ORION SERVICE digest

issue 37 OCTOBER 1979

LOCKHEED · CALIFORNIA COMPANY

TACTICAL NAVIGATION WITH THE P-3C SONOBUOY REFERENCE SYSTEM

ISSUE 37 OCTOBER 1979
LOCKHEED • CALIFORNIA COMPANY

CONTENTS

NOT FOR PUBLIC RELEASE

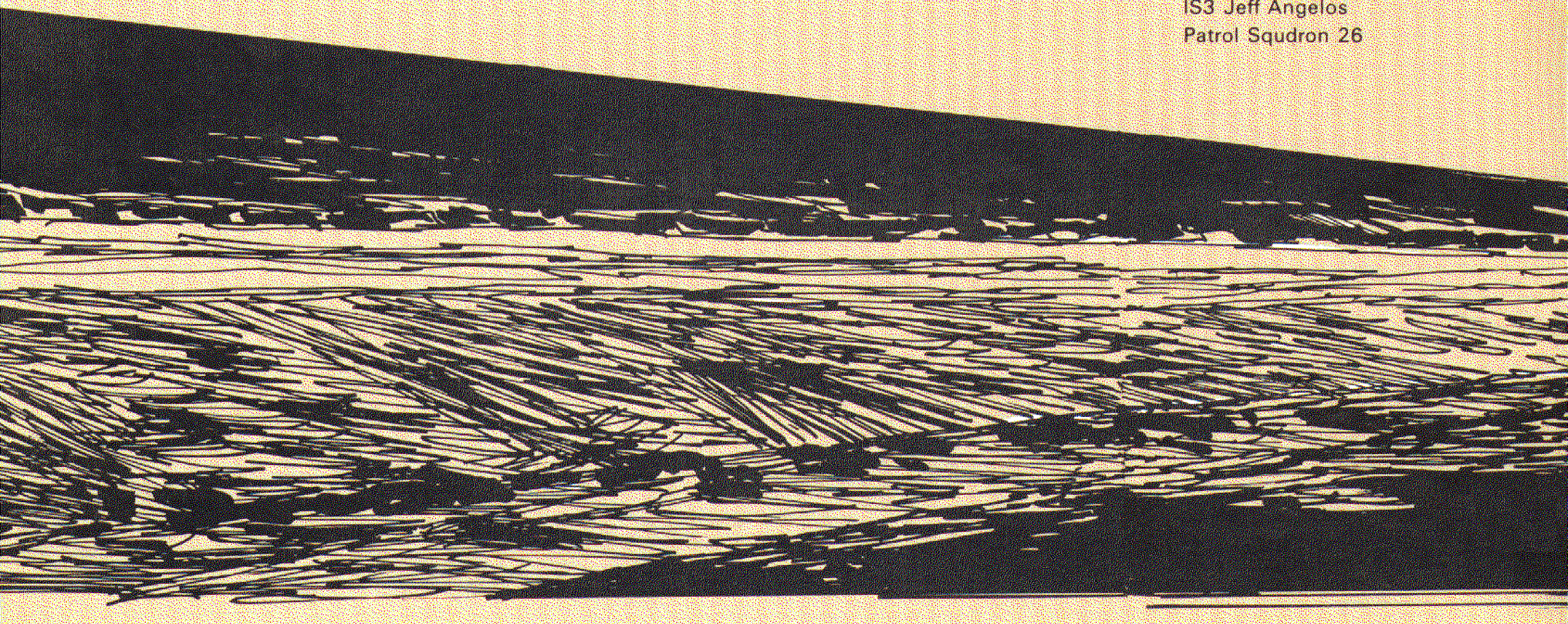
FRONT AND BACK COVERS

Patrol Squadron TWENTY-SIX, a member of Patrol Wings Atlantic and Patrol Wing FIVE, is an ASW command with a worldwide theater of operations. Home-ported at NAS Brunswick, Maine, the *Trident* Squadron is known throughout the North and South Atlantic Oceans, the Pacific, and the Mediterranean.

The squadron's history goes back to August 1943 when it was commissioned as Bombing Squadron ONE HUNDRED FOURTEEN at NAS Norfolk and subsequently equipped with *PB4Y Liberator* aircraft. Five years later the squadron was redesignated Patrol Bombing Squadron ONE HUNDRED FOURTEEN, which was later changed to Heavy Patrol Squadron SIX, and finally to its present designation of Patrol Squadron TWENTY-SIX.

From the beginning, the squadron's mission has primarily been ASW. In this role, it protected the Allied Fleet from U-boats during the Normandy Invasion in June 1944.

Cover Picture Credit:
PH3 Steven Stopler
and
IS3 Jeff Angelos
Patrol Squdron 26



Following WW II, the squadron was based at Port Lyautey, Morocco until 1950. During the Berlin Blockade in 1948, the squadron flew medical supplies to Berlin, and during this same period the squadron became one of the first Navy units to fly hurricane reconnaissance.

While stationed at NAS Patuxent River in 1951, VP-26 received its second type aircraft, The *P-2V Neptune*. Later that year NAS Brunswick was recommissioned, and Patrol Squadron TWENTY-SIX became the first squadron ordered aboard. During the Cuban Crisis in 1962, several squadron aircraft were deployed to NAS Key West and flew over 1000 hours in direct support of the Cuban quarantine.

October 1965 marked the beginning of a new era for VP-26, as its P-2 Neptunes were replaced with the latest word in ASW, the *P-3B Orion*. In the fall of 1967, the squadron deployed to Southeast Asia where it averaged about 1500 hours per month on combat patrols. When VP-26 returned to NAS Brunswick in June 1968, its flight crew members were awarded the Vietnam Service and Campaign Medals and several Air Medals. One month later the squadron was awarded the Fleet Air Wing THREE "E" for Battle Efficiency.

The *Tridents* participated in numerous North Atlantic and Mediterranean deployments from 1968 through 1972, earning commendations and awards for their excellence in performance and safety. As a result of the squadron's tactical efforts throughout 1973 and 1974, VP-26 was awarded the Captain Arnold Jay Isbell Trophy for excellence in ASW. In 1974 the squadron also participated in UNITAS XV, a multi-national operation designed to increase the abilities of the United States and South American countries to defend the sea lanes of the Western Hemisphere.

In 1976, the *Tridents* became actively involved in the celebration of America's 200th birthday, being designated a Navy Bicentennial Command. In June 1976, VP-26 deployed to Rota, Spain and Lajes, Azores and proudly displayed its Bicentennial colors throughout the Mediterranean, much of Europe and the North Atlantic. As a result of this highly successful deployment, the squadron received both the Golden Wrench and Captain Arnold Jay Isbell Awards for calendar year 1976.

From 1977 until the present, PATRON 26 has made several deployments to strategic locations throughout the North Atlantic, participating in numerous ASW exercises with NATO and allied naval forces. Recent awards that the *Tridents* have netted include a Meritorious Unit Commendation, the CNO Aviation Safety Award for 1977, and the Gold and Silver Anchor Awards for retention excellence during 1978.

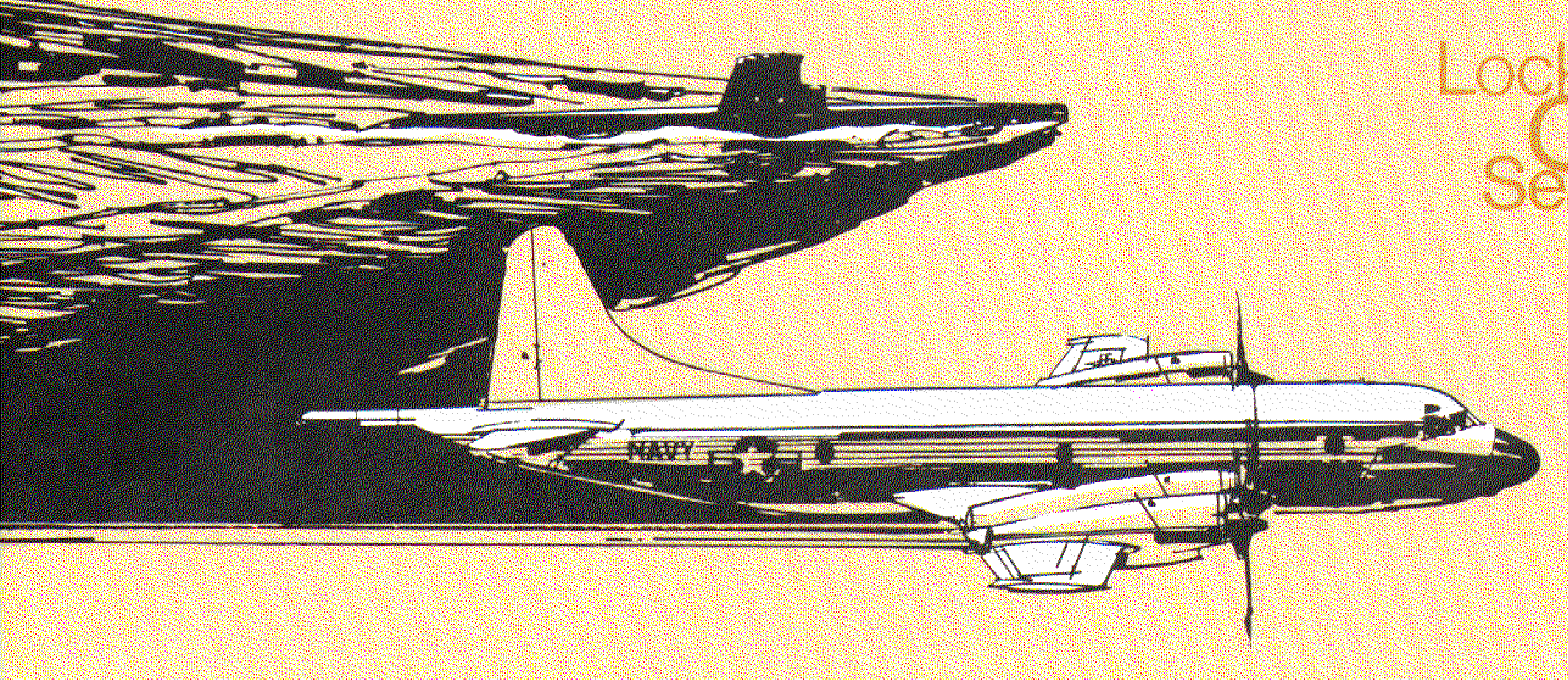
The *Tridents* VP-26 are presently undergoing transition to the *P-3C Update II* aircraft. Early next year the squadron will take their new aircraft on deployment to the North Atlantic.

The Lockheed Orion Service Digest is published by Lockheed-California Company, Burbank, California. Material is not officially approved by the FAA, CAB, or any of the military services unless specifically noted. Military personnel are advised that direct use of the information in this publication may be restricted by directives in their organization. Material contained herein is not classified, but strictures against unauthorized and indiscriminate dissemination of military information apply. Republication of material is not sanctioned unless written permission is granted by Lockheed-California Company. Regulations require that republished material conform to the latest information and changes.

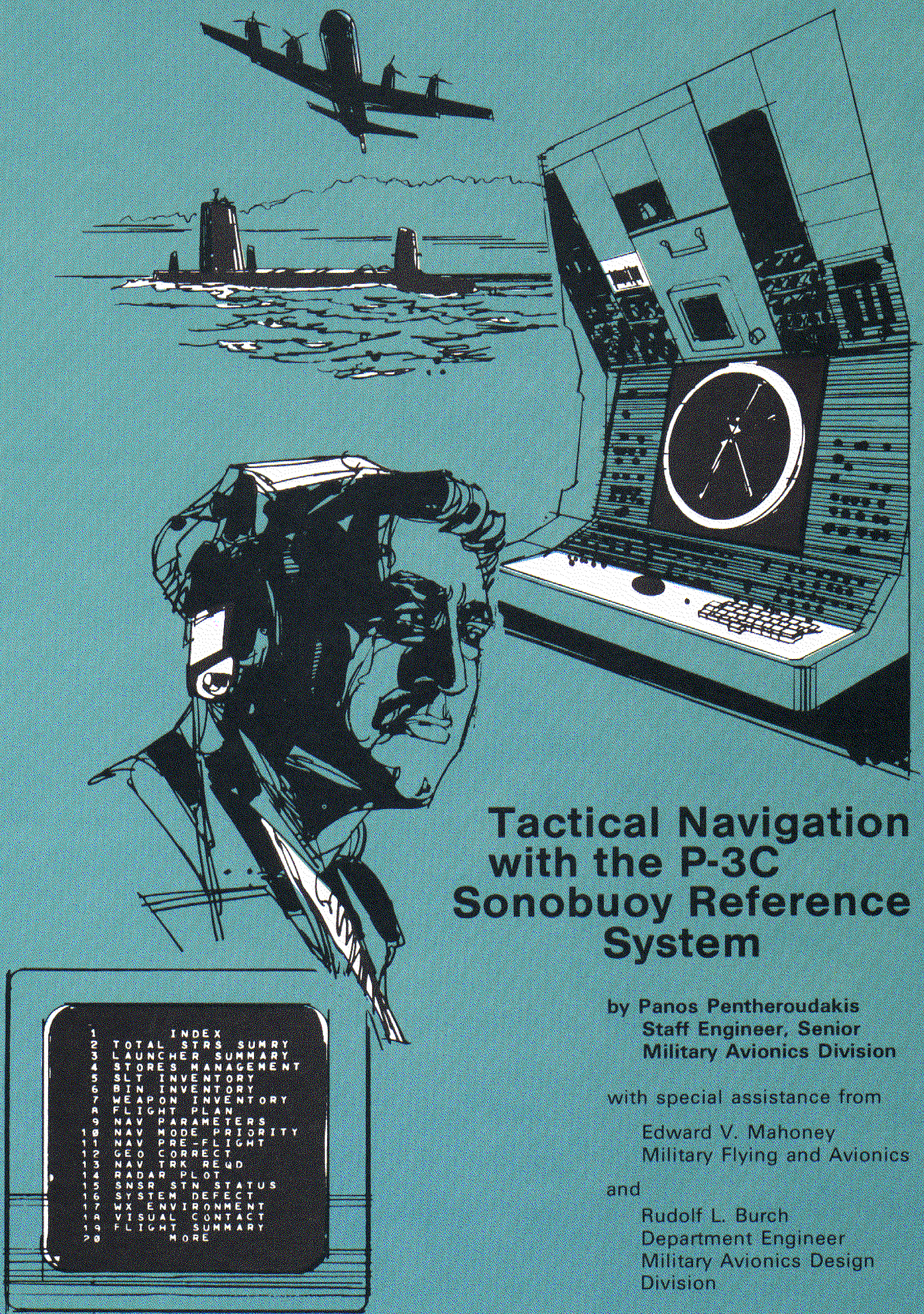
COPIES REQUIRED OR CHANGE OF ADDRESS – Please send your name; present address; occupation; your organization's name; and, if applicable, your old address as imprinted on a Digest envelope to:

YOUR LOCAL LOCKHEED-CALIFORNIA COMPANY SERVICE REPRESENTATIVE OR LOCKHEED ORION SERVICE DIGEST, DEPT. 64-18, BURBANK, CALIFORNIA 91520.

editor | WAYNE CRADDUCK
assistant editor | LUCILE HEMANN
art and production by | ALLEN LUDLOFF



Lockheed
ORION
Service
Digest



Tactical Navigation with the P-3C Sonobuoy Reference System

by Panos Pentheroudakis
Staff Engineer, Senior
Military Avionics Division

with special assistance from

Edward V. Mahoney
Military Flying and Avionics

and

Rudolf L. Burch
Department Engineer
Military Avionics Design
Division

INTRODUCTION

One of the most persistent problems encountered in ASW *is how to maintain accurate relative positions between an aircraft and its deployed buoys and markers*. The P-3C Orion uses a local-coordinate function of its automatic navigation system to address this problem. This function is called *Tactical Navigation, or TACNAV* for short.

Tactical Navigation uses the aircraft's central computer to plot the position of the aircraft relative to that of the deployed stores, which are used as local navigation reference points. Upon command, the computer will present these data to the aircrew on their tactical data displays. Such a presentation, when plotted to local coordinates rather than geographic coordinates, is called a tactical plot. The central computer updates these data continuously to provide a real-time presentation of the tactical plot.

For TACNAV to be an effective tactical aid, the buoy symbols displayed on the tactical plot must appear to be *stationary* reference points. The central computer compensates for buoy motion, both real and apparent, to stabilize the buoy pattern presented on the tactical plot. This process is referred to as tactical navigation system stabilization.

Until relatively recently, the only reliable means of obtaining data for the central computer on buoy motion that is caused by system drift was by over-flying the designated buoy, then electronically noting its position – the familiar Mark-On-Top (MOT) procedure. Although accurate when executed properly, the MOT procedure is time-consuming. During the past few years, the ASW community has developed the Sonobuoy Reference System (SRS) to facilitate tactical navigation plot stabilization.

The Sonobuoy Reference System is an electronic phase-measurement system that provides angle-of-arrival measurements of signals broadcast from deployed sonobuoys. The central computer uses these data to accurately calculate the positions of the buoys relative to the aircraft. Signals from up to 31 sonobuoys can be processed simultaneously, enabling the computer to generate a continuous update of the sonobuoy positions on the tactical plot. The SRS is an accurate and automatic all-weather system that can be used with all types of sonobuoys.

This article describes the Sonobuoy Reference System, and shows how it is used to complement the Tactical Navigation mode of the aircraft's automatic navigation system. As background for this discussion, we have described the use of sonobuoys as navigation reference points and examined the variable factors that affect buoy position accuracy. To round out the background material, we have also included a description of how the P-3C Navigation System is implemented and the way it functions.

THE NAVIGATION PROBLEM

In the search for submarines, the P-3 Orion crew uses sonobuoys of varying types that may be deployed over several miles of ocean. These buoys serve a dual purpose: First, they are the "ears" for the aircrew. They listen for acoustic indications of submarines, then transmit this information to the aircraft by radio. Of equal importance, these sonobuoys also serve as temporary navigation reference points for the aircrew. For the crew to perform their mission, they must be able to position the aircraft relative to these buoys with a high degree of accuracy.

This objective is complicated by several variables. Among them are:

1. Buoy Drop Error
2. Equipment System Error
3. Navigation Error
4. Buoy Drift

Of the four, only buoy drop error is a one-time occurrence; the other three errors can and will vary continuously, and are usually designated as *system drift*.

Buoy Drop Error is the error in calculation of the buoy splash point. The aircraft's central computer is programmed to calculate the buoy splash point based on buoy type, wind, aircraft altitude and airspeed. Error in these calculations can be due to any one of the following:

- *High Altitude Release* – The program uses a *maximum* altitude of 2000 feet to compute buoy trajectory. When buoys are launched from altitudes greater than 2000 feet, there will be an additional error in trajectory computations.
- *Wind* – The wind data utilized by the computer to calculate buoy trajectory are those data currently being used by the navigation system at the time of the buoy drop. Obviously, wind is not constant at all altitudes from the aircraft to the surface. Therefore, error is induced in the buoy trajectory computation by the differences in wind velocity and direction encountered by the descending buoy.
- *Buoy Type* – The computer utilizes the weight and drag coefficient in its trajectory calculations for each of the major buoy types. However, the computer does not take into account that buoys of the same type fabricated by different manufacturers can differ in weight as well as drag coefficient. These differences have little effect upon buoy trajectory calculations unless the buoy uses a parachute retardant system.

Equipment System Error, occasionally referred to as electronic error, is a combination of errors in software equations, rounding or truncation, and in basic electronic equipment inaccuracies. These errors are very minor, and are generally lumped in with navigation error.

Navigation Error is simply the error associated with the aircraft system selected to provide dead reckoning (DR) data to drive the TACNAV system. The major errors for the inertial, Doppler, and air data systems are:

- *Inertial*
    1. Schuler Cycle variations
    2. Linear Drift caused by an improperly biased gyro or improper alignment
- *Doppler*
    1. Doppler-apparent sea motion, caused by sea surface winds
    2. Equipment inaccuracies of the antennas or Doppler Computer Tracker, usually expressed as a percentage of aircraft velocity
- *Air Data*
    1. Wind inaccuracies that are hand-set or caused by frozen sensors
    2. True Airspeed Sensor and Computer inaccuracies

The Omega and Loran sensors, due to signal propagation effects, presently can not provide DR data that can effectively drive the TACNAV system.

Buoy Drift is any movement of the buoy away from the position where it was dropped. Drift is caused by ocean currents and wind. The degree of drift depends upon:

- *Local Ocean Currents* – Ocean currents vary in velocity and direction with the time of year, and with the particular location where the buoy field is placed. With a widely-dispersed pattern, individual buoys may have deployed their hydrophones to different depths and be in different currents.
- *Environmental Motion* – Wind induced sea-swell movement has some effect on the buoy drift rate and direction. Wave motion will tend to move the buoy in the same direction as the wind.
- *Buoy Type* – The degree of drift is also somewhat dependent upon buoy type. A lighter buoy with more area exposed to the wind will drift at a different rate than a heavier buoy with less area exposed.

P-3C NAVIGATION

Navigation in the P-3C is divided into two basic categories: Geographic Navigation (GEONAV) and Tactical Navigation (TACNAV). In both of these navigation modes, aircraft position is calculated by the aircraft's central computer, based upon dead reckoning (DR) data from the aircraft's Doppler, inertial, and air data systems. During preflight, the NAVCOM can designate the primary and backup DR data sources for the computer to use when it calculates aircraft positions. Note that the primary and backup DR sources for TACNAV do not have to be the same as the GEONAV DR sources. For example, the computer may use a primary/backup DR source combination of Doppler/air data to calculate TACNAV position, and use a Doppler/inertial combination to calculate GEONAV position. If the computer determines that the data from the primary DR source are not acceptable, it will automatically switch to the backup DR source. In any mode, the crew can provide the computer with supplementary data to more precisely fix aircraft position.

GEONAV provides the aircrew with the best estimate of the aircraft's position over the earth. Aircraft position is shown in the customary geographic coordinates, latitude and longitude (abbreviated LAT/LONG in this article). GEONAV is mainly intended for long-term navigation applications, such as guiding the aircraft to and from the patrol area. GEONAV accuracy is dependent upon navigational errors only, and can tolerate short-term deviations or nonlinear errors that tend to be self-cancelling with time. During automatic navigation system operation when the GEONAV mode is in use, the central computer is always computing the aircraft's geographic and tactical positions. The aircraft's tactical position is kept identical to the aircraft's geographic position.

TACNAV provides the aircrew with the best estimate of the aircraft's position relative to search stores or other objects in the water that are designated as local navigational reference points. In this mode of operation, aircraft position is shown in local coordinates (X and Y) on a tactical plot of the area of interest. TACNAV is intended for navigation applications in which precise knowledge of the aircraft position relative to local reference points is of prime importance. The accuracy of this mode is dependent upon system drift, and the errors that are predictable and detectable can be corrected. TACNAV was developed to correct aircraft relative position errors and, by minimizing NAV System drift, to help the crew maintain an accurate and stable plot of the buoy field.

When TACNAV is in use, the primary DR source selected for TACNAV is used to compute the aircraft tactical position. If the operator has selected the *same* primary and backup DR sources for both TACNAV and GEONAV, any difference in aircraft position indicated by these two modes will be due to a factor called "bias velocity" that has been applied to the TACNAV calculations. Bias velocity is a correction applied to TACNAV calculations to compensate for the relative drift between the sonobuoy field and the aircraft, and to provide a tactical plot that is stabilized with reference to the drifting pattern of stores in the water. When different primary DR navigation sources are used for TACNAV and GEONAV, any difference in the indicated aircraft position may be due to a combination of bias velocity and differences in the inputs from the two DR sources.

As the GEONAV and TACNAV positions drift apart, the computer program stores the difference in these aircraft positions (hereafter referred to as a *delta value*). When TACNAV is deselected, the computer applies this delta value to the TACNAV-referenced items so that they will be displayed at their correct geographic positions, relative to the aircraft.

When TACNAV is in use, the computer also maintains the aircraft unbiased TACNAV position, which is the aircraft unmodified position. In other words, the unbiased TACNAV position is computed using only data from the TACNAV primary sensors. No additional data from aircraft position corrects or bias velocity factors are used.

When the TACCO selects the TACNAV mode, the center of the tactical display becomes the Tactical Navigation reference point. As the TACNAV and GEONAV systems drift apart, the GEO LAT/LONG position indications of the reference point will change with time due to a combination of bias velocity and the difference in the inputs from the

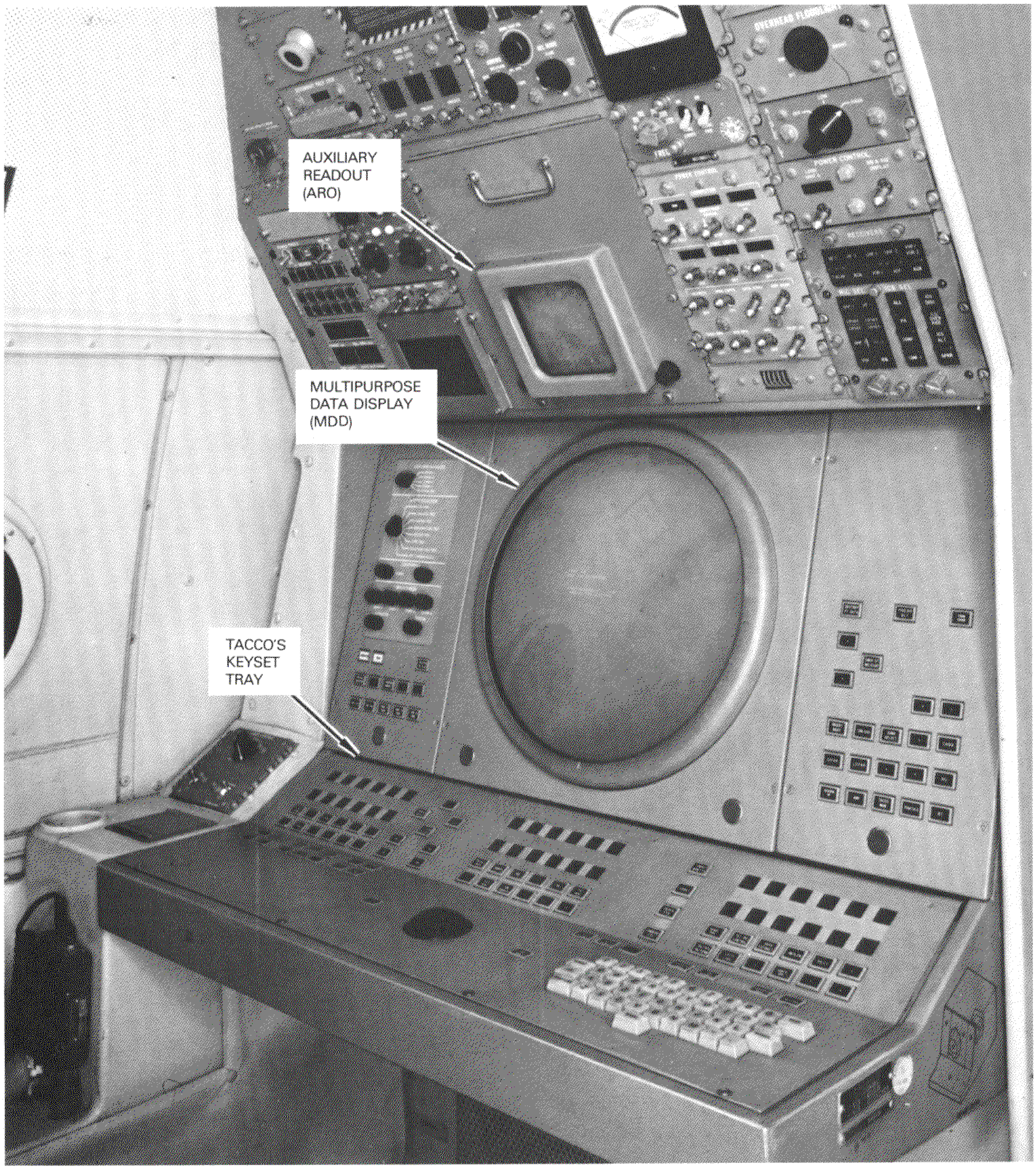


Figure 1. TACCO Station, Showing the Multipurpose Data Display (MDD), Keyset Tray, and the Auxiliary Readout Display (ARO)

two DR sources. Because of this, the latitude/longitude that the TACCO reads of a position at time t_1 will not be the same as the latitude/longitude that he reads of that same position at time t_2. An exception to this occurs when the item "hooked" has a stored position, such as a radar contact. In such a case, the stored position is displayed. The TACCO station is shown in Figure 1.

BUOY TACNAV POSITION The central computer must maintain a tactical position of each sonobuoy in order to achieve tactical plot stabilization. The aircraft and sonobuoys tactical positions are usually maintained relative to a reference sonobuoy. In tactical navigation, the computer assumes that (a) the reference buoy remains stationary, and (b) that any disparity between the actual position (MOT indications) and the display position of the reference buoy is caused by system drift errors.

Four positions are maintained for each buoy by the central computer while TACNAV is in use. The latter two are controlled by the SRS and are used when the SRS is available, and they are discussed in later sections of this article.

1. The sonobuoy's unbiased TACNAV position
2. The sonobuoy's TACNAV position
3. The sonobuoy's SRS position
4. The sonobuoy's SRS display position, which is the sonobuoy SRS position that meets certain display update criteria

The sonobuoy's unbiased (uncorrected) TACNAV position is computed from the aircraft unmodified position. This is an artificial buoy position that is never seen by the operator and is, in fact, used only to compute bias velocity. An unbiased TACNAV position is computed and stored for a buoy whenever one of the following occurs:

- A buoy is launched
- A buoy is inserted on the display via the "on-top" marking procedures
- A buoy position is corrected

The sonobuoy's TACNAV position is computed by using the aircraft TACNAV position. This is the buoy position shown on the displays, and is the position that is retrieved from the data extraction tape as the sonobuoy's tactical position. This position is the latest of the following:

- Splash point of a launched buoy
- Position of a buoy received via ASW summary
- Buoy Corrected position
- A Pattern Corrected position

Buoy corrected and pattern corrected positions are discussed in the next section, "Operator Functions."

Every buoy in the system has a TACNAV position and time that the TACNAV position has been updated. Each TACNAV position, with the exception of buoys inserted via latitude/longitude and hook, has an uncertainty value (covariance) associated with it.

The position that the crew sees on their displays is the latest one of the following:

- The TACNAV position
- An SRS display position (that is the SRS position that passes the acceptance criterion)*
- A buoy corrected position
- A pattern corrected position
- A translated SRS accepted position. (When an aircraft correct position is performed, the accepted SRS positions are slewed the same distance as the aircraft.)*

OPERATOR FUNCTIONS There are several functions unique to TACNAV that can aid the crew to stabilize the plot. The primary purpose of these functions is to generate a bias velocity.

A Bias Velocity, as used in the P-3C program, is a correction vector that is opposite in direction and equal in magnitude to the rate that the tactical position is diverging from a position that is relative to a sonobuoy. Thus, it is a combination of buoy

---

**This position is not available for P-3C Update I and Update II aircraft whose SRS is unavailable.*

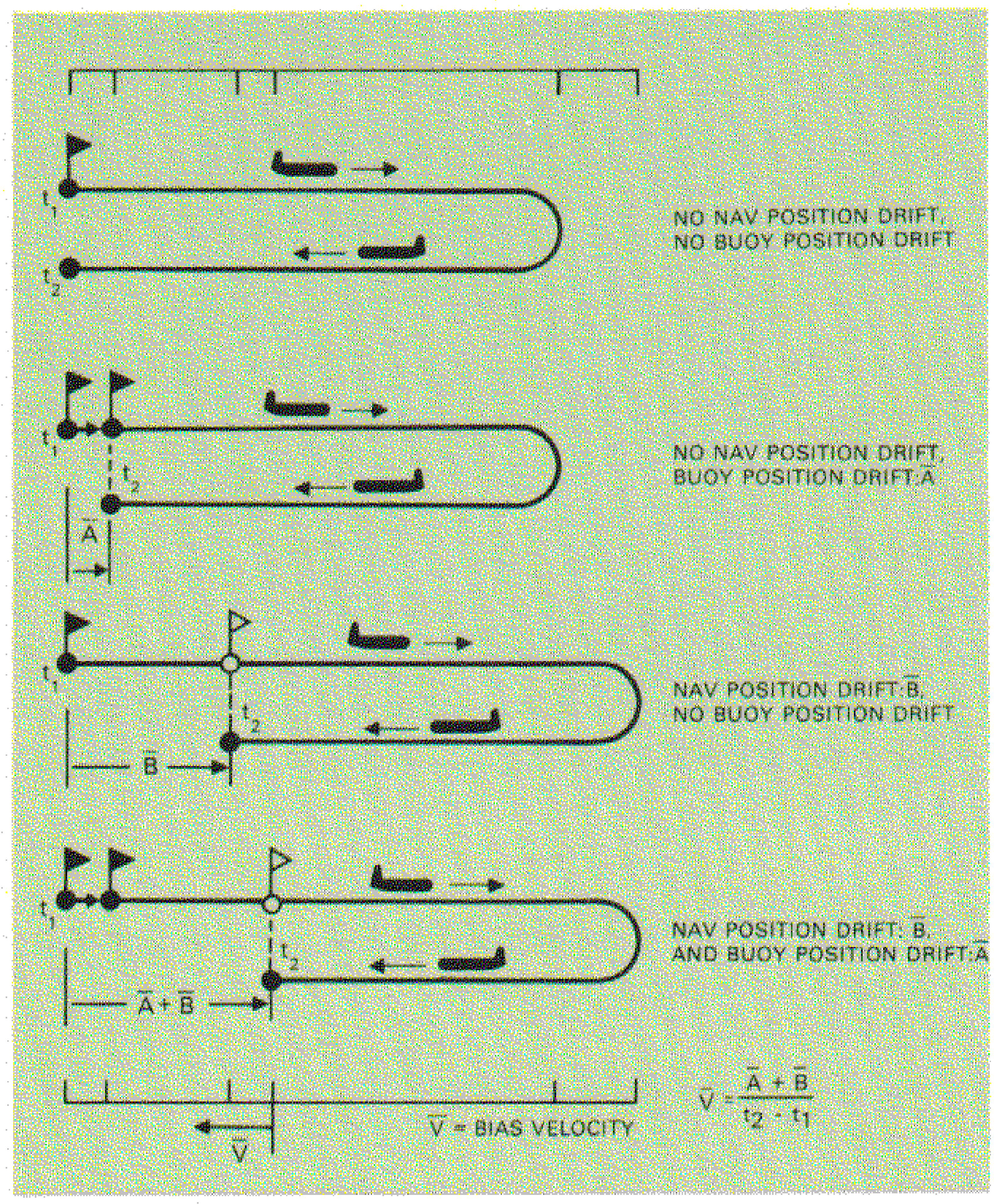


Figure 2. Bias Velocity, a Combination of Buoy Position Drift and Navigation Position Drift

drift and navigation error (see Figure 2). This vector is applied to the aircraft tactical position to help stabilize the aircraft-to-buoy relationship. The current bias velocity is shown on the TACCO's display as direction and velocity in yards-per-minute. The direction indicated is the direction from which the bias is applied.

The latest modifications to the procedure (algorithm) that computes bias velocity permit any sonobuoy to be marked "on top". Navigation drift is computed by determining the difference between the time that the sonobuoy is dropped (or a single sonobuoy correct has been performed) and the present time. The algorithm uses a statistical program called a Kalman Filter to estimate system drift. This Kalman Filter takes a weighted average of each drift velocity that is computed when the aircraft "on-tops" a sonobuoy, then combines this average value with the system drift value that is presently in use. This update is not performed until the algorithm verifies that the navigation drift has not changed direction or magnitude. If a change in navigation drift has been verified, the filter is adapted to reflect this change by reducing the importance of the old data in the computations. This adaptive mode is the method by which the algorithm follows navigation drift for the inertial navigation system (INS), in which the errors contain a sinusoidal and a linear component. Navigation drift for the Doppler and airspeed systems is constant, thus these systems do not require use of this adaptive mode.

Once that navigation drift has been stabilized, the number and frequency of "on top" markings

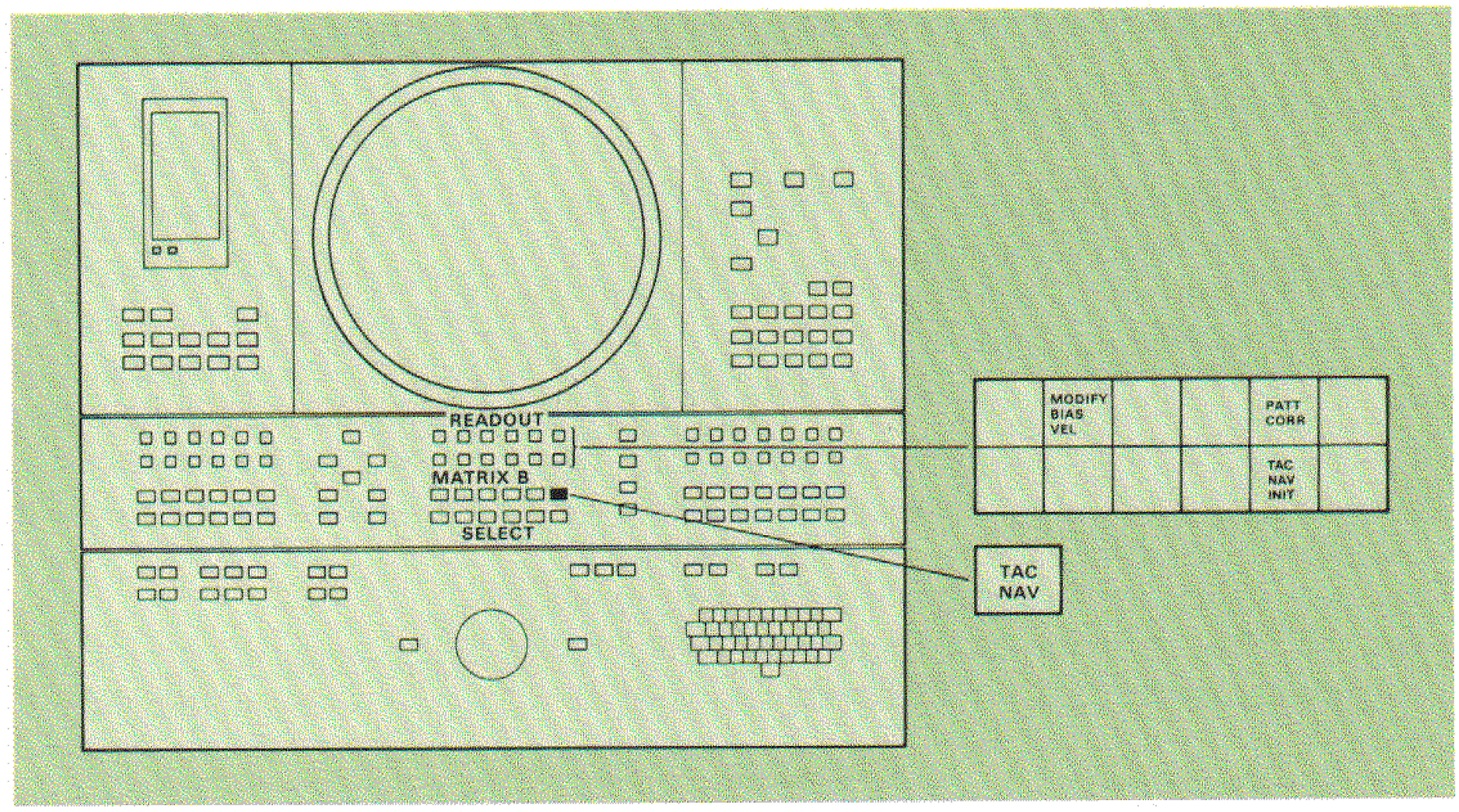


Figure 3. TAC NAV Select and Readout Function Switches on the TACCO Keyset Matrix "B"

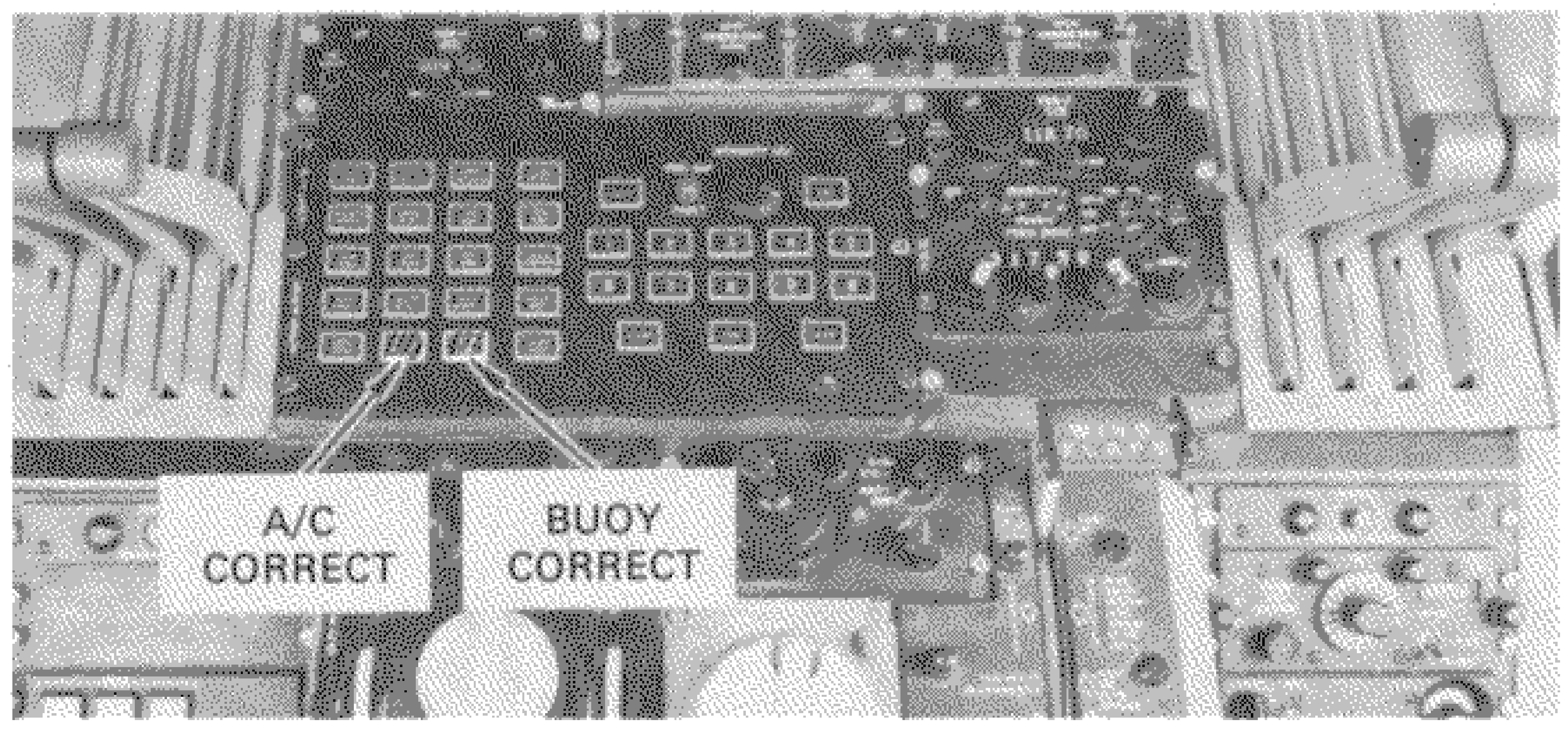


Figure 4. TAC NAV Function Switches on the Pilot Keyset

depend upon (a) the navigation system used, (b) aircraft altitude, and (c) the phase of the mission.

