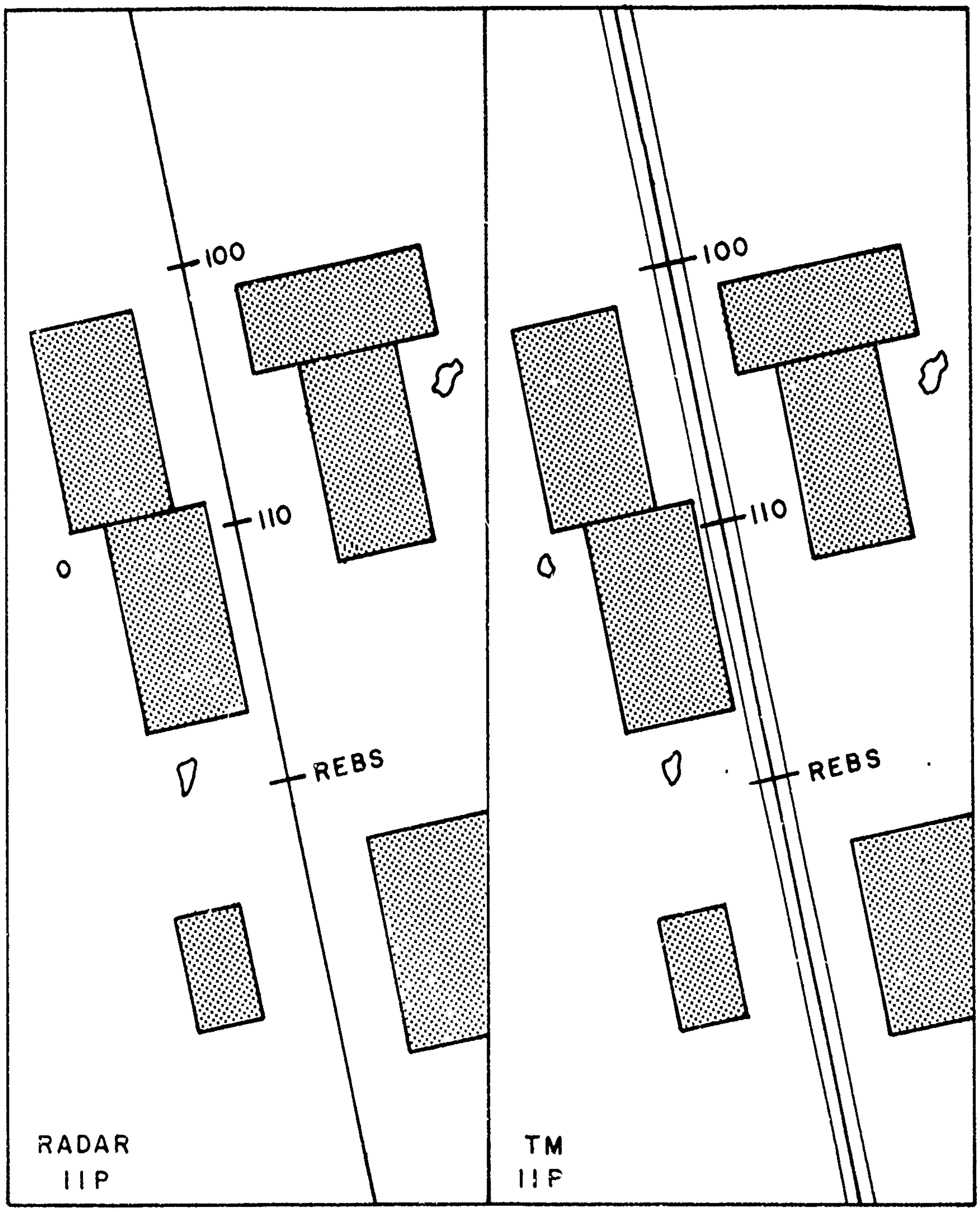


Figure 13. Typical PMTC IIP presentation.

from top to bottom with timing marks, in seconds, and the reentry body separation point. The cross-hatched areas are representative of typical automatic-abort areas. If the IIP goes into one of these areas and the computer is enabled, a destruct or thrust termination function is sent automatically. The two lines parallelling the nominal IIP trace on the TM side of the chart are lines to indicate the point at which TM data may become invalid on a rapidly tumbling missile due to the guidance platform hitting the gimbal stops. The Missile Flight Safety Officer has the capability of simultaneously monitoring the two IIP presentations to see if the data from telemetry and the data from radar agrees. In addition to the data displayed directly to the Missile Flight Safety Officer, three narratives are provided. The launch phase is described by the Assistant Missile Flight Safety Officer at the launch site. When telemetry data is received a missile analyst monitors this data and provides continuous commentary on missile performance by voice circuit. A safety analyst, stationed to the Missile Flight Safety Officer's left, monitors shipboard instrumentation voice nets and provides inputs on tracking equipment performance as necessary.

3.4 • Space and Missile Test Center (SAMTEC)

3.4.1 Summary of Information Presented to Range Safety Officer.

PARAMETERS PRESENTED	DATA SYSTEMS	RATIONALE	
Instantaneous Impact Point			
Latitude vs. Longitude	1.a	1	
Present Position			
X vs. Y	1.a, 3	2	
Range vs. Altitude	1.a, 3	2	
Velocity			
Earth Relative Total	1.a	3	
Acceleration			
Accelerometer Info.	1.b, 3	3	
Attitude			
Yaw, Pitch, and Roll Rate	1.b	3	3
Missile Back Azimuth	3, 4	3	
Missile Program	3, 4	3	
Status Indicators			
Thrust Chamber Pressure	1.b, 3	3	
Command Destruct Receiver Automatic Gain Control	1.b, 3	5	
Stage Jettison Function	1.b, 3	4	
Engine Pitch, Yaw & Position	1.b, 3	3	
Thrust Vector Controls	1.b, 3	3	
Auto Abort Status Indicators	2.c	5	
Arm, Destruct, Thrust Termination Sent	2.c	5	
Time from Liftoff	2.c	4	
Tracking Source Indicators	2.c	5	

3.4.2 Missile Flight Control center

The SAMTEC Missile Flight Control Center is contained in the integrated Test Operations Control Center and is the nucleus for Range Missile Control at Vandenberg AFB. Computers, display systems, and communications are all focused at one point for the specific purpose of providing information to the Missile Flight Control Officer (MFCO) during a missile flight. A block diagram of the Real-Time Missile Flight Safety System is depicted in Figure 14. All consoles are duplicated to allow simultaneous countdown of two missiles. There is only one set of 8 plotting boards, however.

The configuration of the SAMTEC Missile Flight Control Center can be seen in Figure 15. The MFCO, Real-Time Data Controller (RTDC) and Command Transmitter Controller consoles (see Figures 16, 17 and 18) establish a basis from which the performance of both the inflight missile and the Flight Control System can be monitored. During the mission, the status and quality of the data sources are constantly monitored to insure that the best combination of sources is being selected. This selection is usually a computerized operation; however, the RTDC has manual override if desired.

The real-time information is presented to the MFCO in several forms. The missile's present position, instantaneous impact point (IIP) and velocity are displayed on vertical plot boards, as can be seen in the background of Figure 15. Due to the range of missiles being launched from Vandenberg AFB, it is necessary to use individual plot boards to display specific areas along the flight trajectory. These vary from the launch area and short range plots to the long range and terminal area plots. In real time, the missile's performance is compared to a nominal prediction and its present position and instantaneous impact point are constantly monitored to insure no destruct boundaries are violated. During most launches a manual control system is relied upon, since the response time of the MFCO is sufficient to provide the necessary protection. However, on certain missions the terminal velocity is very high and the IIP is moving at a high rate. The human response time is sometimes too slow to assure reasonable inflight control during this portion of flight and an automatic control system is relied upon. The MFCO has the ability to choose the automatic system or to continue manually.

In addition to the plot boards, closed circuit television is used to monitor the early portion of flight to insure normal operation. Weather conditions and range clearance are also observed with television. Additional displays include status indicators presenting information regarding the GERTS track mode, PBV burns, digital countdown, ZULU and local time. During a launch, constant communication is maintained with Missile Flight Control personnel monitoring telemetry data on strip charts.

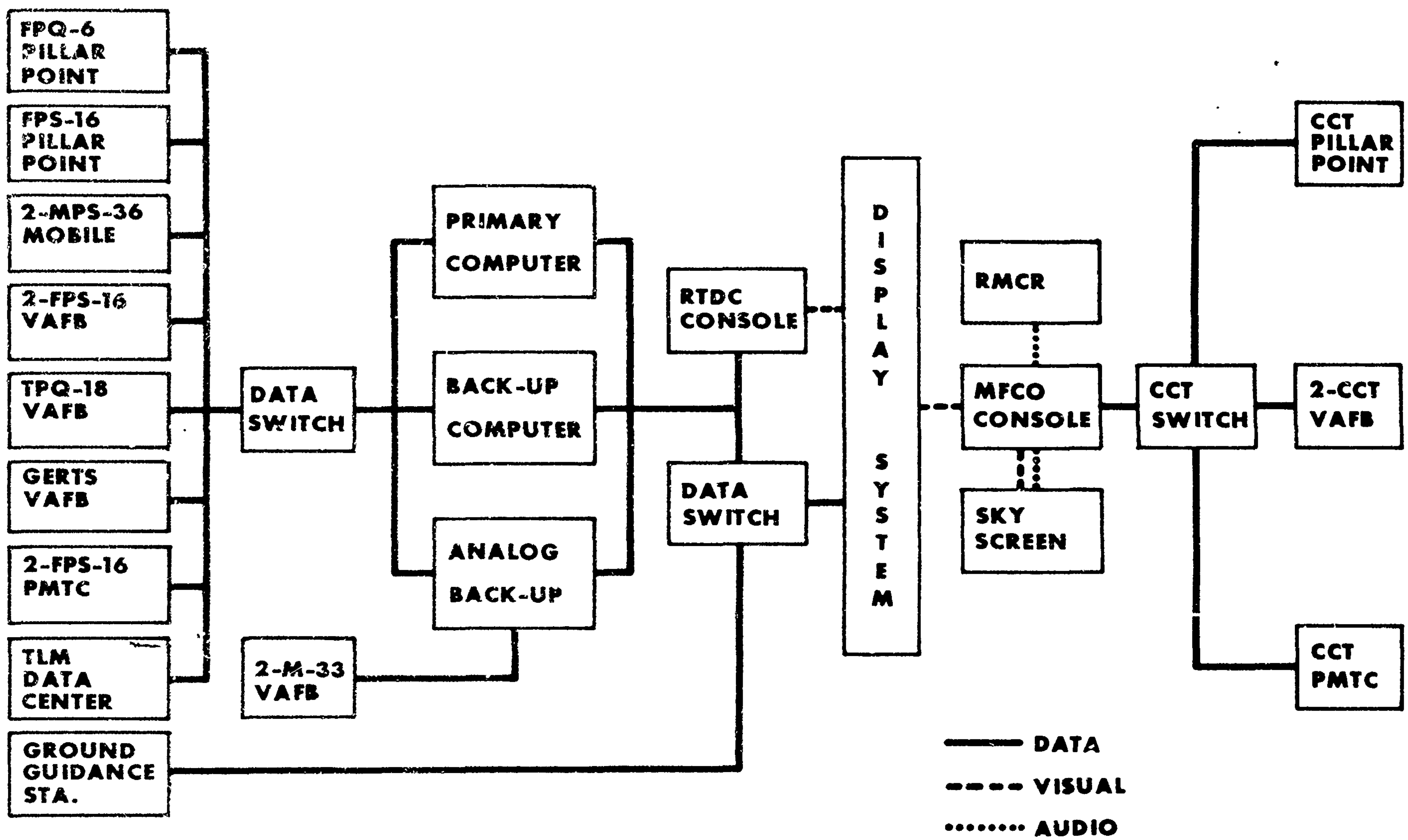


Figure 14. Real-Time Flight Safety System.

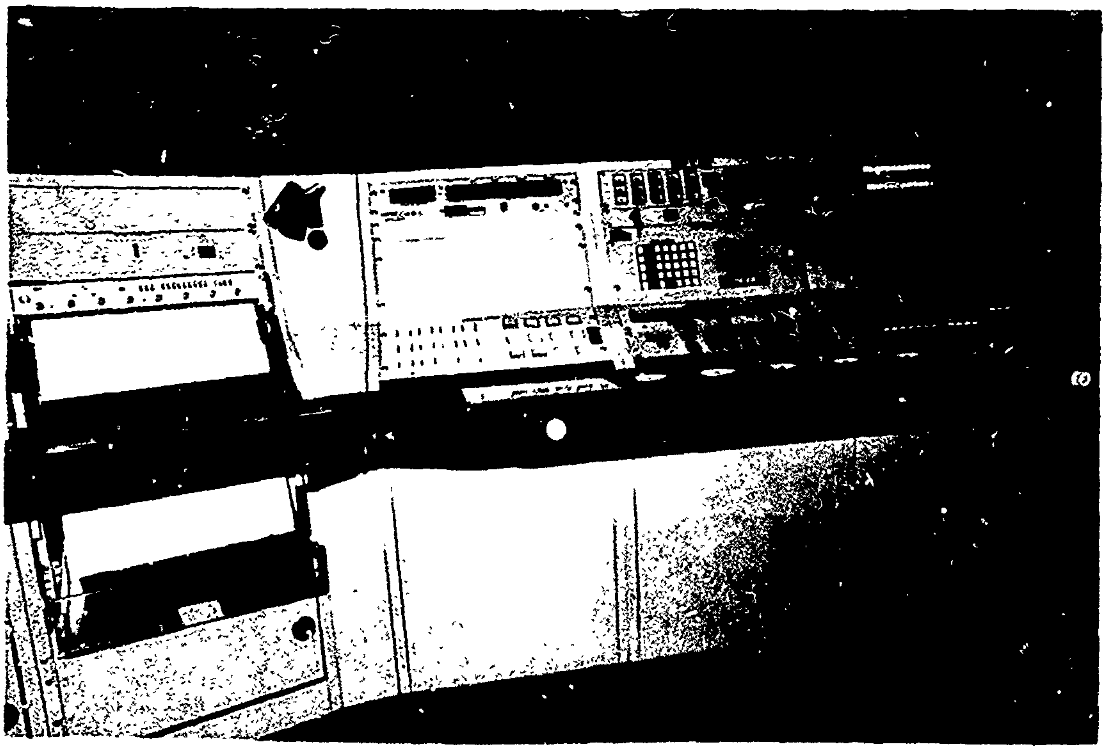


Figure 15. SAMTEC Missile Flight Control Center.

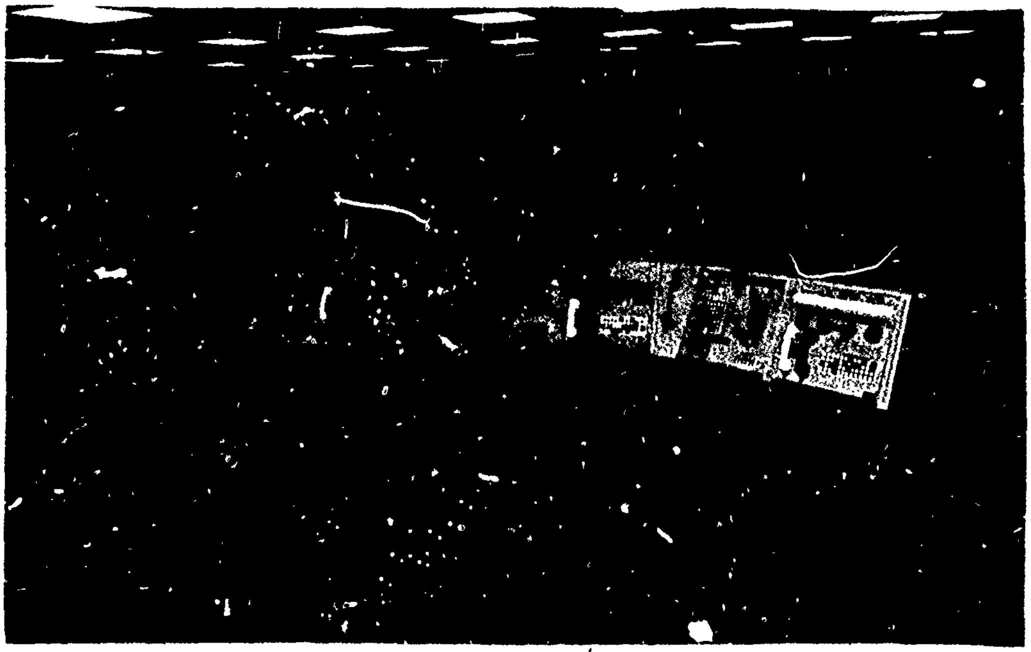


Figure 16. Missile Flight Control Console. There are two duplicate consoles in the Missile Flight Control Center. On the left is the 8-channel strip chart recorder for the display of telemetry data. The right panel is the communications panel. In the center are the status indicators. The command function switches are located on the lower right panel.

