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LTN-211 OMEGA NAVIGATION SYSTEM

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TABLE OF CONTENTS

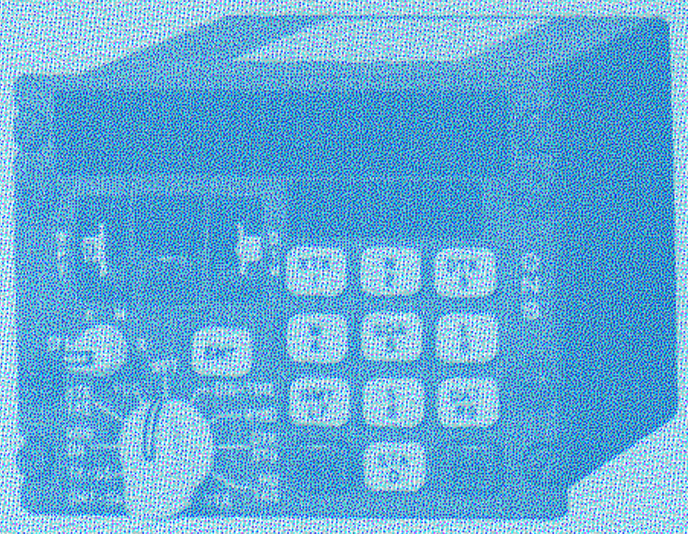
THE AVCM DONALD M. NEAL AWARD FOR EXCELLENCE IN AIRCRAFT MAINTENANCE 4

P-3 LTN-211 OMEGA NAVIGATION SYSTEM 6

PART I–OMEGA NAVIGATION 7
- Introduction 7
- Radio Navigation Systems 7
- Omega Navigation System Development 8
- Omega Radio Navigation Theory 9

PART II – LTN-211 OMEGA NAVIGATION SYSTEM 17
- General 17
- System Components 19
- Aircraft Inputs 23
- Function and Operation 27
- Maintenance 32

SUMMARY 34



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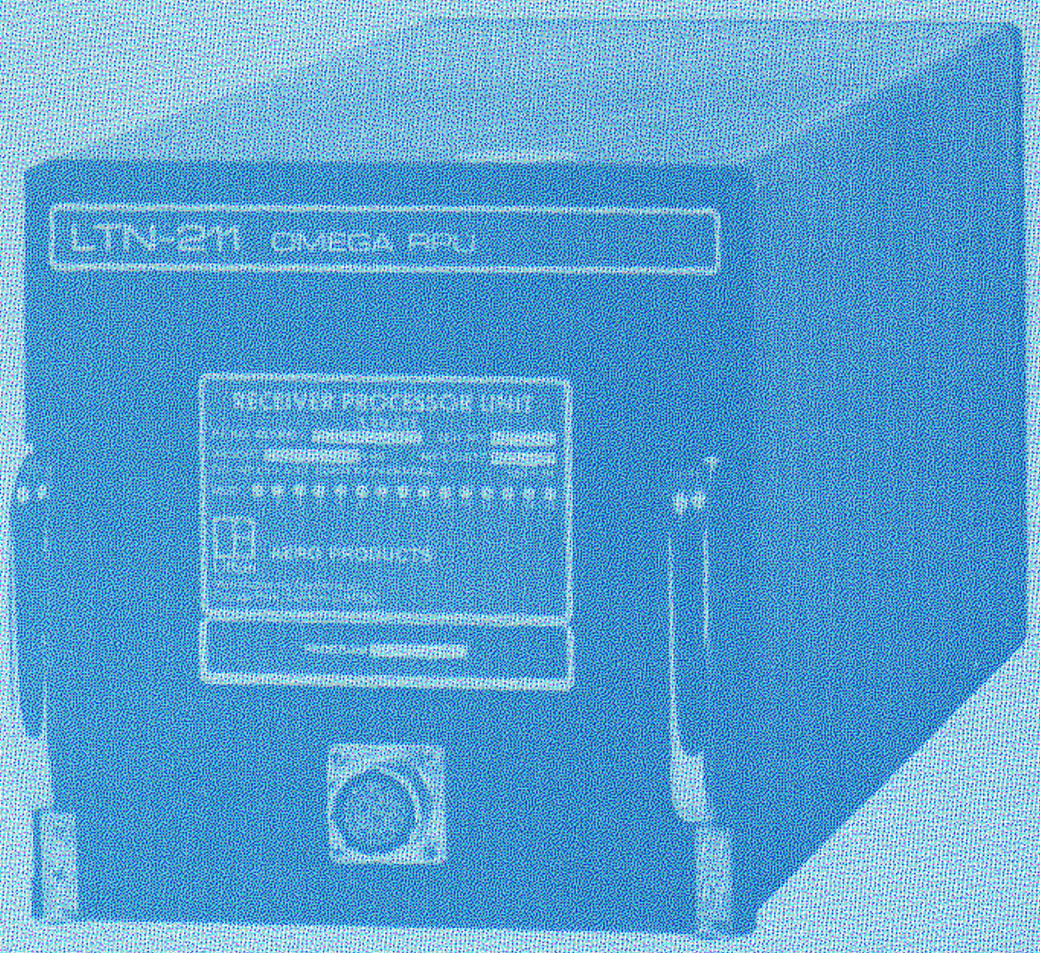
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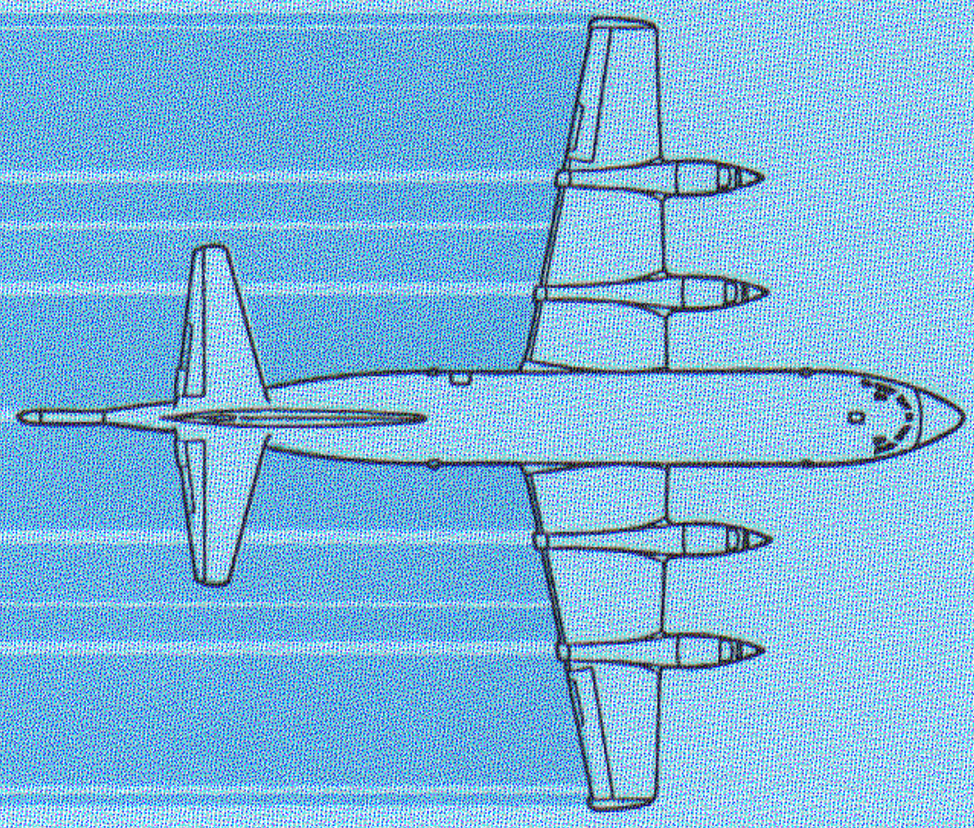
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THE AVCM DONALD M. NEAL AWARD FOR EXCELLENCE IN AIRCRAFT MAINTENANCE

HERBERT A. FRANCK
Manager – Field Support Division



The AVCM Donald M. Neal Aircraft Maintenance Award is presented annually to the Patrol Squadron in the Atlantic Fleet, Pacific Fleet, and Reserve Force that demonstrates the greatest excellence in aircraft maintenance.

The award is dedicated to the memory of the late AVCM Donald M. Neal, who served in the U.S. Navy from 1944 to 1968. During his naval career, Master Chief Petty Officer Neal formulated the advanced maintainability concepts subsequently incorporated into the Orion avionics systems. His advanced thinking and its translation to practical application, as evidenced by the exceptional maintenance and support performance of the P-3, is incontrovertible proof of his distinguished contributions to patrol aircraft maintenance.

The award was initiated by the Chief of Naval Operations in 1965 and is sponsored by the Lockheed-California Company. The first award was for FY 1966 (July 1965 through June 1966). In order for the award competitive cycle to coincide with other Fleet awards (i.e., the Isbell Trophy, "E," etc.), an 18-month cycle was established the following year. In 1976, the competitive cycle was established on a calendar year basis. And, in 1978, the award was extended to the Reserve Force.

Unlike most other aviation trophies, the Aircraft Maintenance Award was not initially named in honor of a person, but was unofficially known as the "Golden Wrench" award. However, since recognition of the effort of aircraft maintenance personnel is the primary consideration for this award, it was felt appropriate to dedicate the award to a former maintenance technician and shipmate so that it would serve as an inspiration to the corps of patrol aviation maintenance personnel. Thus, in 1977, the award was officially designated as the AVCM Donald M. Neal Aircraft Maintenance Award for Patrol Squadrons.

Each winning squadron receives a trophy, retained until the next award, and a permanently retained citation.

The trophy features a background of two golden wrenches, signifying aircraft maintenance superiority and leading to the trophy's colloquial title "The Golden Wrench Award." The trophy base features a sailor atop the globe, depicting Navy conquest of the world-wide elements and geographical locations in which the aircraft must be maintained. Golden eagles perched for flight and a propeller ready to turn signify the bottom line of the aircraft maintenance effort — ready for flight. Plaques identify previous and current winners of the trophy.

The permanent citation is a plaque, again featuring a golden wrench, retained in permanent custody by each winning squadron.

Competition for the award is keen. Winning it demands professionalism, leadership and teamwork at all levels; superb technical expertise; and dedicated performance and individual responsibility by all hands.

Nominations originate with each patrol wing commander, and are reviewed by the functional wing commanders who designate to their respective type commanders the two squadrons judged best. The type commanders select the winning squadrons.

Some criteria used to select the award recipients are:

- Maintenance Department grades from Administration/Material Inspection Reports
- Aircraft Material Condition Inspection grades
- Aircraft Ground Incidents
- Percentage of removed No Defects items
- Percentage of Awaiting Maintenance Time
- Ratio of Corrosion Prevention Manhours to Corrosion Treatment Manhours
- Review of 3-M data
- Factors outside control of the squadron.

Table I lists the squadrons that have won the award since competition began in July 1965.

Following the competitive period for Calendar Year 1985, VP-4, Barbers Point, became the first four-time winner. Three-time winners include VP-19, Moffett Field; and VP-5, VP-16 (the only three-time consecutive winner) and VP-24, Jacksonville. Although included in the program only since 1978, VP-60, Glenview and VP-69, Whidbey Island, are already two-time winners. Other two-time winners are VP-17 and VP-22, Barbers Point; and VP-26, Jacksonville.

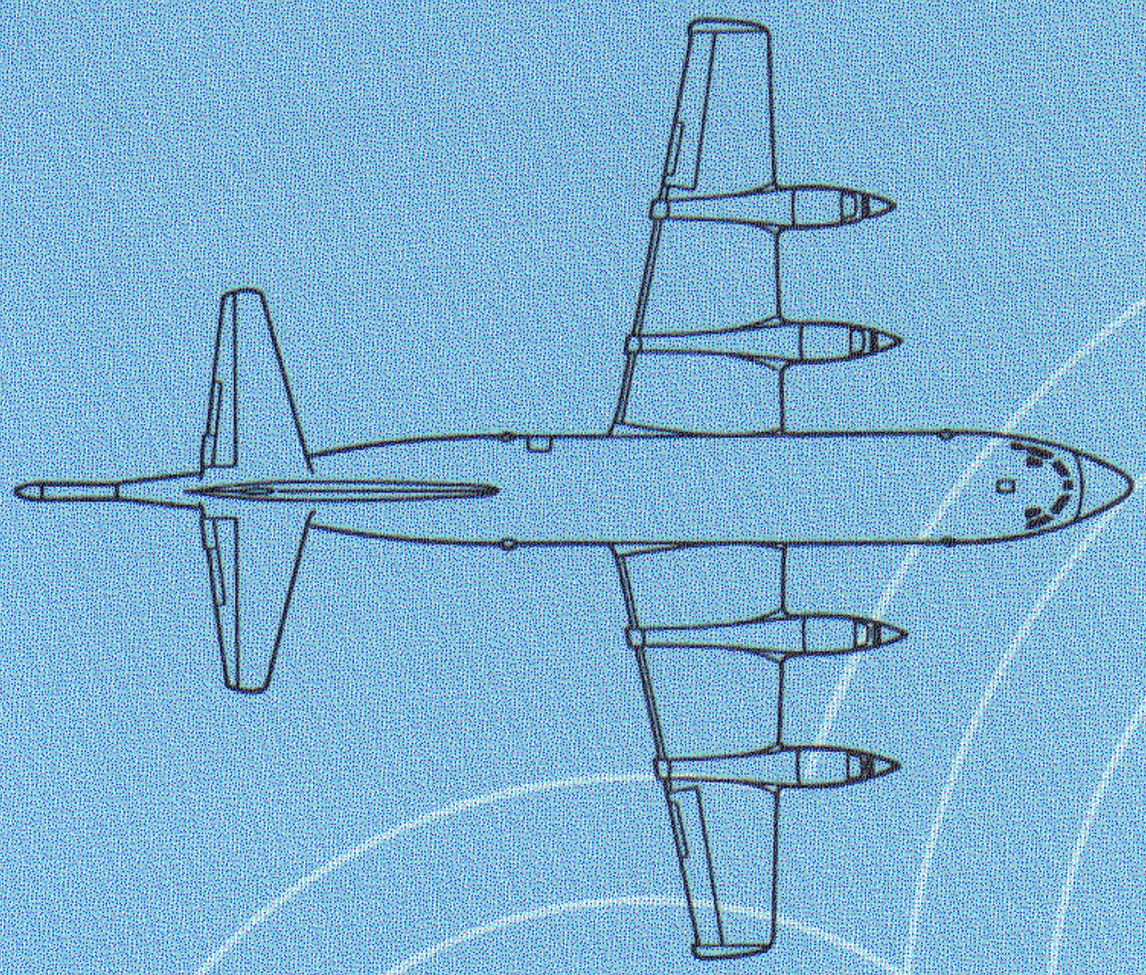
The three AVCM Donald M. Neal Aircraft Maintenance Award trophies are featured on the front cover of this magazine. They represent the hard work and diligence of maintenance personnel throughout the U.S. Navy's Patrol community who strive to achieve excellence in aircraft maintenance — a fitting memorial to their former shipmate AVCM Donald M. Neal.

Editor's Note: At press time, the Reserve Force's VP-60, Glenview, was awarded the AVCM Donald M. Neal Aircraft Maintenance Award for CY 1986. The Atlantic and Pacific Fleet winners for CY 1986 had not yet been announced.

Table I

GOLDEN WRENCH WINNERS

PERIOD	FOR YEAR	PACIFIC FLEET	ATLANTIC FLEET	RESERVE FORCE
JUL 65 - JUN 66	1966	VP-17	VP-49	
1 JAN 67 - 30 JUN 68	1967-68	VP-19	VP-5	
1 JUL 68 - 31 DEC 69	1968-69	VP-4	VP-5	
1 JAN 70 - 30 JUN 71	1970-71	VP-48	VP-24	
1 JUL 71 - 31 DEC 72	1971-72	VP-47	VP-5	
1 JAN 73 - 30 JUN 74	1973-74	VP-22	VP-26	
1 JUL 74 - 31 DEC 75	1974-75	VP-40	VP-23	
1 JAN 76 - 31 DEC 76	1976	NO AWARD	VP-26	
1 JAN 77 - 31 DEC 77	1977	VP-19	VP-8	
1 JAN 78 - 31 DEC 78	1978	VP-17	VP-24	VP-60
1 JAN 79 - 31 DEC 79	1979	VP-4	VP-44	VP-69
1 JAN 80 - 31 DEC 80	1980	VP-4	VP-45	VP-69
1 JAN 81 - 31 DEC 81	1981	VP-22	VP-10	VP-65
1 JAN 82 - 31 DEC 82	1982	VP-1	VP-24	VP-60
1 JAN 83 - 31 DEC 83	1983	VP-46	VP-16	VP-91
1 JAN 84 - 31 DEC 84	1984	VP-19	VP-16	VP-66
1 JAN 85 - 31 DEC 85	1985	VP-4	VP-16	VP-64



P-3 LTN-211 OMEGA NAVIGATION SYSTEM

by E. Rockwell James
Electrical Systems Engineer, Sr.
P-3 Avionics

PART I -- OMEGA NAVIGATION

INTRODUCTION

Navigators in the forty years since World War II have witnessed many significant improvements in radio navigation accuracy. Radio navigation has gained prominence as a navigational tool because the physics of radio waves permits distance to be measured as a function of time, and direction may be determined by making differential measurements from two radio stations or by the use of nulling antennas. Today's navigators commonly use radio navigation systems such as Loran-C, Tacan, VOR, and Omega to precisely track their position.

Computers have played a substantial role in the acceptance of radio navigation systems. They can perform the necessary calculations with the speed and accuracy required by this form of navigation, thus reducing both the navigator's work load and the technical skills required to perform this task. This article discusses the LTN-211 Omega Navigation System, which is a stand-alone system that utilizes its own internal computer rather than the aircraft's tactical computer. The AN/ARN-99 Omega System, discussed in Orion Service Digest Issue 32, requires the use of the aircraft's tactical computer to perform its function.

RADIO NAVIGATION SYSTEMS

Omnidirectional radio ranging, or "omni," was the original all-directional radio navigation system. Through the years, omni progressed to VHF omnidirectional ranging (VOR), an airborne radio navigation technique that is still in everyday use. However, VOR does have some shortcomings. It is very limited in accuracy and range, and is intended to provide only relative bearing information.

Tacan, the military's Tactical Air Navigation system, provides the distance measuring capability that VOR lacks. Tacan also has greater accuracy because its digitally-formatted signal permits use of advanced signal processing techniques. Often VOR and Tacan use combined signal transmission facilities. Such facilities are called VORTAC stations.

The Omega radio navigation system is a very low frequency (VLF) direct ranging system that offers an all-weather, long-range navigation aid. Although Omega is not as precise as other radio navigation aids for short-range and medium-range radio navigation, it can still perform these functions with reasonable accuracy. Omega is most effective as a long-range radio navigation aid, particularly over vast areas of water where other radio navigation aids are not available.

At present, no single radio navigation system can satisfy all of the navigation requirements of the P-3 Orion aircraft. As a result, the Orion is equipped with several types of radio navigation systems that complement one another. The features of the various radio navigation aids that are presently in world-wide use are compared on Table I. From this comparison, it is apparent that several different radio navigation systems are required to meet the Orion's overall navigational needs.

