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NINETEEN SIXTY-EIGHT has arrived, and with its emergence come promises of an eventful year. A year of newness ... advancements ... innovations ... progress. A year of major elections. A year of work. A year with 24 extra hours—a Leap Year.

People speak futuristically of the year 2000. In just 32 more years we will witness its arrival on the Calendar of Time. We are now living in a period of dynamic advances—a period of challenge ... of ingenuity ... of study and analysis ... of decision making. Thirty-two years from now, 1968 will be our history.

It has been said that the world alters as we walk in it. Change has always been a part of the human condition. The difference now is the pace of change and the prospect that it will come faster and faster, affecting every part of life, particularly technology.

The latest and finest in technology is one of the hallmarks of General Dynamics Corporation. The Fort Worth Division is a special world of ideas and products—largely geared to the F-111 Program at present. General Dynamics is strongly fortified with people, facilities, and experience to meet demands of the future. Improving present products, processes, and methods as well as developing new ones are capabilities essential to future programs.

The 111 LOG begins its second volume with this issue. The lead story is an illuminating account of the FB-111A strategic bomber—the newest addition to the Strategic Air Command's bomber force. An in-depth report of SAC and its operations follows.

The magazine also focuses attention on Terrain Following Radar, a unique subsystem of the F-111 avionics systems; CENPAC (Central Processor and Controller), the new boss for five test station types in the Armament and Electronics Shop; the latest developments in welding methods; and a maintainability feature entitled "Keep 'Em Flying Through Maintainability."

Our regular attractions—"Do You Know ..." "Facts and Figures," and the "111 Field Directory"—are also included in this month's 111 LOG.

With pride and confidence, we on the magazine staff welcome in the New Year on behalf of the 111 Logistic Support Department.
This year the Strategic Air Command is scheduled to begin receiving FB-111A aircraft. This version of the basic F-111 design will utilize the F-111A fuselage but will include the longer F-111B wing, external fuel tanks, and improved avionics systems.

A major objective in developing the FB-111A was minimum modification of the F-111A aircraft to take advantage of savings in design and manufacturing costs, as well as a reduction in spares and other support requirements over the life of the weapon system.

Because SAC and TAC mission requirements varied, it was necessary to make some important differences in design:

- Electronics equipment differs as necessary to support mission requirements peculiar to SAC
- Internal and external stores provisions vary for specific mission requirements
- Fuel requirements are higher, and weapons bay and external tanks are provided to support the longer ranges desired by SAC
- The Navy wingtips are incorporated to enhance the range capability
- The landing gear is strengthened and equipped with heavier tires, wheels, and brakes to support heavier loads.
OPERATION

The aircraft is designed to effectively deliver weapons over a wide range of operating conditions against the many known or anticipated types of enemy targets. The FB-111A achieves this capability through its wide Mach-Altitude flight envelope, large fuel capacity, and versatile Mark II avionics system. Its probability of mission success is enhanced by on-board penetration aids and its ability to accurately approach and attack selected targets in all weather at high speeds and minimum terrain clearance. The navigation and bombing capabilities of the FB-111A exemplify the most major advancement in the state of the art.

The sturdy nature of the variable-wing aircraft is emphasized in its wing. Both wings combined are equipped with eight pylons—or “hard points”—which can carry a great variety of conventional weapons. External and weapons bay fuel tanks may be utilized to increase range. Thus, another facet of the flexibility of the FB-111A.

MISSION CAPABILITIES

The FB-111A weapon system is able to react rapidly to impending or existing hostilities by global nonstop deployment. Its quick turnaround, short field takeoff or landing, and multiple weapons loading capabilities allow it to fulfill a wide variety of mission requirements.

Its design for fast reaction from a standby alert posture, a long range or long endurance capability with internal fuel (which may be increased through inflight refueling or the addition of multiple external fuel tanks and/or weapons bay tanks), and a relatively high airspeed capability at either high altitude or at minimum terrain clearance all contribute to the flexibility of the aircraft.

SRAM ASPECT

The FB-111A has been designated as a carrier aircraft for the AGM-69A Missile System, more commonly referred to as SRAM—Short Range Attack Missile. The FB-111A will be capable of carrying six SRAMs, two in the weapons bay and one on each of the four pivoting pylons.

MAINTENANCE CONCEPTS

The maintenance philosophy applied to the FB-111A requires a minimum amount of Aerospace Ground Equipment (AGE) consistent with the support requirements. Organizational maintenance is performed primarily through the use of a built-in self-test capability in the aircraft and supplemented with "suitcase" type flight line testers.

The field maintenance concept provides a capability for complete and thorough repair of the aircraft line replaceable units (LRUs) and those modules or subassemblies which are within the intermediate repair level scope. The integral Avionics Shop consists of functional and system oriented test stations. The stations are designed to include all of the required peculiar and standard equipment necessary for testing the assigned LRUs as well as performing self-test and certification of the test stations. The air transportable stations are formed from standard racks with quick action front covers which provide a work surface when folded into position.

The provision of both semi automatic and manual test stations ensures a high degree of confidence in test results as well as providing an efficient method of testing. Equipment requiring complex accuracy tests and recurring test requirements are loaded on the semi automatic stations which are controlled from a central programmer-comparator. Components having similar characteristics are loaded on functionally oriented test stations and share common instrumentation. This approach eliminates duplication of AGE for testing of equipment such as analog computers, video units, inertial components, and so forth. The system oriented stations are essentially simulated "mock ups" with all the necessary instrumentation supplied as an integral part of the station.

