# ORION SERVICE digest

issue 33 JULY 1977
LOCKHEED · CALIFORNIA COMPANY

OPERATION ECONOMICS

After a long and distinguished career in naval aviation and antisubmarine warfare, **Captain M. O. "Mo" Paul,** project manager of P-3 aircraft (PMA-240), will retire on September 1, 1977. During his assignment as project manager, the P-3B modernization program was implemented, the P-3C Update I was successfully introduced into the Pacific Fleet, the P-3C Update II was developed and put into production, and the P-3C Update III configuration was planned and established in the defense budget. Captain Paul also played a major role in developing logistics support for the Imperial Iranian Air Force P-3F aircraft and directed procurement of ten P-3C Update II aircraft for the Royal Australian Air Force.

Prior to becoming P-3 project manager, Captain Paul had numerous other assignments, including five years as commanding officer, first of VP-17 (1966 to 1969) and then of Air Test and Evaluation Squadron One (1969 to 1971). He was awarded the Navy Commendation medal as a result of VP-17's actions in Vietnam.

Captain Paul's association with the U.S. Navy represents 32 years of devotion to his country's business. He will be missed. We wish him fair winds and following seas in the years to come.

**Captain Gordon Petri** is uniquely qualified to assume his new assignment as project manager of P-3 aircraft in September 1977 upon Captain Mo Paul's retirement. Captain Petri has been associated with naval patrol aircraft for 20 years and the Orion since its inception, beginning with the exhaustive P3V-1 BIS trials in 1962 through assignments with VP-16, Fleet Air Wing One in Okinawa, VP-30, and VP-24. More recently, he spent over four years as NAVAIR P-3 Class Desk officer.

As P-3 manager, Captain Petri will direct and control all aspects of the P-3 program, both domestic and foreign. His responsibilities will include planning, financial management, procurement, engineering, manufacturing, testing, and fleet support for all P-3 aircraft in service, in production, and under development. He will direct the introduction of the modified P-3B into fleet and reserve units, the introduction of the P-3C Update II into fleet operations, and the development of systems hardware, software, and production of the P-3C Update III.

We offer our congratulations and look forward with confidence to our joint effort in meeting the evolving ASW challenge that lies ahead.

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## FRONT AND BACK COVERS –

PATROL SQUADRON SEVENTEEN was called to active duty as VP-772 in September 1950 and became the first reserve unit to participate in the Korean conflict. At the conclusion of the war, the squadron returned to NAS Whidbey Island, Washington, and established itself as one of the best antisubmarine warfare units in the Pacific.

Early in 1953, the squadron dropped its reserve designation and became part of the regular Navy. Also in 1953, VP-17 exchanged its flight-weary P4Ys for Lockheed P2V-6s. In 1956, VP-17 was designated Heavy Attack Mining Squadron Ten for a three-year period. The squadron returned to patrol aviation in 1959, and the "white lightening" insignia on the P2V-6 Neptunes was seen throughout the Pacific.

During the next few years, the squadron received the Chief of Naval Operations Maintenance Award and the coveted "triple crown" of ASW – the Chief of Naval Operations Safety award, the Battle Efficiency "E" for Pacific squadrons, and the Isbell ASW trophy signifying excellence in airborne antisubmarine maneuvers.

In 1968, VP-17 transitioned to the P-3 and moved to its present home base, NAS Barbers Point, Hawaii. Subsequently, the squadron performed a variety of operational missions in support of the Southeast Asia conflict. In 1971, VP-17 became the first Pacific Fleet patrol squadron to participate in the joint North/South American training exercise, UNITAS XII.

In January 1972, the squadron deployed to NAF Naha, Okinawa with detachments at NAS Cubi Point, Republic of the Philippines and Tainan, Taiwan. The overall performance of the squadron during this period was praised by senior commands.

Upon return to NAS Barbers Point in August 1972, VP-17 completed intensive training in the use of the sophisticated new equipment installed on squadron aircraft. In 1973, VP-17 was once again deployed to NAS Cubi Point with detachments in U-Tapao, Thailand and NAS Guam. In October 1973, the squadron flew the final Market Time combat support patrol, which marked the end of over 10 years' daily surveillance flights by patrol squadrons in the South China Sea during the Vietnam conflict.

Upon return to NAS Barbers Point in November 1973, VP-17 began a period of high-intensity operations in the MIDPAC operating areas followed by a ready-alert period of unprecedented length – May through October 1974.

In December 1974, VP-17 deployed to Naha Air Base, Okinawa, and then in May 1975, relocated to brand new facilities at Kadena Air Base, Koza, Okinawa. The squadron operated throughout the Western Pacific, China Sea, and Indian Ocean, and were involved in surveillance patrols of the Vietnam refugee evacuation and support patrols for the recapture of the hijacked merchant ship *SS Mayaguez.* Their efforts once again earned them the Pacific Fleet Battle Efficiency award, the big "E," for maintaining the highest battle readiness of any mid-Pacific patrol squadron for July 1974 to December 1975.

Following a six-month deployment to NAS Cubi Point, VP-17 returned home to Hawaii in November 1976 and embarked on an intensive two-month training cycle. Since January 1977, VP-17 has patrolled the mid-Pacific. With its strong *ésprit de corps,* VP-17 looks with confidence to the years ahead.

Lockheed
ORION
Service
Digest

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# Operation Economics

**by Carl F. Friend**
**Senior Research and**
**Development Engineer**
**Aerodynamics Department**

Recent world events have highlighted our need to better manage our fuel resources. No longer is fuel cheap and plentiful; consequently, we must learn to use it more efficiently. In the airborne ASW community more efficient fuel use can be directly translated into a longer radius of action, more time on station, more fuel for future missions. This can only be achieved by careful mission planning and by using economic aircraft operating procedures. We shall address these topics as they apply to the P-3C Orion aircraft. Operators of other models of P-3 aircraft can apply the principles discussed in this article to their activities as well.

## FLIGHT PREPARATION

During flight planning, careful consideration of flight operation and tactical requirements is of primary importance. Among the tactical requirements are internal and external stores, fuel loading, and the systems that are needed to perform the mission. Maximum operational economy demands use of only those systems and transportation of only those stores that are essential to the mission.

**EXTERNAL CONFIGURATION** The P-3C NATOPS Flight Manual, NAVAIR 01-75PAC-1, lists relative aerodynamic drag values (drag counts) for various external equipment and stores. During flight planning, the sum of the external stores drag counts is used to determine the drag effect of these stores on aircraft performance. The total drag count is used to select the proper charts or tables for determining mission fuel requirements, mission radius, time on station, and so forth. The drag counts of various externally carried equipment and stores are listed in Table 1.

| STORE – INCLUDING ITS PYLON (FOR ANY APPROVED EXTERNAL CARRIAGE) | DRAG COUNTS (PER STORE) |
|---|---|
| NO EXTERNAL STORES OR PYLONS | 0 |
| PYLON (SMALL, MINE LAYER OR #AERO 15D) | 20 |
| LAU-10 ROCKET POD (FAIRED) | 45 |
| LAU-10 ROCKET POD (UNFAIRED) | 90 |
| LAU-68A (FAIRED) 7-2.75 FFAR POD | 31* |
| LAU-68A (UNFAIRED) 7-2.75 FFAR POD | 56* |
| LAU-61 OR 69A (FAIRED) 19-2.75 FFAR POD | 43* |
| LAU-61 OR 69A (UNFAIRED) 19-2.75 FFAR POD | 109* |
| MK 25 MINE (FAIRED) | 150 |
| MK 25 MINE (UNFAIRED) | 230 |
| MK 36 DESTRUCTOR (LOW DRAG) | 30* |
| MK 36 DESTRUCTOR (RETARDED TAIL) | 40* |
| MK 40 DESTRUCTOR (LOW DRAG) | 37* |
| MK 40 DESTRUCTOR (RETARDED TAIL) | 54* |
| MK 52 MINE (FAIRED) | 90 |
| MK 52 MINE (UNFAIRED) | 145 |
| MK 55 MINE (FAIRED) | 150* |
| MK 55 MINE (UNFAIRED) | 230* |
| MK 56 MINE (FAIRED) | 150 |
| MK 56 MINE (UNFAIRED) | 230 |
| MK 76 PRACTICE BOMB | 40* |
| MK 82 BOMB (LOW DRAG) | 30* |
| MK 82 BOMB (RETARDED TAIL) | 40* |
| MK 83 BOMB (LOW DRAG) | 37* |
| MK 83 BOMB (RETARDED TAIL) | 54* |
| MK 87 PRACTICE BOMB | 40* |
| MK 106 PRACTICE BOMB | 40* |
| MK 124 PRACTICE BOMB | 40* |
| AGM-12B MISSILE (INCLUDING AERO 5A-1 LAUNCHER) | 65 |
| AGM-84A MISSILE (INCLUDING AERO 5A-1 LAUNCHER) | 65* |
| AERO 5A-1 LAUNCHER | 35 |
| SUU-40 FLARE DISPENSER | 45* |
| SUU-44 FLARE DISPENSER | 45* |
| PMBR (ANA-SUK-18/A37B-3) | 40 |
| THREE MK 24 MOD-3 PARA-FLARES (INCLUDING PMBR) | 49 |
| SIX MK 24 MOD-3 PARA-FLARES (INCLUDING PMBR) | 58 |
| GTC 85-15 | 50 |
| ESM (ALQ-78) | 60 |
| LOW LIGHT LEVEL TV | 75 |
| IRDS EXTENDED | 100* |
| MANEUVER FLAPS | 600* |
| WEAPONS BAY OPEN | 1000* |
| LANDING GEAR EXTENDED | 2000* |

