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INTRODUCTION

The 111 LOG has been a bi-monthly report for the past year and a half. This month it emerges from its literary cocoon to become a magazine.

A magazine is a looking glass. At the Fort Worth Division of General Dynamics the 111 LOG will reflect interest in and concern for its products and its customers. It will mirror "what's happening."

Happenings come in three categories: technical, general and special. Technical happenings are informative articles, logistic procedures and techniques, and information on significant configurations of 111 airplanes. General happenings are focused on unclassified facts and figures relative to aircraft locations, movements, and flying hours; progress of 111 programs; new programming data; and new procedures. Special happenings include important events involving military personnel, special accomplishments of the weapon system, imminent significant events, and safety information.

World-wide, what's happening is the Space Age. Leaving the confines of the earth has been achieved by man only in our own time. The Modern Magellans manning today's jet aircraft, multi-stage rockets and other spacecraft were preceded just recently by navigators of balloons, gliders, and propeller aircraft.

Researchers and engineers -- free to gather, compare, shuffle ideas and uncover new relationships between new and old data -- have pioneered some dramatic breakthroughs in today's exciting era of spatial victories. We are particularly proud of the 111... its capability, maintainability, reliability, versatility and potential.

The French words, Logist Entier, on the 111 LOG emblem mean "complete support" -- complete support of the 111 weapon system. Quality logistic support is essential to keep the 111 performing per its design. Coupled with the job of building a superior weapon system is the inherent responsibility of the builder to provide the kind of logistic support that enhances the weapon system's performance.

111 LOG aims to unite, through directional intelligence, the Air Force-Industrial concepts of maintenance and operation of the weapon system that will yield optimum mission performance to the customer. To accomplish this task, the magazine will provide you with new avenues of thought in applied logistics.

The 111 LOG intends to be a useful, interesting and thought-provoking magazine. If you have comments or suggestions relative to its content, please write to us.
EVOLUTION OF THE 111

The program, which is producing the 111 aircraft series, is one of the most significant ventures ever attempted in the history of aviation. Teams from both government and industry have been engaged for over seven years in the evolution of the remarkable, new "swing wing" aircraft.

The VASCAR Concept

The unique aerodynamic configuration of the 111, based upon the concept of variable geometry, has been described as the greatest single advance- ment of aircraft design since the advent of jet propulsion. Unlike the piecemeal approach that was taken during the extended experimentation and detailed development of jet engines, the variable geometry airplane has come to the "production hardware" stage as a single program package – a program of vast scope and complexity.

The evolution began with the idea of the variable sweep wing, conceived by NASA Langley Research Center as a feasible method of providing VASCAR (variable area, sweep, camber, and aspect ratio). Subsequently, it was the Air Force and the Navy who were to define and program for the airplane that would take advantage of VASCAR or variable geometry. To the Fort Worth Division of General Dynamics Corporation fell the privileged role of producer-design, development, test and manufacture.

Operational Requirements

The Air Force had originally defined a require- ment for an advanced tactical fighter. It had to operate from austere, hastily prepared bases with short runways. It had to be supportable in a forward combat area with a minimum of maintenance and be quick and easy to service. In other words, it had to have the characteristics of a kind of jet-powered B-26.

At the same time, the new Air Force fighter had to have supersonic speed at both high and low altitude – the characteristics of NASA's X-15.

The airplane was planned by the Air Force for use against all kinds of targets, on interdiction, interception, close air support and area defense missions. It had to have a large weapon capacity, with both internal and external stores and a wide variety of payloads with their on-board avionics systems. Range requirements dictated a large fuel capacity. It, therefore, had to have the characteristics of a kind of super B-57.
Navy requirements were for fighter airplane compatible with aircraft carrier operations. It had to be small in size, like an F-9F5 Panther, with slow landing and takeoff speed and with good handling characteristics on approach.

For fleet air defense, the Navy wanted the airplane to have long endurance and carry a large payload of air-to-air missiles. Some of the characteristics of a U-2 were indicated, but with vastly greater capability.

The military services had defined the operating characteristics and mission requirements of five markedly different airplanes. The objective of the Department of Defense was to meet the needs of both the Air Force and the Navy with a single airplane. Someone described the task as that of "building a Volkswagen with Ferrari performance, Bentley appointments and Mack truck carrying capability". The variable geometry concept, that had in the meantime been proven feasible by NASA Langley, was a big step toward realization of the DOD objective. It was up to the Fort Worth Division of General Dynamics to weld five airplanes into one, translating concept and operating requirements into functional hardware.

**Preliminary Configuration Designs**

The design of an aircraft is iterative process. One or more basic configurations are defined, wind tunnel models are made and tested, aerodynamics and other pertinent factors are analyzed, indicated modifications are made to the basic configurations and the test/analyses/change sequence is repeated as many times as necessary to achieve the desired degree of optimization.

Giving emphasis to the basic Air Force mission requirement for supersonic dash at sea level, the first F-111 configuration designs were long, slender airplanes (i.e., high fineness ratio and low cross sectional area). Configurations 430 and 500 are examples of the basic approach. However, wind tunnel results were disappointing. It became apparent that long, slender airplanes are not necessarily low drag airplanes. The advantage of high fineness ratios and small frontal areas, are more than offset by the increase in surface area exposed to the airstream (wetted area), producing friction drag, and by protrusions and indentations necessary to integrate engine, inlets, weapons bay, avionics and crew into an airplane of small cross section.

To achieve minimum wetted area and structural weight, maximum volume, and clean lines, shorter airplanes with larger frontal area were considered. Configuration 1000 was typical of this approach. Drag was reduced and, at the same time, bi-service requirements were better satisfied. Configuration 9-3A, to accommodate P&W engines and to better provide for Navy requirements, produced Configuration 10-7A. This configuration was the first results of the combined efforts of Grumman and General Dynamics. Subsequent configurations featured improved high lift devices, inlet improvements, a lifting horizontal tail, and other refinements. The optimized, final configuration was in sight.

**GOOD CLEAN LINES** and smooth area distribution in Configuration 1000 are essential to effect low transonic drag.

**REDUCING THE CROSS-SECTION area in Configuration 10-7 decreased aero-**
dynamic drag, as recommended by NASA personnel.
Final Configuration

Configuration 12 was the final derivative of the configuration development process and is basic to the detailed design of F-111 prototype and production airplane. The blended body concept was introduced. Taking advantage of another new design technique, the wing and body of the airplane were blended to concentrate the cross-section area closer to the centerline of the fuselage. This improvement minimized the wetted perimeter of the plane for a given volume, thus reducing the friction drag.

The engine air inlets were changed from D-shaped to quarter circles nested in the corner formed by the intersection of the inboard wing stub and the fuselage.

A smoother wing overfairing contour was made with part of the wing retracting into the fuselage in a fully swept position. Also the chordwise location of the point of maximum wing thickness was

AERIAL EMBRYOS—foresrunners to the final 111 configuration—were wind tunnel tested during the matutinal stages of the F-111 Development Program.

THE SEQUENCE OF EVOLUTION of the 111 airplane series, from concept to operational employment.
moved aft to bring the wing cross-section area closer to the centerline at maximum wing sweep. Bolt-on wing tip extensions were added to give the Navy version improved subsonic cruise performance.

The Configuration 12 refinements improved the aesthetic qualities and aerodynamic performance of the airplane and made it possible to carry more fuel.

Extensive tunnel tests conducted on the refined model yielded highly gratifying results. There have been further modifications in configuration during the conduct of the RDT&E program. The forward fuselage lines and inlet details have been revised; vertical tail area has been increased and ventral fins have been added; but Configuration 12 has proven to be a well chosen, optimum design.

Logistics Evolution

There is a marked parallel between the evolution of the configuration and the evolution of logistic concepts and procedures. While research, development, testing and evaluation proceeded on the airplane, new logistic policies, procedures and techniques were being conceived by the military services and implemented by industry.