Maintenance tasks beyond the capability of field level or occurring infrequently at the using activity are accomplished at depots or specialized repair activities. The AGE provided for this level furnishes a greater depth of maintenance than the field equipment, while retaining full compatibility.

The FB-111A aircraft is so designed that most maintenance and all servicing can be accomplished from ground level and with a minimum of personnel. Its performance—together with its reliability and maintainability—yields a weapon system far superior to its predecessors in terms of operational capability, cost effectiveness, and safety.
The Strategic Air Command, commonly known as SAC, is the aerospace counterforce to enemy military threats of aggression and world domination. With an authorized strength of nearly 200,000 personnel, SAC's primary job is to deter war—to provide a "strategic umbrella" under which leaders can negotiate.

**PEACE IS OUR PROFESSION**, the Strategic Air Command motto, symbolizes the role of deterrence. Although SAC represents the most powerful striking force in the world's history, the command's primary mission is to preserve peace.

Thus, the principal purpose of this military force—to prevent war—is sufficient as a deterrent only as long as it convinces potential enemies that aggression against the United States and our Allies is profitless. If the effort to deter nuclear war should fail, SAC would destroy an enemy's will and ability to fight.

**ORGANIZATION**

Simple, direct organization is one of SAC's most vital elements. Headquarters at Offutt Air Force Base, near Omaha, Nebraska, serves as the nucleus of the command. It is from here that SAC's aerospace force of aircraft and missiles would be directed against an enemy after the order to strike had been received from the President.

Within the continental United States, SAC has three numbered air forces and a missile test/training division. Each numbered air force controls a nearly equal part of SAC's mixed force of operational bombers and intercontinental ballistic missile units.

Second Air Force, headquartered at Barksdale AFB in Louisiana, controls SAC units in the central section of the country. Eighth Air Force, with headquarters at Westover AFB in Massachusetts, has units located in the eastern part of the United States, Labrador, and Puerto Rico. From March AFB in California, Fifteenth Air Force controls SAC units in the western states and in Alaska.

Vandenberg AFB in California is SAC's missile test site and training center for missile crews.
TYPICAL OF THE NEW BREED
of Air Force men is the Minuteman
missile combat crew—an integral
part of SAC's mixed force of
bombers and missiles.

Overseas, the 98th Strategic Wing in Spain
is responsible for SAC operations in Europe, and
the Third Air Division on Guam is concerned with
SAC activity in the Pacific area.

SAC'S MIXED FORCE
To meet enemy military aggression, the com-
mand remains flexible enough to suit the needs
of any situation. SAC's manned bombers can strike
several targets on a single mission and be recov-
ered to be used again. They can carry either nu-
clear or conventional weapons and can be launched
under positive control to demonstrate national
intent. Manned bombers also have the advantage
of placing the judgment and experience of a trained
combat crew over the target.

Missiles are the ideal strategic complement
to the manned bomber. They react quickly, are
easily adapted to hardening and dispersal for pro-
tection, reach their targets quickly, and are able
to penetrate all known defenses.

The missile is not a substitute for the bomb-
er. Missiles and bombers complement each other.
There are certain jobs a missile can do better than
a bomber and vice versa. Next year, Strategic Air
Command is scheduled to begin receiving FB-111A
aircraft, all soon to be operational.

Essentially, the bomber will be a basic F-111A
airplane with some modifications. It will have the
fuselage of the Air Force fighter and the slight-
ly longer wings of the Navy version. The FB-111A
variable sweep wings, together with the afterburn-
ing fan engines, enable a high degree of flexibil-
ity never before achieved in a single aircraft. This
versatility permits efficient operation in any part
of a large flight envelope.

POSITIVE CONTROL
A tested system of codes and communications
procedures ensures positive control of the Strate-
getic Air Command retaliatory force. The SAC bom-
ber and tanker force can be launched in minutes
by the SAC commander in chief if warning of an
attack is received from the North American Air
Defense Command. Getting the bombers airborne
DOES NOT send SAC to war. It DOES insure sur-
vival of SAC's ground alert aircraft should the warn-
ing prove valid.

After reaching a certain point on their routes
(well outside enemy territory), the bombers au-
tomatically return to their bases unless they re-
cieve positive coded voice instructions to proceed
to their targets. Authority from the President is
the only means whereby the SAC force would pro-
cceed to target, beyond the "positive control" point.
If the "go code" is not received, they turn back.

The positive control procedures are tested
repeatedly and have been proved effective under
all circumstances. Multiple safeguards are em-
ployed to prevent bombing without Presidential
direction.
SAC ALERT FORCE

Before positive control can ever be initiated, SAC's alert force must be activated. In today's aerospace age, intercontinental ballistic missiles are able to strike half way around the world in less than 30 minutes. Consequently, SAC must be able to launch its bombers and missiles within minutes.

The SAC alert force is ready to react within the warning time provided by the Ballistic Missile Early Warning System (BMEWS), operated by the North American Air Defense Command (NORAD). Strategic Air Command has approximately 40 percent of its total bomber and tanker force on 15-minute ground alert; its missile launch centers are always manned.

Crews and aircraft, both in a constant state of readiness, are never more than a few minutes from being airborne at any time. And once airborne, SAC's positive control procedures guarantee that the bombers — should they be launched on an actual alert — will not touch off a war under false alarm warning.

As far as future SAC planners can see, manned bombers will be needed along with missiles to give the command flexibility of operations impossible to obtain by relying solely on one weapon system.

COMMUNICATIONS

To control the SAC aircraft and missile force — and maintain contact with aircraft and missile combat crews — the command employs a world wide telephone network, global teletype circuits, and a single side band radio network. Together these give SAC the most advanced and extensive communications system in existence.