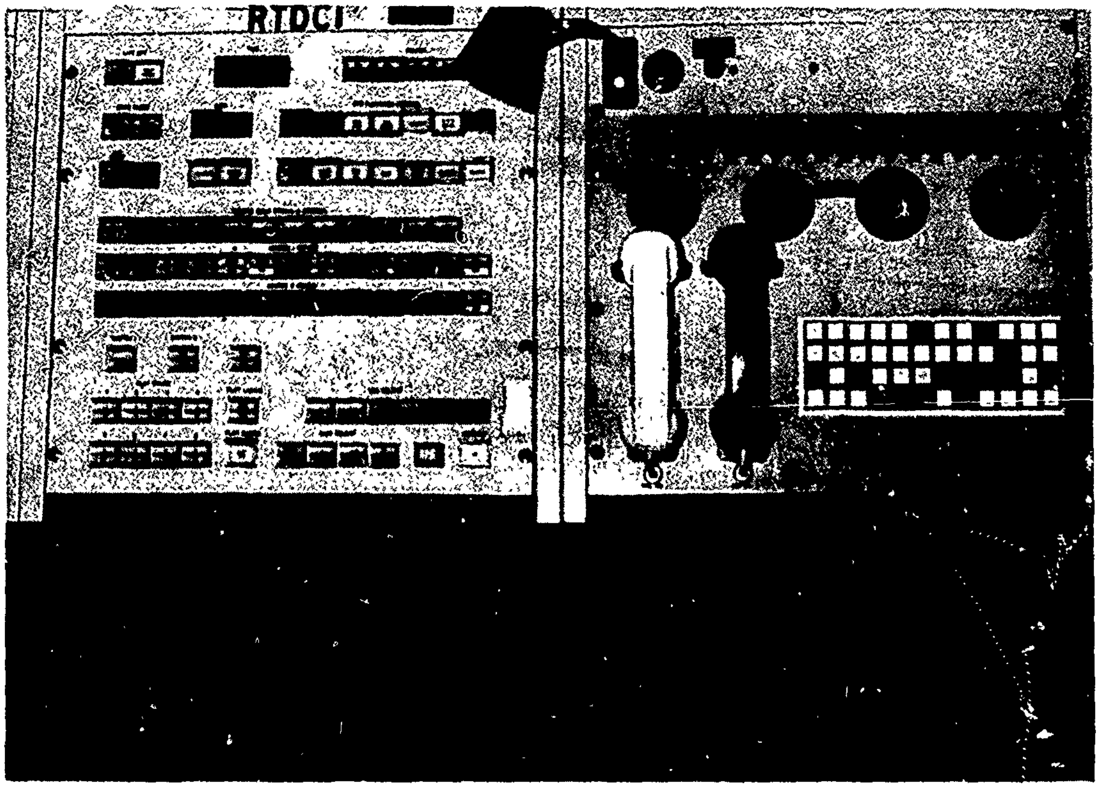


Figure 17. Real-Time Data Controller Console.

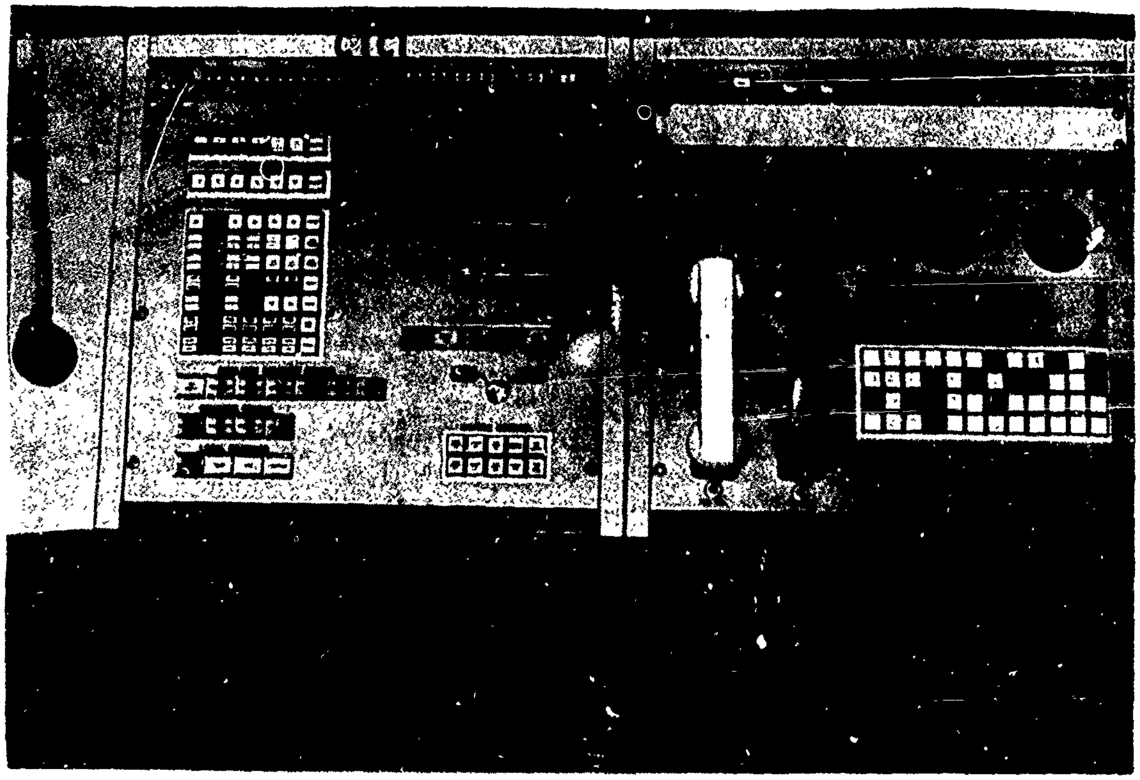


Figure 18. Command Transmitter Controller Console.

(Figures 17 and 18. There are two duplicate consoles in the Missile Flight Control Center. Communication Control is located on the right panel. The left panel contains all data quality indicators and control functions.)

3.4.3 Prototype Range Safety Display System

Currently the range safety display consists of vertical ink pen plotboards which indicate the present velocity, position and predicted impact point. The MFCO must remember and mentally correlate preflight studies of the vehicle flight characteristics and wind conditions with real-time present position and impact predictions to determine if a vehicle is a threat.

New computer capabilities which are nearing completion will provide dynamic range safety data which cannot be plotted on a plotboard, thus requiring CRT. These data will be composed of predicted impact points from multiple radars to help discern good from bad radar data, a dynamic nominal missile performance envelope, a drag corrected impact prediction area, a debris pattern footprint for destroyed vehicle parts and alphanumeric data. A CRT display will allow for current wind conditions to be used instead of statistical wind profiles in the abort criteria. A CRT will allow a smooth change of scale on one screen rather than the current abrupt scale factor change when sequencing through several plotboards.

A prototype Range Safety Display System (RSDS) has been installed for testing to define the final operational display system requirements. Figure 19 depicts the RSDS block diagram. Figure 20 is a photograph of the prototype hardware. During prototype testing, the Backup Impact Data System (BIDS) operating on the CDC 3300 computer will compute multiple impact predictions and present positions and velocities for display on the RSDS. A debris pattern which is conceptually depicted in Figure 21, is also computed in BIDS for display. (See AIAA Journal of Spacecraft and Rockets, May 1976, for debris pattern methodology.) Figure 22 is a typical CRT display to be used in the early launch phase for SAMTEC missions. The left display contains a dynamic, normal-vehicle, dispersion envelope preprogrammed from the nominal and 3σ dispersed trajectories. Impact predictions are displayed from multiple sources and visually compared with the normal performance envelope. Comparison of individual IIP sources will allow the identification and deselection of tracking systems which are providing invalid data. Agreement of multiple sources will provide assurance of valid data. As long as all impact predictions remain within the dispersion envelope, the MFCO can be assured that all systems including the vehicle are performing normally. Agreement between sources, deviating outside of the dispersion envelope, would indicate that the vehicle is performing abnormally but not necessarily in a dangerous manner. When the impact prediction violates an abort line, the MFCO must make a decision to (1)

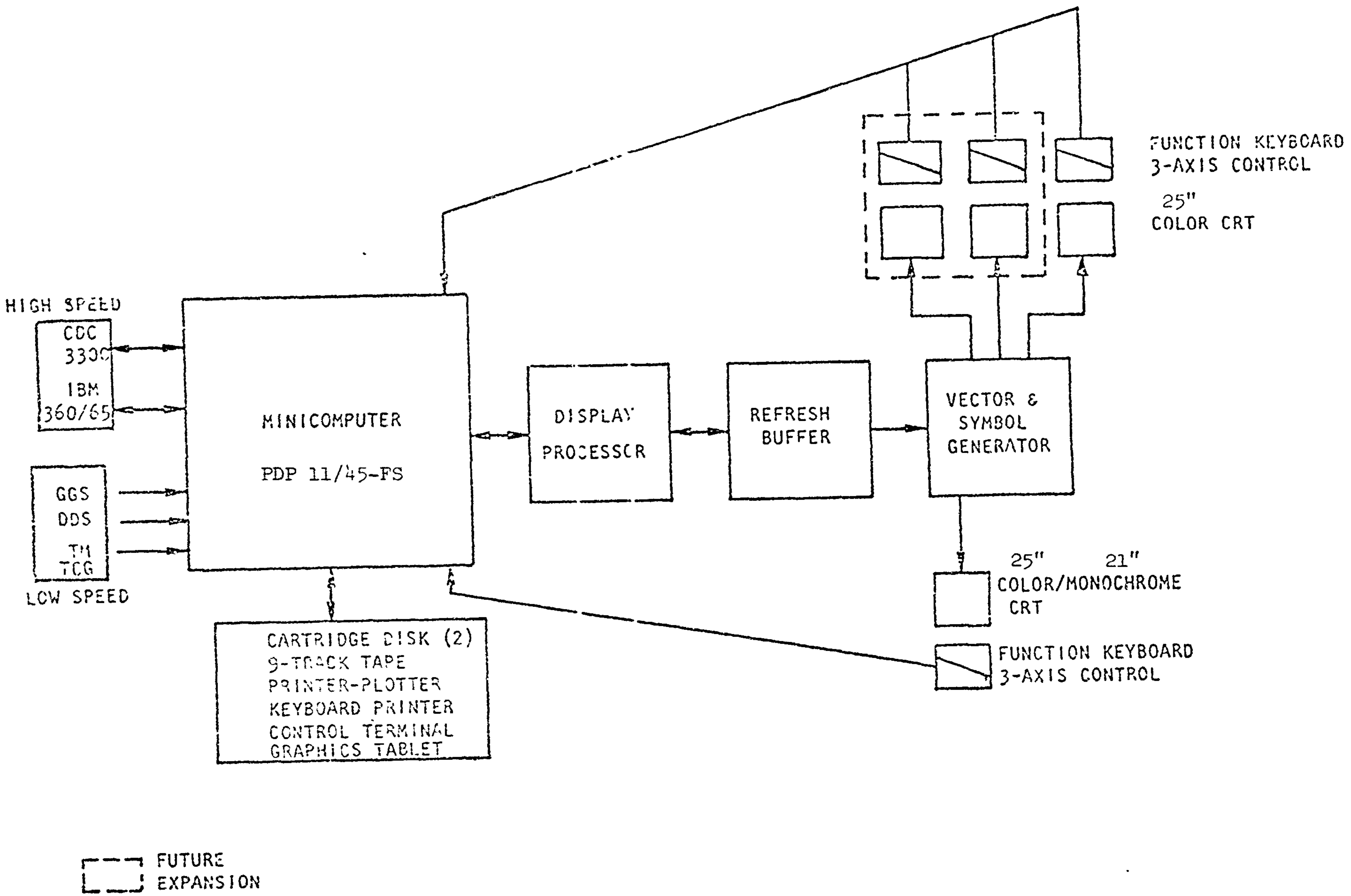


Figure 19. Range Safety Display System (prototype).

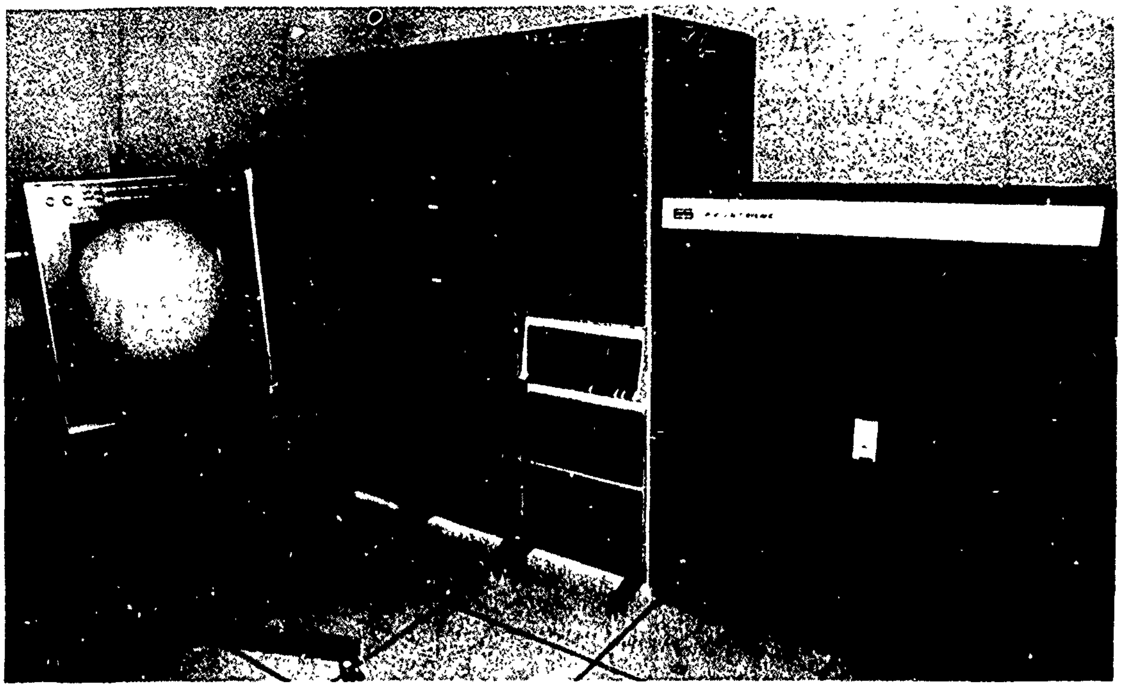


Figure 20. Prototype Range Safety Display System Hardware.

(The Evans and Sutherland Picture System is shown on the right. The next rack contains the PDP-11/45 computer. Next to the computer are racks containing disk and tape drives. The CRT is a 21-inch black and white. The four 25-inch color CRTs are not shown.)