Table I. Radio Navigation Systems Comparison

	VOR	TACAN	OMEGA	LORAN C
FREQUENCY	108-118 MHz	1000-1200 MHz	11-14 kHz	100 kHz
EFFECTIVE RANGE	50-200 N.MI.	400 N.MI. AIR-TO-GROUND 200 N.MI. AIR-TO-AIR	GLOBAL	2000 N.MI.
NAVIGATION INFORMATION	BEARING ONLY	DISTANCE AND BEARING	POSITION FIXING	POSITION FIXING
AMBIGUITIES	180° – RESOLVED BY TO-FROM FLAG ON INDICATOR		LANE SKIPPING RESOLVED BY COMPARING SIGNAL TRANSMISSIONS FROM MULTIPLE STATIONS	SIGNAL DEGENERATES WHEN CLOSE TO TRANSMITTER – CONDITION IS RESOLVED BY BLANKING SIGNAL RECEPTION WHEN NEAR TRANSMITTER
GROUND STATION	CONTINUOUS ROTATING ANTENNA PATTERN	ROTATING DRUM ANTENNAS	CONTINUOUS ROTATING PATTERN	ONE MASTER TRANSMITTER, SEVERAL SLAVE UNITS
FEATURE	LOW COST SYSTEM	TWO-WAY SIGNAL REQUIRES ONLY ONE GROUND STATION	COMPLETE WORLD COVERAGE	DOES NOT REQUIRE INITIALIZATION

For example, Tacan is a strictly line-of-sight radio navigation system, but within its effective range it provides more accurate navigation information than Omega. Loran-C (not currently installed on P-3 aircraft) is a highly accurate navigation system that has been accepted as the standard radio navigation system for the U.S. coastal/confluence region, harbors, and estuaries. However, use of Loran-C is presently limited to continental and coastal regions, although its area of coverage is continuing to expand. Omega navigation, although not as precise as these other systems, is a global position-fixing navigational aid that provides capabilities where no other radio navigation aid is available (see Figure 1). VLF Direction Finding systems provide backup to Omega navigation systems, and serve as a radio navigation aid in areas where Omega systems are subject to inaccuracy. Today, Omega — even with its limitations — is the only active radio navigation system that provides global coverage, and which is widely accepted by both military and commercial users.

OMEGA NAVIGATION SYSTEM DEVELOPMENT

The Omega radio navigation system was developed through an international consortium to provide an accurate, simple and economic global navigation system that could be used by many countries throughout the world. The concept of Omega navigation evolved from studies of LF and VLF radio signals during World War II. It is the survivor over Radux, an early experimental VLF navigation system, and Loran A which is no longer in use. Omega is operated in the 10-kHz to 14-kHz frequency range, which is the optimum frequency range for this form of radio navigation, both from signal propagation and navigation accuracy considerations.

By 1972, the concept of Omega radio navigation had been developed to the point that it was no longer considered experimental, and it was placed in operation. At that time, Omega's primary limiting factor was the availability of enough operational Omega transmitters to afford world-wide coverage. In 1980, this problem was resolved when the eighth and final Omega transmitting station, located in southeast Australia, was placed in operation. The locations of these stations are shown in Figure 2. The aperiodic nature of the Omega signals enables the Omega receiver to make positive identification of each Omega station. The U.S. Coast Guard operates the Omega stations located on United States territory, and it supervises the operation of those Omega stations located elsewhere in the world.

During the years since all Omega transmitting stations became operational, Omega system designers and operators have dedicated considerable time and effort to gaining a further understanding of the system's characteristics and limitations. With this knowledge, they have developed software to improve the systems's accuracy. In

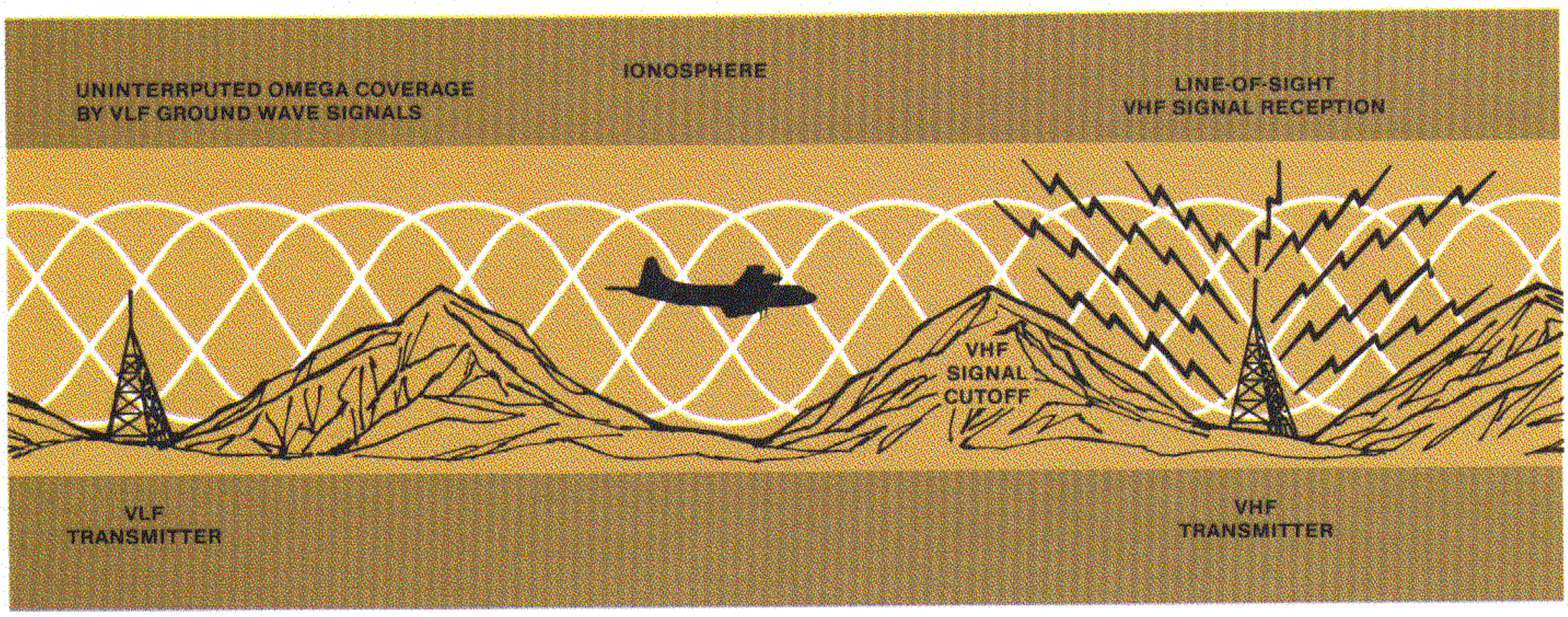
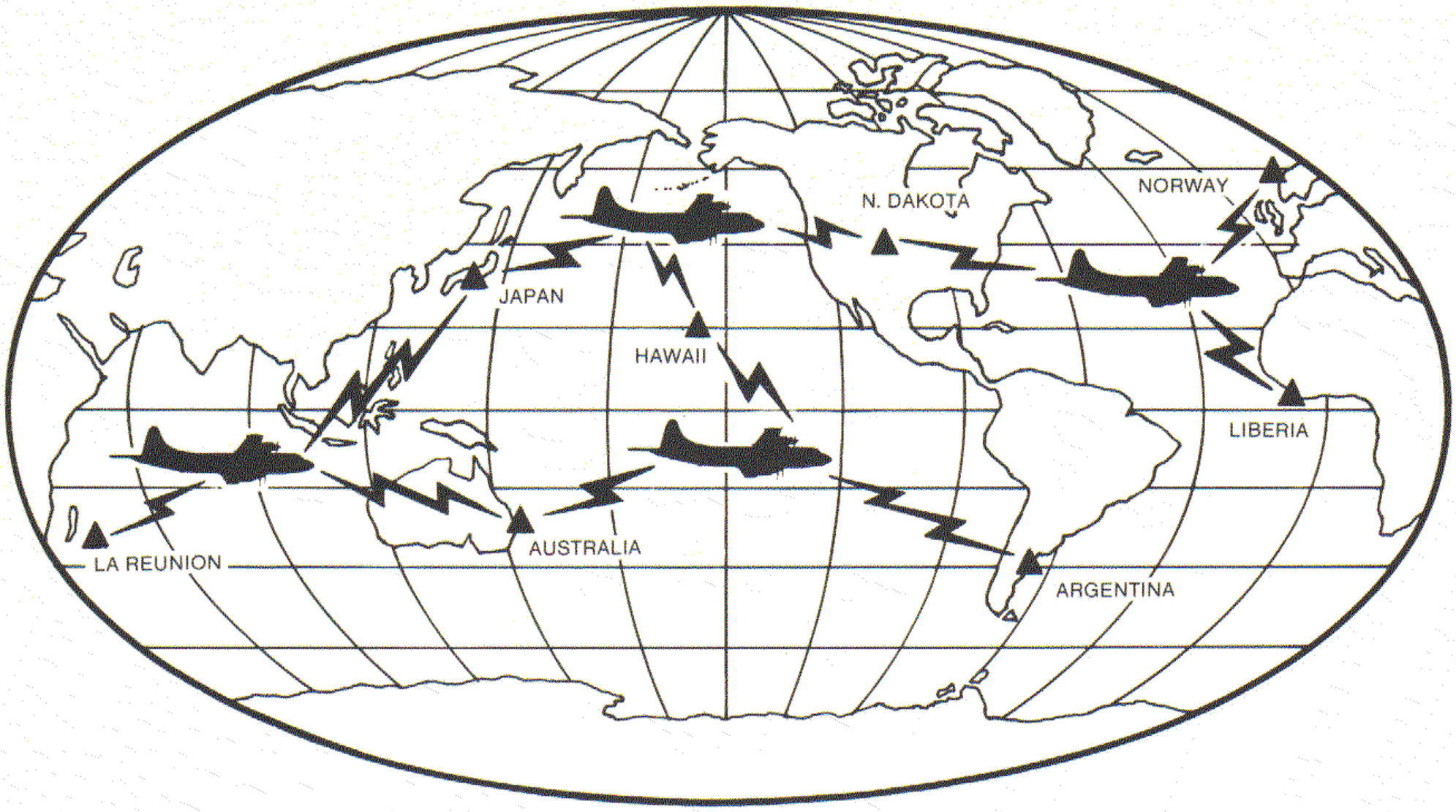


Figure 1. Omega Navigation System VLF Signal Propagation is by Ground Waves. Reception of Omega signals is not limited by line-of-sight as is VHF signal reception.

Figure 2. Omega Navigation System Transmitter Locations



addition, they have also been able to determine areas of marginal Omega signal reception where alternate navigational aids should be used. Currently, Omega signal reception is marginal only at the polar ice caps. This occurs because ice constitutes a poor conduction surface for VLF radio signal propagation.

The LTN-211 Omega Navigation System in non-Update P-3C aircraft — the subject of this article — has a backup mode of operation that can complement Omega system position tracking when Omega transmission signals become weak or distorted. This function is not available with the AN/ARN-99 Omega System. In this backup mode, the LTN-211 Omega receiver monitors signals from VLF radio communication transmitters located at various sites throughout the world. The airborne Omega system determines the direction from the aircraft to several of these VLF communication transmitters, then calculates the position of the aircraft. The U.S. Navy has responsibility for the operation of the nine VLF communication transmitters that are used by this system as backup for the Omega navigation system. These communication transmitters are located in Australia, Great Britain, Hawaii, Japan, Maine, Maryland, Norway, and Washington. The station designations and their locations are presented in the NAVAIR 01-75PAC-1.1 NATOPS Flight Manual.

Lockheed ORION Service Digest

OMEGA RADIO NAVIGATION THEORY

CONCEPT Omega radio navigation uses the technique of direct ranging, which is based upon the principle of signal phase measurement. Very Low Frequency (VLF) radio signals of 10.2 kHz, 11.33 kHz, and 13.6 kHz are used for Omega navigation. Figure 3 shows the timing sequence and transmission periods allocated to the three Omega frequencies for each of the stations. The asymmetry of this pattern enables the Omega system computer to identify the transmissions from a particular station and to track that station ac-

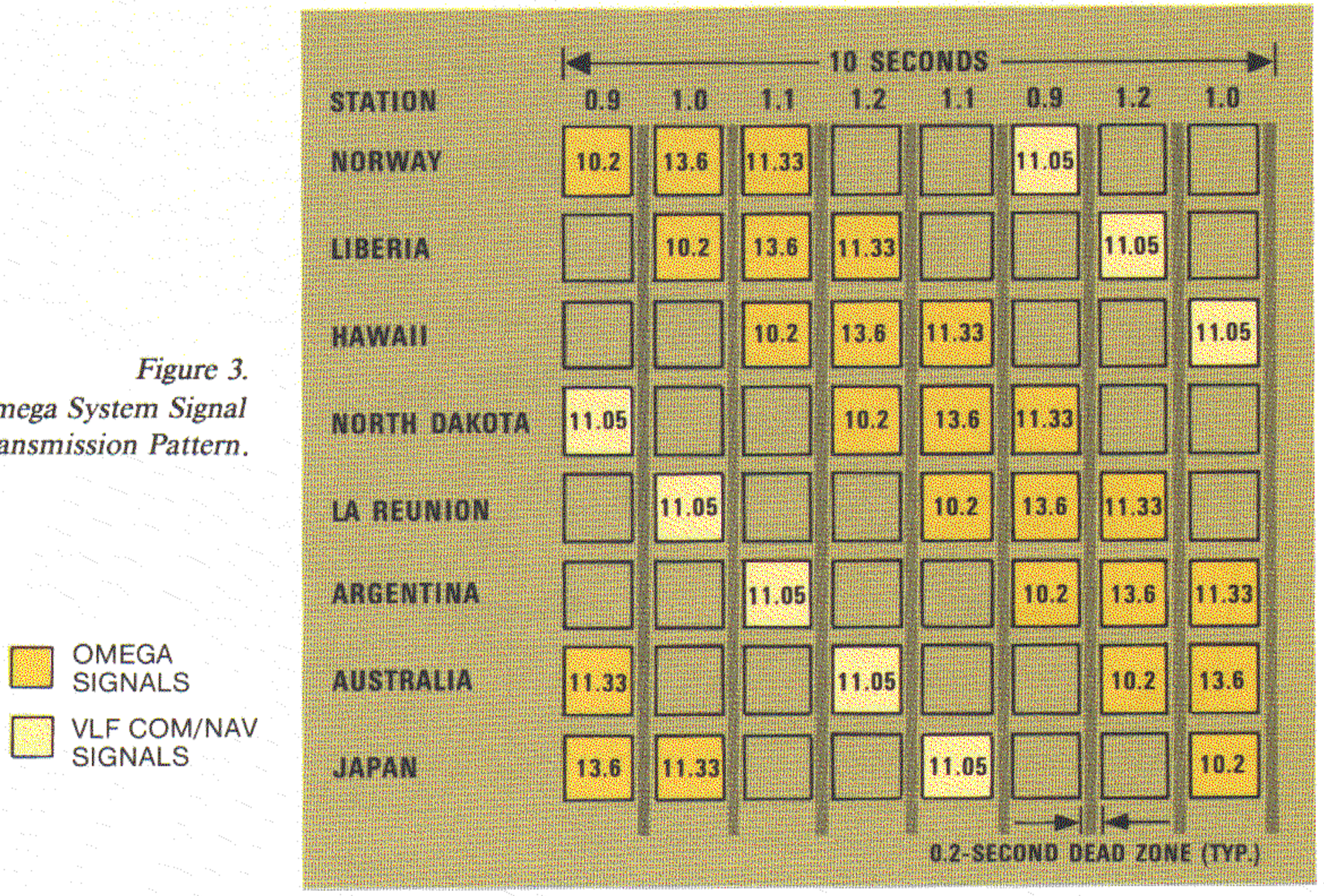


Figure 3. Omega System Signal Transmission Pattern.

cordingly. Figure 3 also shows a timing sequence for 11.05 kHz VLF signals. The LTN-211 Omega system uses this frequency to process the VLF communication transmissions which are used in a backup navigation mode. This feature of the LTN-211 Omega system will be discussed later in this article.

The 10.2 kHz, 11.33 kHz, and 13.6 kHz Omega radio signals have long wavelengths — 16, 14.4, and 12 nautical miles, respectively. Thus, one cycle of an Omega radio navigation signal represents a geographic "lane" that is 16, 14.4, or 12 nautical miles wide. The distance between the Omega transmitter and the navigation system receiver is determined by counting the number of cycles (lanes) between the two locations, then checking the phase differential within the last cycle to refine the final measurement (see Figure 4). The initial lane count is performed by calculating the distance between the geographic position entered when the system is turned on, and the known position of a particular Omega station. The phase differential within the last cycle is measured with precision by dividing that cycle into one hundred parts called centicycles (centilanes).

Calculating the distance from the aircraft to one Omega transmitter produces a circle, any point on which is equidistant from the transmitter. By this calculation, you determine the distance of the aircraft from that transmitter, but not the direction to the transmitter (see Figure 5). By calculating

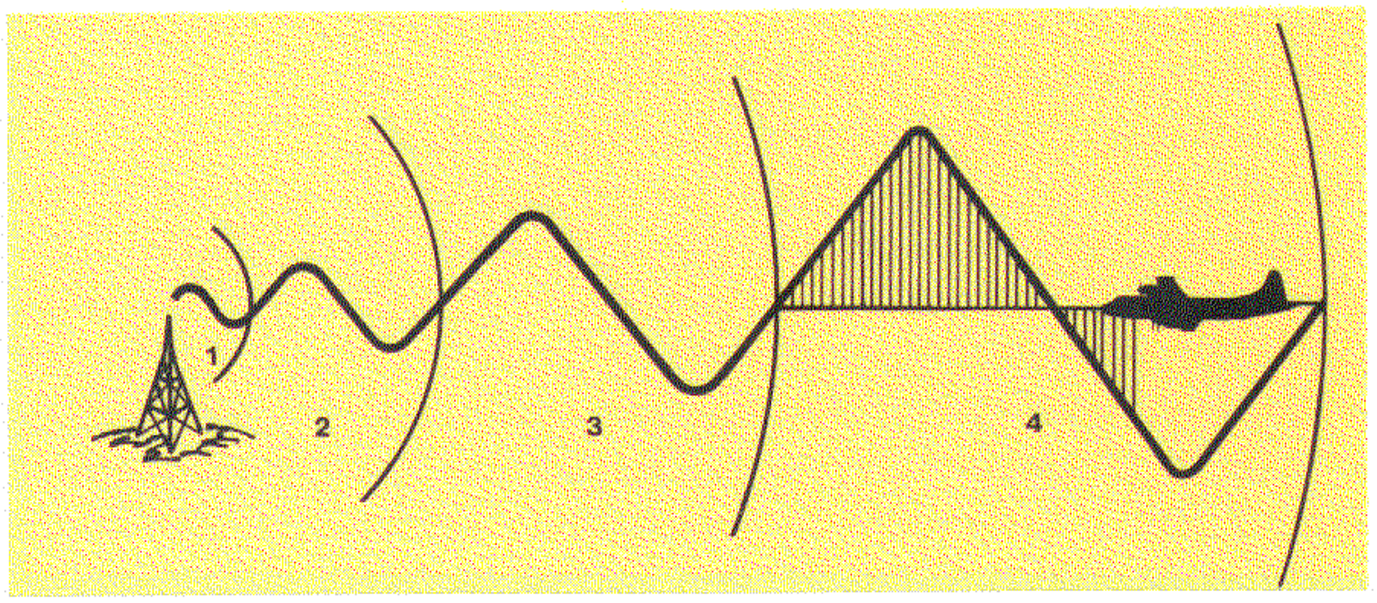
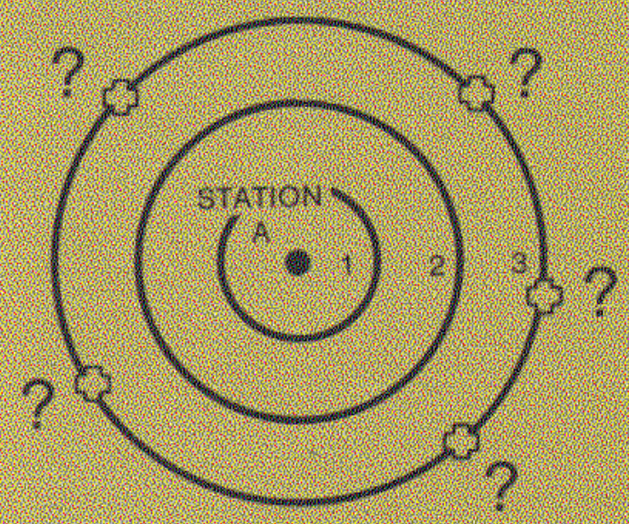


Figure 4. Distance is Measured Between an Omega Transmitter and the Receiver by Counting the Lanes Between the Two Locations, Plus Making a Centilane Count of the Last Fraction of a Lane.