The functions that are unique to TACNAV are located at the TACCO and Pilot keysets (see Figures 3 and 4). The keyset functions that are available only when the TACNAV INIT switch is active at the TACCO station are:

KEYSET FUNCTION	STATION
Modify Bias Velocity	TACCO
Pattern Correct	TACCO
Aircraft Correct	PILOT
Buoy Correct	PILOT

With the exception of the Modify Bias Velocity function, all of the above functions must be preceded by the pilot depressing the On-Top button on the P-3C control wheel (see Figure 5). Because of this requirement, the Mark On-Top function is often considered a TACNAV function. The following paragraphs describe these functions.

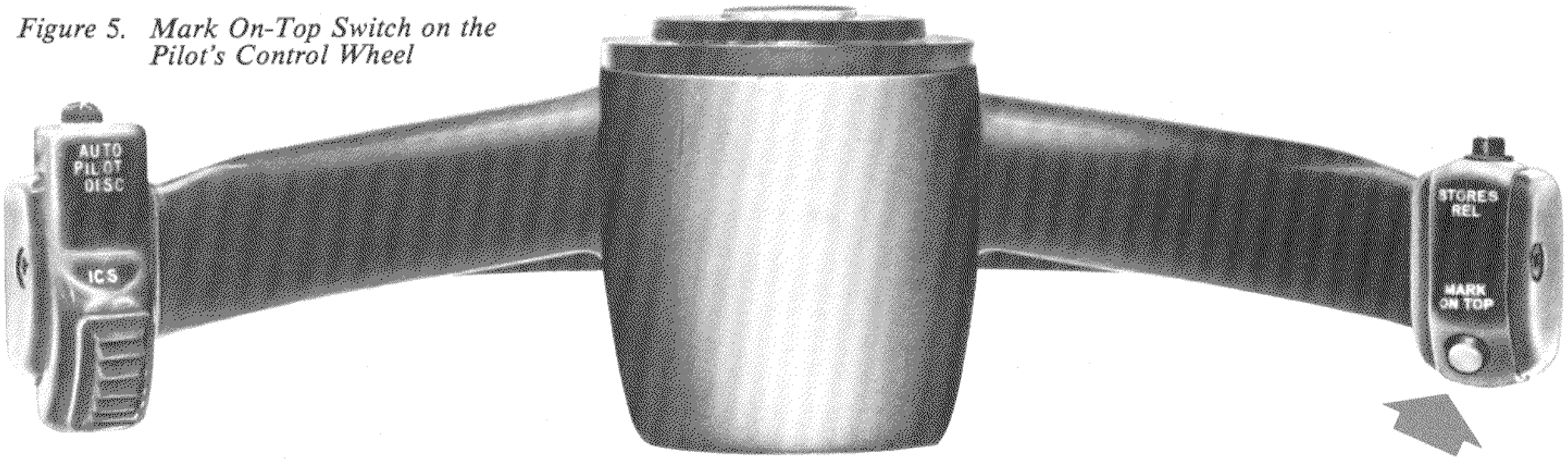
Mark On-Top (MOT) The On-Top function overrides all other computer functions at the Pilot's station. Only one OT symbol will ever be displayed at a time, and it will always be the last OT marking.

Buoy Correct The purpose of the Buoy Correct function is to move the location of the buoy symbol to the OT symbol.

Aircraft Correct The Aircraft Correct function is the heart of the TACNAV system. This function enables the TACNAV system to generate a bias velocity. Before a successful Aircraft Correct function can be performed, the pilot must fly the aircraft to a sonobuoy, either visually or electronically. When the pilot determines that the aircraft is over the buoy, the Mark On-Top button is depressed. The radio frequency (RF) of the buoy must then be entered, after which the Aircraft Correct switch is depressed in response to the SEL FUNCT cue. The program then checks for an unbiased TACNAV position for the buoy. If no such position exists, the alert BUOY CORRECT AVAIL is displayed. This display informs the TACCO that a BUOY CORRECT function must be performed on this sonobuoy if data from it are to be used to generate a bias velocity. Only buoys dropped (or positioned via "on-top") during present TACNAV activation will have an unbiased TACNAV position.

The P-3C Operational Program directs the central computer to calculate a bias velocity, based upon the unbiased TACNAV position of the "on-top" marking and the unmodified position of the aircraft at the time of the "on-top" marking. This bias velocity is tested for consistency against previous bias velocities (if they have been computed).

Figure 5. Mark On-Top Switch on the Pilot's Control Wheel



If this is the first Aircraft Correct computation since TACNAV activation or since the last update in bias velocity computations, an uncertainty value is computed when the bias velocity is computed. When the bias velocity fails the test, the TACCO receives the following cue on the cueing area located at the lower part of his display (see Figure 6):

NEW BIAS VELOCITY UNAVAIL

ACCEPT – REJECT OT

D1 ACCEPT

D2 REJECT

The pushbutton D2 REJECT response is treated by the operational program as if no "on-top" procedure had been performed. Choosing D1 ACCEPT allows the computer to use the "on-top" data to update the internal bias velocity. When the next "on-top" procedure is performed, the program checks the "on-top" measurement against this bias velocity value for consistency.

When the bias velocity value passes the test, the operator can accept or reject the bias value by responding to the TACCO display cue:

BIAS XXX D XXX YD-M

D1 ACCEPT

D2 REJECT

Selecting D1 ACCEPT slews the aircraft display symbol to the correct DR position relative to the "on topped" buoy symbol. In addition, all generated tracks, IRDS contacts, SRS buoys with any associated contact data, and other data referenced to the aircraft position will be slewed on the display. The accepted bias velocity will also be shown on the left side of the TACCO's display. Selection of D2 REJECT displays the cue:

ON TOP

D1 ACCEPT

D2 REJECT

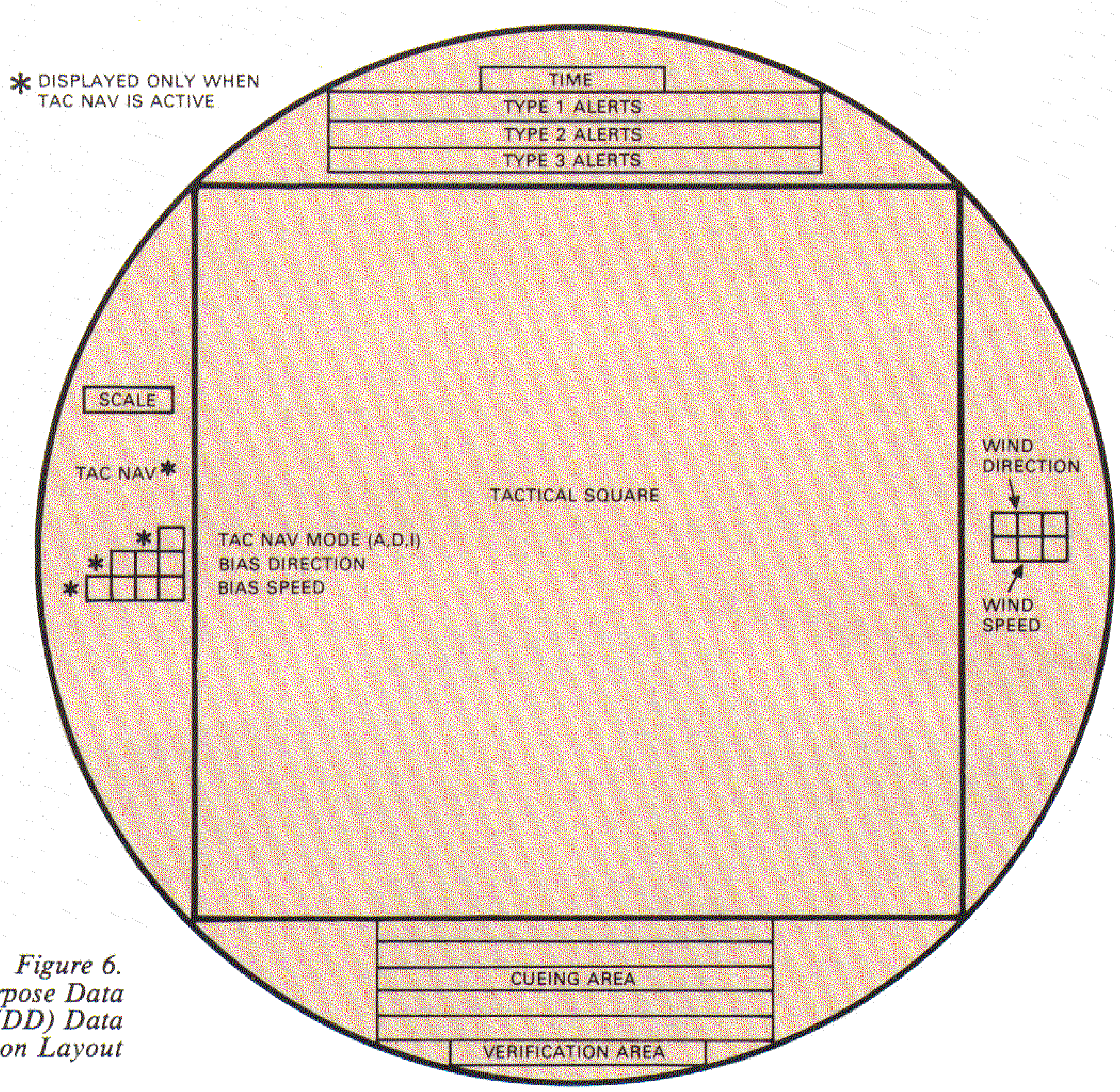


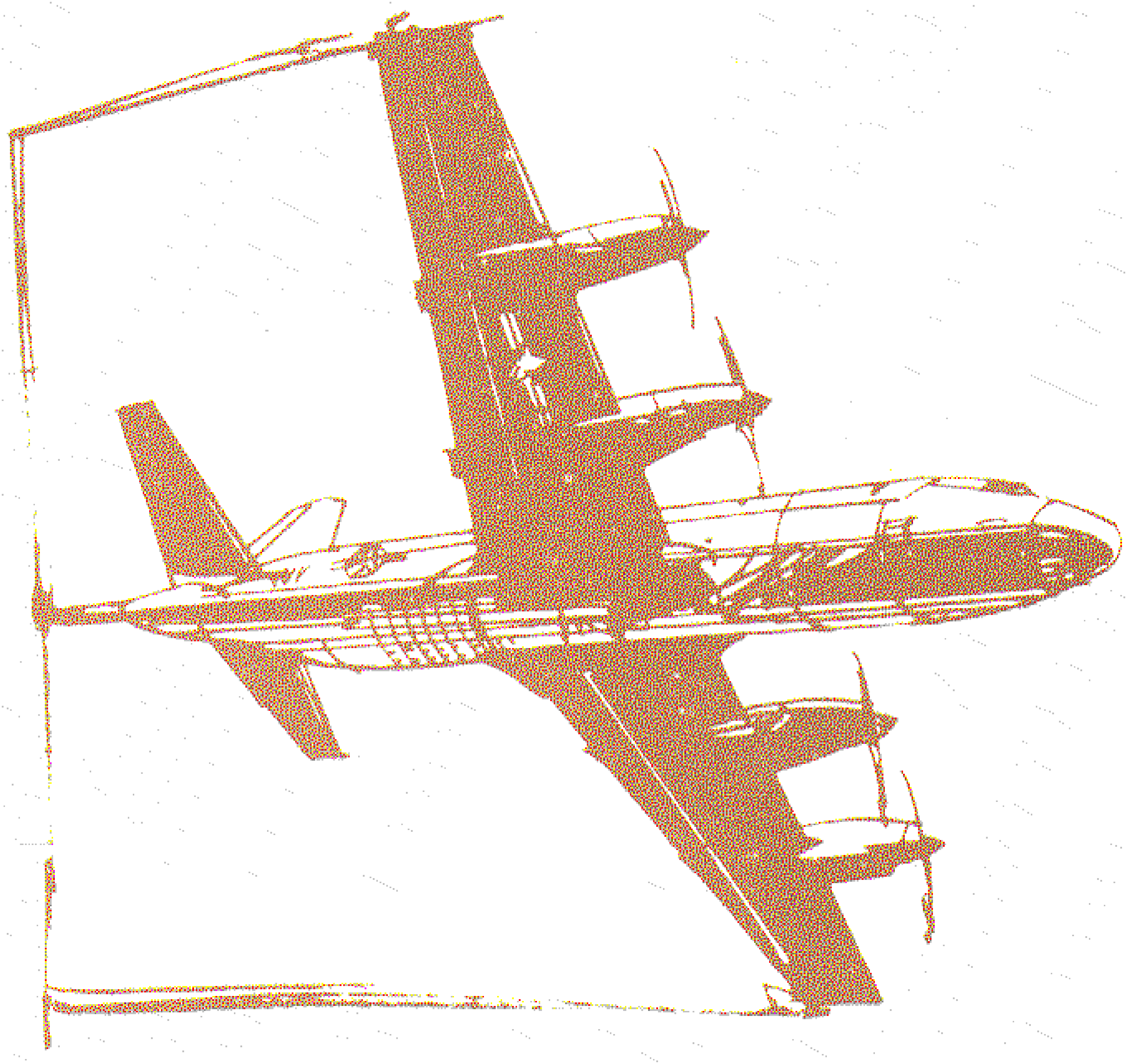
Figure 6. Multipurpose Data Display (MDD) Data Presentation Layout

The outcome of the cue responses is the same as when no bias velocity value was available.

Pattern Correct The Pattern Correct function modifies the TACNAV and corresponding system display positions of sonobuoys, smoke markers, and MAD marks from the currently computed system bias velocity. This function corrects the displayed position of the individual sonobuoys that make up a buoy pattern, to account for the disparity in the drop times of the buoys. The difference in buoy drop times causes a difference in the amount of time that buoy drift and system drift act upon the aircraft TACNAV position, and therefore upon the displayed position of each buoy (at drop) in the pattern. Consequently, a buoy pattern that appears to be symmetrical on the display may have several errors in buoy positioning. This problem is more apparent in large buoy patterns that are spread over large distances rather than in smaller buoy patterns.

The Pattern Correct function can update buoy position only once per TACNAV initiation. For this function to become available, a bias velocity value must be available and accepted following initiation of an Aircraft Correct function. If a Pattern Correct function has *not* been performed on any buoy during TACNAV activation and the previously listed conditions have been met, then the cue "PATTERN CORRECT" is displayed at the TACCO station. The TACCO can clear this cue by depressing the CANCEL key, or simply ignore the cue for 45 seconds (after which it will clear automatically). In either case, the operational Program directs the computer to take no further action. If the TACCO chooses to perform a Pattern Correct function, he depresses the PATTERN CORRECT key in the TACNAV matrix.

When a Pattern Correct function is initiated, the operational program directs the computer to apply a correction factor to the sonobuoy, smoke buoy, and MAD mark positions that have already been recorded. However, if any store drop or MAD mark is recorded after a bias velocity value is put into the system by either the Aircraft Correct or the Modify Bias Velocity function, it is not correctable by the Pattern Correct function.



The correction factor of this function is based upon the current bias velocity multiplied by a time factor. The correction is different for each store or MAD mark and may be either positive or negative, depending upon the time factor. The buoy that is marked on-top when the Pattern Correct cue is first displayed becomes the base buoy for the Pattern Correct function. Generally, the time factor in these computations is the difference between the splash time of the base buoy and the splash time or initial time of the store or MAD mark to be corrected. Two exceptions to this time factor are (a) when buoys are dropped before activation of TACNAV and (b) when displayed buoy positions are corrected with the Buoy Correct function. In these cases, the time of TACNAV initiation or the time of correction (which ever is later is used instead of the item's initial time.

If used correctly, the Pattern Correct function is a useful tool. For optimum performance, the TACCO should resolve the bias velocity by performing several Aircraft Correct operations following acceptance of the initial bias velocity value. This refined bias velocity value would then be used by the TACNAV system for the Pattern Correct computation. The Pattern Correct operation would then correct the displayed position of those sonobuoys that were deployed before a bias velocity was inserted into system computations.

Modify Bias Velocity The Modify Bias Velocity function allows a bias velocity value to be inserted into the system or allows the value to be modified without performing an Aircraft Correct operation. This function can be used only if TACNAV is active. When TACNAV is active, depressing the MODIFY BIAS VEL switch presents the cue:

MODIFY BIAS VELOCITY

DIRECTION XXX DEG

Following a correct response (0–360), the velocity portion of the cue is displayed:

MODIFY BIAS VELOCITY

SPEED XXXX YD-MIN

After entry of a modified bias velocity value, the TACNAV system uses this new bias velocity in its computations.

Use of the Modify Bias Velocity function should be limited because it can induce errors into system computations. However, it may be advantageous to use this function if there is insufficient time for the system to compute a bias velocity. It is also useful following an operational program reload when the previously computed bias velocity can be reinserted.

Lockheed ORION Service Digest

Functions Affecting TACNAV Four functions affect TACNAV processing and positioning: Geo Correct, Radar Geo Correct, Omega Correct, and Recover Aircraft Position. The first three functions can be lumped together under Geo Correct since they affect TACNAV in the same manner. Recover Aircraft Position is unique and is covered separately.

The Geo Correct functions, i.e., GEO CORR, RADAR GEO CORR, and OMEGA FIX ACCEPT, all correct only the displayed geographic position. When a geographic position update is performed while the TACNAV mode is selected, there is no apparent change to the items on the display. However, if the operator inserts a set of LAT/LONG coordinates before performing a geographic position correction *and then inserts the same LAT/LONG coordinates after performing the correction,* the LAT/LONG entries will appear at two different points on the display. This will occur even if no corrections have been made to the tactical plot and the same navigation system is driving both the geographic and tactical plots.

The Recover Aircraft Position function enables the TACCO to correct the aircraft tactical and geographic positions following performance of a program reload and data recovery procedure. If the store or MAD mark used for Recover Aircraft Position has a stored GEO position from the previous "save data" block, that position is used to correct the aircraft's geographic position. The aircraft's tactical position at the time that the Mark On-Top occurs on the display is selected as the TACNAV reference point. When the position of a store or a MAD mark is selected as a reference point, it is commonly referred to as the item "hooked".

When a buoy is used as the reference base for the Recover Aircraft Position function, the Mark On-Top altitude, time, and stored buoy LAT/LONG are used to compute a new aircraft position and a new position uncertainty value for the buoy. The unbiased TACNAV positions for all other buoys are set to the respective GEONAV positions. This is done to prevent false Aircraft Correct bias velocity computations. Such errors could occur if Buoy Correct procedures were performed between the program reload and the Recover Aircraft Position procedure. Therefore, before an Aircraft Correct procedure can be performed on the displayed position of a buoy, the Buoy Correct function must first be performed upon the buoy.*

**The exception to this rule is when the buoy is used as the reference point for a Recover Aircraft Position procedure.*

SRS TACTICAL NAVIGATION

The P-3C Sonobuoy Reference System is required to work both with and without TACNAV. For TACNAV to be effective, the tactical plot must be stabilized. This requires that the MOT procedure be performed repeatedly over several buoys to provide the central computer with system drift data or with a weighted average of the individual buoy system drifts. Frequently, ASW tactics do not allow sufficient time for effective application of TACNAV. On these occasions tactical plot stabilization must rely primarily upon the SRS.

The mating of the SRS and the TACNAV system occurs when the central computer uses the aircraft's stabilized navigation and its dead reckoned position in processing the SRS equations. Each time a sonobuoy position is estimated, the SRS equations use the aircraft position as part of the data base. If the aircraft position is erroneous, the estimated sonobuoy position will be in error. Thus, such sonobuoy position errors are indirectly related to system drift error. The magnitude of the sonobuoy position error also depends upon the range of the aircraft to the sonobuoy, and upon the aspect of the aircraft track relative to the sonobuoy. When the aircraft is flying close to the buoy and the rate of change of the bearing from the aircraft to the buoy is large, system drift has minimal effect upon the sonobuoy position error. However, after the aircraft passes the sonobuoy and the rate of change of bearing from aircraft to buoy is very small, system drift has its maximum affect upon the sonobuoy position error. In fact, the rate of growth of sonobuoy position error due to system drift can be as great as the system drift when the buoy position observations are made along the same line-of-bearing.

As stated earlier, the accuracy of the sonobuoy's relative position to the aircraft becomes more critical as the ASW mission enters its final phase. Sonobuoy position accuracy is important because the buoy positions are used to establish a baseline or a coordinate system to which the target is related. Sonobuoy position changes during successive SRS updates will be displayed as apparent system drift. Sometimes this apparent system drift may exceed actual system drift by a large factor (especially during SRS sonobuoy position solution convergence), due to other system errors.

Since convergence requirements and system drift can adversely affect sonobuoy position estimates, extreme care must be observed when processing sonobuoy positions that are derived from the SRS. On P-3C aircraft, this problem has been tackled by using an additional filter (program) to process the sonobuoy positions that are derived from the SRS. The filter is the navigation system's automatic sonobuoy position accept function. The accept function monitors each successive position estimate from the SRS and detects when sonobuoy positions obtained from the filter have stabilized. If the rate of change of the sonobuoy position exceeds the predicted navigation uncertainty, the accept function inhibits the update of the displayed sonobuoy position until the sonobuoy position estimates are again stabilized. Thus, the sonobuoy positions derived by the SRS and processed by this filter will not be used by the operational program for display, target tracking, and tactical planning unless they represent steady-state (converged) data.

BASIC SRS OPERATION PRINCIPLES

HOW BUOY LOCATION IS DETERMINED The SRS estimates the locations of deployed sonobuoys relative to the position of the aircraft. These estimates are updated periodically and presented to the flight crew on tactical data displays.

The SRS first measures the line-of-sight (LOS) relative bearing from the aircraft to the true buoy position (Figure 7), then computes the distance and bearing from the aircraft to the indicated buoy position. The indicated buoy position is an SRS estimate of buoy position. The SRS uses successive SRS LOS bearing measurements to adjust the buoy position estimate periodically by a technique that is similar to triangulation (Figure 8). This technique employs the "Extended Kalman Filter" (EKF) algorithm, an estimating procedure that has been applied very successfully to "non-linear" target tracking-type problems.

It must be emphasized from the beginning that buoy position can only be estimated. The bearing estimate from the aircraft to the buoy is accurate because it is based upon SRS angular measurements. The range estimate to the buoy is initially inaccurate since the range from the aircraft to the buoy is not measured directly. *Accurate range estimation can only be achieved by processing bearing data from different directions.* This inability to make direct range measurement has complicated both the SRS software design and the system's tactical use. For example, the SRS will operate best if the aircraft is flown in paths (fly-by offset 2 to 3 miles from the sonobuoy) that favor making accurate buoy range estimates to ensure that the SRS can estimate buoy positions as accurately as possible.

The SRS estimates the position of the buoy in much the same manner that the surveyor finds the distance from a given point to an inaccessible object. For example, suppose the surveyor wanted to know the distance from point B (on one side of a river) to point C (on top of a peak on the other side of the river) as shown in Figure 9. First, he must establish line AB as a baseline, then measure angle LOS_1; next, he must measure distance D between points A and B; finally, he must measure angle LOS_2. With these data, he can calculate

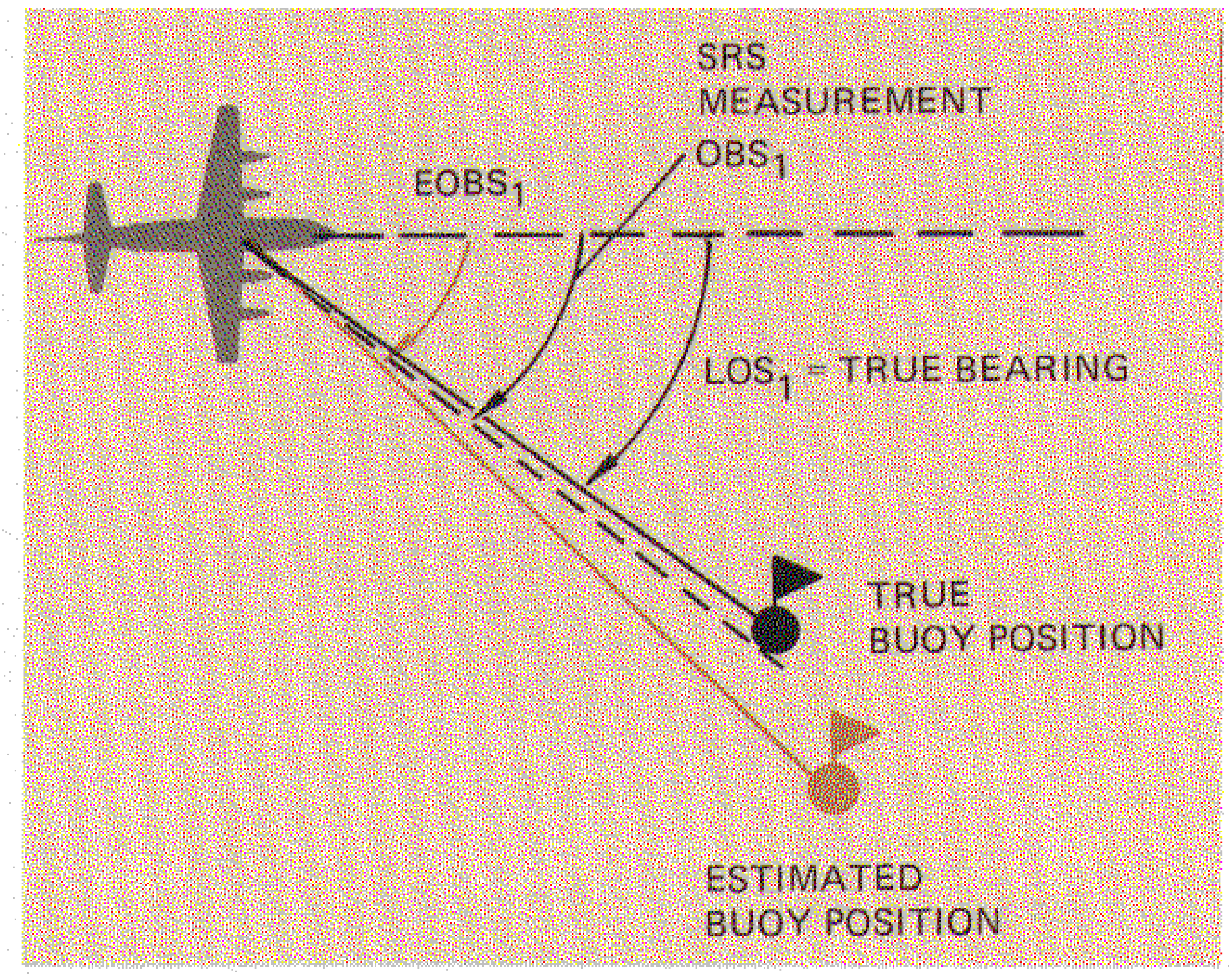


Figure 7. Buoy-to-Aircraft Position

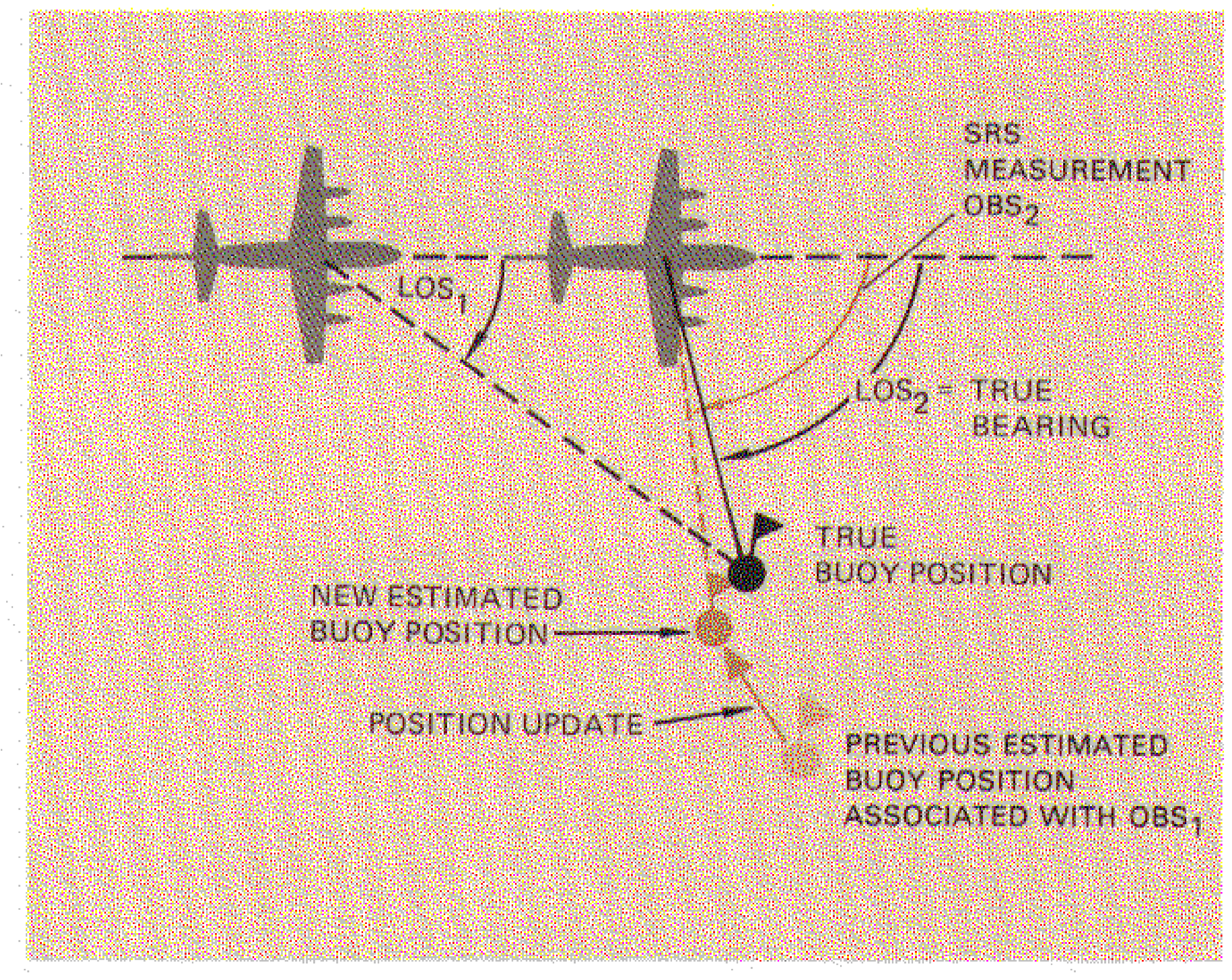


Figure 8. Buoy Position Update.

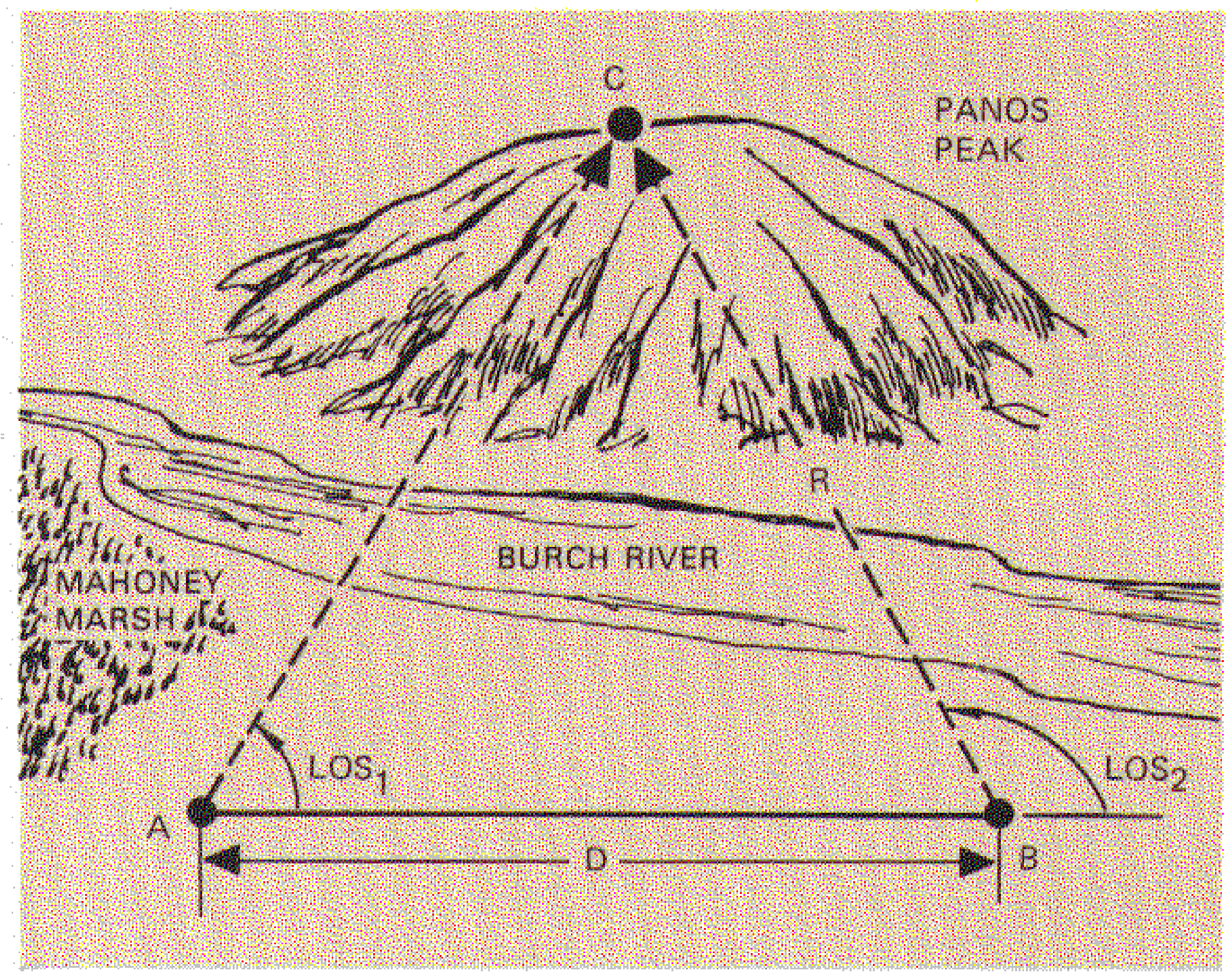


Figure 9. Position Fixing

range R, the distance between points B and C. Although the SRS does not estimate the range from the aircraft to the buoy in exactly this manner, the technique is analogous. Just as the surveyor must establish a baseline for his measurements and then use geometry to calculate the range from point B to point C, the pilot should fly a favorable pattern, during which the SRS and its software make measurements to estimate the buoy position.

The SRS intercepts signals from a sonobuoy, then measures these signals to obtain the relative bearing to the sonobuoy. Each measurement is then processed to improve the sonobuoy position estimate by updating the indicated bearing to the buoy and its range. The SRS also determines the uncertainty factor of the sonobuoy position estimate by computing an "error ellipse" about the indicated bearing, with the indicated buoy position at its center. Each measurement produces a new error ellipse about the new estimated buoy location. Successive measurements produce a series of error ellipses that tend to define a successively smaller area within which the buoy is located – sort of a zeroing-in technique. The orientation of each successive error ellipse influences the direction in which buoy position updates move from the initial position estimate.

Figure 10 illustrates an SRS buoy position estimate made from moving aircraft A to the relatively stationary sonobuoy located at true position B_T. At time t_1, when the aircraft is at position A_1, the SRS provides the estimated bearing $EOBS_1$ from the aircraft to the buoy. Since aircraft navigation system drift, buoy drift, and Kalman filter gain will influence the accuracy of SRS updates, it is unlikely that the *estimated* bearing to the buoy ($EOBS_1$) will coincide with the true bearing to the buoy

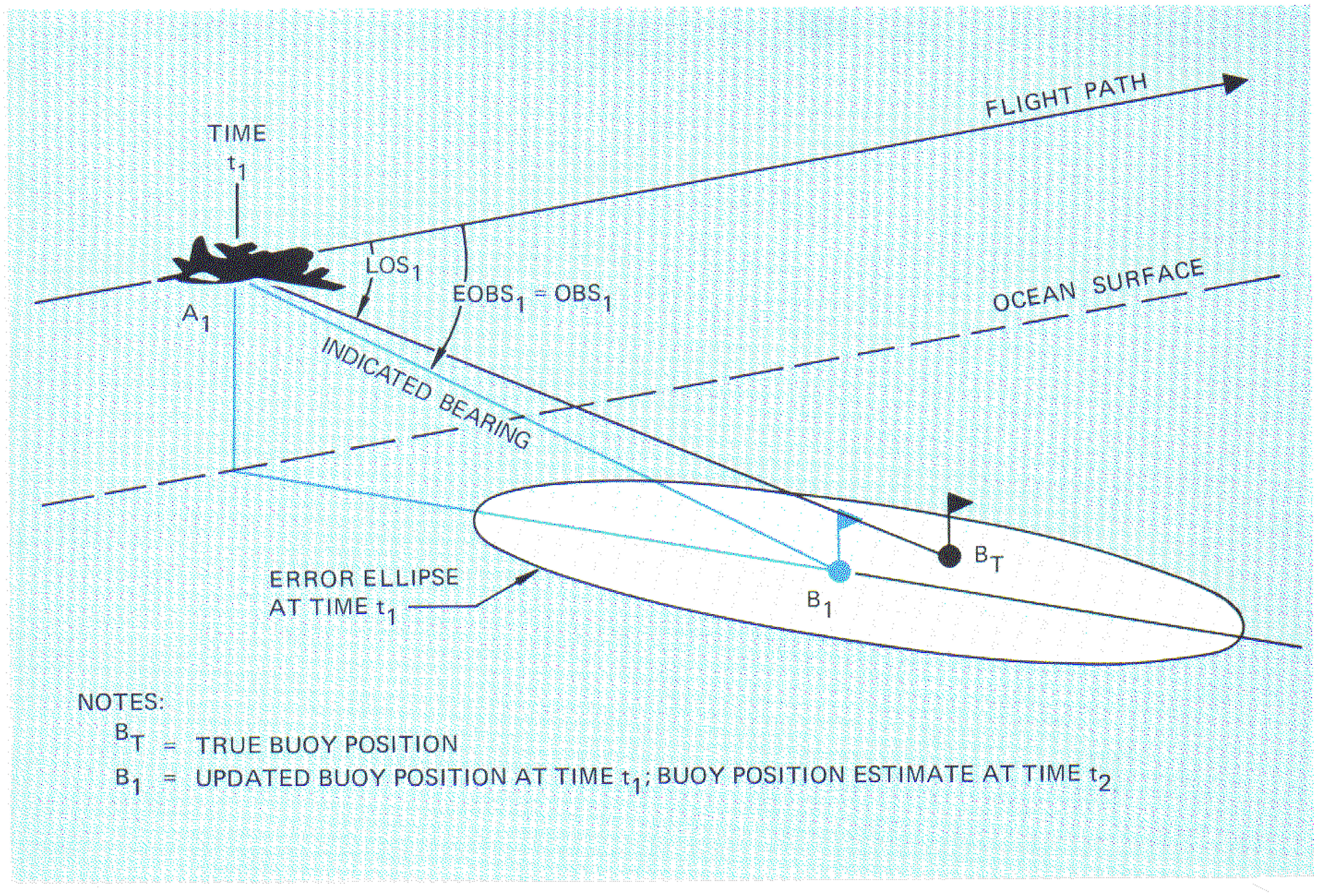


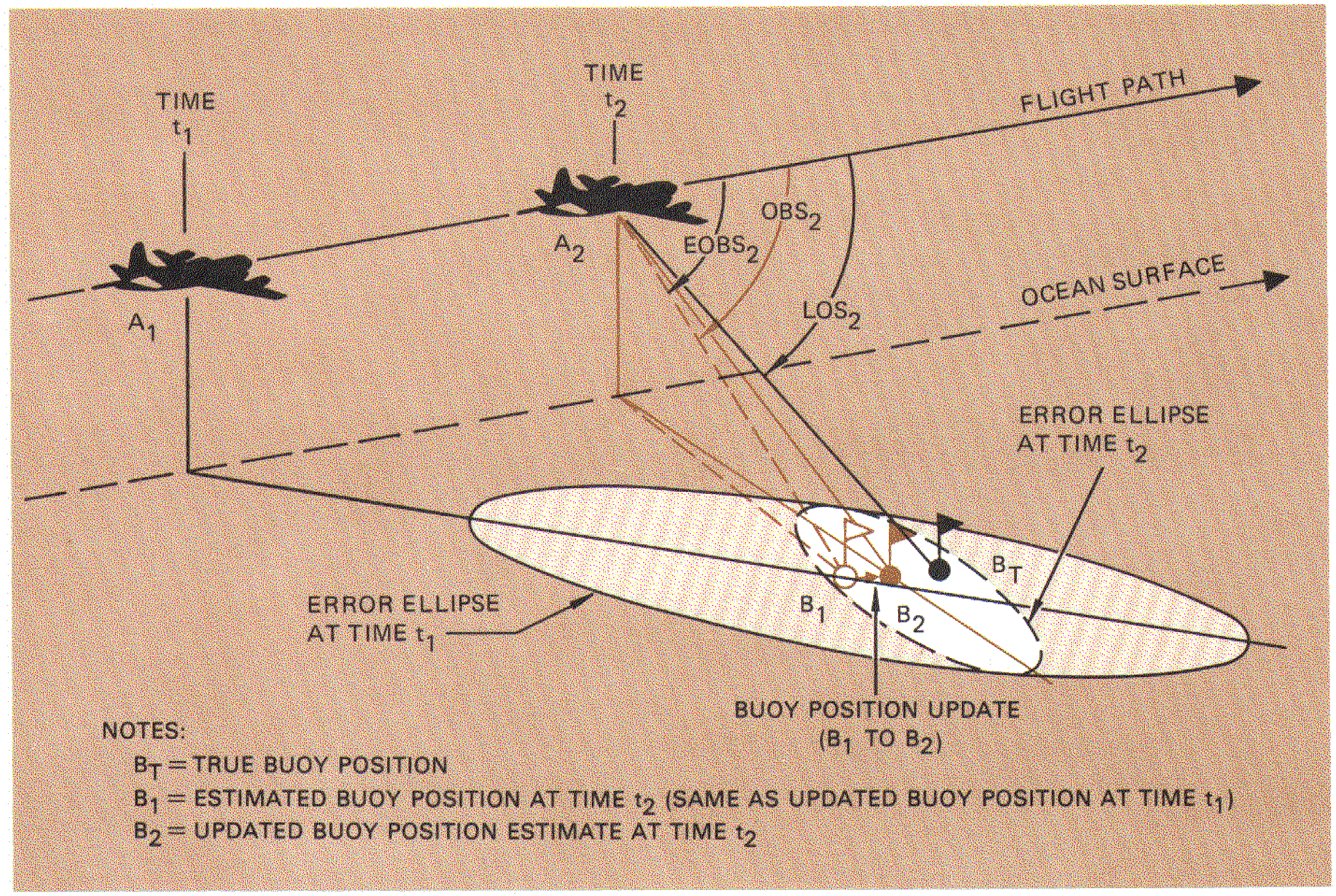
Figure 10. SRS Update Process (t_1)

LOS_1. Thus, the SRS will estimate that at time t_1 the buoy is located on bearing $EOBS_1$ at position B_1, when actually the buoy is located on bearing LOS_1 at position B_T within the error ellipse.