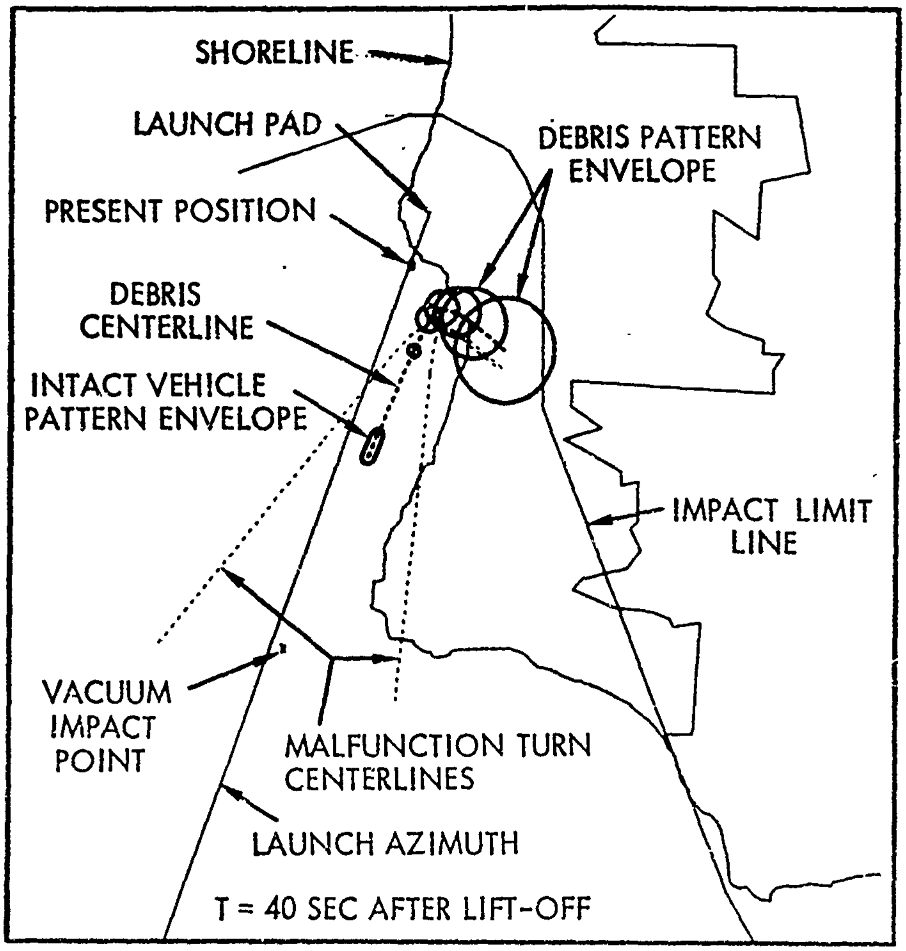


Figure 21. Debris Pattern Concept.

T+110.0

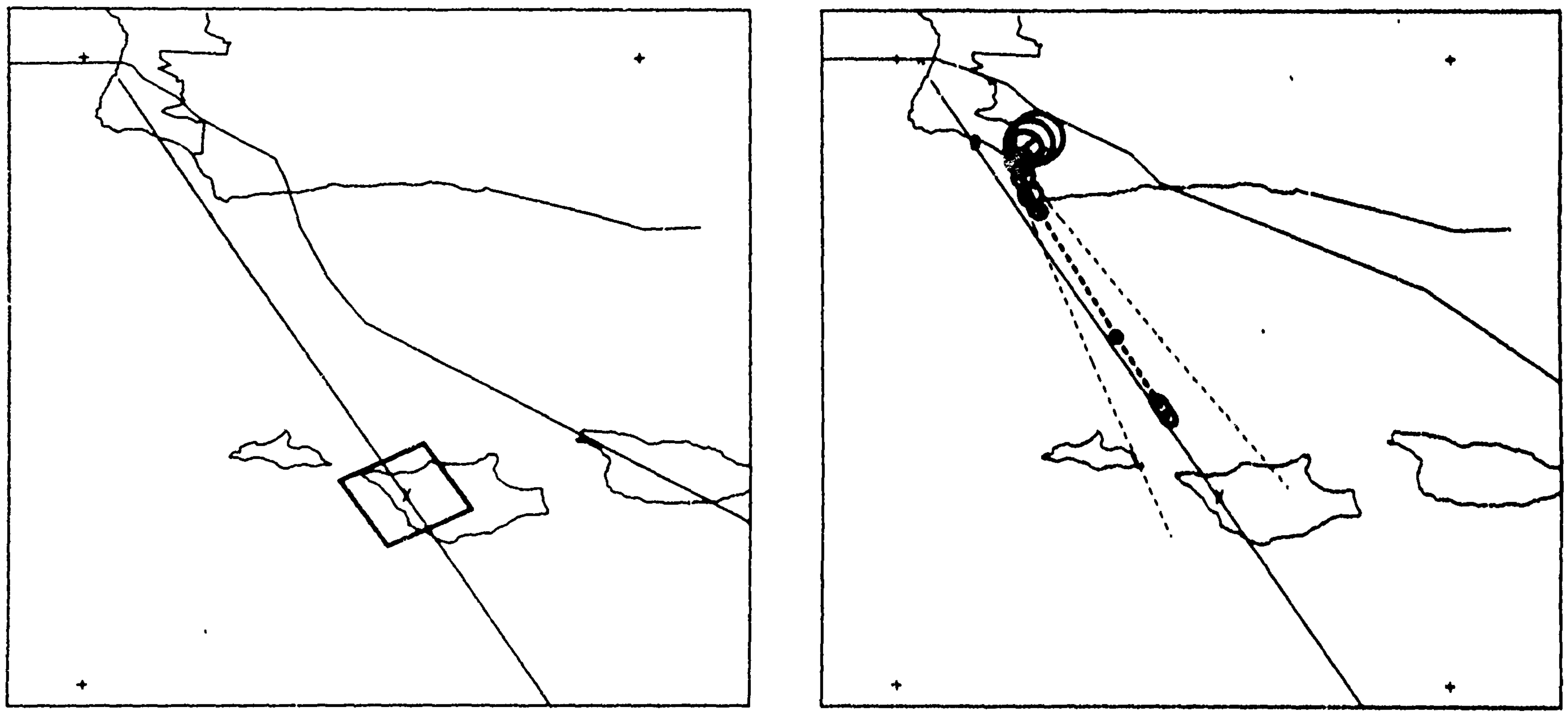


Figure 22. Typical Debris Pattern Display.

send fuel cut-off, (2) send destruct, or (3) delay sending functions until the situation either improves or further degrades. This decision is made based upon displayed information indicating: (1) the area in which intact vehicle will be expected to fall if he sends fuel cut-off, (2) a number of circles, the envelope of which defines the area in which fragments will be expected to fall if he sends destruct, and (3) the additional area which could be threatened if he delays sending functions for a given time (i.e., 3 seconds). Analysis of the use of the debris pattern for decision making indicates that decisions based upon vacuum impact prediction violation of an abort line usually result in functions being sent earlier than necessary due to the conservatism which must be built into the abort lines. Exceptions result from launching under wind conditions more severe than those used in development of the abort lines or from launching near to or over population centers.

Prototype testing will allow trade-offs in terms of display formats, additional display concepts, evaluation of various displays by MFCO and human engineering testing. The results of these tests will then be used to define the requirements for the operational display system. Most of the prototype system will be usable in the operational system with augmentation to eliminate single point failures which could cause system failure.

3.5 NASA-Wallops Station

3.5.1 Summary of Information Presented to Range Safety Officer

PARAMETERS PRESENTED	DATA SYSTEMS	RATIONALE
Instantaneous Impact Point		
PHIB - Longitude of Impact	1.a, 2.b	1
PHIPR - Longitude of Impact (PHIB) Predicted	1.a	2
THAB - Latitude of Impact	1.a, 2.b	1
THAPR - Latitude of Impact (THAB) Predicted	1.a	2
DRIIP - Distance to IIP	1.a, 2.b	3
PERGEE - Perigee of Trajectory Ellipse	1.a, 2.b	2
Present Position		
Skyscreen	3	2
Flat Earth Altitude	1.a, 3	2
Flat Earth Ground Range	1.a, 3	2
Flat Earth Distance East-West and North-South	1.a, 3	2
HBN - Altitude Above Spherical Earth	1.a, 2.b	2
DRDIS - Horizontal Range; Length of Ground Trace Relative to Launch Pad on Round Earth	1.a, 2.b	2
PERGEE - Perigee of Trajectory Ellipse	1.a, 2.b	2
UPN - U, East Positive Relative to Launch Pad	1.a, 2.b	2
VPN - N, North Positive Relative to Launch Pad	1.a, 2.b	2
WPN - W, Up Positive Relative to Launch Pad	1.a, 2.b	2
Velocity		
Velocity	1.a, 3	3
Flight Elevation (velocity component)	1.a, 3	3
Flight Azimuth (velocity component)	1.a, 3	3
GAMB - Bearing-Famy; Azimuth of Ground Trace-Flight Azimuth	1.a, 2.b	3
GAMY - Flight Azimuth; Azimuth of Round Earth Velocity Vector	1.a, 2.b	3

PARAMETERS PRESENTED	DATA SYSTEMS	RATIONALE
GAMP - Flight Elevation; Elevation of Round Earth Velocity Vector	1.a, 2.b	3
Acceleration (computed from Telemetry)	1.a, 1.b, 3	3
Attitude (computed from Telemetry)		
Pitch Program	1.a, 1.b, 3	3
Displacement (Pitch, Yaw, Roll)	1.b, 3	3
Rates (Pitch, Yaw, Roll)	1.b, 3	3
Orbital Elements		
APOGEP - Apogee of trajectory ellipse (predicted)*	2.b	3
PERGEP - Perigee of trajectory ellipse (predicted)*	2.b	3
Status Indicators		
Command Destruct Receiver Signal Strength	1.b, 3	5
Command Destruct Receiver Monitor Channel	1.b, 3	5
TRSØ - Elapsed Time in Seconds from Liftoff	1.a, 2.b	4
TGSTG - Time Until Next Staging	1.a, 2.b	4
VGAIN - Flat Earth Velocity to be Gained Before Next Staging Event	1.a, 2.b	3
Command Destruct System	2.d, 3	5
Error Analysis Parameters		
ERRIIP - Area of IIP Ellipse	1.a, 2.b	5
QTMIKE - Velocity Covariance of Best Radar	1.a, 2.b	5

*The orbital elements are predicted ahead and may predict over additional vehicle performance periods assuming nominal performance for those which have not occurred.

3.5.2 Range Safety Control Center

Figures 23 - 27 show the Wallops Station Control Center, the Range Safety Console, and some of the display devices used by the Range Safety Officer (RSO). The survey board for keeping track of marine traffic in the vicinity of Wallops Island (Figure 23) is updated manually and is primarily used before vehicle launch. Figure 24 shows the ceiling displays and radar and computer plotting boards. Figure 25 depicts the Datanet 706 remote terminal and CRT display device. This device is used for prelaunch wind compensation and is tied directly to the computer system.

The Wallops Control Center is the control point for all launches conducted at Wallops Station. This center provides consoles for the test director and his assistants, project engineers, experimenters, radar supervisor, and range safety personnel. As can be seen from Figures 26 and 27, the RSO has numerous display devices which can be used to assist in the determination of vehicle trajectory. Numerous plotboards from the various radars and the computer provide information on the present position, velocity, and predicted impact of the vehicle. Digital displays present more accuracy for the vehicle's flight heading and velocity as well as predicted impact. Television monitors provide early optical information on performance. The Range Safety Console contains monitors, communications networks, radar, computer and trajectory status indicators as well as the necessary devices for destruct or disarming of a vehicle.

The Range Safety function at Wallops is accomplished by the RSO and his assistant located in the Range Control Center. In addition, other range safety support personnel are located at strategic sites. Such sites are the computer center, radar facilities, telemetry facilities, skyscreens, launch complex, etc. All of these representatives are in constant communication with the RSO by a closed communications network. All decisions remain with the RSO in the Control Center. In addition, some redundant computations on the vehicle's position and velocity are performed with other computers to assume minimum loss of information should the main computer system fail during vehicle flight.

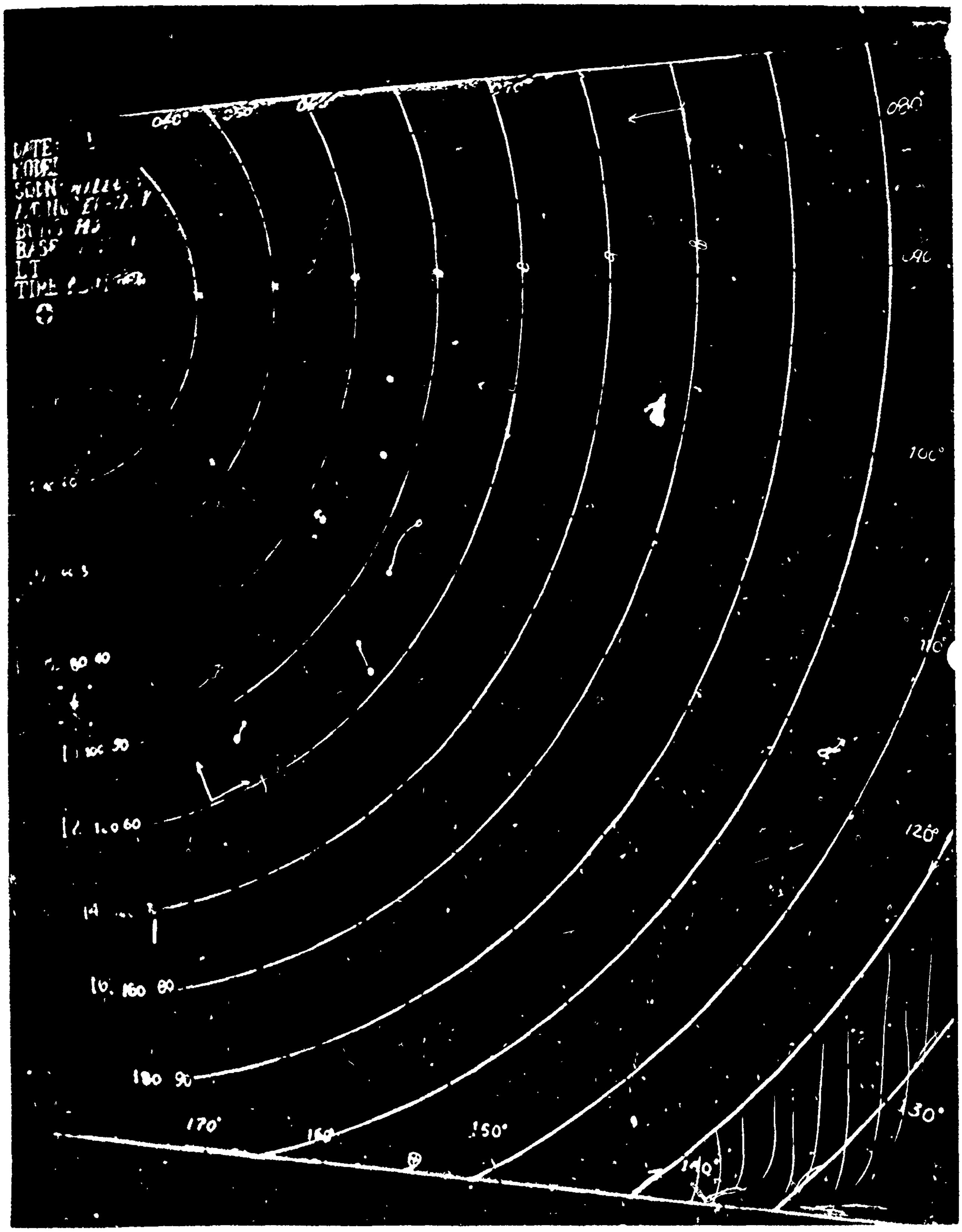


Figure 23. Survey Board for Keeping Track of Marine Traffic in the Vicinity of Wallops Island.