ONE OMEGA STATION:

DISTANCE FROM AIRCRAFT TO STATION A = 3 LANES

DIRECTION FROM AIRCRAFT TO STATION A UNKNOWN

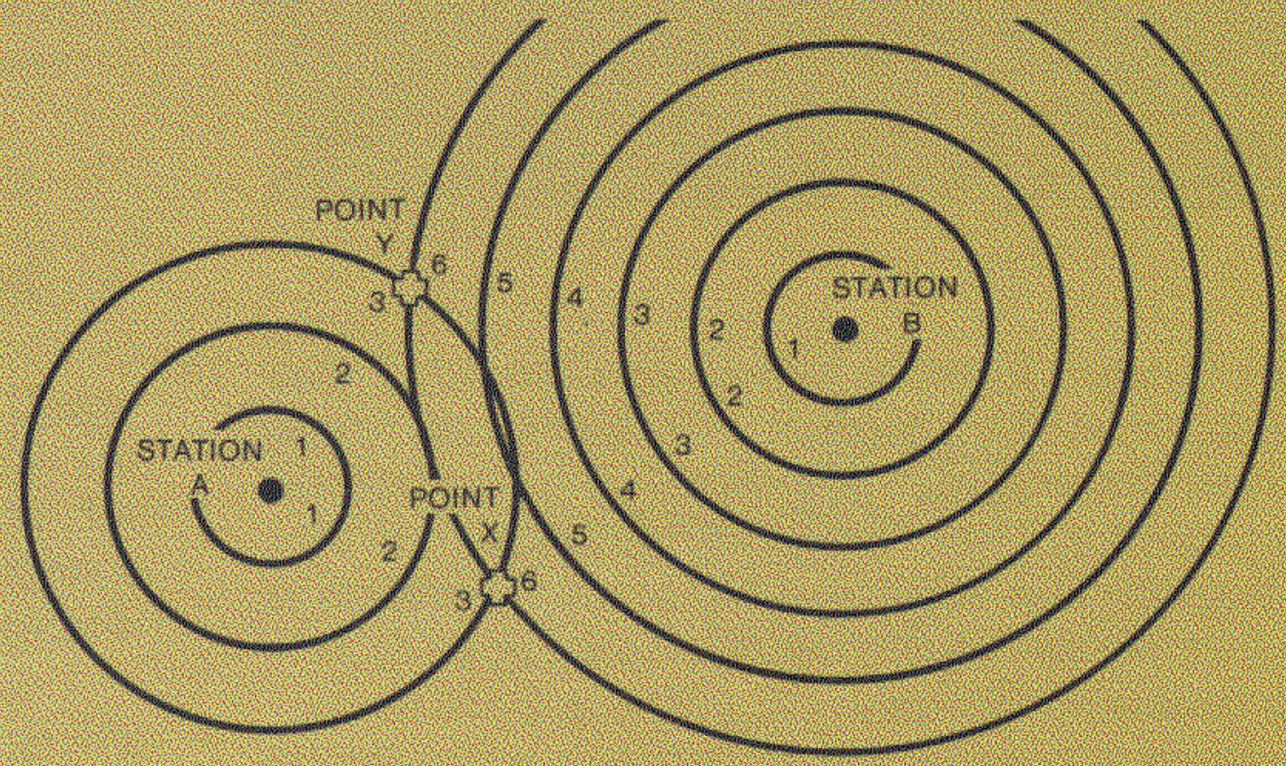


TWO OMEGA STATIONS:

DISTANCE FROM AIRCRAFT TO STATION A = 3 LANES

DISTANCE FROM AIRCRAFT TO STATION B = 6 LANES

AIRCRAFT LOCATED AT EITHER POINT X OR POINT Y



THREE OMEGA STATIONS:

DISTANCE FROM AIRCRAFT TO STATION A = 3 LANES

DISTANCE FROM AIRCRAFT TO STATION B = 6 LANES

DISTANCE FROM AIRCRAFT TO STATION C = 4 LANES

AIRCRAFT IS LOCATED AT POINT X

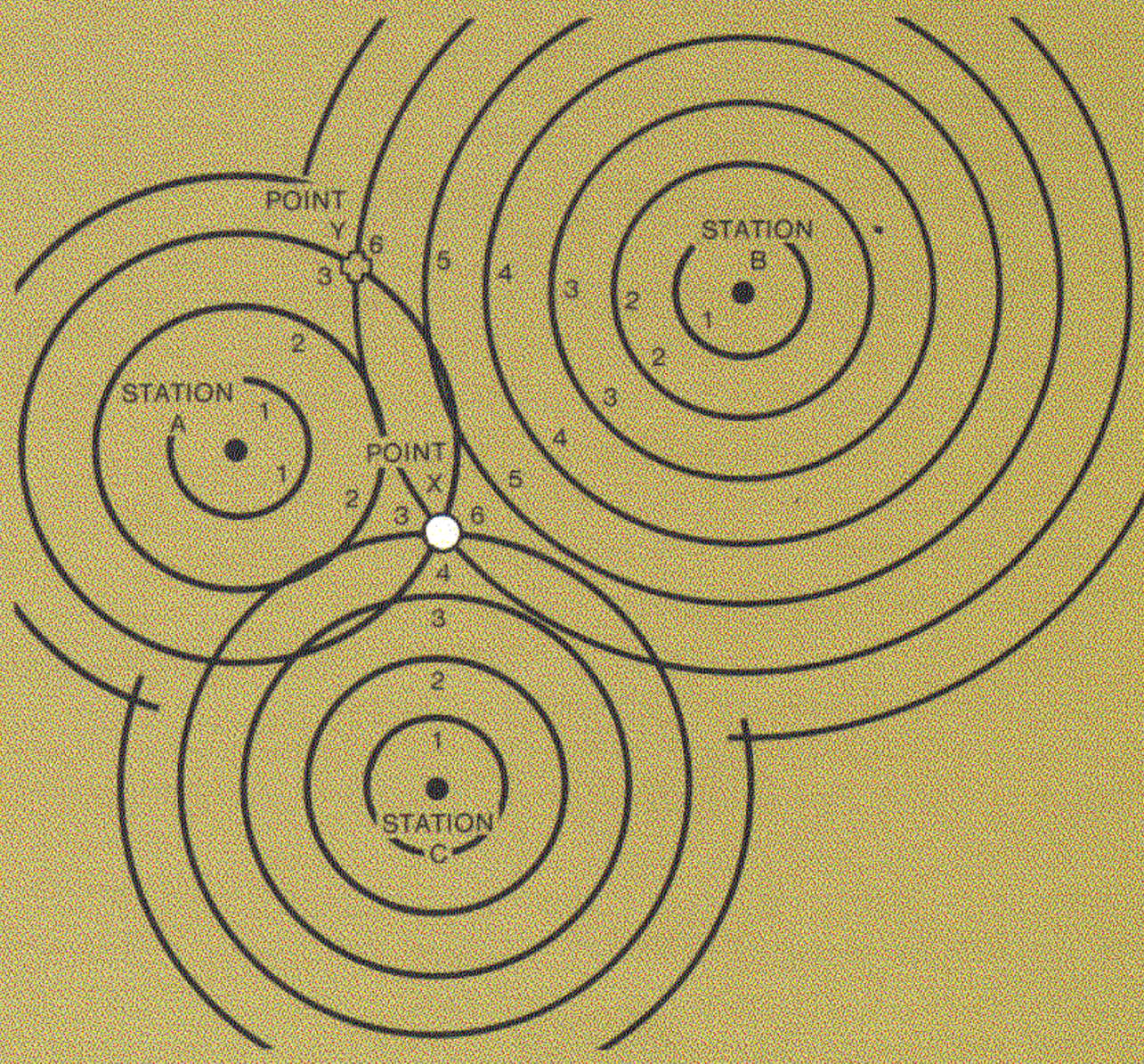


Figure 5. Omega Rho-Rho-Rho Direct-Ranging Radio Navigation Technique.



the distance from the aircraft to a *second* Omega transmitter, you produce a *second* circle whose circumference is equidistant from the second transmitter. The position of the aircraft can then be resolved as being at either of the two points at which the two circles intersect (see Figure 5). It is necessary to calculate the distance from the aircraft to a *third* Omega transmitter to determine the true location of the aircraft. The circle produced by this third calculation will intersect or closely approach one of the two points at which the other two circles intersect, and thus indicate the true location of the aircraft (see Figure 5).

As the aircraft moves, its Omega system maintains a lane count to all three selected Omega stations as it transitions from lane to lane. This enables the aircraft Omega system to continuously track aircraft position by using the range-to-Omega station calculations that it derives from signal phase measurements.

In this direct ranging method of navigation, the Greek letter "rho" is used to indicate that the distance is measured from the Omega receiver to the Omega transmitter. Since the LTN-211 Omega Navigation System uses signals from *three* Omega stations to calculate the position of the aircraft by direct ranging, it is called a "rho-rho-rho" system. Under certain circumstances, if the operator provides the LTN-211 Omega system with a precise geographic starting point, the system's computer can accurately track the aircraft's position without ambiguity by using the signals from only two Omega transmitters. This is called the "rho-rho" Omega system operating mode.

Each of the Omega stations must transmit signals at precisely the correct time, as shown in Figure 3. To achieve this accuracy, the eight Omega stations are linked to a near-absolute common time reference by using cesium clock oscillators located at each station. These atomic clocks are accurate to one second in 3000 years. Each Omega station compares its transmissions to those of the other stations twice daily to maintain signal phase accuracy.

The aircraft Omega navigation system also requires an extremely accurate time reference. Although it would be ideal to equip the aircraft with the cesium clock oscillator, the clock's size, weight and cost make this impractical. However, the LTN-211 Omega Navigation System still achieves excellent timing accuracy through use of a crystal-controlled oscillator clock that is accurate to better than one second in two years.

The phase of the received signal is compared against the local reference oscillator. Even though the local oscillator is very accurate, it is not precisely locked to the Omega transmitters. This introduces a phase shift error that is called clock offset. Fortunately, clock offset can be easily eliminated by comparing the signals from two or more Omega stations, then subtracting the error. This technique is used to eliminate clock offset in all received signals.

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OMEGA ERROR SOURCES AND ERROR COMPENSATION All navigation systems are subject to error, and the Omega system is no exception. Since accurate Omega signal phase measurement is necessary to determine the aircraft position, anything that distorts the Omega signal phase relationship can contribute to system error. Such errors can be introduced by signal propagation itself (propaga-

tion errors), by the peculiar physical characteristics of the earth (earth errors), or by the Omega system's own signal processing system (system errors).

Propagation Errors Propagation error sources are present at all times. The three most common are diurnal effects on the earth's atmospheric ionization level, wrong-way signals, and modal interference. The following paragraphs describe these error sources and explain how modern Omega systems have overcome them.

Omega signal propagation takes place in the space between the earth's surface and the D-layer of the ionosphere. This space acts as a waveguide for the Omega VLF radio signals. Variations in the height of the ionosphere change the depth of the available communication medium, which affects the propagation velocity of the Omega signals (see Figure 6). These changes of the ionosphere's height are caused principally by the impact of the sun's rays on the earth's atmosphere. During daylight hours, solar bombardment tends to compress the atmosphere and drives the ionosphere lower to a height of about 60 km. At night, the height of the ionosphere increases to about 90 km due to the absence of the impact of the sun's rays (see Figure 6). Signal propagation errors caused by the daily variations of the height of the ionosphere are called *diurnal effects.*

The propagation velocity variations of Omega radio signals caused by diurnal effects produce phase shifts in the signals that are received by the Omega system. The Omega receiver computer will compensate for these diurnal effects while it tracks aircraft position. In order for the computer to do this, the navigator must enter the exact time-of-day (Greenwich Mean Time), the date, and precise local geographic coordinates when the Omega system is initialized.

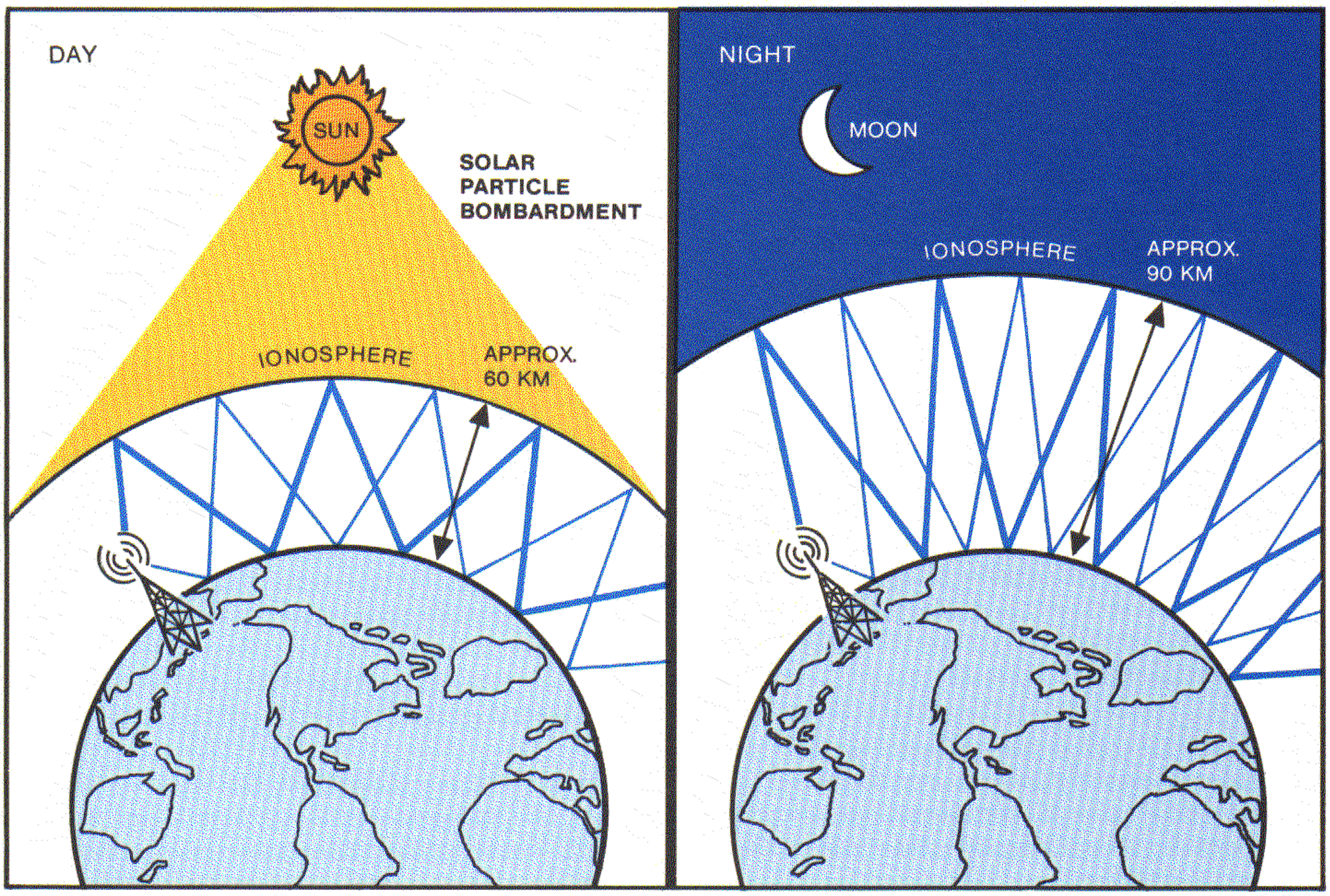


Figure 6. Diurnal Effects on Omega System Signal Transmissions.

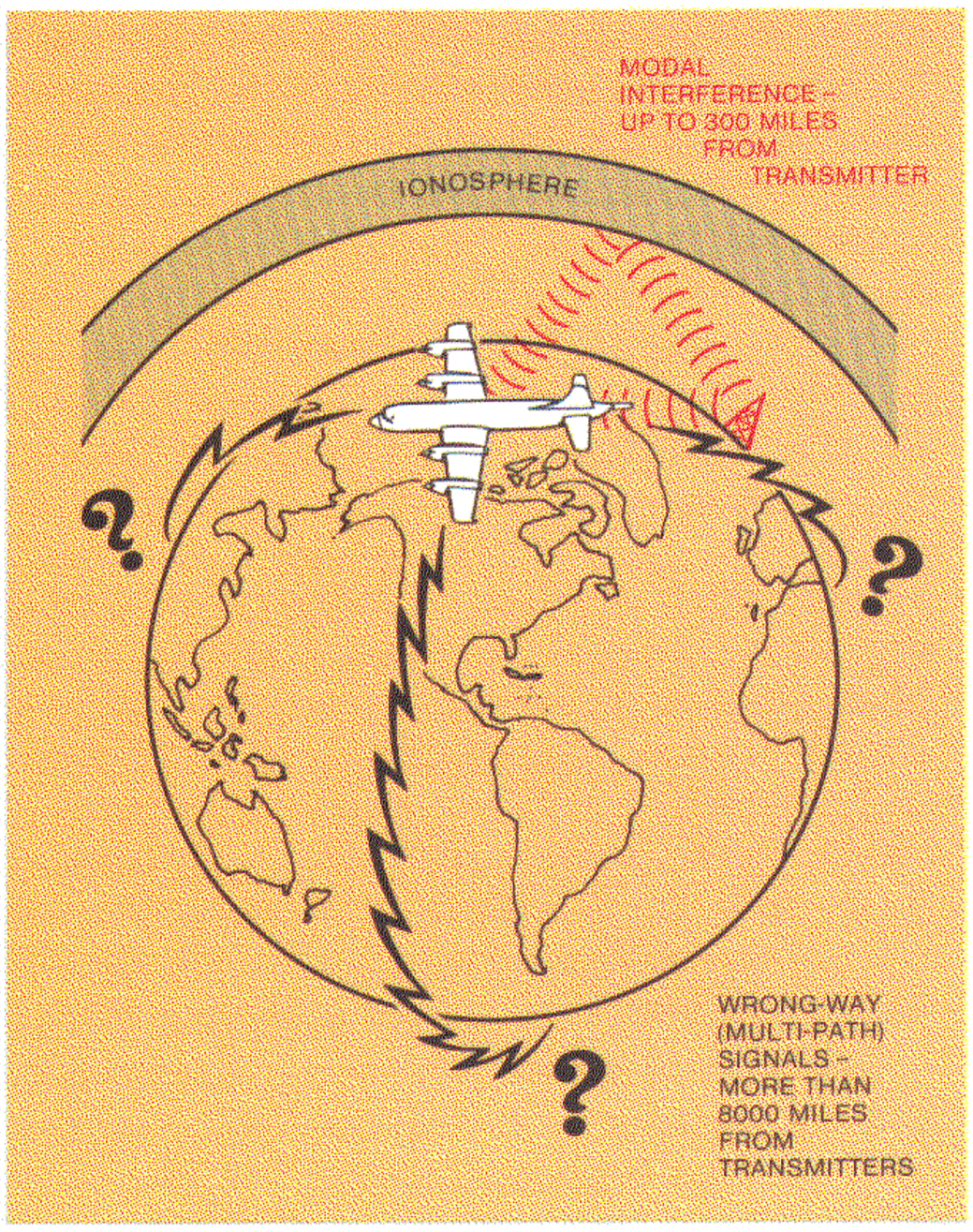


Figure 7. Modal Interference and Wrong-Way Signals.