***ESTIMATED*

*Table 1. External Store Drag Counts*

For any given aircraft weight, altitude, drag configuration, and ambient temperature, NATOPS operating tables and charts provide horsepower, fuel flow, true and indicated airspeed, range and loiter times, and segment range (the distance the aircraft will travel on 5000 pounds of fuel). These operating tables and charts vary depending on which configuration is designated. To account for variations in aircraft performance for different external arrangements, five levels or ranges of drag counts have been designated for the P-3C: Configurations A, B, C, D, and E (see Table 2). The NATOPS Flight Manual performance graphs and tables are based upon the average value of the applicable configuration. For example, the count range for Configuration C is 261 to 480, and the average value is 370. In the past, when less emphasis was placed upon fuel conservation, use of graphs or charts corresponding to any value of drag count within the range designated in Table 2 was acceptable for most flight plans. Now, however, the need for fuel conservation or extending maximum range frequently makes this planning practice undesirable. In a case where a drag count falls near either end of the drag configuration range, performance projections and fuel requirements should be determined by interpolation.

For example, let us assume that a P-3C is to be dispatched with the following external equipment and stores: the ALQ-78 Electronic Support Measures pod, the AXR-13 Low Light Level TV pod, and eight mining pylons. Table 1 shows that the total drag count for the equipment is 295, which falls within Configuration C but is 75 counts less than the average value. If the range and fuel flow projections are based upon the Configuration C average value rather than the actual drag count, these projections will be about 2 percent too conservative. Operation based on these conservative projections thus increases the fuel burned by the aircraft's having to "tanker" extra fuel.

| CONFIGURATION | DRAG COUNT RANGE | AVERAGE |
|---|---|---|
| A | 0 TO 50 | 25 |
| B | 51 TO 260 | 155 |
| C | 261 TO 480 | 370 |
| D | 700 TO 1050 | 875 |
| E | 1051 TO 1500 | 1275 |

*NOTE: FOR DRAG COUNTS BETWEEN 480 AND 700, INTERPOLATE BETWEEN CONFIGURATIONS C AND D.*

*Table 2. Configuration Drag Count*

Continuing our example, if the P-3C's gross weight falls within the range of 117,500 to 122,500 pounds and is flown at 26,000 feet, we will find the segment range to be greater than that listed in the NATOPS maximum range operating tables for Configuration C (349 nautical miles), but less than that listed for Configuration B (367 nautical miles). The segment range is interpolated as follows:

$$R_C + \frac{(R_B - R_C) \times (D_C - D_B)}{(D_C - D_{ACT})}$$

where

$R_B$ = Segment range, Configuration B
$R_C$ = Segment range, Configuration C
$D_B$ = Average drag count, Configuration B
$D_C$ = Average drag count, Configuration C
$D_{ACT}$ = Actual drag count

Substituting the actual figures gives:

$$349 + \frac{(367 - 349) \times (370 - 295)}{(370 - 155)} =$$

$$349 + \frac{18 \times 75}{215} = 349 + 6.3 =$$

355.3 nautical miles.

Loiter time segments, fuel flow, horsepower, etc., can be interpolated to improve the accuracy of performance projections.

Our example P-3C's maximum specific range (nautical miles per pound of fuel) is 10 percent less than that of a P-3C without external stores, and the minimum loiter fuel flow is 9 percent greater. However, these differences can be considerably less, as little as 3 or 4 percent, during non-optimum (low altitude) operations. In the example, we have not considered the effect that the weight of these stores has on range and loiter.

A large quantity of fuel can also be conserved (or range increased) by the aircraft *not* carrying various external stores. The data in Table 3 are based on computations that consider the effects of both drag and weight on an aircraft flying the following typical flight profile: aircraft warmup, takeoff, and acceleration to climb speed consumes 600 pounds of fuel; cruises out at 21,000 feet; loiters four hours on station at 5000 feet; returns at 28,000 feet; arrives over base with 6000-pound fuel reserve. These values are relative to a clean P-3C (no external stores) on a typical ASW mission with 62,560 pounds of JP-5 fuel.

**SURFACE CLEANLINESS** Skin surface roughness and air leakage can add drag that reduces aircraft operating efficiency. Inspection should detect abnormalities such as exterior dirt, chipped paint, dents, loose fasteners, poorly fitted doors, and improperly rigged surfaces – especially wing flaps. Table 4 lists the effects of various external irregularities on maximum radius and fuel. All aircraft are particularly sensitive to roughness or leakage in leading edge areas (Figure 1).

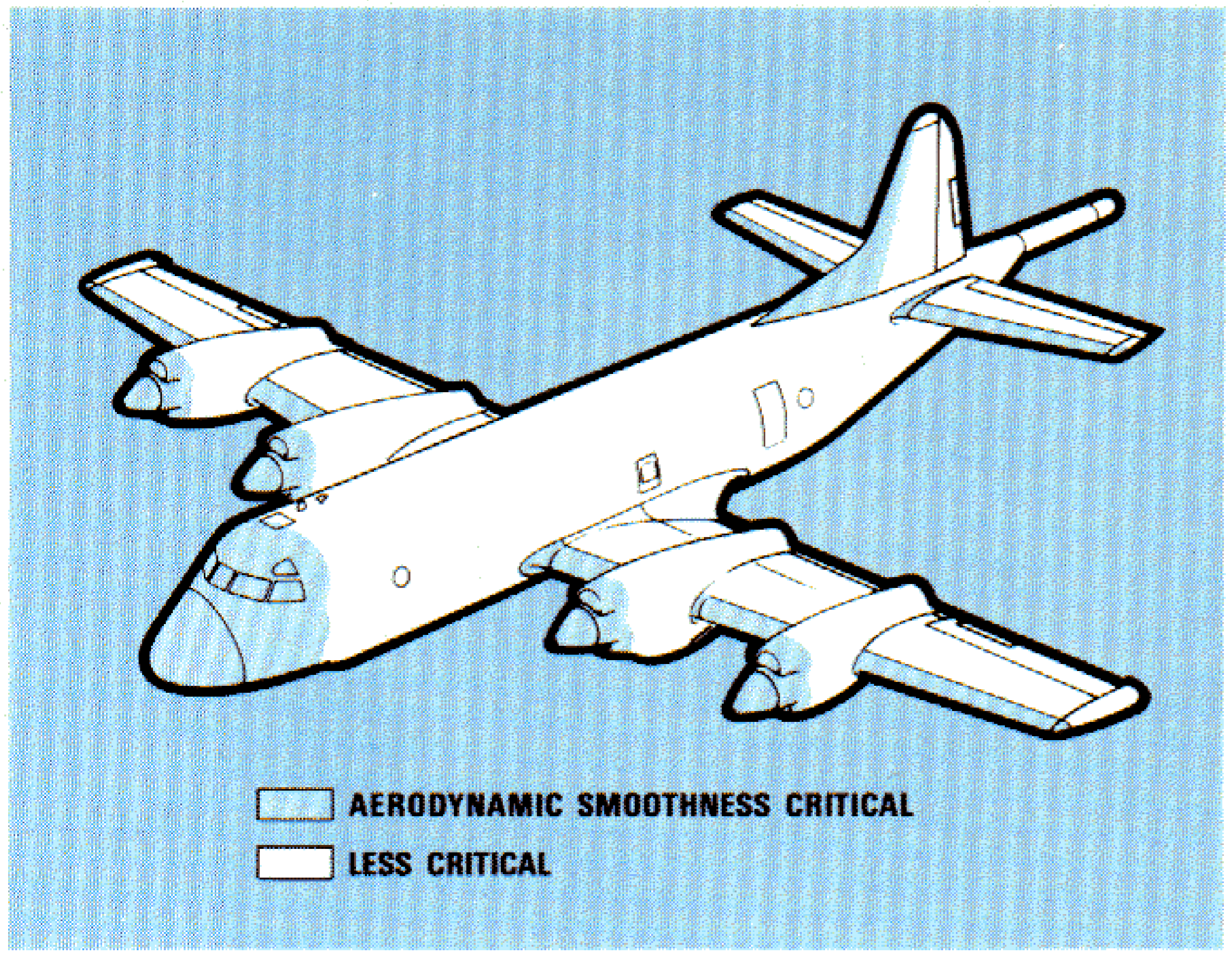


*Figure 1. Critical Drag Areas*

| | ITEM REMOVED | FUEL SAVED (LB/MISSION) | OR | RADIUS INCREASE (NM/MISSION) |
|---|---|---|---|---|
| DRAG: | EIGHT PYLONS (160 DRAG COUNTS) | 3200 | | 110 |
| | LOW LIGHT LEVEL TV POD AND PYLON (75 DRAG COUNTS) | 1500 | | 50 |
| WEIGHT: | FOUR MK 46 TORPEDOES INSTEAD OF EIGHT (2400 POUNDS LESS) | 1400 | | 120 |
| | 6000 POUNDS RESERVE FUEL INSTEAD OF 8000 POUNDS | 1200 | | 100 |