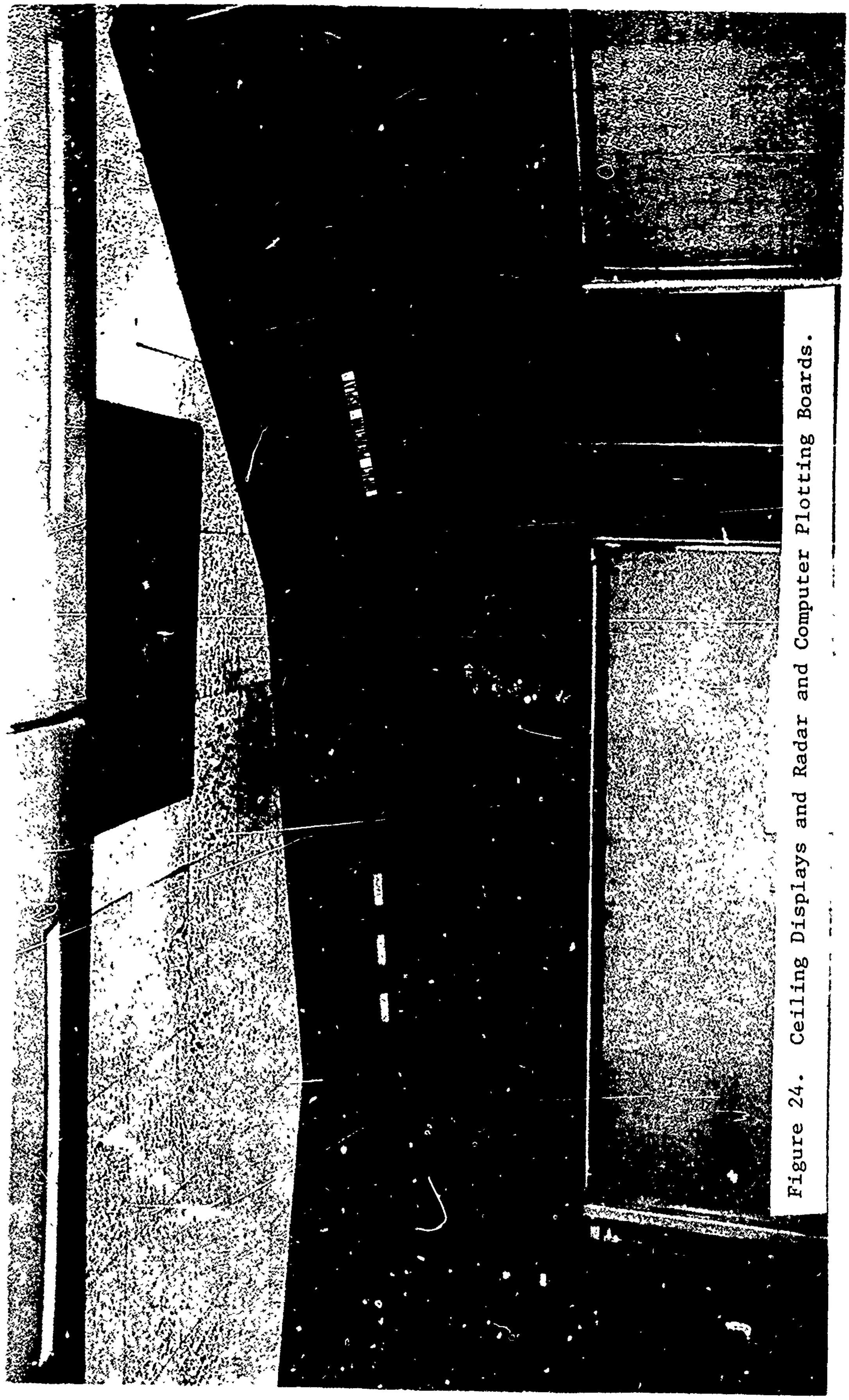


Figure 24. Ceiling Displays and Radar and Computer Plotting Boards.

Figure 25. Datanet 706 Remote Terminal and CRT Display Device.

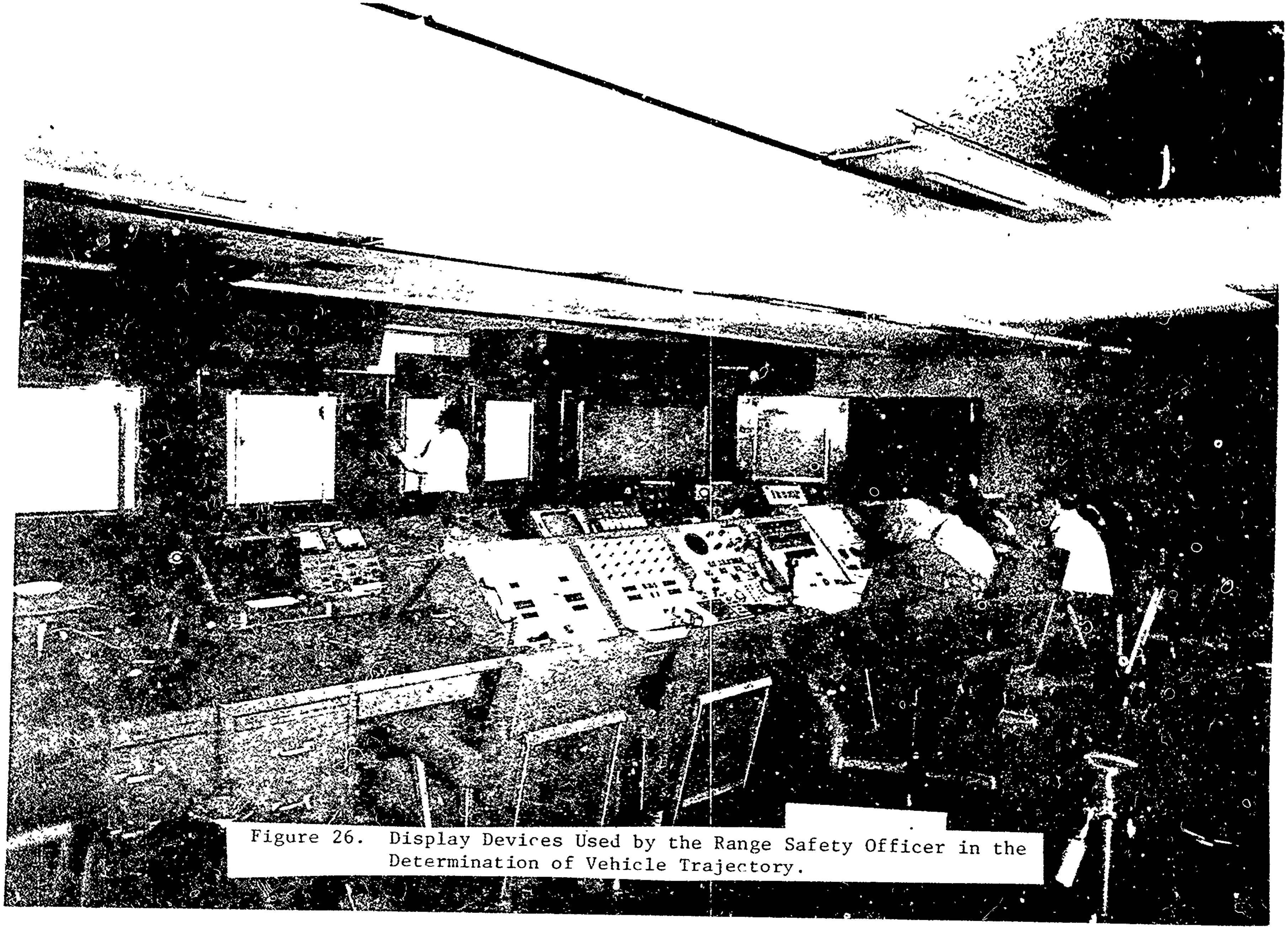


Figure 26. Display Devices Used by the Range Safety Officer in the Determination of Vehicle Trajectory.

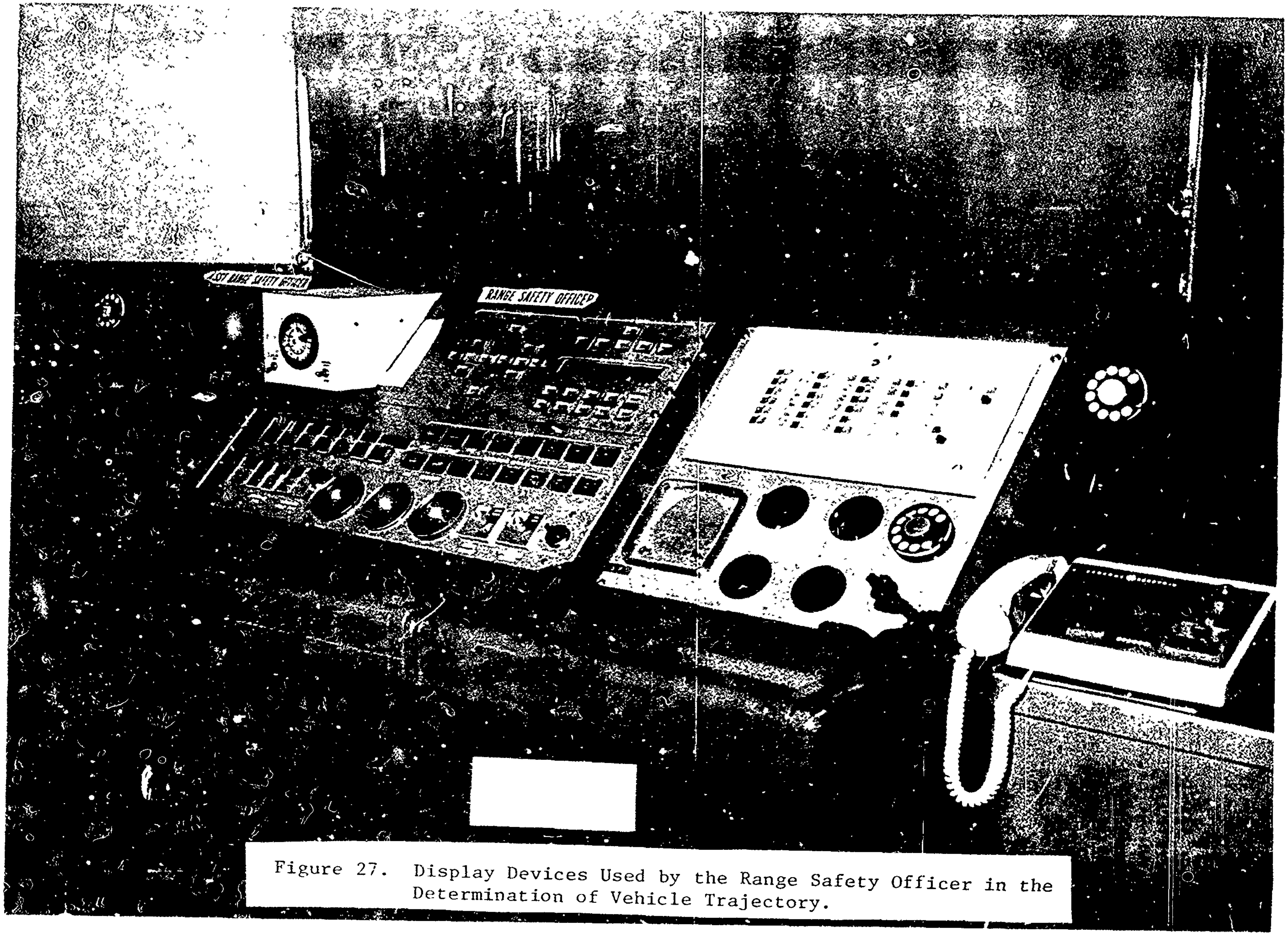


Figure 27. Display Devices Used by the Range Safety Officer in the Determination of Vehicle Trajectory.

3.6 White Sands Missile Range (WSMR)

3.6.1 Summary of Information Presented to Range Safety Officer

PARAMETERS PRESENTED	DATA SYSTEMS	RATIONALE
Instantaneous Impact Point		
Latitude vs. Longitude	1.a	1
Present Position		
Latitude vs. Longitude	1.a	1.2
Altitude vs. Range	1.a, 2.b	1.2
Velocity		
Altitude Velocity vs. Downrange Velocity	1.a	3
Velocity Direction and Magnitude	1.a, 2.b	3
Attitude		
Guidance Corrections (pitch, yaw, spin)	1.b, 2.b	3
Status Indicators		
Vehicle Stage Burnout	1.b, 2.b	3
(Chamber pressure, Longitudinal Acceleration, Guidance Cutoff, etc.)	2.c, 3	
Instrumentation Status	2.b, 2.c	5
Selected Instrumentation	2.b, 2.c	5

3.6.2 Range Control Center

Real-time presentations for Missile Flight Safety are available at five different range control centers at WSMR. Building 300, located in the Post Area, is the largest facility in size and capability. In Building 300, two UNIVAC 1108 computer systems are capable of producing real-time presentations. Tracking data is available from FPS-16 radars, MPS-36 radars, and other data sources such as telemetry and angle measuring instrumentation. The following pictures and descriptions (Figures 28-38) show computer related functions performed in Building 300 in support of Missile Flight Safety.

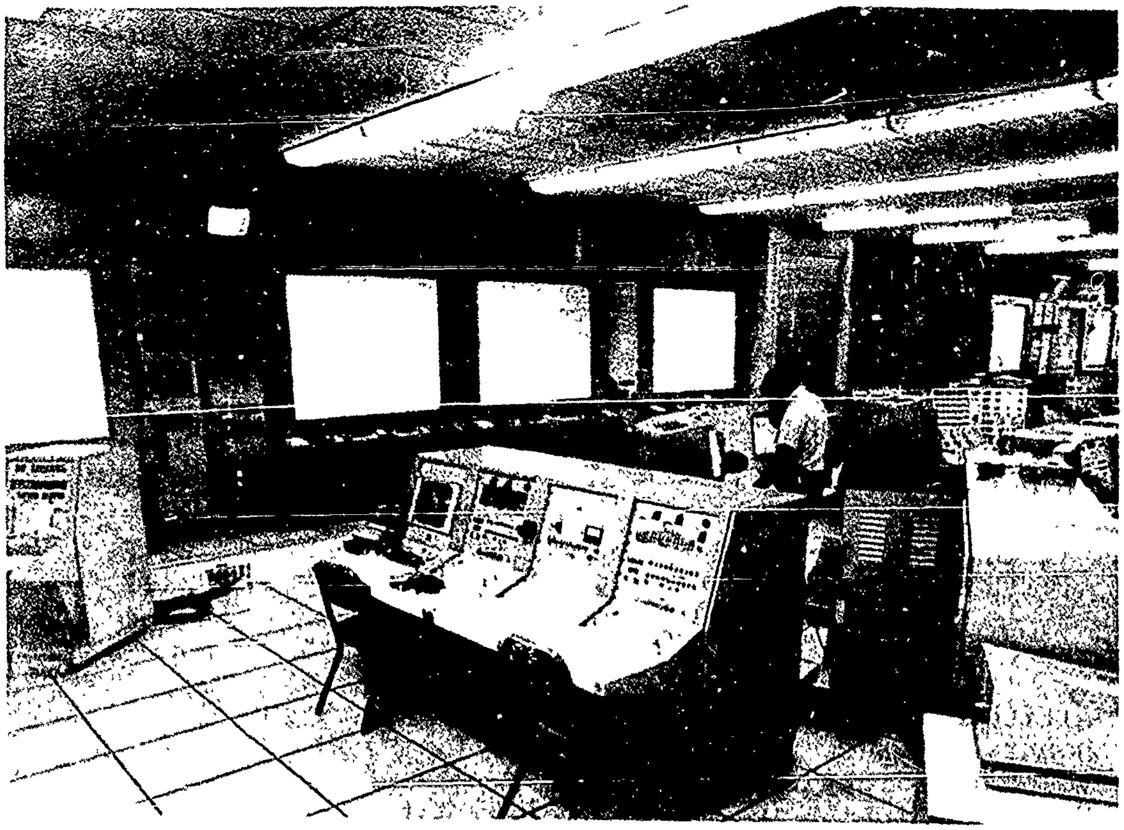


Figure 28. Missile Flight Safety Display Area A.

newly constructed (1976) Operations and Control Display Facility (OCDF) at WSMR provides two locations for Missile Flight Safety presentations. The above picture shows the Missile Flight Safety Console in the fore- ground within the east display area. The console contains a computer video monitor, destruct circuitry with indicators, voice communications, and various status indicators. Plotter and lighted display facilities are shown in the background. The 45"X60" plotter boards are used extensively for IIP, present position, and velocity component presentations.