New concepts in applied logistics resulted in the generation of Maintenance Engineering Analysis Records (MEARS), the use of MEAR data in spares provisioning, and the application of Logistic Mathematical Models for planning and evaluation. Complete sets of logistic specifications were prepared to define contractual responsibilities and relationships between the Contractor and Government as well as between the Contractor and Subcontractors. Detailed integrated logistic support plans have been developed for each of the programs of the 111 series.

One of the significant policies, in the developing area of applied logistics, is that which directs the use of tactical aerospace ground equipment (AGE) and instructional manuals during the Contractor's manufacturing and flight test programs. This action has permitted the 'de-bugging' and completion of compatibility checkout of the airplane, AGE and technical publication before delivery to the customer.

THE MILITARY REQUIREMENTS which initiated the F-111 programs, required that the characteristics of five airplanes be combined into a single vehicle.

### AIR FORCE REQUIREMENTS

- **RUGGEDNESS, STOL CAPABILITY AND SUBSONIC PERFORMANCE**
  - AS A JET POWERED B-26

- **SUPERSONIC SPEED AT HIGH AND LOW ALTITUDES**
  - AS AMODIFIED X-15

- **LARGE PAYLOAD-FUEL AND WEAPONS**
  - AS A SUPER B-57

### NAVY REQUIREMENTS

- **SMALL, RUGGED AND COMPATABLE WITH CARRIER**
  - AS AN F-9F5 PANTHER

- **LONG ENDURANCE ON STATION**
  - LIKE AN ADVANCED U-2

- **DOD REQUIREMENT**

- **COMMONALITY**
Reliability and Maintainability

The worth of formal Reliability procedures and Maintainability design have been proven during the course of earlier weapon system programs. During the F-111 program development, significant advances have been made in functions such as "piece parts", selection, specification control of parts, and incentive fee penalty fixed price contracts with Subcontractors on quantitative reliability requirements.

Contractor data collection systems that are machine processible have been developed for use during the manufacturing and flight test phases of the programs. They have been developed to obtain the maximum degree of compatibility possible with Government data collection systems such as AFM 66-1, and the MMM data collection system of the Navy. Such data systems allow great flexibility in the use of statistical data relative to a single program phase, relative to a single weapon system, the progression of knowledge from predicted to experience data, and the early combination of all these data into a large base for statistical evaluation.

During the evolution of the 111 airplane, great strides have been made in the field of Maintainability. Early in the program, quantitative maintainability requirements were established in terms of maintenance manhours per flight hour for complete systems and for subsystems. As a result, the airplane provides for a high degree of accessibility, of convenience (through ground level servicing) of maintenance efficiency.

Operational Employment

The evolution of the 111 continues. Today the airplane is well along its way through a test program that has proven the validity of the concepts upon which its design was based. Its capabilities have been shown to be of such scope that new and expanding mission roles are feasible of assignment.

More than a tactical fighter/bomber, the 111 with modest changes in configuration, has been designated as a strategic bomber and a reconnaissance airplane. Its potential in a variety of other applications is being explored.

Tomorrow, upon introduction into the operational inventory of the military services, the 111 will make its contribution to the defense of the free world. The challenge of an everchanging world and new and unforeseen demands of military reunion will bring about other changes – further stages of the evolution of the most versatile, dynamic airplane yet conceived and built by man.

WITH ITS DISGUISE of earth-brown and olive-green, the F-111A camouflage plane will travel with its identity greatly concealed wherever its missions direct.

THE PRINCIPAL FEATURES OF THE FINAL CONFIGURATION represent the results of an extensive design effort, and the most exhaustive wind tunnel test program ever conducted.
GENERAL ARRANGEMENT

1. ENTRANCE LADDER AND STEP
2. WING POSITION LIGHTS
3. FORWARD FUEL TANK
4. ROTATING GLOVE
5. PIVOTING PYLONS
6. PRIMARY HYDRAULIC SYSTEM RESERVOIR
7. SLATS
8. WING FUEL TANKS
9. SPOILERS
10. WING FLAPS
11. WING FORMATION LIGHTS (UPR & LWR)
12. HORIZONTAL STABILIZER
13. SPEED BUMPS
14. ENGINES
15. AFT FUEL TANK
16. UTILITY HYDRAULIC SYSTEM RESERVOIR
17. AIR REFUELING RECEPTACLE
18. ANTI-COLLISION LIGHTS
19. TAIL POSITION LIGHT
20. RUDDER
21. FUEL VENT TANK
22. FUEL DUMP OUTLET
23. ARRESTING HOOK
24. TAIL BUMPER
25. FUSELAGE FORMATION LIGHTS
26. STRAKE (2)
27. FORWARD LANDING GEAR DOOR/SPEED BRAKE
28. AIR CONDITIONING SYSTEM COOLING AIR INTAKE
29. TRANSLATING COWL
30. SPIKE
31. SPLITTER VANE
32. FUEL SYSTEM PRECHECK SELECTOR PANEL
33. SINGLE POINT REFUELING ADAPTER RECEPTACLE
34. AFT ELECTRONIC EQUIPMENT BAY
35. WEAPONS BAY
36. FORWARD ELECTRONIC EQUIPMENT BAY
37. PITOT STATIC PROBE
CREW MODULE EJECTION SEQUENCE

(0–300 KNOTS AND 0–15,000 FEET)

1. **TIME — 0.00 SEC (ALT — 0 FT)**
   - Initiate ejection

2. **TIME — 0.05 SEC (ALT — 0 FT)**
   - Inertia Reel retraction starts
   - Emergency Oxygen and Pressurization trips

3. **TIME — 0.35 SEC (ALT — 0 FT)**
   - Crew Module severs
   - Rocket Motor fires

4. **TIME — 0.48 SEC (ALT — 0 FT)**
   - Full emergence into slipstream

5. **TIME — 0.50 SEC (ALT — 30 FT)**
   - Stabilization Brake Chute deploys

6. **TIME — 1.15 SEC (ALT — 90 FT)**
   - Rocket Motor burns out

7. **TIME — 1.6 SEC (ALT — 125 FT)**
   - Recovery Chute deploys
- **TIME – 3.00 SEC (ALT – 280 FT)**
  Chaff Dispenser actuates

- **TIME – 3.3 SEC (ALT – 330 FT)**
  Recovery Chute lines stretch

- **TIME – 4.35 SEC (ALT – 425 FT)**
  Impact Attenuation Bags deploy

- **TIME – 5.85 SEC (ALT – 445 FT)**
  Recovery Chute disreefs

- **TIME – 8.35 SEC (ALT – 345 FT)**
  Crew Module repositions

- **TIME – 8.6 SEC (ALT – 335 FT)**
  Impact Attenuation Bags inflated

- **TIME – 11.00 SEC (ALT – 220 FT)**
  Recovery Chute fully blossomed

- **TIME – 17.90 SEC (ALT – 0 FT)**
  Crew Module impact
F-111A RELIABILITY PROGRAM

DR. N. H. SIMPSON, Director F-111 Quality Assurance,
General Dynamics, Fort Worth Division

THE CHALLENGE

Four and one-half years ago the Fort Worth Division of General Dynamics Corporation embarked upon an ambitious program to achieve a multitude of extremely high operational requirements for this evolutionary new weapon system. Mission reliability is one of the more exacting of these requirements. Prescribed by weapon system specification, the development requirement is a composite .85 probability of mission success for six (6) defined missions ranging from 1 to 10 hours in duration.

Proof of specification compliance is satisfied by successful completion of a reliability-maintainability demonstration which consists of 150 missions flown by 5 test aircraft during the final phase of Customer Evaluation Flight Tests. In operational use, production aircraft are expected to possess a still higher reliability for the stipulated missions, thus making the F-111 the most reliable combat aircraft in America's defense arsenal.

F-111 requirements are being pursued under a Fixed Price-Incentive Fee contract with the Aeronautical Systems Division of the Air Force Systems Command which has Department of Defense procurement and management responsibilities for the joint Air Force-Navy program. The development contract contains several Incentive/Penalty Fee provisions, one of which is to be applied to the results of the weapon system reliability-maintainability demonstration.