*NOTE: P-3C WITH CONFIGURATION A, 139,760 POUNDS TAKEOFF GROSS WEIGHT INCLUDING 62,560 POUNDS JP-5 FUEL. AIRCRAFT WARMUP, TAKEOFF, AND ACCELERATION TO CLIMB SPEED CONSUMES 600 POUNDS OF FUEL; CRUISES OUT AT 21,000 FEET; LOITERS FOUR HOURS ON STATION AT 5,000 FEET; RETURNS AT 28,000 FEET; ARRIVES OVER BASE WITH 6,000 POUNDS OF RESERVE FUEL.*

*Table 3. Effects of Drag and Weight Reduction*

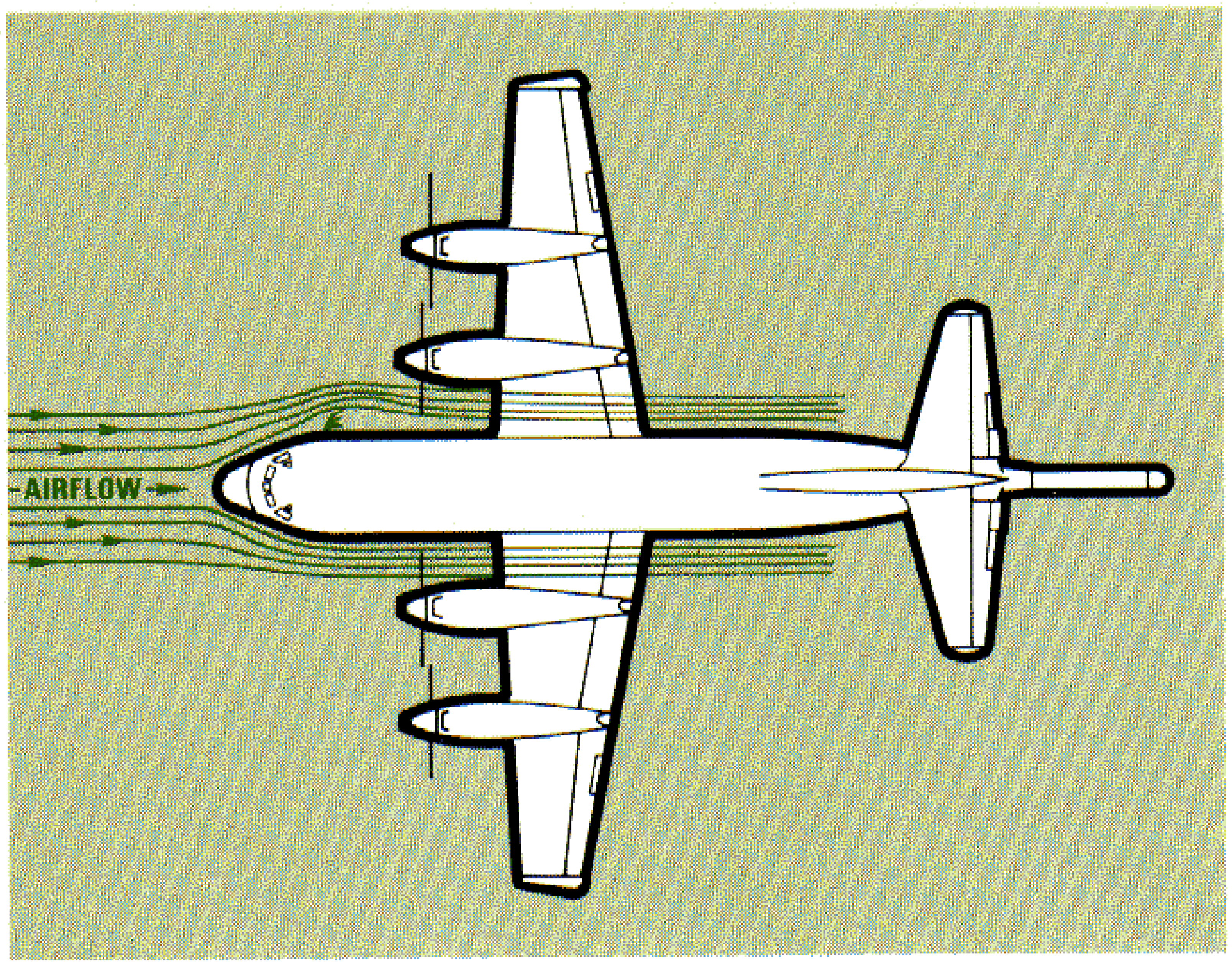
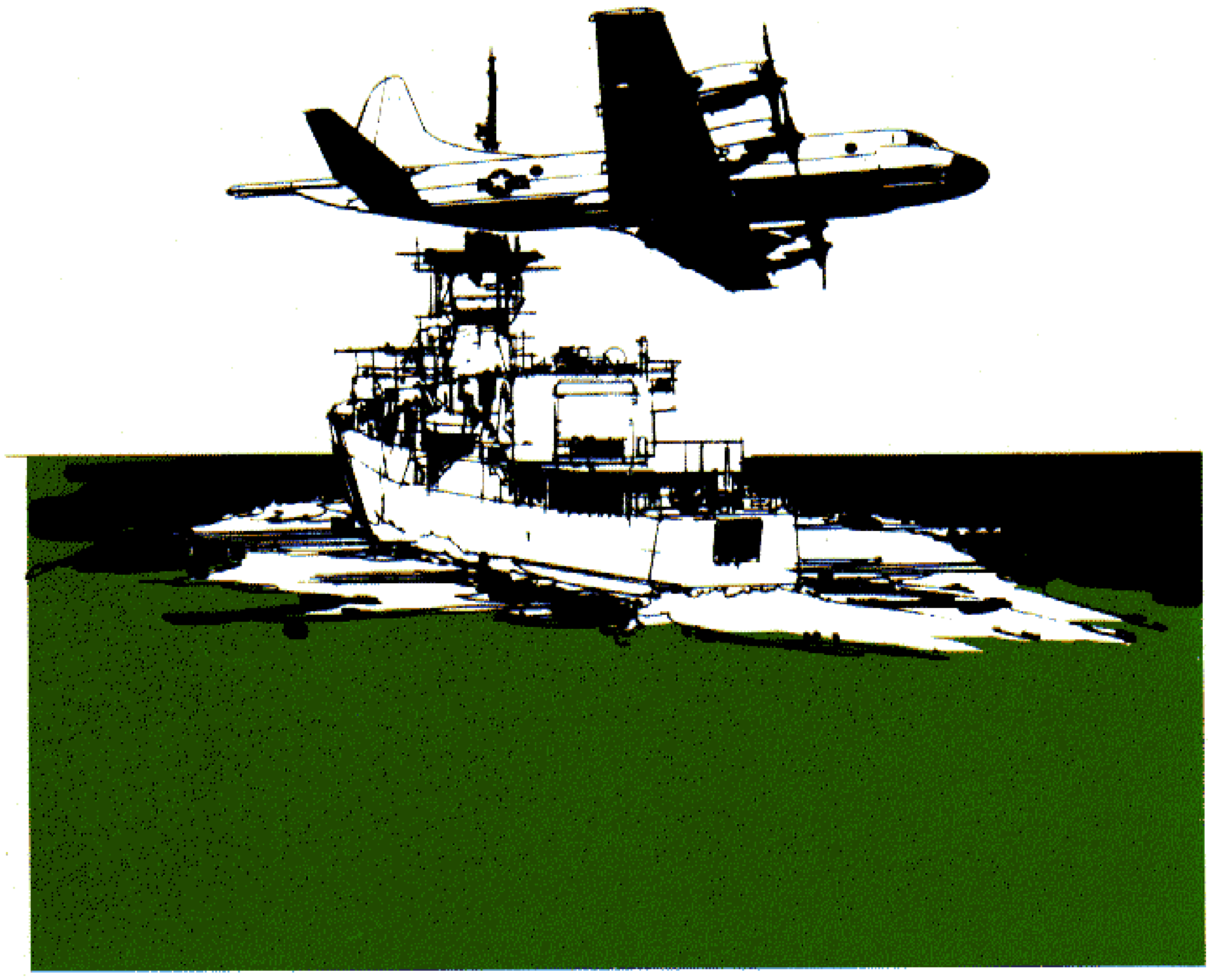


*Figure 2. Effect of Air Leakage*

**Air Leakage** Air leakage typically occurs perpendicular to the surface causing an interruption of external airflow parallel to airplane surfaces as shown in Figure 2. Leakage is not confined to pressurized areas; the external airflow can develop pressure differentials between openings in different locations and cause separated flow. The drag effect of missing or damaged door seals is given in Table 4.