Omega VLF radio navigation signals are capable of circling the earth, a necessity for their use as a global navigation aid. Because of this phenomenon, it is possible for the Omega receiver to receive the signal transmitted by a particular Omega station from more than one direction (see Figure 7). Under some circumstances, the multiple signals from the same Omega transmitter could have similar strengths, and the Omega receiver would have difficulty telling the principal signal from secondary *(wrong-way)* signals. The LTN-211 Omega system receiver's computer resolves this problem by deselecting signals received from any transmitter that is sufficiently distant to make ambiguity likely. The computer is programmed by U. S. Navy program 18-04 to deselect signals from any transmitter that is more than 8000 nautical miles distant.

Omega VLF signal transmission ground waves propagate around the surface of the earth in the waveguide formed by the earth's surface and the ionosphere, a characteristic that makes Omega effective for long-range global navigation. However, these VLF radio transmissions can also reflect off the ionosphere, providing the Omega receiver with both direct and reflected signals from the same Omega transmitter (see Figure 7). This problem is called *modal interference.* It is significant only when the Omega receiver is close to the transmitter, where both the direct and reflected signals have similar strength. The LTN-211 Omega system receiver's computer compensates for modal interference by deselecting signals from any Omega station that is closer than 300 nautical miles.

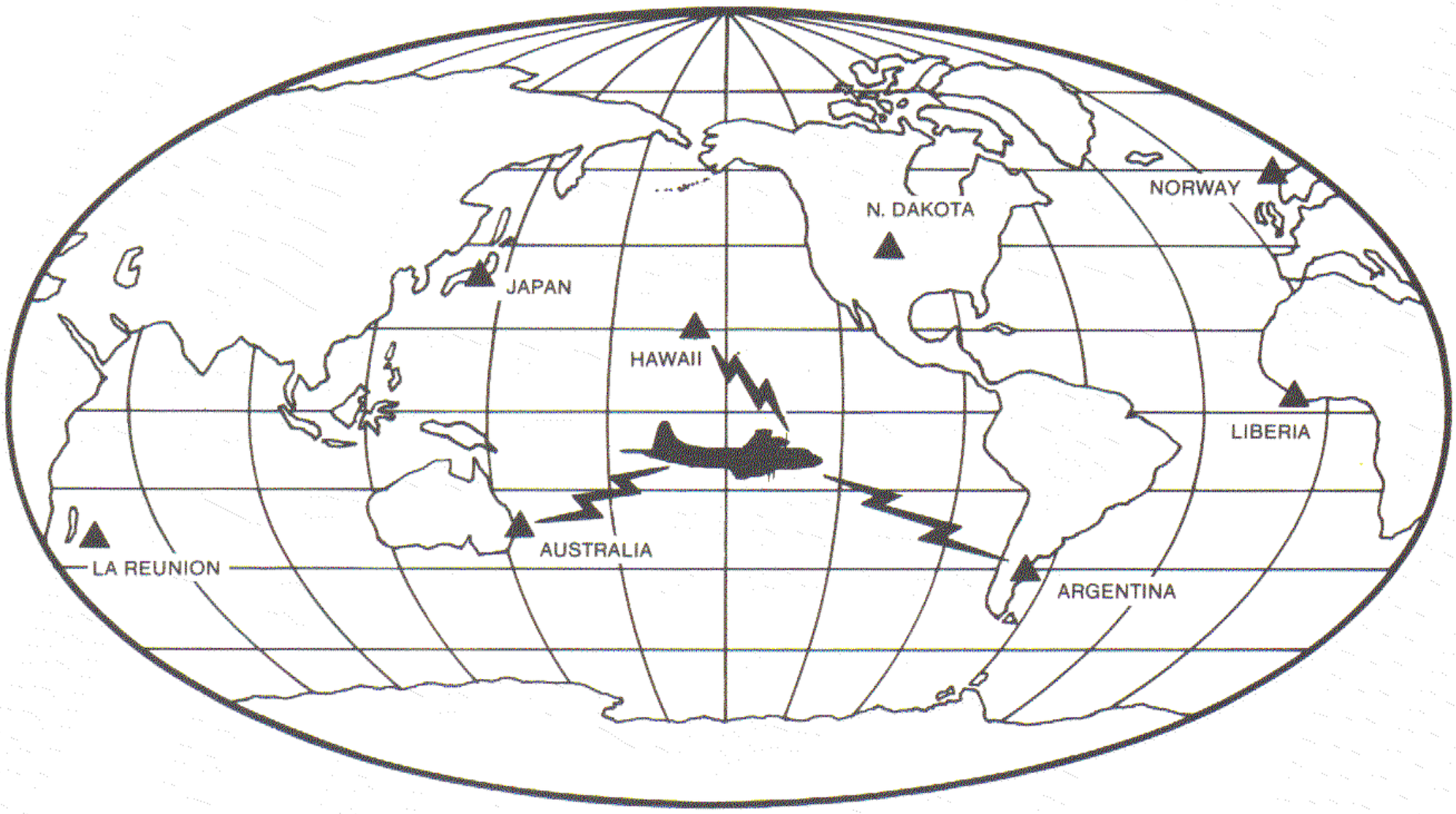
Earth Errors The wide variations of the earth's physical characteristics also affect Omega signal propagation and the accuracy of Omega navigation measurements. Errors produced by the effects of earth's varied physical characteristics on Omega navigation signals are called earth errors. Three major causes of earth errors are distortions of the earth's spherical shape, distortions of the earth's magnetic field, and the effects that the earth's wide variety of surface features have on Omega signal propagation.

Since the earth is not a perfect sphere, the areas between adjacent lines of latitude and longitude are not the same throughout the world (see Figure 8). These variations of the earth's shape are called *spheroidal distortions.* The aircraft's Omega system computer is programmed to compensate for the earth's spheroidal distortions while it is tracking the aircraft position, otherwise the Omega position fixes would be inaccurate. To perform these calculations, the Omega computer must be given the aircraft's precise geographic location when the Omega system is initialized. Accurate initialization is essential to Omega system accuracy.

The earth's magnetic field affects the accuracy of any precise navigation system because it varies in strength at different locations on the earth's surface (see Figure 9). These variations are called *magnetic field distortions.* The Omega system computer will compensate for magnetic field distortions, provided that the exact local geographic coordinates are entered when the system is initialized. Again, accurate initialization is essential.

Earth's diverse surface has the most complex effect on Omega navigation system signal propagation. These surface characteristics are called *topographical factors.* For example, large surface areas of water are excellent VLF signal conductors, and

Figure 8. Spheroidal Distortion Effects. The Omega System compensates for the effects that the earth's nonspheroidal shape has on the signal paths from the Omega transmitters to the Omega receiver.



they pass Omega navigation signals with ease. On the other hand, the surface effect of land masses on Omega VLF signals varies, depending upon the vegetation cover and the terrain. The worst surface condition for VLF signal propagation is ice, as is found in the polar regions. During the years that Omega has matured as a viable, long-range radio navigation system, considerable data have been collected to produce an accurate physical map of the earth's surface. With a program based upon this information, the Omega system computer can make suitable compensation for the earth's varied topographical factors while it is tracking the aircraft's position.

System Errors As mentioned previously, system errors are those navigation errors produced by the Omega system's own signal processing system. System errors can be virtually eliminated at the system's design stage by incorporating self-calibration techniques, and by using modern, stable, solid-state electronic components. For example, the LTN-211 Omega Navigation System automatically verifies the calibration of its antenna system, and it constantly runs a systems check while it is operating.

OMEGA SIGNAL PROCESSING The preceding discussion of the Omega system's main error sources clearly shows why the computer is essential to Omega navigation. During flight, the Omega navigation system must compensate for these error sources continuously. The use of microprocessors has enabled the Omega navigation system to

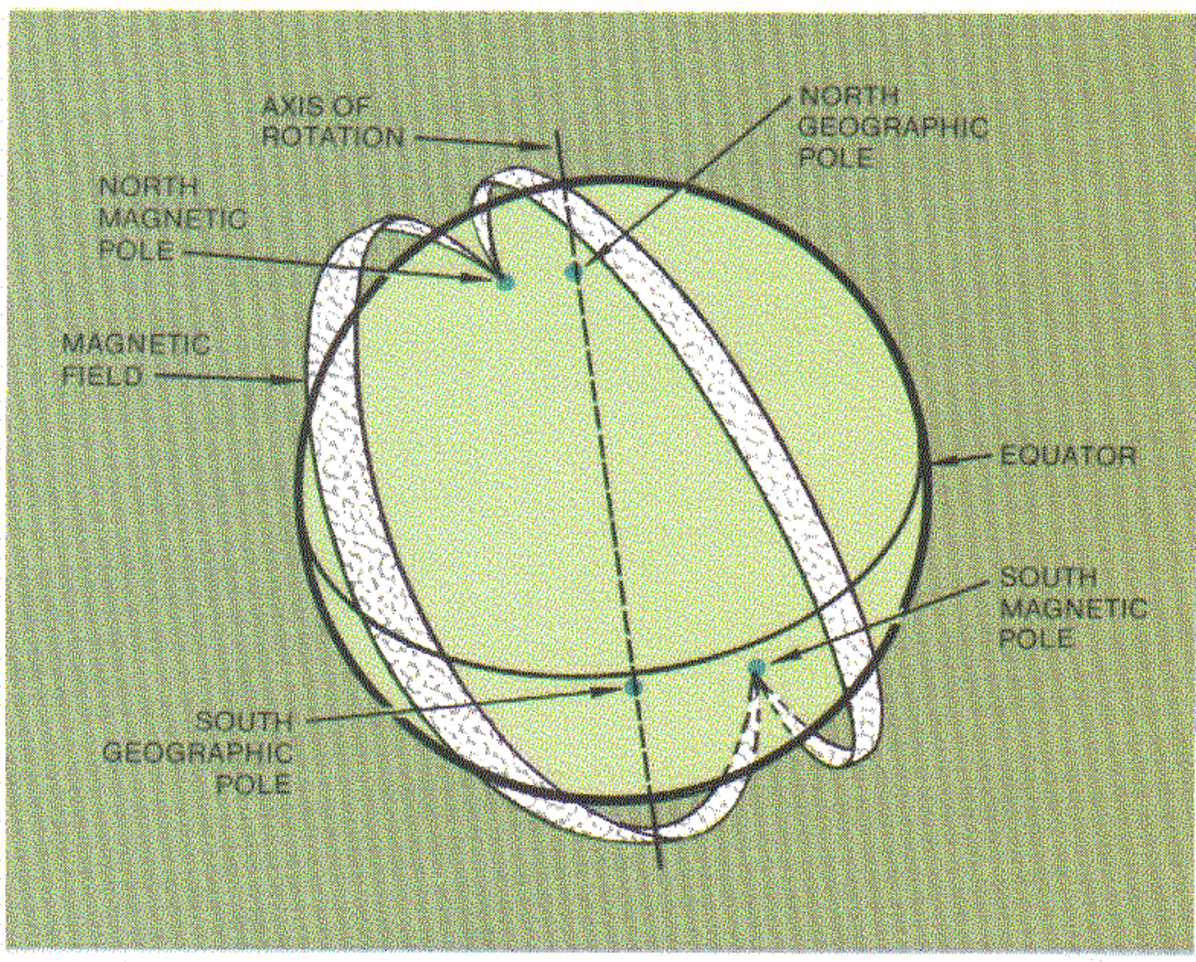


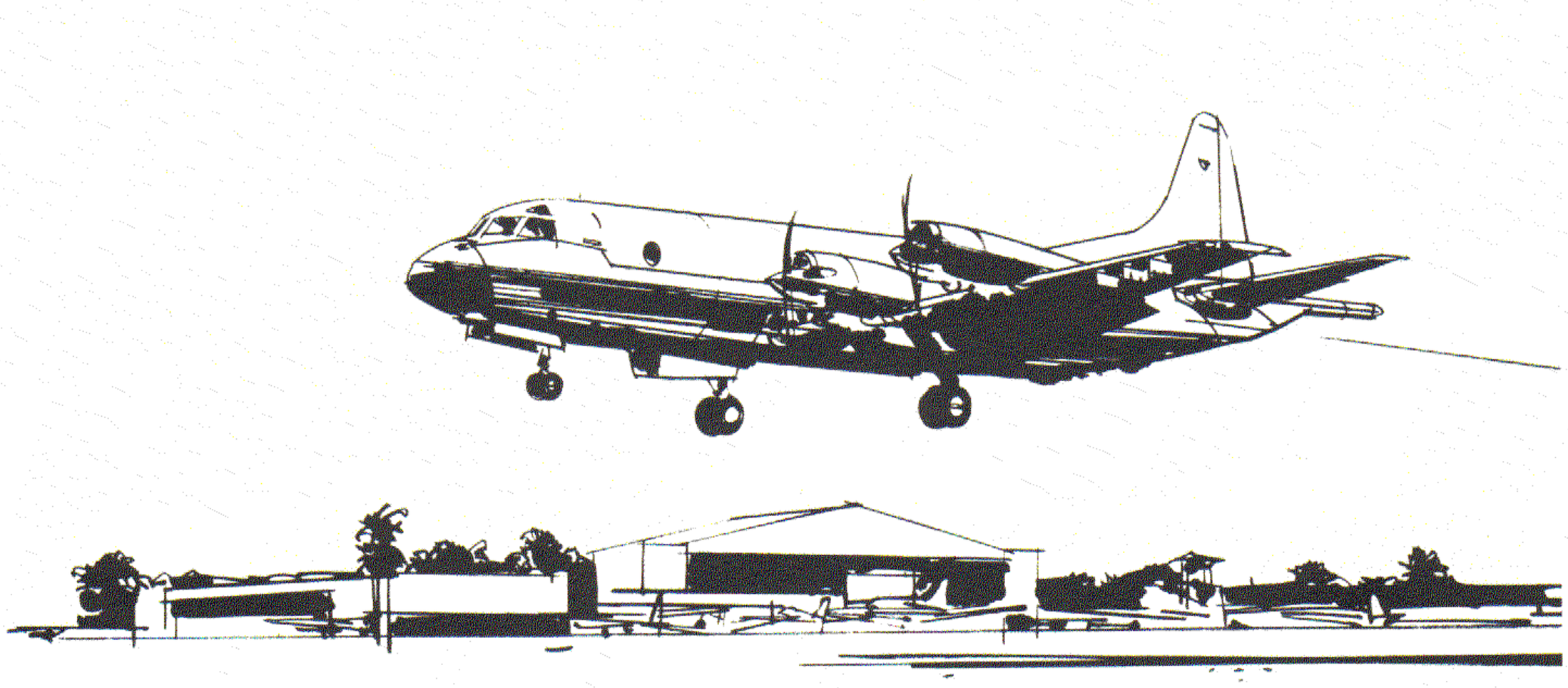
Figure 9. Magnetic Field Distortion Effects. The strength and direction of the earth's magnetic field affect Omega signal frequency and the direction of signal travel.

process this information rapidly, so that the system can track the position of the aircraft in real time.

The aircraft's Omega navigation system must be initialized prior to takeoff. During this procedure, the NAV/COMM operator must enter the time-of-day in Greenwich Mean Time (GMT), the date, and the local geographic coordinates. During subsequent flight, all of the aircraft's Omega position calculations will be based upon these data. As the Omega computer tracks aircraft position, it compares the current GMT with data stored in its memory to compensate for signal propagation errors that are due to diurnal effects. The computer uses the current date in its calculations to compensate for the effect of seasonal changes of the earth's physical characteristics on Omega signal propagation. The computer requires LAT/LONG coordinates (entered during initialization) to calculate the real-time position of the aircraft, and to compensate for the effects of the earth's spheriodal distortions and topographical factors on Omega VLF signal propagation.

As the Omega system tracks the aircraft's position, the computer's calculations are passed into tracking filters. The tracking filters employ time as a factor to average and further smooth the aircraft position calculations. The LTN-211 Omega Navigation System uses twenty-four tracking filters, one filter for each of the three VLF radio signal frequencies transmitted by each of the eight Omega stations. This signal error compensation feature makes the LTN-211 Omega Navigation System a "stand-alone" system, a system that does not depend upon the aircraft's tactical computer to make navigation calculations. This is important to a tactical aircraft like for mission calculations. The LTN-211 Omega System can also be updated with improved programming (when available) without affecting the tactical computer's software. The manufacturer of the LTN-211 system accomplishes this by making a simple change to the system firmware.

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PART II -- LTN-211 OMEGA NAVIGATION SYSTEM



GENERAL

The LTN-211 Omega Navigation System is a world-wide, all-weather radio navigation aid. The system has a bounded error capability (the error is predictably controllable) for long-range, great circle navigation that enables it to fix the aircraft position with an accuracy of within two miles during the day, and within four miles at night. The system displays the real-time position of the aircraft in latitude and longitude. It can also display the track angle, desired track angle, waypoint positions, the distance and time to waypoints, and the wind direction and velocity.

All non-Update P-3C aircraft are being equipped with the LTN-211 Omega system by incorporation of P-3 Airframe Change No. 414. Update

P-3C aircraft are production-equipped with the AN/ARN-99 Omega Navigation Set. In addition to P-3C Orion non-Update aircraft, LTN-211 Omega equipment has been installed on numerous other types of commercial and military aircraft.

The LTN-211 Omega system installed on the P-3C Orion also can continuously monitor signals transmitted by nine VLF communication stations that are operated by the U.S. Navy, using these signals in a backup navigation mode if the quality of Omega transmission reception becomes unacceptable. This feature greatly reduces the likelihood that the NAV/COMM operator will misinterpret the aircraft position because of reliance on invalid Omega navigation data. If unacceptable signal reception during flight makes both the Omega and VLF navigation modes unavailable, the LTN-211 system will switch to operation in the Dead Reckoning mode.

The NAV/COMM operator initializes the Omega system prior to takeoff by turning it on, and then entering the time-of-day in GMT, the date, and the local geographic coordinates. Once these data have been entered, the system automatically synchronizes its crystal-controlled oscillator clock with the transmissions from the ground-based Omega and VLF communication stations. The system then selects the three Omega stations with the best quality transmission reception (but not stations that would provide wrong-way signals or modal interference), then uses their signals as references for solving the navigation problems. The only data that the Omega system needs from other aircraft systems are the aircraft heading and true airspeed inputs, plus a weight-on-wheels signal to inform the Omega system that the aircraft is on the ground.