The SRS makes its next measurement at time t_2 when the aircraft is at position A_2 (see Figure 11). At this new position, the estimated bearing from the aircraft to estimated buoy position B_1 is bearing $EOBS_2$; the SRS measurement at time t_2 produces bearing OBS_2; and, true buoy position B_T at time t_2 is located on true bearing LOS_2. The aircraft's computer must now update the buoy position estimate and compute a new error ellipse, using the difference $OBS_2 - EOBS_2$ as part of its data base. The error ellipse produced at time t_2 falls within the first error ellipse, but it is oriented roughly along a bearing leading toward the aircraft at location A_2. The SRS uses the orientation of the error ellipse for time t_1 to update and adjust the estimated buoy position at time t_2, shifting the estimated buoy position from B_1 to B_2 (located at the center of the new error ellipse for time t_2).

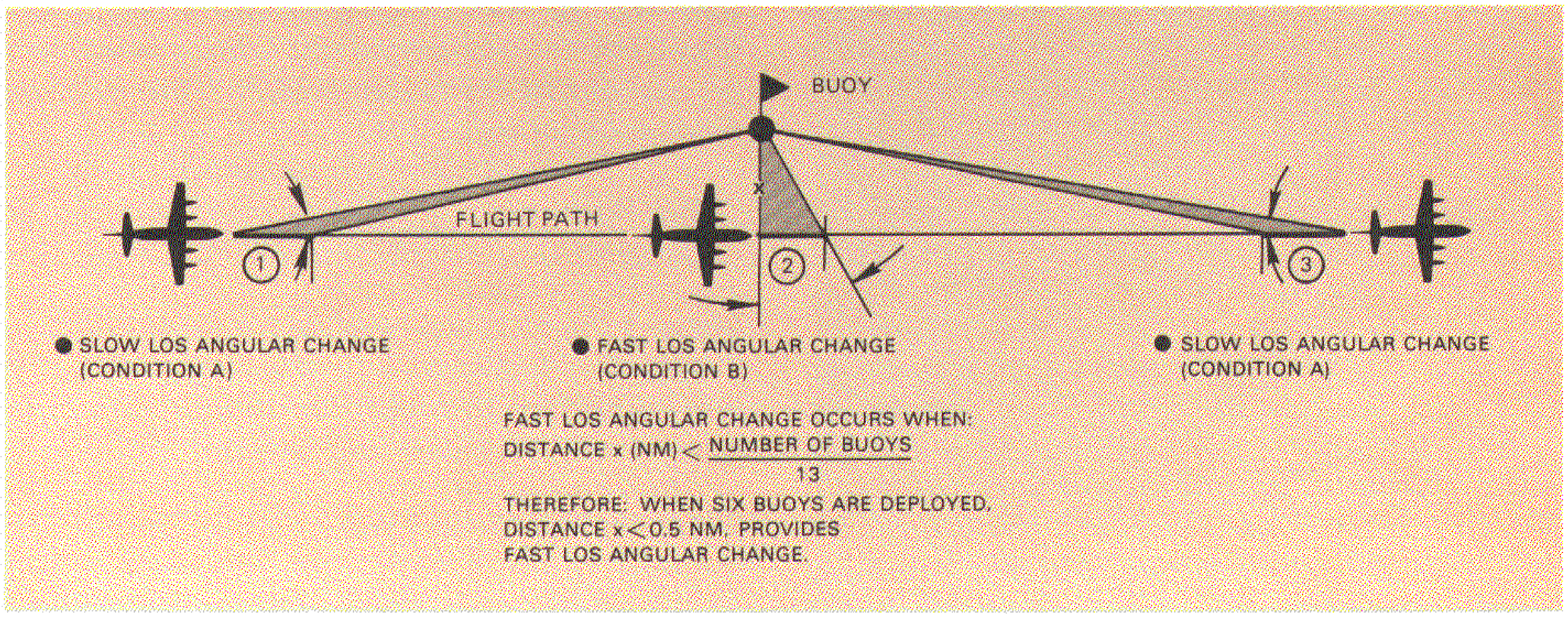
Updated buoy location B_2 will then serve as the estimated buoy location when the SRS makes the next bearing estimate. At that time the SRS will use the same process to calculate a new updated buoy location estimate, and compute a subsequent smaller and differently-oriented ellipse that represents the uncertainty of the buoy location.

To get an effective buoy solution convergence, this buoy ranging process requires that the aircraft's flight path geometry be such that during ranging two conditions should be fulfilled. Condition A: The line-of-sight from the buoy to the aircraft should change by at least 30 degrees. Condition B: Six or more position updates should be performed during the ranging process. Flight path geometries such as those shown in Figures 12 and 13 (points 1 and 3) are not considered good because there is a



NOTES:
B_T = TRUE BUOY POSITION
B_1 = ESTIMATED BUOY POSITION AT TIME t_2 (SAME AS UPDATED BUOY POSITION AT TIME t_1)
B_2 = UPDATED BUOY POSITION ESTIMATE AT TIME t_2

Figure 11. SRS Update Process (t_2)



FAST LOS ANGULAR CHANGE OCCURS WHEN:

$$\text{DISTANCE } x \text{ (NM)} < \frac{\text{NUMBER OF BUOYS}}{13}$$

THEREFORE: WHEN SIX BUOYS ARE DEPLOYED, DISTANCE $x < 0.5$ NM, PROVIDES FAST LOS ANGULAR CHANGE.

Figure 12. Poor Flight Path Geometry for SRS Operation. Line-of-sight (LOS) angular change is too small at points 1 and 3, and too great at point 2.

near-zero LOS bearing change when the SRS is performing position updates, or when sufficient LOS bearing changes do occur there is not time to perform an adequate number of updates. In Figure 12, points 1 and 3, the aircraft is too far away from the buoy for the LOS relationship to change at least 30 degrees during the ranging process. *In Figure 13, flying either directly towards or away from the buoy results in a near-zero LOS bearing change.* Returning to Figure 12, point 2, SRS operation is also ineffective when LOS bearings change so rapidly that there is not sufficient time for the SRS to perform an adequate number of updates. For example, if the closest-point-of-approach (CPA) to a particular buoy in a six-buoy pattern is less than 1/2-mile, the SRS will not be able to perform an accurate position fix on that buoy. The minimum CPA to a buoy in a pattern can be determined by use of the formula in Figure 12.

WHY THE SONOBUOY SYMBOL DRIFTS ON THE TACTICAL DATA DISPLAY When the SRS is operating, there are three causes of buoy movement on the tactical data display – buoy drift, aircraft navigation system drift, and SRS measurement error.

Buoy Drift Buoy drift is any movement of the buoy away from the position where it was dropped. Drift is caused by ocean currents and wind. As described earlier, the degree of drift depends upon buoy drop location, environment, and buoy type. The drift rate can be as high as 5 knots in the Gulf Stream, but in most of the oceans it is less than 0.5 knot. Buoy drift motion on the tactical data

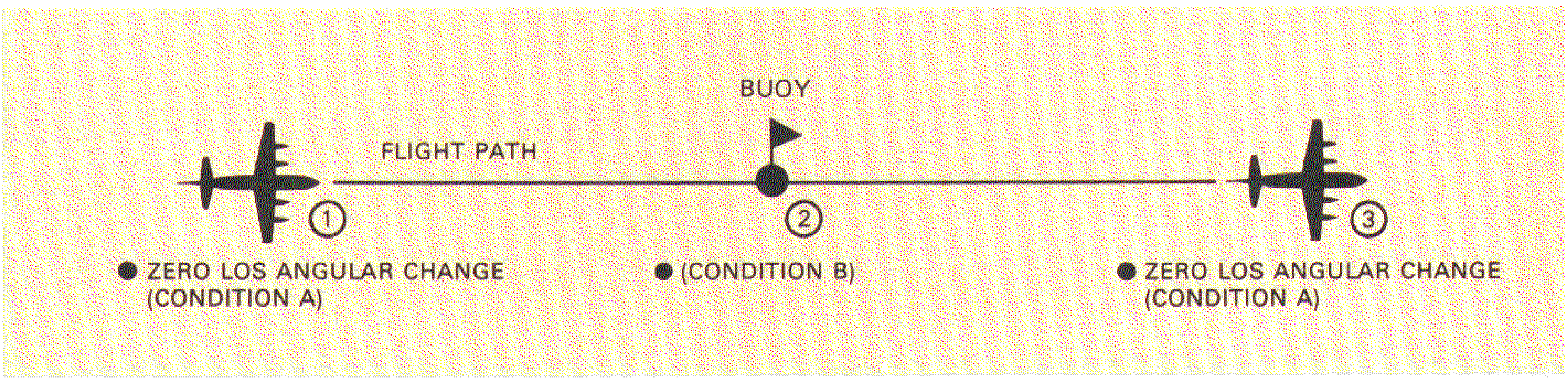


Figure 13. Poor Flight Path Geometry for SRS Operation. Flying either directly toward or away from the buoy results in a near-zero LOS bearing change.

display is depicted in Figure 14. Buoy motion on the display is a true representation of buoy drift in the water, provided that the SRS can maintain an accurate buoy-to-aircraft relative position.

Navigation Drift The positional accuracy of the aircraft's navigation system degrades as a function of time due to drift in the aircraft's DR navigation systems. The inertial DR system sensor is subject to Schuler oscillations and gyro alignment errors, while the Doppler DR sensor is subject to sea motion errors. The characteristics of these errors relate directly to the stability of the tactical plot that can be achieved by use of the tactical navigation bias velocity algorithms, and are critical in nature.

Navigation error associated with an inertial navigation system varies with time (Schuler cycle) as shown in Figure 15. Sometimes the navigation error rate can change rapidly (as between times t_1 and t_2), although the average rate of change (as between times t_0 and t_3) may be slow. Thus, often the long-term navigation drift may be only about 0.5 knot, *while short-term Nav drift may be as great as 3 to 4 knots during a 15-minute period.*

Doppler system navigation error varies linearly with time as shown in Figure 16. Its rate of increase (and that of Nav drift) is estimated empirically, mainly by the velocity of the surface winds that prevail during overwater flights. This empirical relationship provides that:

$$\begin{matrix}\text{Nav Drift}\\ \text{(in knots)}\end{matrix} = 1.28\sqrt[3]{\begin{matrix}\text{Wind Velocity}\\ \text{(in knots)}\end{matrix}}$$

Figure 17 depicts buoy motion on the tactical data display that is due to a combination of Nav drift and buoy drift, provided that the SRS can maintain accurate buoy-to-aircraft position.

SRS Measurement Error Since the SRS has been designed to *estimate* the buoy's position relative to the aircraft, its measurements are imprecise to some extent. The degree of SRS inaccuracy is called measurement error, which is attributable to limitations of the SRS design and its software. Like buoy drift and navigation system drift, *SRS measurement error contributes to buoy motion on the tactical plot.*

Total Drift Figure 18 shows the interaction of buoy drift, navigation drift, and SRS measurement and processing error-related drift, and how these factors affect the motion of the sonobuoy and airplane marking symbols on the tactical data display. It can be readily seen that:

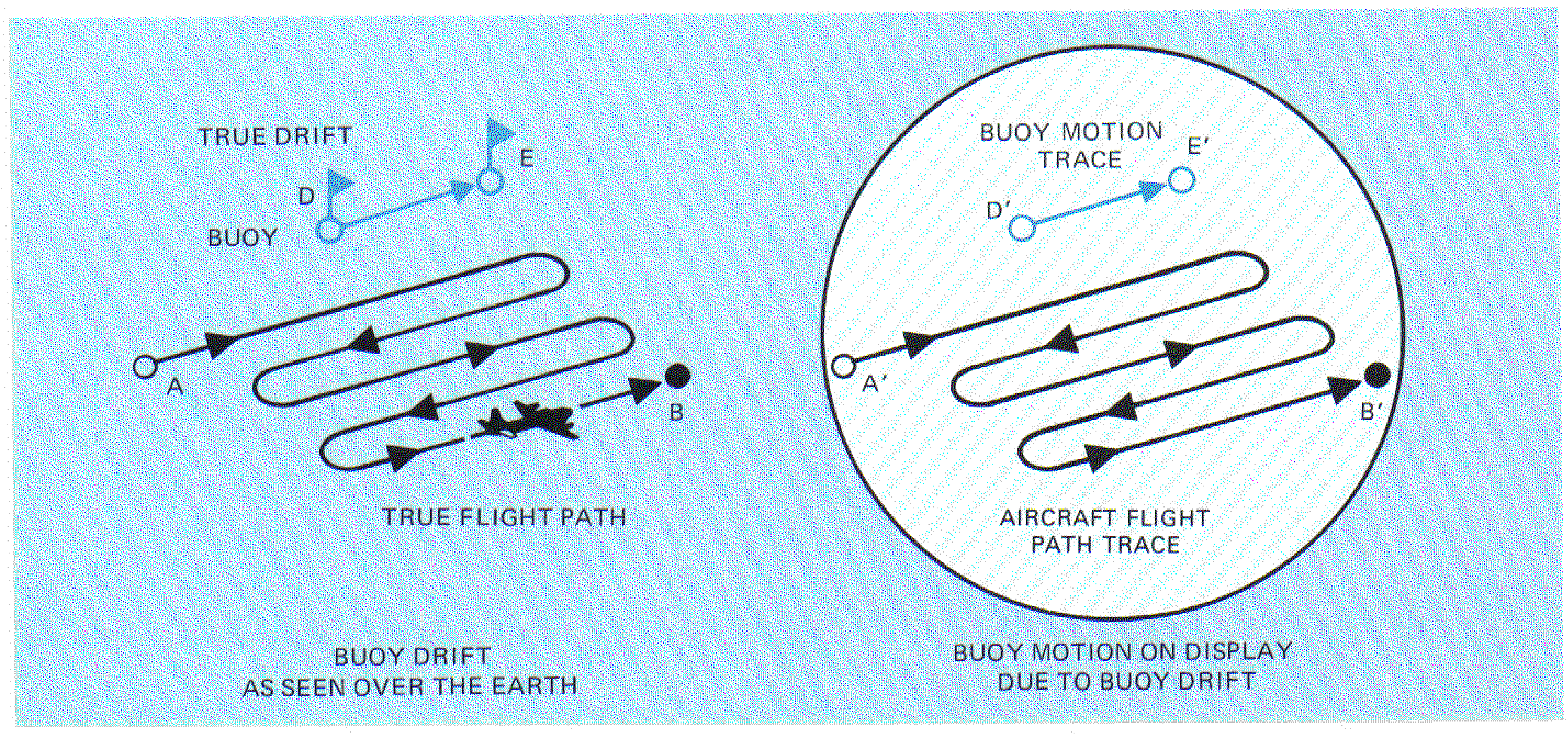


Figure 14. Buoy Drift as Seen over Earth, and as Displayed on the Aircraft MDD

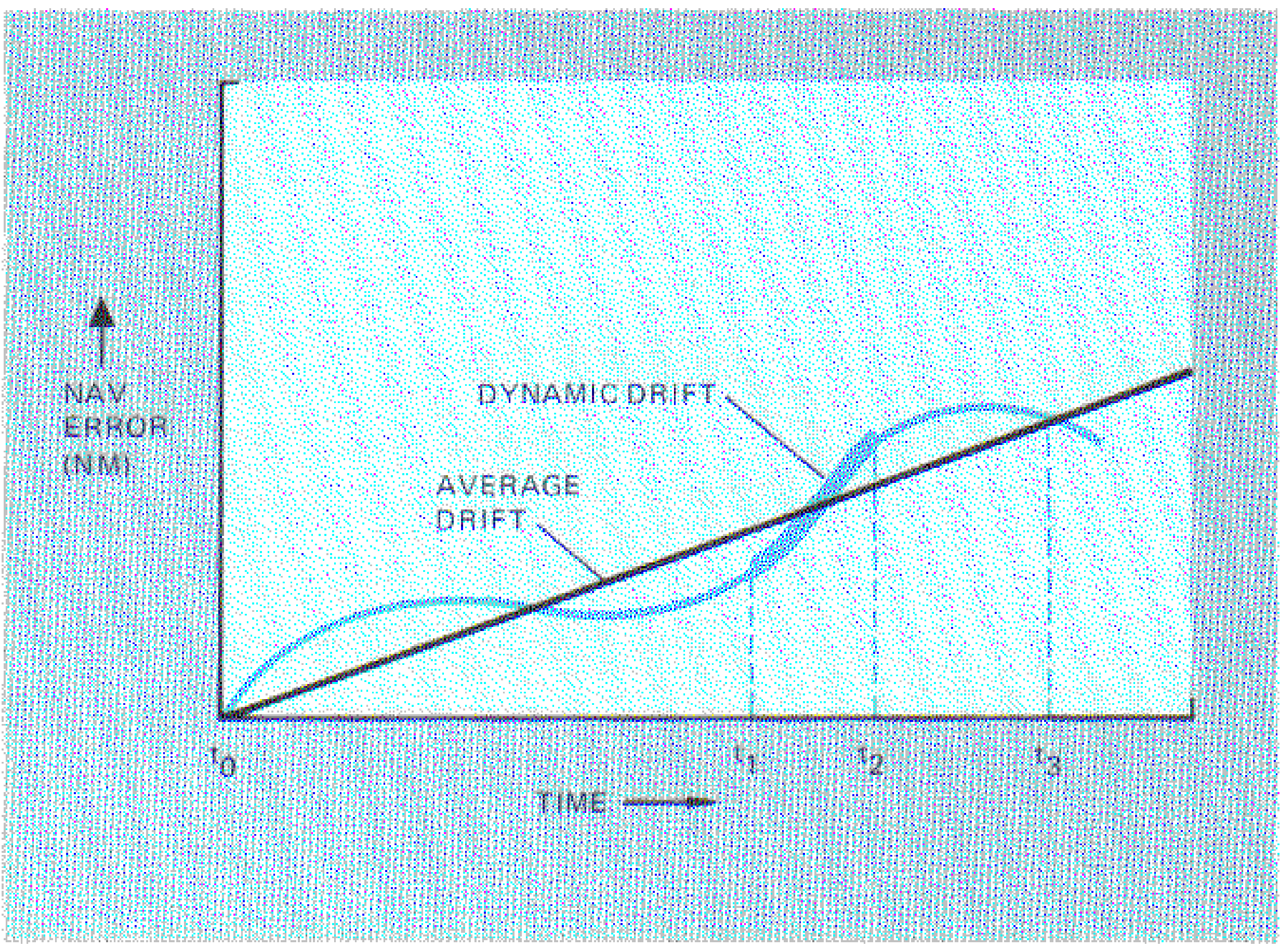


Figure 15. Navigation Error vs. Inertial Navigation Drift

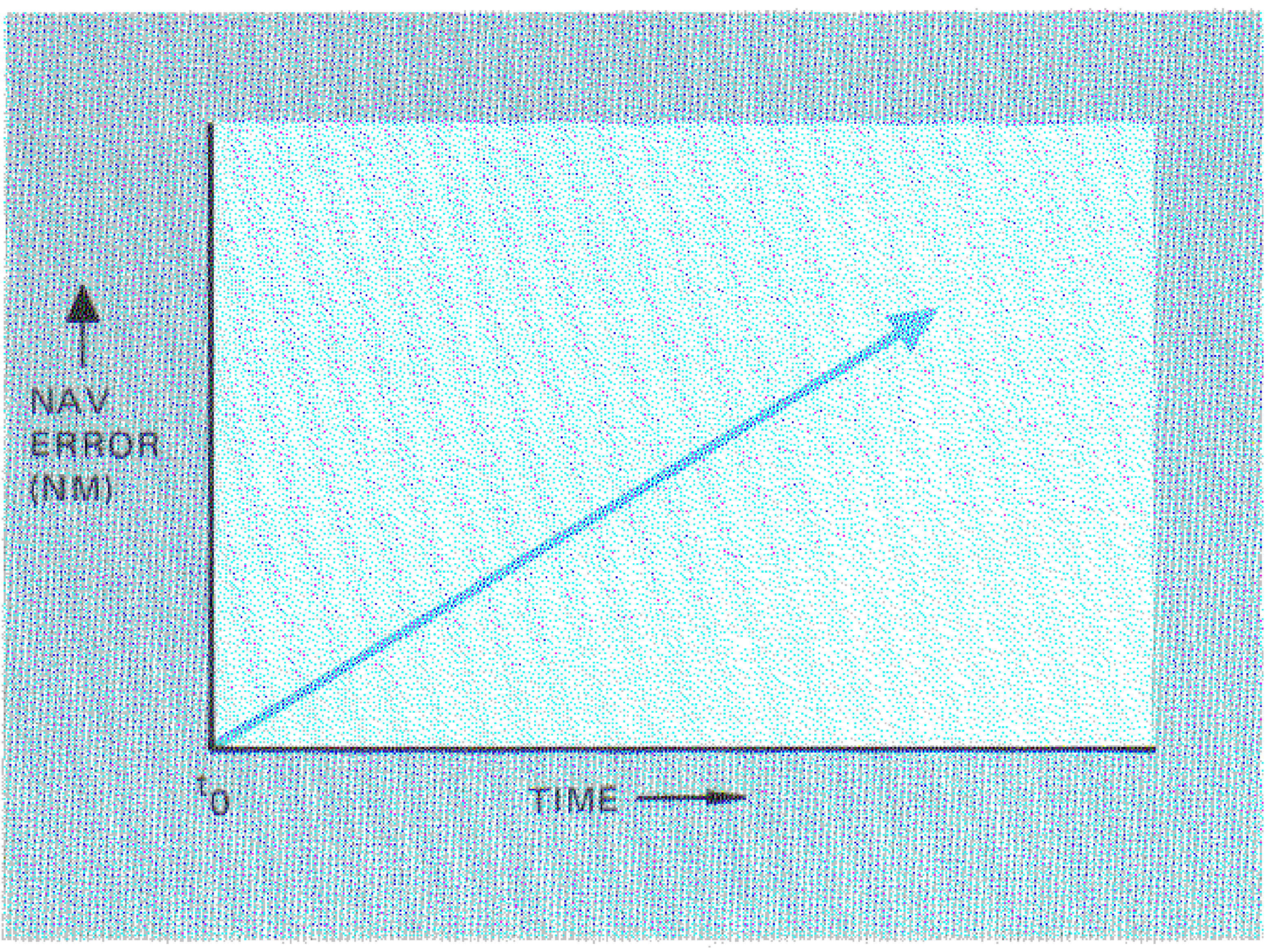


Figure 16. Navigation Error vs. Doppler Navigation Drift

Displayed Buoy Motion = True Buoy Drift
(D′ to E‴) (D′ to E′)

\+

Navigation Drift
(E′ to E″)

\+

SRS Error
(E″ to E‴)

The SRS operates in the TACNAV mode, which uses the primary DR navigation source available to compute the tactical position. Thus, a bias velocity can be accepted to improve tactical position accuracy by minimizing navigation system drift.

Referring back to Figure 15, the reader can see that it would be difficult to debias the tactical data display to compensate for inertial navigation system drift because the drift rate is always changing at a non-linear rate. However, the tactical display can be debiased to compensate for Doppler navigation system drift because the Doppler drift rate is linear (see Figure 16).

Buoy Field Display Stabilization The buoy field presented on the tactical plot must be stabilized and system drift must be minimized so that the SRS can be used most efficiently. The accuracy of SRS buoy updates on the tactical plot can be maintained by compensating for navigation system drift and by keeping SRS angle measurement errors to a minimum (see Figure 18).

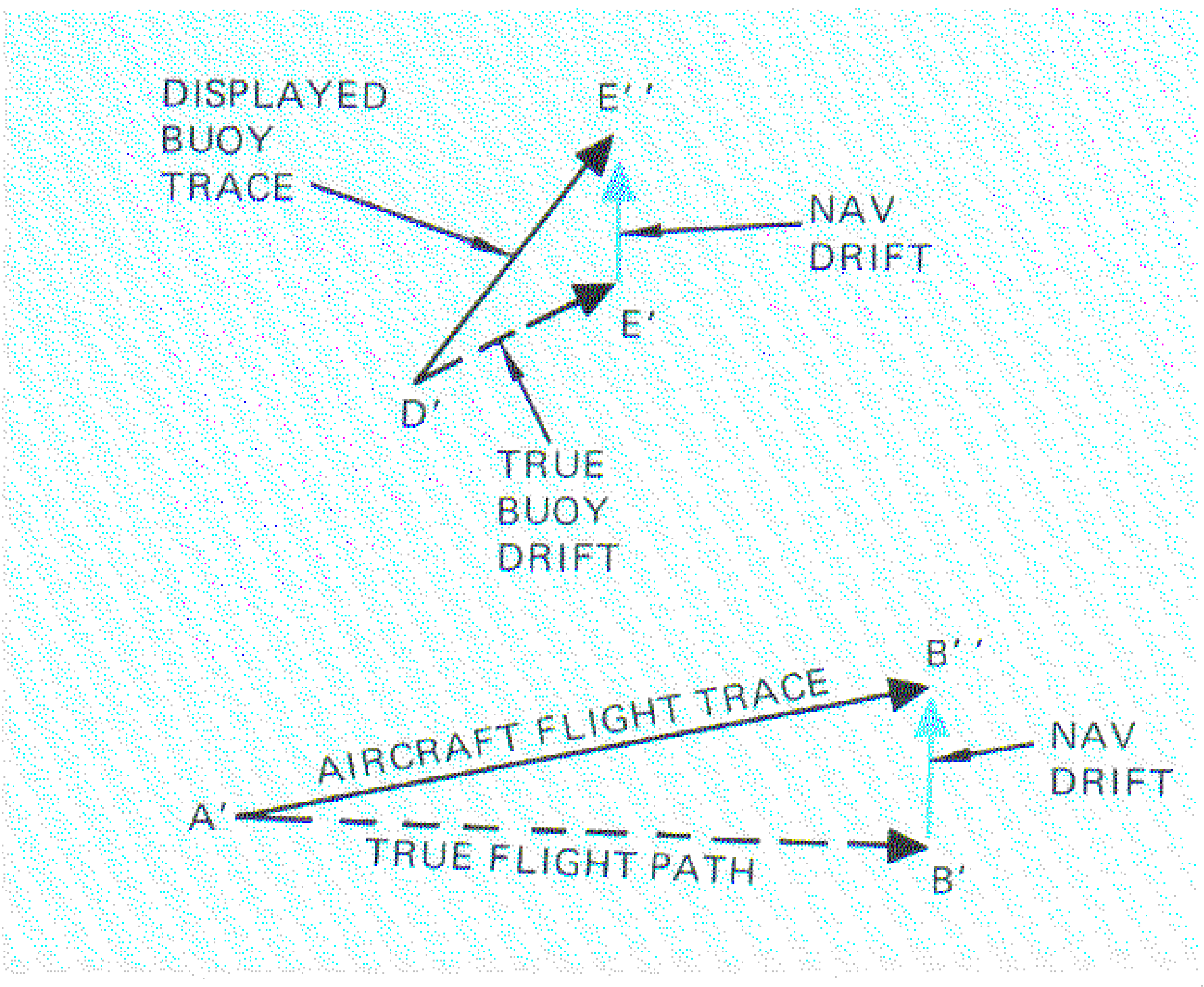


Figure 17. MDD Buoy Trace, Showing True Buoy Drift and Navigation Drift

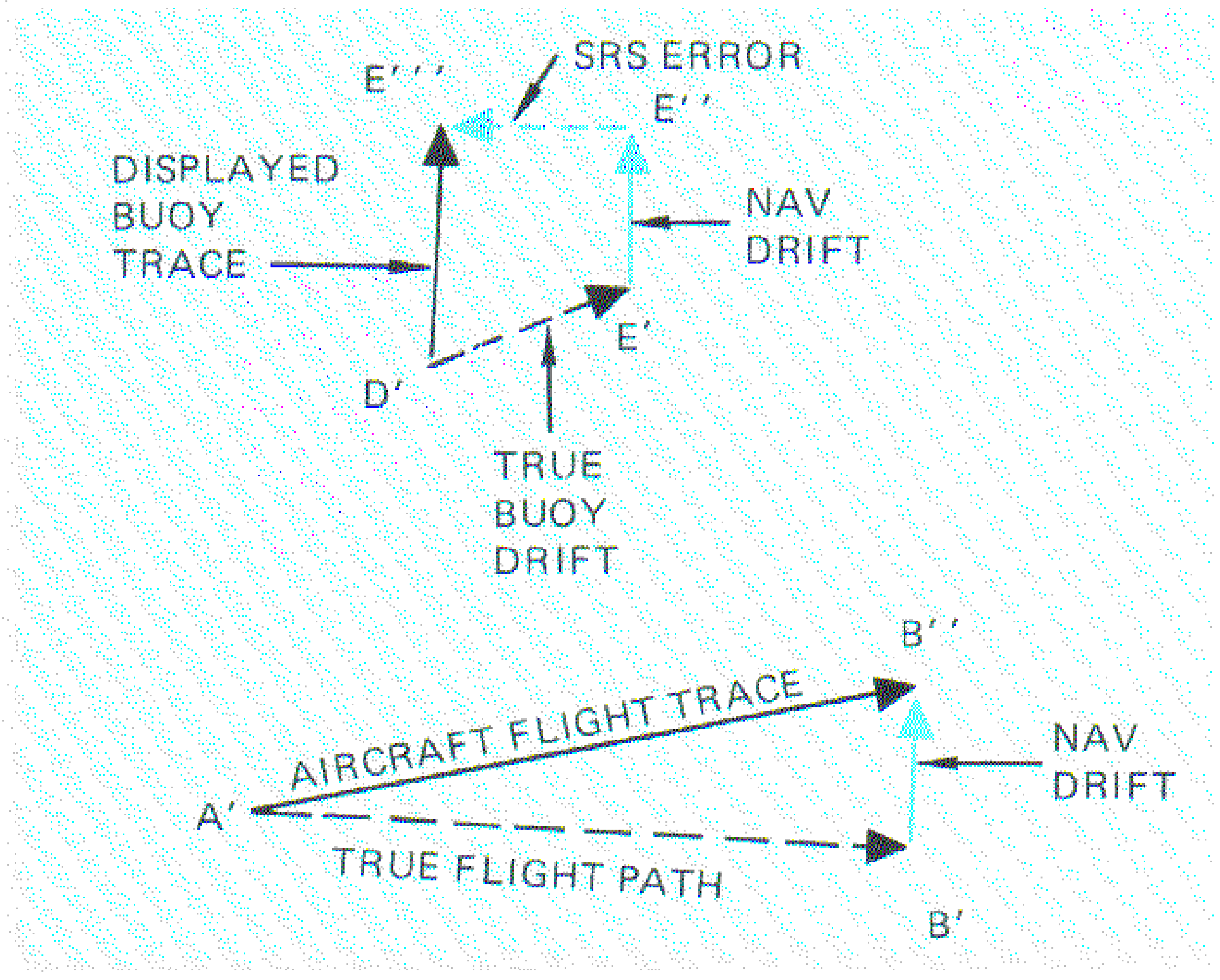


Figure 18. MDD Buoy Trace, Showing Total Drift (True Buoy Drift + Navigation Drift + SRS Error)

Compensating for Buoy/Nav System Drift Buoy and navigation system drift can be determined, then compensation can be made for such motion. Compensation for this motion is more effective when the navigation system that is used for reference provides a constant-rate drift rather than a variable-rate drift. For example, a Doppler system with a constant-rate drift (Figure 16) is preferred to an inertial system with a variable-rate drift (Figure 15). The following discussion describes how the P-3C's tactical navigation system can be used to determine navigation system-plus-buoy drift.

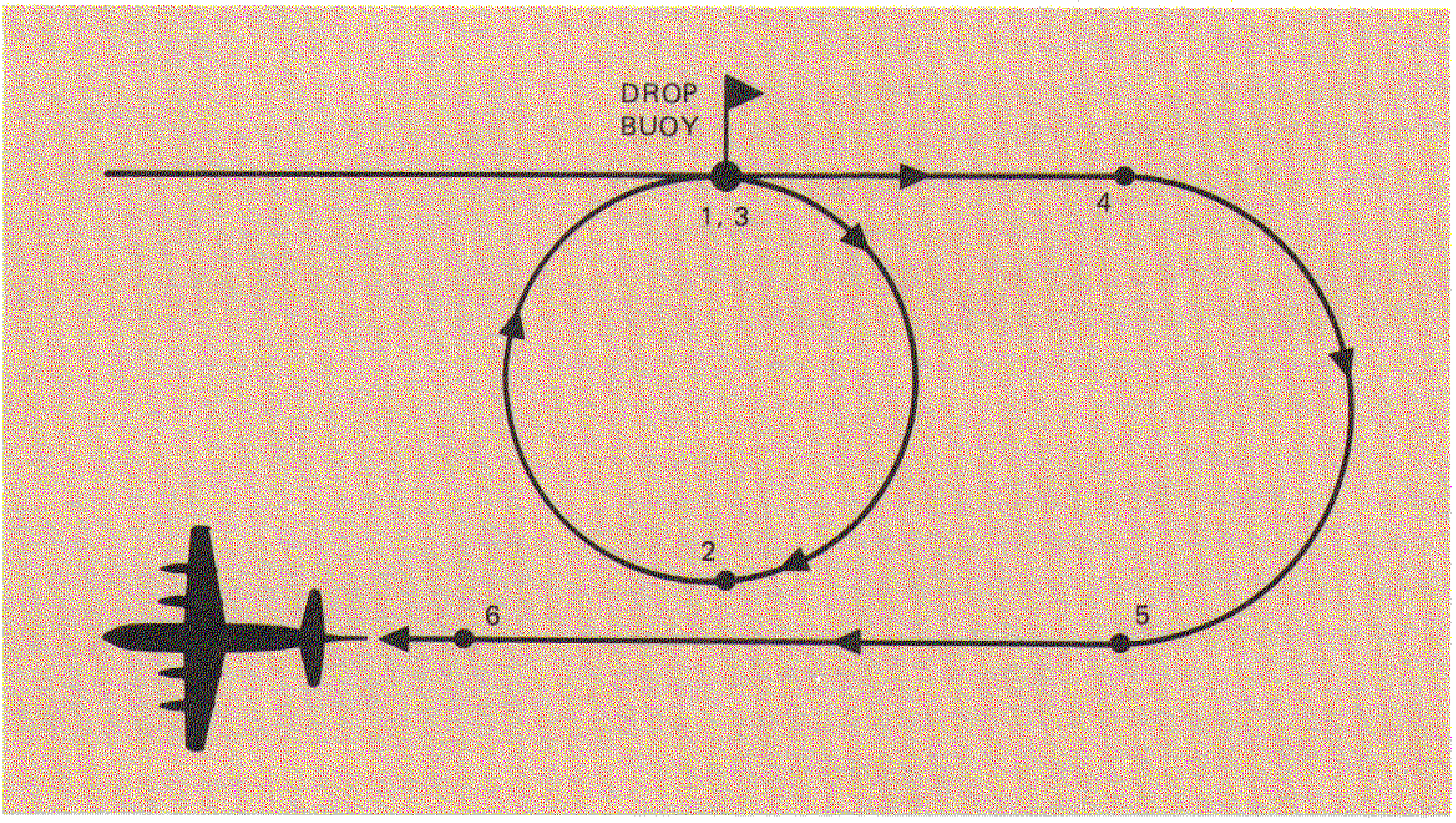
The P-3C's tactical navigation system is designed to work both with and without the SRS. Operationally, the tactical navigation system functions as if no SRS exists. The algorithm that computes navigation drift has been modified to permit the "on top" marking of any sonobuoy. This algorithm has also been modified to include the total time difference between the present and the time that the sonobuoy was dropped (or a single sonobuoy correct operation was performed) in the calculations for estimating navigation drift. Finally, the algorithm also uses a statistical filter (Kalman filter) in the calculations to estimate system drift.

The Kalman filter takes a weighted average of each drift velocity computed at the time that the aircraft performs an "on top" marking of a sonobuoy, and then combines this weighted average with the system drift value that is presently being used. The filter does not combine these values until the algorithm verifies that the navigation drift has not changed direction or magnitude. If a change in navigation drift has been verified, the Kalman filter is adapted to permit this change to occur by reducing the importance of the old data in the calculations. The feature just described, called the adaptive mode, is the method that the algorithm uses to follow the navigation drift of the inertial navigation system, a system whose errors contain a sinusoidal and linear component. The adaptive mode is not used to calculate navigation drift when the Doppler system and the air data sensors are the navigation data sources, because the drift rate for these systems is constant.

Once the navigation drift has been stabilized, the number and frequency of "on top" markings depend upon: the navigation system in use, aircraft altitude, and the phase of the mission.