**Surface Condition** Small dust particles (up to 0.0010-inch diameter) distributed uniformly on the surface will not measurably affect aircraft performance. However, a layer of 0.0012-inch particles requires an increase of 1.6 percent in power and fuel flow to maintain "normal" aircraft performance. For a maximum range mission, this could cause an increased consumption of 1000 pounds of fuel or a loss of 30 nautical miles operating radius.



According to air pollution experts, typical California smog contains particles from 0.0008 to 0.0012 inch that adhere to aircraft. Since ASW aircraft are frequently washed to prevent corrosion, dust deposits may not be a problem. However, if the aircraft has not been washed recently, it may have accumulated enough dust to significantly reduce performance. A good rule of thumb – if the windshield is dirty enough to warrant cleaning, all external surfaces should be cleaned.

The foregoing describes only "clean" conditions. At some of the more primitive bases where mud is prevalent and maintenance is limited, severe surface deterioration can create drag that will cause as much as a 25-percent increase in fuel flow. Severe surface deterioration includes poorly applied or badly eroded paint and wet or oily surfaces that collect 0.0080-inch particles. This size particle is the most common ingredient of coarse "Arizona dust," a dust standard recognized worldwide that contains particles from almost zero to 0.0200-inch diameter.

It is possible to determine whether the aircraft has excessive drag by making an in-flight comparison of actual torquemeter shaft horsepower with the shaft horsepower specified by the NATOPS Flight Manual for the existing configuration. If the power required exceeds that specified by the NATOPS Flight Manual after accounting for the drag of external stores, there is excessive drag and a careful inspection of the aircraft's surfaces should be performed. However, if the *power* is consistent with NATOPS performance specifications but the *fuel flow* is excessive, the deviation should be recorded in the engine log and an evaluation of engine performance considered.

**LOADING** For maximum economy, the airplane should be operated as light as possible with only those load items required for the mission or safety. In general, fuel flow is proportional to power required, and power required is proportional to the airplane gross weight for maximum range or minimum fuel flow loiter conditions. Examples of various load items and their effect on fuel saving and operating radius are given in Table 3. A 1000-pound increase in zero fuel weight with a 1000-pound reduction of fuel will decrease operating radius 50 nautical miles. A 1000-pound addition to zero fuel and takeoff weight with no change in fuel will decrease operating radius 20 nautical miles. *Zero fuel weight* is discussed in detail in the Fueling section.

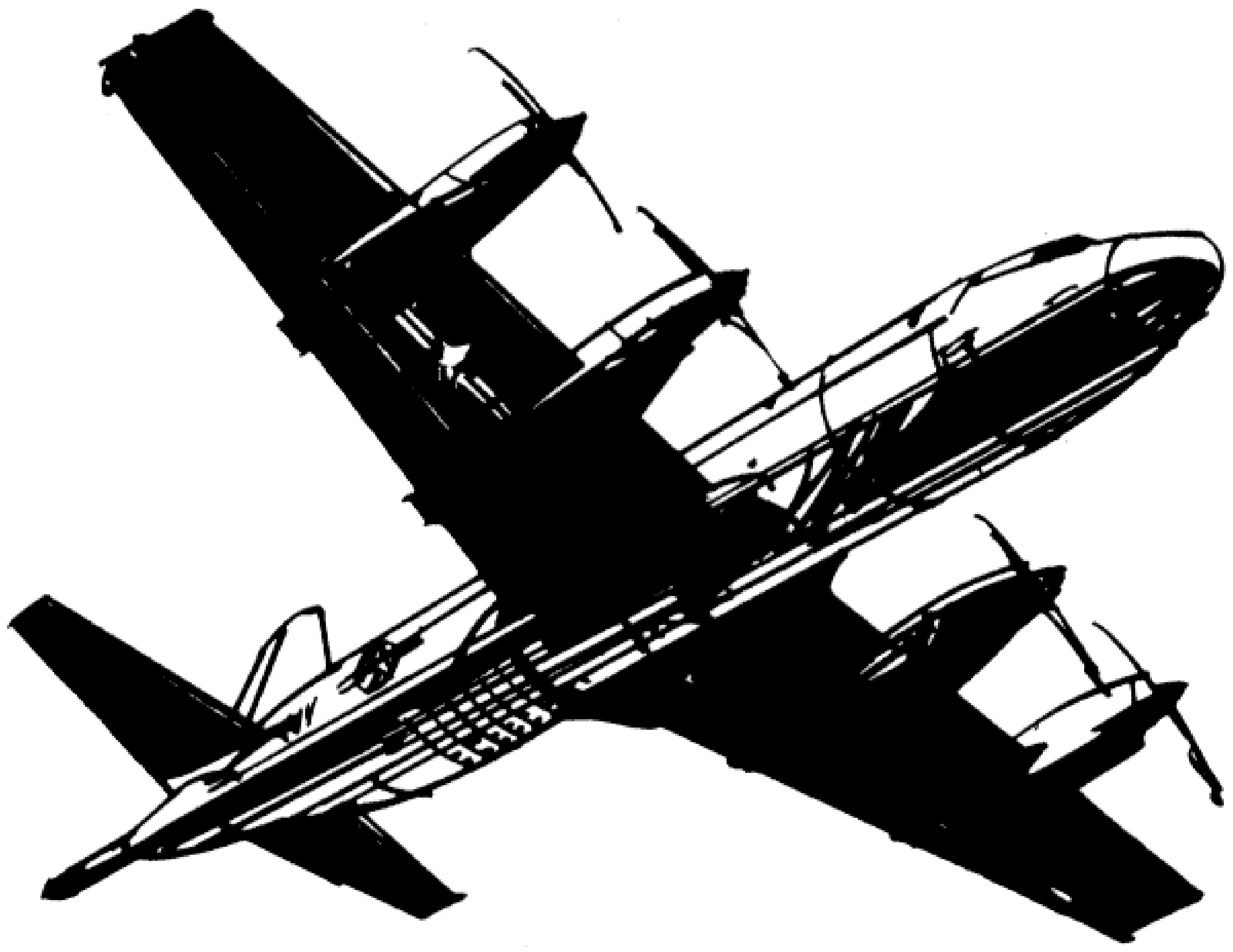
## FUELING

**Allowable Fuel** The more fuel on board the airplane, the more miles it is possible to travel. One thousand pounds additional fuel increases the operating radius of a typical ASW mission (defined previously) by about 33 nautical miles. However, takeoff weight limitations may not allow the airplane to be taxied to the pump with the direction, "Fill 'er up." Each mission dictates its own gross takeoff weight. This weight is further dependent on structurally permissible weight (including zero fuel weight), available field length, atmospheric conditions, and wind. Recommended maximum gross takeoff weight is 135,000 pounds. Overload takeoffs up to the maximum structural takeoff weight limit of 139,760 pounds may be authorized only when operational necessity dictates and due consideration is given to weather, taxiway, runway, and aircraft conditions.

If a full load of 62,560 pounds of JP-5 fuel is put aboard a P-3C Update I airplane with four MK 46 torpedos and 84 sonobuoys, the total weight of the

| IRREGULARITY | FUEL WASTED (LB/MISSION) | OR | RADIUS DECREASE (NM/MISSION) |
|---|---|---|---|
| DOOR LEAKAGE (NO SEAL): | | | |
| • WEAPONS BAY | 2,100 | | 70 |
| • MAIN LANDING GEAR (EACH) | 1,500 | | 50 |
| • NOSE LANDING GEAR | 300 | | 10 |
| • NOSE RADOME FUSELAGE JOINT | 1,200 | | 40 |
| • ENGINE SECTION (QEC); NACELLE JOINT (EACH) | 900 | | 30 |
| SKIN CONDITION: | | | |
| • DIRTY AIRPLANE (VERY DIRTY; REMOTE BASE) | 16,500 | | 550 |
| • DUSTY AIRPLANE (ONE WEEK NORMAL ACCUMULATION) | 1,350 | | 45 |
| • LEADING EDGE DENTS (GOUGED 0.8-INCH DEEP, 6 INCHES CHORDWISE) | 1,200 | | 40 |
| • LEADING EDGE PATCH (12 INCHES SQUARE BY 0.1 INCH THICK SCARF) | 90 | | 3 |
| TIEDOWNS INSTALLED | 750 | | 25 |

*Table 4. Drag Effect of Aircraft Cleanliness*



airplane is 138,884 pounds, thus exceeding the recommended maximum of 135,000 pounds by 3884 pounds. If the maximum gross takeoff limit is to be observed, the fuel load must be reduced by 3884 pounds or mission stores of an equal weight must be removed. Otherwise, the possibility of an overload takeoff must be investigated. During overload operation, the maximum structural takeoff weight limit of 139,760 pounds must be observed.

**Type of Fuel** The standard fuels for the P-3 airplane are JP-4 and JP-5, with *nominal* densities of 6.5 and 6.8 pounds per U.S. gallon respectively at 15°C. However, production specifications for these fuels permit a density range of plus or minus 0.2 pound per gallon, and the fuel density can increase by as much as 0.32 pound per gallon at -40°C.