Figure 29. Missile Flight Safety Display Area B.

The OCDF west display area as seen from behind the computer console in the foreground. The computer console contains 11 subconsoles for control and monitoring of computer related functions. The name of each subconsole from left to right is as follows:

1. Voice Communications
2. Video Monitor (computer driven or live television)
3. Uniscope (interactive computer CRT device)
4. Raw Data Display
5. Discrete Input Panel (Remote B)
6. Uniscope
7. Discrete Input Panel (Master)
8. Video Monitor
9. Discrete Input Panel (Remote A)
10. Raw Data Display
11. Plotter Control Panel

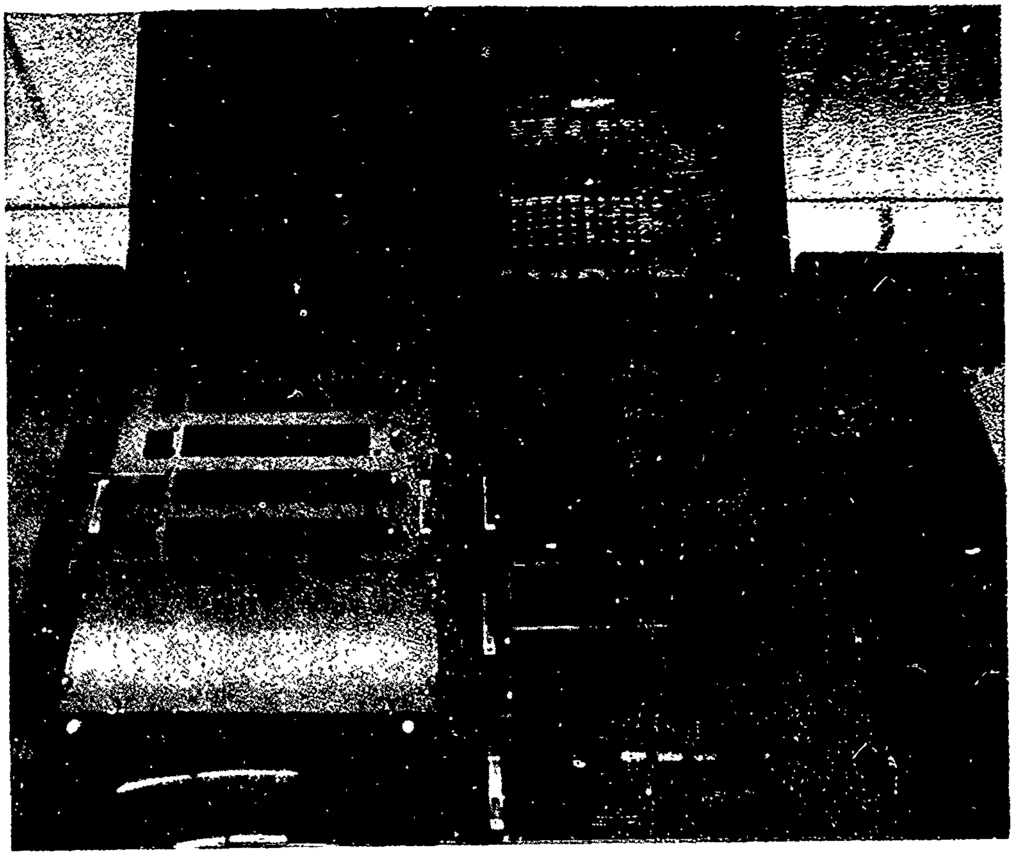


Figure 30. Digital, Video and Lighted Displays.

Two vertical bays located between the plotter boards display Missile Flight Safety information — to supplement plotter presentations. The following diagram describes the types of displays shown.

RANGE COUNTDOWN CLOCK	RANGE STATUS LIGHTS
	VIDEO MONITOR
FIVE 7-DIGIT DISPLAYS	FIVE 7-DIGIT DISPLAYS
	INSTRUMENTATION DISPLAY
VIDEO MONITOR	COMPUTER STATUS LIGHTS

Figure 31. Data Control.

Data Control is the station in Building 300 which interfaces computer related equipment with communications. Facilities are available to monitor and record communication signals input to the 1108 computer and data being transmitted from the 1108 computer.

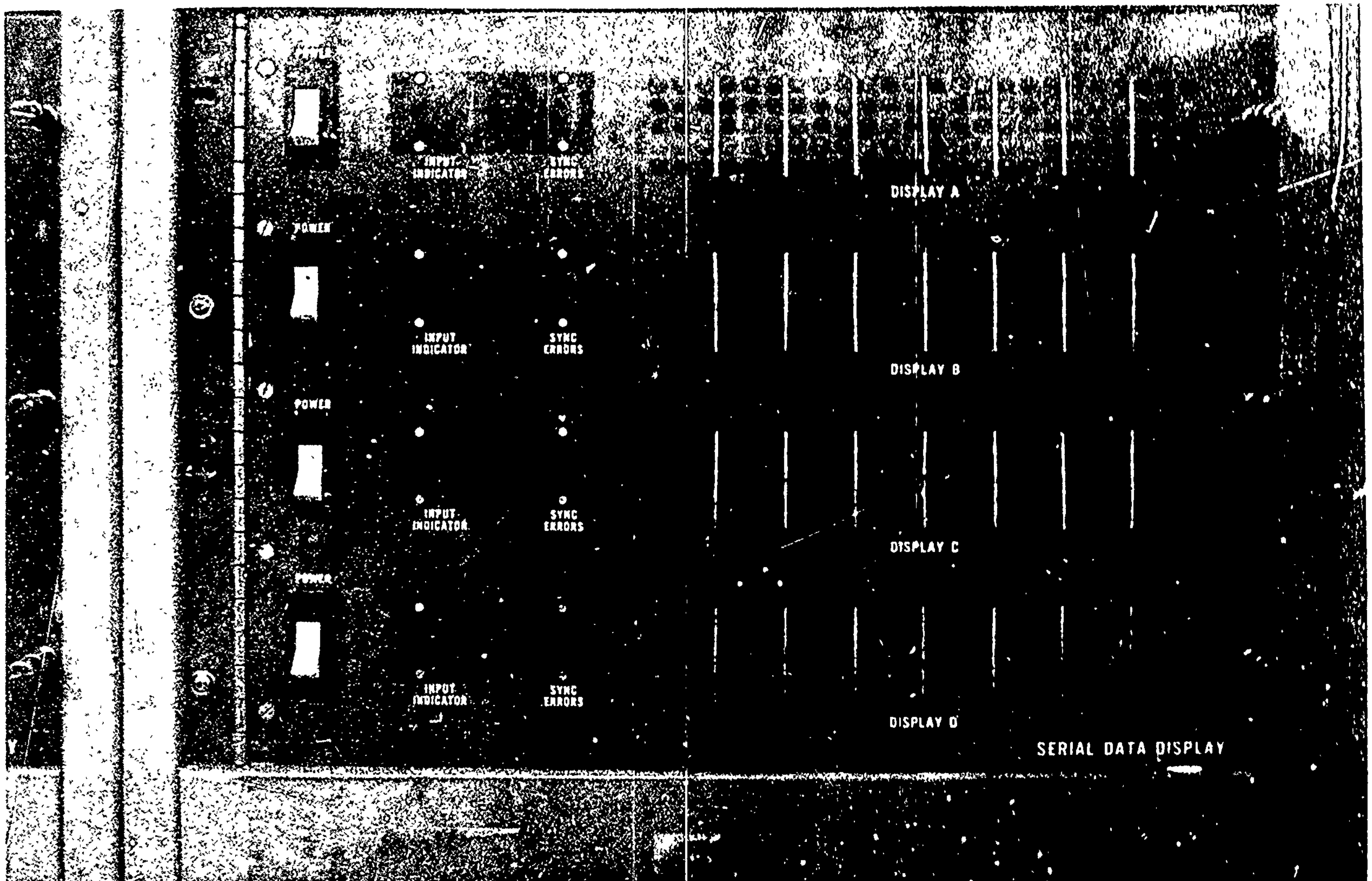


Figure 32. Raw Data Display.

Raw data displays provide a responsive visual check of computer input and output data. The display format is designed to represent the standard WSMR data format (120 bit message/five words of 24 bits each). Raw data is tapped from the digital side of a modem for displays which represent binary values of range, azimuth, elevation, site identification, and tracking mode.

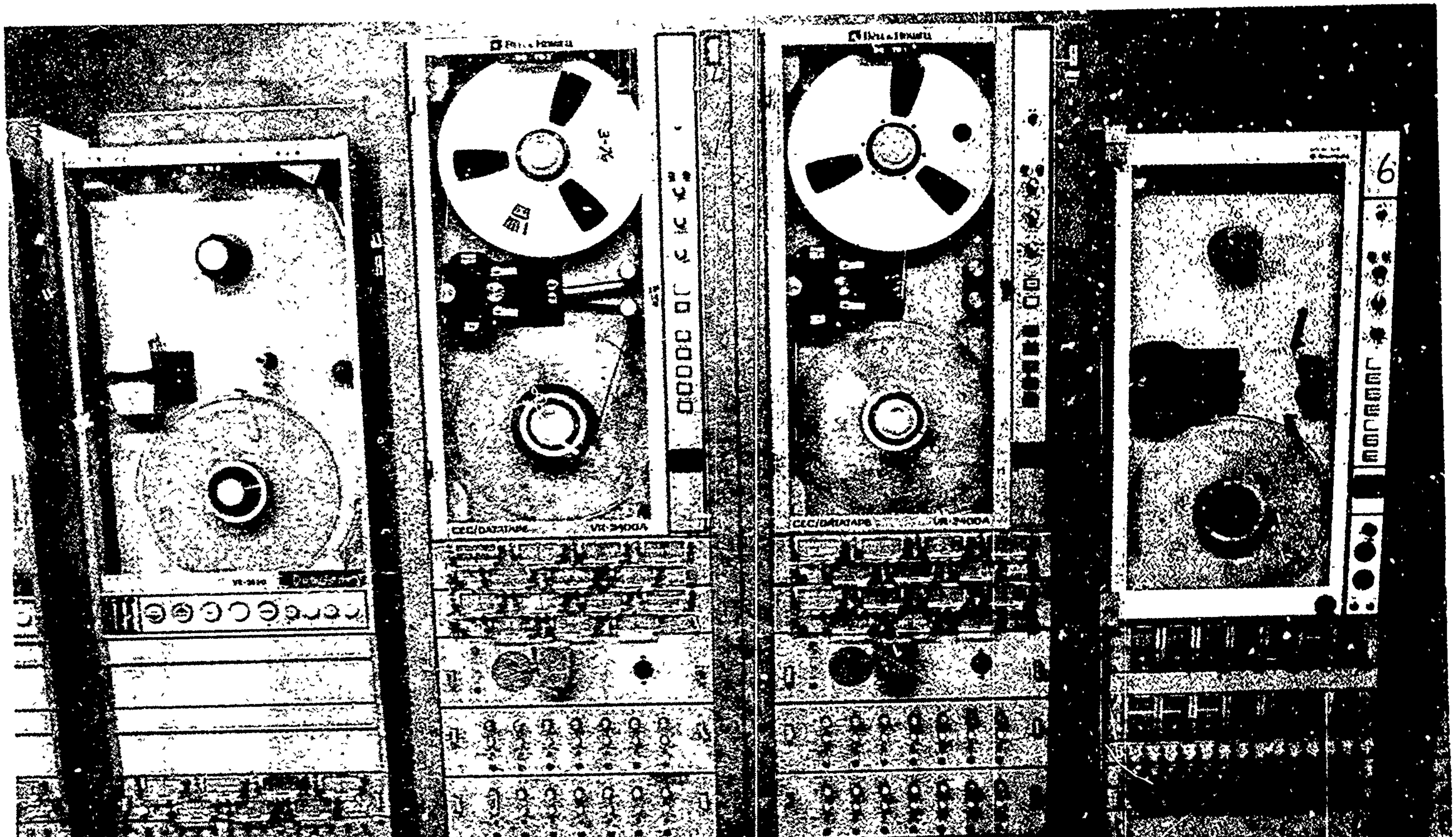


Figure 33. Analog Recorders.

Analog data are recorded in Data Control on 14 channel tape recorders. The purpose of the recordings is to reproduce, at a convenient time, all of the electronic signals needed to simulate actual mission conditions. An operational replay of the recorded data is referred to as a "Mission Playback". Playbacks are crucial for Missile Flight Safety to insure mission preparedness. The information recorded on the tapes is instrumentation data (radar and telemetry), events (liftoff and burnout), voice (annotations), and timing (IRIG-B format).

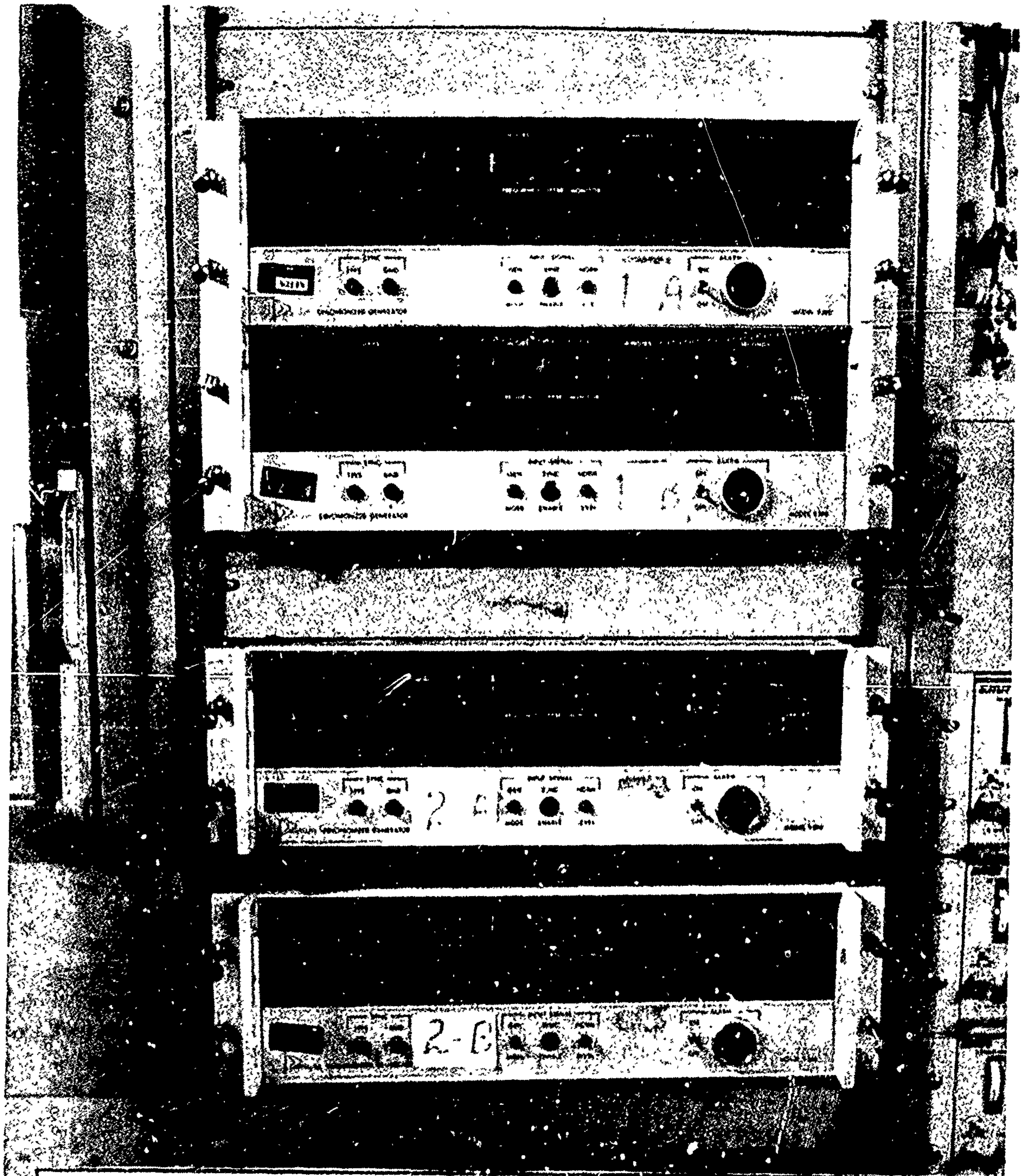


Figure 34. Timing Units.