Figure 19a shows a typical TACNAV MOT flight pattern after the sonobuoy is dropped. Figure 19b shows the relative navigation accuracy yielded by the bias velocity compensation procedure at various points in the flight pattern. The initial error associated with this procedure occurs at the

Figure 19a. TACNAV Mark On-Top (MOT) Flight Pattern



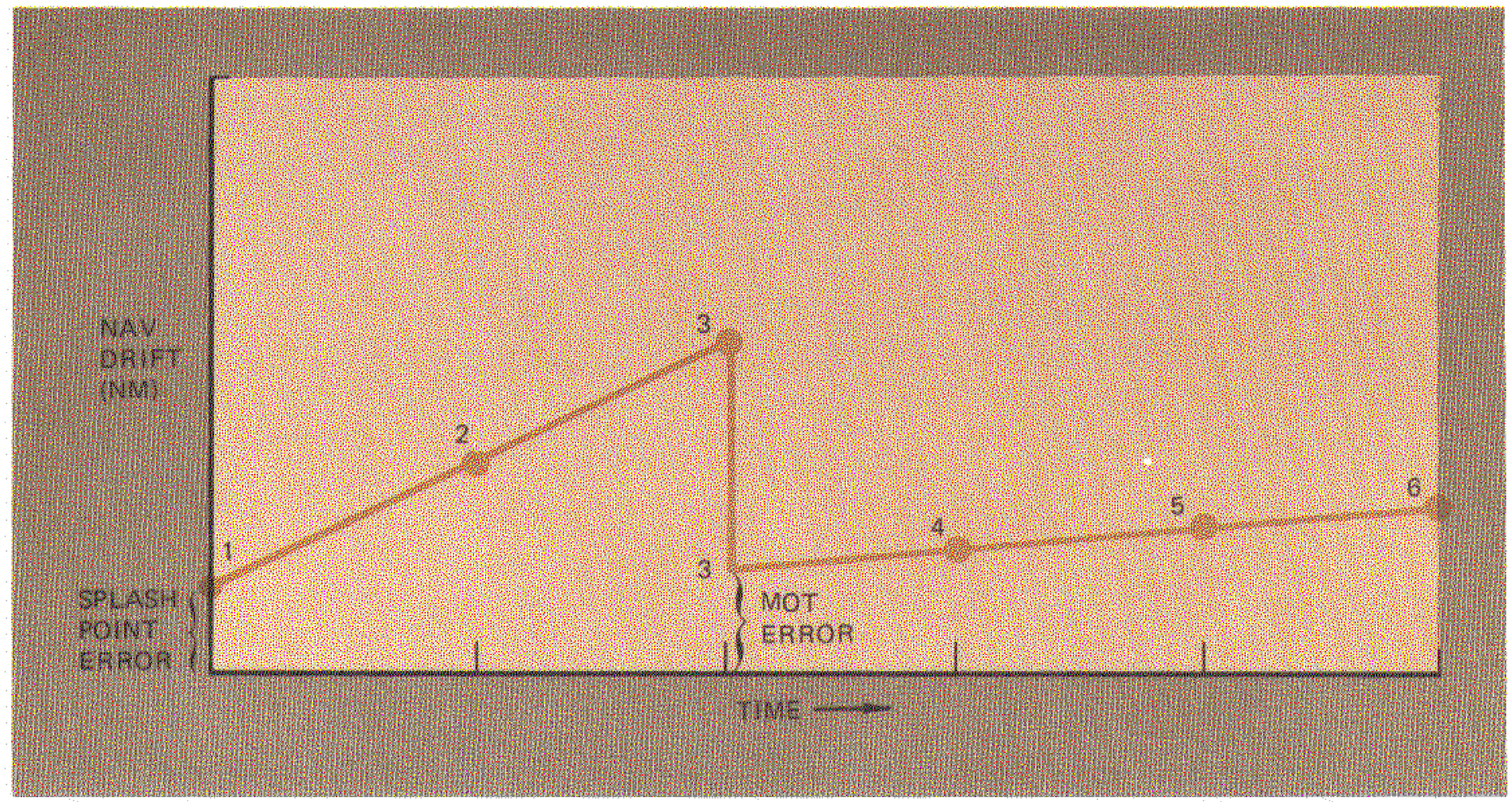
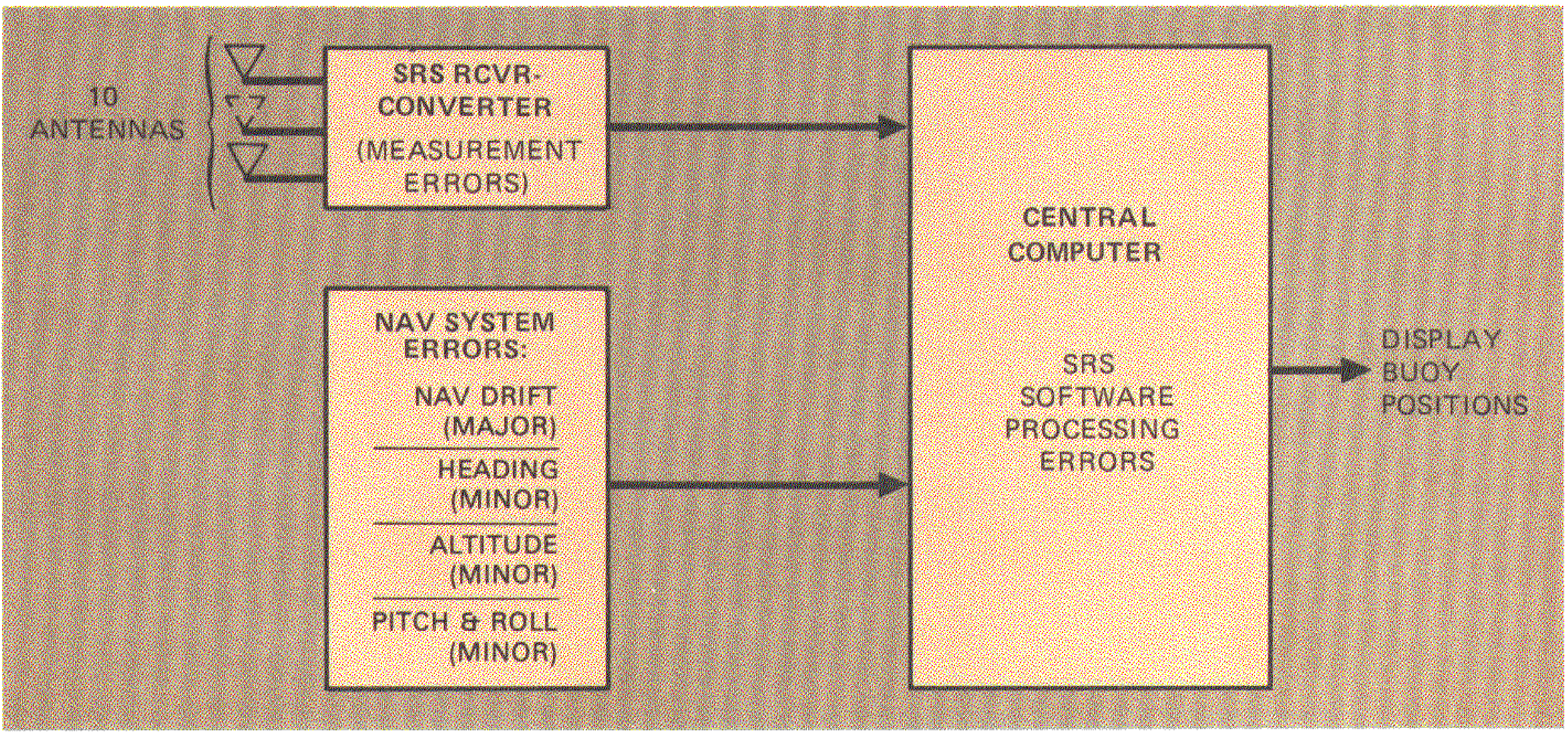


Figure 19b. Navigation Drift Error Rate Reduction when the TACNAV MOT Procedure is Employed

splash point (1), when the buoy is deployed. After buoy deployment, TACNAV error builds up rapidly as the aircraft flys past point (2) and returns towards the drop point. As the aircraft overflies the buoy (3), the MOT procedure is performed. This procedure reduces the TACNAV error to the MOT navigation error at point (3), after which the tactical navigation bias velocity algorithms are applied to the navigation calculations to reduce subsequent error buildup as the aircraft flies to points (4), (5), (6), etc. If desired, the aircraft can again overfly and MOT the buoy to reduce the TACNAV error to the MOT error, and improve the bias velocity estimate that could again be applied to the navigation calculations.

HOW TO ATTAIN SRS ACCURACY We have emphasized that the two major causes of aircraft-to-buoy relative position error are SRS angle measurement error and Nav drift. Figure 20 shows that the aircraft's central computer accepts data from the SRS receiver-converter and the aircraft navigation

Figure 20. Sonobuoy Reference System Error Sources



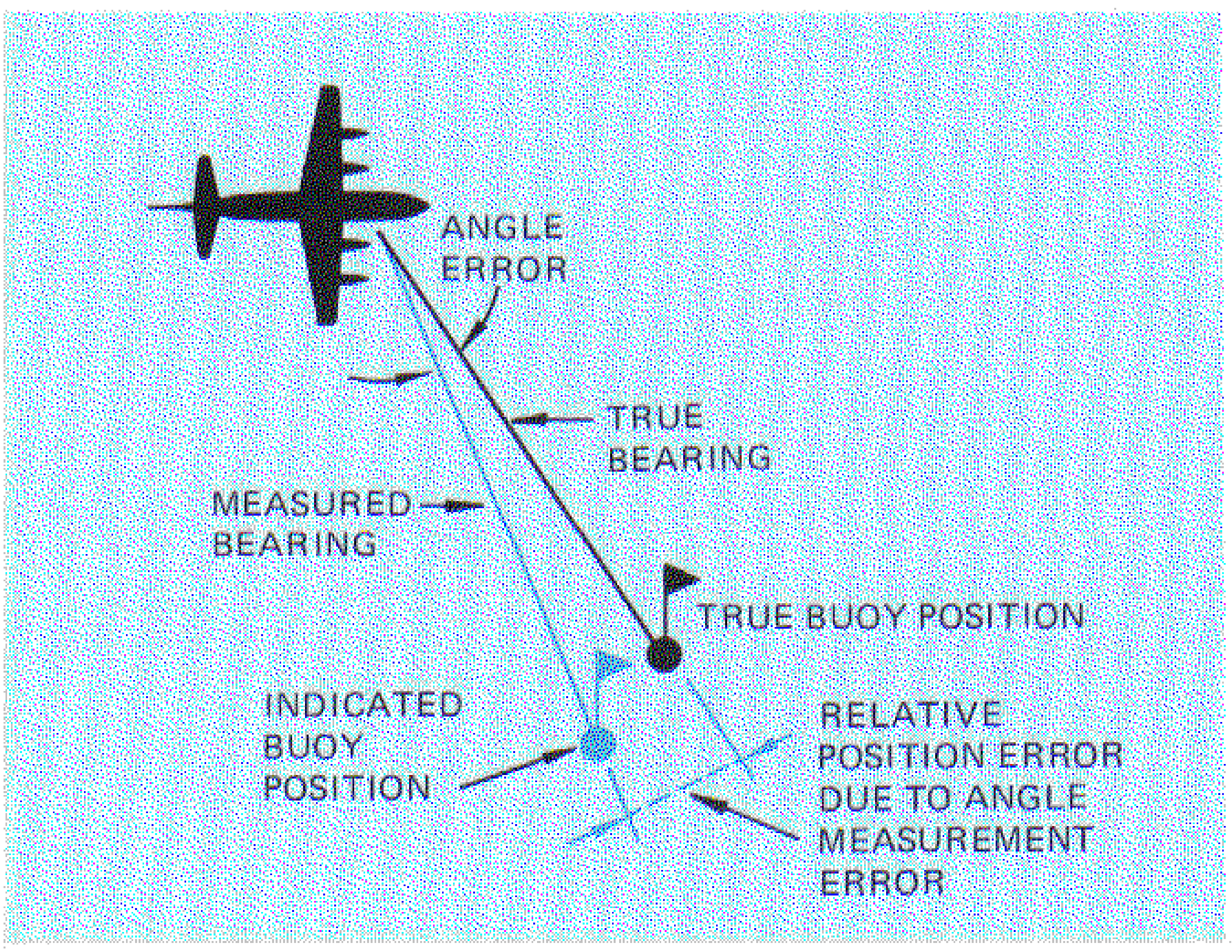


Figure 21. Effect of SRS Angle Measurement Error on Indicated Buoy Position

system, then processes these data with SRS software. Buoy positions based upon these data are then displayed on the tactical plot. The effect of SRS angle measurement error on the aircraft-to-buoy bearing measurement is shown in Figure 21, while the effect of navigation drift on distance measurements is shown in Figure 22.

Fortunately, the accuracy of aircraft-to-buoy relative position measurements that are computed from SRS AME measurements can be predicted, for their accuracy is simply a function of aircraft flight path geometry versus relative buoy position.

To realize good accuracy from the SRS, it is desirable to employ flyby courses once the buoy has been deployed. Figure 23a shows a flight pattern that is suitable for SRS operation; Figures 23b and 23c show the relative accuracy of the SRS at various points in the flight pattern for Doppler and inertial navigation operations respectively. Note that in the SRS flight patterns, buoy overfly paths do not provide optimum geometry for good SRS operation, and should be flown only when buoy on-top markings are required. As mentioned previously, flying either directly towards or away from the buoy results in a near-zero LOS bearing change. *The most accurate results with flyby courses occur when the closest point-of-approach to the buoy (a) is offset between 2 and 4 NM when aircraft altitude is 4000 feet or less, or (b) is offset three times the flight altitude from the buoy when the aircraft is flying above 4000 feet.*

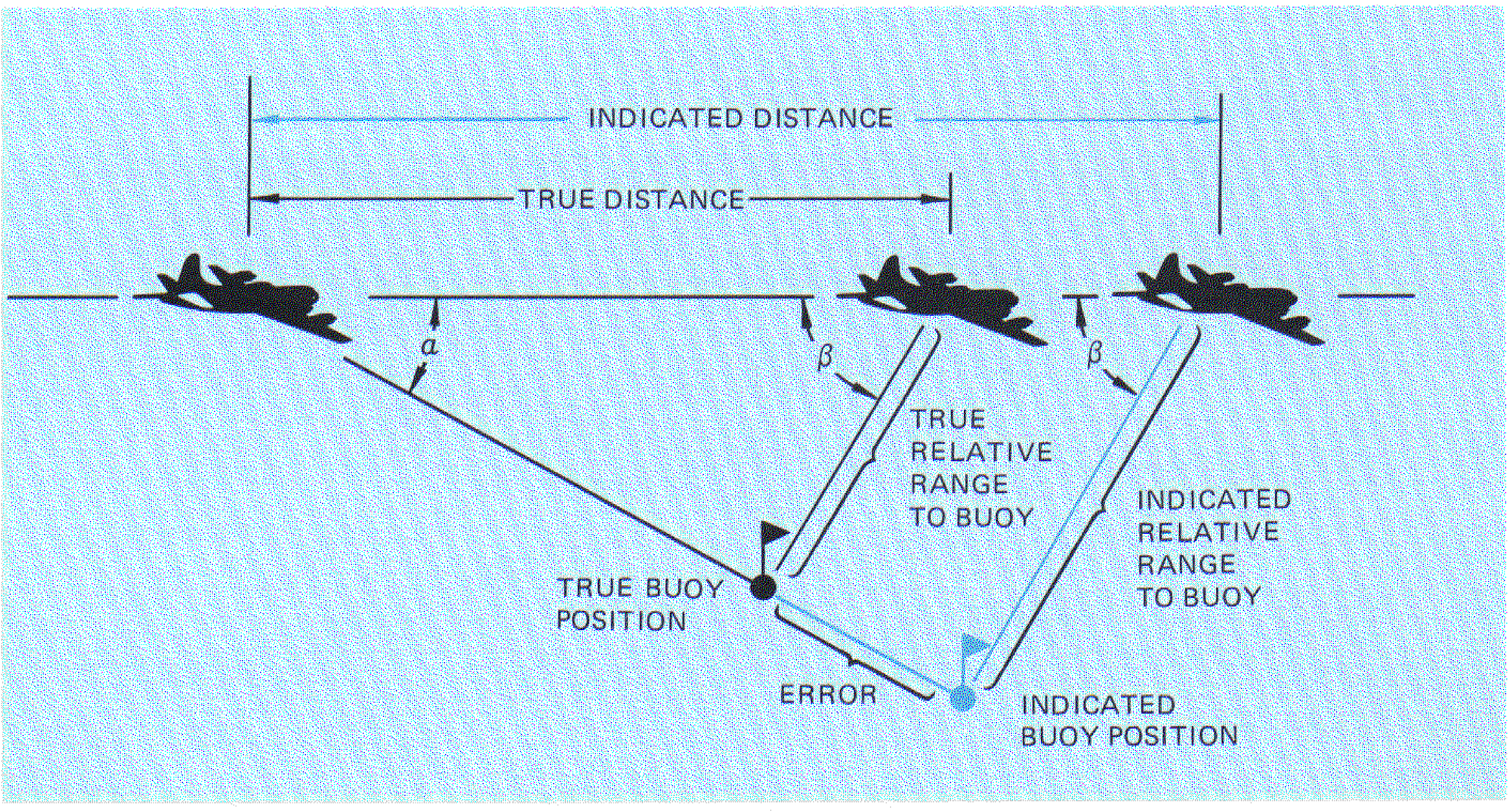


Figure 22. Effect of Navigation Drift Error on Indicated Buoy Position

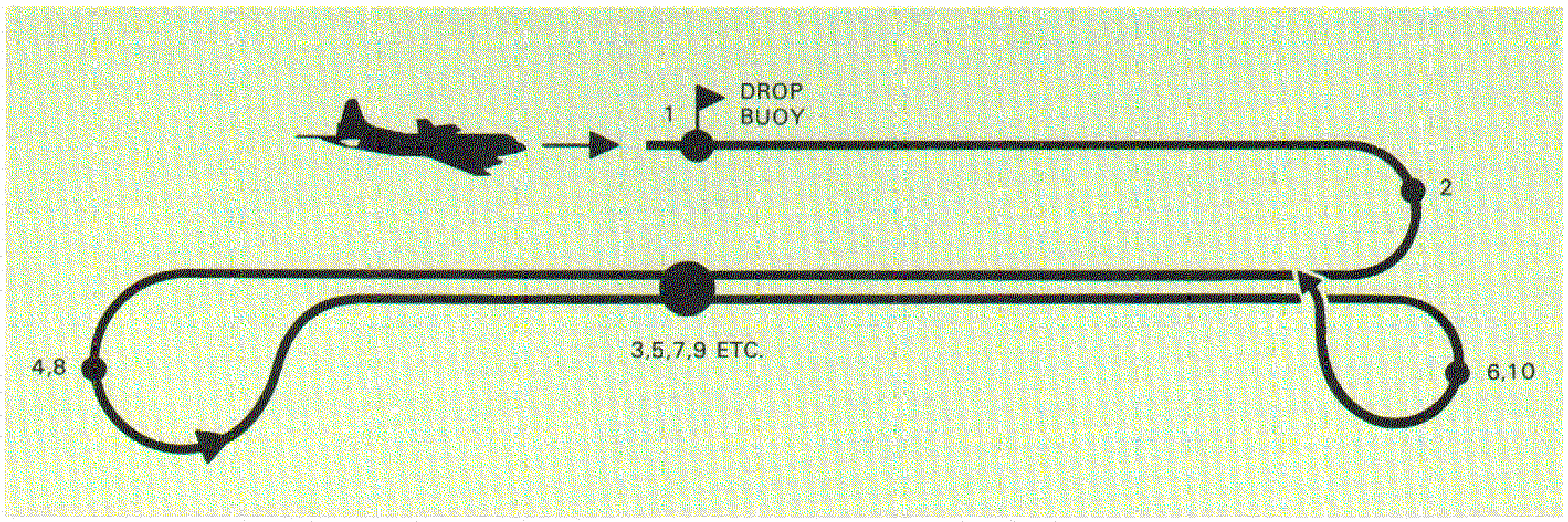


Figure 23a. SRS Flyby Pattern

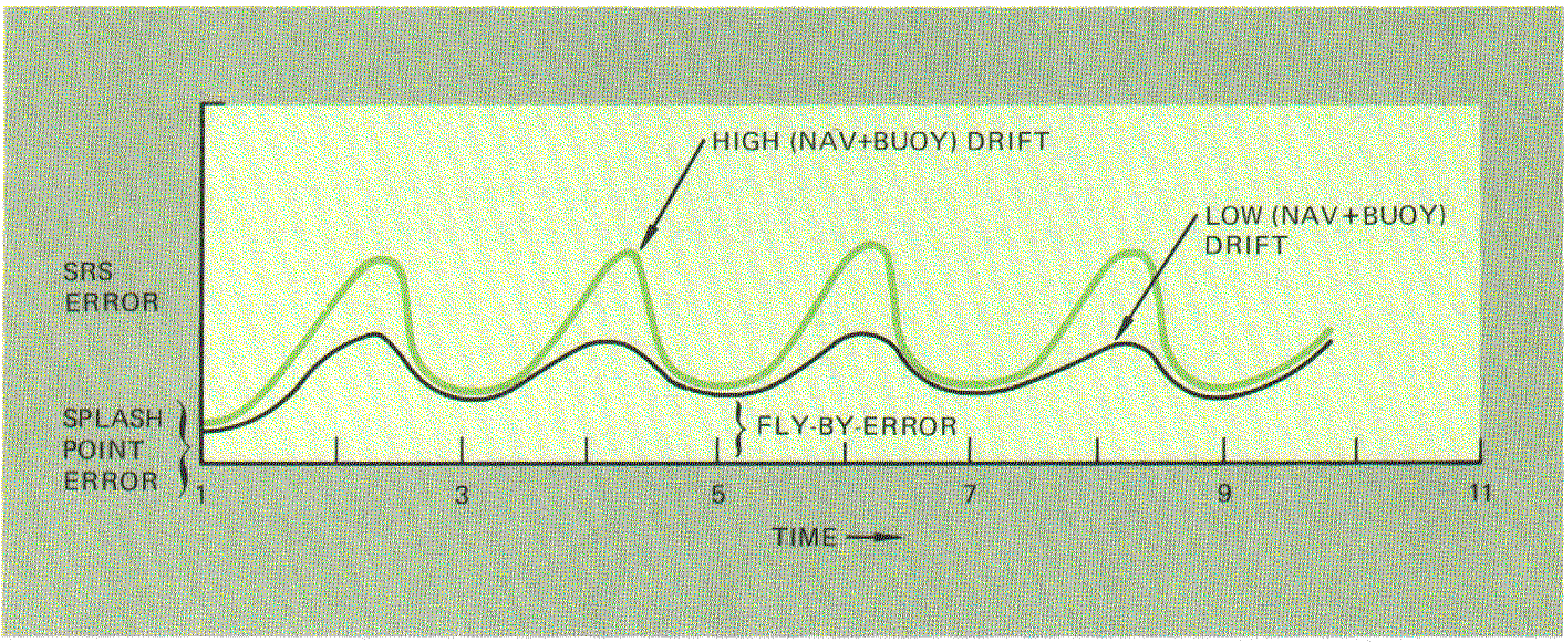


Figure 23b. SRS Accuracy During Flyby Pattern when Doppler System Provides Navigation Data

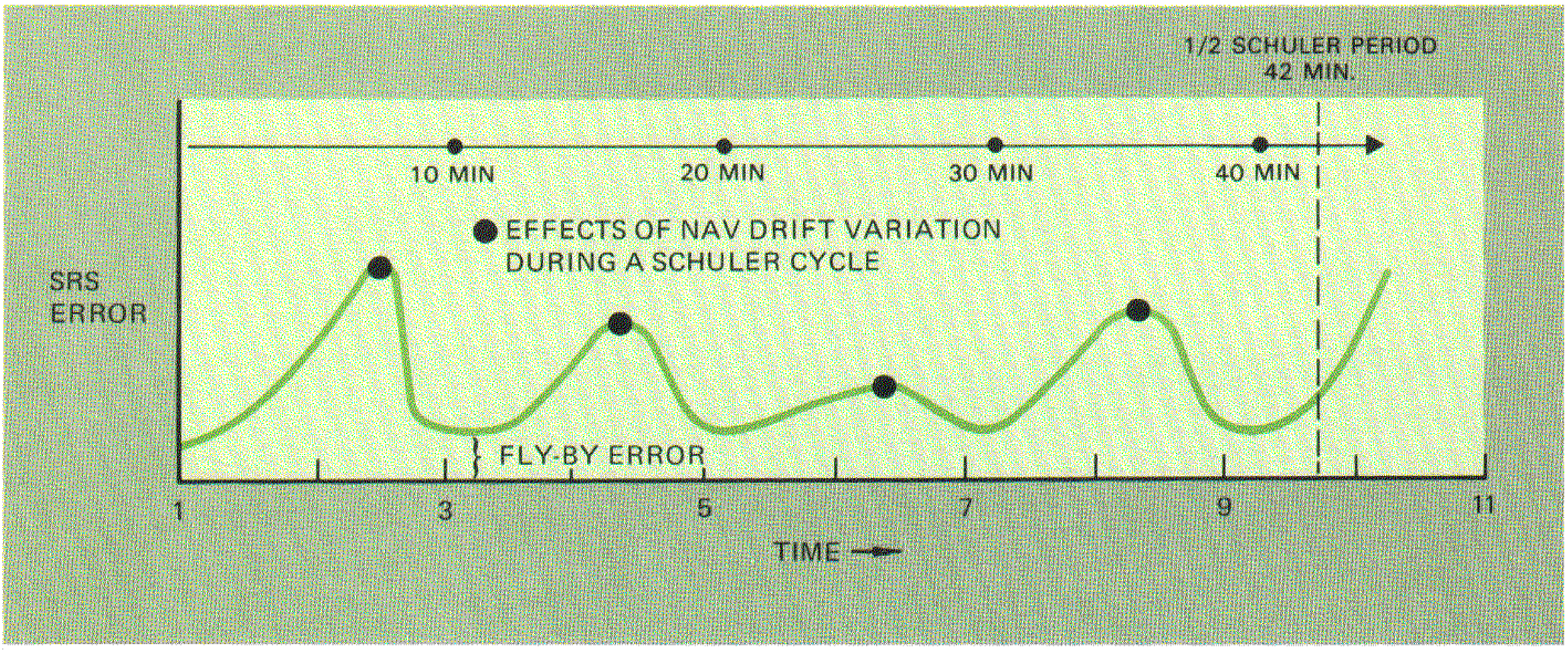
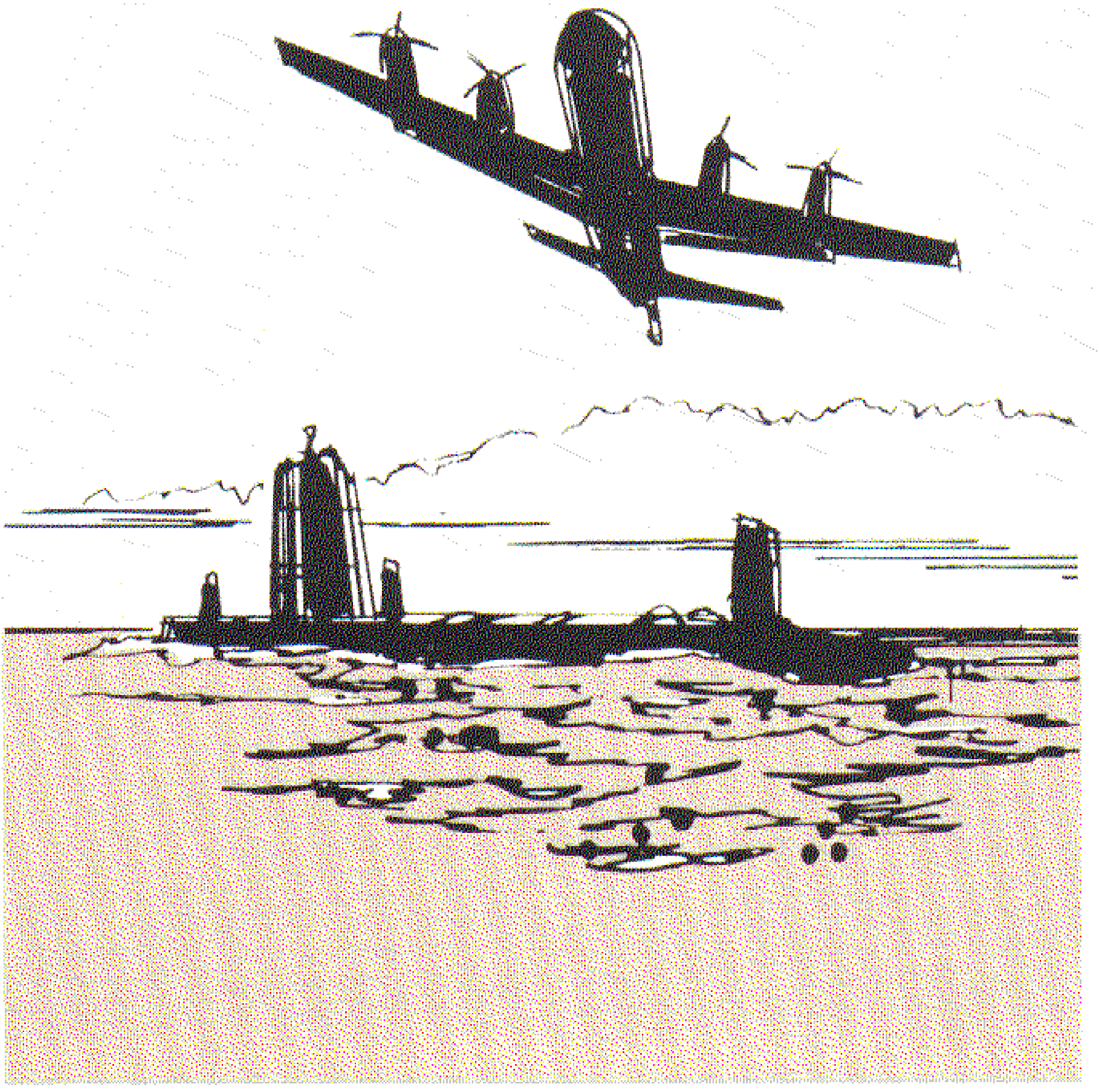


Figure 23c. SRS Accuracy During Flyby Pattern when Intertial System Provides Navigation Data

Referring again to Figures 23a and 23b, the initial SRS error occurs at the splash point (1). SRS error remains fairly constant for a time, then it slowly increases because of Nav drift, increased range, and flight path geometry. At point (2) the aircraft turns and flies back toward the buoy. As the SRS bearing measurements made during inbound flight are processed, the SRS error rate levels off, then rapidly diminshes in magnitude before the aircraft reaches the CPA (3) to the buoy. SRS error at this point is almost minimal and is called *flyby error*. As the flight proceeds, system error again remains constant for a time, after which it again increases slowly. When the aircraft again turns (4) to fly back toward the buoy, SRS error again decreases, and so forth.

If the flybys are approximately 2 NM from the buoy, SRS flyby error will be small and reasonable system accuracy can be maintained for the next 10 NM of flight. Subsequently, the buoy position solution will degrade with range and/or time proportionally to Nav system drift. Figure 23b provides two error curves, one for high Doppler Nav drift and another for low Doppler Nav drift, and shows the degree of Doppler drift reduction that can be realized by use of the bias velocity procedure. Since Doppler drift is fairly constant and the flight path geometry is repetitive, the SRS Error curve will also be repetitive in shape and magnitude. From the two curves in Figure 23b one can deduce that if the Doppler drift is low or if the Doppler drift has been previously compensated with the TACNAV bias velocity algorithm, better SRS relative position accuracy will be attained. On the other hand, the SRS Error curve on Figure 23c is not repetitive in shape due to the varying drift of an inertial system. Thus, inertial system data are not very suitable for compensation with the TACNAV bias velocity procedure.

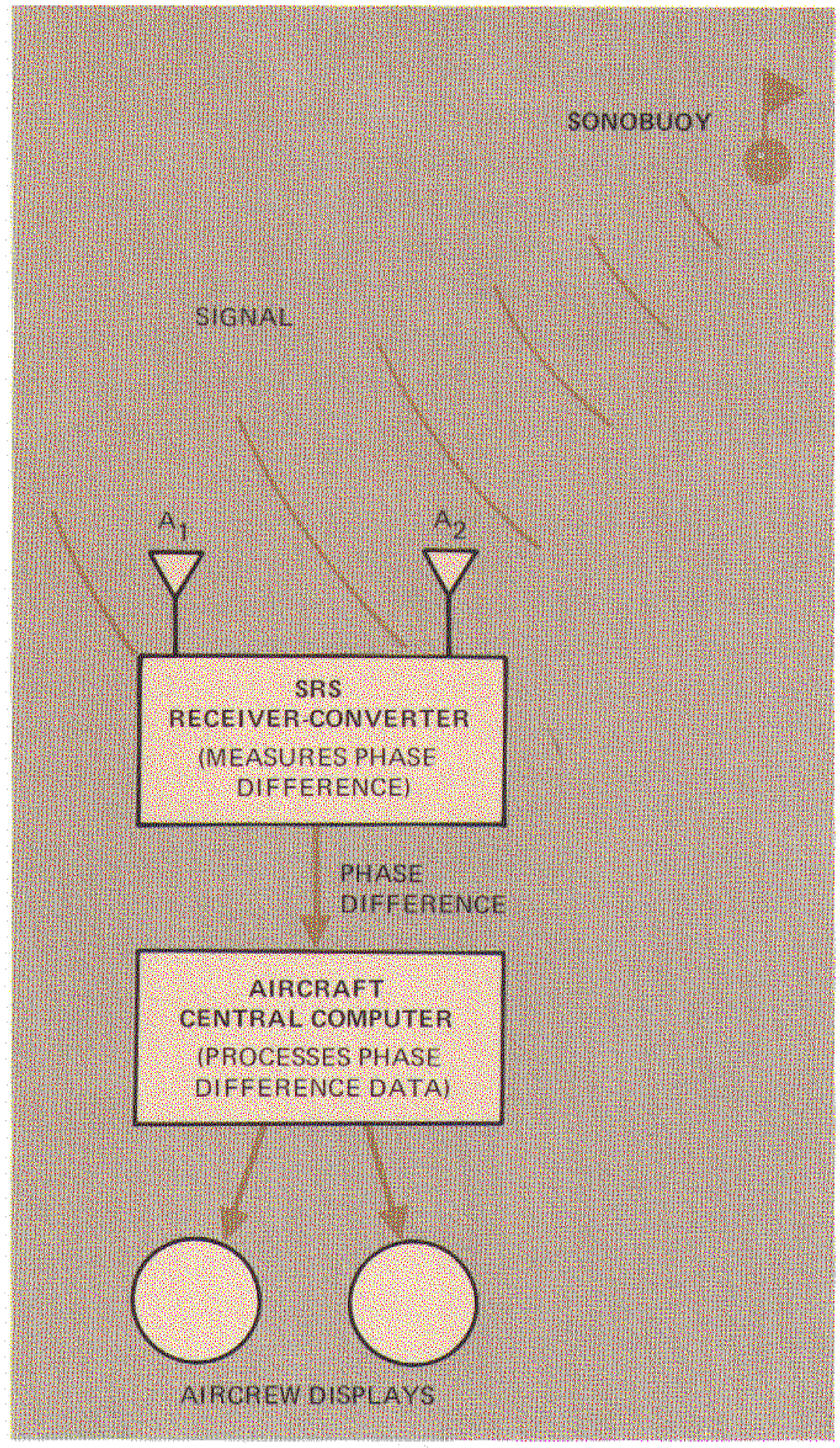


At this point it can be concluded that SRS errors cannot be fixed to stay minimal at all times. SRS errors tend to grow as a function of Nav drift and poor flight path geometry. They can be minimized only by the use of optimum flight paths (good geometry) relative to the buoy while performing the tracking maneuvers.

The following points should be observed to keep SRS Error to a minimum:

- Maintain the aircraft as close to the buoy field as the tactical situation allows, especially the buoy of interest, but maintain a minimum aircraft-to-buoy range of 2 NM when flying below 4000 feet and maintain a minimum aircraft-to-buoy range of three times the flight altitude during operations above 4000 feet.
- When possible, fly by each buoy with a 2 to 4 NM offset range. Since the SRS errors can be kept to a minimum when the aircraft is operated close to the minimum offset range, accurate SRS measurements will be processed at that time.
- Avoid large roll maneuvers when the aircraft is close to the buoy. Such maneuvers are associated with inaccurate SRS angular measurements.
- When initializing a buoy that was dropped by another aircraft: (a) if the tactical situation permits, perform an on-top marking and a buoy correct procedure; (b) as an alternative, fly a straight-line path that is at least 5 NM offset from the buoy at flyby. (A 5 NM indicated offset may become from 3 to 7 NM offset after the initial buoy position errors are removed.)

ORION SONOBUOY REFERENCE SYSTEM



◀ *Figure 24. Sonobuoy Reference System Functional Diagram*

PRINCIPLES OF OPERATION The ARS-3 Sonobuoy Reference System set is an angular measuring equipment (AME) type system that operates on the principle of an interferometer. Radio signals broadcast by sonobuoys are detected by antenna pairs that are mounted externally on the aircraft. The antennas are located so that they have fixed relationships to the directions from which the signals are arriving. The difference of the time-of-arrival of a common signal at each of two antennas produces a signal phase difference that is detected by the SRS set at the output terminals of both antennas. This phase difference is processed by the aircraft's central computer to determine the direction and the distance of the sonobuoy from the airplane.

The sonobuoy reference system is comprised of an SRS receiver-converter set, the antenna arrays, a central computer and its software, and display units on which to show sonobuoy position and other related data (Figure 24). A typical antenna array (A_1 and A_2) is located on the aircraft as shown in Figure 25. When the signal from the

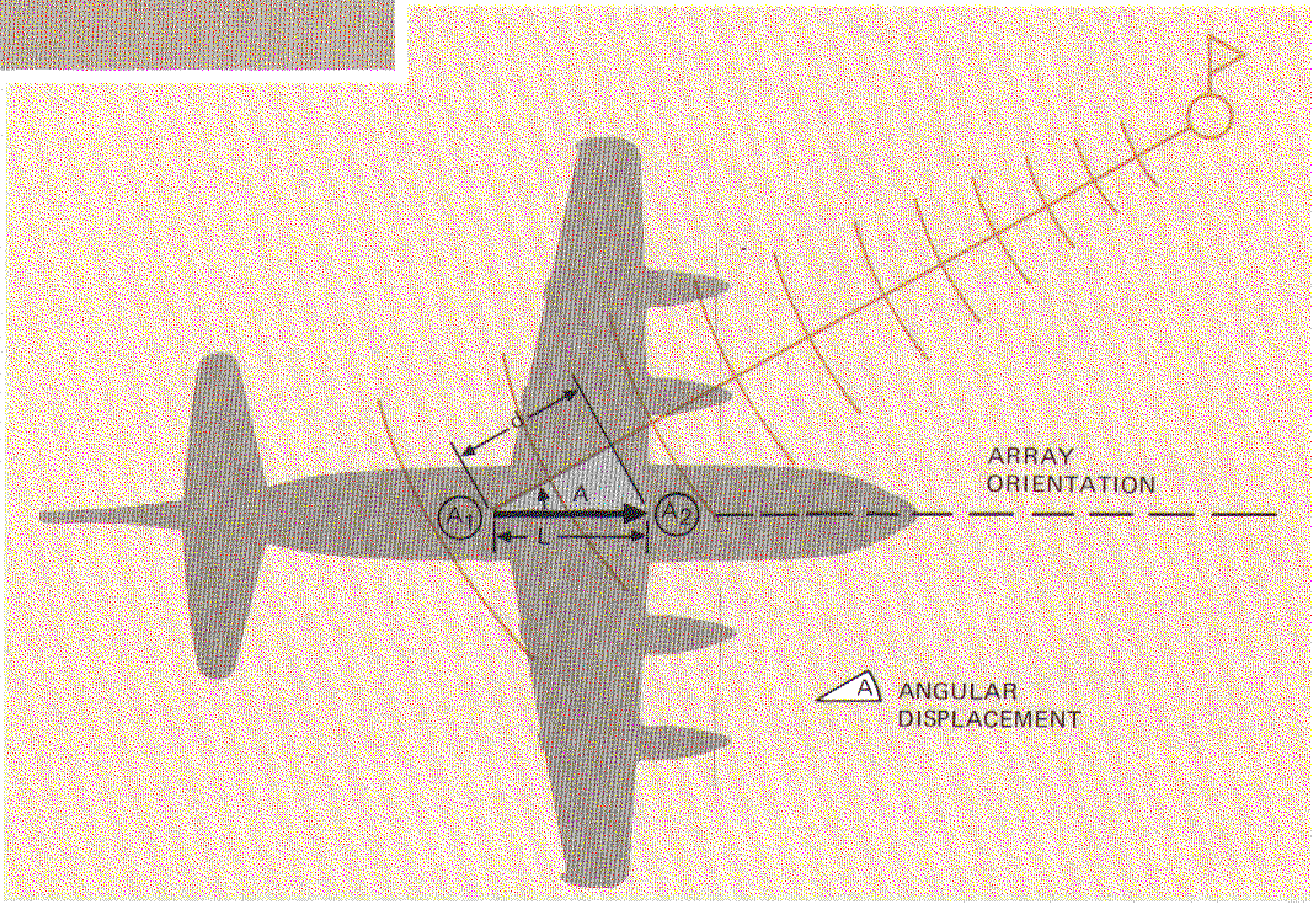


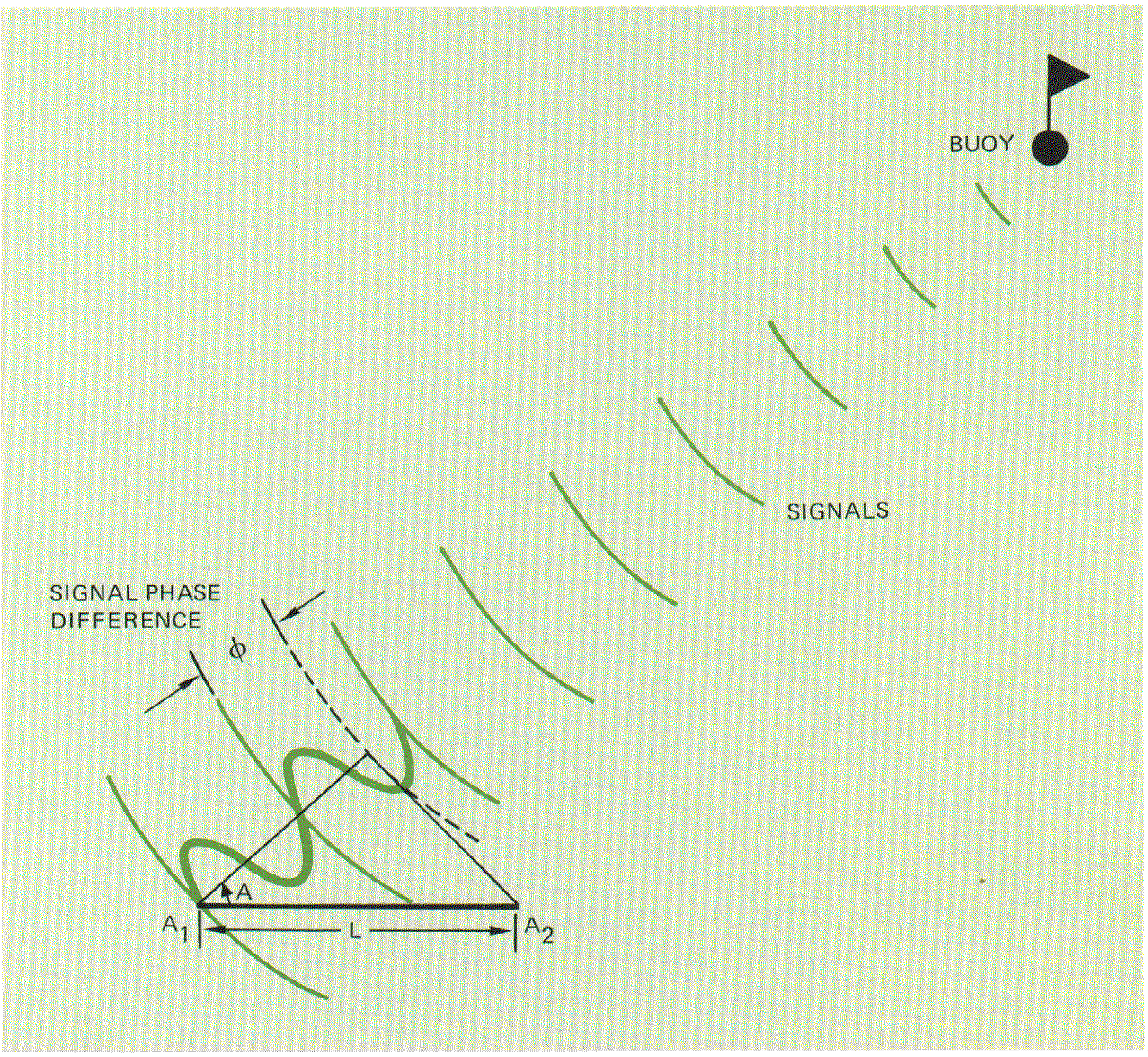
Figure 25. SRS Antenna Array Receives Signal from Sonobuoy

sonobuoy is received by antennas A_1 and A_2, the SRS receiver-converter measures the phase difference of the signal at the two antenna outputs. This signal phase difference measurement is sent to the aircraft's central computer, which processes the data with special software to determine the relative bearing of the sonobuoy and its distance from the aircraft. This information is then displayed on tactical data displays to the flight crew.