JP-5 has a heat content approximately 1 percent less than JP-4, *pound for pound*. Thus, for a given *weight* of fuel, the aircraft range would be approximately 1 percent less when using JP-5 than when using JP-4. However, since JP-5 weighs approximately 4.5 percent more than JP-4 for an *equal volume*, the net change in range when using JP-5 will be an *increase* of approximately 3.5 percent for *equal volumes* of fuel. Therefore, a full load of JP-5 fuel would supply additional pounds for extended range *provided the aircraft loading is not exceeded*. If the fuel load is limited to 59,800 pounds or less by other considerations, JP-4 is the preferred fuel for maximum range.

**Reserve Fuel** Reserve fuel is the extra fuel carried that *exceeds* the amount calculated to conduct the mission, return home, and fly to an alternate airfield. This fuel reserve is allowed for such contingencies as an inaccurate fuel quantity indicating system, unanticipated wind conditions, assignment of a less favorable flight plan by traffic control, etc. Variations in engine performance that differ from performance data in the NATOPS Flight Manual should be included in mission fuel estimates, not reserve estimates.

Reserve fuel is like any other load item – it requires additional fuel for transport. For example, if the fuel reserve for a basic mission is reduced from 8000 pounds to 6000 as given in the NATOPS Flight Manual, either 1200 pounds of fuel can be saved or the mission radius increased by 100 nautical miles. Before dispatching an aircraft with a 6000-pound fuel reserve, check the fuel quantity with a dipstick and record the measurements in the fuel log.

If the minimum contingency reserve is to be used in flight planning, there must be confidence in the accuracy of the fuel quantity indicating system. The maintenance and calibration of the indicating system is of primary importance in planning safe and efficient missions. A major investigation was conducted into the fuel quantity indicating system, and the results were published in the *Orion Service Digest*, May 1972 issue. This issue detailed the requirements for calibrating and maintaining the system for maximum accuracy. Subsequently, these procedures were incorporated into the P-3 Maintenance Instruction Manual, NAVAIR 01-75PAA-2-4. These calibration procedures should be followed religiously.

The amount of reserve fuel carried on the airplane has often been based on the flight crew's estimate of overall fuel requirements. As such, many missions have been flown carrying too much reserve or "on top" fuel. Besides causing extra fuel consumption, carrying excessive fuel may cause the airplane to be overweight upon its return to the field. Overweight landings unduly stress the main landing gear fulcrums, wheels, tires, wing spars, and wing attachment points, shortening service life accordingly. Further, effects of overweight landings can be magnified considerably if adverse landing conditions are encountered.

**Zero Fuel Weight** One of the important factors in aircraft loading is *zero fuel weight*. By definition, zero fuel weight is the gross weight of the airplane, less the weight of usable fuel. This is a basic weight around which the load carrying capability of the airplane is designed. For the P-3C airplane, the basic zero fuel weight should not exceed 77,200 pounds. This weight is made up of basic aircraft structure (airplane empty weight), crew, unusable fuel, oil, survival equipment, and internal stores. These are the weights which the wing structure must support during flight, resulting in maximum allowable wing bending. Weights such as fuel and stores *on the wing* relieve wing bending and permit the gross weight to be increased without unduly affecting the structural capabilities of the airplane.

As noted, the P-3C's basic allowable zero fuel weight is 77,200 pounds. However, there *is* a circumstance under which this allowable weight may be increased. The weight of any item installed *on the wing* will balance an equivalent amount of airload as far as the wing's structural load distribution is concerned. Therefore, if an ESM pod (177 pounds), an LLLTV pod (259 pounds), and eight pylons (126 pounds each) which weigh a total of 1444 pounds are installed *on the wing*, the allowable zero fuel weight *can be increased* by 1444 pounds to a new value of 78,644 pounds. Any additional item installed on these pylons would further increase the allowable zero fuel weight. However, as the allowable zero fuel weight increases, the point is reached where the maximum gross weight exceeds the maximum takeoff weight when a full load of fuel is added. At this point the decision must be made – which is more important, fuel or mission stores. It is imperative that the zero fuel weight be known and controlled.

A factor which can adversely affect zero fuel weight is the fuel carried in the number 5 tank located in the center section and fuselage. If for any reason this fuel cannot be transferred, it becomes unusable fuel and becomes part of the airplane zero fuel weight. For example, an airplane has an acceptable zero fuel weight of 77,200 pounds due to the loading of crew, equipment and stores. It then encounters a condition where the fuel in fuel tank 5 cannot be transferred. This, in effect, increases the airplane's zero fuel weight to as much as 95,200 pounds and requires operation with load factor limitations.

To summarize, the zero fuel weight of the airplane is the gross weight of the airplane less the usable fuel. The maximum allowable zero fuel weight for the P-3C airplane is 77,200 pounds plus the weight of any wing stores. The zero fuel weight computations shown by the charts in the P-3C NATOPS Flight Manual should always be followed so that zero fuel weight is known and can be controlled.

The lower the zero fuel weight with a full load of fuel, the lower the takeoff weight and hence, the greater the range. Therefore, carrying the *minimum* zero fuel weight required to accomplish the mission with the maximum allowable fuel load will result in increased range.

**FLIGHT PLANNING** Efficient flight planning is vital to fuel conservation and for realizing the maximum range from the fuel load. Using the assigned mission as the basis for the flight plan, several other factors must be weighed. These include atmospheric conditions, tactical and air traffic control situations, and the safety of crew and airplane. Several alternative routes and cruise profiles should be considered, particularly when forming a flight plan that requires minimum fuel or provides maximum range or time on station. Routes that take advantage of optimum wind conditions frequently are not great circle routes.

Due to the many variables that must be considered, flight planning is a time-consuming task. This leaves the flight plan susceptible to human error and outdated information. A much more accurate and rapid approach to flight planning can be obtained by using the Lockheed Jetplan©. This system uses an IBM 360-44 computer to select the

| | TIME REQUESTED | NAS MOFFET TO NAS BARBERS POINT | AIRCRAFT/ JP-5 FUEL | °C TIT/ MINIMUM FUEL | INSTRUMENT FLIGHT RULES | DATE |
|---|---|---|---|---|---|---|
| PLAN 560 (PILOT'S NAME)<br>NONSTOP COMPUTED | 1739Z | KNUQ TO PHNA FOR ESTIMATED DEPARTURE TIME 2000Z | P3CS | 925/F | IFR | 04/18/77 |

| | | (LB) | LENGTH OF MISSION (HR/MIN) | DISTANCE (NM) | | WEIGHT IN POUNDS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | FUEL | TIME | DIST | ARRIVE | TAKEOFF | LAND | PAYLOAD | OPNLWT |
| **POINT OF ARRIVAL** | POA PHNA | 027364 | 06/42 | 2112 | 0242Z | 110964 | 083600 | 000000 | 073600 |
| | ALTERNATE | – | – | | | | | | |
| | HOLD | – | – | | | | | | |
| | RESERVE | 010000 | 02/47 | | | | | | |
| | TOTAL | 037364 | 09/29 | | | | | | |
| **ROUTING** | KNUQ . . . FRUI R65 . . . AGAT . . . R65 . . . MAG . . . V12 . . . PHNA | | | | | | | | |
| **AVERAGE WIND** | WIND M027 | | | | | | | | |
| **FLIGHT LEVEL (100'S OF FT)** | 260 | | | | | | | | |
| **TURBINE INLET TEMP** | 925°C TIT | 027364 | 06/42 | | | | | | |