In addition, a rigid, demanding schedule of performance is required. These time and cost constraints on the program have necessitated extensive use of existing technology which the performance and reliability requirements are expected to push to the limit. The high reliability required, its relationship to the overall success of the F-111 program, and the aforementioned time and cost factors have created a formidable challenge to General Dynamics' and its subcontractors' engineering, manufacturing, and management capabilities.

THE F-111A Continued from Page 9.

FIRE POWER CONTROL

An all-weather capability for target acquisition and attack with a high degree of accuracy, is provided in the F-111A with the integrated fire power control system. This system is made up of five major subsystems, including a navigation and attack set, an attack radar set, the terrain following radar set, a low altitude radar altimeter and a lead computing optical sight set.

The F-111A's Terrain Following Radar (TFR) constantly looks down, ahead, and to each side, guiding the aircraft over the earth's contours day or night. Signals are relayed to the autopilot for automatic flight, or are displayed on a cockpit instrument for manual flight. Should any of the TFR's circuits fail, the overall avionic system is programmed to put the aircraft automatically into a "2G" climb to higher altitude.

A navigation and attack set provides navigation and guidance from takeoff to landing in any weather. Together with its radar equipment it provides attitude, track, and speed of the aircraft and guides it to the target by a continuous flow of commands. Additionally, it supplies data for automatic radar bombing. This system also allows instrument landings on any runway, even one not equipped with radio or radar landing aids.

The attack radar set performs mapping showing ground or airborne targets regardless of visibility.

A lead computing optical sight set and missile launch computer permits precise firings of missile and guns by using data shown on a transparent optical display in the cockpit.

With its many systems and subsystems the F-111A is able to react rapidly under the most varied conditions to successfully fulfill the wide variety of tactical mission requirements for enemy target destruction.
THE APPROACH

The immediate approach to the challenge was the documented recognition, understanding, and utilization of firm contract specification requirements. These requirements were formalized in the F-111 reliability program specifications which provide for both quantitative and assurance requirements for the overall weapon system as well as in-house developed and subcontracted equipment. The specifications insure a stringent reliability influence from design inception through production and support elements. They also provide for continuing reliability control throughout the development and production phases of contract performance.

Preliminary quantitative estimates were formulated from reliability analyses of representative demonstration missions, equipment complexities, state-of-the-art data, and the feasibility of equipment reliability improvement in the allotted span time. These estimates were then subject to trade-offs with performance, maintainability, supportability and costs, from which balanced requirements were established for the weapon system and equipment. These requirements constitute the "baseline" operational reliability requirements of the prime and sub-contract specifications.

Since cost and time elements associated with redesign and retest were almost prohibitive, concerted attention was given the efforts involved in providing an original design with the required inherent reliability. Specialists were utilized to an unprecedented extent to assist the designer in achieving these inherent requirements in his design. Efforts equal to that were also applied to the planning, procurement, manufacture, and operation steps to assure maximum preservation of this inherent design reliability.

Much of the F-111 equipment and component design effort is accomplished by the Fort Worth Division's subcontractors and suppliers. A great majority of the subcontracts and purchase orders written for sub-system procurement make provisions for incentive/penalty performance in attaining reliability specification requirements. This facet of operation not only assists in the achievement of system/mission reliability requirements for the weapon system, but serves as an inducement for sub-contractors and suppliers to participate in reliability growth. Several of the sub-contract specifications also contain a "no defects or failures allowed" provision during qualification and acceptance testing of the respective equipment and components, thereby adding known qualitative values to the reliability program.

This emphasis on sub-tier contractor participation is not meant to imply that he is left to his own devices to successfully achieve his goals — quite the contrary. Contractor reliability and quality assurance personnel maintain a constant vigilance over the subcontractor's and supplier's programs to enhance the assurance of meeting prime contract requirements.

In a few cases this involves only a monitoring effort but it can, and often does, involve active participation in a coordinated effort of problem solving, and, if necessary, redesign. Progress reports, failure data and analyses, test data, and reliability prediction reports are submitted on a periodic basis to the contractor. These data are integrated with contractor in-house data and associated contractor data to maintain a current assessment of prime weapon system status and are used for updating the model reliability equations. The data is also used to institute corrective and preventive action where necessary.

In order to sustain an effective program of failure analysis, a malfunction review group comprised of design, reliability, quality assurance/control, and manufacturing representatives was formed. Use is made of all applicable documentation, as well as the failed item in determining the cause of failure. If the cause of failure is not determinable by analysis of the events and conditions attendant to failure, the failed part or any suspected contributing parts may be subjected to diagnostic tests and/or laboratory analysis. When a failure occurs, other parts of the type are suspected of being unreliable until proven otherwise by the failure investigation. Failure reports are considered complete only after team investigation has afforded a firm conclusion as to the cause and recommendations for the solution. Thus, the system of failure analysis is more than merely a function of accumulating failure data; it requires action to correct the fault.

A thorough study was made during the pre-proposal stage of the F-111 program to determine the primary causes of system failure in airborne weapon systems. One source of trouble so identified was electronic piece parts. More specifically, the failure of electronic parts such as semiconductors, resistors, capacitors, etc., which, as common part groups, constituted approximately 75% of the total parts population of the equipment. Immediately after contract award the Fort Worth Division established a Parts Control and Standardization (PC&S) Program. Basic objectives of the PC&S Program are (1) standardization of common elec-
tronic parts throughout the F-111 electronic equipment by joint evaluation, selection, and use of preferred part types; (2) preparation of Specification Control Drawings and recommendations for suppliers' use of the preferred part types. This was accomplished by upgrading conventional military part specification, when necessary, or by documenting total specification requirements for non-military parts; and (3) exchange of parts data and information and discussion of related piece parts design and application.

Although margins for degradation have been included in the quantitative reliability requirements, the degree of product variation which inevitably results from the variability of materials, machines, and workmanship must be closely controlled in order to preserve the inherent design reliability. During the program planning phase, quality assurance engineers, who specialize in reliability control, identify areas of most probable reliability degradation and assure that adequate controls are included in tooling, manufacturing, and quality control plans to prevent product deterioration. Specifications prepared for procured items also contain requirements for controlling these variations. Reliability and quality plans of suppliers are reviewed by quality assurance engineers to assure that requirements are understood and implemented. Limits of acceptance or rejection of equipment are firmly established and coordinated with suppliers to assure adherence. Engineering drawings and specifications are reviewed by quality assurance engineers to determine if the design, when transposed into hardware, will be compatible with minimum reliability requirements. The responsibilities of the quality assurance engineers in performing these tasks cover in-house production as well as procured items.

Equipment burn-in of 50 hours is generally required on all units prior to delivery or entering Reliability Qualification Tests (RQT). To further aid in reliability development, a Preliminary Reliability Qualification Test is also used to identify prevalent failure modes which have not been eliminated or sufficiently minimized in the design. This test thus expedites correction of deficient designs and processes. Reliability Qualification Tests are required for electronic equipment. These are fixed duration test, and are for the purpose of demonstrating the achieved Mean-Time-Between-Failure (MTBF). Test times are at least six multiples of the MTBF, and are performed on deliverable equipment. Not less than 100 hours or one-fifth the MTBF, whichever is greater, are run on each unit. At the conclusion of the RQT, an assessment of equipment MTBF – demonstrated at the 90% confidence level – is made using the total operating time and total relevant failures. If the demonstrated MTBF equals or exceeds the specified MTBF requirements, the equipment has passed the RQT. Conversely, if the demonstrated MTBF is lower, the equipment has failed the test.

THE RESULTS

The results of the above described program have been gratifying. The experience to date indicates that the high reliability required of the F-111 will be met. General results include the successful demonstration of electronic equipment reliabilities; a significant reduction in the failure rate of common electronic piece parts; early identification and correction of failures; reduction of "infant mortality" failures in delivered equipment; and dependable equipment performance in a grueling flight test program.
OLD PROBLEM ... NEW SOLUTION

Whoever said "Necessity is the mother of invention" must have envisioned aircraft manufacturing. Almost daily, new demands are thrust upon the aircraft industry to keep the performance of our nation's air weapon arsenal second to none.