The antenna array is positioned so that, in general, the signal from the sonobuoy will reach one antenna before the other, and thus provide the SRS receiver-converter a signal phase difference that it can measure (see Figure 26). If the incoming signal reaches both antennas at the same time (see Figure 27), the signals at the antenna outputs will be in phase with one another, and hence there will be no phase difference for the SRS to measure. Figures 26 and 27 show that the signal phase difference at any given moment establishes the angular relationship between the antenna array baseline and the line-of-sight direction to the sonobuoy.

Before proceeding further, certain terms that we shall use in this SRS discussion should be defined. To begin with, the imaginary line between the two

Figure 26. SRS Antenna Array Positioned so that Phase Difference of Incoming Signal can be Measured



antennas of an array is called a baseline (compare line L in Figure 25 with the baseline in Figure 28). The length of this baseline is not expressed in inches, feet, centimeters, etc., but rather in the number of wavelengths (λ: lambda) – wavelengths being the distance that the incoming signal completes a full cycle (360 electrical degrees). Thus, the baseline value of an antenna array (expressed as a number of wavelengths or complete cycles) depends upon the frequency of the sonobuoy radio signal.

When the baseline length of an antenna array is equivalent to or less than one-half the wavelength of the incoming signal, only two possible directions from the aircraft to the sonobuoy can provide the same phase difference measurement. The two directions (bearings) are symmetrical to the baseline as shown in Figure 28. This produces what is called an *ambiguity*, a situation where there is more than one answer or solution to a problem. A 0.5λ antenna array provides the type of bearing ambiguity described above, which is known as a mirror-image ambiguity. The SRS resolves this type of ambiguity (i.e., arrives at one answer) by using a two 0.5λ-antenna array configuration, with the arrays positioned 90° to each other as shown in Figure 29. The common solution provided by antenna arrays L (solution = LOS_{L1}) and T (solution = LOS_{T2}) indicates the correct relative

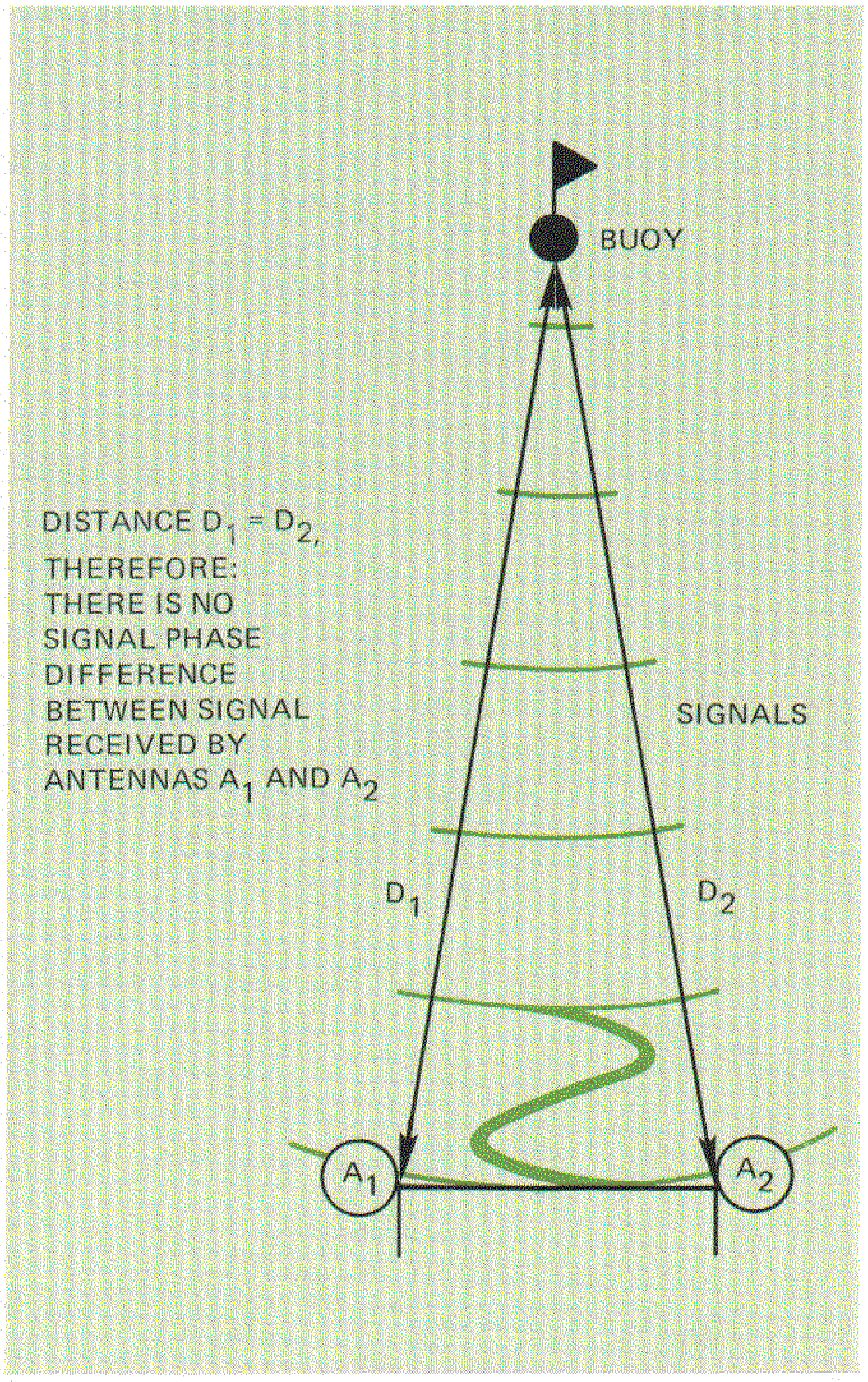


Figure 27. Incoming Signal Arrives at Both Antennas of SRS Antenna Array Simutaneously - No Signal Phase Difference is Present to be Measured

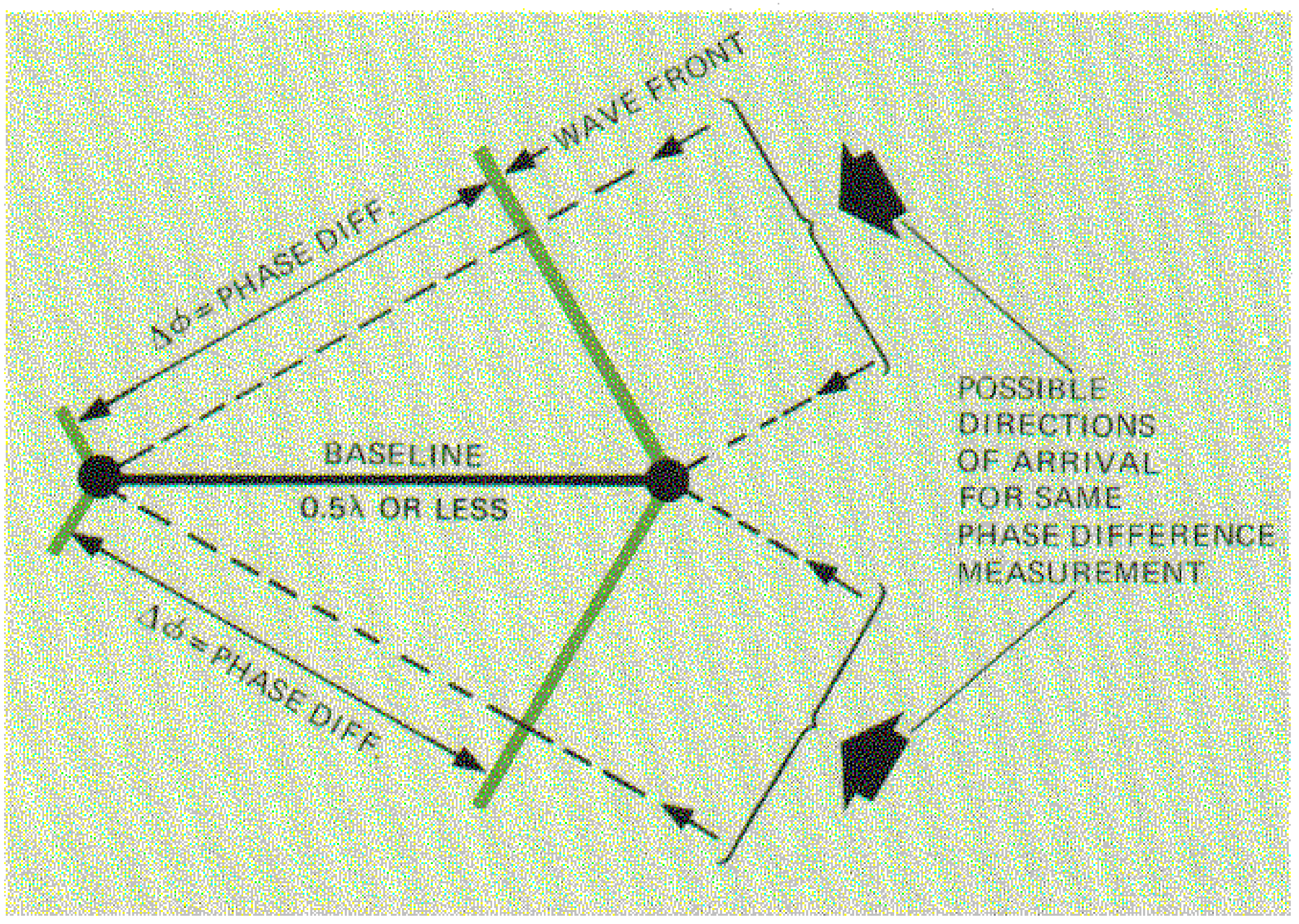


Figure 28. Mirror Image Ambiguity Occurs when SRS Measurements are Made with One Antenna Array that is 0.5λ or Smaller

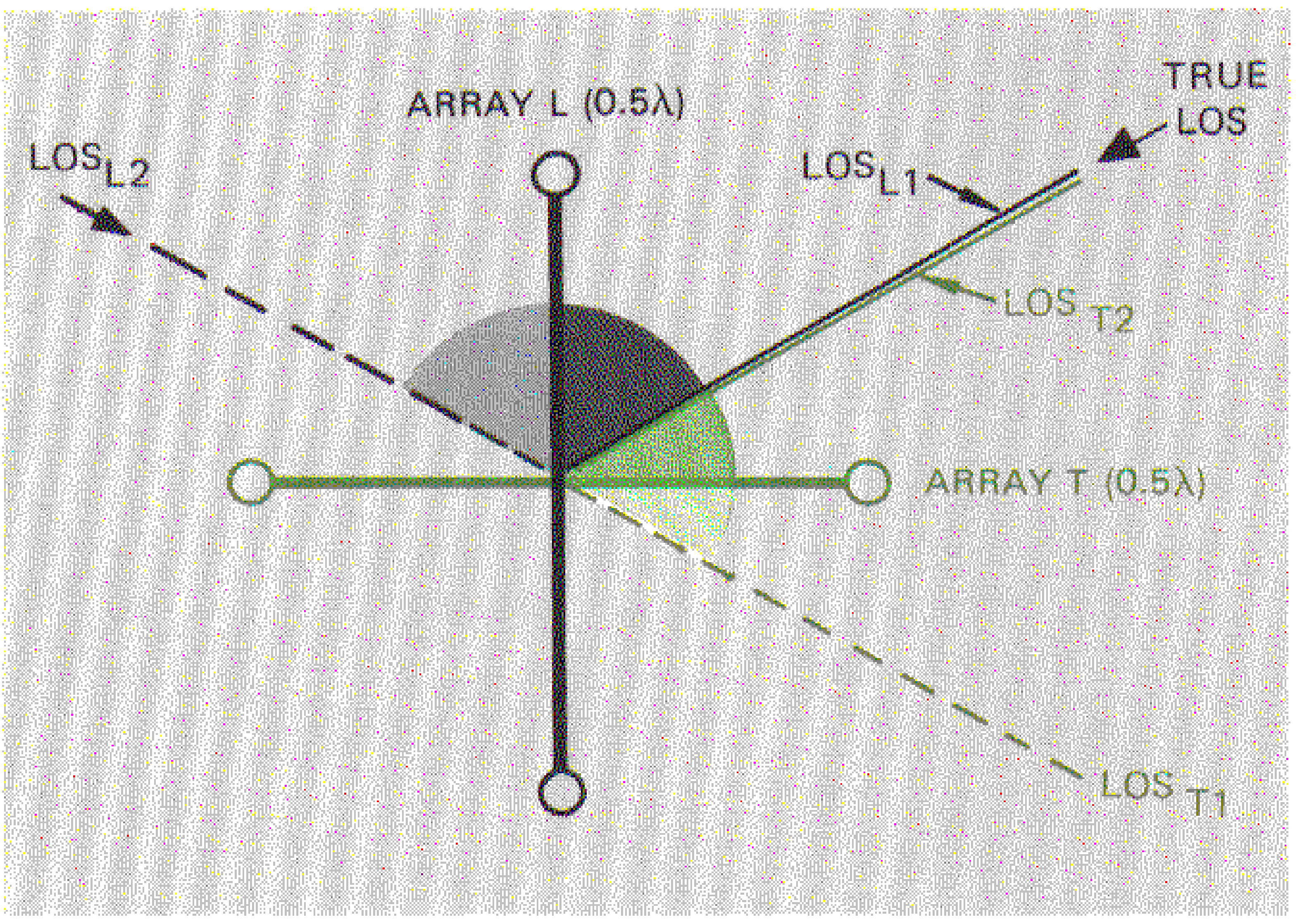


Figure 29. Mirror Image Ambiguity is Resolved when SRS Measurements are Made with Two Antenna Arrays of 0.5λ or Smaller that are Positioned at a 90° Angle to Each Other

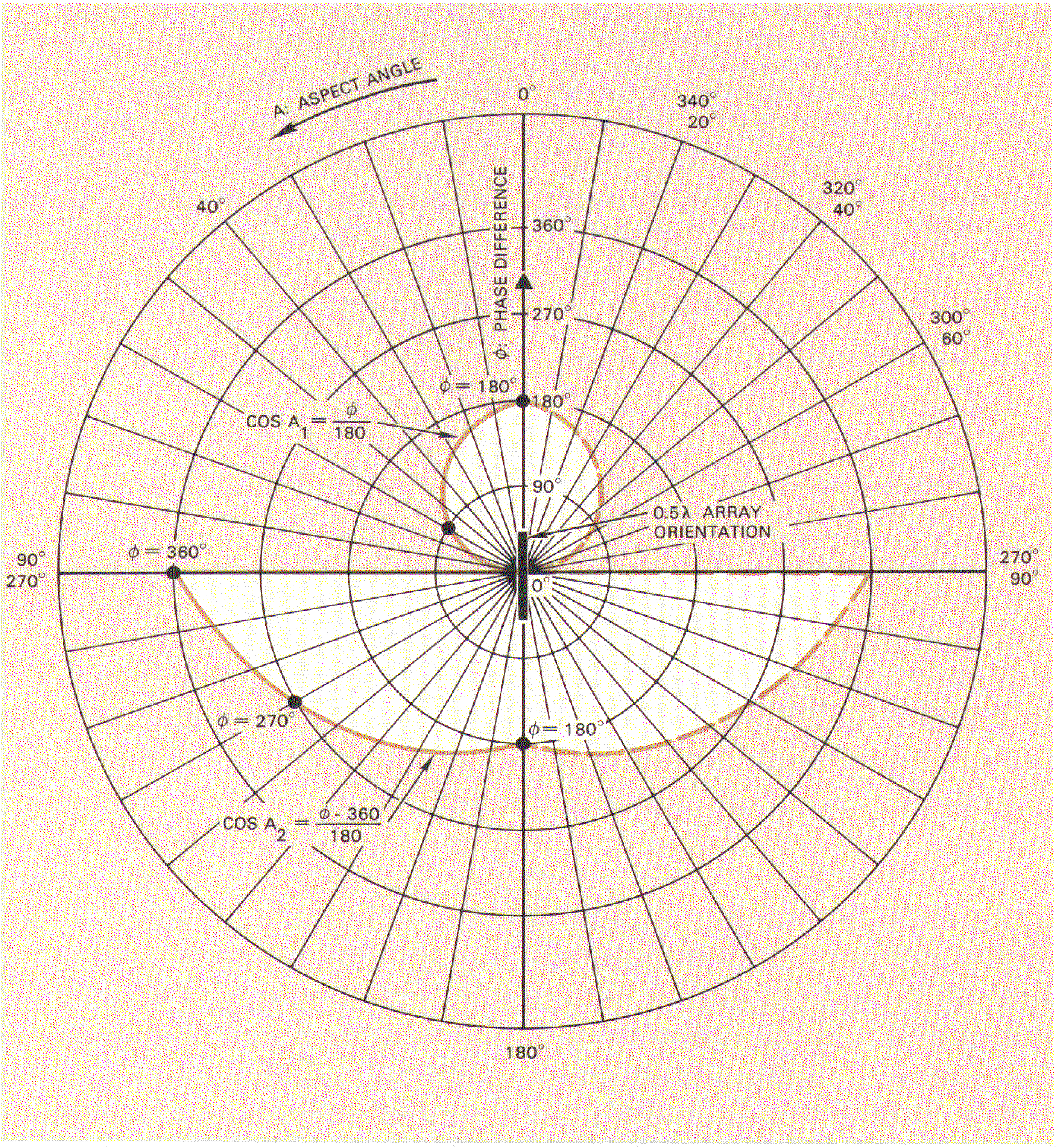


Figure 30. Phase (φ) vs. Aspect Angle for 0.5λ SRS Antenna Array Case

bearing of the buoy signal transmission to the aircraft.

Figure 30 shows that the signal phase difference measurements provided by the 0.5λ antenna array are a function of aspect angle A_1, relative to the array baseline. Since the SRS phase meter range is from 0° to 360° (electrical degrees), phase measurements of signals that arrive from directions perpendicular to the antenna array baseline will be subject to a discontinuity – that is, the phase meter will indicate 0° or 360° in such instances.

An interferometer-type system experiences some difficulty when the antenna array baseline is greater than one-half the wavelength of the radio signal. When this is the case, the signal phase measurements of the interferometer can be ambiguous because any single phase measurement can represent more than one angle-of-arrival. The ambiguity occurs because the SRS phase detector cannot determine how many cycles have occurred between the signal's time-of-arrival at each of the two antennas (see Figure 31). For example, at the output of the signal detector, a phase difference of 30° will appear to be the same as the phase difference of one complete cycle plus 30° (360° + 30°). This occurs because the residual portion of the phase difference (that portion *less* than one cycle) is the only part of the phase difference that is reported to the SRS for processing. Since multiples of 360° are not reported, they represent an ambiguity. Indications derived from such data are referred to as being ambiguous.

Ambiguities are present whenever an antenna array has a baseline that is longer than one-half the wavelength of the signal. Such an array is usually referred to as a multi-lambda (nλ) array. Figures 32 and 33 illustrate that the phase difference measurements of the incoming signal are a function of aspect angle A for 1λ and 2λ antenna array baselines, respectively. The ambiguity or number of ambiguities that relate the phase difference measurement to aspect angle A are clearly indicated by the number of "lobes" in these figures.

Since multi-lambda antenna arrays produce ambiguities, this would seem to point to the exclusive use of shorter baseline arrays. However, the shorter arrays provide relatively inaccurate signal bearing measurements, compared to bearing measurements derived from multi-lambda antenna arrays. Thus, the situation is one in which the signal bearing measurements produced by shorter antenna arrays are unambiguous but relatively inaccurate, whereas measurements produced by multi-lambda arrays are relatively accurate but ambiguous.

This dilemma has been recognized, and various techniques are being used to remove ambiguities from SRS measurements while retaining accuracy. One such technique employs multi-array configurations that include a one-half lambda array and various multi-lambda arrays of intermediate and long baseline lengths. Ambiguities in the multi-lambda baseline measurements are removed by sequentially processing the signal angle-of-arrival data to progressively remove the ambiguity from

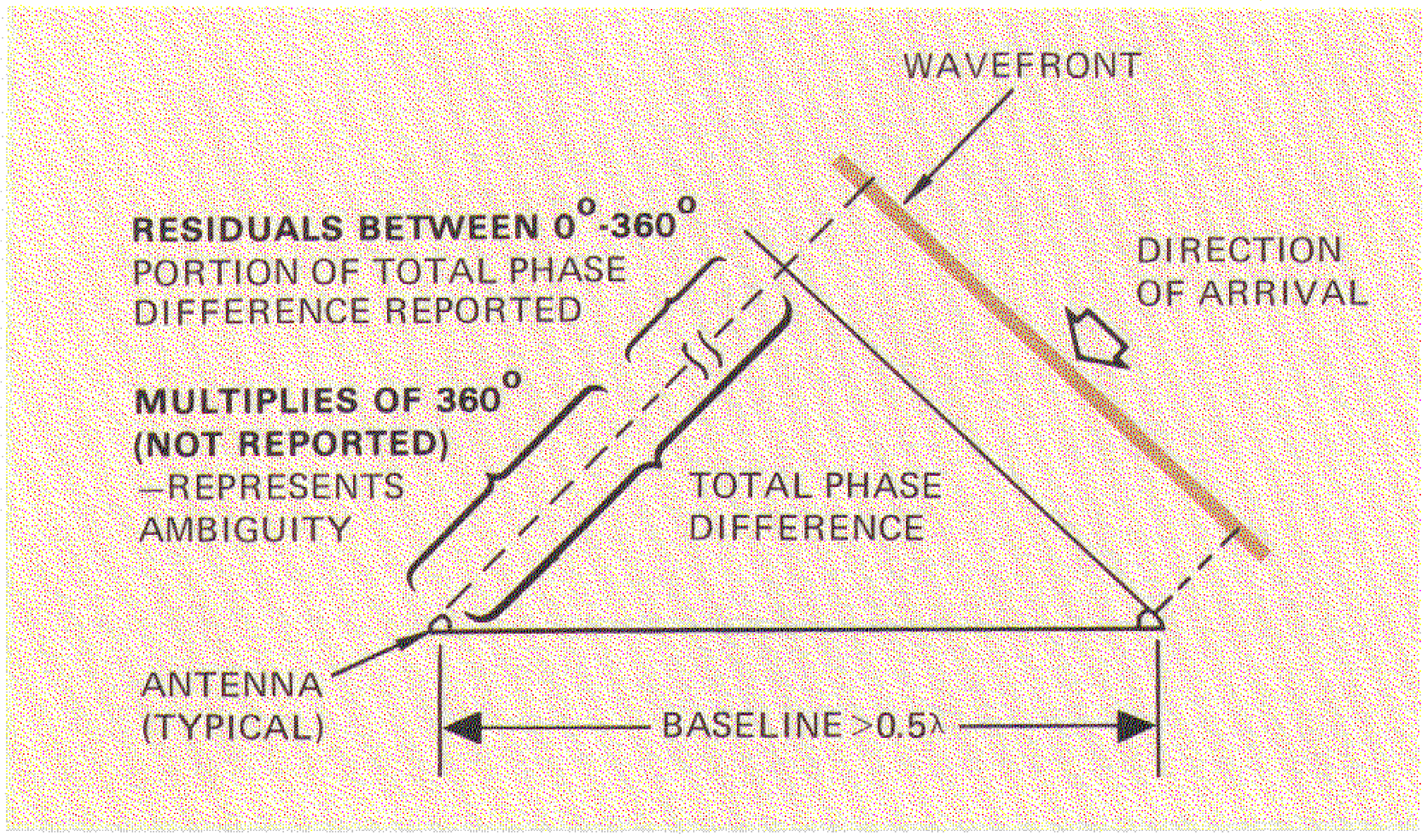


Figure 31.
Ambiguous Measurements Result when the SRS Antenna Array is Greater than 0.5λ

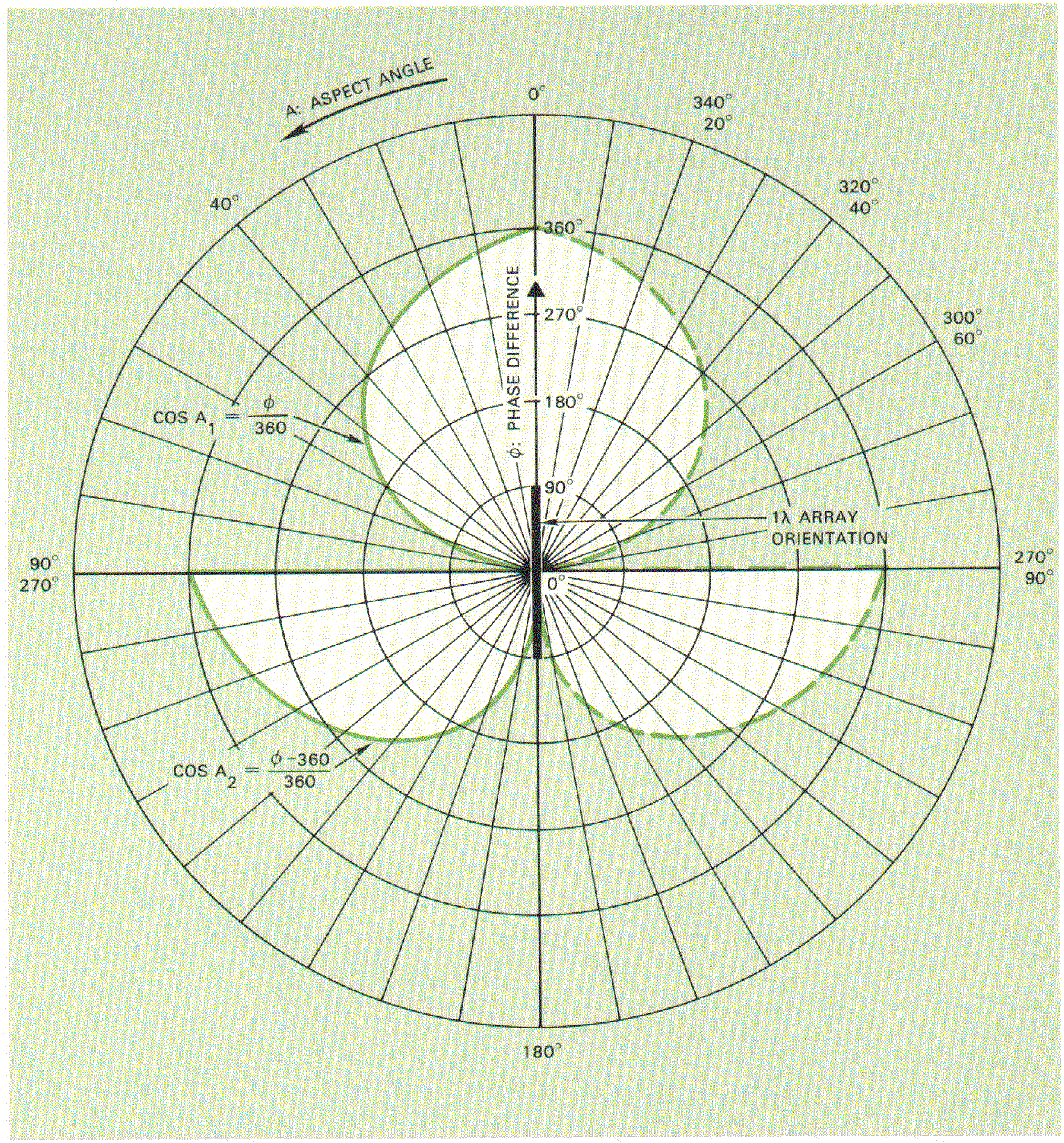


Figure 32. Phase (ϕ) vs. Aspect Angle for 1λ SRS Antenna Case

the shorter to the longer baseline phase difference measurements. Usually, the ambiguity of intermediate baseline array measurements is removed by the application of one-half lambda array data, then the ambiguity of long baseline array measurements is subsequently removed by the application of intermediate baseline array data.

In the present P-3C SRS design, the approach to resolve ambiguities differs from the above method

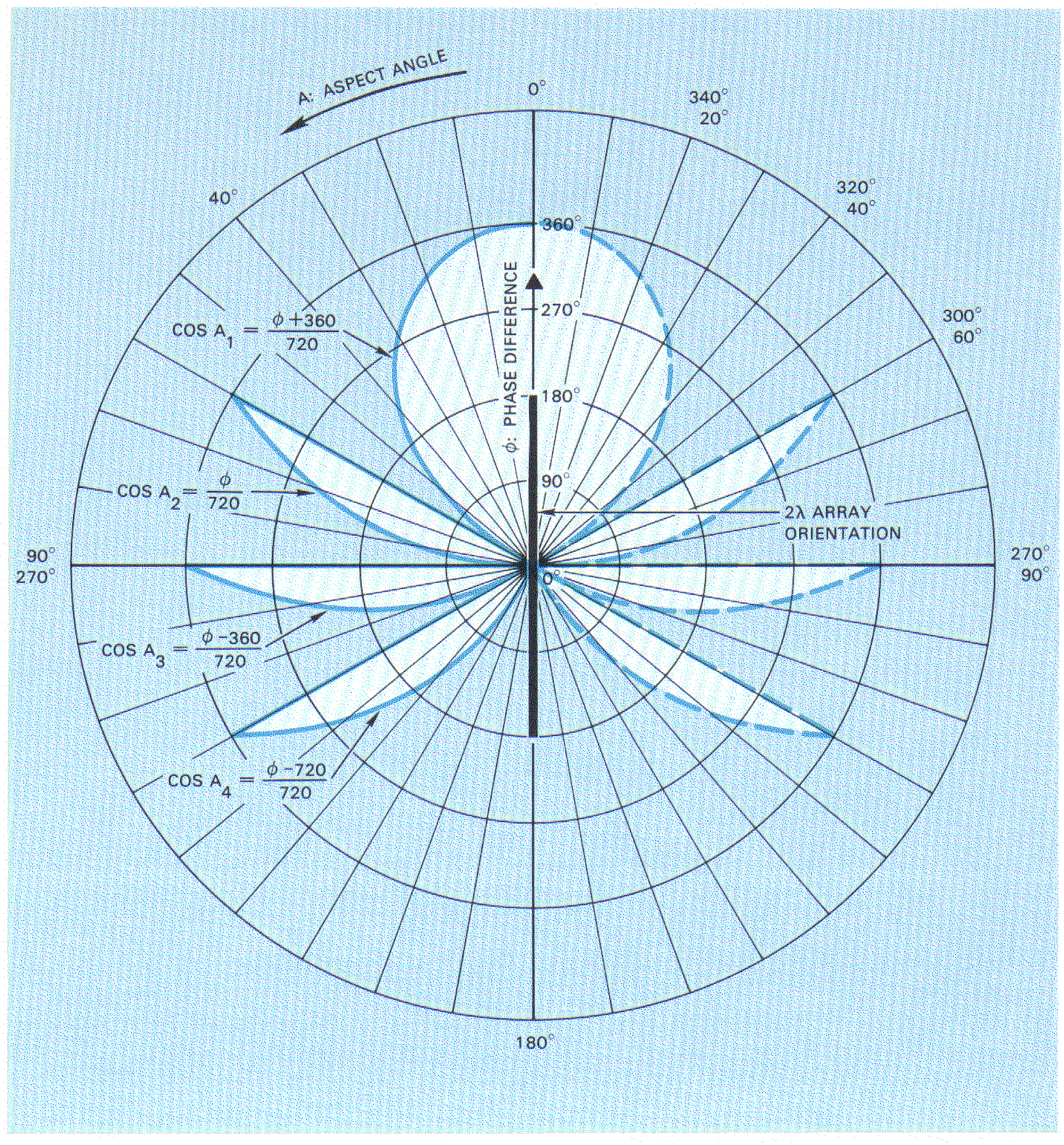


Figure 33. Phase (ϕ) vs. Aspect Angle for 2λ SRS Antenna Array Case

to the extent that sonobuoy position solution (best estimate) data are utilized to remove ambiguities from data derived from multi-lambda antenna arrays. When the sonobuoy position uncertainty is too great, one-half lambda array data are utilized until the sonobuoy position estimate is improved sufficiently to permit the ambiguity to be resolved by use of intermediate baseline array data. The intermediate baseline array data are sequentially processed, which progressively improves the sono-

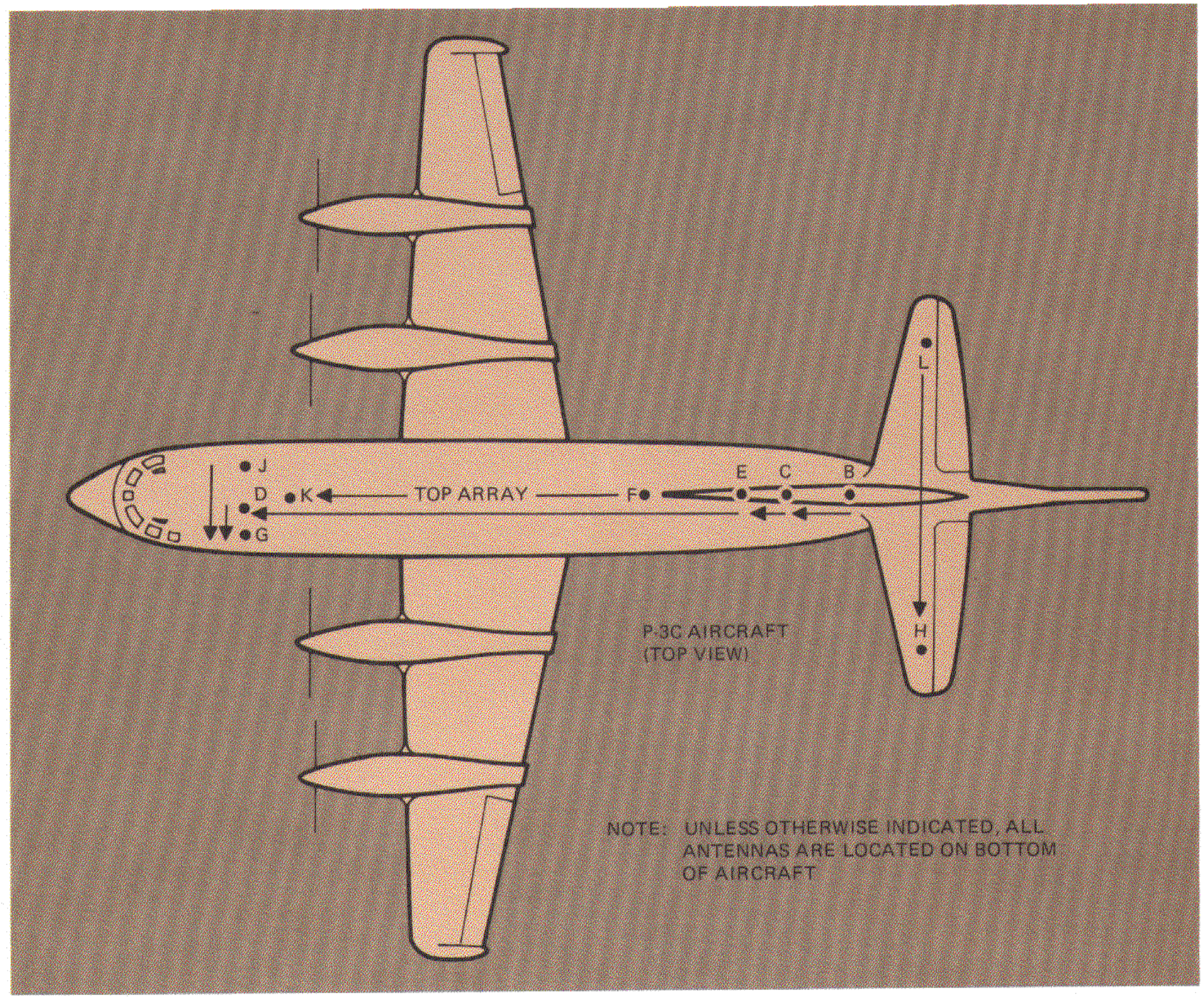


Figure 34. SRS Antenna Locations on the P-3C Aircraft. Antennas F and K are located on top of the aircraft; all other SRS antennas are located on the aircraft lower surfaces.

buoy position estimate to the point that longer baseline array data can be used to resolve the ambiguity. Sequential processing of the longer baseline array data then enables the SRS to estimate the sonobuoy's position with the required accuracy.

The P-3C SRS multi-array antenna configuration is illustrated on Figure 34. It has three transverse antenna arrays (DG, GJ, and LH) and four longitudinal antenna arrays (EC, BC, ED, and KF). The longitudinal antenna arrays are used to measure radio signals arriving from the left or right of the aircraft heading, and to resolve fore and aft ambiguities of transverse antenna array measurements. The transverse antenna arrays are used to measure radio signals arriving from fore or aft of the aircraft heading, and to resolve left and right ambiguities of longitudinal antenna array measurements. One longitudinal antenna array (KF) is mounted on top of the aircraft to enable measurements to be made when the aircraft is in a steep bank.

The SRS receiver-converter takes the signals from the output terminals of the seven antenna arrays, makes the signal phase difference measurements, converts these measurements into digital data format, then routes the information to the aircraft's ASQ-114 Digital Computer. The computer fixes the position of as many as 31 sonobuoys sequentially through a process that is similar to triangulation, but which actually consists of an *estimation* of the relative position of each sonobuoy followed by a correction based on the latest phase difference measurements. Continuous updating of the sonobuoy positions requires repetitive processing. To obtain improved accuracy, the computer program processes the phase difference measurement data with a Kalman filter algorithm. This procedure permits only a partial correction of the sonobuoy position estimate on each calculation. The degree of correction to be applied to the calculations is determined by the computer after it assesses the relative statistical accuracies of the sonobuoy position estimate and the latest measurement. This position estimation technique provides an optimum solution when errors are random.

During convergence the buoy position will change, apparently in a random manner, then as more phase difference measurements are taken the buoy will settle into one position. This position will be a good estimate of true buoy position only if the flight path geometry favors making measurements that converge upon the buoy location. This measurement convergence process is illustrated by Figure 35, which shows the relative accuracies of the sonobuoy position solutions at times t_1, t_2, and t_3.

When only one buoy is deployed in the water, its position is updated once every second. If ten buoys are being monitored, the location of each buoy will be updated once every ten seconds, since buoy location data is processed sequentially for one buoy after another rather than for all buoys simultaneously. If the bearing to the buoy (relative to the aircraft) is changing rapidly (e.g., when the buoy is at short range), the computer software will cause the estimated buoy position fixes to converge rapidly and accurately – usually within a minute. If the bearing to the buoy is not changing rapidly (e.g., when the buoy is at long range), the estimate of the buoy position will stabilize more slowly and the accuracy of that buoy location estimate will be less certain.