Because communications circuits cannot be completely secured from destruction, SAC relies on a combination of these systems to guarantee centralized control of its forces. Each system has a number of alternate control and routing points in the United States and overseas to further ensure survivability.

UNDERGROUND COMMAND POST

The SAC headquarters building at Offutt AFB consists of seven floors — three above ground, a basement, and the three-story underground command post. Only persons having a definite requirement are allowed to enter the SAC underground limited access area.

Constructed of steel reinforced concrete, the 24-inch thick walls of the underground area are topped by a 10-inch ceiling at each level. The entire underground area is covered by a structural roof slab five feet below ground level. In time of war, the underground would be sealed off and would be totally self-sufficient.

SAC's control room, communications status center, trajectory center, global weather center, and portions of the Joint Strategic Target Plan-
ning Staff, intelligence, materiel, and operations activities are located in the underground.

The commander in chief of SAC and members of his battle staff would be stationed on the command balcony during time of emergency. The balcony overlooks the control room and display panels below. Within 30 seconds, vital operational data can be taken from a computer drum and flashed on screens before the entire SAC battle staff.

AIRBORNE COMMAND POST

Command and control are essential elements of the Strategic Air Command striking force. Without them, in time of war, the finest military force ever developed to protect the interests of the Free World would not be able to function effectively and efficiently.

If the SAC command post and alternate ground-based command posts are destroyed, the airborne command post—complete with communications equipment and manned with an experienced team of controllers—can assume direction of the command’s bomber and missile force.

The control team aboard the airborne command post is always commanded by a SAC general officer. He has a staff of highly experienced operations, intelligence, materiel, and communications personnel.

Ultra high frequency and single side band radio equipment is used to maintain contact with the SAC underground command post, alternate SAC command posts, the USAF command post at Washington, and the joint war room in the Pentagon.

TARGET PLANNING

In event of global war, the SAC force and other U.S. military elements would be applied against carefully selected enemy targets. A single, integrated operational plan (SIOP) for initial U.S. retaliatory strikes has been developed at Headquarters SAC by the Joint Strategic Planning Staff. This staff of experts is directed by the SAC commander.

With a mission to blueprint wartime targets and select weapons to be used, the Joint Strategic Planning Staff provides operational planning under the Joint Chiefs of Staff policy, and provides control and direction to ensure integration and employment of all strategic systems—bombers, fighters, land-based missiles, air-launched missiles, and missile-armed naval vessels and submarines.

The staff has more than 175 Air Force, Navy, Army, and Marine personnel who work at Headquarters SAC. Staff representation includes top personnel from commands in the European, Atlantic, Pacific, and Alaskan areas.

HISTORICAL HIGHLIGHTS

SAC—established March 21, 1946, at Bolling AFB, D.C., and relocated at Andrews AFB, Maryland, seven months later—was given the responsibility for developing an atomic striking force. At the year’s end, Strategic Air Command had two air forces, the Fifteenth and the Eighth; 37,000 people; 18 bases; 9 bomb groups and 2 fighter groups.

In 1947, SAC bomb squadrons rotated to the Far East, beginning the development of SAC’s global mobility. SAC also began flying simulated attacks against major U.S. cities. By the end of the year, SAC boasted 50,000 people, 15 bases, 16 bomb groups, and 5 fighter groups.

General Curtis E. LeMay took command of SAC in October of 1948 and moved the headquarters to Offutt AFB, Nebraska, in November. In this same year—for the first time in Air Force history—in-flight refueling was used in organized missions to extend the range of strategic bomb units.

SAC’s operations continued to make history, and during the year of its tenth anniversary (1956) SAC’s jet forces had accumulated two million flying hours by December. It had taken eight years for SAC jet aircraft to fly the first million hours; it required only 18 months for the accumulation of the second million. By the end of 1956, SAC had 217,000 people, 37 U.S. and 18 overseas bases, and 3,100 strategic aircraft.

1958 saw the incorporation of several new concepts in the SAC program. Among these were Positive Control, Reflex Action, and Force Dispersal. Positive Control is a tested and proved means of recalling aircraft which have been launched toward enemy targets. Under Reflex Action, SAC aircraft move to forward bases overseas and remain on alert for a short period, being relieved by a like force. The Dispersal program was designed to place small groups of SAC bombers on many bases, thus providing a more complex target for enemy forces.

The B-58 Hustler—the Free World’s newest, swiftest, and most versatile long-range bomber—became operational August 1, 1960. This and innumerable other milestones in SAC’s 21-year history have aided SAC in its effectiveness. Most of all, Strategic Air Command has been paced by the ingenuity and drive of its professional man-power together with the development of its organization, weapons and tactics.
SAC'S FUTURE

Never before has a military force of such tremendous power been dedicated to preventing war. The Strategic Air Command and its deterrent mission of today... and tomorrow... is founded on both careful military planning and the experience of World War II.

Already a stage in military technology and operations—where minutes could be decisive—has been reached. SAC maintains its force in a state of constant readiness never before achieved by any military force in peacetime. SAC has been given the responsibility for the delivery of between 80 and 90 percent of the total nuclear firepower of the Free World.

The Strategic Air Command looks to the future with confidence. The command constantly employs new techniques and scientific methods to improve mobility, flexibility, and the striking power of the force. As new aerospace weapons are developed, SAC will be ready to use them to maintain an honorable peace.