Air Force maintainability specifications for the F-111A catapulted a new arrow of necessity to General Dynamics' center of attention. What the contractor is faced with is the old problem of designing maintainability into an airplane. In the past, aircraft have lacked, due to an absence of specific requirements for maintainability, many basic maintainability features required by the military services.

In the present program, the achievement of three specific goals is required. First, during the design phase, scheduled and unschedule maintenance requirements and servicing time will be kept to a minimum. Second, realistic scheduled maintenance frequencies will be established, keeping quantity of men required as low as possible. Third, the performance of all maintenance tasks will be simplified through ease of access, limited on-aircraft troubleshooting, and simplified testing. General Dynamics is probably the first weapon system contractor to receive definitive, quantitative requirements for maintainability in a firm, fixed price, incentive fee/penalty contract.

How General Dynamics is handling this challenge represents a fresh approach.

THE ORGANIZATION

Effectiveness. That describes the organizational emphasis of the F-111A Maintainability (M) program. Judge for yourself.

The Systems Project Office (SPO) sits topside. Underneath, three functionally oriented departments emanate - the F-111A Engineering Department established M requirements and designs M into the components; the Logistic Support Department provides the support elements; and the Quality Assurance Department assures utilization and evaluation of maintainability provisions.

An explanation of delegated M authority in the F-111A Engineering Department will illustrate the way the organizational system works. Between the Systems Project Office and Manager Support Requirements, the Vice President of Engineering has the responsibility for the Engineering Maintainability function and communicates directly with the SPO on all M matters. Working level authority for the maintainability function rests with the Maintainability Requirements Group.

An important aspect of this setup is the fact that the position of the Maintainability Requirements Group within engineering is equal to the hardware design groups and is not subservient to the design effect. Consequently, in trade studies, maintainability and design are given equal consideration. If agreement on design trades cannot be accomplished by joint action within Engineering, the in-house General Dynamics Review team - consisting of Managers of Engineering, Logistics, Quality Assurance, Factory, and Configuration Control - makes final decisions to resolve conflict.

The short and direct lines of authority in the F-111A maintainability program provide an organization with a capability of quick response and action on all phases of the program.

MAINTENANCE ENGINEERING ANALYSIS RECORDS

As the Maintainability Analyses (MAs) on the F-111A, its systems, assemblies, and related repairable components becomes available, it is forwarded from the Engineering Department to the Logistic Support Department (Maintenance Engineering Section). There the information is accumulated for the purpose of compiling Maintenance Engineering Analysis Records (MERA) and Logistic Data Packages (LDP) for spares provisioning. The MEARs constitute the major criteria to be utilized in the evaluation of the F-111A M program.

Throughout the F-111A program, full scale design aids and mockups are used to develop and test M. In preliminary design, full size, three-dimensional, cardboard and plywood design aids of each maintenance-significant area of the aircraft are used, in lieu of layouts, to determine optimum equipment location, cable and harness routing, etc. Through the low cost, timesaving mockups, most design maintainability problems for the affected systems, assemblies, equipment, and structure are resolved prior to release from engineering. As the program develops, maintainability design efforts are directed to metal mockups.
Further, time and motion studies on all mockups provide preliminary verification of numerous maintainability capability tasks such as removal and replacement of items of equipment, engine installation, and weapon loading. Mockups are invaluable to the data gathering process.

Maintainability Analyses (MAs) may be viewed as bridging the gap between raw information (for instance, information collected from the mockups) and Maintenance Engineering Analysis Records. From predesign through manufacturing and testing, MAs provide progressive data on each maintenance-significant component in the aircraft. Since complete drawings and system information are not available in predesign, at that stage much of the criteria, and therefore many of the MAs, are necessarily estimated. During design, expansion of the MAs is accomplished through the addition of Military and Industry man-hour and task data. As hardware becomes available, the MAs are supplemented by data compiled from system and component tests and flight test aircraft. Additional MAs are supplied by subcontractors. After design deficiencies are fed back to the proper design group where corrections are made, the MAs are utilized to update the Maintenance Engineering Analysis Records.

The scope of the MEARs includes all requirements for maintenance and support at the Organizational and Field (Intermediate) levels. Specifically, MEARs are written to cover Contractor Furnished Equipment and Aerospace Equipment (CFE/CFAE), reparable end items of airborne equipment, support equipment, and items of Government Furnished Property and Aeronautical Equipment (GFP/GFAE) to the degree required to cover organizational level maintenance.

When it is determined that an item must be overhauled or repaired at depot, notation is made on the appropriate organizational level MEAR, "depot repair/overhaul required," and the following depot data is provided in the MEAR:

a. Identification of the depot requirement
b. Type personnel required
c. Special AGE required
d. Facilities required
e. Turnaround time in depot
f. Exhibit XII Material Summary of MEAR to include depot material requirement

Monitoring of MEAR progress proceeds through the medium of scheduled Government General Dynamics Maintainability Review Team (MRT) meetings. As MEAR data is generated, Government MEAR review personnel scrutinize and comment; differences between the Government and the contractor may materialize. In MRT meetings, these differences are resolved.

Assistance to the MRT in monitoring the Maintainability Program is provided by six aids. First, the Maintainability Analysis Data System (MADS) is a master file of F-111 maintainability information which includes determinations of Maintenance Man Hours Per Flight Hour (MMH/FH), number of personnel, and Aerospace Ground Equipment (AGE) required. Second, the Maintenance Analysis Review Technique (MART) is composed of three mathematical models. One model, the Subsystem Simulation Model (SSM), has been developed to simulate the maintenance required by each aircraft subsystem. The second model, Network Analysis Model (NAM), is used to evaluate turnaround sequence options which are determined by the series and parallel maintenance activities for the various subsystems. The third model, Base Maintenance and Operational Model (BMOM), simulates the operation of a group of weapon systems and measures the operational capability in the actual environment. Third, submitted as a presentation at each periodic meeting of the Government/GD Maintainability Review Team, a Program Summary and Progress Report contains summaries of weapon system progress, problem areas, and achievement of predicted goals. Fourth, if negative slack in reaching established goals occurs, a report by the Contractor Program Evaluation and Review Technique (PERT) team is submitted to the Maintainability Requirements Group. Fifth, Monthly Data Collection Summaries are utilized as input data for refining the Maintainability Analysis and updating the MEAR. Sixth, predictions of the design requirements for each system are recorded on MEAR Exhibit III. By observing the relation of the predicted analysis and actual data, the progress of the maintainability program can be realized. Continual monitoring is performed during design, manufacturing, and in service to ensure that the weapon system meets all the maintainability requirements of the customer.

Utilizing the MEAR data from the maintainability program, detailed maintenance plans are developed for basic military units. These plans fully describe unit capabilities and requirements for organizational and field level maintenance.
MATHEMATICAL MODELS ...
TOOLS FOR LOGISTICS MANAGEMENT

At the First Annual Logistics Management Symposium last September, R. N. Johns of Douglas Aircraft Company left concrete evidence that certain facets of the logistics spectrum have been with us for hundreds of years. During the dinner closing remarks, he quoted the following entry from the log of the United States Ship Constitution (1779–1780) which relates to the supply support aspect of logistics management:

"On the 23rd of August 1779, the United States Ship Constitution set sail from Boston. She left with 475 officers and men, 48,000 gallons of fresh water, 7,400 cannon shot, 11,600 pounds of black powder, and 76,400 gallons of rum on board. Her mission was to destroy and harass English shipping.

"Making Jamaica on 6 October, she took on 826 pounds of flour and 68,300 gallons of rum. Then she headed for the Azores, arriving there on 12 November. She provisioned with 550 pounds of beef and 64,300 gallons of Portuguese wine. On 18 November, she set sail for England.