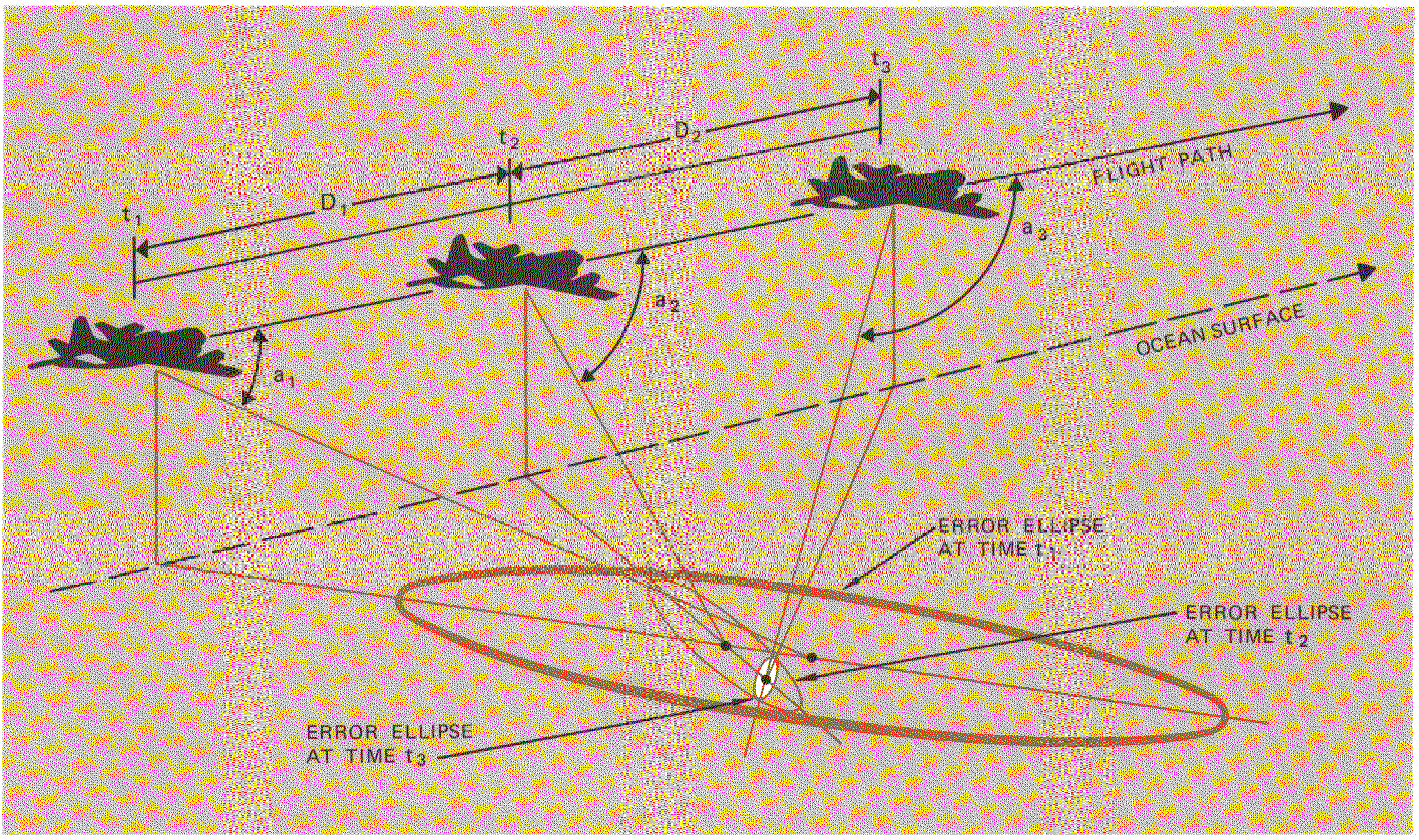
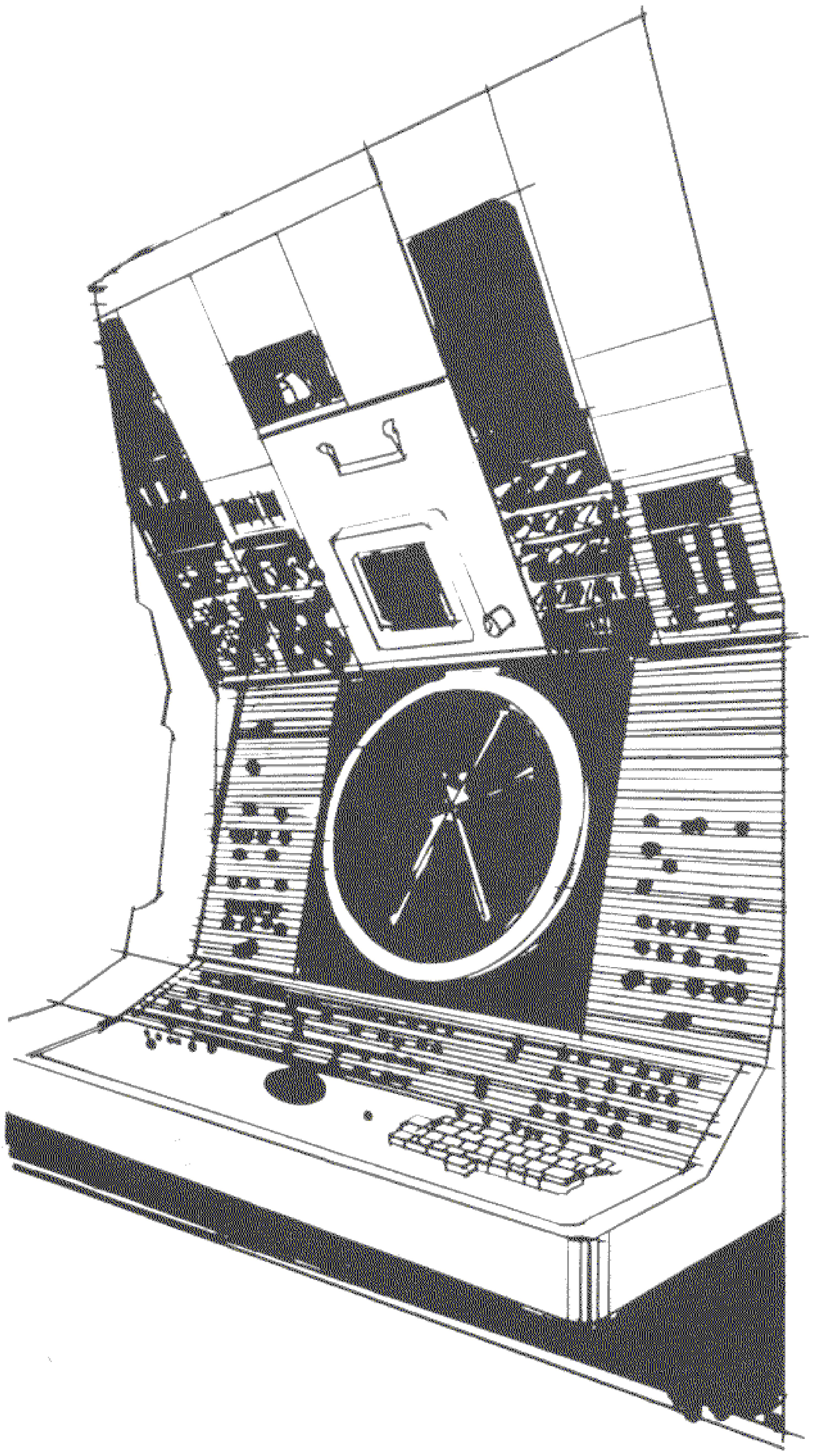


Figure 35. Angle Measuring Equipment (AME) Error Ellipses Converge upon the sonobuoy Location as Successive Measurements are made at Times t_1, t_2, *and* t_3

SRS PROCESSING AND TACTICAL APPLICATIONS

SRS POSITION CONVERGENCE CONCEPT The system solution to any SRS-related situation begins by initially estimating the buoy location because:

- The initial RF phase measurements are initially computed by using short baselines. This produces position estimates that tend to be less ambiguous, but that are also less accurate.
- Buoy position solution convergence is dependent upon the relative geometry between the buoy and the aircraft.
- Like the Omega navigation system, the SRS uses a Kalman filtering technique that determines buoy position by using successive position approximations.



The SRS position convergence concept uses the last nineteen Kalman filter estimates of a sonobuoy's position to calculate the displayed tactical buoy position. This information is then processed by an automatic data accept routine that either accepts or rejects the updated sonobuoy position estimate. If accepted, the updated buoy position estimate is presented on the crew displays. By processing buoy position estimate data in this manner, the SRS displays buoy position data after the buoy position solution has converged, and thus improves the accuracy of the position estimates that are displayed.

For each update, the Kalman filter computes the difference between the estimate of the current buoy position and the last automatically accepted position. The automatic position accept function then computes the sum of the previous eighteen position updates and the latest update, then divides this sum by an estimate of uncertainty accumulated from all nineteen updates. If the result passes a confidence-level test, the current sonobuoy position estimate will be accepted and its new position will be displayed at the next display update cycle. This process is performed for each buoy on the SRS buoy list and only those buoy estimates that pass the acceptance criteria are updated on the crew displays. In addition, whenever a buoy RF is reinitialized by initiating Sono Select, Restart, or SRS NAV, the process of accumulating a sequence of nineteen buoy position estimates must be repeated.

DISPLAY UPDATE When the SRS NAV mode is active, the update refresh rate for the sonobuoys and their associated contacts on the TACCO's display is a function of the display scale. Upon completion of the automatic position accept function, a test is performed to determine if sufficient time has elapsed since the last display update. If it has, the TACCO display positions are updated.

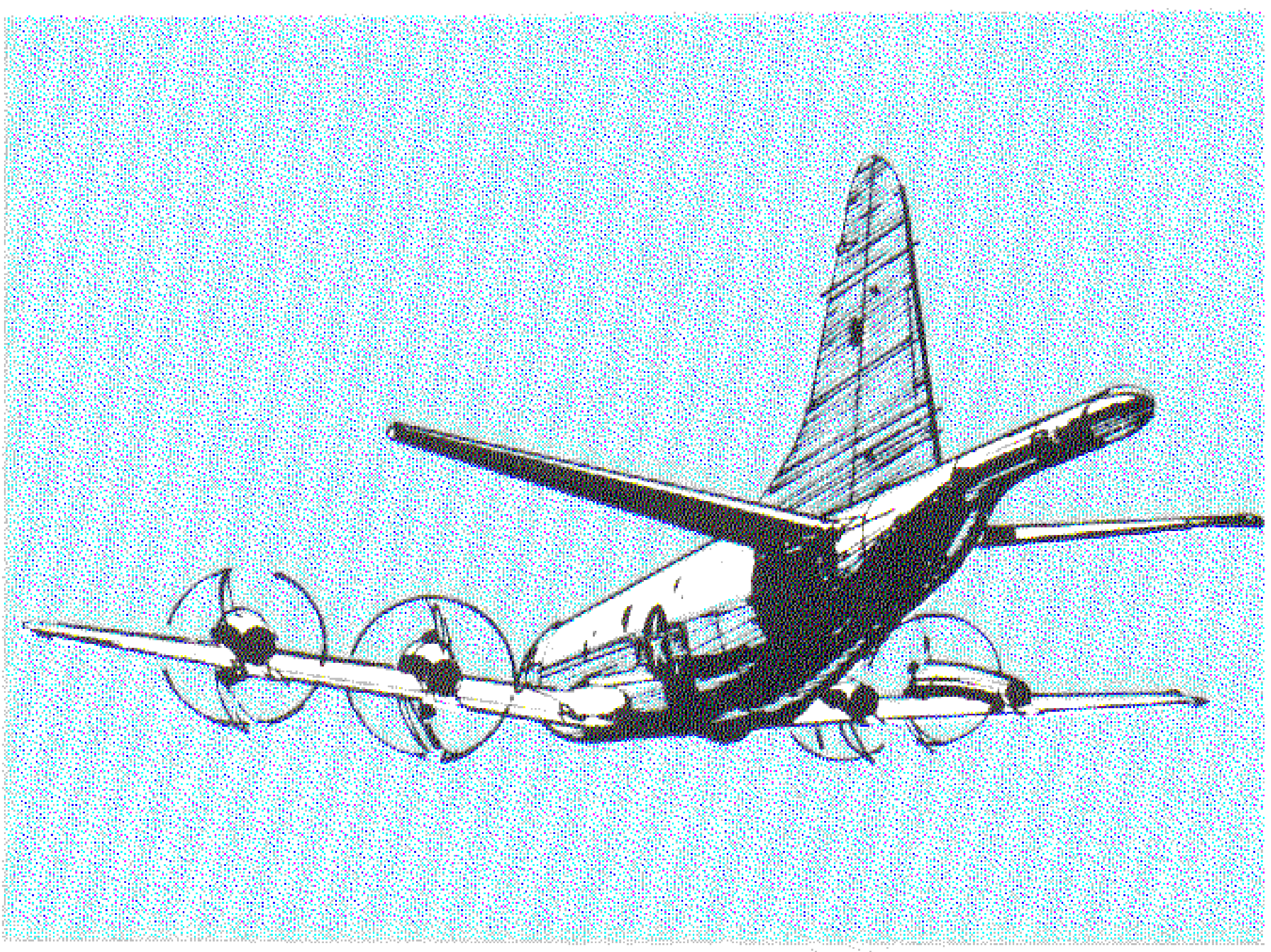
SRS ACCURACY The degree of SRS accuracy depends upon the complex interrelationships of several major system components. Those major components that affect signal phase measurement accuracy and position estimate accuracy are:

- Phase Measurement Accuracy
  1. Multipath signal errors
  2. Equipment noise
  3. RF interference in the sonobuoy signal band
- Position Estimate Accuracy
  1. Phase measurement
  2. Short-term navigation system inaccuracy
  3. Measurement rate and relative geometry (depression >25 degrees degrades accuracy)
  4. Number of angular measurements

After correcting the SRS for initial variance, its accuracy continues to be affected by aircraft altitude, attitude, and its distance from the sonobuoy. Generally, the accuracy of SRS measurements is improved if the aircraft heading is perpendicular to the buoy line-of-sight, and when the distance from the aircraft to the buoy is greater than the aircraft altitude.

As the aircraft travels along its flight path, the SRS makes angular measurements of the RF signal from the sonobuoy. With any two angles from the aircraft to the buoy and the known distance travelled by the aircraft, the SRS can determine a buoy position. Because of inherent error in the angular measurements, the more frequently that the SRS measures the changing angle to the buoy, the more data will be available to the system for the Kalman filter processing to yield accurate buoy position data.

The distance from the buoy to the aircraft also affects sonobuoy positioning accuracy. At distances nearing the RF horizon, lower RF power levels may affect the number of measurements available (invalid data). At very close ranges, the angles change so rapidly that SRS measurement accuracy can be adversely affected. In addition, some multipath error may be encountered when external stores are hung on the aircraft.



The operator can select the tactics and system operation that improve the accuracy of buoy position estimates. The following suggestions are offered to help the flight crew utilize the SRS effectively in a tactical environment.

First, flying directly down a row of buoys adversely affects SRS processing. For improved SRS processing, fly a racetrack pattern that is parallel to the buoy field and is offset by a distance of at least three times the aircraft altitude.

Second, use the Sonobuoy Delete function to delete buoys from the SRS that are not critical to the tactical problem. The fewer the sonobuoys that are being processed by the SRS, the more measurements will be taken of the remaining buoys.

Third, use the best DR navigation source possible for TACNAV. This will help minimize the navigation drift rate.

Fourth, if there is random noise on a particular RF, avoid using that RF on the SRS. Although an SRS Noise Test is performed, it may still be advisable to perform a manual RF noise check in high RF noise environments.

Fifth, since the SRS uses a method of triangulation to determine buoy location, the best angular measurements can be obtained if the TACCO and pilot coordinate their efforts in positioning the aircraft during SRS operations.

Sixth, develop an accurate bias velocity value. One of the major advantages of using the SRS with TACNAV is that the computer can compensate for drift on the tactical plot by including a bias velocity correction value in the TACNAV calculations. An accurate bias velocity, applied properly, should compensate for system drift and thereby improve the accuracy of SRS buoy position estimates.

TARGET TRACKING During target tracking, DIFAR bearings, comparative LOFAR circles, and RO/CASS ranges that are presented on the displays will originate from the buoy as expected. However, comparative LOFAR circles that have been adjusted by the comparative LOFAR function will remain displayed where they were marked, and so may not be around a buoy mark if there is considerable drift or if the TACNAV mode is deactivated. The TACCO should bear in mind that combining information from a buoy that has been accepted by the SRS and from a buoy that is not accepted could affect target positioning accuracy.

BUOY INSERTION AND PROCESSING There are three ways that buoy positions can be inserted into the SRS: by buoy launch, by using the Insert Buoy keyset function, and by receiving buoy positions via ASW Summary (data link data). The SRS processing assigns different standard deviation values to each of these methods. When a buoy is launched from the aircraft, the initial standard deviation value for the buoy position is based upon the altitude of the aircraft and the indicated wind velocity. Buoy positions inserted via data link inputs have an initial standard deviation value of 5 NM. Buoy positions inserted by the Insert Buoy keyset function have a standard deviation of 30 NM. The standard deviation for *each* buoy is displayed in the SRS BUOY STATUS tableau in the form of a *sigma value*. This sigma value is equal to the square root of one-half the sum of the N/S and E/W SRS position deviations.

If the standard deviation is low, minimal buoy position movement would be expected. However, at times the operator may be forced to insert buoy positions. If these inserted buoy positions are accepted into the SRS, at first their sigma values will be relatively high. As the Kalman filter receives additional measurements, the SRS will resolve where the buoys are positioned and the sigma values will decrease. Kalman filtering and automatic position accept routines prevent rapid or erratic buoy movement on the display. Thus, even if the displayed buoy positions are in error by a few miles initially, their markers will be moved slowly to their correct positions. When a sonobuoy is inserted with no information other than an OTPI bearing, insertion should be made down that bearing at a range of one-half the radar horizon.

When practical, the TACCO should consider performing individual buoy position correct operations. These operations will reduce the sigma value of each buoy and ensure the accuracy of each displayed buoy position. In large buoy patterns, it may not be possible to correct every buoy position on the display. When this situation exists, the TACCO must be aware that tactical position information on the uncorrected buoy positions will be degraded until the SRS resolves where the buoys are positioned.

With the SRS NAV mode active, the central computer calculates four positions for sonobuoys:

- The sonobuoy's unbiased TACNAV position computed from the aircraft unmodified position.
- The sonobuoy's TACNAV position computed from the aircraft tactical position.
- The sonobuoy's SRS position computed by the SRS algorithm.
- The sonobuoy's system display position computed by the SRS algorithm and accepted for display.

All of the above positions are stored by the computer in tactical LAT/LONG coordinates.

The sonobuoy's SRS position is the direct output of SRS AME processing. Associated with this position is a time and a position uncertainty. Once a bias velocity is accepted by the operator during an aircraft correct operation, the SRS positions on the display are translated in position the same distance as the aircraft symbol, and SRS processing is resumed at these translated values. Time and position uncertainty values are not affected by an aircraft correct operation.

The system display position is the latest of either the TACNAV position or an SRS value that passes the automatic position accept criteria. If a buoy is deselected from the SRS by the Buoy Delete function, the buoy's system display position is set equal to its present TACNAV position.

When the SRS is deactivated while the TACNAV mode is still selected, all system display positions are set equal to their present TACNAV values and all bias velocity computations are retained. If the GEONAV mode is selected or the TACNAV mode deactivated, system operation shifts to the GEONAV mode and the system display positions of all buoys are changed from tactical to geographic coordinates.

SRS NAV PROCESSING SOFTWARE The ASQ-114 Digital Computer and its software comprise the heart of the sonobuoy reference system. SRS NAV processing is activated through a switch depression on the Matrix B keyset. SRS-related switch locations are shown in Figure 36. This processing is outlined in the following steps that occur when SRS NAV is activated:

1. Select the first sonobuoy from the SRS buoy list.
2. Adjust the estimated accuracy of the SRS buoy position (position uncertainty value).
3. Determine the sector in which the sonobuoy is located, relative to the aircraft.
4. Collect 12 sets of navigation data from the primary DR source.
5. Command the SRS hardware to acquire AME data for the selected RF. Collect phase measurements for all baselines.
6. Select the baseline type.
7. Select a baseline.
8. Estimate the angular measurement expected from the selected baseline.
9. Select the actual baseline phase measurement from received AME data.
10. Correct errors in the actual phase measurement by adding calibration factors, and

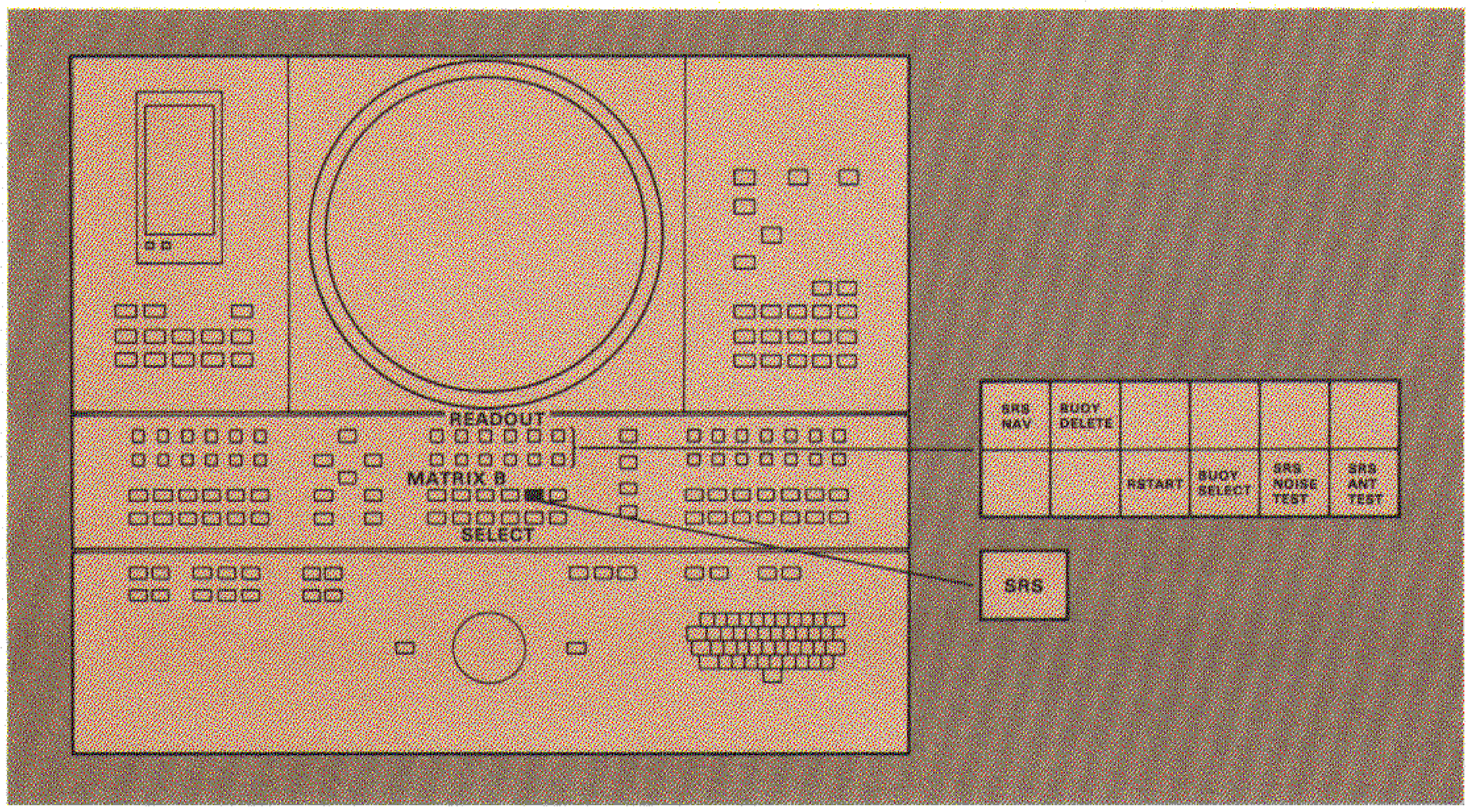


Figure 36.
SRS NAV Select and Readout Function Switches on the TACCO Keyset Matrix "B"

compute the corresponding angular measurement by properly resolving angular data ambiguities.

11. Compute the residual, which is the difference between the estimated angular measurement and the actual angular measurement.
12. Compute the correction for the sonobuoy position with the Kalman filter algorithms.
13. Update the sonobuoy position.
14. Update the sonobuoy position uncertainty estimate (covariance matrix) with Kalman filter algorithms.
15. Apply the automatic position accept function test to the sonobuoy updated position.
16. If it is accepted, display the sonobuoy position at the next display update cycle.
17. Select the next sonobuoy from the SRS buoy list.

SRS CALIBRATION PROCESSING SOFTWARE The Sonobuoy Reference System is calibrated in order to measure the phase shift values of the SRS receiver and all of the antenna transmission lines. These measurements are used to compensate for phase changes in the system and they provide a periodic hardware check for the SRS hardware.

The measured calibration factors that are applied to each SRS phase-difference measurement are called calibration sets. A calibration set consists of a receiver calibration count factor and the corresponding receiver/line calibration factors (for each baseline). Measurements for each RF channel consist of a receiver calibration measurement and seven receiver/line calibration measurements.

Consistent calibration data for at least 20 RF channels will allow the SRS AME processing to become active. Once consistent calibration has been achieved and SRS NAV has become active, additional calibration measurements and calibration factor updates will be performed every 30 minutes.

Receiver and line calibration values received from the SRS hardware are subjected to two tests – validity and consistency. The validity test consists of reading the validity data received to establish if the corresponding calibration data are usable. The consistency test compares successive calibration values for each RF and baseline to determine if the difference between them is within an allowable limit.

System calibration is initialized by: SRS NAV activation; Restart; 30-minute periodic recalibration; performing an initial "on-top" operation; activation of an SRS noise test or an SRS antenna test if no previous system calibration has been performed.

SRS NAV Activation One calibration set is computed at the time of SRS NAV activation, and a consistency test is performed with a prior set. If the prior calibration set is more than 30 minutes old, two calibration sets are obtained at the time of SRS NAV activation.

Restart When the operator depresses the RSTART, POWER Transfer, or DMS Initialization switch, system calibration is reinitialized. This causes two calibration sets to be computed.

Thirty-Minute Periodic Recalibration This periodic recalibration causes one calibration set to be performed. It is activated by depression of the SRS NAV keyset switch, and will remain active periodically only as long as the SRS NAV mode is active. During recalibration, measurements are interleaved with normal AME processing.

Initial On-Top Two calibration sets are obtained automatically when (a) the operational program is loaded *and* (b) the initial on-top marking is accomplished *and* (c) the bomb bay doors are closed.

SRS Noise Test and SRS Antenna Test The SRS NOISE TEST or the SRS ANT TEST keyset switch functions cause system calibration to be initialized if no previous initialization has been performed.

Lockheed
ORION
Service
Digest

SRS EQUIPMENT GENERAL DESCRIPTION

The AN/ARS-3 Sonobuoy Reference System (SRS) set, together with the AN/ASQ-114 digital computer and the operational program, constitute the airborne sonobuoy positioning system. The data communication interface between the central computer and the SRS set is via Logic Units 1 and 4. The SRS power status (on/off) is reported to the central computer through the status logic in Logic Unit 1; the main information interface between the SRS set and the central computer is through the Data Multiplexer Subunit in Logic Unit 4. The AN/ARS-3 SRS set consists of an antenna system and a receiver-converter that is powered by 3ϕ 115-VAC from Main AC Bus A.

AS-3101/ARS-3 ANTENNAS The SRS antenna system is composed of ten 13-inch blade antennas (see Figure 37) mounted on the exterior of the aircraft. Each antenna has a built-in RF filter, a calibration circuit, and a PIN-diode switch. The RF filter aids the receiver-converter in discriminating between sonobuoy RF and the set's own UHF transmissions. The calibration circuit enables the SRS to measure the phase shifts in the differential coaxial cable lengths between a pair of antennas. The PIN-diode switch connects the coaxial cable to either the antenna radiating element or to the calibration circuit.

R-1997/ARS-3 RECEIVER-CONVERTER The receiver-converter (see Figures 38 and 39) contains the circuitry to tune a selected RF channel, switch in the various antenna pairs, make phase-difference measurements, pass these measurements to the central computer, and perform self-test calibration measurements. The receiver-converter is installed on the starboard side of the aircraft, immediately forward of the ordnance station and aft of electronics rack F2 (see Figure 40). It is designed to operate with convection cooling alone.

The receiver-converter has a circuit breaker/on-off switch located on its front panel (see Figure 38). This switch must be *on* for the SRS to operate in any mode. A test control panel is also located on the front of the receiver-converter. This panel has two rotary TEST POINT SELECT switches and

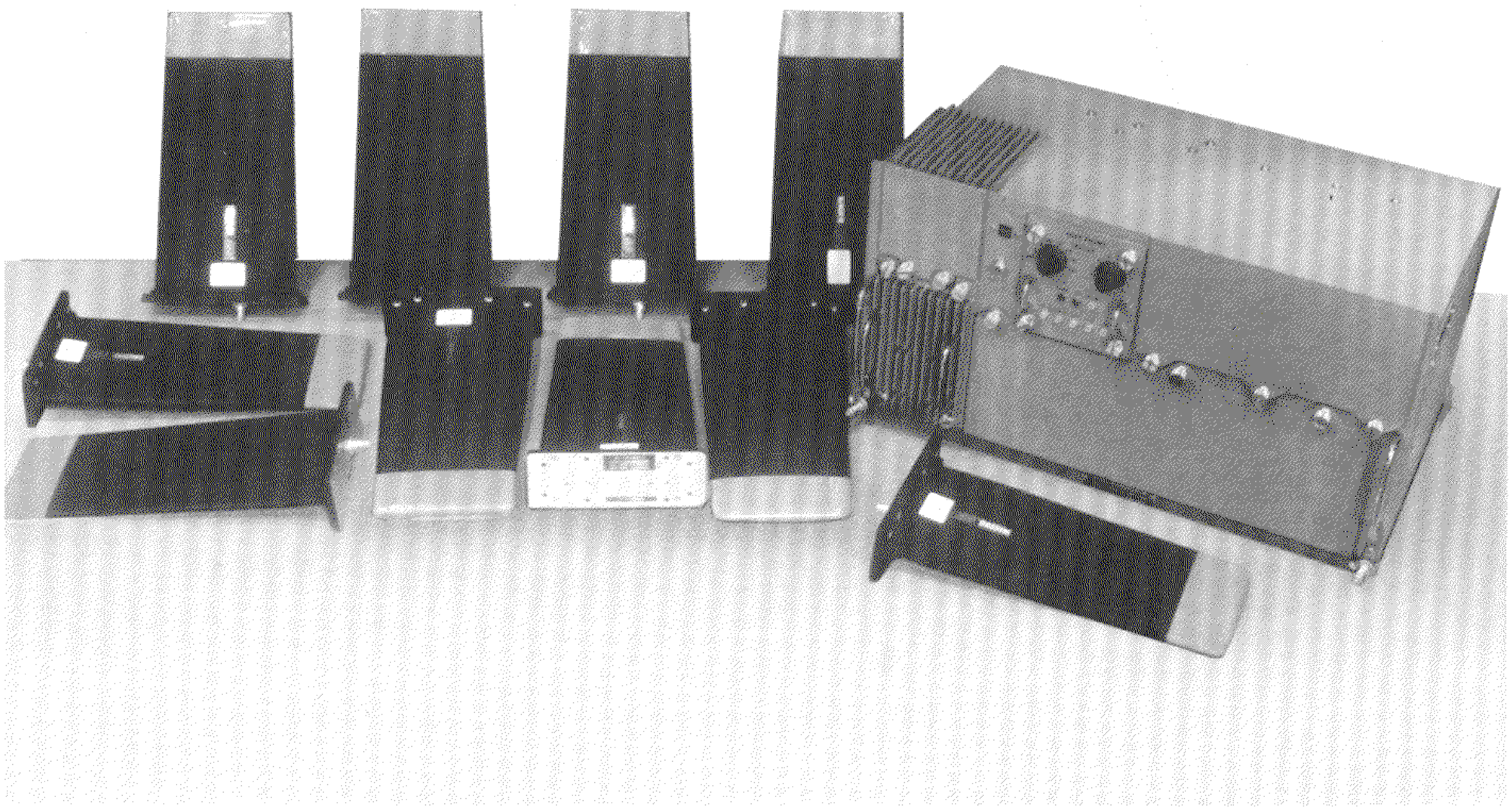
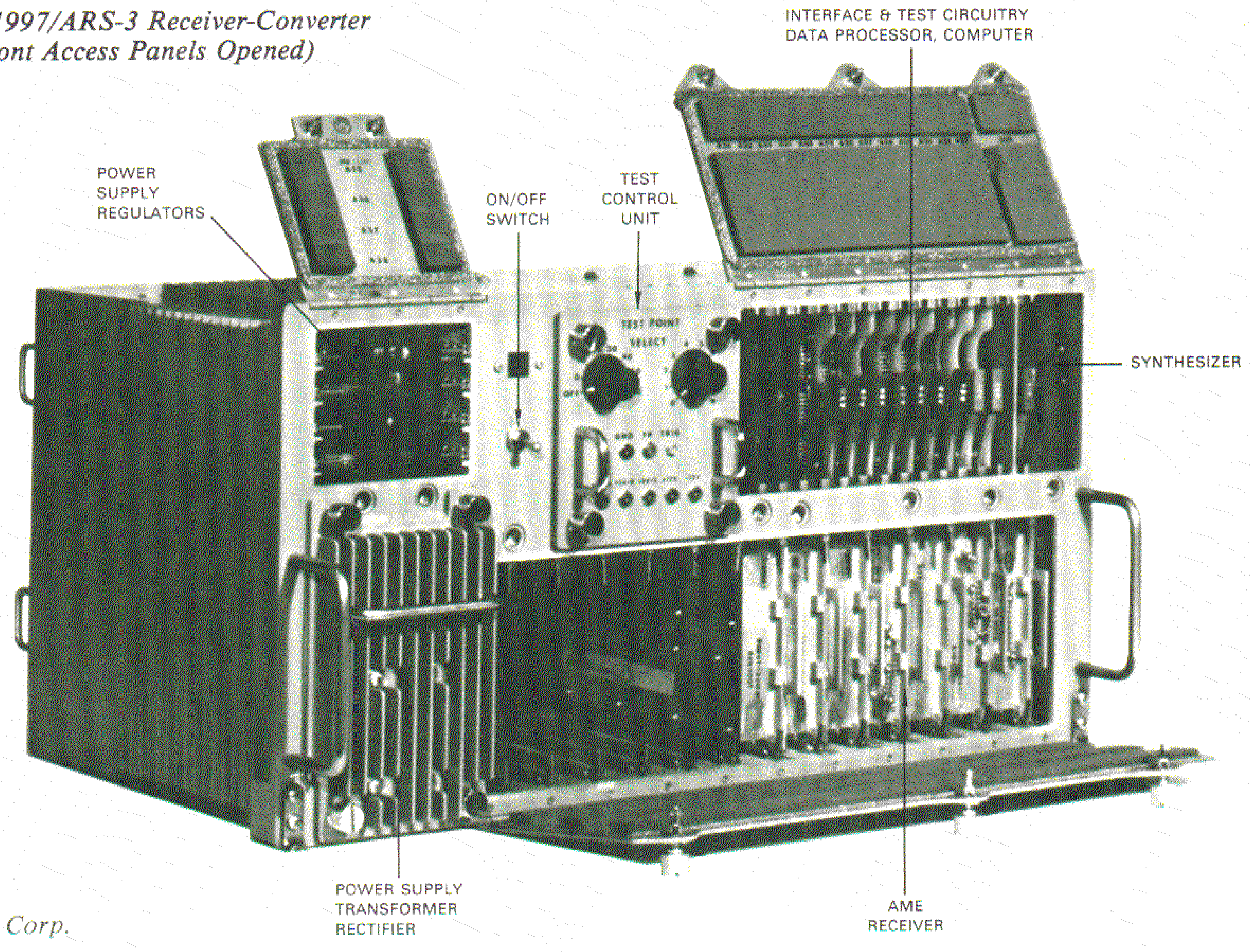


Figure 37. R-1997/ARS-3 Receiver-Converter and AS-3101/ARS-3 Antennas

Figure 38. R-1997/ARS-3 Receiver-Converter (Front Access Panels Opened)



Courtesy Cubic Corp.

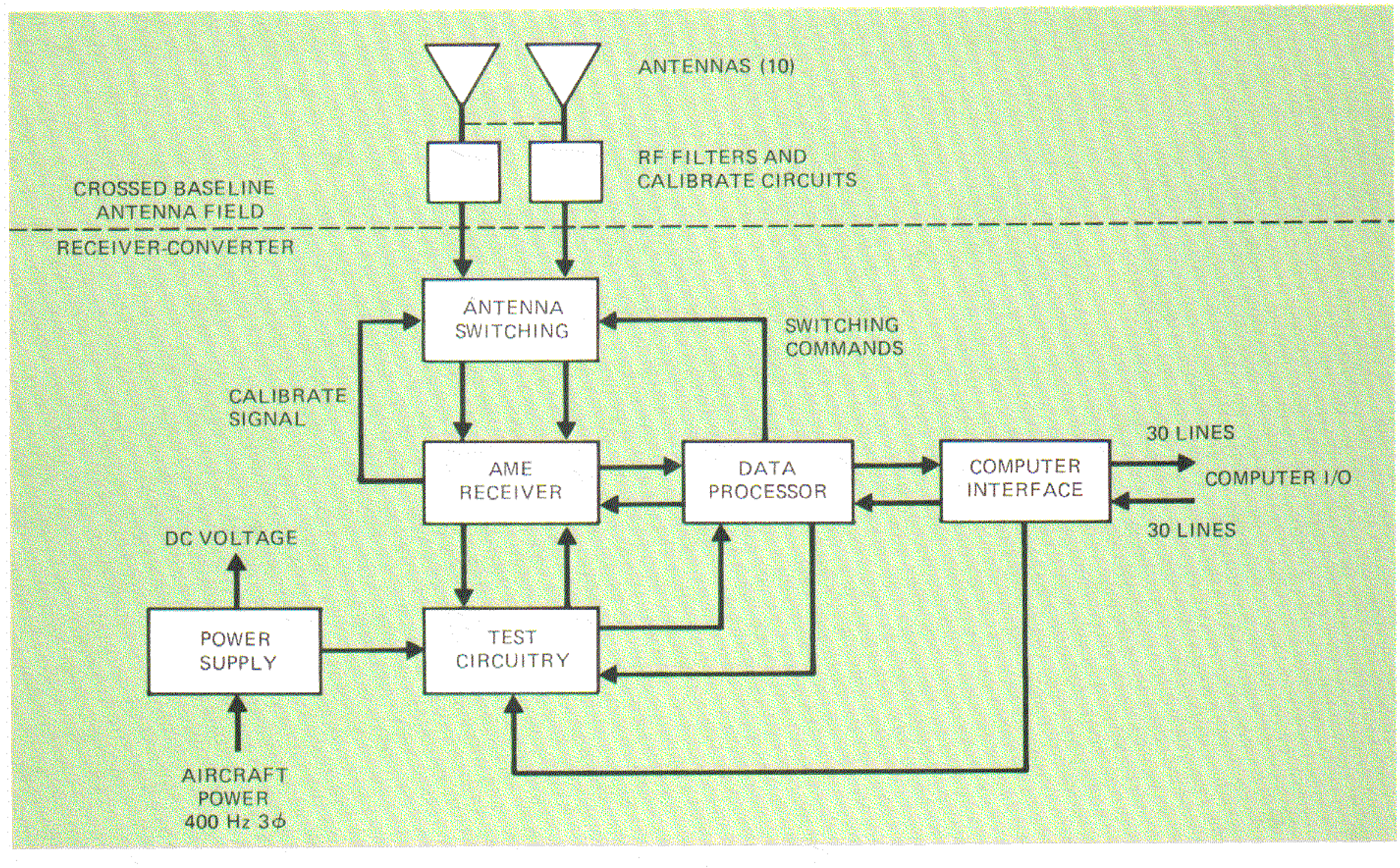


Figure 39. AN/ARS-3 Sonobuoy Reference System Set Block Diagram

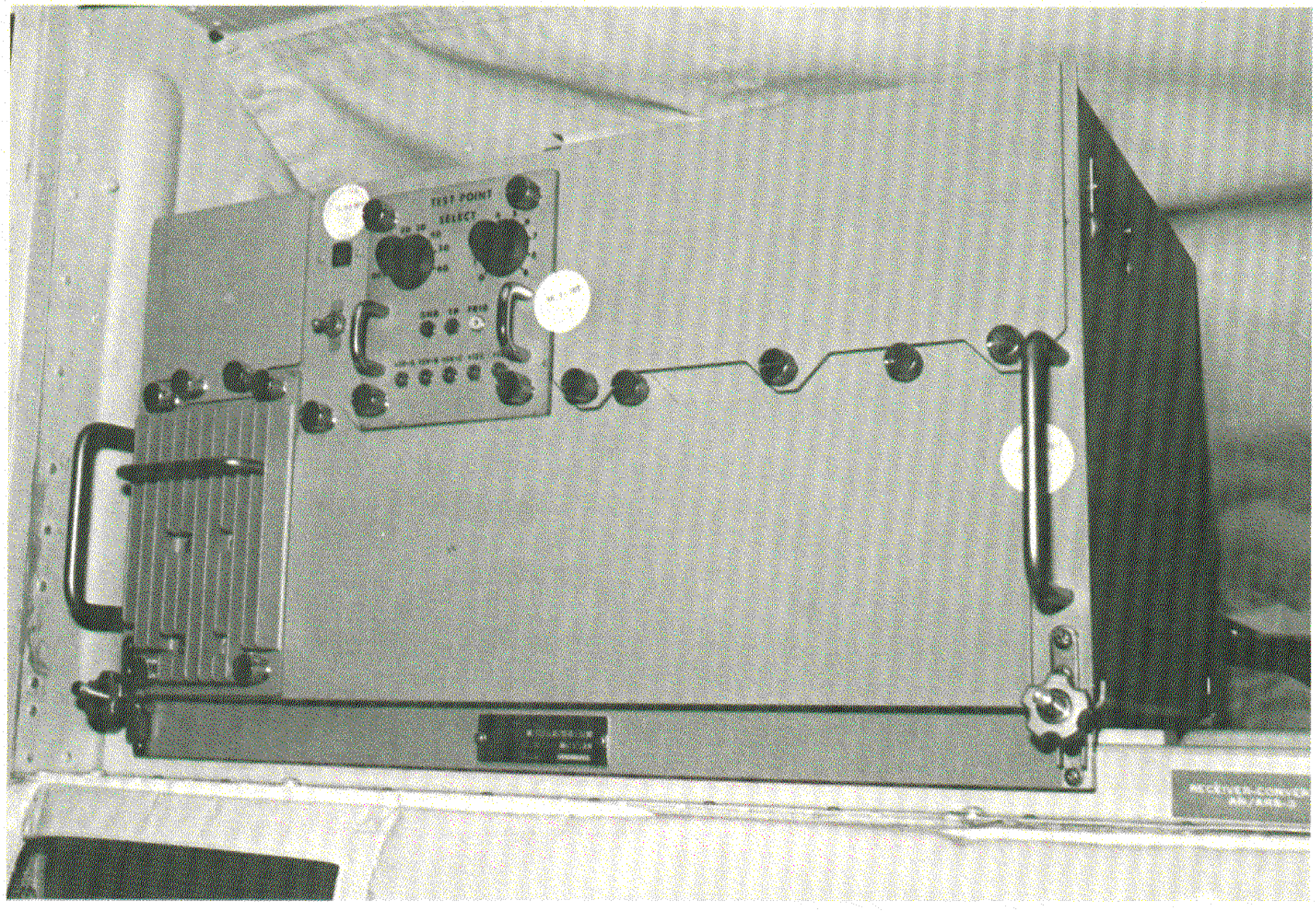


Figure 40. SRS Receiver-Converter Installation aft of Electronics Rack F2

eight test points (see Figure 41). The test control assembly enables the technician to perform off-line testing (manual testing without computer control) on the receiver-converter. Maintenance and troubleshooting for the SRS is presented in NAVAIR 01-75PAC-2-7 and in NAVAIR 01-75PAC-12.

SRS SET OPERATION The ten SRS antennas, designated "B" through "L", are located precisely on the aircraft exterior. They are used in combination to define seven antenna pairs. Chosen pairs of the antennas are used by the SRS receiver-converter as baselines for making phase-difference measurements of incoming sonobuoy RF. The phase-difference measurements are then used by the central computer to determine the direction, relative to the aircraft, from which the RF emanated. As the aircraft moves and data processing continues, the sonobuoy positions are estimated by a process similar to triangulation (see Figure 35).