| | CHECKPOINT | FLIGHT LEVEL | TEMP (°C) | HEADING/ SPEED (KT) | TURBULENCE STRENGTH | TRUE AIRSPEED (KT) | GROUNDSPEED (KT) | MAGNETIC COMPASS | DISTANCE BETWEEN ENTRIES | DISTANCE REMAINING | EST TIME BETWEEN ENTRIES (HR/MIN) | EST TIME REMAINING | FUEL BETWEEN ENTRIES (100's OF LB) | FUEL REMAINING (100's OF LB) | FUEL FLOW (LB/HR/ENG) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CPT | FL | T | WIND | S | TAS | GRS | MCS | DST | DSTR | ETE | ETR | FU | FR | FF/E |
| **TOP OF CLIMB** | TOC | 260 | – | 00023 | – | 262 | 274 | 222.3 | 088 | 2024 | 0/19 | 6/23 | 021 | 0353 | – |
| **MAP COORDINATES** | FRUI | 260 | 37 | 32046 | 2 | 346 | 334 | 222.3 | 068 | 1956 | 0/12 | 6/10 | 008 | 0344 | 1035 |
| | COST | 260 | 35 | 32036 | 2 | 344 | 327 | 233.7 | 229 | 1727 | 0/42 | 5/28 | 031 | 0314 | 1092 |
| | COPP | 260 | 33 | 29015 | 1 | 344 | 333 | 231.3 | 299 | 1428 | 0/54 | 4/34 | 038 | 0276 | 1061 |
| | COFE | 260 | 32 | 24010 | 0 | 342 | 332 | 229.1 | 299 | 1129 | 0/54 | 3/40 | 037 | 0239 | 1028 |
| | CITT | 260 | 31 | 23015 | 1 | 339 | 324 | 227.4 | 300 | 0829 | 0/56 | 2/45 | 037 | 0202 | 0998 |
| | CHEK | 260 | 29 | 22024 | 2 | 338 | 315 | 226.2 | 300 | 0529 | 0/57 | 1/48 | 037 | 0165 | 0968 |
| | AGAT | 260 | 28 | 23032 | 3 | 336 | 304 | 225.2 | 306 | 0223 | 1/00 | 0/47 | 038 | 0127 | 0940 |
| | SHA | 260 | 28 | 24034 | 4 | 335 | 301 | 236.6 | 085 | 0138 | 0/17 | 0/30 | 010 | 0116 | 0923 |
| | –X– | 260 | 27 | 24035 | 4 | 336 | 301 | 218.7 | 019 | 0119 | 0/04 | 0/27 | 002 | 0114 | 0915 |
| **BEGINNING OF DESCENT** | BOD | 260 | 27 | 24037 | 4 | 335 | 298 | 219.3 | 027 | 0092 | 0/05 | 0/21 | 003 | 0111 | 0916 |
| **MAP COORDINATES** | MAG | – | 02 | 20017 | – | 334 | 320 | 219.3 | 018 | 0074 | – | – | – | – | – |
| | CKH | – | 02 | 20017 | – | 334 | 319 | 218.6 | 054 | 0020 | – | – | – | – | – |
| | PHNA | – | 02 | 20017 | – | 200 | 200 | 265.6 | 020 | 0000 | 0/21 | 0/00 | 011 | 0100 | – |

| | | | | | | |
|---|---|---|---|---|---|---|
| **LAT/LONG MAP COORDINATES** | FRUI | N36050W124500 | COST | N34469W129145 | COPP | N32511W134468 |
| | COFE | N30412W140042 | CITT | N28189W145072 | CHEK | N25458W149565 |
| | AGAT | N23000W154390 | SHA | N22311W156056 | –X– | N22191W156210 |
| | MAG | N21507W156581 | CKH | N21161W157423 | PHNA | N21186W158042 |

*Table 5. Jetplan*

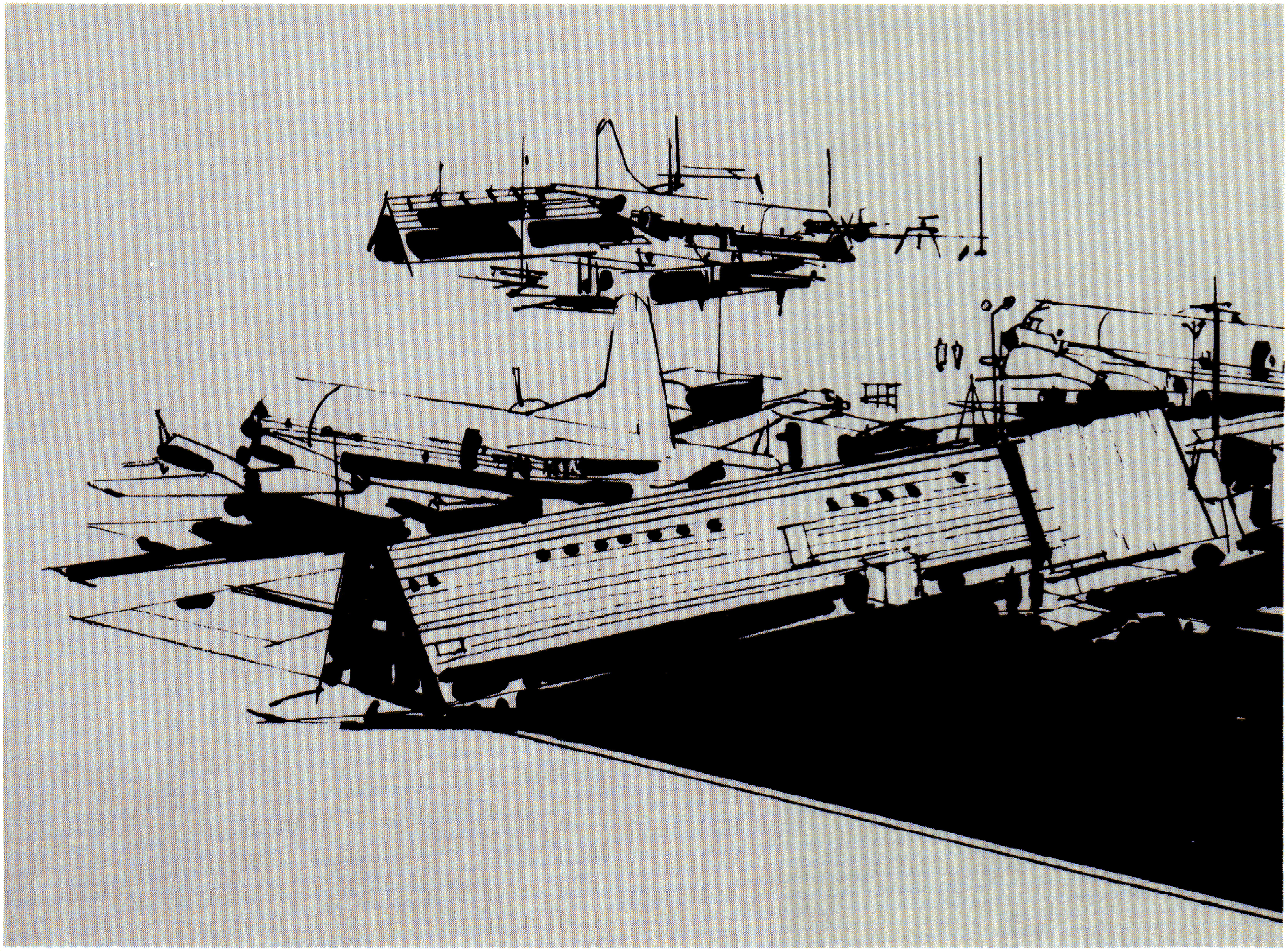
most economical route and flight procedures based on latest available weather data for a specified mission. Jetplan will determine the minimum fuel to accomplish a required mission for a given loading with specified reserves and alternates. Typical output data from Jetplan are shown in Table 5.

**GROUND TESTS, STARTING, AND TAXIING** Ground power equipment usually costs less to operate and burns less fuel than aircraft power units. Thus, whenever practical, ground power equipment should be used to start and ground-check aircraft systems. Use of aircraft systems, including lighting, should be kept to a minimum on the ground as well as in flight. All system checks and preflight planning should be completed and clearance obtained before starting the aircraft engines. If taxiing or ground-holding time is expected to be extensive, use only two engines. Use low engine speed to minimize fuel consumption; this also reduces noise and the possibility of foreign object damage due to excessive propwash. Expected fuel flow during ground operation is given in the NATOPS Flight Manual.

## FLIGHT OPERATION

Several flight operating procedures can be incorporated into the flight plan to enhance fuel economy. If the Jetplan is used, most of these fuel-saving procedures will be automatically programmed into the flight plan.

**TAKEOFF AND CLIMB** Fuel consumption for takeoff, acceleration to best climb speed, and climb is minimized by operating the engines at maximum permissible power. Unfortunately, operating at maximum power significantly reduces engine life. The slight improvement of range (10



nautical miles of operational radius) is hardly worth the expense. Consequently, it is recommended that military power (1049°C TIT) be used for climb *only* when it is essential to mission performance and safety, and normal power (1010°C TIT) be used for climb during all other operations.

**TRANSIT** Airplane operating procedures employed during the cruise segments of the flight play a most significant role in fuel conservation and range extension. The following operating recommendations will help you obtain the maximum range. Some of these recommendations may have to be tempered by safety, tactical, atmospheric, and air traffic control considerations. See Table 6 for quantitative data on fuel savings or radius improvement for a typical maximum radius ASW mission under standard atmosphere and zero wind conditions.