THE STRATEGIC AIR COMMAND

- United States Air Force's global strike force—operating on a global basis, the world's most powerful military force.
- Operator of global communications and support systems needed to operate intercontinental weapon systems, including manned bombers and intercontinental ballistic missiles.

THE MISSION

- Peacetime: Maintain a force capable of deterring enemy aggression.
- Wartime: Destroy the enemy's war making capability.

THE ORGANIZATION

- With headquarters at Offutt AFB near Omaha, Nebraska, SAC force is located at more than 50 bases worldwide.

THE CAPABILITY

- The jet bomber force, through aerial refueling, has global range.
- Day and night about 40 percent of the force is on ground alert in the United States and overseas, armed and positioned to take off within the warning time of an ICBM attack as provided by the Ballistic Missile Early Warning System (BMEWS). The concept of airborne alert has been tested, found feasible, and all SAC heavy bomber units are engaged in regular airborne alert training.
- ICBMs are constantly on alert, supplementing SAC's manned bomber force.
- Effective bomber/tanker and missile forces are operation-ready.

THE OPERATION

- Continuous combat training: more than 20 million flying hours completed; about 40 percent of SAC's bomber/tanker force and all of SAC's operational ICBM squadrons on alert at all times.

THE MEN

- An authorized strength of more than 182,000 personnel: 24,000 officers authorized, 133,000 enlisted personnel, 24,000 civilians.
A solution to the age-old problem of low-level penetration (terrain following) has been incorporated into the F-111 avionics system. This unique subsystem is proving to be efficient and reliable.

The F-111 sweep wing aircraft is designed to allow low-level flights at supersonic speeds for the penetration of enemy defenses. Terrain following radar (TFR) is the unique avionics subsystem that provides the pilot with continuous terrain clearance information and allows him to maintain a constant separation from the ground and any objects in his flight path.

The TFR set is a Ku-Band dual channel radar system used to furnish an all-weather, day/night, low altitude penetration capability at all speeds within the aircraft capability at that altitude. The system supplies information for terrain following, terrain avoidance, and blind letdown to low altitude. Automatic terrain following is available through system tie-in to the autopilot.

HOW TFR IS USED

Terrain following radar may be used in either a manual or an automatic mode. In the automatic mode, the flight control system automatically responds to commands from the TFR to fly the aircraft along the vertical flight profile that will maintain the selected clearance above the terrain. Steering commands for vertical separation are displayed on the pilot’s attitude director indicator and on the optical sight. The pilot can use these steering commands to fly manually a terrain following profile or to monitor the automatic terrain following mode. The pilot may also fly the system manually by performing horizontal course corrections to avoid those obstacles that are presented on the radar scope.

Two separate TFR channels are provided for redundancy. Each channel may be operated in any of three modes: Terrain Following, Situation Display, or Ground Mapping.

OPERATING MODES

The Terrain Following Mode allows the aircraft to be flown manually or automatically in order to maintain a preselected clearance above the terrain. In the automatic mode, climb and dive signals are coupled with the autopilot system and may be displayed on the attitude director indicator and on the optical sight if desired.
For manual operation, the pilot can fly the climb/dive commands displayed on the vertical steering bar of the attitude director indicator and the optical sight. The Terrain Following Mode can also be used for making blind letdowns to a selected terrain clearance, using either the automatic or the manual procedure.

Only one of the two available channels can be used in the Terrain Following Mode at one time. If both channels are selected to the Terrain Following Mode at the same time, the second channel will go to standby condition and come into operation automatically if the first channel should malfunction or fail. (Should the flying channel fail, a fly-up command will be generated until the second channel assumes operation or the mode is disengaged.)

In the Terrain Following Mode, the operating antenna is scanning vertically, and an E-Scope display is presented to the pilot. Terrain clearance reference is provided by a cursor on the scope—the slope of which will vary with the speed of the F-111, terrain clearance selected, and the type of ride selected.

The range display on the scope is non-linear. Thus, ranges up to two miles are displayed on the first three-fourths of the scope, and the remaining one-fourth of the scope displays the next eight miles. To maintain the selected terrain clearance, the F-111 pilot flies to keep video returns displayed on the scope below the cursor reference line. Whenever a return appears above the cursor, it indicates that an object higher than the desired flight profile is in front of the aircraft.

A second mode of operation—the Situation Display Mode—is used in conjunction with the Terrain Following Mode. During this operation the antenna scans in azimuth, 30 degrees on each side of ground track. Returns from terrain higher than the altitude of the aircraft are displayed...
on the radar scope. Using this mode, the pilot may elect to maneuver around an obstacle rather than to fly over it.

Ground Mapping Mode is a third mode of operation that can be selected. It gives the pilot a scope presentation similar to other navigational and bombing radars and is used primarily for navigation. In this mode the terrain ahead of the aircraft—both above and below the aircraft—is presented on the scope.

MODE VARIATIONS

Three basic options (or combinations of these) are available to the pilot. First, any one of six selections for terrain separation can be chosen. The range varies from the minimum to the maximum limits of the equipment. Second, like choosing a pillow, either a "soft, medium, or hard" ride can also be selected. This selection controls the magnitude of the negative "G" forces imposed upon the aircraft during terrain clearing maneuvers, the maximum positive "G" forces being a constant. The third basic option is between automatic or manual flight. As the aircraft starts its flight through hills and valleys, the pilot can preplan how he wants to fly the course—how high above the terrain, the magnitude of the maneuver to maintain that clearance, and whether he wants to do it himself or to let the autopilot do it.