Once the Omega system is initialized, the NAV/COMM operator enters the geographic coordinates of the mission's various waypoints and the final destination. After these data are entered and the first track leg is initiated, the Omega system can automatically navigate from waypoint to waypoint, providing the operator with continuous navigation data. At any time during the flight, the NAV/COMM operator can bypass waypoints, change waypoint positions, and employ several methods of changing position tracking to accommodate flight plan changes. At this point in this article, the reader is reminded that he must refer to the official NAVAIR documents for approved LTN-211 Omega Navigation System operating and maintenance procedures. These procedures are presented in the NAVAIR 01-75PAC-1.1

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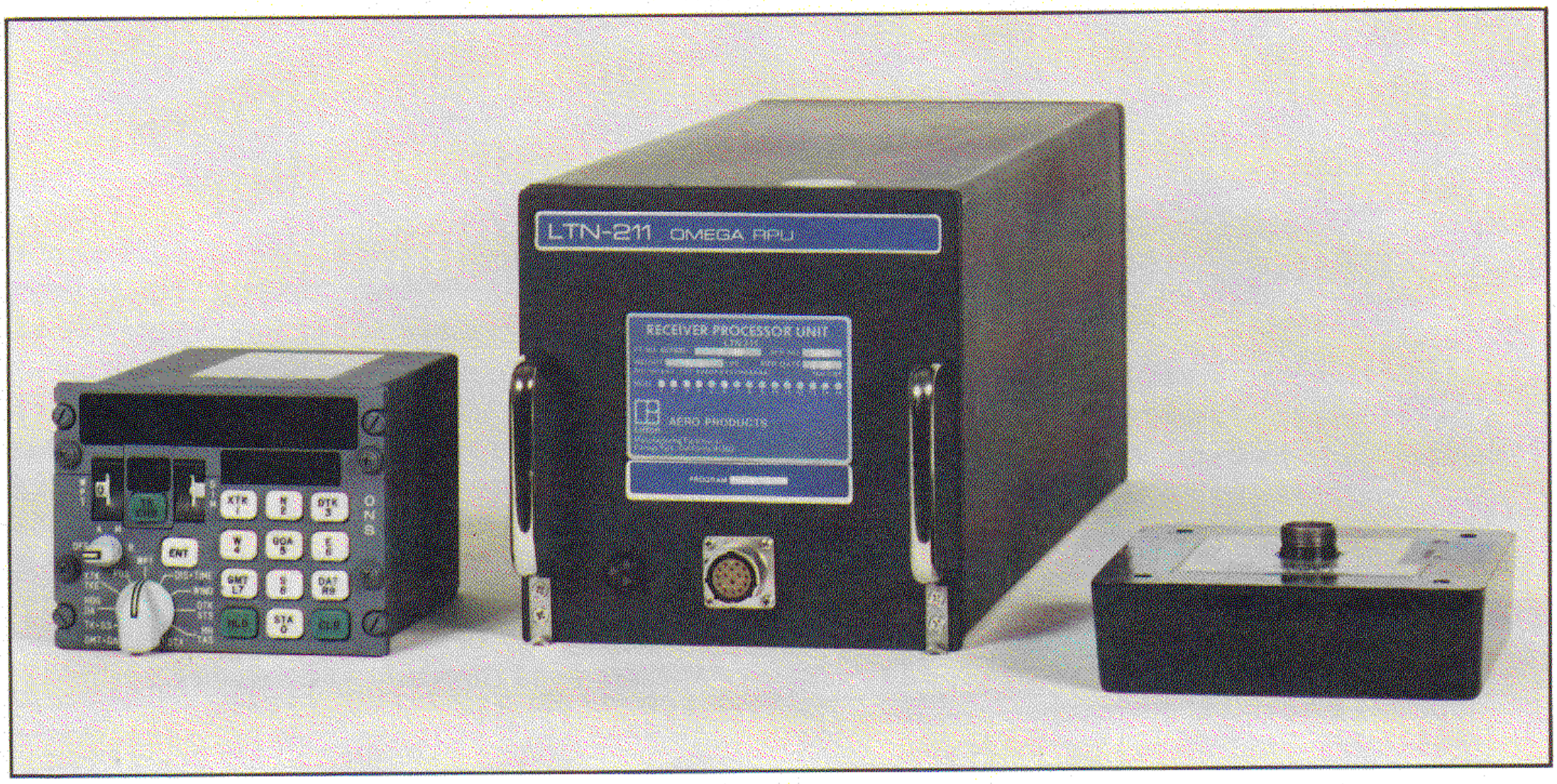


Figure 10. Litton LTN-211 Omega Navigation System Control-Display Unit, Receiver-Processor Unit, and Antenna Coupler Unit.

Table II. Basic Characteristics of the LTN-211 Omega/VLF Radio Navigation System.

	RECEIVER PROCESSOR UNIT	CONTROL DISPLAY UNIT	ANTENNA COUPLER UNIT	TOTAL
SIZE (INCHES)	7.5 W x 7.6 H x 19.6 D	5.75 W x 4.5 H x 6.55 D	18.0 L x 10.5 W x 1.75 H	–
VOLUME (CU. IN.)	1120	158	211	1489
WEIGHT (LB)	26	3.8	8.0	37.8
POWER (WATTS)	62	24	1	87
COOLING (LB/MIN)	0.3	NONE	NONE	0.3

NATOPS Flight Manual, NAVAIR 01-75PAC-2-10 Maintenance Instruction Manual, and the NAVAIR 01-75PAC-12-3 NAV/COMM Crew Station Organizational Maintenance Manual.

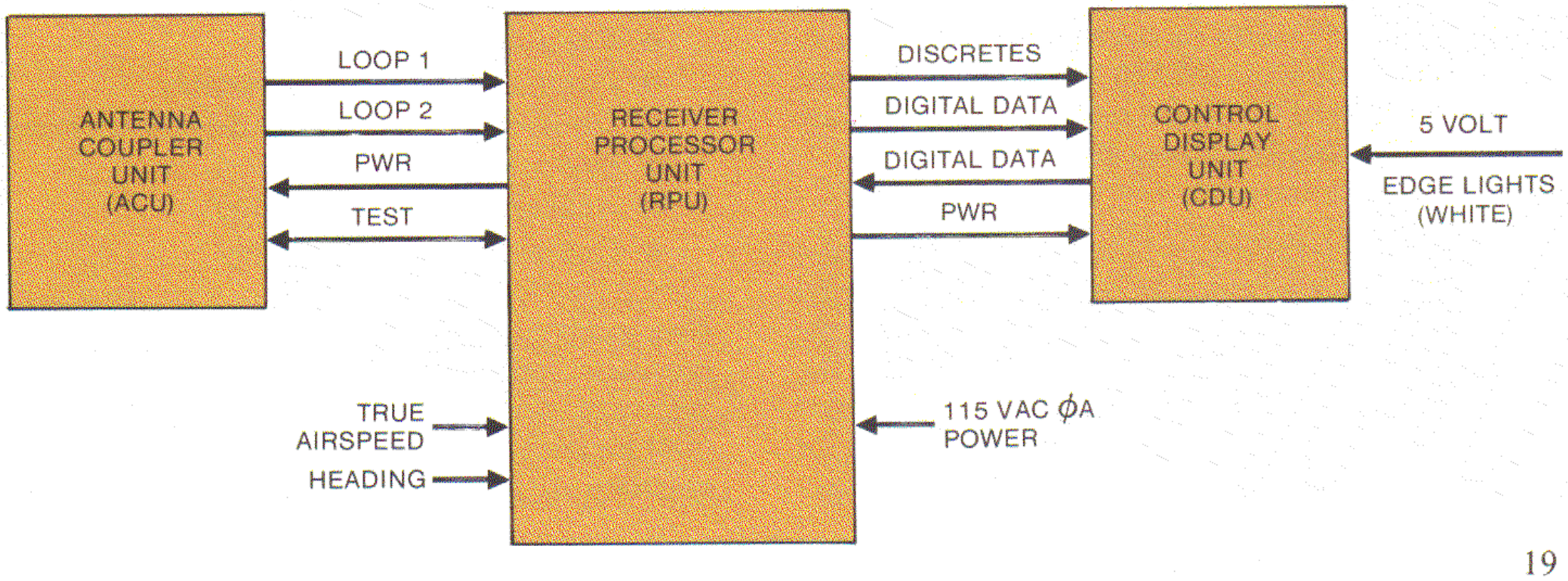
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SYSTEM COMPONENTS

The LTN-211 Omega Navigation System is composed of three Weapons Replaceable Assemblies (WRAs): the Receiver-Processor Unit (RPU), the Control-Display Unit (CDU), and the Antenna Coupler Unit (ACU). These primary system components are shown in Figure 10, and their basic specifications are listed in Table II. The LTN-211 Omega system is a self-contained, stand-alone system that requires no connection to the aircraft tactical computer. All Omega navigation data are displayed on the CDU. The LTN-211 Omega system provides no outputs to other aircraft equipments or displays. The Omega system is powered with 115 VAC Phase A power from Main AC Bus A in the Main Electrical Load Center. A block diagram of the LTN-211 Omega system is shown in Figure 11.

RECEIVER-PROCESSOR UNIT The Receiver-Processor Unit is the principal unit of the LTN-211 Omega Navigation System, and is located in Elec-

Figure 11. LTN-211 Omega Navigation System Functional Signal Flow Schematic.



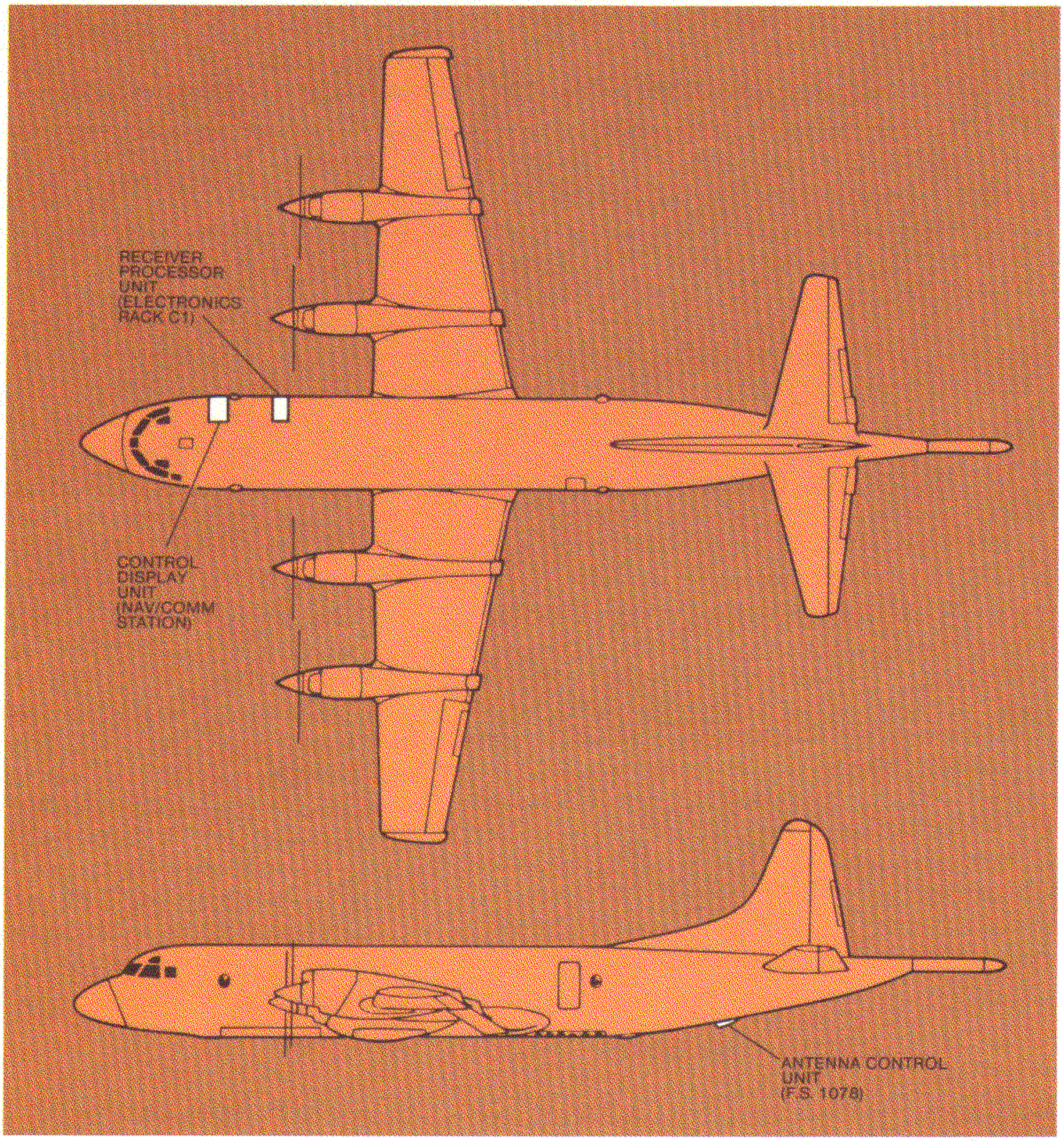


Figure 12. P-3C LTN-211 Omega Navigation System Component Locations.

tronics Rack C1 (see Figure 12). It contains the receiver, the precise phase-measuring circuitry, the computer, and the power supply. Figure 13 shows the RPU with its cover removed. A Built-In-Test Equipment (BITE) indicator and a test connector (used for Depot repair of the WRA) are installed in the RPU front panel.

The Receiver-Processor Unit separates the three Omega signals received from each of the selected Omega stations, and compares them with the transmission pattern information stored in the system computer memory. The RPU computer performs calculations, and prepares the results for display on the Control-Display unit. These functions are contained within the RPU's six Shop Replaceable Assembly modules listed below:

- Receiver Assembly
- Computer/Processor Assembly
- Ultraviolet Erasable Read-Only Memory
- Power Supply Assembly
- Analog Interface Assembly
- Digital Interface Assembly

The receiver assembly contains four individual precision receivers and associated phase measurement circuits. One independent channel is used for each of the three basic Omega radio frequencies (10.2 kHz, 11.33 kHz, and 13.6 kHz). A

Courtesy Litton Aero Products

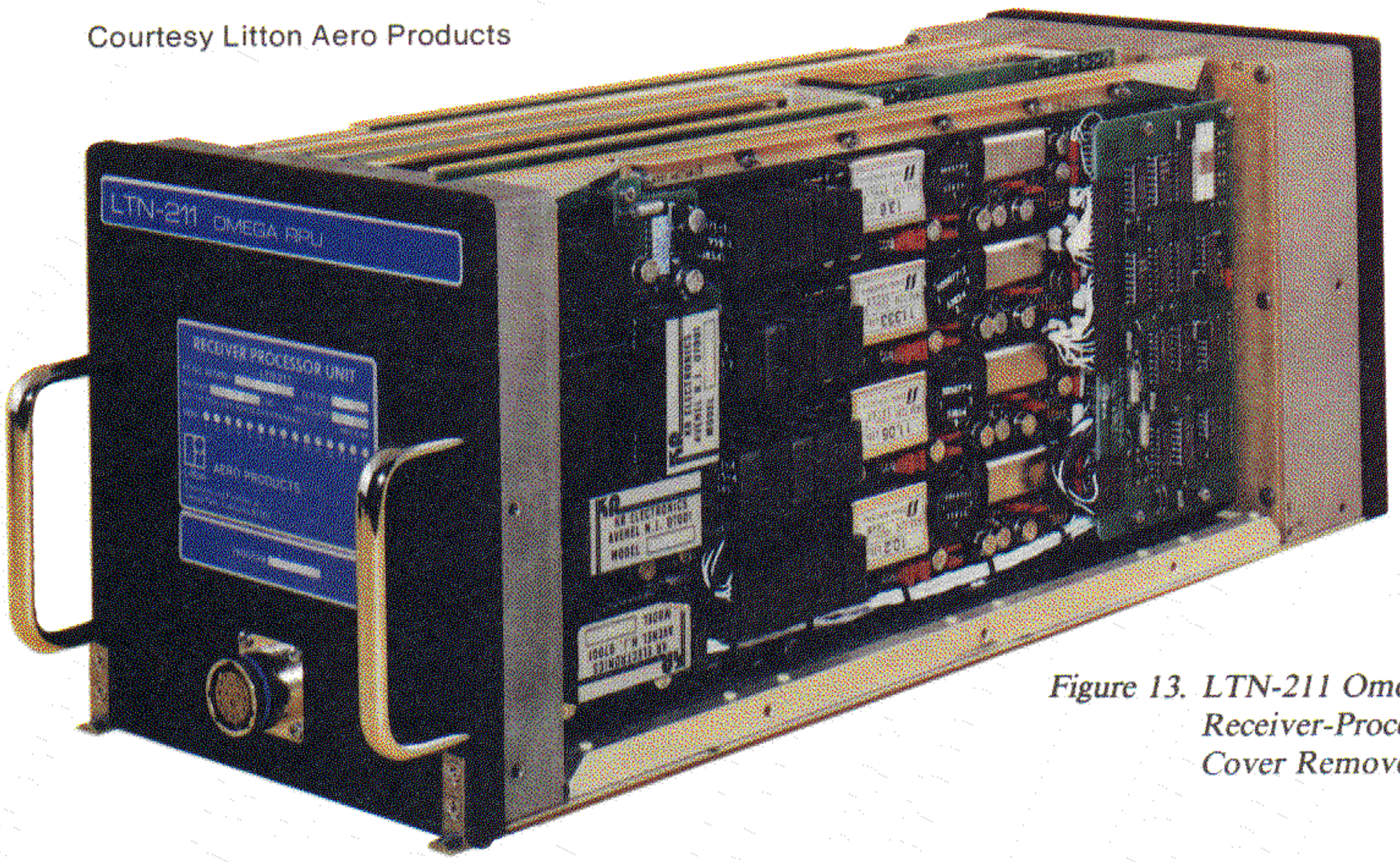


Figure 13. LTN-211 Omega Navigation System Receiver-Processor Unit, with Cover Removed.

fourth channel (11.05 kHz) is used to process VLF Communication station signals. The Computer/Processor contains the precision local oscillator and clock circuits, as well as the system microprocessor.

The Ultraviolet Erasable Read-Only Memory assembly (UVE-ROM) is a programmable memory unit that contains the Omega operational program. The LTN-211 system manufacturer can alter this program for updates, if required, by using a computer-controlled programming adapter. Ordinary light will not damage the UVE-ROM assembly memory, and only lethal doses of x-rays or cosmic rays can cause memory erasure.

The Power Supply contains voltage monitors that will shut down the system in case of excessive voltages or current loads. The Analog and Digital Interface cards furnish the RPU with the circuitry necessary to provide the Omega system's ARINC and discrete outputs.

CONTROL-DISPLAY UNIT The Control-Display Unit is located at the NAV/COMM Station (see Figure 12). The operator controls, operates, and tests the LTN-211 Omega navigation system by making inputs with the CDU. He uses the CDU to transmit position coordinates, the time, date, waypoints, and other manually-entered data to the Receiver-Processor Unit. The LTN-211 Omega system has capability for additional interfaces through which external devices can control system operation and data display, but the P-3C does not use them. Instead, the Orion relies on the CDU for these functions and uses the LTN-211 as a stand-alone system.

Operation of the Control-Display Unit is straightforward. The CDU control panel is shown on Figure 14. Data entry is via a standard pushbutton

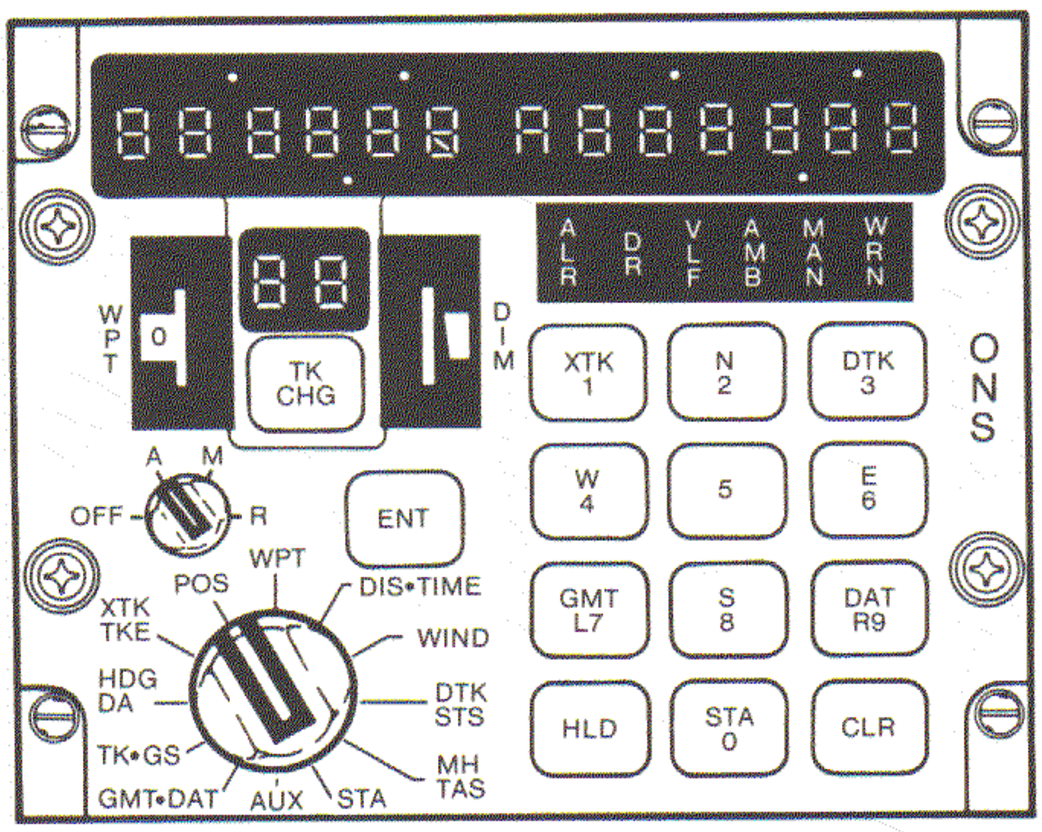


Figure 14. LTN-211 Omega Navigation System Control-Display Unit Control Panel for P-3C Aircraft, with VLF Communication System Navigation Option.