1. Fly at the cruise ceiling (925°C TIT, or 1010°C TIT if essential for the mission) as shown in Table 7.
2. If cruise ceiling cannot be attained, fly a step cruise profile as near cruise ceiling as possible. It is suggested that a climb be made to a new cruise ceiling after each 5000-pound fuel burn, except when the last burn will be less than 5000 pounds. Climbs should be at normal power (1010°C TIT).
3. Fly at or slightly less (not slower than 10 KIAS) than the speeds given in the NATOPS Flight Manual for maximum range operating tables that correspond to the configuration, gross weight, and altitude. Maximum range data provided in NATOPS are approximately 99 percent of the maximum specific range, providing a

| FLIGHT OPERATION | ALTITUDE (FEET) |  | FUEL SAVED (LB/MISSION) | OR | RADIUS INCR (NM/MISSION) |
|---|---|---|---|---|---|
|  | OUTBOUND | INBOUND |  |  |  |
| FOUR ENGINES OPERATING AT CONSTANT POWER SETTINGS AND ALTITUDE | 2,000 | 2,000 | – |  | – |
| FOUR ENGINES OPERATING AT OPTIMUM POWER SETTINGS AND CONSTANT ALTITUDE* | 2,000 | 2,000 | 600 |  | 20 |
| OPTIMUM NUMBER OF ENGINES OPERATING AT OPTIMUM POWER SETTINGS AND CONSTANT ALTITUDE* | 2,000 | 2,000 | 7,700 |  | 260 |
| FOUR ENGINES OPERATING AT CONSTANT POWER SETTINGS AND ALTITUDE | 18,000 | 29,000 | 17,400 |  | 580 |
| FOUR ENGINES OPERATING AT OPTIMUM POWER SETTINGS AND CONSTANT ALTITUDE* | 18,000 | 29,000 | 19,800 |  | 660 |
| FOUR ENGINES OPERATING AT 925°C TIT (TURBINE INLET TEMPERATURE) CRUISE CEILING | 18,000 TO 24,000 | 29,000 TO 34,000 | 24,900 |  | 830 |
| FOUR ENGINES OPERATING AT 1010°C TIT (TURBINE INLET TEMPERATURE) CRUISE CEILING | 23,500 TO 28,000 | 33,000 TO 34,000 | 27,000 |  | 900 |

*NOTE: P-3C WITH CONFIGURATION B, 139,760 POUNDS TAKEOFF GROSS WEIGHT INCLUDING 62,560 POUNDS JP-5 FUEL. AIRCRAFT WARMUP, TAKEOFF, AND ACCELERATION TO CLIMB SPEED CONSUMES 600 POUNDS OF FUEL; LOITERS FOUR HOURS ON STATION AT 5,000 FEET; ARRIVES OVER BASE WITH 6,000 POUNDS OF RESERVE FUEL.*

**POWER REDUCED FOR EACH 1,000 POUNDS OF FUEL CONSUMED.*

*Table 6. Flight Operation – Transit*

transit speed about 10 KIAS faster than maximum nautical miles *per pound*. Do not exceed the NATOPS recommended speeds; range decreases rapidly at higher speeds.

4. Set engine power to maintain the appropriate *speed* and altitude listed in the NATOPS Flight Manual. *Do not* set engine power at the listed NATOPS power setting and allow the speed to establish itself. Adjust engine power frequently, at least after every 1000 pounds of fuel consumed, to maintain the speed specified, reducing power as fuel is consumed when holding altitude. Do not allow speed to exceed NATOPS values. The power settings in NATOPS are provided as a cross-check on airplane performance. If the power indicated for the NATOPS speed does not correspond to that given in the manual, after the mission, check the airspeed indicator and examine the exterior of the aircraft for unusual dirt, roughness, or misalignment. If the fuel flow is 5 percent more than that given in the manual when operating at NATOPS power, speed, altitude, and weight, corrective action should be considered.

5. If tactics or traffic control prevent cruise near the ceiling, reduce the number of engines operating. This is a particularly effective means of improving maximum specific range when the aircraft is lightweight and operating at low altitudes. Under these conditions, four engines operating at considerably less than maximum power use more fuel than three engines operating at somewhat greater power. Table 7 shows the initial cruise altitude for maximum specific range as a function of weight, configuration, and number of

| **INITIAL CRUISE WEIGHT (LB)** | **AIRCRAFT ALTITUDE (FEET)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **CONFIGURATION A** | | | **CONFIGURATION B** | | | **CONFIGURATION C** | | | **CONFIGURATION D** | | | **CONFIGURATION E** | | |
| | **ENGINES OPERATING** | | | **ENGINES OPERATING** | | | **ENGINES OPERATING** | | | **ENGINES OPERATING** | | | **ENGINES OPERATING** | | |
| | **4** | **3** | **2** | **4** | **3** | **2** | **4** | **3** | **2** | **4** | **3** | **2** | **4** | **3** | **2** |
| 140,000 | 24,100<br>20,000 | 13,400 | – | 22,400<br>17,600 | 12,300 | – | 20,500<br>15,500 | 9,900 | – | 23,400<br>18,200 | 6,000 | – | 20,600<br>15,000 | – | – |
| 130,000 | 26,400<br>22,400 | 16,200 | 1,300 | 24,900<br>20,200 | 15,100 | – | 23,000<br>18,100 | 12,900 | – | 26,000<br>21,300 | 8,900 | – | 23,600<br>18,500 | – | – |
| 120,000 | 28,700<br>24,800 | 19,000 | 4,600 | 27,400<br>23,000 | 17,900 | 2,500 | 25,500<br>20,800 | 15,900 | – | 28,600<br>24,400 | 11,800 | – | 26,600<br>22,000 | – | – |
| 110,000 | 30,900<br>27,200 | 21,800 | 7,900 | 29,900<br>25,700 | 20,700 | 6,000 | 28,000<br>23,600 | 18,900 | 4,200 | 31,200<br>27,500 | 14,700 | – | 29,600<br>25,500 | – | – |
| 100,000 | 33,100<br>29,600 | 24,600 | 11,200 | 32,400<br>28,400 | 23,500 | 9,500 | 30,500<br>26,400 | 21,900 | 7,600 | 34,000<br>30,600 | 17,600 | – | 32,600<br>29,000 | – | – |
| 90,000 | 34,400<br>32,000 | 27,400 | 14,500 | 34,400<br>31,100 | 26,300 | 13,000 | 33,000<br>29,400 | 24,900 | 11,000 | 34,400<br>33,800 | 20,500 | – | 34,400<br>32,500 | – | – |
| 80,000 | 34,400<br>34,400 | 30,200 | 17,800 | 34,400<br>33,800 | 29,300 | 16,500 | 34,400<br>32,200 | 27,900 | 14,400 | 34,400<br>34,400 | 23,500 | – | 34,400<br>34,400 | – | – |
| 70,000 | 34,400<br>34,400 | 33,000 | 21,100 | 34,400<br>34,400 | 32,600 | 20,000 | 34,400<br>34,400 | 30,900 | 19,000 | 34,400<br>34,400 | 26,500 | – | 34,400<br>34,400 | – | – |

*NOTES: 1. ALTITUDE IS IN FEET.*

*2. STANDARD ATMOSPHERE; FOR NONSTANDARD ATMOSPHERE, USE NATOPS MAXIMUM RANGE FUEL CHARTS.*

*3. FOR T56-A-14 ENGINE, INITIAL POWER IS NORMAL RATED (1010°C TIT).*

*925°C TIT IS THE OPERATING LIMIT TO MINIMIZE SULFIDATION.*

*Table 7. Initial Cruise Altitude for Maximum Specific Range*

engines operating. Assume, for example, it is desirable to operate a P-3C at a maximum range flight profile. With 130,000 pounds initial cruise weight, Configuration A, and engines operating at 1010°C TIT, Table 7 shows that maximum range can be attained with four-engine operation beginning at 26,400 feet. This is the maximum altitude at which a P-3C can operate with this weight without exceeding 1010°C TIT. Within the altitude envelope of 1300 to 16,200 feet, three-engine operation provides maximum specific range. Below 1300 feet, two-engine operation provides maximum range. However, at least three engines must be operated below 1000 feet to assure safety of flight.

The effect of wind on specific range (in this case, ground nautical miles per pound of fuel consumed) is shown in Table 8. Specific range is significantly improved when the airplane is flown slightly faster in headwinds and slightly slower in tailwinds. Since the NATOPS maximum range operating speeds are based on 99 percent of the maximum miles per pound, these figures remain valid for operations against headwinds up to 100 knots.

**LOITER** Determination of fuel required for loiter operations is considerably less complicated than transit operations since optimum routing and wind factors are not involved. The operating procedure for minimum fuel consumption during loiter can be ascertained by scanning the loiter operating tables in the P-3C NATOPS Flight Manual and selecting the combination that gives the maximum loiter time for the configuration, gross weight, and temperature. The remaining engines should be set at equal power.