The TFR furnishes either the pilot or the autopilot with a fly-up signal any time there is a malfunction in the system. Warning and caution lights are also provided to give the pilot a definitive indication of malfunctions. Two fail lights are installed on the TFR control panel, one for each radar channel. Additionally, a TFR red warning light is installed on the left side of the instrument panel to alert the aircraft commander of a TFR channel malfunction.

DESIGN ADVANCES

Design features of the TFR yield several advances over previous terrain avoidance systems. Redundancy and flexibility of operation is obtained by duplication of all system components (except for cockpit controls and displays) to provide two independent channels. Factory boresight of antenna components, combined with monopulse design techniques, removes any requirement for system calibration once the initial installation is complete.

The Terrain Following Radar Set complements the Attack Radar Set and Inertial Navigation Set. It is further supplemented by the Low Altitude Radar Altimeter Set and Penetration Aids—Radar Homing and Warning System, Electronic Countermeasures System, Countermeasures Dispenser Set, and Countermeasures Receiver Set. The TFR is indeed an effective, integral part of the F-111 avionics system, providing the capability to perform selected missions with a high degree of success and survival.

FACTS AND FIGURES:

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<td>3056</td>
<td>6060.1</td>
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<tr>
<td>F-111B</td>
<td>471</td>
<td>712.7</td>
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<tr>
<td>TOTAL</td>
<td>3527</td>
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AS OF 25 DECEMBER 1967
Test stations begin their work after a faulty LRU (line replaceable unit) has been detected at the aircraft and sent to the Armament and Electronics Shop (A&E Shop) for repair. Each test station has an assignment of Avionics LRUs and modules to test in minimum test time with minimum skill level requirements.

Five test station types in the A&E Shop have a new boss. Though not human, the Central Processor and Controller—alias CENPAC—could hardly be called just a machine.

For one thing, intelligence is usually thought a human characteristic. But CENPAC is intelligent; has a brain—a D-84 Computer.

Like other brains, the D-84 contains knowledge stored in a memory. Knowledge, LRU and module test procedures, inhabits the computer’s four module working memory. Together, the four modules contain 16,384 words, 25 bits (24 information bits plus one parity bit) each.

How did the knowledge get there? Initially, LRU and module test procedures were in the form of raw information—charts and tables. Later the information was translated into computer language and run into the D-84’s memory by means of a paper tape. (Test station procedures can be modified by programming a new paper tape and then feeding it through CENPAC’s paper tape reader into the memory.)

Two magnetic tapes serve to permanently store the test procedures knowledge. The tapes, each capable of storing over 70 million bits of information, periodically replenish the working memory’s knowledge supply.

A test station requests LRU or module test procedures by sending, via the Data Transfer and Control Unit (DATAC), a test number. Upon receipt of the number, CENPAC checks the corresponding test to see if it is valid, i.e., checks whether the test will cause damage to the test station or LRU.

Once CENPAC is sure that the test is valid, the computer’s Central Data Processor (CDP) uses binary arithmetic to figure which part of the memory’s knowledge the test station needs in order to compute test results. Either of the CDP’s two arithmetic registers can perform addition, subtraction, multiplication, and logic. Eight microseconds are required for the execution of operations in addition or subtraction; 29 microseconds for multiplication; and four microseconds for logic.
On the F-111 Program, most D-84 uses have been limited to logic functions, but the computer is a parallel-stored-program, general purpose computer. In the future, the D-84 may be programmed to solve complicated mathematical problems, maintain LRU histories, evaluate LRU failures, and control LRU inventories.

Characteristically intelligent, CENPAC also has an ability normally associated with human beings—the ability to communicate. CENPAC transmits test procedures information to a test station, via the DATAC, in 24-bit digital words.

An echo check assures that the data transmitted between CENPAC and the DATAC is correct. On receipt of each word of information from CENPAC, the DATAC echoes the word right back. CENPAC compares the original word to the word echoed by the DATAC. If the two words are not the same, CENPAC retransmits the original word. A second consecutive mismatch stops the program and illuminates the ECHO light on CENPAC. A signal, echo check complete, is transferred to the DATAC if the original word and echo match.

The information sent from CENPAC to the DATAC is used to program test stations. In turn, test stations transfer LRU and module test results back to CENPAC for evaluation. A NO-GO on a test station control panel indicates a faulty LRU or module.

Less time is required for CENPAC to transmit data than for a station and LRU to reply. Therefore, CENPAC can control as many as ten test stations simultaneously.

As a machine CENPAC exemplifies desirable reliability and maintainability qualities. On the basis of a Mean Time Between Failure of 500 hours, CENPAC experiences a malfunction very infrequently.

However, an operator who suspects a malfunction may initiate a comprehensive self-test of CENPAC simply by depressing the self-test button on the control/maintenance console. Subsequently, CENPAC halts testing; completes a self-test by using a routine located in its core; and illuminates a red light on the console if a malfunction exists.

CENPAC's diagnostic program, contained on an ancillary tape, can isolate a malfunction to a major assembly (CDP, memory, Input/Output, etc.) and subassembly (disposable Circuit Network Module). When the program diagnoses a malfunction, a display on the control/maintenance panel can be correlated to the identity of the specific faulty part(s).

CENPAC repair involves a relatively easy remove and replace procedure. Circuit Network Modules—subassemblies—are designed as easily replaceable components within CENPAC's major assemblies. On discovering the identity of a faulty part from the control/maintenance panel, an operator (maintenance man) pulls the appropriate major assembly and Circuit Network Module. Next, he inserts a spare Circuit Network Module into the major assembly. Finally, the operator reinserts the major assembly into CENPAC.