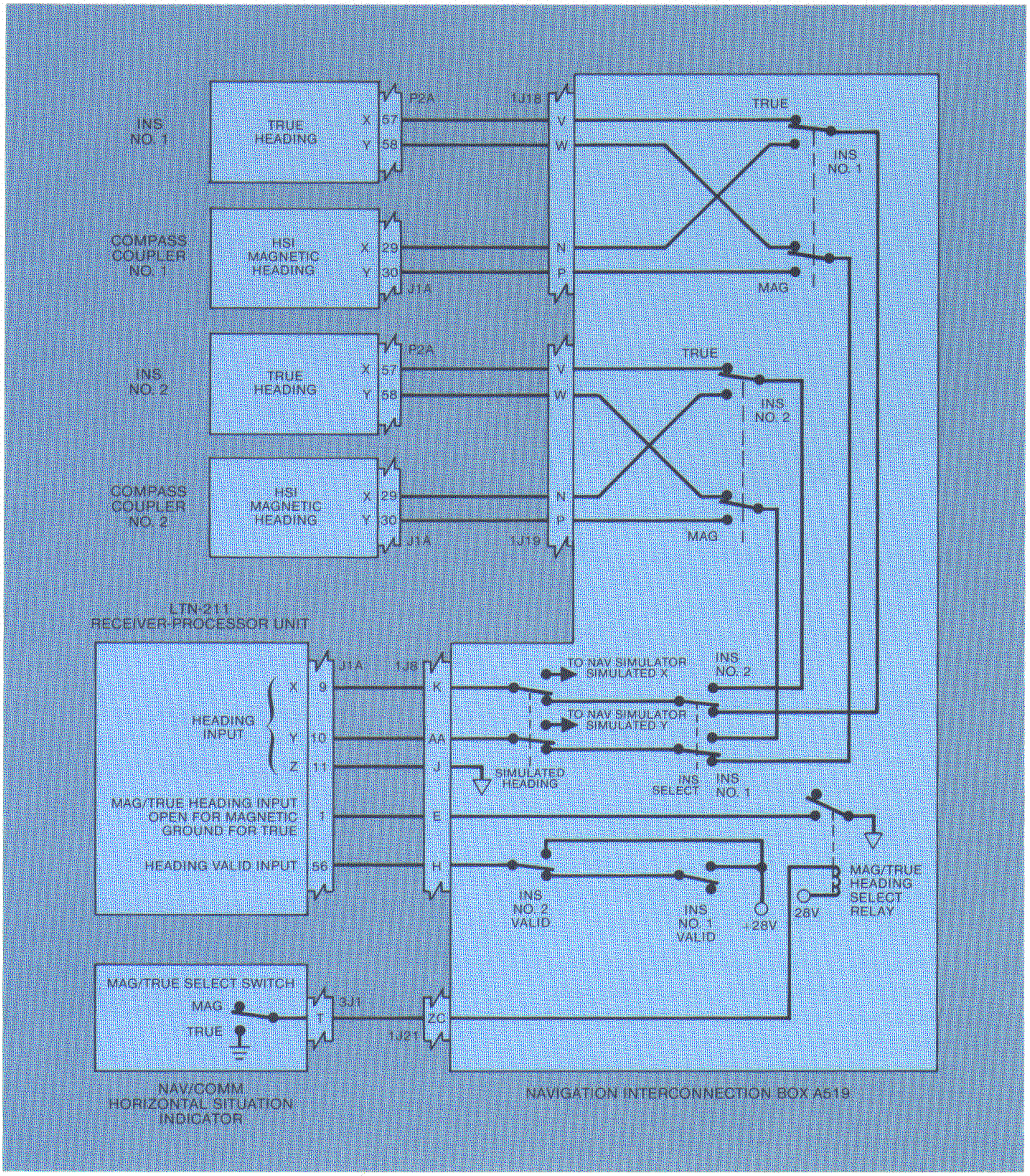


Figure 15. P-3C Aircraft Heading Input Interconnection Schematic for the LTN-211 Omega Navigation System.

keyboard, and the navigation and built-in-test data are presented to the operator on two digital displays. The mode selector switch enables the operator to turn the system on, and to select the mode of system operation – automatic, manual or remote. The operator selects data for presentation on the left and right digital displays with the display selector switch. Annunciator lights alert

the operator to Omega system conditions or events that require his attention or action. Navigation waypoints are inserted and displayed with the WPT selector thumbwheel, and with the From/To and Waypoint digital display. Brightness of the CDU digital displays is controlled by the DIM thumbwheel.

When the Omega system performs its internal built-in-test functions, the Control-Display Unit displays a specific numeric readout for each test as it is performed, and likewise indicates which test reveals a fault. This feature is discussed later in more detail in the Maintenance section of this article.

ANTENNA COUPLER UNIT The LTN-211 Omega Navigation System Antenna Coupler Unit is installed on the bottom of the fuselage at F.S. 1078 (see Figure 12). The ACU contains the system's bidirectional H-field ferromagnetic antenna elements, two highly-selective low-noise preamplifiers, and the associated antenna selection circuitry. The antenna selection circuits and preamplifiers amplify the Omega signals directly from the two ferrite antennas in order to achieve the maximum signal-to-noise ratio (SNR).

Radio transmissions are made up of both E-fields and H-fields. The E-fields are associated with electrostatic waves, while H-fields are associated with magnetic fields. Omega navigation systems can be designed to use antenna systems that receive either E-field or H-field transmission signals, depending upon the system design requirements. The LTN-211 Omega system uses a bidirectional H-field antenna unit because this type of antenna is insensitive to precipitation static. This results in less interference to signal reception from static charges that accumulate on the aircraft skin.

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AIRCRAFT INPUTS

The LTN-211 Omega Navigation System requires certain aircraft data inputs to enable its internal computer to calculate the aircraft's dead reckoning position and to relate these data to the Omega navigation computations. These inputs are the aircraft heading, true airspeed, and the weight-on-wheels signal. If these signals are not available to the Omega system or if the signals are invalid in any manner, the Omega system self-test will indicate a failure. If a failure occurs, the Control-Display Unit will display the appropriate malfunction code(s) to indicate which signal is erroneous. System malfunctions are discussed later in the Maintenance section of this article.

HEADING INPUTS The aircraft Heading Input signal to the LTN-211 Omega system is a standard analog synchro signal, with electrical zero equal to 0 degrees. The Heading Input Valid discrete signal to the Omega system is +28 volts for a valid heading and zero for an invalid heading. Figure 15 is an interconnection schematic that shows the Heading Input signal flow to the LTN-211 Omega system. With this schematic, the reader can trace the aircraft heading inputs and discrete signals to their origins.

The NAV/COMM operator selects either the magnetic or true aircraft heading input by actuating the MAG/TRUE toggle switch on the operator's Horizontal Situation Indicator Control Panel. This switch, in addition to selecting the heading reference, controls a relay in the Navigation Interconnection Box that closes or opens a switch that is in series in the Magnetic/True Heading circuit (see Figure 15). When MAG is selected, the relay is deenergized, and the switch is opened. The open circuit input signals the RPU that magnetic heading inputs are being supplied to the Omega system. When TRUE is selected, the relay is energized, and the switch is closed. This grounds the circuit, which signals the RPU that the aircraft is supplying true heading inputs to the Omega system.

The LTN-211 Omega system requires true heading for the navigation calculations. When Magnetic Heading is selected as the aircraft heading input, the LTN-211 Omega computer converts these signals to True Heading by adding the local

magnetic variation (MAG VAR) to the magnetic heading signal. The computer uses an internal algorithm to derive the MAG VAR value from the aircraft's geographic location, therefore it does not require a MAG VAR input from the aircraft.

TRUE AIRSPEED INPUTS The True Airspeed (TAS) input signal interconnection schematic for the LTN-211 Omega system is shown in Figure 16. The True Airspeed computer supplies the Omega system with a standard synchro signal that has a range of 70 to 450 knots and a scale factor of 36 degrees per 100 knots. The True Airspeed input excitation signal is 26 VAC Phase B 400 Hz, and the TAS Valid input is the same 26 VAC signal. The TAS Valid signal comes from the TAS Valid On Relay, which is mounted in Electronics Rack C1. This relay is actuated by the TAS POWER ON signal. The TAS ID connection on the Receiver-Processor Unit tells the LTN-211 system computer which type of airspeed system the airplane uses. The specific connection shown in Figure 16 tells the Omega computer that the P-3C Orion aircraft uses a KIFIS B-type[1] TAS System.

INPUT PROCESSING The Omega system computer takes True Airspeed and Heading synchro inputs every 0.1 second to update the system's dead reckoning position. The TAS input is filtered with a 1.0 second time-constant, low-pass filter as:

$$TAS_n = TAS_{n-1} + 1/10(TAS_I - TAS_{n-1})$$

Where:

TAS_n is the present filtered value

TAS_{n-1} is the previous value

TAS_I is the new input

Similarly, the Magnetic Heading input is filtered with a 0.5-second time constant. The Magnetic Heading is summed with Magnetic Variation to compute the True Heading.

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[1] Kollsman Integrated Flight Instrumentation System

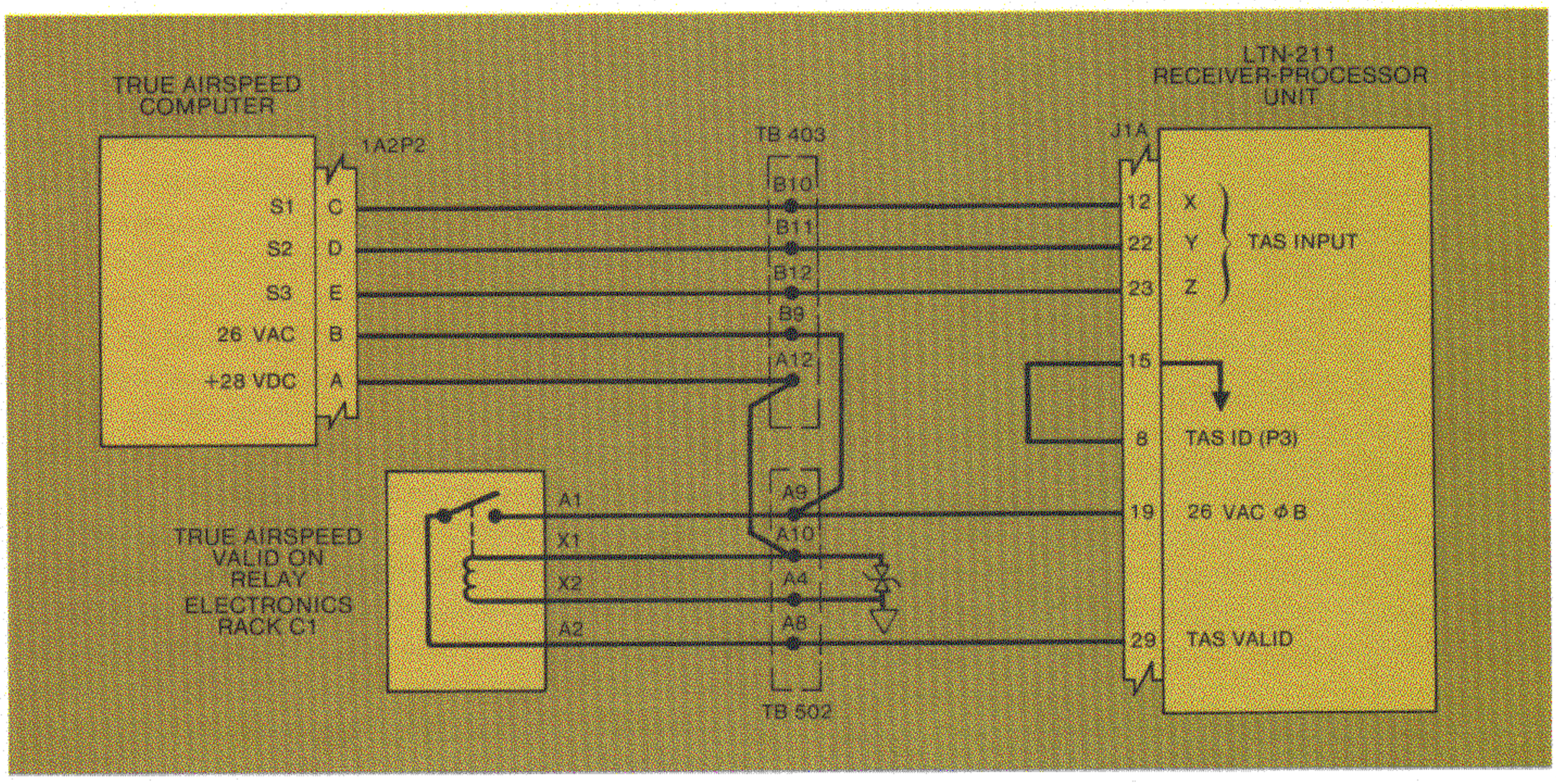


Figure 16. P-3C Aircraft True Airspeed Input Interconnection Schematic for the LTN-211 Omega Navigation System.

True Airspeed and True Heading are combined to give displacements North and East for rate-aiding the tracking filter:

$$\triangle N_c = \triangle N + W_n \cdot \triangle T$$

$$\triangle E_c = \triangle E + W_e \cdot \triangle T$$

These quantities are then used to update aircraft position by:

$$\triangle LAT = \triangle N_c/R_m + H$$

$$\triangle LON = \triangle E_c \text{ secant } LAT/R_n + H$$

Where:

R_m = radius of curvature of the earth in the meridian plane

R_n = radius of curvature of the earth in the vertical east-west plane

H = altitude of the Omega receiver above the reference ellipsoid

Omega System position $LAT_s/LONG_s$ is updated by adding $\triangle LAT_s$ and $\triangle LONG_s$ to the present system calculation.

WEIGHT-ON-WHEELS SIGNAL The weight-on wheels (oleo strut) input to the LTN-211 Omega system is shown on Figure 17 schematic. The Omega system requires this signal for the system to operate properly when the aircraft is on the ground. When the Omega system receives this signal, it filters the inputs to the system computer in order to compensate for the noisy signal conditions that are encountered during ground operations. The response time of the Omega system is also lengthened to reduce system errors caused by extraneous signals that are encountered during ground operation.

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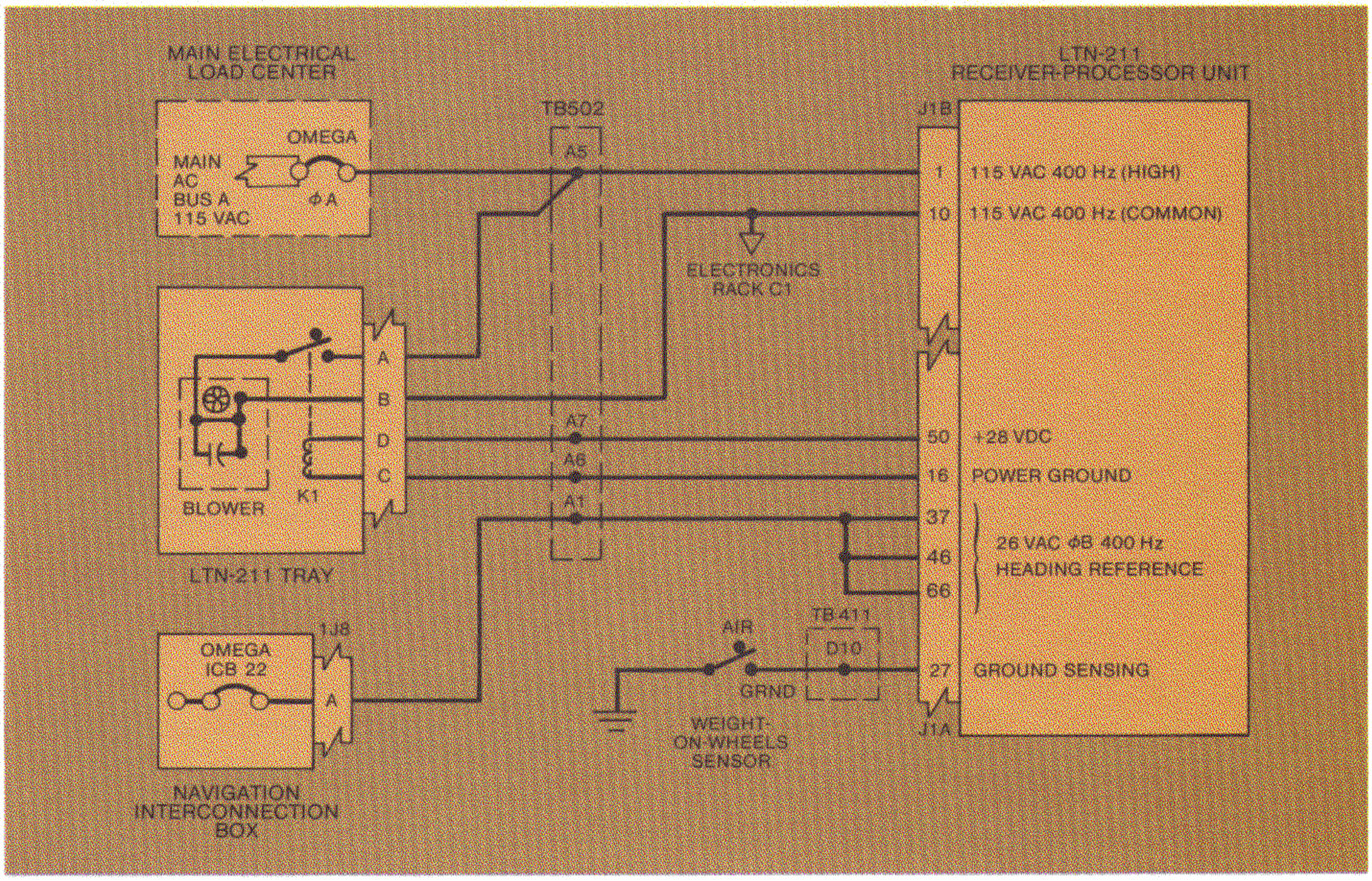


Figure 17. P-3C Weight-On-Wheels (Oleo Strut) and Power Supply Input Schematic for the LTN-211 Omega Navigation System.