Four clocks provide timing information for real-time computer programs. Two units are attached to Computer System A and two units to Computer System B. Each clock provides the computer with a time of day value and a twenty per second periodic interrupt signal (master pulse).

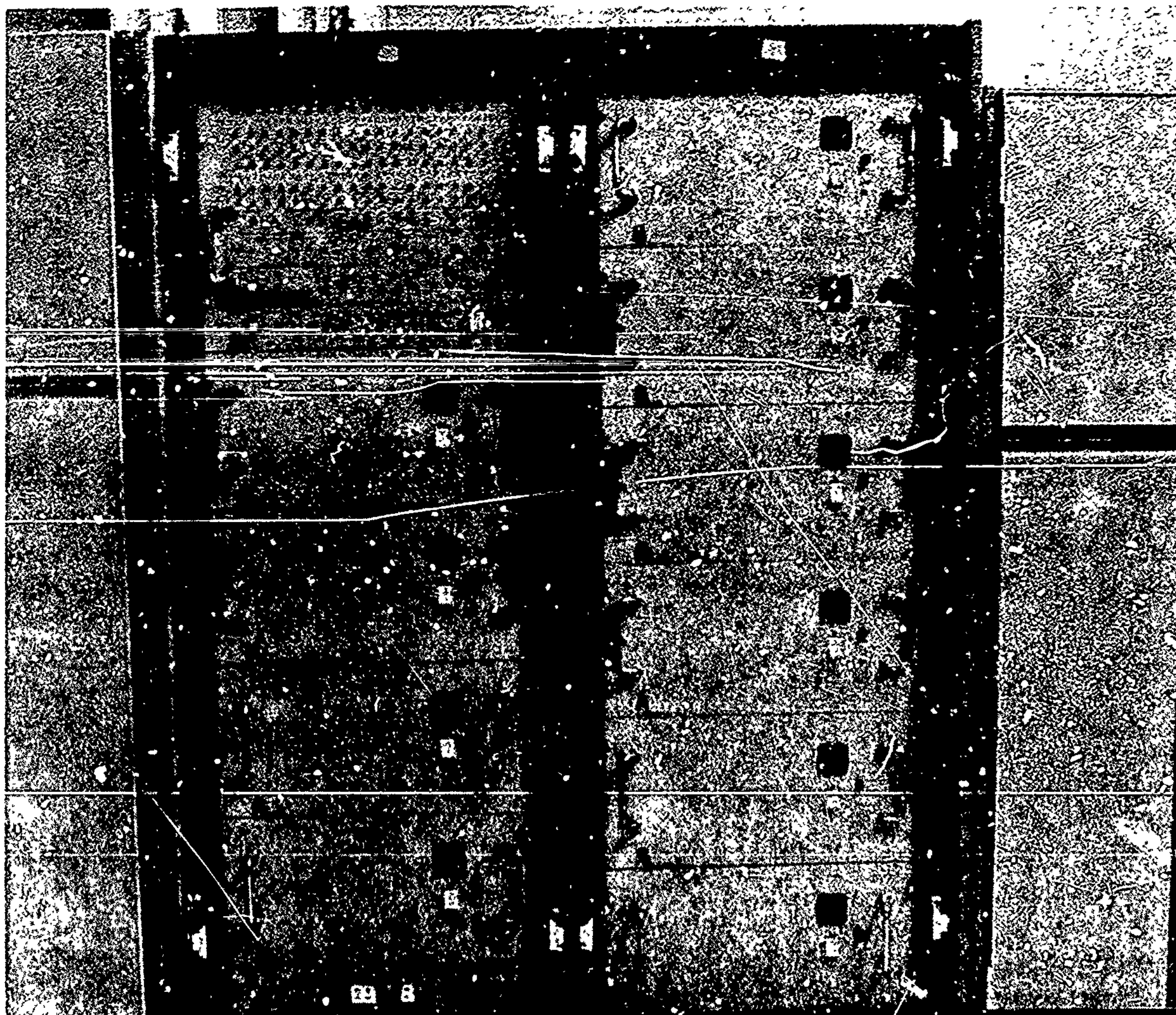


Figure 35. Special Interface Equipment (SIE).

The SIE, Special Interface Equipment, interfaces with the 1108 computer for various types of Missile Flight Safety displays and computer control functions. The SIE contains separate units for pr essing of clock input, discrete events, general purpose input and output, plotter output, and commands.

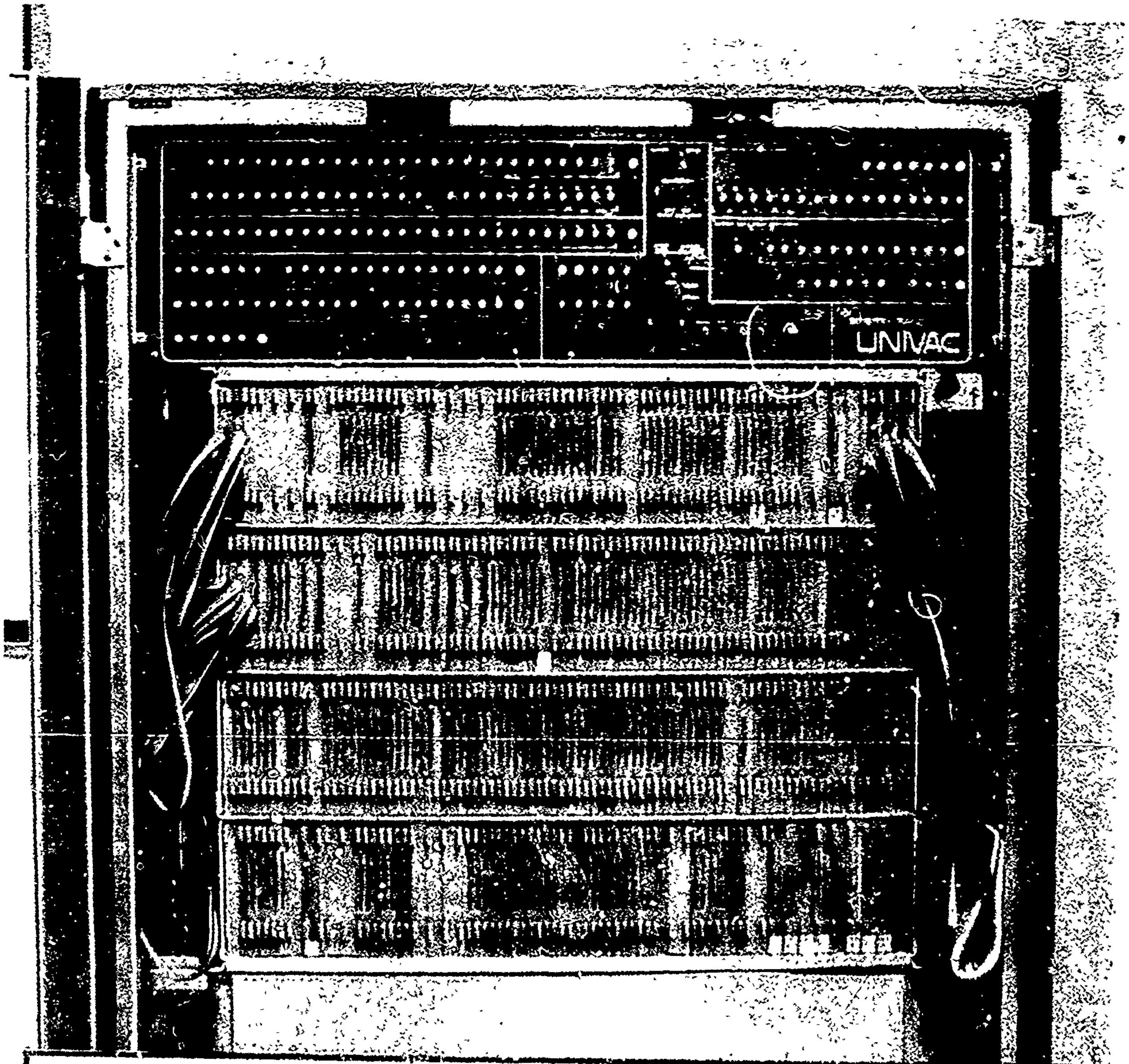


Figure 36. Instrumentation Input/Output Multiplexor (IOMUX).

The IOMUX, Instrumentation Input/Output Multiplexor, is the interface between the Lenkurt data modems and a computer channel. The IOMUX transforms one 1108 computer channel into 32 input and 32 output data lines. Generally, the 1108 computer receives radar data on the input lines and transmits pointing data on the output lines.

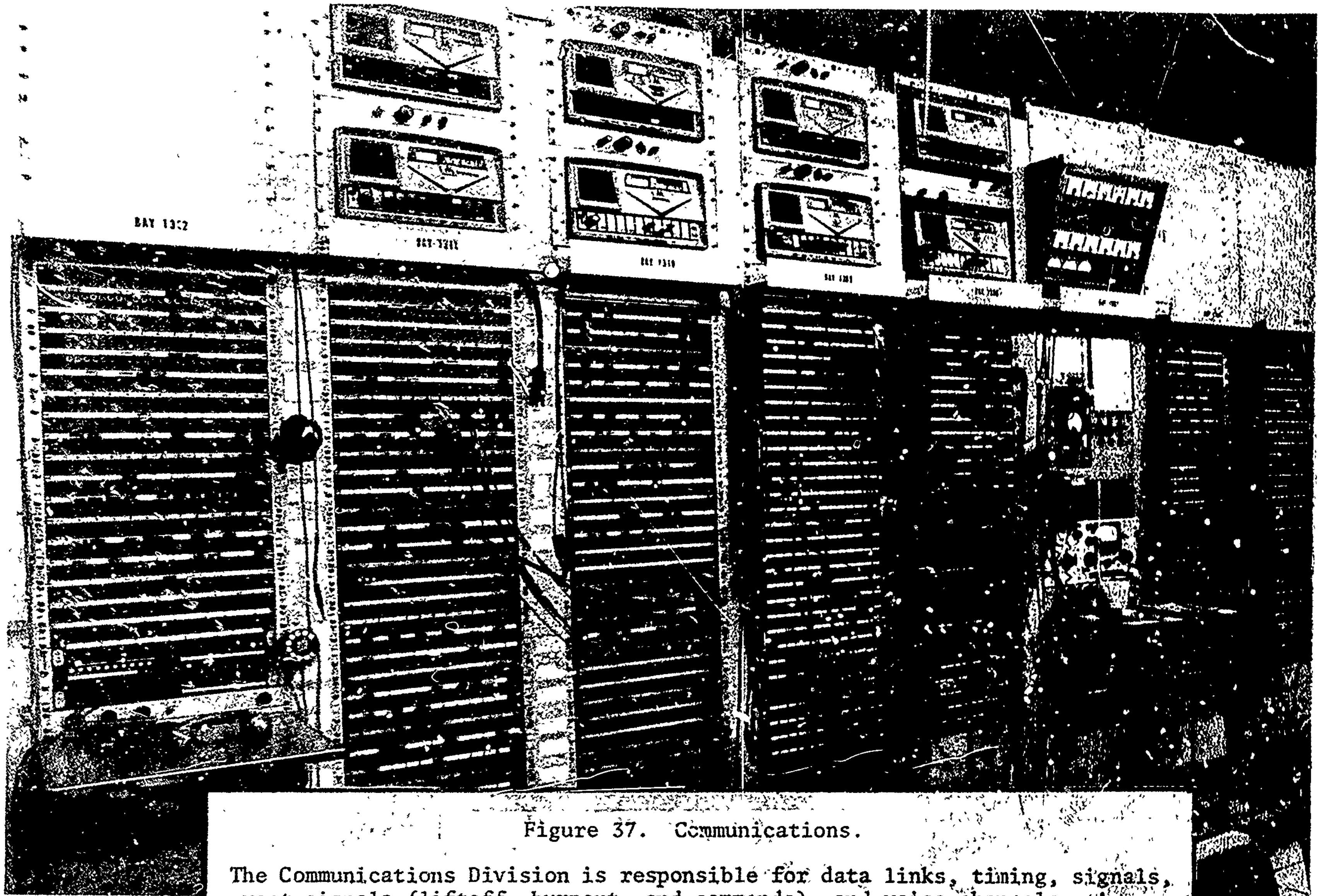


Figure 37. Communications.

The Communications Division is responsible for data links, timing, signals, event signals (liftoff, burnout, and commands), and voice channels. A patching network in the communications area creates a flexible method of assigning data circuits to modems.

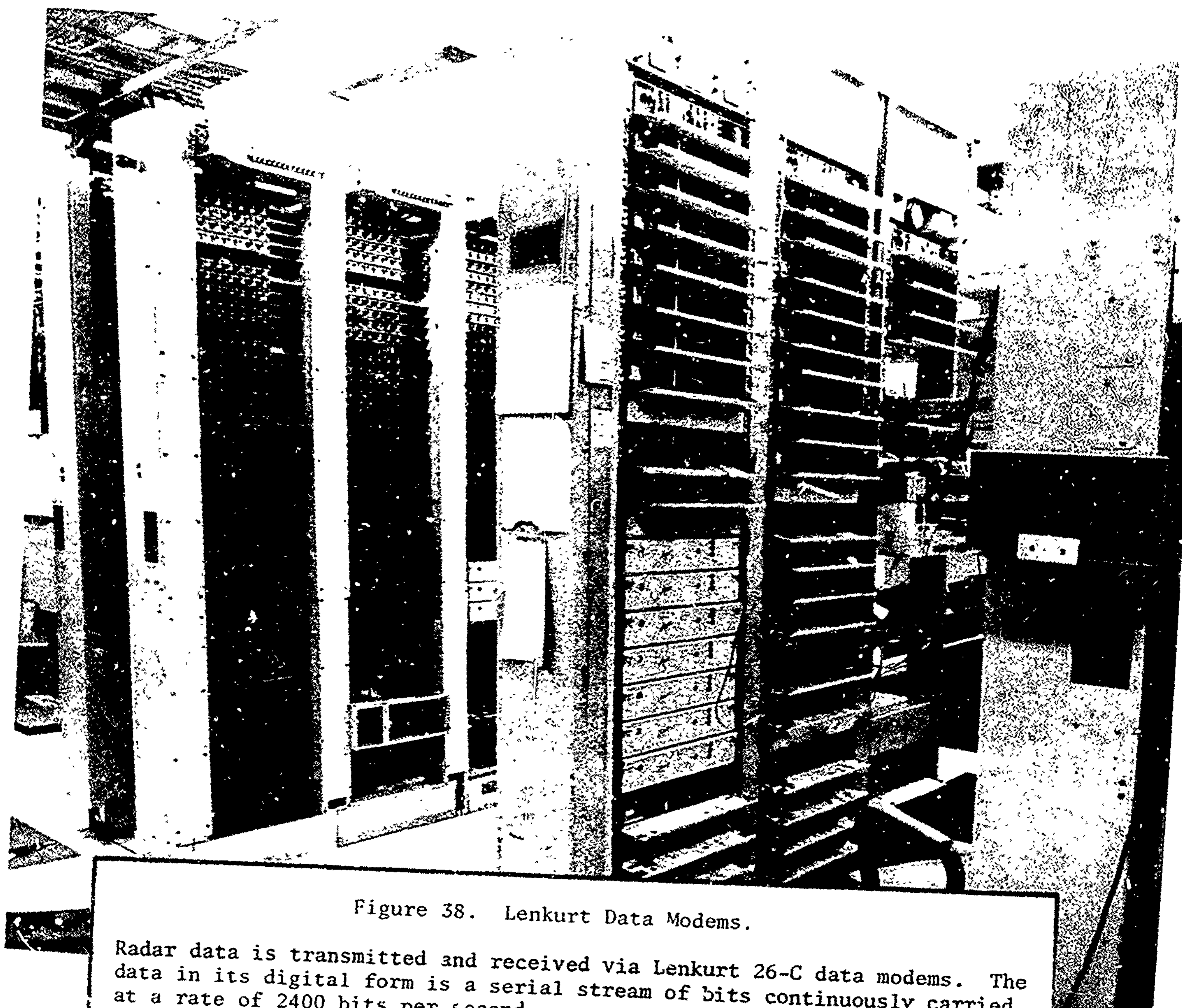
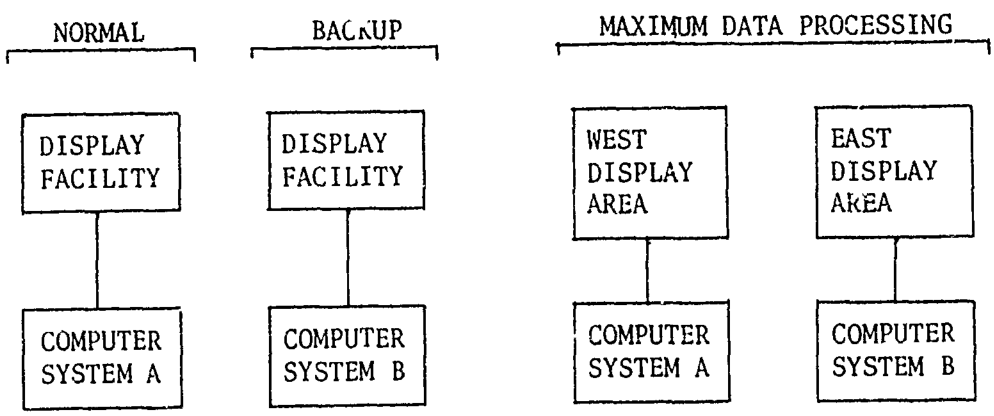


Figure 38. Lenkurt Data Modems.