Occasionally, CENPAC repair involves the removal of peripheral equipment (magnetic tape unit, teletype writer, etc.). Downtime due to malfunction of CENPAC averages only 30 minutes for every 500 hours use.

As a test station boss, CENPAC demonstrates peerless efficiency. Previous Programmer/Controllers (P/Cs) required an operator to change tapes with the testing of each different LRU. CENPAC's memory, after initial loading, contains all pertinent test procedures. Therefore, by using CENPAC, tape selection and installation time is eliminated. Also, CENPAC's computer allows simultaneous use of all five of the test station types it controls. (In fact, the computer allows simultaneous operation of ten test stations.) Last, CENPAC's maintenance features (self-test capability, tape fault isolation, and component removal and replacement) are vast improvements over the features of previous P/Cs.

Designed by the Burroughs Corporation to meet specifications prepared by General Dynamics, Fort Worth Division, CENPAC is a significant addition to the 111 Aerospace Ground Equipment inventory.
Welding plays a fundamental role in the production of the F-111 aircraft. In fact, more welding is required to build the F-111 than any other aircraft in the United States arsenal.

The increased use of welding stems from the F-111's basic design concept—the variable sweep wing. The wings can be positioned in flight to the optimum aerodynamic configuration for both supersonic and subsonic speeds. This feature enables a single airplane, the F-111, to perform several different missions for the Air Force and the Navy. From a structures standpoint, the concept requires a departure from conventional aircraft design. Fixed-wing airplanes have an integral wing that carries all of the flight loads. The variable-sweep concept requires that the wings attach to a centrally located pivot mechanism. The structural elements of the pivot mechanism are the principal load-carrying members of the aircraft. These structures are D6Ac steel weldments produced by the gas tungsten-arc process.

DESIGN CONSIDERATIONS

The wing sweep mechanism, Figure 1, consists of two wing-pivot fittings and a central support structure which are connected through clevis arrangements by eight and one-half inch diameter pins. The components are D6Ac steel weldments. The lower boxlike portion of the support structure and the pivot fittings are heat treated to 220-240 ksi (kilopounds per square inch). The pins and the lid of the support structure are heat treated to 260-280 ksi. After heat treatment, the parts are shot peened, cadmium plated or aluminum flame-sprayed, and painted.

The reliability of the components has been augmented by the application of three weld-design criteria. First, butt-joints, which are ground flush after welding, are used exclusively. This type of joint provides the maximum fatigue strength. Second, each weld-joint is located in a position accessible for tooling and radiographic inspection. Third, the principal loads on each joint are either shear or compression. These criteria have been met by locating all welds in the vertical stiffening members.

WING PIVOT SUPPORT FITTING

The wing-pivot support fitting (support structure) is a 14-foot long steel yoke that serves as the backbone of the F-111. It is comprised of vertical shear webs and trusses welded to an integral lower plate (Figure 2) and of an upper plate that is bolted to a flange on the vertical shear webs. Both the upper and lower plates are machined from plate stock.

The vertical members are welded along the joints marked in Figure 2 into one T-shaped and two boxlike subassemblies. These subassemblies are completely welded, stress-relieved, and inspected prior to machining the edge-preparation
SUBASSEMBLY WELD
FINAL ASSEMBLY WELD

Figure 2 WING-PIVOT SUPPORT FITTING

Figure 3 WELDING THE SUPPORT STRUCTURE IN THE HOT BOX
for the final assembly welds. Excess material is left to allow for shrink during the final welding operation.

Most of the final welding operation is performed in a hotbox at a 300° F minimum preheat. After the corners and terminations are hand-welded, all of the outer surface welds are completed using mechanized equipment. These welds are post-heated (650°F) prior to manual welding of the internal joints. After post-heating the hand welds, the tools are removed and the part is stress-relieved at 1250°F in the hotbox. The completed weldment has 36 linear feet of weld. A photograph of production operations on the support structure is shown in Figure 3.

WING-PIVOT FITTING

The wing-pivot fitting, Figure 4, connects the wings to the support structure. There are three principal attachment points: the shear ring connects to the clevis end of the support structure, the arms attach to the wing sweep actuator, and the upper and lower caps fasten to the wing skins and spars.

The wing-pivot fitting is produced by welding vertical stiffeners and a shear ring between two large forgings, the upper and lower caps, in a three-step sequence: (1) the flanges are welded to the shear ring, (2) the shear ring and vertical stiffeners are welded to the lower cap, and (3) the upper cap is welded to the vertical stiffeners and shear rings. After each step the assembly is stress-relieved and inspected; then, the joint preparation for the next weld is machined.

The pivot fitting is preheated in a hotbox. Prior to welding, the hotbox is removed. The preheat is maintained with a base plate heater and asbestos blankets. After welding, the hotbox is used to post-heat and stress-relieve the weldment. This component has 32 linear feet of weld.

PIVOT PIN

The pivot pins connect the wing-pivot fittings to the support structure. Wing bending-loads are transferred from the wing-pivot fitting to the pivot pin and then through self-aligning spherical bearings to the lugs of the support structure.

The pins are produced by machining two half-pins from forged billets and joining the pair with a circumferential weld at the centerline. The welding operation is fully mechanized. After preheating, the part is rotated on a positioner and continuously welded.

The F-111 flight test program has indicated that the variable sweep wing is the greatest advancement in aircraft design since the advent of the jet engine. Fabrication of the wing-pivot weldments has made an important contribution to this achievement. The use of welding to produce these critical components should lead to a more complete realization of the tremendous potential of welded aircraft structures.
DO YOU KNOW —

that there are many classes of medicines commonly used today, any of which may impede your reaction time without your realizing it?