It will quickly be discovered from the NATOPS Flight Manual or Table 9 that the loiter minimum fuel flow always occurs with the minimum number of engines operating, even when allowing for the trim drag of operating two engines on one side only. All P-3C NATOPS two-engine data *allow for*

| **CRUISE SPEED (KIAS)** | **195** | **205** | **215** | **225** | 235 | **245** | **255** | **265** |
|---|---|---|---|---|---|---|---|---|
| **CRUISE SPEED (KTAS)** | **261** | **275** | **289** | **303** | 316 | **330** | **343** | **356** |
| **100-KNOT HEADWIND** | | | | | | | | |
| SPECIFIC RANGE (NM PER LB OF FUEL) | 0.0434 | 0.0457 | 0.0475 | 0.0490 | 0.0498 | 0.0499 | 0.0497 | 0.0494 |
| CHANGE IN SPECIFIC RANGE | -12.5% | -7.0% | -4.5% | -1.4% | 0.0% | +0.3% | -0.1% | -0.7% |
| **ZERO WIND** | | | | | | | | |
| SPECIFIC RANGE (NM PER LB OF FUEL) | 0.0704 | 0.0718 | 0.0727 | 0.0732 | 0.0728 | 0.0716 | 0.0702 | 0.0687 |
| CHANGE IN SPECIFIC RANGE | -3.3% | -1.4% | -0.1% | +0.6% | 0.0% | -1.6% | -3.6% | -5.5% |
| **100-KNOT TAILWIND** | | | | | | | | |
| SPECIFIC RANGE (NM PER LB OF FUEL) | 0.0974 | 0.0979 | 0.0979 | 0.0974 | 0.0958 | 0.0933 | 0.0907 | 0.0880 |
| CHANGE IN SPECIFIC RANGE | +1.6 | +2.2% | +2.2% | +1.6% | 0.0% | -2.7% | -5.4% | -8.2% |

*NOTE: 1. CONFIGURATION C AIRCRAFT, ALTITUDE 20,000 FEET, WEIGHT 100,000 POUNDS.*

*2. THE VARIATION IN SPECIFIC RANGE IS SIMILAR FOR CONFIGURATIONS A AND B AND OTHER WEIGHTS AND ALTITUDES AS WELL.*

*NATOPS RECOMMENDED CRUISE SPEED.*

*Table 8. Effect of Cruise Speed and Wind on Specific Range*

*the worst asymmetrical engine failure*. This is a turbine/propeller engine airplane characteristic that is rarely found in jet or fan-engined aircraft. The lower specific fuel consumption of the remaining engines operating at higher power more than compensates for the propulsion system drag with a feathered propeller (and even the trim drag in case of asymmetrical power). This is especially true for low altitude operation. Just be sure to follow the safety procedures in the NATOPS Flight Manual when operating with one or more engines secured.

NATOPS loiter operating tables and Table 9 show that fuel flow is only moderately affected by altitude when the minimum number of engines are operated to maintain altitude. If the mission plan projects descent from high altitude cruise (maximum range) to loiter for a short period (less than two hours), usually it is more economic to maintain altitude or make only a short descent if the mission plan requires return to high altitude cruise after loiter. Fuel savings should be realized in this case, even if it is necessary to operate more engines than would have been required for loiter at a lower altitude. The overall fuel savings is gained by eliminating the high fuel consumption required to climb back from low altitude to the high transit altitude (maximum range). Naturally the best procedure depends on the loiter duration, tactical situation, weather factors, etc. *Use of manuever flaps during loiter increases fuel flow*.

The loiter airspeed given in the NATOPS Flight Manual should not be exceeded; fuel flow increases rapidly as speed increases. Remember, NATOPS loiter power settings are provided to check airplane and engine performance, not to establish aircraft speed. The NATOPS loiter speeds were conservatively selected to provide a large speed margin above the "back side" of the speed/power curve and a still larger margin above stall – in the case of loiter speeds, the stall margin is 60 KIAS for 1-g stalls. At the Navy's request, Lockheed has developed maximum endurance operating data for the P-3C Orion. It is estimated that these operating techniques will produce a 2 to 4 percent reduction

| **NUMBER OF ENGINES OPERATING** | **LOITER ALTITUDE** | **FUEL SAVED (LB/HR)** | **OR** | **RADIUS INCREASE (NM/HR)** |
|---|---|---|---|---|
| FOUR | SEA LEVEL | – | | – |
| | 20,000 FEET* | 880 | | 28 |
| THREE | SEA LEVEL | 535 | | 28 |
| | 16,000 TO 20,000 FEET* | 940 | | 31 |
| TWO | 1,000 FEET | 1090 | | 38 |
| | 6,000 TO 10,000 FEET* | 1170 | | 39 |

*NOTE: P-3C WITH CONFIGURATION B, 139,760 POUNDS TAKEOFF GROSS WEIGHT INCLUDING 62,560 POUNDS JP-5 FUEL. AIRCRAFT WARMUP, TAKEOFF, AND ACCELERATION TO CLIMB SPEED CONSUMES 600 POUNDS OF FUEL; CRUISES OUT AT 21,000 FEET; RETURNS AT 28,000 FEET; ARRIVES OVER BASE WITH 6,000 POUNDS OF RESERVE FUEL.*

**OPTIMUM ALTITUDE FOR MINIMUM FUEL FLOW.*

*Table 9. Number of Engines Operated – Effect on Loiter*

in fuel flow compared to the NATOPS loiter data for Configurations A through C. Considerably more fuel reduction is projected for Configuration D. The Navy is currently investigating the inclusion of these data in the NATOPS Flight Manual.

**DESCENT AND LANDING** The NATOPS Flight Manual presents performance curves for (1) descent at loiter speeds, (2) descent at placard limit airspeeds at "flight idle" power, (3) a recommended operational descent at 275 KIAS, and (4) descent with gear down at limit speed. Low rate-of-descent letdowns at loiter airspeed are most economical. These letdowns should be initiated allowing about two and one-half nautical miles out for each 1000 feet above the final altitude. If low altitude operation with less than four engines is planned (e.g., for loiter or search), additional fuel will be conserved if engine shutdown is performed prior to initiating the descent. Letdowns at high rates of descent are intended primarily for emergency or tactical use, such as cabin pressure failure. *To minimize loads on flaps, avoid use of flaps during descent.*

When flying a holding pattern prior to landing, the aircraft commander should keep in mind the recommendations given in this article's section on loiter. Final descent should be planned to minimize flight at low altitude. Four engines should be used in landing to provide maximum climb-out safety in event of waveoff. If extensive taxiing is required after clearing the runway, secure the outboard engines and maintain low engine speed.

**OPERATION UNDER ICING CONDITIONS** Engine anti-ice and wind de-ice systems operation consumes fuel. Since ice is rarely encountered even intermittently for more than two hours total during a maximum mission, the normal fuel reserve is considered adequate. Engine anti-ice system operation consumes about 200 pounds of fuel per hour, an increase of about 5 percent over the aircraft's normal fuel flow. When wing de-icing operation is added, the total fuel flow increase amounts to 500 pounds per hour. Wing de-icing should be turned on when ice builds up and turned off after ice is removed.

## CONCLUSION

In the ASW community, the most efficient use of an aircraft's fuel load is translated into greater operational radius or more time on station. This efficiency can be achieved by careful mission and flight planning, and by using the most economical operational procedures during the mission. Additional fuel economy can be realized during maintenance and preflight activities by maximum use of ground power sources. In this way, more base fuel is available for in-flight training and mission operations.

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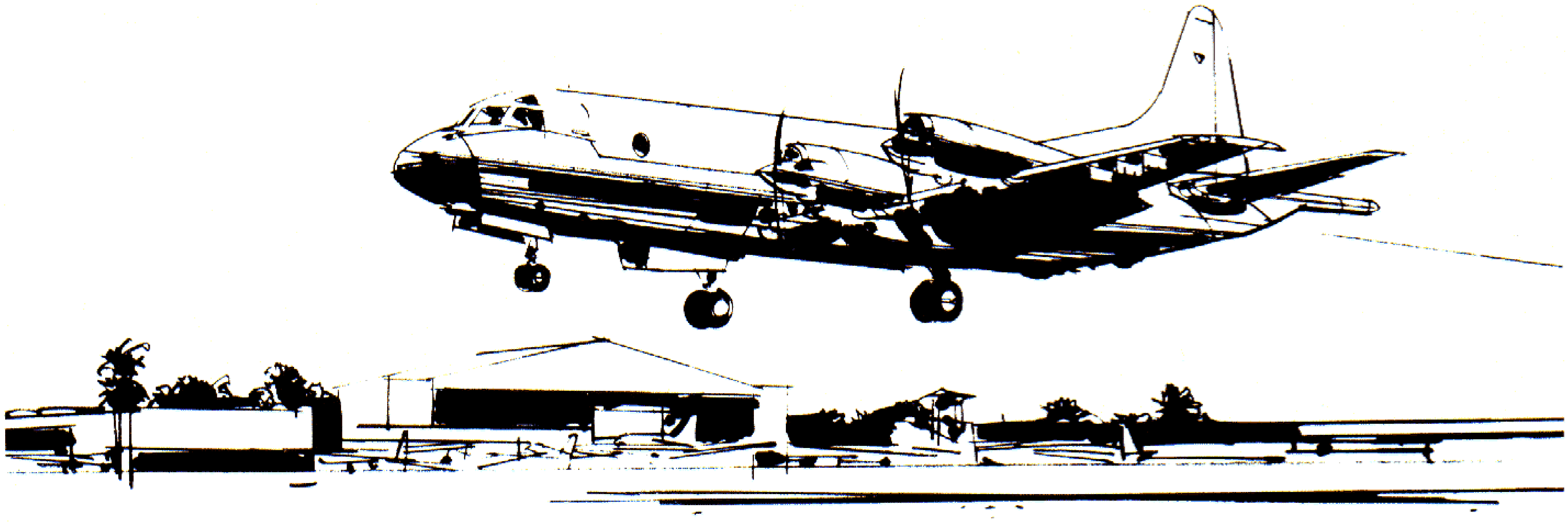

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