"In the ensuing days, she defeated five British men-of-war and captured and scuttled twelve English merchantmen. By 27 January, her powder and shot were exhausted.

"Unarmed, she made a raid on the Firth of Clyde. Her landing party captured a whiskey distillery and transferred 40,000 gallons on board by dawn. Then she headed home.

"The Constitution arrived in Boston harbor on 20 February 1780 with no cannon shot... no powder... no food... no rum... no whiskey... but with 48,000 gallons of stagnant water..."

Obviously, the crew of the Constitution was not aware of the finer points of logistic support planning. For that matter, it is doubtful that they were very aware of anything by the time they reached Boston.

Ah, logistic support must have been a bed of roses in the 18th Century compared to logistic support today.

Provisioning in those days was accomplished through rough estimates. They took all they could carry. If the supply ran out, they put into port and took on what they needed. If they completed a mission with provisions leftover... what the heck, water's cheap.

But not even water is cheap today, and supply support is just one among many areas associated with the Logistic Support functions of today. Over the years, logistics has grown from the one-time function of spares and supply to include such elements as maintainability, reliability, personnel, support equipment (AGE), training, technical publications, transportation, and facilities. These items are key considerations in the definition of every phase of a weapon system program — concept formulation, contract definition, development, test, evaluation, production and operational.

In addition, these key items need to be systematically planned, acquired, and managed as an integrated interlocking whole to obtain maximum material readiness and optimum cost effectiveness.

Today, the entire defense industry is concentrating on designing a sound and effective logistics program into the weapon system, rather than paying a penalty in terms of decreased operational or systems effectiveness and the excessive costs of delays and redesign. To accomplish this, it has become necessary to develop improved methods, techniques, and procedures for use in the analysis of logistic problems.

Extensive use has been made of mathematical models programmed for computers. The first logistic models were designed for use in the analysis (through simulation) of the field operations of an operational weapon system. The Rand Corporation was an early leader in the development of a simulation model for logistics in the operational phase.

Due to the unique operations and logistic requirements of the 111 program, models had to be developed which were applicable to the early phases of weapon system development.

Sound easy? Don't you believe it! There was little data available on a weapon system in the conceptual design or program definition phases. Instead, reliability, engineering, and maintainability estimates backed up by historical data, test results, and operational data on similar types of systems.
as well as preliminary design data had to be used.

Early in 1962, the Operations Research Section initiated the development of a set of logistic models to form the basis for logistic decision-making and program-planning at all levels and phases of the 111 program.

By early 1963, the logistic models were developed to the point that they could be applied to the 111 program with confidence (checkouts were completed late in 1962 by using B-58, F-100, F-102, and F-106 data).

Four basic sets of models have been developed. The first set, MART (Maintenance Analysis and Review Technique), is used to simulate ground operations in a "real-world" environment and to measure weapon system readiness. MART consists of three models. What they are and how they are used is shown on the figure above.

The second set, also shown above, is used to simulate the asset flow and determine the requirements for assets to support a given operational program. Named the Logistics Assets Requirements Models (LARM), this set consists of four models. Specifically, they analyze the asset requirements for personnel, AGE, facilities, spares, and other equipment at operational basis and deployed sites.

The third set, Related Effectiveness Models, are used to analyze the various missions, and to measure mission effectiveness. Factors considered are defense postures, threat, penetration capability, survivability, mission reliability, targets, weapons delivered, etc.
The fourth set, cost models, are used to determine total program costs: Research and Development costs, investment costs, and operational costs.

Effectiveness, as determined from the first three model sets, is combined with the costs to produce a cost-effectiveness measure where cost-effectiveness is defined as the value received (effectiveness) for the resources expended (cost).

You should understand that these mathematical models were not developed and used as an end in themselves, but as an aid in improved logistic analysis for the decision maker. For example, the models have been used extensively in the preparation of the System Analysis Report (a required quarterly effectiveness evaluation of the F-111A) and the AGE/Maintenance Deployment Study. Also, systems effectiveness analysis has been used in evaluating effectiveness for alternative versions of the F-111 (FB-111, F-111C, RF-111, STOL/VSTOL). The models and the systems effectiveness approach were used in the F-111 MARK II avionics studies.

Even so, the use of models is still in its infancy. We have a real challenge in the future for use of machine systems. When we have developed logistic models to the point that management has enough confidence in them, there will be no reason why logistic functions (spares provisioning, for example) should not be completely processed by machine. Incidentally, spares provisioning and ordering can well be integrated with a world-wide automatic inventory control system, in lieu of the cumbersome and antiquated methods used today.

The use of these current mathematical models and those of the future is undoubtedly the best approach in utilizing the ever decreasing amount of time available to us in performing efficient logistic analysis.
NEW DIMENSIONS IN TESTING

No air weapon system is more efficient than the Aerospace Ground Equipment used to maintain it. Realization of this truism has prompted General Dynamics to synthesize the present avionics shop in support of the F-111A.

Framers of the program followed Aristotlie's "golden mean" concept. The basic idea was to devise an effective, yet economical, system of maintenance at the depot and field levels utilizing both extremes from which avionics aerospace ground equipment may be approached—manual and automatic. A manual system appeared somewhat attractive, but such a setup means more personnel at high skill levels to adequately test the equipment functions. Any attempt to reduce skills raises cost through increased detailed procedures and increased quantities of AGE. On the other hand, a completely automatic solution is meritorious in that it reduces test time, means a high degree of accuracy and repeatability and requires low skill level operation; faulty, however, in that automated test equipment means greater complexity and, therefore, higher skill level requirements in maintaining the test equipment. Rather than make a strictly "either-or" choice between manual or automatic equipment, a balanced compromise was elected.

From the inception of the program, it should also be noted that the planners were directed to design test equipment which would conform to certain rigid specifications. For instance, characteristics to achieve a 75 percent readiness rate, when all elements of support were available and used as required, were considered necessary. Also, the maintenance cost for supporting the F-111A at the specified readiness rate was not to exceed 35 manhours per flying hour of direct labor as defined by Air Force Manual 66-1. Based on careful analyses to determine which units would benefit from either manual or automatic testing, or both, a best mix of capability was devised, and what actually emerged were today's multipurpose automatic/manual test stations.

REPAIR FLOW

A review of the sequence of events leading to the eventual repair of the aircraft places the test stations in proper perspective. Repair involves isolation to, and replacement of, a Line Replaceable Unit (LRU) at the aircraft. Test stations begin their work after a faulty LRU has been detected and sent to the intermediate shop. Each test station has an assignment of Avionics LRU's and modules to test in minimum test time with minimum skill level requirements. Defective subcomponents are isolated and replaced. Finally, the LRU or subcomponent is certified and returned to stock as a completely interchangeable unit requiring no on-aircraft adjustments. This approach to repair virtually eliminates the bulky, complex, trailer-like equipment of past AGE programs required to support the flight-line operations.

A "functionally oriented" system of AGE is unique to the F-111 Program. Prior to the advent of the F-111 aircraft, a "system oriented" approach had been utilized whereby a particular aircraft system was tested by a system tester. For instance, for the B-58 one tester had assignments for the bombing-navigation system alone. In contrast, the F-111 approach emphasizes the testing of a number of LRU's having similar characteristics regardless of the systems to which they belong. Consequently, the number and types of shop AGE is kept to a minimum.

But what about the repair of the test equipment itself? Each of the avionics test stations includes a built-in self-test capability which provides confidence testing, performance testing, fault isolation, and certification with built-in transfer standards. Though calibration of the test stations' standards must be performed in the Precisions Measuring Equipment Lab (PME), Test Replaceable Units (TRU's) may be checked and certified in place. Maintenance of peculiar TRU's (excluding the Common and Standard Voltmeters, Oscilloscopes, etc.) involves isolating a malfunction to a faulty module which is replaced; the Test Station is then given a confidence check to verify repair. Assuming a nine-hour operating day, the average daily downtime for each test station maintenance is only 17 minutes!