Why should you care? Well, if you are associated with high performance aircraft either as pilots, other flight crew members, maintenance men, or etc., you have need for quick reactions. Certain common medicines and all of those classified as drugs may affect your ability to react properly.

The following discussion of various medicines is not so much in the order of their relative importance but rather in the frequency of their use. Antibiotics are perhaps the most commonly used prescription medicines today. There are many of them and most of them you already know by name. Antibiotics cure or help to cure infections by acting to reduce the function of the infecting organism so that the body may more easily free itself of them. Most of them do not kill the infecting organism but only retard its growth. In slowing down the growth of the infecting organisms, the antibiotics also impede your own bodily functions to a lesser extent in the same way. Because of this you will not function as well as you would had you not taken these medicines. There is very little cumulative effect from these drugs, so that within a short time after stopping medication most of the drug is gone from your body. However, the effect remains for a longer time.

Since each of us reacts differently to any type of medication, it is difficult to lay down specific rules about them. However, if you are a pilot, you should not fly while taking these drugs and you should remain grounded for at least 24 to 48 hours after stopping treatment. Reactions to some of the antibiotics may occur as long as 10 days after taking them. After the usual grounding time, you may fly again as soon as, in your own judgment, your normal physical function has returned. As with all of the other medicines, common sense should dictate your decision. Stay on the ground longer if you think it is necessary. No one will condemn you for an extra day’s grounding if you cannot perform as you should.
The second most commonly prescribed class of drugs are the tranquilizers or "happy pills." These are the potential pilot (and perhaps also driver) killers of our medical armamentarium. There are many of these, some of which are sold only on prescription, and others of which may be bought without prescription. These drugs act by tending to destroy the natural fear reaction everyone has. They also depress our natural reflexes and dull our alertness. There have been several major aircraft accidents with numerous fatalities which have been directly due to the flight crew's use of tranquilizers.

Fear is something you have and can control. It is not cowardice. It is nothing to be ashamed of. You must face it and accept it. Fear is physiological. It is your body's normal way of marshaling all its energies to meet some emergency. You think faster and act faster when your nervous system receives a "red alert." In other words, fear is useful if you understand it.

The human body has its own machinery to cope with the normal everyday fears that momentarily overpower us when confronted with sudden danger. In general, psychiatrists hold that a person who is emotionally mature, healthy, and well-adjusted is better equipped to mobilize his faculties and respond adequately to a danger situation than one who is not. The best way to cope with your fears is to admit that you have them. You are not unique.

As you are now beginning to suspect, everyone has a panic button. The normal individual keeps it well under control. Tranquilizers of all kinds destroy the panic button. They tend to destroy a normal human physiological function.

The third class of drugs are the sedatives, the nerve medicines (not properly tranquilizers). These drugs are used mainly to bring about sleep. Their reaction is not so much in the nature of preventing fear reaction but rather to calm it after it sets in. They also tend to dull the senses and cause mental confusion.

A fourth class of drugs are those used for motion sickness. These drugs for the most part, do a good job in this respect, but they also tend to make the individual very drowsy and occasionally cause confusion. They should be used with caution.

Fifth, the sulfa drugs. These drugs are not as commonly used as they formerly were. They act by tending to destroy the infecting organism, in contradistinction to the antibiotics which tend to impede its growth. All of them can be dangerous, the newer ones to a lesser degree. They also tend to change depth perception and, on occasion, can cause changes in thought perception.

Sixth, antihistamines. These drugs are used in the treatment of allergies such as hives, hay fever, asthma, and the like. All of them tend to make you drowsy, and some of them tend to make you downright goofy. Antihistamines are also the active ingredients in many of the commercial cold preparations. Allergic reactions can come from the use of cold preparations and can make you quite ill. If you are a pilot and use these drugs, you should not fly as a crew member.

Seventh, the hypoglycemic drugs (insulin, etc.). These drugs are used in the treatment of diabetics. Diabetics are forbidden to hold pilot licenses—enough said.

Eighth, stimulants. These are the drugs which tend to produce wakefulness. There are many on the market, and several may be sold without prescription. The same type of medication (amphetamine) is the active ingredient in all of the popularly prescribed anti-appetite or weight-reducing medications. These drugs are habit forming, and susceptibility to the drug varies widely with each individual. Overdosing causes headaches, dizziness, and some mental disturbances. This group is also known as the "pep pill" group and is no substitute for sleep—this includes the so-called "stay-awake pills." Do not fly as a crew member if you use these types of drugs.

Ninth, steroids. (cortisone, hydrocortisone, etc.) This is a class of drugs designed at first to treat arthritis, but are now used for many other conditions. These drugs act to build up body function, but their actual reaction on the body is as yet not completely understood. Some of them cause depression and suicidal tendencies; some do the opposite. Most can be used safely for short periods of time. However, as a standing rule, crew members should remain on the ground when using steroids.

Talking to pilots again—there is one other topic that should be discussed, and that is the matter of blood donations. Blood donations and flying just don't mix. The average donor delivers one pint of blood as a donation. As a rule, little effect is felt by the donor. However, if the donor were to lose this amount of blood as a result of an accident or surgery, he would be in shock. It takes approximately a month for the body to rebuild the blood cells that are lost following a blood donation, but the volume of the blood is replaced within a few hours, mainly by increasing the fluid intake. We need blood to carry oxygen to all parts of the body, and the fewer blood cells we have, the smaller quantity of oxygen we will have in time of need. The military forbids crew members to fly for 72 hours following blood donations. Those individuals involved in civil aviation should also use this rule as standard operating procedure.