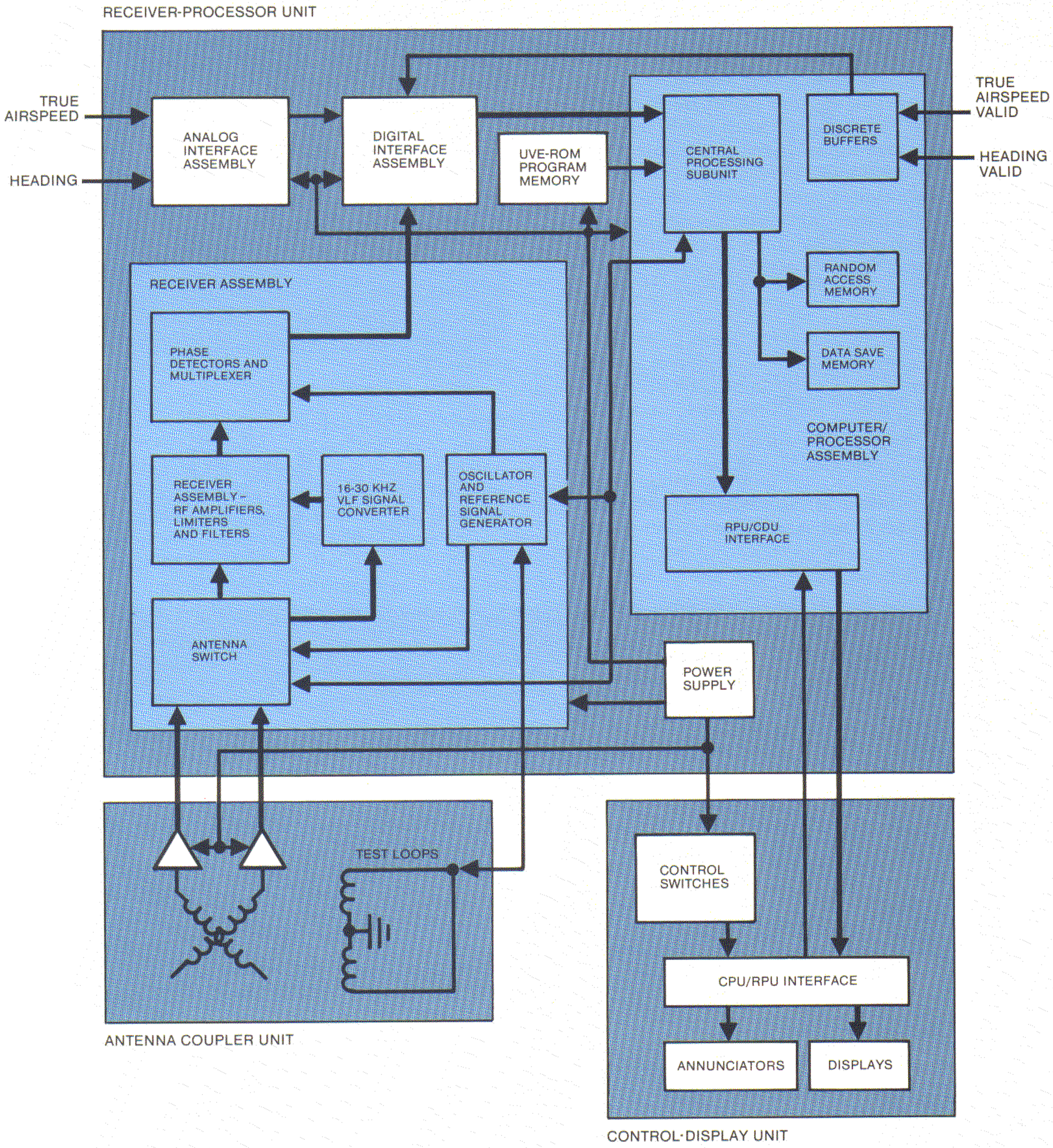


Figure 18. LTN-211 Omega Navigation System Signal Flow Block Diagram.

FUNCTION AND OPERATION

The LTN-211 Omega Navigation System maintenance and operation publications use the term "mode" two ways. In one context, the term "mode" is used to indicate which means of radio navigation is being employed by the Omega system – "Normal" Omega radio navigation, VLF radio navigation, or Dead Reckoning. In the other context, the term "mode" describes how the NAV/COM operator chooses to operate the system – to *manually* enter the navigation track leg at each waypoint, to have the system *automatically* track the aircraft position from waypoint to waypoint, or to *remotely* monitor various navigation data while the Omega system is tracking the aircraft position. The operational procedures for the LTN-211 Omega system are presented in the NAVAIR 01-75PAC-1.1 NATOPS Flight Manual. The following is a brief discussion of the LTN-211 Omega system navigational modes, which for convenience will be called "Radio Navigation Mode Functions."

RADIO NAVIGATION MODE FUNCTIONS The LTN-211 Omega receiver has four independent channels – 10.2 kHz, 11.33 kHz, 13.6 kHz, and 11.05 kHz, each of which processes the signals from the radio navigation station in a similar manner. The 11.05-kHz channel is used for processing navigation data received from the U.S. Navy's VLF Communication stations. The Omega system's VLF adapter converts the VLF Communication broadcast frequencies in the 16-kHz to 30-kHz range to the intermediate frequency of 11.05 kHz. From this point on, VLF Communication signal processing is similar to that for the three Omega signal channels. The LTN-211 Omega Navigation System functions in one of three navigational modes: the "Normal" Omega mode, the VLF Radio Navigation mode, and the Dead Reckoning mode.

Normal Omega Mode During the Normal Omega mode of operation, the LTN-211 system selects the three best Omega stations and uses their signals for radio navigation. The Omega signals are received by the LTN-211 system Antenna Coupler Unit, which is designed to intercept the H-field of signals in the 10-kHz to 30-kHz frequency range. The ACU contains two identical loop antennas and two preamplifiers. The RF loop signals are amplified and routed separately to the Receiver-Processor Unit via a special shielded, twisted-pair cable. Figure 18 is a simplified block diagram that shows the signal flow of the LTN-211 Omega system.

The Omega system computer controls the Receiver-Processor Unit antenna switch to select the loop antenna with the best Omega signal. Loop signal sampling and switching is performed during the 0.2-second rest period between Omega transmission bursts. During the transmission rest periods, test signals are sent from the RPU reference generator to the ACU as end-to-end tests, or as inputs to the receivers for calibration.

Each Omega signal is amplified, filtered, and limited in the Receiver-Processor Unit before it is applied as a sinusoidal signal to the signal phase detector. The phase detector compares the sine wave signal with a stable reference to determine the phase shift of the Omega station signal within one-hundredth of a cycle (centicycle) in a digital format.

The Receiver-Processor Unit calculates the range to each of the computer-selected Omega stations and uses this information to update aircraft position and navigation data. The data are displayed at the Control-Display Unit for the NAV/COMM operator. Communication between the RPU and the CDU is by the ARINC 575 digital data bus.

VLF Navigation Mode If Omega reception signal quality falls below acceptable levels, the Receiver-Processor Unit automatically switches Omega system operation from the "Normal" Omega Navigation mode to the VLF Navigation mode if adequate information about the VLF Communication stations is stored in the computer memory. In the VLF Navigation mode, the RPU computer selects four of the nearest U.S. Navy-operated VLF Communication stations by tuning the VLF Signal Adapter to those station frequencies. (It is necessary for the Omega system to operate for at least 20 consecutive minutes in the Normal Omega mode for the system to accumulate enough data for it to operate in the VLF Navigation mode.) Further station selection may follow, depending on unacceptable station signal-

to-noise ratio (SNR) and other criteria. The computer monitors each of the four selected VLF Communication stations every fifth transmission burst period of the 11.05-kHz signal time slot (see Figure 3). As with system operation in the Normal Omega mode, the antenna loop for a VLF Communication station is selected during the 0.2-second rest period preceding each transmission burst.

Dead Reckoning Mode If both Omega and VLF Communication station signal reception quality falls below acceptable standards, the LTN-211 Omega system automatically switches to the Dead Reckoning mode of operation. In this mode, the Omega system computer tracks aircraft position from the last Omega system position fix by analysis of the aircraft true airspeed and heading inputs. Dead Reckoning accuracy depends upon the accuracy of these aircraft system inputs.

OPERATIONAL MODE SELECTION The NAV/COMM operator can select three modes of LTN-211 Omega Navigation System operation with the Display-Control Unit: Automatic (A), Manual (M), and Remote (R). The Omega system is activated by turning the mode switch from OFF to either A or M. This selects the desired operational mode and starts the system initialization sequence, which will be discussed in greater detail later in this section. But first, the following is a brief explanation of the function to these three position tracking modes.

In the *Automatic mode,* the Omega system navigates through each selected waypoint in sequence, and automatically changes the track leg at each waypoint. The ALR (Alert) annunciator light on the Display-Control Unit illuminates two minutes before arrival at each waypoint, and goes out when the computer automatically enters the next track leg.

In the *Manual mode,* the Omega system navigates from waypoint to waypoint, but the operator must manually enter the next track leg at each waypoint. The ALR light illuminates two minutes before arrival at the selected waypoint, and begins flashing at 0.5-minute before arrival at the waypoint to signal the operator that a track leg change must be entered manually.

During flight, the NAV/COMM operator can select the *Remote mode* to monitor the distance, time and track angle between any two waypoints.

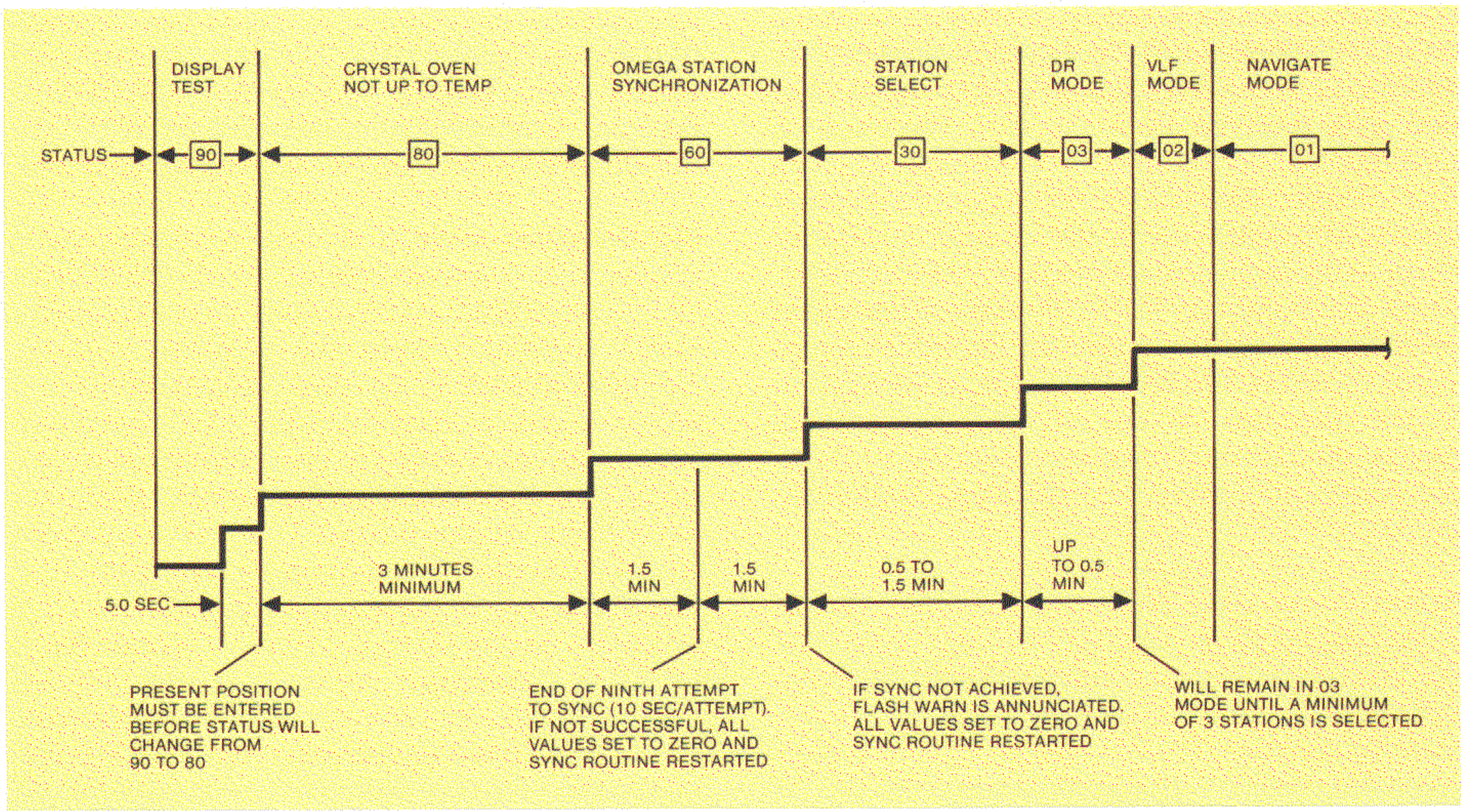


Figure 19. LTN-211 Omega Navigation System Alignment Sequence Diagram.

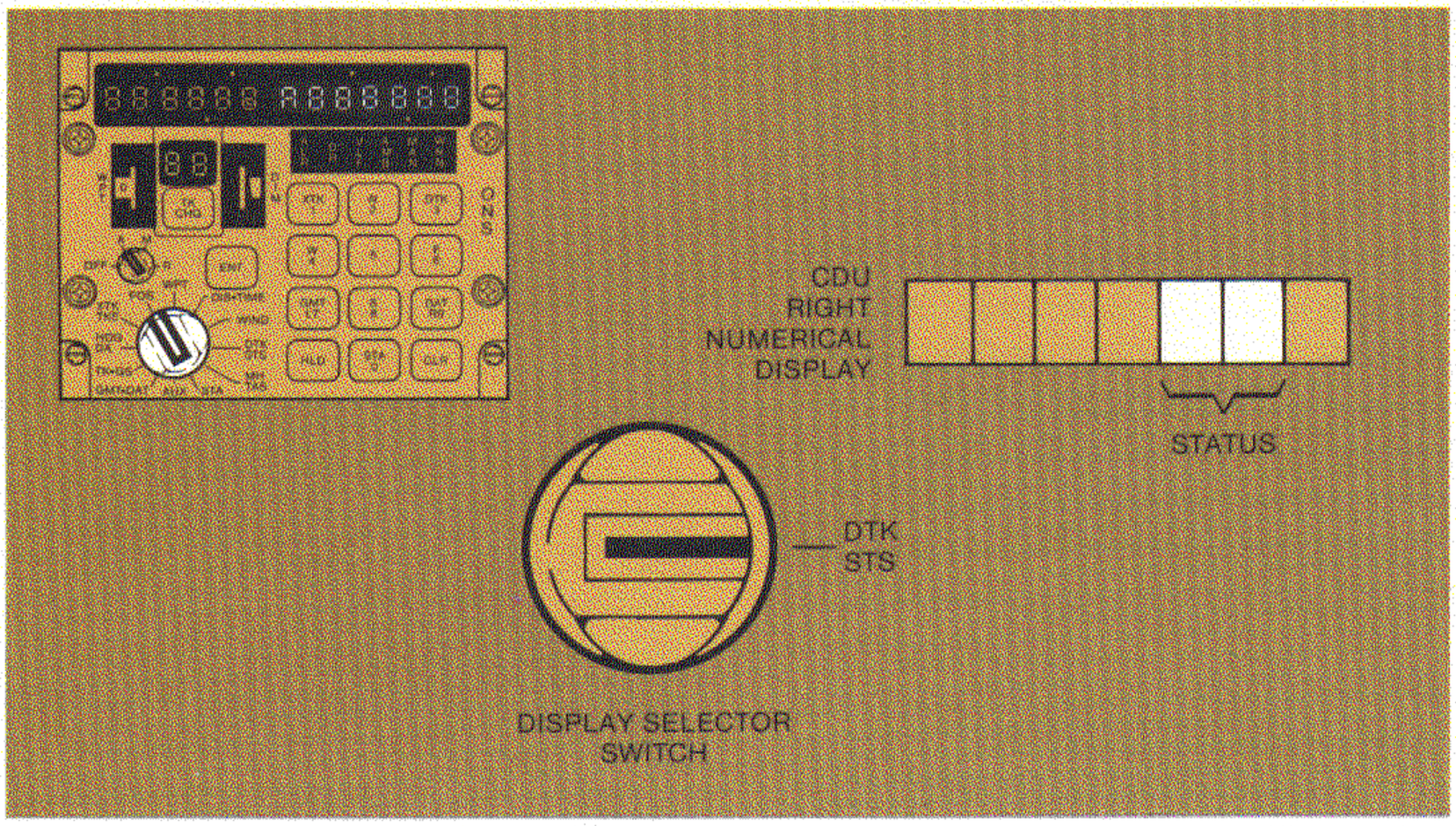


Figure 20. Set the LTN-211 Omega Navigation System Control-Display Unit Selector Switch to DTK/STS During Initialization and Alignment to Observe the System Status Codes.

The operator can also monitor this information from the aircraft directly to any selected waypoint, or from the aircraft to any selected waypoint via the planned flight path. The Omega system's normal position tracking calculation functions are not interrupted when the Remote operational mode is selected.

INITIALIZATION AND ALIGNMENT The LTN-211 Omega Navigation system, as is true of all Omega navigation systems, requires accurate initialization and alignment. During this procedure, the operator enters the current Greenwich Mean Time (GMT), the date, and the Latitude/Longitude (LAT/LONG) of the aircraft's present location. This enables the Omega system to synchronize its crystal-controlled clock oscillator with the Omega transmitting stations, select three Omega stations for reference, and determine the lane count from the aircraft to each of the selected three Omega stations. As explained earlier in the Omega error discussion, the Omega computer also relies on the data entered during initialization to correct for signal propagation errors. Therefore, insertion of accurate initialization data by the operator is essential for accurate Omega calculations. Figure 19 shows the LTN-211 Omega system initialization and alignment sequence.

Each time the Omega system is turned on, its computer performs the initial self-check procedure. The operator can monitor this procedure on the Control-Display Unit during the initialization and alignment sequence by setting the display switch to DTK/STS and observing the status codes (see Figure 20). Table III lists the meanings of these status codes.

Table III. Built-In-Test (BIT) Status Codes Displayed by the LTN-211 Omega Navigation System During the Initialization and Alignment Sequence.

STATUS CODE	DEFINITION
90	SELF-TEST MODE. ENTER PRESENT POSITION, TIME (GMT), AND DATE.
80	RPU OSCILLATOR WARM-UP MODE.
60	OMEGA PATTERN SYNCHRONIZATION MODE. RPU SAMPLES RECEIVED SIGNALS AND COMPARES THEM WITH WHAT THE TRANSMISSION PATTERN SHOULD BE.
30	STATION SELECTION MODE. RPU EXAMINES ALL RECEIVED SIGNALS, REJECTS ANY STATIONS THAT ARE MANUALLY DESELECTED, AND AUTOMATICALLY REJECTS ANY STATION WHOSE SIGNAL DOES NOT MEET ACCEPTABLE STANDARDS. AT LEAST THREE STATIONS MUST BE SELECTED FOR THE OMEGA SYSTEM TO ENTER THE NAVIGATE (01) MODE.
03	DEAD RECKONING NAVIGATION MODE. OMEGA SYSTEM ENTERS STATUS 03 IF OMEGA STATIONS SIGNAL QUALITY FALLS BELOW ACCEPTABLE STANDARDS.
02	VLF NAVIGATION MODE. CAN BE ENTERED ONLY AFTER THE OMEGA SYSTEM HAS BEEN OPERATING IN STATUS 01 FOR AT LEAST 20 MINUTES.
01	OMEGA NAVIGATE MODE.

At the beginning of the initialization and alignment procedure, the first number shown on the Control-Display Unit display is 90. This number indicates that the operator must enter the time-of-day in GMT, the date, and the present position in latitude/longitude. The position data must be entered when the system status display is 90, or the initialization and alignment countdown will not continue. The red WRN light will flash until all data have been entered correctly. After these data have been correctly entered, the initialization and alignment procedure will continue automatically.

Progress of the Omega system initialization and alignment procedure is displayed by the status code display as it decrements from 90, to 80 while the Receiver-Processor Unit is warming up to operating temperature, and then to 60, at which time the system automatically synchronizes its crystal-controlled oscillator with transmissions from the ground-based Omega stations. When synchronization is complete, the system status display decrements from 60 to 30. At this point, the system computer analyzes all received Omega signals.