Radar data is transmitted and received via Lenkurt 26-C data modems. The data in its digital form is a serial stream of bits continuously carried at a rate of 2400 bits per second.

3.6.3 Computer Switch

The computer switch (Figure 39) is a hardware device for switching interface equipment with associated display from Computer System A to Computer System B or vice versa. The switch is operator controlled via a manual push button. The position of the switch determines three possible real-time computer support configurations.



Experience has proved the computer switch is an invaluable tool in providing reliable Missile Flight Safety Support.

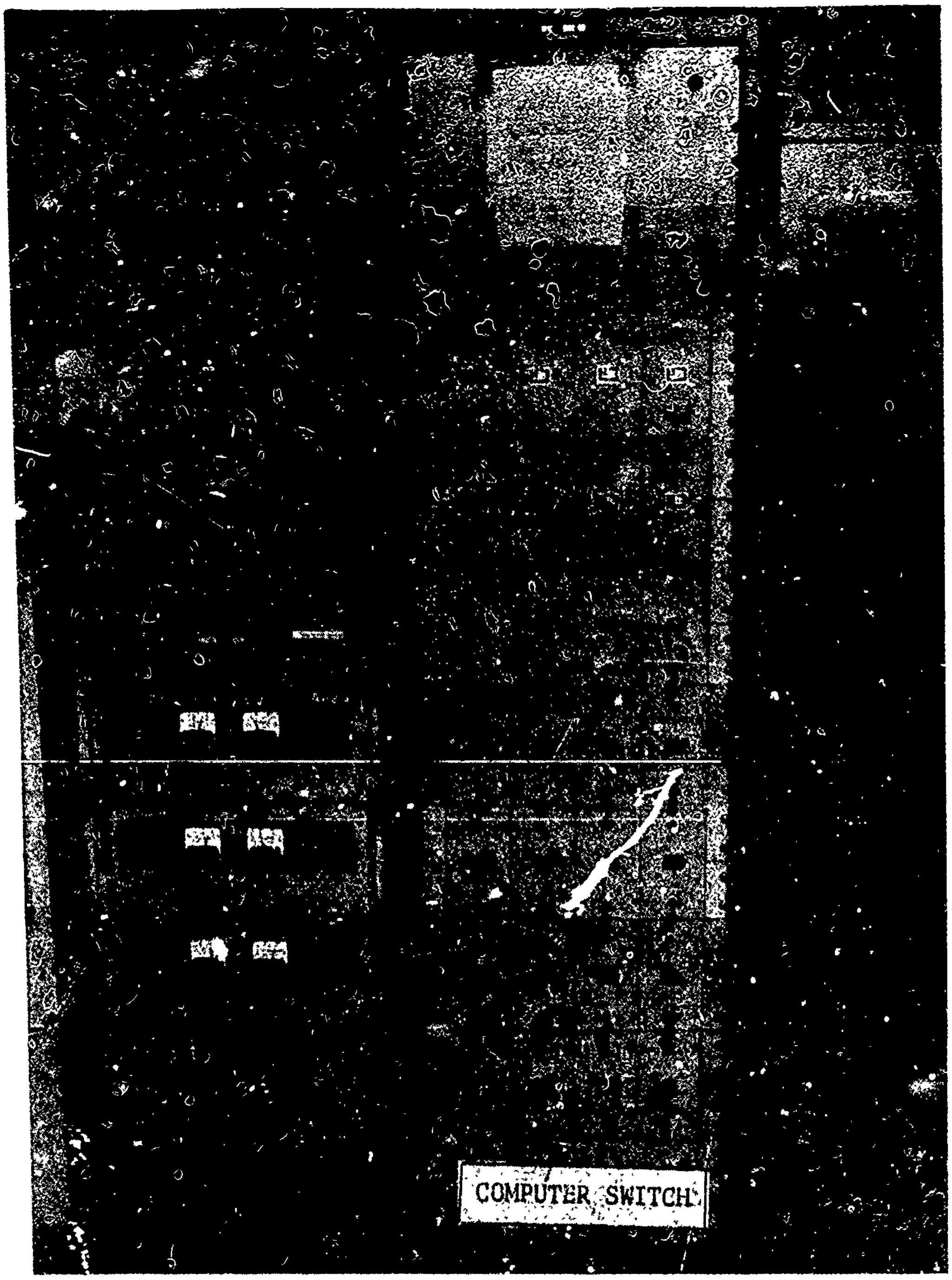


Figure 39. Computer Switch.

3.7 Armament Development and Test Center (ADTC)

3.7.1 Summary of Information Presented to Range Safety Officer

PARAMETERS PRESENTED	DATA SYSTEMS	RATIONALE
Instantaneous Impact Point		
Vacuum	1a, 2a, 2b	1, (6)
Wind/Drag	1a, 2a, 2b	1, (6)
Debris triangle	2a	1, (6)
Present Position		
X vs Y	1a, 2a, 2b	1, 2,(6)
H vs t	1a, 2a	1, 2,(6)
Velocity		
V vs t	1a, 2a, 2b	1, 2,(6)
Flight Control Parameters		
Altitude	2a, 2b	1, 2,(6)
Delta Altitude	2a, 2b	1, 2,(6)
Climb Rate	2a, 2b	1, 2,(6)
Delta Slant Range	2a, 2b	1, 2,(6)
Separation	2a, 2b	1, 2,(6)
Velocity in Ground Plane	2a, 2b	1, 2,(6)
Closing Velocity	2a, 2b	1, 2,(6)
Time to Go	2a, 2b	1, 2,(6)
Bearing	2a, 2b	1, 2,(6)
Course	2a, 2b	1, 2,(6)
Depression Angle	2a, 2b	1, 2,(6)
Angles Off	2a, 2b	1, 2,(6)
Flight Path Angle	2a, 2b	1, 2,(6)
Track Crossing Angle	2a, 2b	1, 2,(6)
Status Indicators		
Command/Destruct Status	2a, 2c	3, 5
GMT	2c	4
Source Track Status	2a, 2c	5
Source Track Mode	2a, 2c	5
Sky Screen TV	4	1
Seeker/Guidance TV	4	3
Radar Boresight TV	4	3
Sky Screen/HARP Observers	3	1
Error Analysis Parameters	2a, 2b	5

3.7.2 Range Safety Control Complex

The ADTC is presently in the midst of a transfer of safety support from plotboard operations at several remote control sites to a new centralized single control facility. The range safety support complex is contained in the new system, designated the Consolidated Eglin Real-Time System, CERTS. The CERTS facility merges all control elements and utilizes cathode ray tubes as the device for primary and secondary displays.

3.7.2.1 Display and Control Philosophy. Even though a wide variety of missions are conducted by ADTC, they can all be described by either one or a combination of control categories. Range safety display and control problems and procedures generally are peculiar to the following mission control phases:

a. Launch Control. This term applies to the launch and deployment of all guided and unguided surface-to-air vehicles, including targets, drones, probes, rockets, and weapons. These items may be configured with destruct packages that can be actuated by remote command.

b. Flight Control. This term applies to the monitoring and control of aircraft flight. This includes the vectoring of single or multiple aircraft toward objective flight profiles and the maintenance and monitoring of flight particulars, such as relative separation, heading, altitude, attitude and speed.

c. Release Control. This term applies to the release of unpowered air-to-ground weapons and objects, such as ballistic and aerodynamic glide bombs. Safety involvement is to evaluate associated hazards, provide clearance to release, and take destruct action, if required.

d. Fire Control. This term applies to control of the firing of powered air-to-air and air-to-ground weapons. Safety involvement is to evaluate associated hazards, provide clearance to fire and to monitor item performance for possible destruct actions on items so configured.

e. Mission Analysis. Safety personnel have access to a computer and CRT oriented analytical capability for pre-mission analysis, mission support evaluations, and post-mission performance analysis. Mission support-period applications normally are associated with contingency procedures for the evaluation of anomalies and test criteria violations. Evaluation of the effects of winds and short lead-time changes in flight profiles, launch azimuth, test objectives, and other mission constraints are accommodated. This capability provides exceptional flexibility in test design and rapid response to the changing test environment associated with tactical weapons systems.

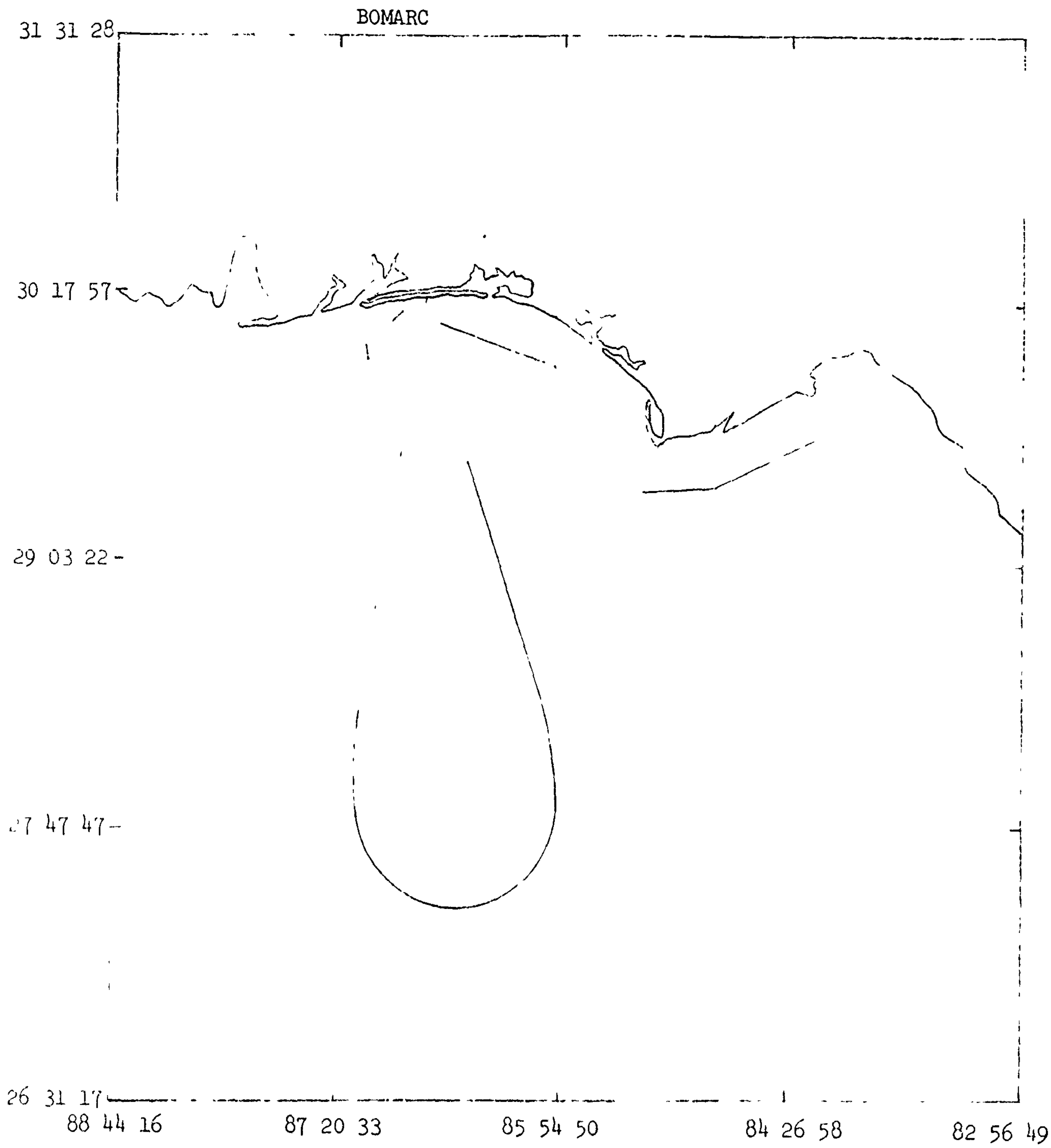
3.7.2.2 Display Selections. Safety displays are designed for CRT presentation. Primary displays are provided at each support console by a pair of storage tube CRT's. Presentations are developed through the central computer complex using CDC-6600, IBM 360-65, and PDP-15 computers operating on radar and telemetry data in real time. Each support console is augmented by a CRT secondary data display system independent of the central computer, data handling network, and power supply. This system is used to augment primary displays and to provide a fail-soft capability to maintain mission control should the central system fail during real time. The safety support personnel configure the displays to support mission-peculiar requirements associated with launch, fire, release, and flight control problems, as applicable. Basic displays can be composed of the following:

a. Real-Time Location of Position and Instantaneous Impact Points of Objects Against a Map Background. The operator has the capability to select the test area and scale of the display at set-up time, or in real time. The geographic area of interest includes the entire Eglin land and water test ranges. The operator has the capability at set-up time of locating on the display such features as shooting boxes, flight corridors, clear-to-fire lines, impact-limit lines, destruct lines, population centers, etc. Impact data can be either vacuum, wind/drag corrected, or debris pattern. (See Figure 40)

b. Graphical Displays of Time-Dependent Variables Derived From Radar and Telemetry Data. Certain data are presentable in this manner. The scales of these displays are selectable by the operator in real time. (See Figure 41)