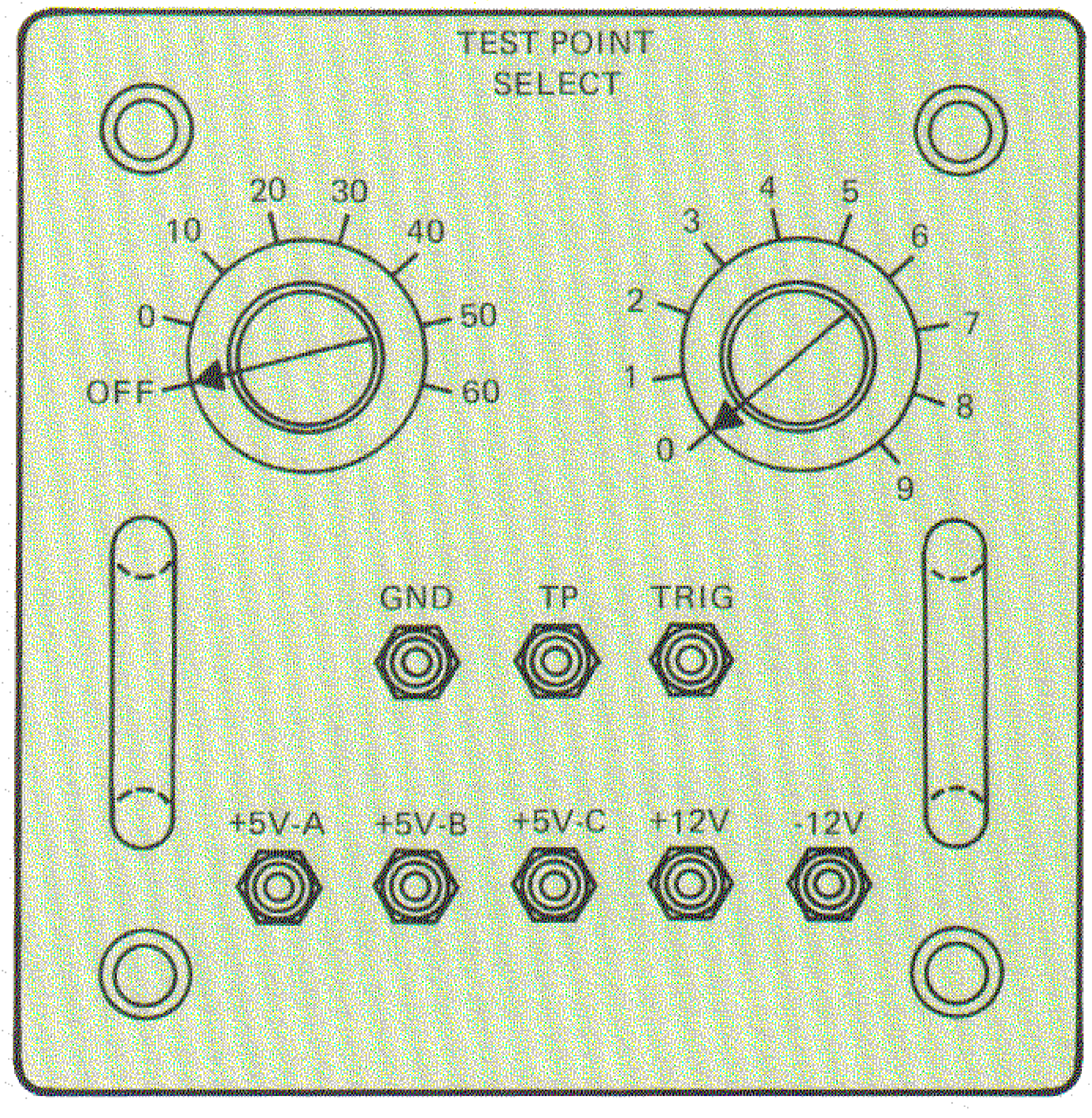


Figure 41. SRS Receiver-Converter Test Control Assembly Panel

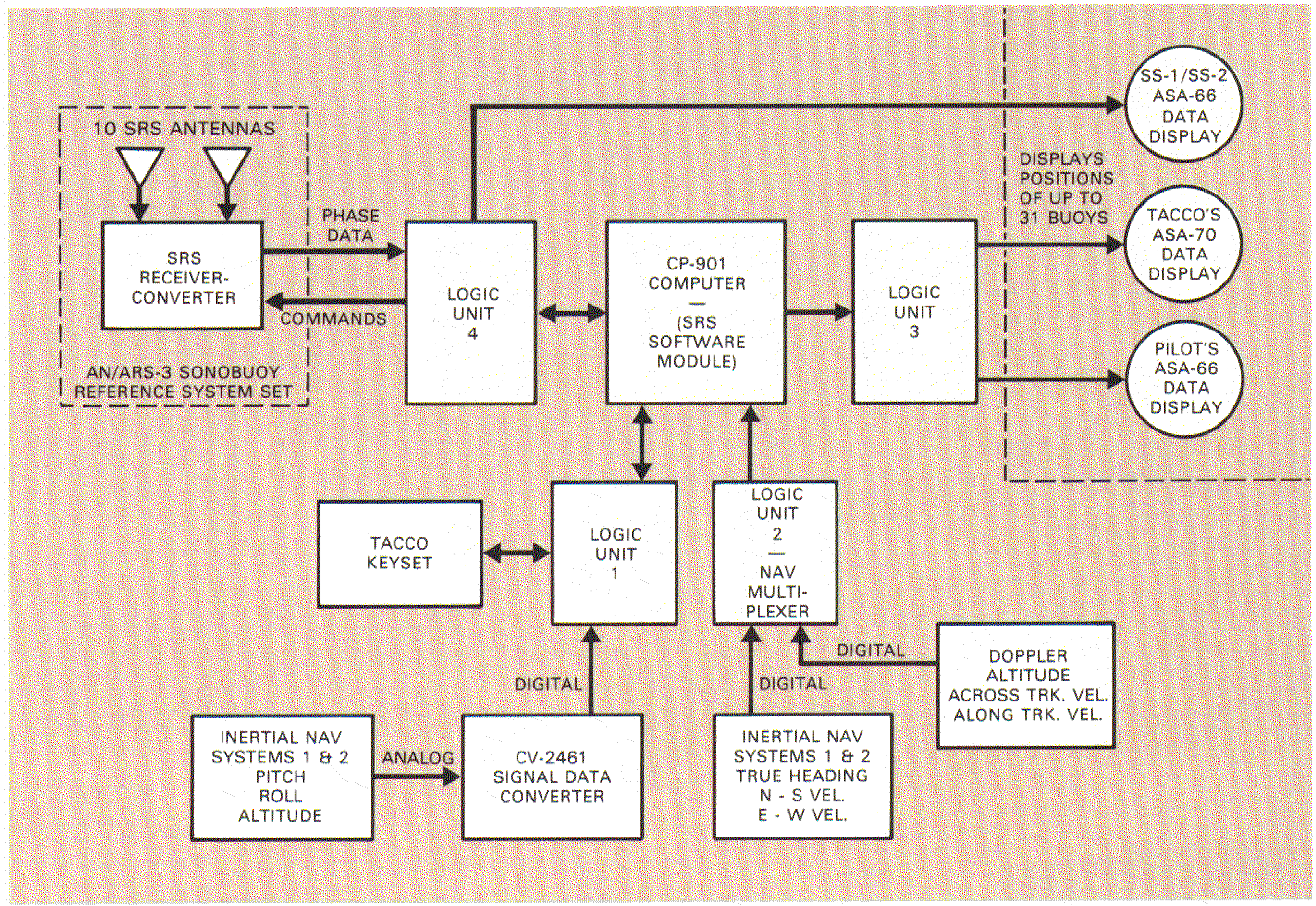
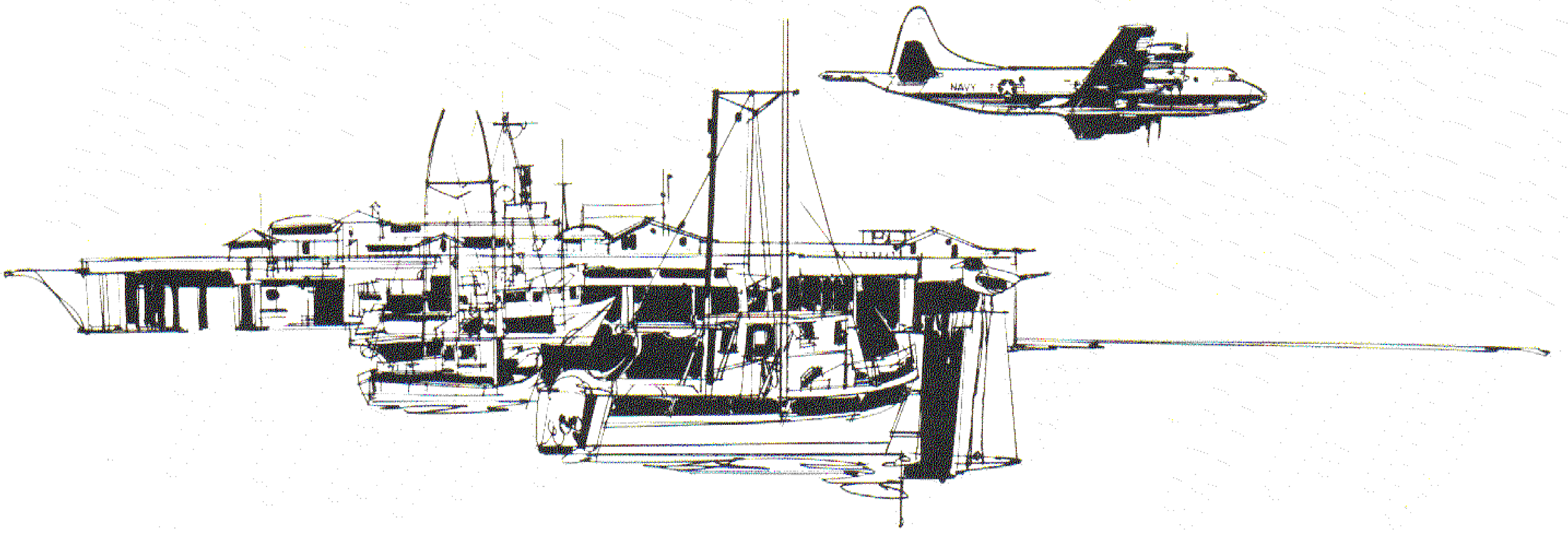


Figure 42. P-3C Update II Sonobuoy Reference System Schematic

This information is displayed in the aircraft on the ASA-66 and ASA-70 display systems, and is stored in the computer memory.

Figure 42 is a block diagram of the Sonobuoy Reference System, showing the interrelationship of its various equipments. The receiver-converter receives operating commands from the ASQ-114 digital computer, performs the functions commanded, converts the resultant information into digital format, then reports the results of that operation to the computer. Together, these equipments and their software comprise the P-3C Sonobuoy Reference System (SRS).



OPERATOR INTERFACE

The SRS processing has two basic operating modes: the Angular Measuring Equipment (AME) Mode, and the Calibrate/Self-Test Mode. These operating modes are implemented by certain SRS software functions that permit the operator to control, modify, and monitor SRS processing. The operator interface with the SRS includes the keyset functions as well as SRS-peculiar tableau displays. In addition, some operational program functions have been modified for the SRS.

KEYSET FUNCTIONS Access is gained to the SRS and the system is controlled through the SRS keyset matrix located at the TACCO station. The keyset functions allow the operator to:

- Initiate and terminate SRS processing.
- Add or delete any RF in the current SRS processing list.
- Perform noisy RF and antenna ASSG* tests.
- Perform SRS restart.

TABLEAU DISPLAYS The SRS tableaux are presented to the TACCO on the auxiliary readout (ARO) display. They allow the operator to monitor the following:

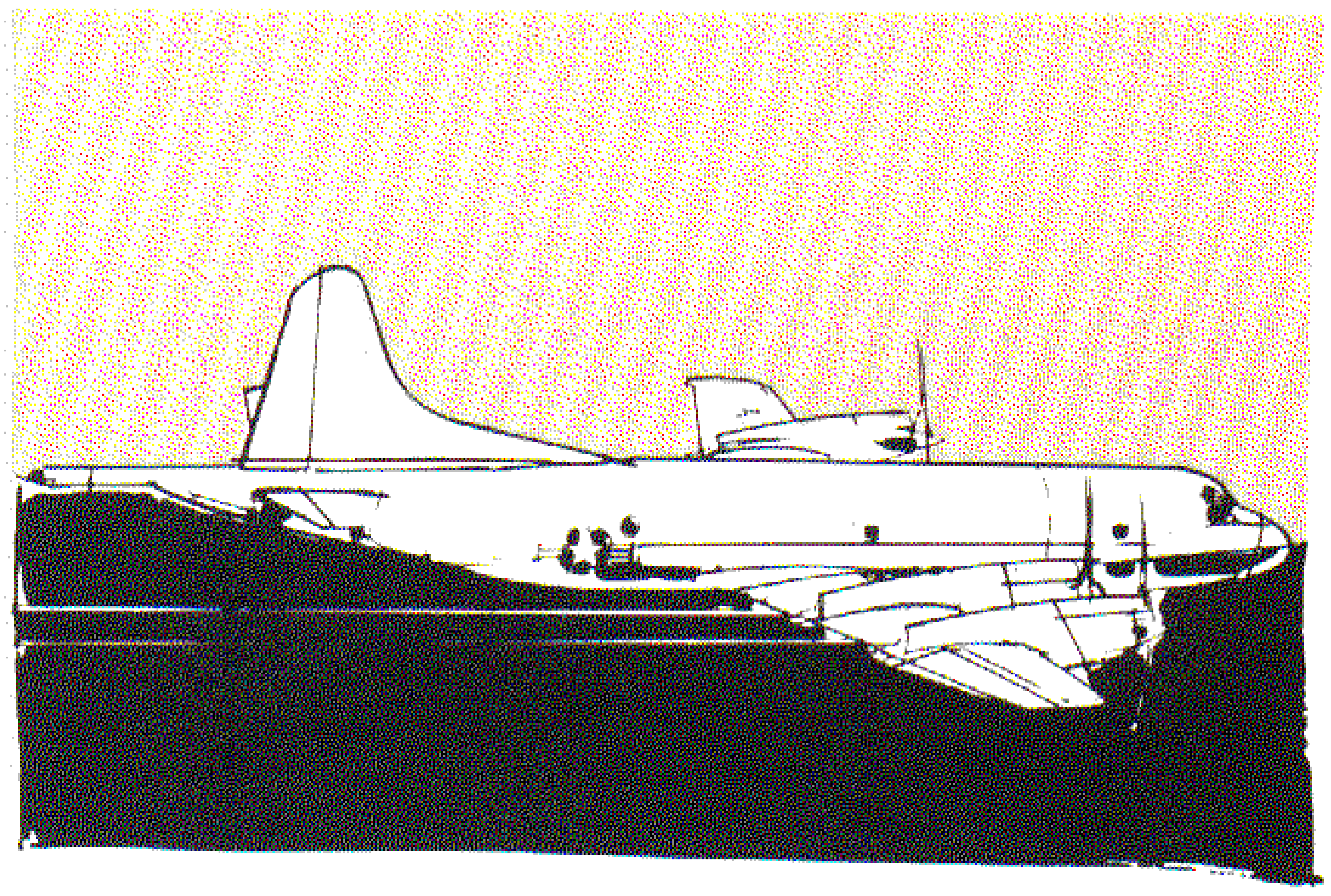
- Receiver status.
- RF status
- Calibration status
- Noisy channels for SRS
- Calibration values for each RF and each baseline.

OPERATIONAL PROGRAM FUNCTIONS MODIFIED FOR SRS Three functions of the operational program have been modified to implement the SRS subsystem into TACNAV. They are Sonobuoy Correct, Aircraft Correct, and Recover Aircraft Position.

Sonobuoy Correct If a single Sonobuoy Correct function is performed on a buoy that is being processed by the SRS, the displayed buoy location will be corrected to the new position. SRS processing for that buoy will be reinitialized, with the buoy tactical position set at the aircraft position at the time that the on-top marking was performed. An unbiased TACNAV position on the buoy is also computed using the same aircraft position.

Aircraft Correct When an Aircraft Correct function is performed while the SRS is active, SRS updates will be inhibited until the Aircraft Correct processing is completed. That is, the symbol on the display will be slewed the distance between the aircraft's tactical position at the time of a mark on top and the position of the "on-topped" buoy. The active SRS positions and accepted SRS display position will be converted to X-Y (local) coordinates, slewed this same distance, then reconverted to LAT/LONG coordinates. The update inhibit will then be removed from the SRS, and data processing will resume using these corrected aircraft and sonobuoy position values. Both the TACNAV and the system bias velocities are then set to the computed bias velocity, and the system correction factor is updated.

Recover Aircraft Position When the displayed aircraft position is corrected by use of the Recover Aircraft Position function while the TACNAV mode is in use, the unbiased TACNAV positions will be set to the new GEO NAV positions. If the Recover



Acoustic Sensor Signal Generator

Aircraft Position function is performed using a buoy as a reference point, then the computer will use the current aircraft altitude, time and position to compute a new position uncertainty value for that buoy. All positions for that buoy, including SRS, TACNAV, system display, and unbiased TACNAV, will be set equal to the stored GEO NAV position for that buoy. The initial time for velocity bias calculations is reset to zero.

If an aircraft correct function is attempted on any buoy other than the buoy used for the recover aircraft position function, or if a reference point other than a buoy position is used for the recover aircraft position function, the alert BUOY CORRECT AVAIL will be displayed. In other words, following performance of a recover aircraft position function, a displayed buoy position must first be "buoy corrected" before that position can be used for plot stabilization. This procedure is designed to prevent errors in bias velocity computations.

Finally, whenever a Recover Aircraft Position function is performed, operation in the SRS NAV mode is terminated automatically. SRS NAV must be reinitialized to resume SRS AME processing.

Lockheed
ORION
Service
Digest

SRS SOFTWARE FUNCTIONS

The primary means of communicating with the central computer are the keyset and the auxiliary readout display. The keyset contains matrix select switches, matrix switches, function switches, etc. The ARO displays parts of the computer memory in the form of page data. These pages are called tableaux. This section gives detailed descriptions of several important SRS keyset functions and SRS tableaux. These descriptions of SRS keyset functions are based upon P-3C Operational Program I 4.3, and are intended to help show the reader how the SRS operates. Since this operational program is subject to modification, so too are the switch functions and their cues and alerts. *The reader should consider the information presented in this section in this light, and refer to the appropriate P-3C System Operators Manual (SOM) in series NAVAIR 01-75PAC-11-2 as the official authority on this subject.*

SRS KEYSET FUNCTIONS The following paragraphs present a detailed description of these SRS keyset functions: SRS Matrix, SRS NAV Switch, Buoy Delete Switch, Restart (RSTART) Switch, Buoy Select Switch, SRS Noise Test Switch, and the SRS Antenna (ANT) Test Switch (see Figure 36.) With the exception of the SRS Matrix select switch, all of these switches are annotated as alternate action or momentary. Alternate action switches are activated (and illuminated) when the switch is depressed to initiate an action. Action is terminated by redepressing the switch, which extinguishes the switch indicator light. Momentary switches direct performance of a single discrete function or sequence of discrete functions. The switch will be illuminated when the function contains cues. An illuminated momentary switch is extinguished when the function is completed. Redepression of a momentary switch while the function is active terminates the function.

SRS Matrix The SRS Matrix switch at the TACCO keyset tray provides the operator access to individual software functions for on-line SRS control. These functions are available only when the following conditions are met:

- The aircraft must maintain the SRS hardware configuration, and the SRS status in the System Status tableau must be up. Otherwise, the type 1 alert SRS UNAVAILABLE is displayed.
- The SRS Matrix select switch must be activated.

SRS NAV Switch (Alternate Action) The SRS NAV switch enables SRS AME processing for locating sonobuoy positions. In addition, activation of this switch automatically activates the TACNAV mode if it is not already active, and initiates performance of an SRS calibration set. Two calibration sets are performed if no previous set was computed, or if

30 minutes have elapsed since the last calibration. The initial calibration can be observed in the SRS Calibration Tableau by watching the ones (1's) being cleared from the antenna array columns as each RF goes through calibration. Thereafter, the only indication of a successful calibration is an update of the time and the number of CAL SETS at the bottom of the second page of the SRS Calibration Tableau.

Depression of the SRS NAV switch while illuminated will produce the cue:

SELECT NAV MODE

D1 GEO

D2 TAC NAV

The TACCO can select whether he wishes to remain in the TACNAV mode without the SRS available, or switch to the GEO NAV mode of operation. Either response to SELECT NAV MODE within 45 seconds of switch depression will terminate the SRS NAV function. If SRS NAV operation is terminated for any other reason, the system will remain in the TACNAV mode.

This SRS NAV function cannot be initiated if:

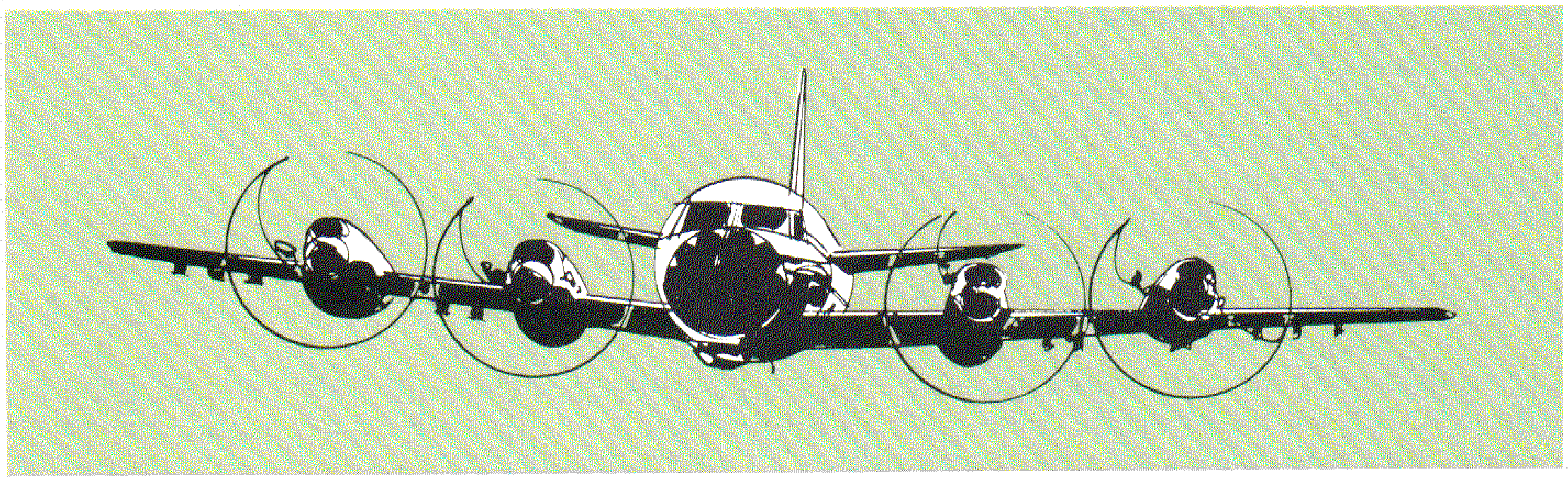
- SRS hardware is turned *off*.
- Restart is in progress.
- RECOVER A/C POSIT function is active.

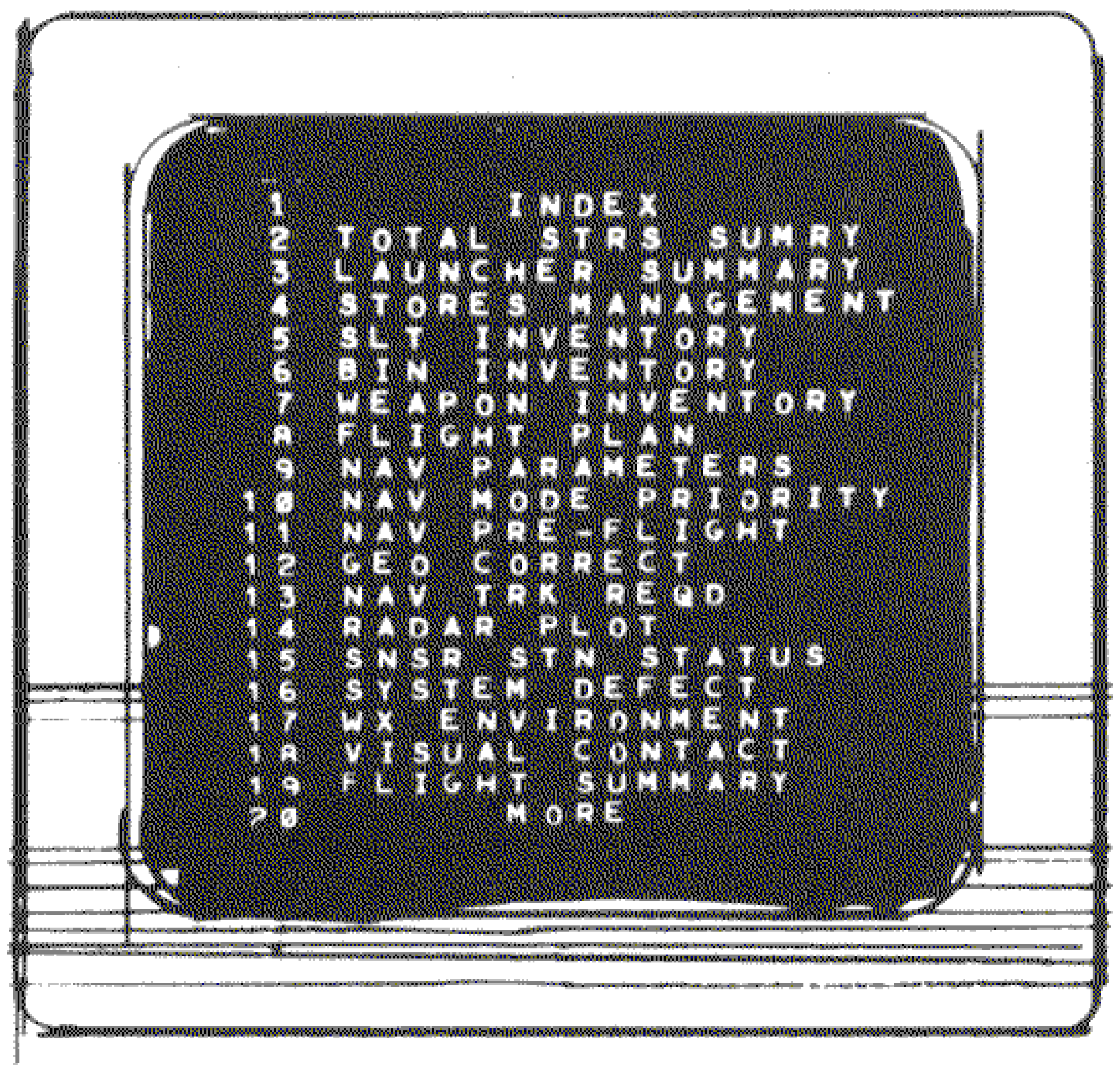
The following alerts are associated with the SRS NAV switch function and are presented on the top edge of the tactical display:

- SRS UNAVAILABLE
- SRS RESTART IN PROG
- RECOVR AC POS ACTIVE
- SRS HDWR OFF
- SRS FAIL

Operation of the SRS NAV function is terminated by any of the following:

- Depression of the SRS NAV switch when the function is illuminated active, and when responding to the SELECT NAV MODE cue within 45 seconds of switch depression
- Deactiviation of TACNAV
- SRS failure (SRS FAIL alert displayed)
- Initialization of Data Multiplexing System (DMS; Logic Unit 4)
- Pilot performs MOT when the RECOVER A/C POSIT function is active
- Performing a RECOVER DRUM data recovery operation.





```
 1        INDEX
 2  TOTAL STRS SUMRY
 3  LAUNCHER SUMMARY
 4  STORES MANAGEMENT
 5  SLT INVENTORY
 6  BIN INVENTORY
 7  WEAPON INVENTORY
 8  FLIGHT PLAN
 9  NAV PARAMETERS
10  NAV MODE PRIORITY
11  NAV PRE-FLIGHT
12  GEO CORRECT
13  NAV TRK REQD
14  RADAR PLOT
15  SNSR STN STATUS
16  SYSTEM DEFECT
17  WX ENVIRONMENT
18  VISUAL CONTACT
19  FLIGHT SUMMARY
20        MORE
```

- Performing a RECOVER TAPE data recovery operation.
- Turning the SRS hardware *off*.

Buoy Delete Switch (Alternate Action) The Buoy Delete function allows the operator to delete individual RF's from the SRS processing list. The primary reason for this function is to de-select buoys that are no longer important to the tactical problem. This increases the processing iterations on the remaining buoys, which should improve the accuracy of their position estimates.

This function is activated by depressing the BUOY DELETE switch, which causes the cue DELETE RF XX to be presented at the bottom of the tactical display. The TACCO may then select the RF's that he no longer wishes the SRS to process. The cue will remain displayed until the BUOY DELETE switch is redepressed, or until the Buoy Delete function is terminated. When RF's are deleted from the SRS, the deleted RF's are marked NSEL (not selected) in the Buoy Status Tableau, and are marked with an "S" (SRS defective) in the status line of the STORES MANAGEMENT Tableau. The RF's of buoys that are not yet deployed may be deleted, but the TACCO will receive the alert RF XX NOT IN WATER.

For the Buoy Delete function to become active, the SRS must be available (conditions must be met for enabling the SRS Matrix Select switch). If active, the Buoy Delete function terminates any other function using the cueing area of the display. Redepression of the BUOY DELETE, CANCEL or any other function switch that uses the cueing area will terminate the Buoy Delete function. If any function other than Buoy Delete terminates the function, no RF's will be deleted.

The following alerts are associated with the Buoy Delete function:

- SRS UNAVAILABLE
- RF XX NOT IN WATER
- OUT OF LIMIT 1 - 31

RSTART Switch (Momentary) Depression of the RSTART switch reinitializes SRS processing for all RF's in the SRS processing list at the current TACNAV position, and at the initial uncertainty values. All previous calibration data are destroyed, and two calibration sets are performed. Operator use of the Restart function should be limited to those times when a complete reinitialization of the SRS is desired. The operational program automatically performs a restart under the following conditions:

- Performing a RECOVER DRUM data recovery operation.
- Performing a RECOVER TAPE data recovery operation.
- DMS Initialization.
- When the SRS hardware is turned *on*.
- Drum Reload with Recovery selected.

Operation of the RSTART switch requires that the SRS is available. If the SRS is active, depressing the RSTART switch terminates the following functions:

- SRS ANT TEST
- NOISE TEST

Depression of the RSTART switch while it is illuminated is ignored by the system, and the alert SRS RSTART IN PROG is displayed.

The alerts associated with the RSTART function are:

- SRS UNAVAILABLE
- SRS RESTART IN PROG
- SRS FAIL

The SRS restart switch stays illuminated and the function is active for 25 seconds to ensure complete initialization of SRS hardware. Subsequently, the restart function is terminated automatically.

BUOY SELECT Switch (Alternate Action) The Buoy Select function allows the operator to process RF's that were previously de-selected with the Buoy Delete function. Depression of the BUOY SELECT switch displays the cue:

RESELECT

RF XX

D1 ALL.

The TACCO may then select specific RF's for SRS processing by using the ASA-70 keyboard to type in the channel desired. The cue will remain displayed until the BUOY SELECT switch is redepressed or until the function is terminated. Selection of D1 ALL reselects all previously deleted RF's. The TACCO may select RF's of buoys not in the water for processing, but when this is done the alert RF XX NOT IN WATER will be displayed. If the TACCO duplicates an RF selection, the alert RF XX DUPLICATE will be displayed. An RF is assumed duplicated if there are two buoys with RF's of the same channel in the water simultaneously. The SRS must be available for this function to operate.

The alerts associated with the Buoy Select function are:

- SRS UNAVAILABLE
- RF XX NOT IN WATER
- OUT OF LIMIT 1 – 31
- RF XX DUPLICATE

Redepression of BUOY SELECT, CANCEL or any other function switch that uses the cueing area will terminate the buoy select function. If any method other than redepressing the BUOY SELECT switch is used to terminate this function, no deleted RF's will be added to SRS processing.

SRS NOISE TEST Switch (Momentary) Depression of the SRS NOISE TEST switch initiates a check of all sonobuoy frequencies for RF interference. This noise test must be performed prior to performing an SRS Antenna Test so that a clear RF channel can be selected for the antenna test. The SRS Noise Test should also be performed when the aircraft arrives on station. This check, which is more sensitive than the LOD (Light-Off Detector) check, will automatically update the SRS NOISY RF Tableau and the STORES MANAGEMENT

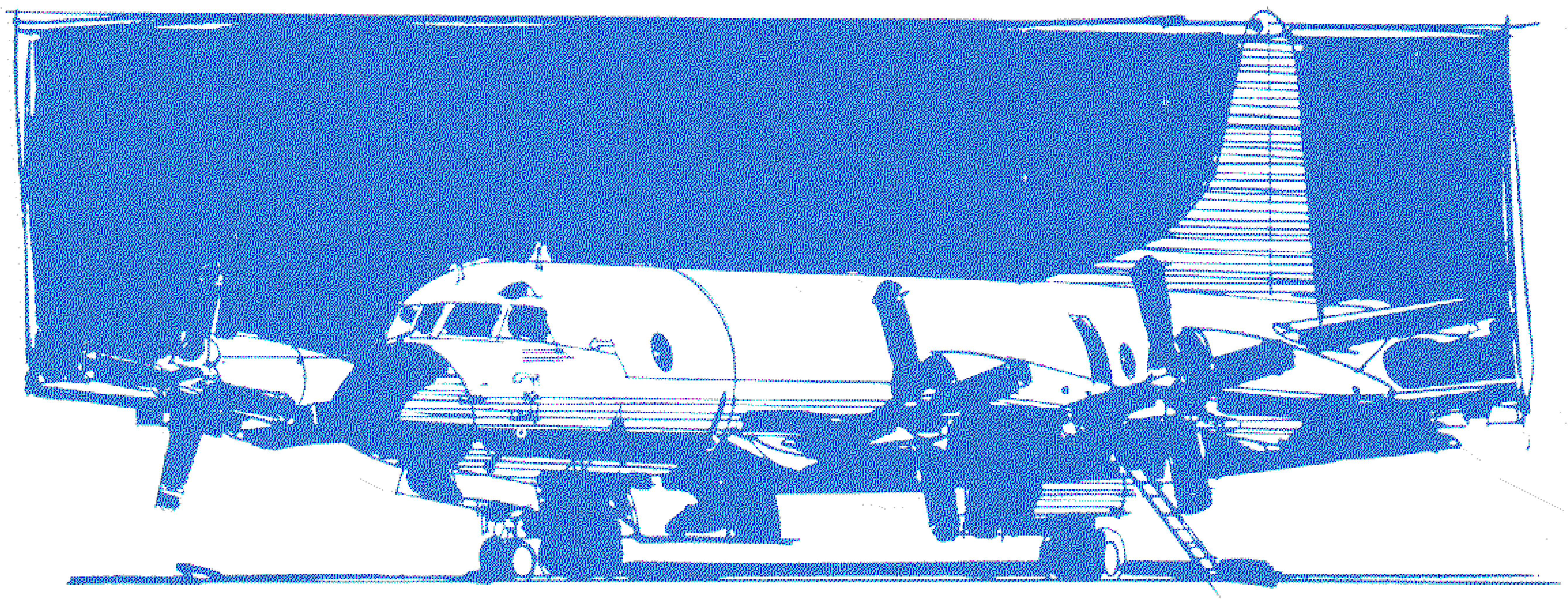


Tableau. If an RF is determined to be noisy, the computer will not select that RF automatically for patterns or for individual buoy selections. The TACCO may select a noisy RF with the SONO SELECT function switch or through conflict cueing sequences.

Depression of the SRS NOISE TEST switch displays the alert TURN ASSG OFF. This alert reminds the operator that the ASSG transmitter must be turned *off* to successfully perform the SRS noise test. It also will initialize calibration if calibration has not been initialized previously. While the SRS NAV mode is active, the SRS Noise Test is performed 15 minutes after a calibration. The SRS Noise Test is a 30-minute periodic function.

The following conditions must be met for the SRS Noise Test function to be operable:

- SRS must be available.
- SRS hardware must be *on*.

The SRS Noise Test cannot be performed if either a restart or an SRS Antenna Test is in progress. The alerts associated with an SRS Noise Test are:

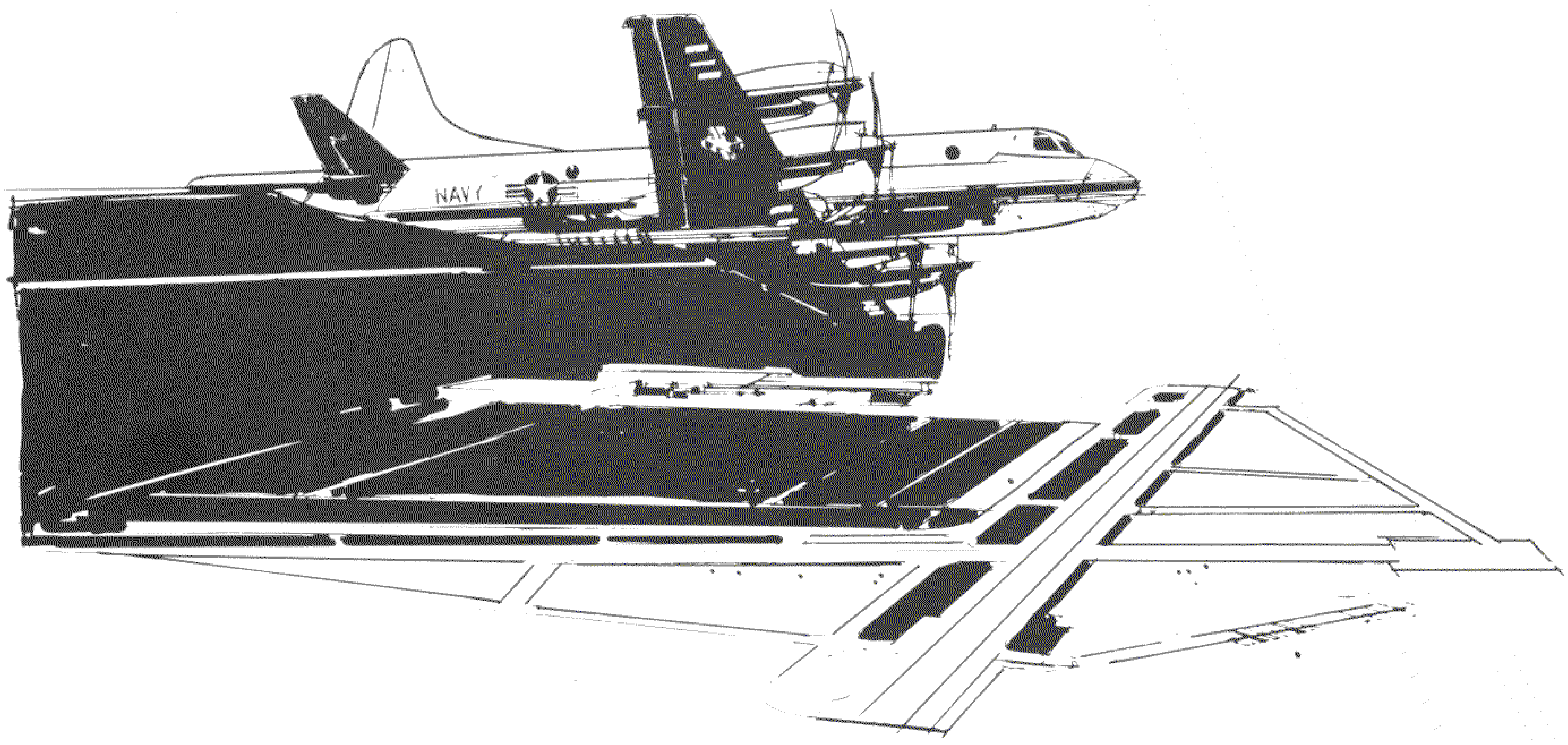
- SRS UNAVAILABLE
- SRS RESTART IN PROG
- ANTENNA TEST ACTIVE
- SRS HDWR OFF
- TURN ASSG OFF

An SRS Noise Test function is terminated upon completion of the test, or if the SRS NAV function is de-selected.

SRS ANT TEST Switch – Matrix Readout Switch (Alternate) The primary purpose of the SRS Antenna Test is to determine whether the SRS antennas are able to receive RF signals. This test must be performed in-flight, and should be performed immediately following an SRS Noise Test. If an SRS Noise Test has not been performed within the past five minutes, depression of the SRS ANT TEST switch will be ignored and the alert PERFORM SRS NOISE TS will be displayed. SRS ANT TEST switch depression will also be ignored if the SRS NAV, RESTART, or SRS NOISE TEST functions are active, and the appropriate alert will be displayed.

During normal operation, the following cue is displayed when the SRS ANT TEST switch is depressed:

SRS ANTENNA TEST
SELECT CLEAR RF
XX



The TACCO must select a clear RF in response to this cue. If a noisy RF is selected, the alert RF XX NOISY will be displayed. A list of noisy RF's is displayed in the SRS NOISY RF Tableau. If an RF is selected and the receiver is malfunctioning, the alert SRS RCVR RF XX DOWN will be displayed. In both cases, the cue remains on display until the TACCO enters a clear RF. To perform this test, the ASSG transmitter must be turned on, selected to high, and tuned to the same channel selected by the TACCO. The alert TUNE ASSG TO RF XX is displayed as long as the test remains active to remind the TACCO to coordinate the tuning of the ASSG with the selected RF.

The antenna test also may be used to provide a limited check on the operability of SRS antenna sets whose baselines have computed angles that are close to 90 degrees (baselines CE, DG, HL, and GJ). If the operator notes in the SRS NOISY RF Tableau that the angles displayed for any of these baselines are (a) more than 100 degrees, (b) less than 80 degrees, or (c) vary more than 5 degrees in successive displayed values, he can conclude that the baseline antenna set is not functioning properly. It must be stressed that this is a gross test, and there is no guarantee of the operability of those baseline antenna sets that pass it.