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The identifying mark of a superior maintenance organization is pride—pride in doing an excellent job and in keeping more satisfied pilots flying more hours than any other outfit. Of the many factors that influence this pride—maintainability makes the real difference. Maintainability covers a multitude of characteristics beginning with concepts and designs all the way through training, spares, etc. It is basic to assume that an aircraft which is designed to be maintainable has the best chance of having a proud maintenance organization supporting it.

From its inception, the F-111, by contract, has had a Maintainability (M) program. The basic requirements specify 75 percent operational readiness with an expenditure of no more than 35 direct maintenance man-hours per hour of flight. How this requirement is achieved and some of the important details involved is discussed in the following paragraphs.

**CONCEPT**

A simple analysis of aircraft employment reveals that airplanes undergoing maintenance are airplanes not available for flight. Therefore, any reduction in the on-aircraft maintenance makes for increased aircraft availability. Additionally, any maintenance that can be performed in the shops in lieu of on the aircraft, enjoys an improved environment and better facilities. For this reason, the F-111 was designed on a line replaceable unit (LRU) concept with an absolute minimum of on-aircraft alignment and adjustment. Built-in self-test features were implemented, where feasible, to reduce the need for Aerospace Ground Equipment (AGE) for testing and troubleshooting. These design considerations, together with good accessibility and location of equipment and servicing points reached from ground level, have made the F-111 easy and quick to maintain.

With the transfer of maintenance tasks from the flight line to the shop, increased emphasis was placed on equipping the shops to meet the precise LRU requirements demanded for replacing the airborne components without further adjustment. Particularly in the area of avionics, the frequency and complexity of each task was analyzed to determine the need for automatic or manual testing to ensure rapid equipment turnaround. These tasks were then organized to provide a functional shop capability and hence, maximum shop capability with the minimum of AGE. In short, the shops were effectively tailored for direct and efficient support of the flight line maintenance concept. Tasks which were identified as being beyond the capability of field level personnel or not eco-
maintainability

nomical to perform were scheduled for depot. This approach yields a well-rounded, highly efficient maintenance function at all levels, while providing an optimum level of base self-sufficiency.

DESIGN

Invariably, design reflects the personality of the designer. The stress engineer would build his aircraft of solid steel; the avionics engineer would cram in unlimited black boxes and so on. Proper balance, however, requires equal emphasis on factors of performance, stress, weight, reliability, maintainability, and others equally as important. This balance necessitates trade-offs for maximum achievement of the desired results. The F-111 has undergone several judicious cycles of design reviews in an effort to obtain the optimum balance. Maintainability has been a constant effort and continues to yield improvement. Basic considerations have been given to (1) location of equipment, (2) access panels (ease and speed of opening versus frequency of access), (3) first tier locations of components (not having to remove one component to get to another), (4) weight of components for ease of handling, (5) simplicity of testing and fault isolation, and (6) reduced requirements for flight line AGE. The replaceable components or LRUs have had similar design emphasis for ease of repair in the shops. Modular construction has been employed where feasible for isolation of faults and quick replacement of defective parts. Each and every repairable component of the aircraft has been analyzed as design progressed, and consideration of factors affecting maintenance has been evaluated. Some of these analyses, of necessity, are theoretical during design phases and must be reevaluated as hardware experiences the aircraft environment. For this reason, the true maintainability characteristics of each piece of equipment are not known until the complete aircraft is assembled and operated. Admittedly, this approach requires continued pursuit, but the payoff from early flight test operations helps to ensure good design for maintainability.

MEASUREMENT OF MAINTAINABILITY

In past programs the AFM 66-1 Data Collection System and the Unsatisfactory Report (U.R.) were the primary inputs to the performance of maintenance and to the correction of problem areas. With the advent of formal maintainability requirements, better reporting methods have been developed to monitor performance and make improvements. The Contractor's Quality Assurance Data and the Air Force's 258 Data Collection System have provided invaluable inputs throughout the Category I and II Flight Test Programs. This approach has made it possible to accurately measure maintainability as a function of "growth toward maturity" and to highlight trouble areas. A breakdown of maintenance data by systems and equipment reveals areas of low reliability, excessive maintenance times, and inability to perform certain tasks. This data is collected continuously and distributed monthly so that each designer may determine exactly how his equipment is performing.

One of the most beneficial aspects of the program has been the periodic Maintainability Review Team (MRT) meetings. The MRT has had an effective beginning with most of the inputs coming from Edwards Air Force Base the past year and a half. MRT members (about 40 from all agencies of the Government) ferret out and present maintenance problems encountered in support of the flight test program. These are real problems written up by the men who are responsible for maintaining the aircraft and, thus, closely reflect tactical operations. Each problem is forwarded to the contractor prior to the MRT meeting where it is analyzed, and corrective action is recommended. This action is further discussed in a work-group meeting with the MRT members, and a final course of action is determined. Each of these items impact, in some fashion, the ability to maintain the aircraft—improve reliability, reduce maintenance time, identify additional tools, etc. There is virtually no limit to the scope of problems covered in these meetings. Although maintainability, perse, is a characteristic of equipment design, in practice it has expanded to encompass problems confronting the maintenance man and affecting aircraft availability.

In summary, there are, however, "roses among the thorns." The F-111 promises to be a highly maintainable aircraft while fulfilling a tremendously complex mission role. Many new avenues have been opened for identifying and correcting problems. Thus, proper maintainability will keep'em flying.
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