PHYSICAL DESIGN

The Avionics Aerospace Ground Equipment, built by the Electronics Division of General Dynamics in support of the F-111, has been designed in modular bays. Equipment cabinets, when grouped in configurations of one, two, or three, form a bay. To facilitate connection between two or more bays, interbay connector wells (all provided with a moisture drainage tube which removes condensation) are recessed in the tops of
the units. Numerous bays may be connected to form an individual test set or station.

Transportability! Key word in aerospace ground equipment, transportability has been incorporated into the modular bays through compactness, durability, and minimum weight. Approximately 72 inches high, 24 inches wide, and 30 inches deep, each individual bay is equipped with an equipment shelf which folds to provide an environmentally protected cover for transporting the Test Station, shock and vibration system, full protection against rain, sand, dust, and other elements, and an internal cooling system. Through selective use of components, the package density is several times greater than comparable equipment for other aircraft systems. The self contained stations have minimum reliance on ancillary equipment and may be made ready for use with application of power as the only requirement. Constructed of light-weight aluminum, modular bays provide the solution to the maintenance of Tactical Air Command mobile strike force test equipment capable of rapid, worldwide deployment.

CENPAC

One phase of avionics aerospace ground equipment is undergoing an exciting new change. Early in the F-111 Program a detailed study of Programmer/Controllers (P/Cs) to govern test stations was begun. Primary emphasis was placed on the application of P/Cs by use of mathematical models to simulate avionics shop operation. During 1965, the contractor was given a new approach of squadron deployment rather than wing deployment. As a result, a detailed study of AGE/Maintenance concepts was made and applied to computer math models. The purpose was to determine the best compromise between AGE vs. Spares and the design approach to the AGE. Five types of tape-programmed and two types of computer-controlled P/Cs were considered for automated testing control. The tape-programmed P/Cs were found to be marginable for handling the F-111 avionics test station workloads. In view of increased emphasis on future digital airborne hardware and a cost effectiveness evaluation, the adequacy of
tape-programmed versus computer controlled P/Cs in automated maintenance testing became questionable.

Utilization of Computer Control, i.e., CENPAC (Central Processor and Controller), Case VII of the P/C Study, in the F-111 shop affords numerous maintenance advantages over the other five Programmer/Controller systems. First, CENPAC, providing the F-111 shop with a flexible, high speed, digital, general purpose computer, allows simultaneous use of all semiautomatic test stations. Communicating through a Common Data Transfer and Control Circuit (DATAC), the computer is capable of operating 10 test stations at one time. Second, less maintenance on shop hardware is required since CENPAC means a reduction in total shop hardware. Third, less hardware and better P/C self-test consequent higher shop availability. Fourth, growth potential for further improved maintenance is enhanced through advanced testing techniques (including such items as RMS averaging, time varying inputs, and tolerance calculations). The availability of the computer complements maintenance management by providing mechanized individual aircraft maintenance trends, maintenance personnel proficiency, and overall maintenance efficiency when programmed to do so. Most economical in terms of total cost, weight, flexibility, number of operating personnel, and the important aspect of growth potential, CENPAC should prove to be a significant AGE addition.

IN CONCLUSION

The purpose of a tactical unit, whether it be a wing, squadron, or subordinate unit, is to carry out a designated operational assignment. Success in that effort necessarily requires coordination between operational and logistic elements.

Having given birth to the avionics shop equipment for the F-111, the parent initiators were anxious to know if logistic flexibility had been enhanced. Results? Thousands of operating hours accumulated at General Dynamics, Edwards Air Force Base, and Grumman Aircraft Engineering installations have proved this AGE system to be flexible and capable of keeping abreast of changing aircraft requirements. Thus, a concept becomes reality!
That the voltage and current levels of aircraft AC electrical power generation systems are sufficiently high to cause DEATH?

Of course you do.

Most of us have been taught since we were kids not to do things like stick our fingers into light sockets, poke around electrical wall outlets, and operate electrical appliances in or around water. But even those of us who are exposed to electrical equipment as sophisticated as that on-board high performance aircraft, and know the dangers involved, tend to suffer a bit from what psychologists call the "immortality syndrome." We subconsciously think, "It can't happen to me."

Okay, so an accident can't happen to you; but perhaps a review of the hazards associated with electricity and the procedures to follow in case of electrical shock may help you to assist someone else if it happens to them.

The danger lies in the amount of current passing through the muscles, especially those of the heart, and whether the current is alternating (AC) or direct (DC). Although DC is not as great a shock hazard for a given voltage as is AC, it will burn more severely since DC arcs are more persistent. A voltage below 140 volts DC has never proved fatal, even if the skin resistance is low. However, under similar conditions, AC can be fatal if the current exceeds 50 milliamperes.

Keep in mind that current is the killing factor in electrical shock, not voltage. Voltage is important only in determining how much current will flow through a given body resistance. Of course, the drier the skin, the higher the resistance to current flow. Dry skin resistance is between 100,000–600,000 ohms and wet skin resistance is 1,000 ohms. Internal body resistance varies from 100–600 ohms. You can see why moisture multiplies the hazard.

The more current passing through the body, the more severe the effects. We don't condone using a multimeter and then touching a live conductor, even though no sensation or pain will be felt when the current value is one milliamperes or less. A painless shock sensation will be felt from one to eight milliamperes. Muscle control is not lost until the current value reaches 15–20 milliamperes — when the shock becomes painful and the ability to let go is lost. At current values of 20–50 milliamperes breathing becomes difficult and muscle contractions are severe. A current of 100–200 milliamperes causes the heart muscles to beat independently and without rhythm, a condition known as ventricular fibrillation. This is best treated by a physician. However, it is almost always FATAL. When the current exceeds 200 milliamperes, the heart stops completely.

In the event a serious electric shock occurs, and the victim is still in contact with the live conductor, turn the current off if possible. If not, use a dry nonconductor (a dry stick, a length of dry rope, etc.) to remove the person from contact.

Be extremely careful so that you yourself do not become another victim. Make certain your hands are dry and that you are standing on a dry surface, even after the current has been turned off.

Call for a physician and an ambulance immediately. If the victim is unconscious, breathing in all probability has stopped. Breathing may resume in a short time if the shock was not too severe, but there is no time to wait and see. Quickly check the mouth for obstructions such as gum, false teeth, tobacco, position of tongue, etc., and start mouth-to-mouth resuscitation immediately; a delay of five or ten seconds could prove fatal. Keep the victim warm and continue resuscitation without interruption, until natural breathing is restored (three or four hours if necessary) unless advised otherwise by a physician.

If there is no pulse or heartbeat it will also be necessary to institute external cardiac massage. This is best accomplished by alternating pressure over the anterior chest at the rate of 15–16 times a minute. Ideally, mouth-to-mouth breathing and external cardiac massage should be done simultaneously. But if you are the only one present, continue with mouth-to-mouth resuscitation.

Often, where unconsciousness has resulted from electrical shock, the victim's body becomes rigid and stiff. DO NOT LET THIS DISCOURAGE YOU. Many persons have been revived after this stage has developed.

A brief return of natural breathing is not a certain indication to stop resuscitation efforts. Frequently, the victim of a shock stops breathing again. Therefore, watch the victim closely and if he stops breathing again, resume resuscitation immediately. Keep the victim quiet and warm until the doctor arrives.
One of a kind...

AIR FORCE SCHOOL
of
SYSTEMS AND LOGISTICS

So you want to be a logistician. You’ve heard about the great need for more highly trained logistic engineers, and now you want to embark on a new career in this demanding, yet richly rewarding, field. How do you plan to become an educated logistician? First you must decide to what logistics tree-branch you want to attach yourself. Let’s take a look at some of these appendages and what they entail.

Military logistics—the art and science of determining, acquiring, distributing and maintaining material resources of our military forces in an operation-ready status—is the support of all Department of Defense operations throughout the world. Consuming some 70 cents of each defense dollar, this support requires streamlined management. Thus, the size and complexity of management situations demand that the most scientific methods and the best executive skills be focused on this area.