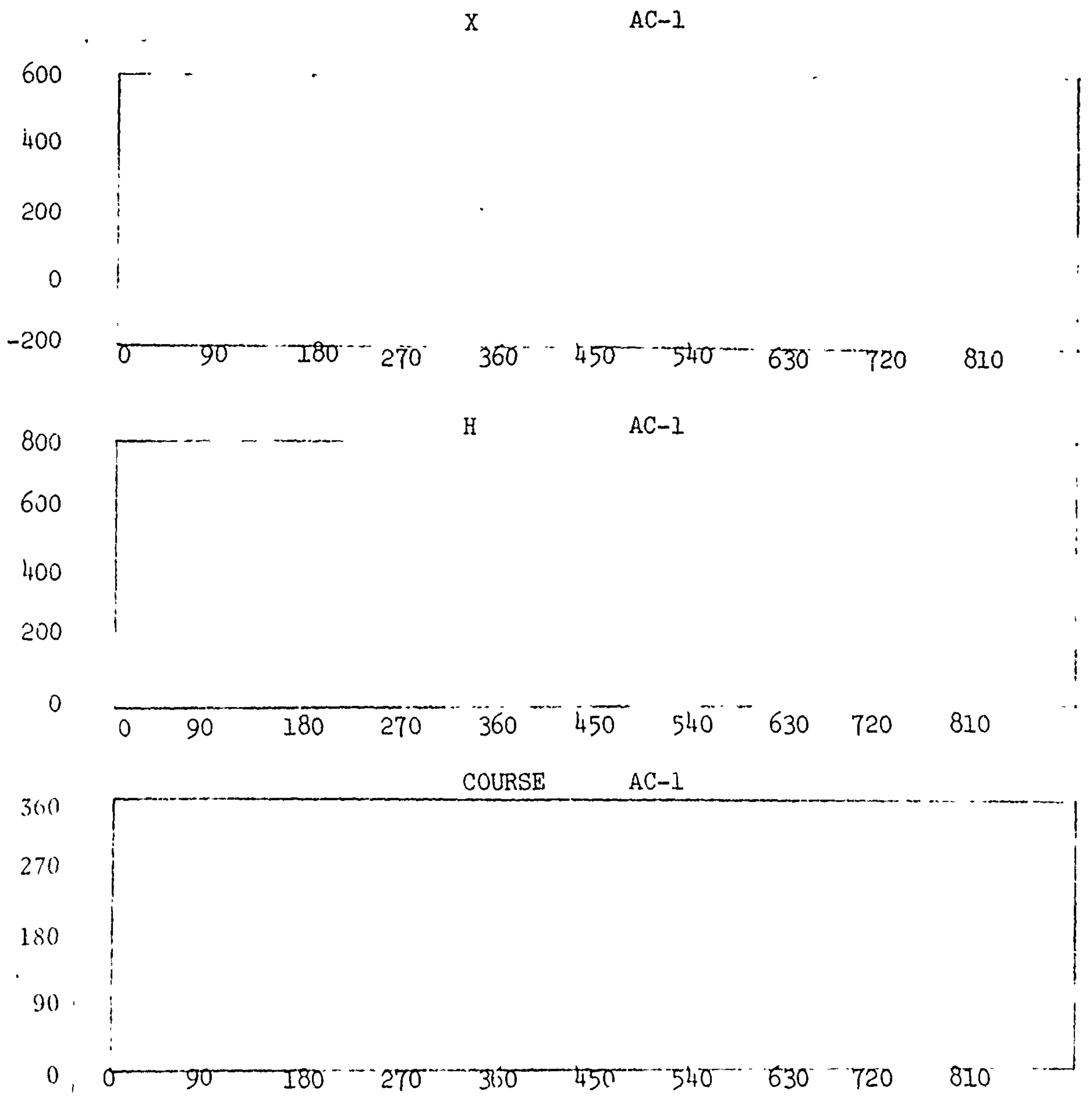
c. Alphanumeric Information. Certain data are presented in this manner. They include those items identified below as well as radar status and data source for each display.

d. Flight Control Displays. Certain missions involve multiple aircraft or a shooter and a target. For terminology on displays showing differences between two data sources, one is identified as the primary aircraft and the other as the secondary aircraft. The following data are derived from simultaneous track data in real time and made available for alphanumeric or time-history display on the CRT's:



ALTITUDE P 50000 MACH P 1.5 ALTITUDE S 30000 MACH S .95
SPEED P 1435 COURSE P 190 SPEED S 800 COURSE S 150

Figure 40. Real-Time Location of Position and Instantaneous Impact Points of Objects Against a Map Background.



CH	PAD		TRACK		FILTER	RANGE	ALTITUDE	VELOCITY
1	22	TG	BEACON	ON	INIT	80000	72000	1435
2	24	TG	SKIN	ON	UN	80000	72000	1435
3	23	SH	BEACON	OFF	EX	20000	35000	800

Figure 41. Graphical Displays of Time-Dependent Variables Derived from Radar and Telemetry Data.

(1) Altitude. Height above the Clark Ellipsoid of 1866 for both the primary and secondary vehicles. This shall be available as digital displays in units of thousands of feet, and as a time-history presentation.

(2) Delta Altitude. The difference in altitude in feet between any two vehicles. This is available as digital displays in feet and as a time-history recording. The digital display also indicates when the primary vehicle is above or below the secondary vehicle.

(3) Climb Rate. The rate of change of altitude in feet-per-second for each vehicle is available as a digital display. Dive and climb status is also indicated.

(4) Delta Slant Range. The total spatial distance between the primary and secondary vehicle. This is available as a digital display in nautical miles and as a time-history recording.

(5) Lateral Separation. To calculate this item a tangent plane is established by using the real-time present space position of the primary vehicle as the origin and orienting the coordinate system so that the positive X-axis lies along the velocity vector, the positive Y-axis lies 90 degrees right of the X-axis and the Z-axis is positive up and passes through the center of the earth. Lateral separation is defined as the "Y" value of the position of the secondary vehicle measured in the above coordinate system. This is available as a digital display in nautical miles and as a time-history recording.

(6) Horizontal Separation. The distance between the primary and secondary vehicle in the X-Y tangent plane as defined above. This is available as a digital display in nautical miles and as a time-history recording.

(7) Velocity Magnitude. The magnitude of the three dimensional velocity vector of both the primary and secondary vehicles. This is available as digital displays in feet-per-second and as time-history recordings.

(8) Velocity in the Ground Plane. The magnitude of the velocity vector of both the primary and secondary vehicles projected on the ground tangent plane. This display gives an approximation of ground speed. This is available as a digital display in feet-per-second and as time-history recordings.

(9) Mach Number. The speed of primary and secondary aircraft given as Mach number, based on the velocity and altitude of the aircraft. These are available as digital displays.

(10) Closing Velocity. The time rate of change of the delta slant range (see (4) above). This is available as a digital display in feet-per-second and as a time-history recording.

(11) Time to Go. The delta slant range divided by the closing velocity (see above). This is available as a digital display in seconds.

(12) Bearing. The angle, measured clockwise, from north (magnetic or true) to the line between the positions of the primary and secondary vehicles. This is available as a digital display in degrees.

(13) Course. The angle measured clockwise from north (magnetic or true) to the velocity vector of the vehicle. This is available as a digital display in degrees.

(14) Angle of Depression. The arc tangent of the quotient of delta height and horizontal separation, or:

$$\text{ATAN}\ \frac{\text{Delta Height}}{\text{Horizontal Separation}}$$

(15) Angles Off. The angle defined by the velocity vector of a vehicle and the line connecting the position of that vehicle to the position of another vehicle and projected on the horizontal tangent plane. This is available for both the primary and the secondary vehicles as a digital display in degrees.

(16) Flight Path Angle. The angle between the velocity vector of a vehicle and the local horizontal tangent plane. This is available for both the primary and secondary vehicles as digital displays in degrees.

(17) Track Crossing Angle. The angle between the velocity vectors of the vehicles measured from the primary vehicle to the secondary. This is available as a digital display in degrees.

3.7.3 Control Center

ADTC is presently in the midst of a transfer of Range Safety support from scattered plotboard oriented control sites to a central control facility utilizing cathode ray tubes for primary display. The new control facility utilizes the Consolidated Eglin Real-Time System (CERTS). The system utilizes four computers including a PDP-15 computer used as a telemetry data processor, providing discrete and engineering data to a CDC-6600 computer. The CDC-6600 receives all radar and telemetry data and performs impact prediction and data parameter calculations. The reduced data is then passed to the IBM-360/65 computer which serves as the display driver and command/control interface to the safety officers who operate the system. Totally independent of this configuration is a PDP-11 computer which receives radar data from a secondary distribution system, performs limited calculations, and drives a CRT display system. The PDP-11 system serves as an auxiliary display capability and provides a fail-soft capability to allow retention of mission safety should the primary system fail.

3.7.4 Control Room Equipment

Figure 42 shows the arrangement of equipment in the Control Room. There are two separate control complexes separable by a lead-vinyl curtain. Thus, the complexes can be used separately, allowing for simultaneous support of two missions.

3.7.5 Control Complex Configuration

Figure 43 shows the configuration of the control complex. From left to right:

a. Secondary Data Display CRT. This is a 19-inch storage tube and is driven by the PDP-11 computer independently of the primary displays. There are two such devices per console. Another is seen at the far right. Since this device is movable, it can be relocated as necessary.

b. Communications and Status Indicator Panels. These panels contain the communications intercom set and command/destruct system status indicators. There are two sets per console, as shown.

c. Primary Display CRT. The central point of the console consists of two 23-inch cathode ray tube primary displays. Also, shown are the operator keyboards and function button sets.

d. Video Monitors. Directly above the main CRT displays are two 9-inch TV monitors used to display skyscreen, radar boresight, or missile-seeker video.

e. Command Destruct Switches. The command/destruct switches are recessed into the console top and are located at the right hand of the right operator console position.

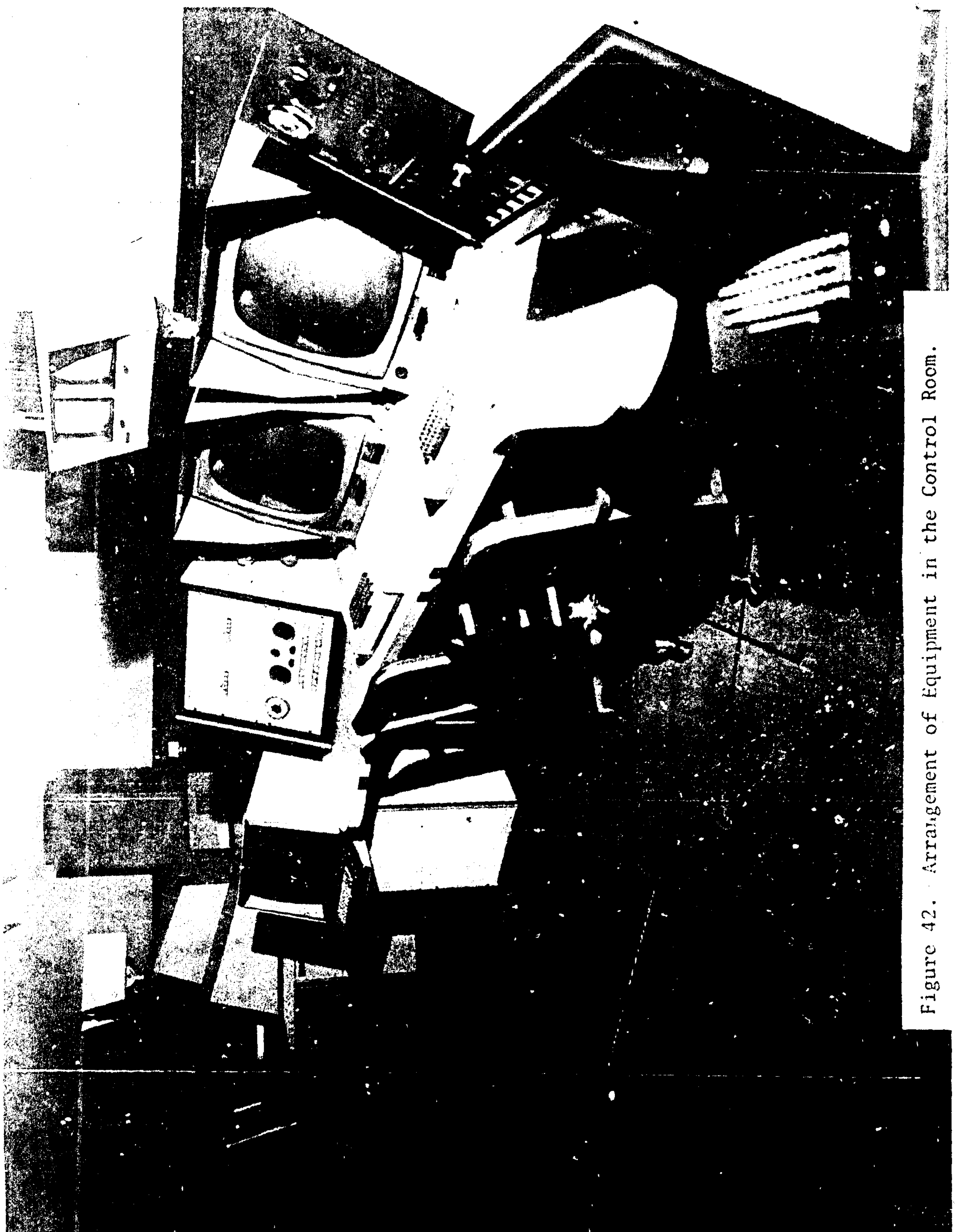


Figure 42. Arrangement of Equipment in the Control Room.

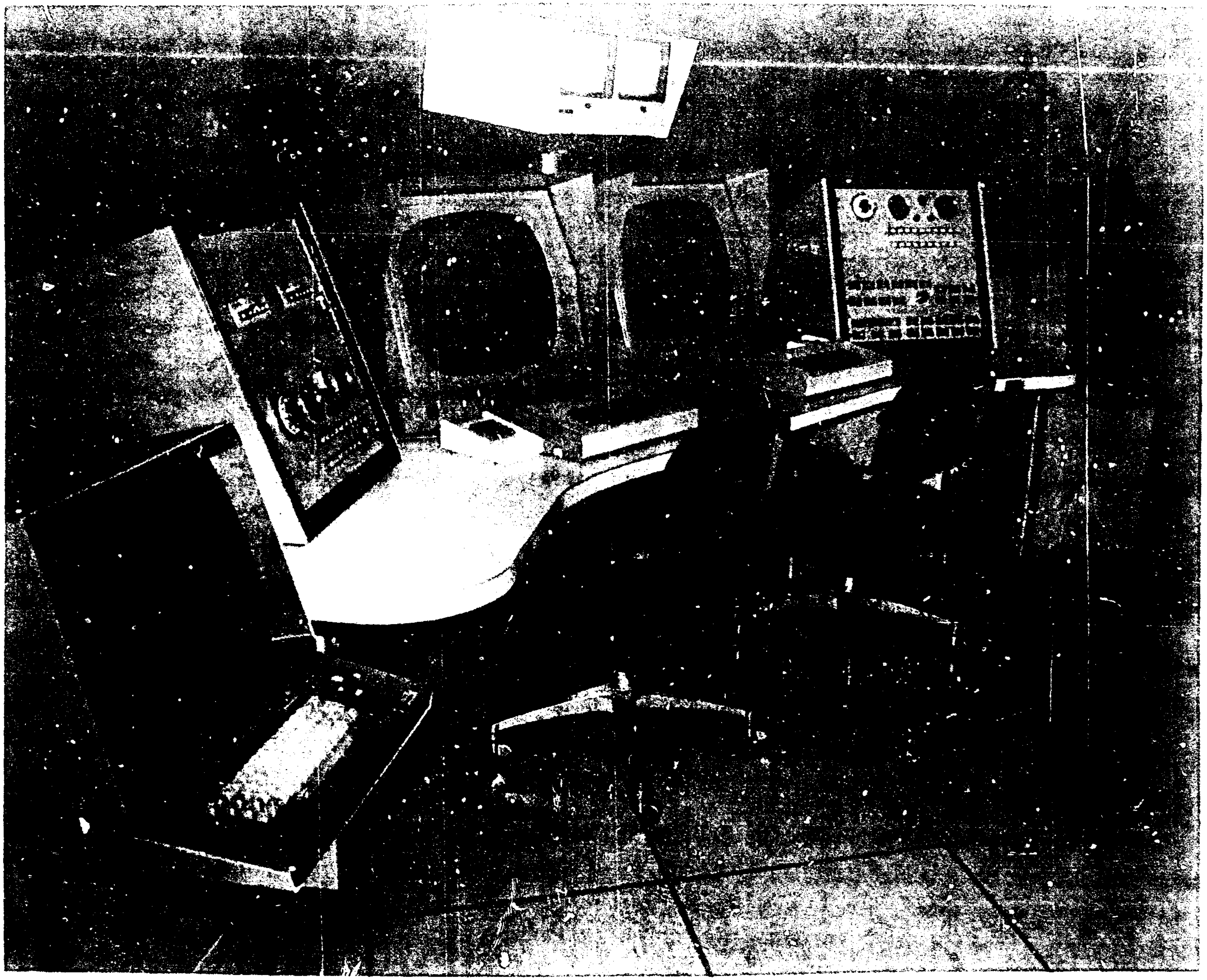


Figure 43. Configuration of the Control Complex.