The following prerequisites must be satisfied before an SRS Antenna Test can be performed:

- SRS must be available.
- SRS hardware must be *on*.
- An SRS Noise Test must have been performed within five mintues of antenna test selection.
- ASSG must be *on* and selected to the chosen RF.

The alerts associated with an SRS Antenna Test are:

- SRS HDWR OFF
- SRS NAV ACTIVE
- SRS UNAVAILABLE
- SRS RESTART IN PROG
- SRS NOISE TST IN PRG
- PERFORM SRS NOISE TS
- SRS FAIL
- OUT OF LIMIT 1 - 31
- RF XX NOISY
- SRS RCVR RF XX DOWN

An SRS Antenna Test cannot be initiated if:

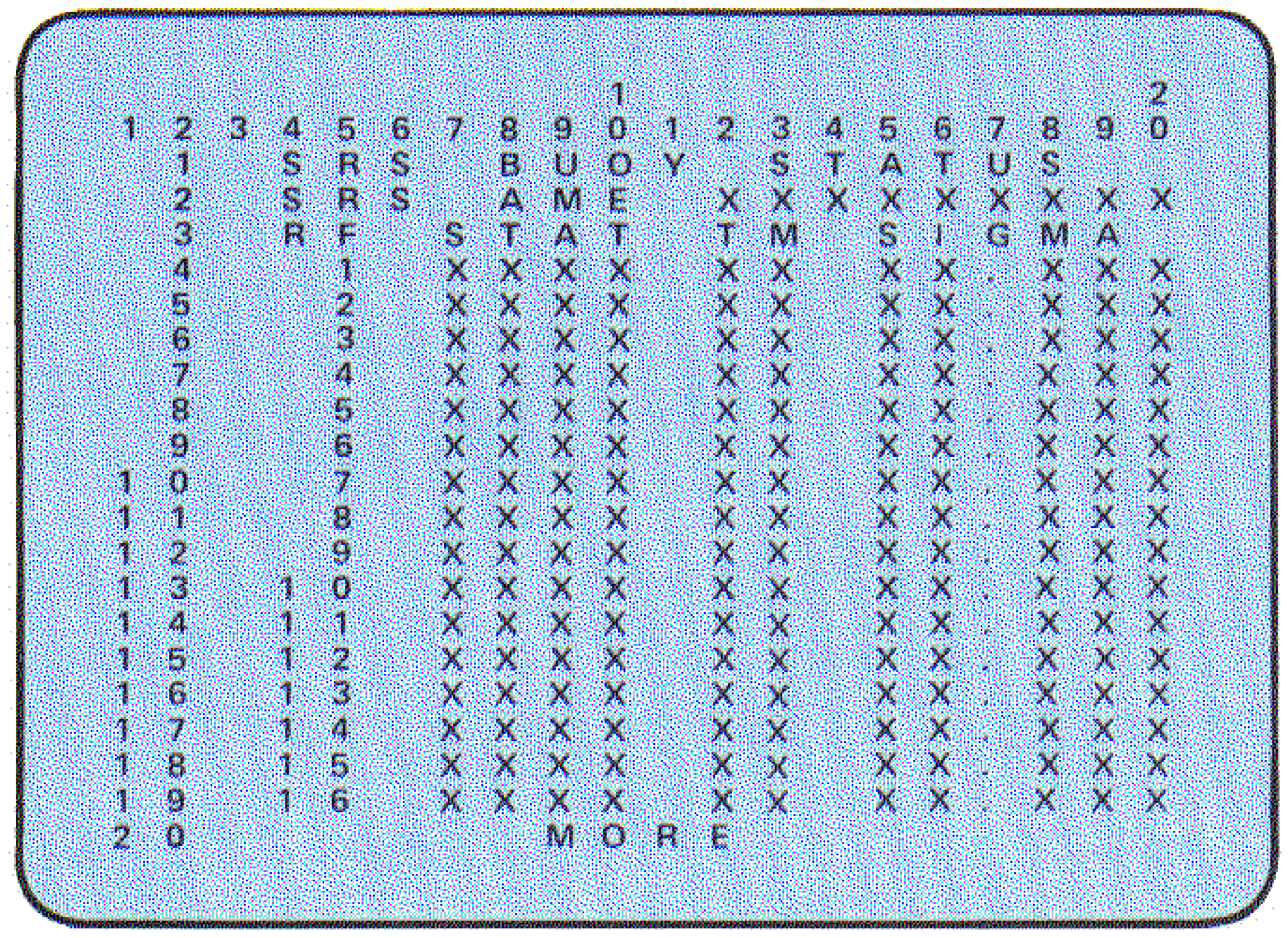
- Restart is in progress.
- SRS NAV is active.
- SRS NOISE TEST is in progress.
- No noise test has been performed within five mintues.

The SRS Antenna Test function is terminated when any of the following occur:

- Depressing the SRS ANT TEST switch when the function is active.
- Selection of SRS NAV.
- Selection of Restart.

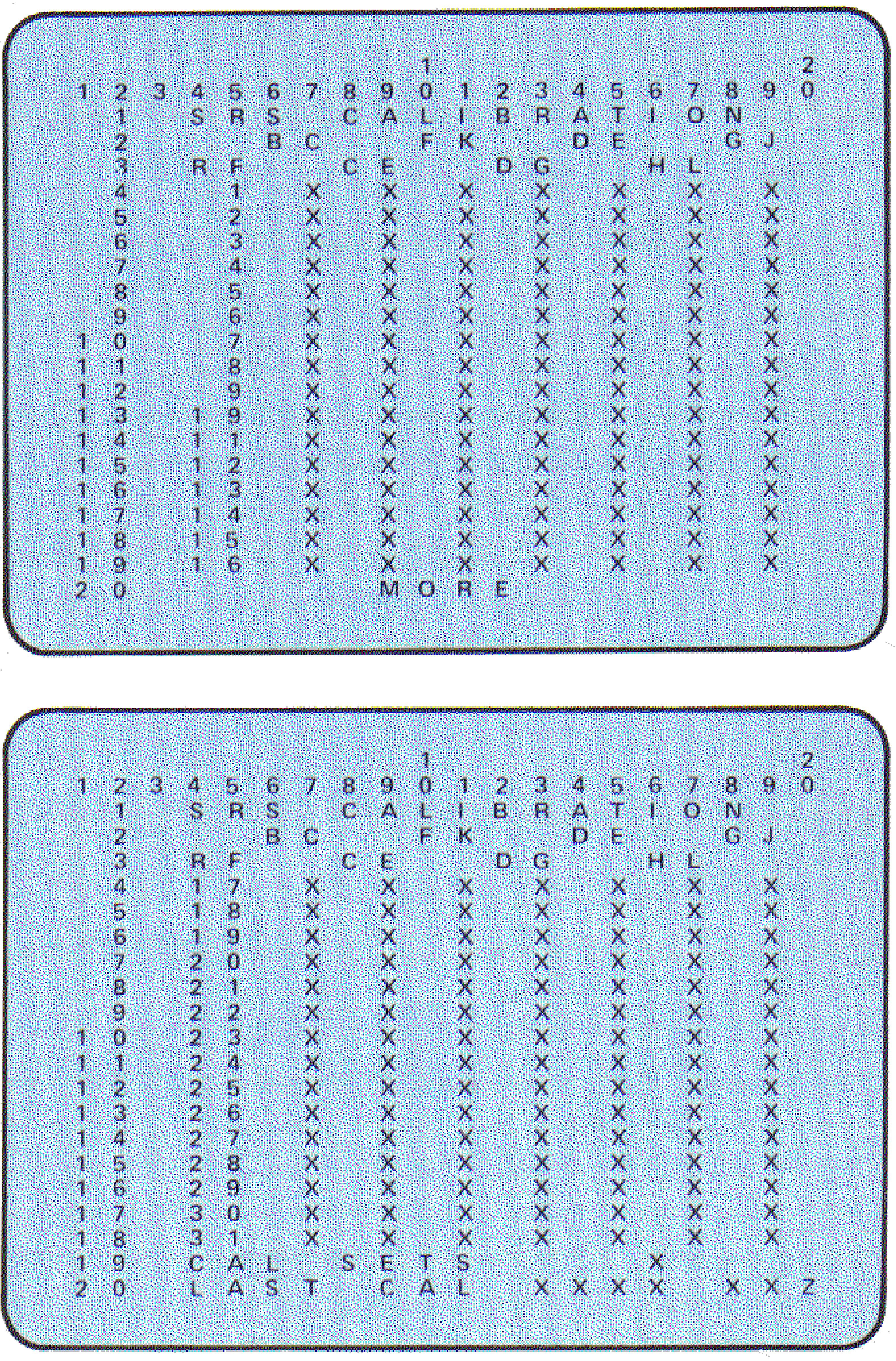
SRS TABLEAU DATA SRS processing and status data are displayed to the operator on six tableaux:

- SRS BUOY STATUS
- SRS CALIBRATION
- SRS NOISY RF
- SRS IFPM DATA
- SYSTEM STATUS
- STORES MANAGEMENT



```
                  1                   2
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
  1   S R S   B U O Y   S T A T U S
  2   S R S   A M E   X X X X X X X X X
  3   R F   S T A T   T M   S I G M A
  4     1   X X X X   X X   X X . X X X
  5     2   X X X X   X X   X X . X X X
  6     3   X X X X   X X   X X . X X X
  7     4   X X X X   X X   X X . X X X
  8     5   X X X X   X X   X X . X X X
  9     6   X X X X   X X   X X . X X X
1 0     7   X X X X   X X   X X . X X X
1 1     8   X X X X   X X   X X . X X X
1 2     9   X X X X   X X   X X . X X X
1 3   1 0   X X X X   X X   X X . X X X
1 4   1 1   X X X X   X X   X X . X X X
1 5   1 2   X X X X   X X   X X . X X X
1 6   1 3   X X X X   X X   X X . X X X
1 7   1 4   X X X X   X X   X X . X X X
1 8   1 5   X X X X   X X   X X . X X X
1 9   1 6   X X X X   X X   X X . X X X
2 0             M O R E
```

Figure 43. SRS BUOY STATUS Tableau (Page 1 Shown)



```
                  1                   2
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
  1   S R S   C A L I B R A T I O N
  2       B C     F K     D E     G J
  3   R F     C E     D G     H L
  4     1   X   X   X   X   X   X   X
  5     2   X   X   X   X   X   X   X
  6     3   X   X   X   X   X   X   X
  7     4   X   X   X   X   X   X   X
  8     5   X   X   X   X   X   X   X
  9     6   X   X   X   X   X   X   X
1 0     7   X   X   X   X   X   X   X
1 1     8   X   X   X   X   X   X   X
1 2     9   X   X   X   X   X   X   X
1 3   1 9   X   X   X   X   X   X   X
1 4   1 1   X   X   X   X   X   X   X
1 5   1 2   X   X   X   X   X   X   X
1 6   1 3   X   X   X   X   X   X   X
1 7   1 4   X   X   X   X   X   X   X
1 8   1 5   X   X   X   X   X   X   X
1 9   1 6   X   X   X   X   X   X   X
2 0             M O R E
```

```
                  1                   2
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
  1   S R S   C A L I B R A T I O N
  2       B C     F K     D E     G J
  3   R F     C E     D G     H L
  4   1 7   X   X   X   X   X   X   X
  5   1 8   X   X   X   X   X   X   X
  6   1 9   X   X   X   X   X   X   X
  7   2 0   X   X   X   X   X   X   X
  8   2 1   X   X   X   X   X   X   X
  9   2 2   X   X   X   X   X   X   X
1 0   2 3   X   X   X   X   X   X   X
1 1   2 4   X   X   X   X   X   X   X
1 2   2 5   X   X   X   X   X   X   X
1 3   2 6   X   X   X   X   X   X   X
1 4   2 7   X   X   X   X   X   X   X
1 5   2 8   X   X   X   X   X   X   X
1 6   2 9   X   X   X   X   X   X   X
1 7   3 0   X   X   X   X   X   X   X
1 8   3 1   X   X   X   X   X   X   X
1 9   C A L   S E T S         X
2 0   L A S T   C A L   X X X X   X X Z
```

Figure 44. SRS CALIBRATION Tableau (Pages 1 and 2 Shown)

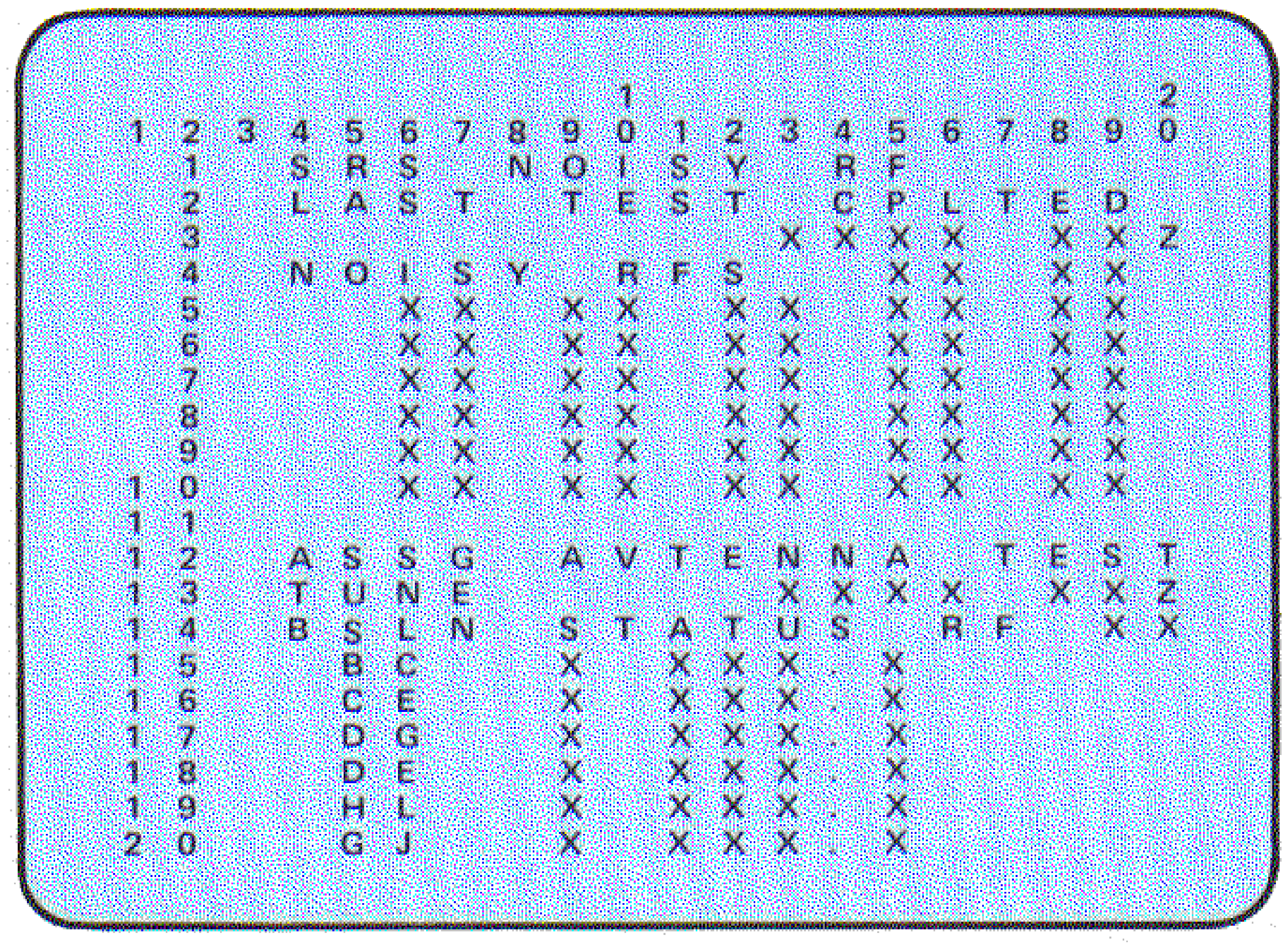
SRS BUOY STATUS Tableau This tableau displays the SRS status for the 31 RF channels, based upon receiver validity for each RF (Figure 43). It indicates hardware status (go/no-go) based upon passive BITE data, and displays the time in minutes since the last accepted SRS position update. A circular area-of-probability of the sonobuoy position (SIGMA) is also displayed. The operational program updates the data presented on the SRS BUOY STATUS Tableau every thirty seconds.

SRS CALIBRATION Tableau This tableau displays the calibration status for each RF/baseline combination, and displays the number of calibration sets that have been performed once since system start or the last restart (see Figure 44). The time of the last calibration set is also displayed. A "+" is displayed for calibration data if calibration has not been initialized; after initialization, a blank or a "1" is displayed. The tableau is updated only after a complete calibration, and only by the operational program.

When a "1" is displayed on the calibration tableau, it indicates that the calibration value for a particular RF and baseline is invalid. Invalid RF calibration data will also be indicated in the STORES MANAGEMENT Tableau and the SRS BUOY STATUS Tableau. The operational program will not automatically select a buoy with an invalid RF as long as SRS is set available in the SYSTEM STATUS Tableau. If a buoy with an RF that failed SRS calibration is launched, its signals will not be processed by the SRS as long as its RF continues to fail calibration. The effects of a failed baseline depend upon the particular baseline that has failed. Failure of a long baseline may affect the accuracy of buoy positioning. Loss of a short baseline could prevent the SRS from resolving ambiguity or extend the time required to resolve ambiguity. A failed RF indicates receiver problems, while a failed baseline may indicate an antenna problem.

SRS NOISY RF Tableau This tableau displays the current status of the SRS noise and antenna tests, indicating which RF's are noisy (see Figure 45). The time of the last test is also displayed. The tableau is modified by the program only after completion of each test.

SRS IFPM DATA Tableau The Inflight Performance Monitor Data Tableau is used to check exact



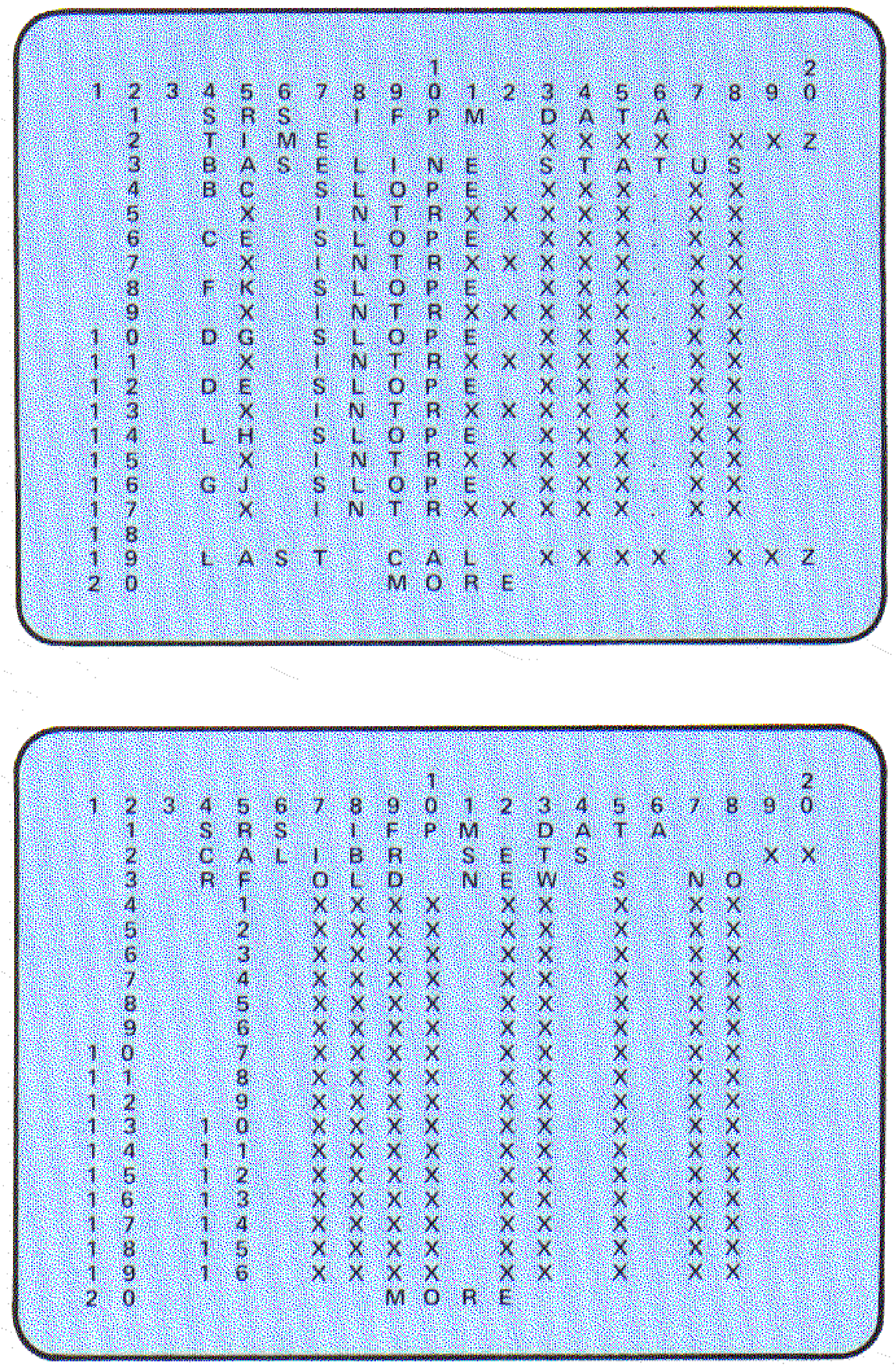
```
                  1                   2
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
  1   S R S   N O I S Y   R F
  2   L A S T   T E S T   C P L T E D
  3                     X X X X   X X Z
  4   N O I S Y   R F S     X X   X X
  5       X X   X X   X X   X X   X X
  6       X X   X X   X X   X X   X X
  7       X X   X X   X X   X X   X X
  8       X X   X X   X X   X X   X X
  9       X X   X X   X X   X X   X X
1 0       X X   X X   X X   X X   X X
1 1
1 2   A S S G   A V T E N N A   T E S T
1 3   T U N E           X X X X   X X Z
1 4   B S L N   S T A T U S   R F   X X
1 5     B C     X   X X X . X
1 6     C E     X   X X X . X
1 7     D G     X   X X X . X
1 8     D E     X   X X X . X
1 9     H L     X   X X X . X
2 0     G J     X   X X X . X
```

Figure 45. SRS NOISY RF Tableau

calibration values (see Figure 46). It provides in detail the following:

- Slopes and intercepts for each baseline.
- System time of last calibration set.
- Number of calibrations since start-up or re-start.
- Last calibration values for each RF.
- Number of valid receiver calibrations for each RF

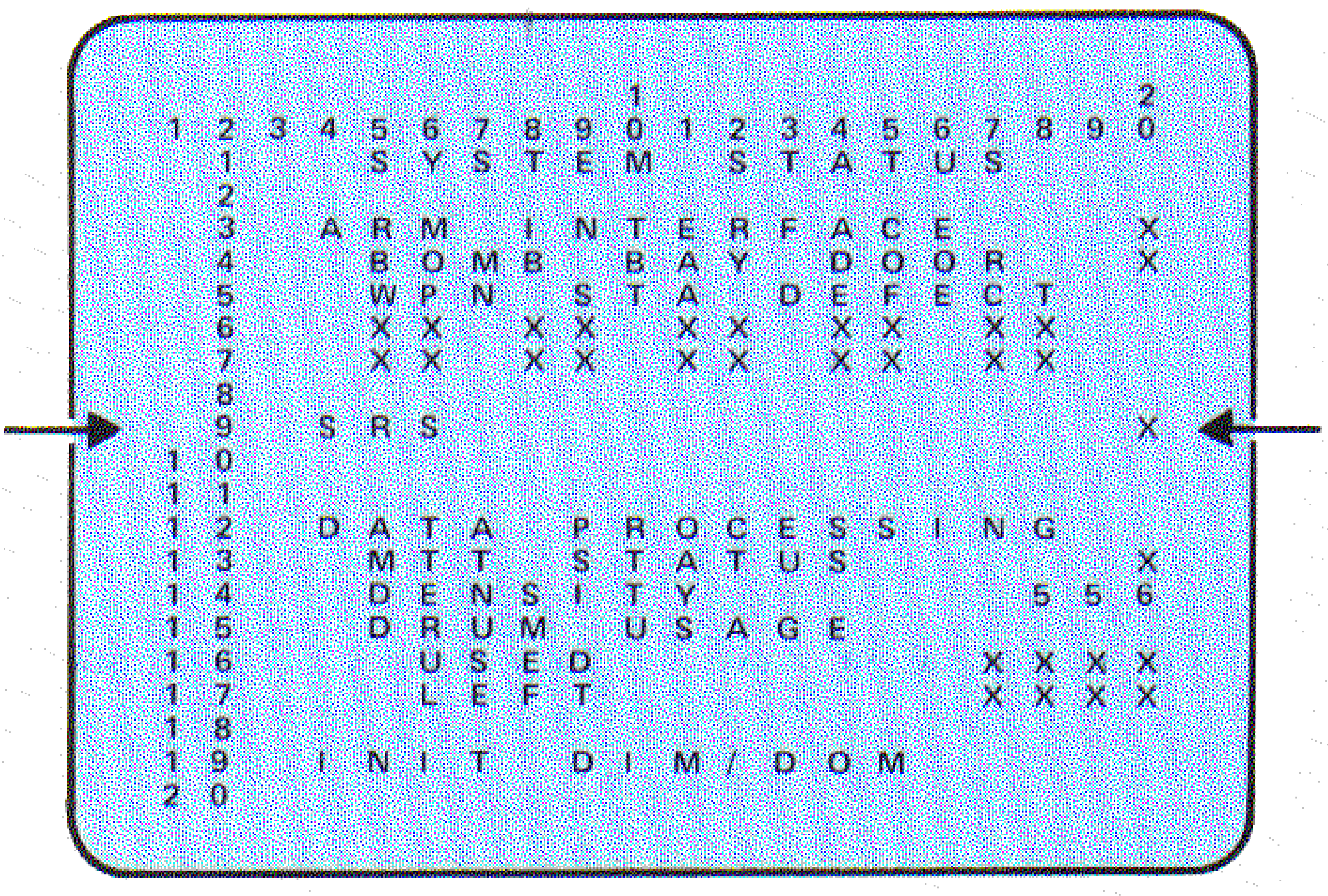
SYSTEM STATUS Tableau The SYSTEM STATUS Tableau displays the status of various hardware equipments, including the SRS. The SRS status is displayed on page 4, line 9 of the SYSTEM STATUS Tableau (see Figure 47). This line can be modified by the operator, and can be used to set the SRS "unavailable" (defective) if the SRS fails or is hung-up prior to one calibration. This operator-modification of SRS status is important because if it occurs, it disallows the use of all RF's either in the normal buoy selection mode or in the pattern function. In this situation, the TACCO is forced to use SONO SELECT or go through the conflict cueing sequence for each buoy selection. By defecting SRS, normal ordnance selection procedures can be performed.



```
                  1                   2
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
  1   S R S   I F P M   D A T A
  2   T I M E           X X X X   X X Z
  3   B A S E L I N E   S T A T U S
  4   B C   S L O P E   X X X . X X
  5     X   I N T R X X X X X . X X
  6   C E   S L O P E   X X X . X X
  7     X   I N T R X X X X X . X X
  8   F K   S L O P E   X X X . X X
  9     X   I N T R X X X X X . X X
1 0   D G   S L O P E   X X X . X X
1 1     X   I N T R X X X X X . X X
1 2   D E   S L O P E   X X X . X X
1 3     X   I N T R X X X X X . X X
1 4   L H   S L O P E   X X X . X X
1 5     X   I N T R X X X X X . X X
1 6   G J   S L O P E   X X X . X X
1 7     X   I N T R X X X X X . X X
1 8
1 9   L A S T   C A L   X X X X   X X Z
2 0             M O R E
```

```
                  1                   2
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
  1   S R S   I F P M   D A T A
  2   C A L I B R   S E T S         X X
  3   R F   O L D   N E W   S   N O
  4     1   X X X X   X X   X   X X
  5     2   X X X X   X X   X   X X
  6     3   X X X X   X X   X   X X
  7     4   X X X X   X X   X   X X
  8     5   X X X X   X X   X   X X
  9     6   X X X X   X X   X   X X
1 0     7   X X X X   X X   X   X X
1 1     8   X X X X   X X   X   X X
1 2     9   X X X X   X X   X   X X
1 3   1 0   X X X X   X X   X   X X
1 4   1 1   X X X X   X X   X   X X
1 5   1 2   X X X X   X X   X   X X
1 6   1 3   X X X X   X X   X   X X
1 7   1 4   X X X X   X X   X   X X
1 8   1 5   X X X X   X X   X   X X
1 9   1 6   X X X X   X X   X   X X
2 0             M O R E
```

Figure 46. SRS IFPM DATA Tableau (Pages 1 and 2 Shown)



```
                  1                   2
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
  1     S Y S T E M   S T A T U S
  2
  3   A R M   I N T E R F A C E       X
  4     B O M B   B A Y   D O O R     X
  5     W P N   S T A   D E F E C T
  6     X X   X X   X X   X X   X X
  7     X X   X X   X X   X X   X X
  8
  9   S R S                           X
1 0
1 1
1 2   D A T A   P R O C E S S I N G
1 3     M T T   S T A T U S           X
1 4     D E N S I T Y             5 5 6
1 5     D R U M   U S A G E
1 6       U S E D               X X X X
1 7       L E F T               X X X X
1 8
1 9   I N I T   D I M / D O M
2 0
```

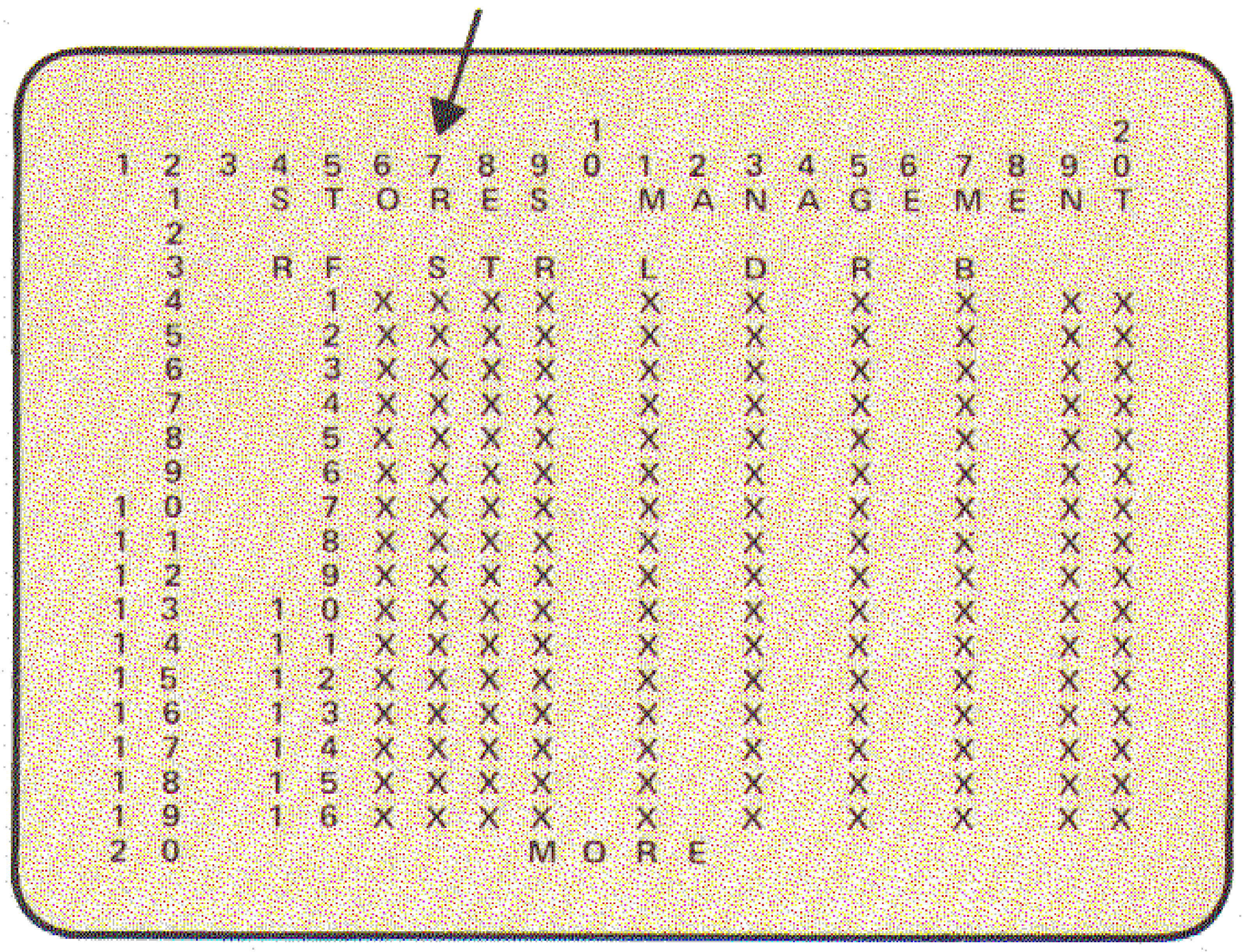
Figure 47. SYSTEM STATUS Tableau (Page 4 Shown)

Normally, the status bit for SRS is set at program load. If a program without SRS is selected in response to the configuration processing cue, then the status bit is set to SRS Unavailable in the tableau. Conversely, if the Update II Operational Program is selected, then the SRS status is set as available.

STORES MANAGEMENT Tableau The STORES MANAGEMENT Tableau contains sonobuoy data for each RF. In column 7 for each RF, this tableau gives the availability status of the RF channel for processing (see Figure 48). Among the reasons for buoy nonavailability is failure of the SRS to operate at the buoy's RF. This condition is shown as an "S" in column 7. The causes for a buoy being unavailable are:

- Buoy (RF) has been deleted.
- RF is SRS Noisy.
- SRS fails initial calibration.
- SRS fails, followed by an unsuccessful Restart.

If either of the "SRS fail" events occurs, it will fail all the RF's (all the buoys will become unavailable). The SYSTEM STATUS Tableau then must be set as SRS unavailable to enable normal buoy selection.

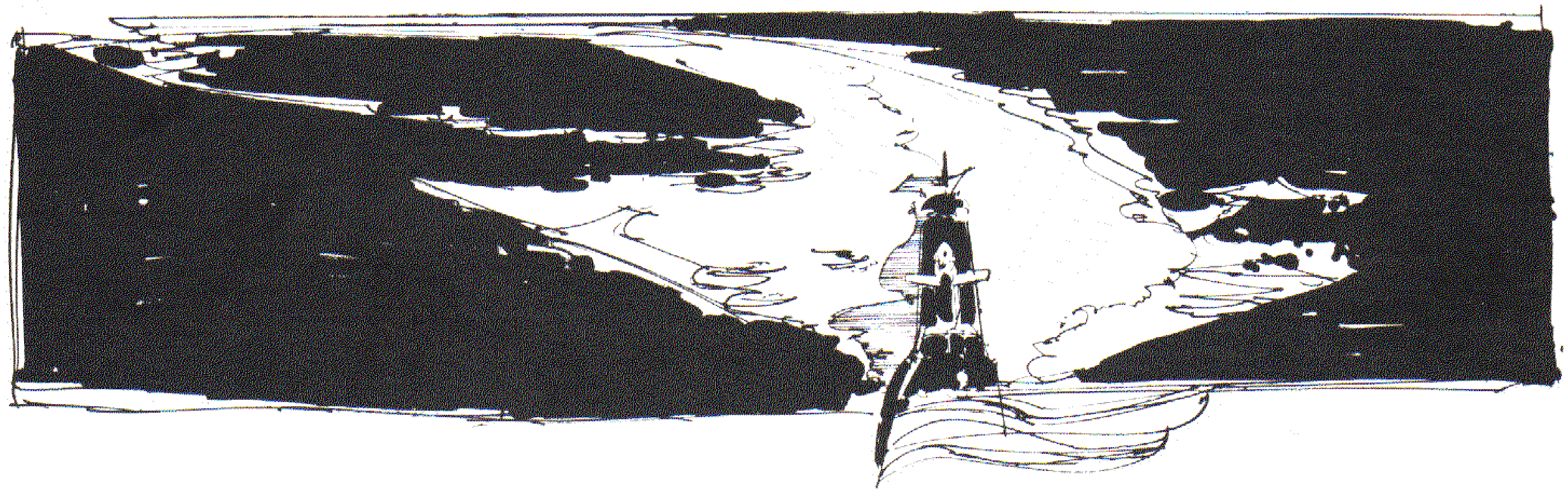


```
                  1                   2
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
  1   S T O R E S   M A N A G E M E N T
  2
  3   R F   S T R   L   D   R   B
  4     1 X X X X   X   X   X   X   X X
  5     2 X X X X   X   X   X   X   X X
  6     3 X X X X   X   X   X   X   X X
  7     4 X X X X   X   X   X   X   X X
  8     5 X X X X   X   X   X   X   X X
  9     6 X X X X   X   X   X   X   X X
1 0     7 X X X X   X   X   X   X   X X
1 1     8 X X X X   X   X   X   X   X X
1 2     9 X X X X   X   X   X   X   X X
1 3   1 0 X X X X   X   X   X   X   X X
1 4   1 1 X X X X   X   X   X   X   X X
1 5   1 2 X X X X   X   X   X   X   X X
1 6   1 3 X X X X   X   X   X   X   X X
1 7   1 4 X X X X   X   X   X   X   X X
1 8   1 5 X X X X   X   X   X   X   X X
1 9   1 6 X X X X   X   X   X   X   X X
2 0             M O R E
```

Figure 48. STORES MANAGEMENT Tableau (Page 1 Shown)

SRS DATA EXTRACTION AND RETRIEVAL The data extraction events for the SRS enable post-flight analysis of SRS buoy positioning information, as well as analysis of SRS operability. They can be used for reconstruction of SRS processing and, to some extent, for SRS troubleshooting. The events extracted for SRS analysis are:

EVENT NO.	TITLE
260	SRS BUOY POSITION
261	SRS BUOY DATA AT TIME OF ACCEPT
262	SRS RF/BASELINE HARDWARE STATUS
263	SRS INVALID NAV DATA
264	SRS RESTART
265	START SRS
266	SRS INOPERABLE
267	SRS TERMINATION



LOCKHEED-CALIFORNIA COMPANY
PRODUCT SUPPORT – GOVERNMENT PROGRAMS

T. J. BALL, VICE PRESIDENT

DIRECTOR INT'L SUPPORT PROGRAMS A. B. Stacey	DIRECTOR P-3 SUPPORT H. A. Franck	DIRECTOR S-3 SUPPORT E. E. Mouton	DIRECTOR CP-140 SUPPORT R. R. Humphrey

FIELD SUPPORT DIVISION – W. C. Bowden, Manager

P-3 Services	**D. R. Steele, Manager**
S-3 Services	**A. J. Neibauer, Manager**
Military Field Modifications	**M. J. Galli, Manager**
Maintenance Training	**F. N. Simmons, Manager**
Administrative Services	**A. V. Christophersen, Manager**

FIELD SERVICE OFFICES

MAJOR LOCATION	MAILING ADDRESS AND BUSINESS TELEPHONE
NARF Alameda P. H. Gerard	P.O. Box 1363 NAS Alameda, CA 94501 *(415) 869-4694/521-2283*
NAVAIRSYSCOM Arlington E. O. Skidmore F. D. Payne (PMA-240) B. S. Ashbaugh (AIR-4101B3)	Lockheed-California Co. 1745 Jefferson Davis Hwy Suite 400 Arlington, VA 22202 *(703) 521-8228*
NAS Barbers Point A. W. Vitaglin	P.O. Box 268 NAS Barbers Point, HI 96862 *(808) 681-3444/682-3671*
NAS Brunswick K. M. Prideaux	P.O. Box 38 Brunswick, ME 04011 *(207) 921-2472/921-2521*
NAS Cecil Field T. E. Stratton	P.O. Box 162 NAS Cecil Field Jacksonville, FL 32215 *(904) 772-8517/778-5128*
NS Cubi Point, R.P. D. K. Payne	P.O. Box 47 FPO San Francisco, CA 96654 *Cubi Point 63-898-56161*
Greenwood CFB, Canada E. C. Joslen	P.O. Box 1300 Greenwood, Nova Scotia Canada BOP 1NO *(902) 765-3385*
NAS Jacksonville S. L. Solomon	P.O. Box 31300 Jacksonville, FL 32230 *(904) 772-3535*
NAS Moffett Field J. Berezonsky	P.O. Box 159 Moffett Field,CA 94035 *(415) 966-5461*

MAJOR LOCATION	MAILING ADDRESS AND BUSINESS TELEPHONE
NS Naples, Italy J. McLean	Lockheed-California Co. COMFAIRMED/NSA FPO New York, NY 09521 *Naples 081-7605-400, Ext. 4434*
CNAVRES New Orleans G. A. Seipp	P.O. Box 189 Gretna, LA 70053 *(504) 948-1220*
NAS Norfolk W. H. Beydler	P.O. Box 15148 U.S. Naval Base Norfolk, VA 23511 *(804) 423-8321*
NAS North Island J. D. McKnight	NAS Box 5 San Diego, CA 92135 *(714) 435-8910*
Ottawa, Canada E. G. Herrmann	LAC of Canada, Ltd. 255 Albert St. Suite 603 Ottawa, Ontario Canada K1P 6A9 *(613) 238-8144*
NATC Patuxent River M. D. Garino	P.O. Box 218 NATC Patuxent River, MD 20670 *(301) 863-8186*
NADC Warminster L. E. Atkins	P.O. Box 220 Warminster, PA 18974 *(215) 674-3550*
NAVAIRSYSCOM Washington, D.C. J. J. Rousseau (PMA-244)	Lockheed Corporate Office 900 17th St., NW Washington, D.C. 20006 *(202) 872-5955*

LOCKHEED-CALIFORNIA COMPANY • A DIVISION OF LOCKHEED CORPORATION