But military logistics is only one phase of the field. Logistic engineering is, by comparative definition, the professional art of applied science to optimum planning, handling and implementation of personnel, materiel, and facilities involving lifecycle cost and design, procurement, production, maintenance and supply support.

While logistic engineering is an ancient profession, its practice has become sophisticated in our time. Today’s logistic systems distribute goods and services to fulfill material needs and desires; spread progress culturally, socially and economically; accomplish the goals of foreign policies of aid and assistance; and serve as highways for the national will of the people.

The efficiency of modern logistic systems opens the door to commercial world-wide markets. No matter where you go, you’ll find Coke machines, Japanese transistor radios, American gasolineservices, French perfume, Brazilian coffee, and California oranges. When national strikes disrupt the industrial logistic system, our whole routine may be upset with discomfort and confusion.

The much-used term logistic engineer is synonymous with field engineer, service representative, maintenance engineer, training instructor, supply support engineer, and like job classifications. Jobs for the logistic engineer are numerous. The greatest challenge today is supporting the United States in foreign operations.

Logistic difficulties in space are also paramount. Channeling food to hungry mouths in need areas is urgent, as is systematically developing the earth’s resources to adequately produce useful crops. Data collected by manned and unmanned spacecraft and satellites will help international humanitarian agencies to accommodate the future world population. (At the current rate of population growth, estimates show the world will number
between six and seven billion in 2000 A.D., and will double just 35 years later in 2035.) These jobs will challenge the thinking of the most visionary logistic engineer.

Although many people are unaware of the enormous scope of the tasks performed in the logistic area, logistic support is a major portion of most large development projects. It is a primary cause for the success or failure of many undertakings. The volume of money involved in logistic activities alone makes it an important requirement. And today the training of logistic personnel is a national problem.

SOLE ROLE

The Society of Logistics Engineers—SOLE—encourages its members to "engage in educational, scientific, and literary endeavors to advance the art of logistics technology and management." Plans include sponsoring a series of symposia, publishing technical papers, funding scholarships and a university chair, supporting research projects, promoting academic courses in logistics, and associating logistics with management and technology.

SOLE's efforts in establishing curricula for the civilian contractor logistic engineer have already begun. The Society proposes instruction of every logistic specialty including maintainability, systems and equipment maintenance, maintenance support equipment, human factors, training and training equipment, spare parts, overhaul and repair, handbooks, field site activation and operation, field engineering, facilities, packaging, materials handling and transportation.

Objectives for SOLE's three-phase plan for education in logistics are short term, intermediate, and long term. The short term phase features interchange of information through the sponsorship of short courses, symposia and seminars. Specialized college courses and the development of specific educational objectives for career logisticians are included in the intermediate phase. The long term program calls for college degree and graduate level courses based on joint studies with the academic community to define and refine the logistic disciplines into a professional career structure.

Short term goals have already been partially achieved through the sponsorship of Logistics Operating Management Symposia. In September SOLE will hold its major annual technical conference and convention in Washington, D.C. A fast growing organization, SOLE has won the active participation of many top executives and technicians from industry, government, education and the military.

AIR FORCE ROLE

The Air Force School of Systems and Logistics—the only school of its kind—aims to meet the need of highly trained, capable logistic engineers. While most colleges and universities are jammed with a wide selection of engineering courses, formal academic training in the field of logistics essentially is non-existent. The USAF School's mission is to generate the development of selected personnel in scientific management procedures, analyzing ways and means that will improve the use of human and material resources.

With an in-depth college-level curriculum designed to educate logisticians, the School of Systems and Logistics courses endeavor to train Air Force and other Defense personnel in order to improve current and long-term on-the-job effectiveness. Gaining a thorough knowledge of advanced logistic concepts is achieved by integrating current management principles with practical logistic techniques.

Broad objectives of the School are (1) to develop a cadre of professional logisticians for eventual assignment to key positions throughout the Department of Defense. These individuals will be selected on the basis of educational qualifications, experience, effectiveness, and capacity for development; and (2) to serve as a focal point for research into logistic disciplines with a view toward establishing basic doctrine for use in designing and operating logistic systems.

Specific objectives of the School of Systems and Logistics are (1) to provide a working knowledge of the primary systems and procedures within the DOD and the several services; (2) to provide detailed information about government functions which affect all DOD logistics; (3) to understand the interrelationships of military sciences, logistics, and economics; (4) to accomplish logistic research of value to student participants and to the national military establishment; (5) to develop an understanding and appreciation of the individual's role in accomplishing the logistic mission; (6) to encourage the development and application of ethical standards and discipline in military management; (7) to provide approaches for the solution of high-level logistic problems; and (8) to develop new or refined management methods applicable to DOD requirements.

ABOUT THE SCHOOL

An integral part of the Air Force Institute of Technology, the School of Systems and Logistics is a credited institution of higher learning. Augmenting the military and civilian faculty and staff of the School is a contract with the Defense Man-
agement Center of Ohio State University. OSU facilities were used to research, develop, and prepare the first school program, which began in October 1955. However, instruction was given at Wright-Patterson Air Force Base near the Air Force Logistics Command Headquarters, formerly Air Materiel Command.

Air University entered into an intercommand agreement with the Air Materiel Command in September 1958. The result was the development of a series of logistic education courses at the Air Force Institute of Technology. Courses were a part of the Air Materiel Command Logistics Education Center, but were also incorporated into the School of Logistics at the Institute. The name of the School was changed to "School of Systems and Logistics" on February 1, 1963.

Since then, the School's operation has been expanded to provide instruction for selected personnel throughout the Air Force and Department of Defense. Courses offered are designed for use in the joint logistics training program of the Department of Defense and to specifically serve the needs of the Air Force Systems Command, Air Force Logistics Command, and other major commands of the Air Force.

ORGANIZATION

Synthesizing the many complex and varied logistic activities into a systematic unity has long been recognized by leaders in the field of logistics. The Systems and Logistics School is set up in such a way as to eliminate the feelings of frustration (due to disorganization) of numerous logisticians. To improve performance of logistic tasks, the School is organized into two major programs, each with its own set of sub-programs.

Under the Directorate of Graduate Education are the departments of Quantitative Studies, Management Studies, Communicative Studies, and Research Studies and Publications.

The Directorate of Continuing Education offers the departments of Systems Program Management; Maintenance, Supply and Transportation; Procurement and Production; Logistics Plans, Cost and Economic Analysis; and Nonresident Studies. Each course given in the School is under the jurisdiction of one of the above departments.

COURSES

The School operates two categories of courses. First, the Graduate Logistics Management Program is a one-year course leading to a Master of Science degree in Logistics Management. Fully accredited by the North Central Association of Colleges and Secondary Schools, this graduate program produces logistic managers who will make significant contributions to the defense effort.

The second category is the Continuing Education Program, which consists of some 35 courses of relatively short duration—from one to fifteen weeks. Courses are designed to provide continuing educational opportunities for managers in systems and logistics, or in the functional areas of maintenance, supply, transportation, and procurement.

SCOPE

The Air Force School of Systems and Logistics teaches and graduates logisticians—persons who can see and understand the practical application of logistic management to funds, manpower, facilities, and complete weapons systems. They must be knowledgeable of the management tools available and have an ability to determine the need for new tools of planning, organizing and controlling as situations may demand.

Logistic engineers must be able to coordinate appropriate staff elements in the achievement of practical decisions as to type, quantity, and disposition of materiel to be budgeted for, procured, distributed, and maintained. In addition to being capable of determining personnel and facility requirements, logisticians are responsible for large quantities of human and physical resources. So they must be competent executives, able to run a major phase of business. All of these capabilities are the products of experience and education.

Previously, the development of the logisticians has been primarily a matter of chance, not plan. As a result, there are a limited number of officer and civilian personnel who have developed into well-qualified logistic engineers. An urgent need exists for more capable logistic managers, and the School of Systems and Logistics is designed to help meet this need.