The Omega computer will reject any Omega stations that have been manually deselected. It also automatically deselects any Omega stations that are within 300 miles or are more than 8000 miles distant, that have known diurnal or modal interference problems, or that have unacceptable signal quality. At least three stations must be selected for the Omega system to decrement from status 30 to status 01, the Navigate mode. Otherwise, the system status will not decrement past 03, the Dead Reckoning mode. The system status also will not decrement past 30 until the date and GMT have been entered. When all Omega system initialization and alignment criteria have been met, the system status will decrement to 01, the Navigate mode, and the Omega system will be ready for normal operation.



The LTN-211 Omega system computer contains a Built-In-Test program that completely checks system operation, and checks to ensure that the operator has properly entered initialization data. Once a function key is pressed and data entry begins, the computer makes the following checks:

- Each key pressed is a valid entry for the function being entered.
- The entered data are complete, in the correct format, and within the proper limits.
- The initialization routine is complete.

When the Omega computer detects a procedural error, it will respond by presenting an operator error (OE) message on the Control-Display Unit right display and illuminate the CLR pushbutton light. No further entries can be made to the Omega system until the error has been corrected. The initialization and alignment self-check procedure is discussed in more detail later in this article in the Maintenance section under Built-In-Test.

OMEGA SYSTEM AUTOMATIC FEATURES Essentially, the LTN-211 Omega Navigation System is an automatic, self-contained system when the Automatic operation mode is selected. Once initialization and alignment are complete, the system can perform without further operator intervention. After the initial aircraft position, date and GMT have been entered, the Omega system computer will automatically check the SNR of the transmissions from the eight Omega stations, and then select the three best stations that meet Omega system operation criteria. The Omega system computer will then continually track the aircraft's position and correct, as necessary, for errors introduced by changes in geographical parameters. The only time that an operator needs to intervene during Omega system operation is to change a waypoint, or to reset the system if power failure occurs.



If Omega signal reception falls below acceptable standards, the system automatically reverts to the VLF Navigation mode and illuminates the VLF annunciator lamp on the Control-Display Unit. If reception of both Omega and VLF Communication station signals is below acceptable criteria for accurate position computation, Omega system operation will automatically revert to the Dead Reckoning mode and illuminate the DR annunciator lamp on the CDU.

In the case of power failure, the Omega system will retain all essential navigation data for a limited time. If the power interruption is less than seven seconds, the Omega system will automatically restore itself to operate when power is restored. If the power interruption is seven seconds or greater, but less than seven minutes, the operator can reset the Omega system by simply entering the current GMT and geographic location (LAT/LONG). Any power interruption longer than seven minutes requires the operator to completely reinitialize the Omega system.

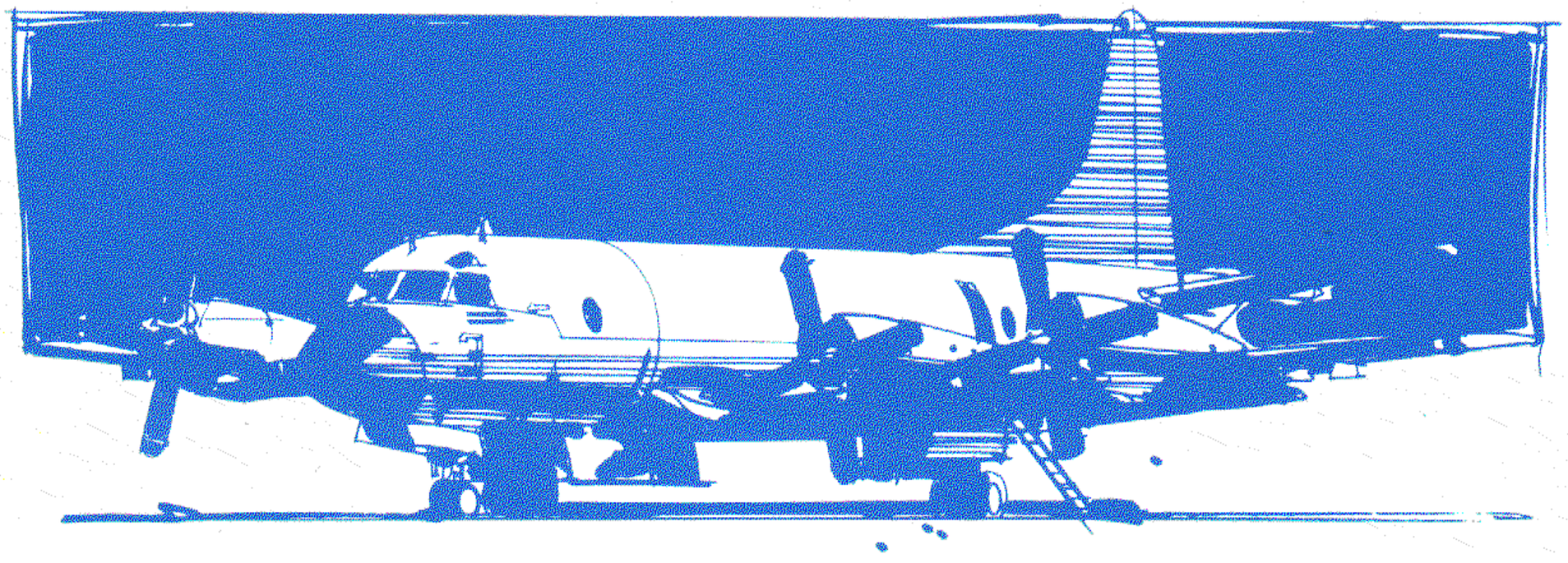
As mentioned earlier, the LTN-211 Omega system has a large variety of operational capabilities besides displaying the current aircraft position geographic coordinates. For example, the Omega system can also display the aircraft track angle, ground speed, heading, drift angle, cross-track and track angle error, desired track angle, waypoint coordinates, distance, estimated time-of-arrival, wind direction and velocity, GMT, and the date. During flight, the NAV/COMM operator can manually insert or change waypoints. True airspeed and aircraft heading can also be inserted manually if the aircraft-supplied inputs fail.

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MAINTENANCE

The basic LTN-211 Omega Navigation System is maintained at the Weapons Replaceable Assembly (WRA) level. The official maintenance and troubleshooting procedures for the LTN-211 system are presented in the NAVAIR 01-75PAC-2-10 Maintenance Instruction Manual and the NAVAIR 01-75PAC-12-3 NAV/COMM Crew Station Organizational Maintenance Manual.

Each time the Omega system is activated, the computer's Built-In-Test program checks the operation of its three WRA units — the Receiver-Processor Unit, Control-Display Unit, and Antenna Coupler Unit. If a defective unit is indicated, it should be replaced and the system BIT again performed by conducting a normal system activation and initialization. However, since the Omega BIT calculations are extremely complex, a system should not be considered to have failed (even though a malfunction is indicated) until several rechecks have been performed to verify the indicated failure. The RPU is most likely to fail because of its complexity, followed by the CDU and the ACU.



System failures are indicated on the Control-Display Unit by illumination of the red WRN annunciator light, accompanied by additional information presented in the numeric codes on the CDU display. These maintenance aids are very helpful to the technician who is troubleshooting the system. A continuously illuminated WRN light indicates that the Omega system has failed and is no longer providing valid data. A flashing WRN light indicates failure of a subassembly, loss of the true airspeed or heading input, or insufficient initialization data.

Omega system failure is also indicated by a trip of the Built-In-Test Equipment indicator on the front panel of the Receiver-Processor Unit (see Figure 21). A test connector is also installed on the RPU front panel to facilitate troubleshooting by upper level maintenance activities.

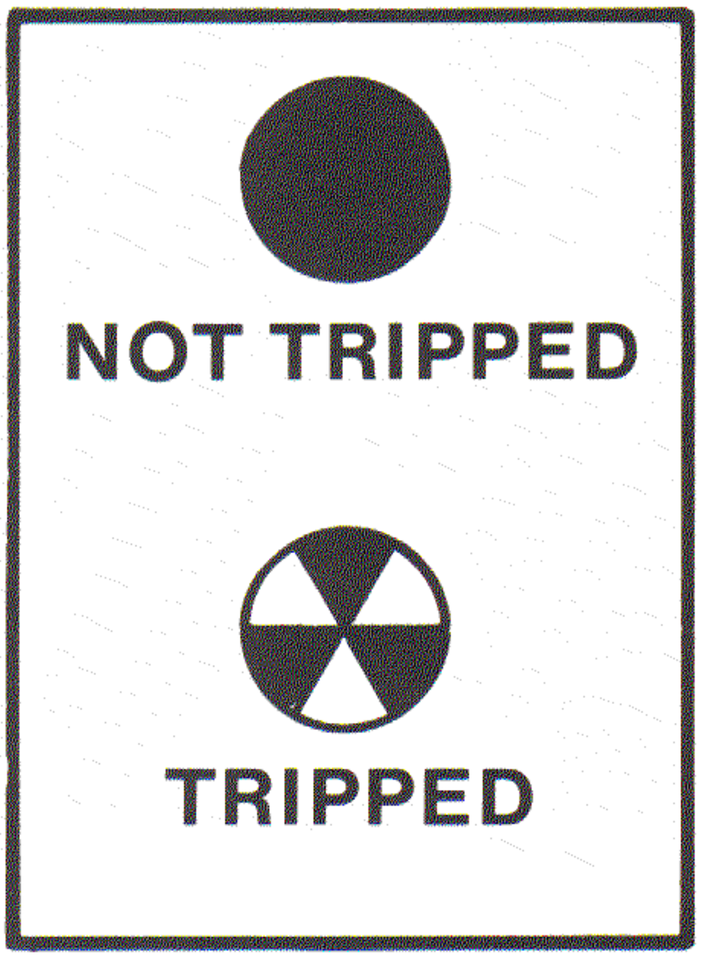


Figure 21. LTN-211 Omega Navigation System Receiver-Processor Unit BITE Indicator.

BUILT-IN-TEST (BIT) The LTN-211 Omega Navigation System computer contains a Built-In-Test program that completely checks system operation each time the system is turned on. After the Omega system enters normal operation, its Built-In-Test program will continuously monitor system performance. It will also monitor transmissions from all Omega stations, and continually select the three best Omega stations for signal analysis. If signal reception quality deteriorates sufficiently, the BIT program will cause the Omega system to revert to the Dead Reckoning (03) mode.

ACTION AND MALFUNCTION CODES If the LTN-211 Omega system Built-In-Test program detects a malfunction, it will illuminate the red WRN annunciator light on the Control-Display Unit. An action code will be presented on the CDU right-hand display when the operator positions the display selector switch to DTK/STS (see Figure 22). By pressing the HLD pushbutton, the operator

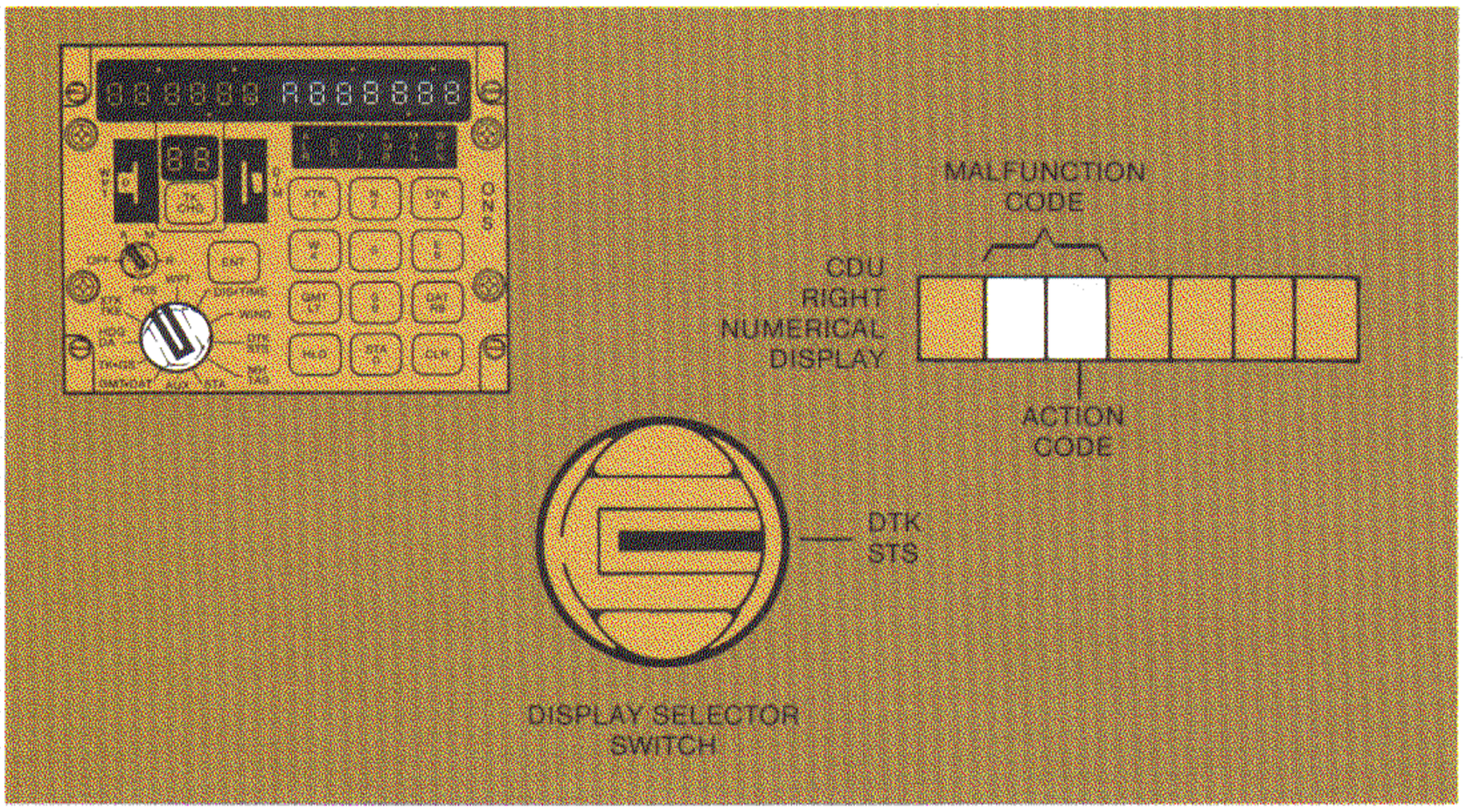


Figure 22. Set the LTN-211 Omega Navigation System Control-Display Unit Selector Switch to DTK/STS When the System Built-In-Test Program Detects a Malfunction in Order to Observe the System Action and Malfunction Codes.

will change the action code to the malfunction code associated with that action code. Repeatedly pressing the HLD button will display any additional information codes present. After all malfunction codes have been displayed, subsequent pressing of the HLD button will again display the action code. The LTN-211 Omega system action and malfunction codes and their meanings are presented in the NAVAIR 01-75PAC-1.1 NATOPS Flight Manual and the NAVAIR 01-75PAC-12-3 NAV/COMM Crew Station Organizational Maintenance Manual.

SUMMARY

The LTN-211 Omega Navigation is a sophisticated, state-of-the-art radio navigation system. It can fix aircraft position with an accuracy of within two nautical miles during the day, and within four nautical miles at night. The LTN-211 system is completely independent of other aircraft systems, except that it requires valid heading and true airspeed inputs from the aircraft. Because the system has its own computer, it monitors its own health and the validity of the incoming signals without taking valuable time from the aircraft's tactical computer. This also enables the Omega system to serve as backup for the aircraft's other navigation systems.

The LTN-211 Omega system also continuously monitors signals from the U.S. Navy's VLF Communication stations, using this information in the VLF navigation backup mode to fix aircraft position. This feature greatly reduces the likelihood that invalid Omega navigation data will significantly affect the accuracy of the Omega system's aircraft position fix. Also, the NAV/COMM operator can use the other navigation and guidance data presented on the LTN-211 Control-Display Unit to check the progress of the flight plan.

Today, Omega navigation is employed universally to provide viable long-range, great-circle radio navigation throughout the world. Only at the polar ice caps is Omega signal reception marginal.

The Omega radio navigation system is now well established and playing a vital role as a worldwide navigation aid. It is doubtful that the more sophisticated satellite navigation system, the Global Positioning System (GPS), will replace Omega until the 21st century.

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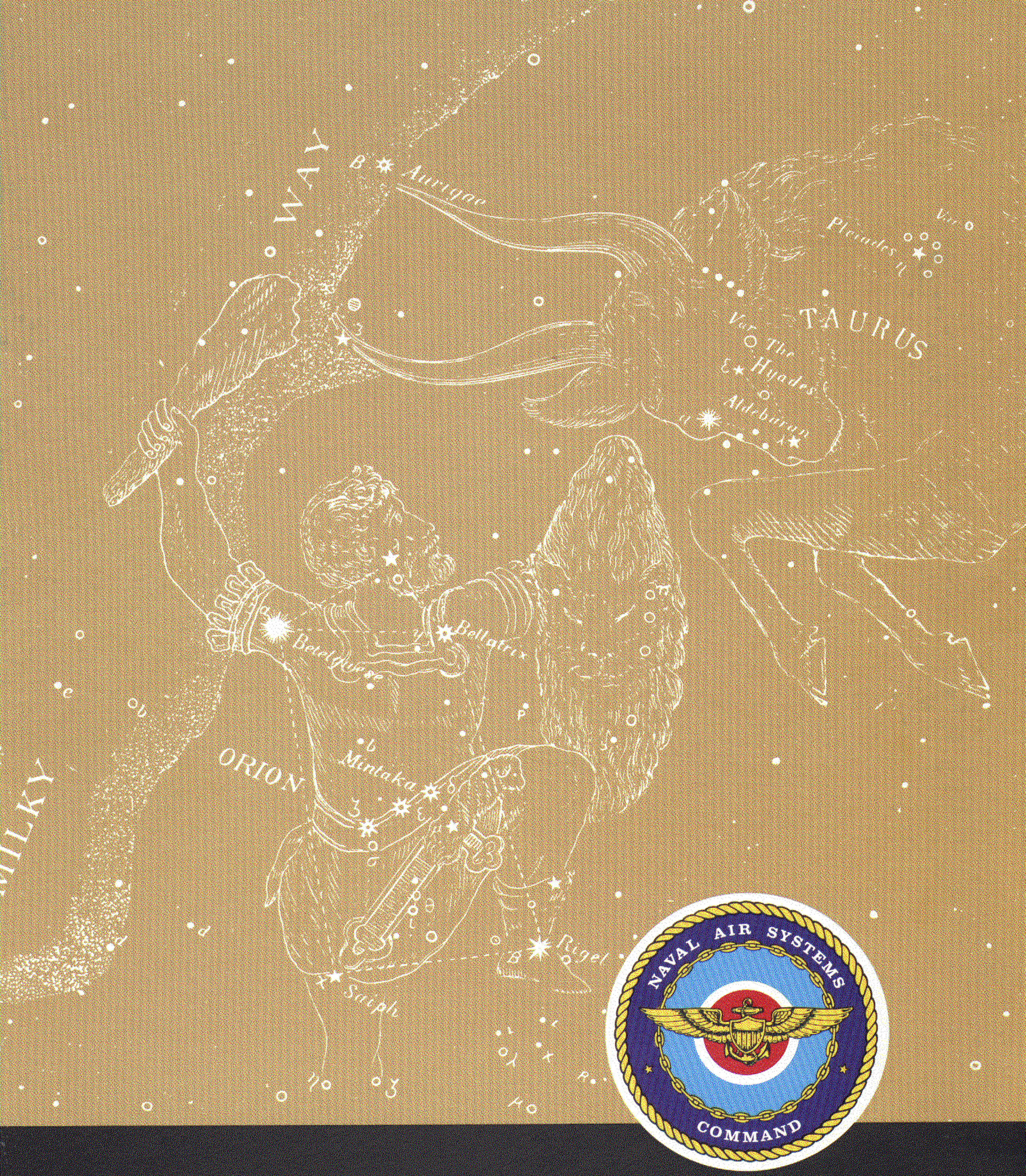
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