THE FUTURE

With a mosaic of logistic disciplines now available at the Systems and Logistics School—plus impending logistic curricula in colleges and universities—career logisticians are able to prepare for the increasingly complex tasks that lie ahead. You can see that logistics is a demanding field with strong managerial and technical challenges. Logistic managers are expected to approach perfection in performing a multiplicity of difficult tasks. And we seem to take these routine miracles for granted every day, just like food on the dinner table.
Eleven years ago on March 21 Tactical Air Command was born into the U.S. Air Force family of combat air commands. At birth TAC was charged with "supplying tactical air support to ground forces... giving them the flexibility and mobility necessary to accomplish missions."

Thus, from the outset, the two essential qualities of flexibility and mobility dominated the minds of men responsible for advancing the art of tactical air power. Their minds were like a garden, which could be intelligently cultivated or allowed to run wild. Fortunately, the TAC "gardeners" allied thought to purpose and created a productive force—the Tactical Air Command.

The story of TAC is as full of ups and downs as the sky itself. At its inception TAC's role was relatively minor compared with the Strategic and Air Defense Commands. Although tactical air power had figured significantly in World War II's successful conclusion, military planners were preoccupied with more urgent matters. There was little to suggest how rapidly tactical air potency would grow in importance.

Achievement is the crown of effort, the diadem of thought. But there can be no progress, no achievement without sacrifice. From 1946 to 1950, TAC experienced irregular fortunes, rising and falling like a barometer in capricious weather. This period of uncertainty was also one of transition. Jet power was rewriting many military textbooks and TAC was constantly experimenting with new and exciting ideas to provide across-the-board support for ground forces.

Despite considerable progress during the first two years, TAC reached its low point in 1948 when it became a part of the newly organized Continental Air Command (CONAC). In the shift TAC lost its aircraft, equipment, manpower and status in one sweep. A command planning section was all that remained.

Under CONAC the TAC planning section worked to refine and improve tactical air and joint operational doctrine. Forward Air Controllers—to become vital in the jet-fighter age—were put through jump school. The idea for a TAC troop carrier tactical airlift mission came to light. The bold scheme for special troop carrier packages for Joint Operation Centers, Ground Control Approach and Control Towers was advanced. All were to become important when tactical air emerged as a powerful, flexible and versatile military force in an era of growing global tensions.

In 1950 in Korea the significance of "nuclear parity" was made clear. With Russian encouragement and material assistance, the North Korean Communists struck south across the 38th Parallel and gave military science a new phrase—the "limited war." Korea brought about swift changes in the character of TAC and held great importance for tactical air power as a whole.

By August 1, 1950, Tactical Air Command was accorded major command status under CONAC, and by December 1 of that year, TAC was reestablished as an independent major air command. Congress had officially declared TAC a legal entity again.

Meanwhile...

While TAC was undergoing the trials of on-again, off-again status, men and science were charting the future. Propelled by jet power and armed with pioneering zeal, pilots were challenging the speed of sound and gaining more distance in less time. The first American jet engine was tested in 1942 and five years afterward the fearful sound barrier was cracked—exposing beyond it a world of limitless potential.

The next step? To build a jet-powered aircraft structure that would successfully blend the air weapon system with the attainable speeds at that time. As early as December 1945—just four months after Hiroshima—the 412th Fighter Group at March Field received P-80 Shooting Stars (even before the famous P for pursuit gave way to the F for fighter). Over the next three years the family of Eighties grew, producing the F-82, F-84 and F-86.

Long before we openly acknowledged the realities of the Cold War in 1947, military planners were building a defense posture around the nuclear-armed bomber. It was a "deterrent force" before the term gained popular recognition. Another interesting note: At the beginning of Korea
many felt that jets were too fast for close support. However, it wasn't long until every commander was clamoring for them. Why? Because pilots could easily locate and hit precise targets at speeds in excess of 550 mph and the planes could reach distant points quicker with far less vulnerability to ground fire.

But speed and precision weren't the only qualities necessary to exploit the full potential of jet aircraft. Range had to be extended to make the most of the new dimension in air power. While bold aerial pioneers were pushing speeds higher and higher, others were challenging distance.

"JET SET" TESTS

Early tests of essential capabilities of tactical air power – TAC in particular – measured up to the great promises of science and technology. Despite the diversion of Korea and the heavy responsibility for supporting its insatiable appetites, TAC continued to press forward to meet its expanding obligations.

In 1951 TAC deployed five fighter, bomber and troop carrier wing squadrons to Europe in a series of deployment trials. Airlift and air support doctrines were continuously refined and tested, including development of the precise Computed Air Release Point method that took guesswork out of dropping men and equipment into battle zones.

TAC also helped SAC with cargo-lift missions to support strategic air units in England; 17 missions moved 40 bomber engines and 125 tons of freight monthly in a test of capability, costs and procedures. In another test TAC troop carriers dropped 360,000 pounds of gear in a simulated battle zone in less than 10 seconds.

During this same period (1950-54) new ideas were stirring in the minds of visionary men who saw in tactical air power the kind of flexibility that a changing environment would demand. The Air Force Commander in Korea was determined to produce – more than anything else – mobility in TAC. He emphasized in-flight refueling and fast airlift. This meant mobility.

TACTICAL AIR COMMAND BASES
After a series of capability tests—in which lightning speeds, long ranges and firepower were blended and integrated to form the Composite Air Strike Force—TAC gained a major role in free-world defense planning. Stressing the importance of austere, rugged operational techniques, TAC was engaged in new concepts, refining joint operational tactics and techniques, and constant growth.

Two milestones in TAC's history emerged in 1955; the birth of the Nineteenth Air Force and Exercise Sagebrush, the latter of which proved conclusively that supersonic jet tactical fighters could provide the three basic elements of air support—close fire, counter-air, and interdiction—with precise accuracy and great flexibility. Activation of the Nineteenth Air Force proved responsive to the reality of TAC's global obligations.

SUCCESS TASTES GOOD

After completing a successful roster of operations, in July 1958 TAC got full responsibility for advanced tactical flight training from Air Training Command. This led to more stringent flight training and an expanding TAC role.

International crises—including the Berlin buildup, Cuban crisis, Congo rebellion, Dominican Republic emergency, and Vietnam conflict—saw a tightly knit TAC respond with maximum efficiency, speed and strength to some of the most dangerous crises since the Korean conflict. Strength can be developed only by effort and practice. TAC had both, plus professional skill and organizational competence.

Today Tactical Air Command is a force of integrated weapon systems and professionally skilled airmen poised to move anywhere in the world on short notice to deter or fight any brand of action at any level of conflict. Serving as USAF's long-range, mobile nuclear and non-nuclear tactical strike force, its units operate independently or in conjunction with other air or surface forces on a world-wide basis.

TAC units, after deployment overseas, are under the operational and logistic control of an element of the theater air command. Theater logistic systems—geared to the forces assigned and specified support of war additive forces—provide overseas support facilities and prepositioned material comprised of equipment, supplies and spare parts.

Enroute logistic support includes M-kits, engines, and support service teams who perform maintenance. This support is the responsibility of the deploying unit.

Thus, as a global force with international responsibilities, TAC is well-equipped to fight wars—large and small scale—with conventional or nuclear weapons by participating in prompt and sustained tactical air operations. Missions include tactical fighter, tactical air reconnaissance, special air warfare and tactical airlift. Scheduled to join the TAC inventory soon is the F-111A variable sweep-wing fighter. Possessing the widest possible range of combat capabilities, it is the future aircraft for TAC's world-wide fighter-bomber operations.

In all human affairs there are efforts and there are results, and the strength of the effort is the measure of the result. TAC has strived for the maximum in mobility, flexibility and versatility—just as the 111 Programs have—and TAC has achieved each goal, only to find that new goals emerge and await conquering. There will be a continuing need for the highest quality—men and equipment—to meet the increasing role of tactical air power.

Tactical Air Command has become vital to America's safety from foreign domination and is indispensable to the United States Air Force. TAC—we salute you.
# FACTS AND FIGURES

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