F-16 AVIONICS MAINTENANCE CONCEPT AND MULTINATIONAL ASPECTS

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Abstract

The background of the F-16 program is presented, highlighted with a discussion of the multinational aspects of the procurement. After a general presentation of the aircraft itself, the reader is introduced to the three level avionics maintenance concept, and the iterative process by which it was tailored to the F-16 Weapons System. The depth of maintenance performed at each level is explained, along with the type of approach used.

Background

In January 1975 the Air Force selected YF-16, General Dynamics entry into the Light Weight Fighter Program, over the competing aircraft from Northrop, the YF-17. The F-16 was selected because its lower acquisition and operating cost will allow an optimum mix of F-15s and F-16s to achieve air superiority into the next century. In June of 1975, the F-16 became a multinational procurement program with the entry of the European Participating Governments (EPGs) of Belgium, Denmark, The Netherlands, and Norway. The vehicle for their entry was a Memorandum of Understanding (MOU) between the countries stating the intentions of the respective governments to procure, co-produce, and in the future, sell the F-16 aircraft to third countries. The aircraft, as well as most of its major avionic and support equipment items, will be produced from assembly lines both in the United States and in Europe. The Memorandum of Understanding indicates that the United States Government will procure 650 F-16 aircraft and the European Participating Governments (EPG) will procure 348 aircraft. It further specifies the intention of the Consortium to share the procurement value of the aircraft, its components and support material, with 10% of the USAF procured value of aircraft being co-produced in Europe, 40% of the EPG aircraft procurement value co-produced in Europe and 15% of the value of any aircraft sold to third countries produced by the European partners. The current planned total buy of F-16s for the overall program is as follows:

United States	1388
Belgium	116
Denmark	58
The Netherlands	102
Norway	72

Two additional countries, Iran and Israel, have signed Letters of Offer and Acceptance (LOAs) indicating their desire to purchase the F-16.

Aircraft Detail

The aircraft vital statistics are:

LENGTH	49 1/2 feet
HEIGHT	16 feet
WING SPAN	32.8 feet
DESIGN TAKEOFF GROSS WEIGHT	22,800 lbs
MAXIMUM TAKEOFF GROSS WEIGHT	33,000 lbs

The aircraft is propelled by a Pratt & Whitney F-100 turbofan engine, a derivative of the engine currently used in the F-15 aircraft. It delivers 25,000 lbs of thrust. The aircraft active range is over 500 miles and is capable of being ferried in excess of 2000 miles. The F-16 service ceiling is in excess of 50,000 feet. It is armed with an internal 20mm gatling gun and has the capability to carry up to 6 AIM-9 missiles as well as other external bombs and stores. It's speed is in excess of Mach 2.

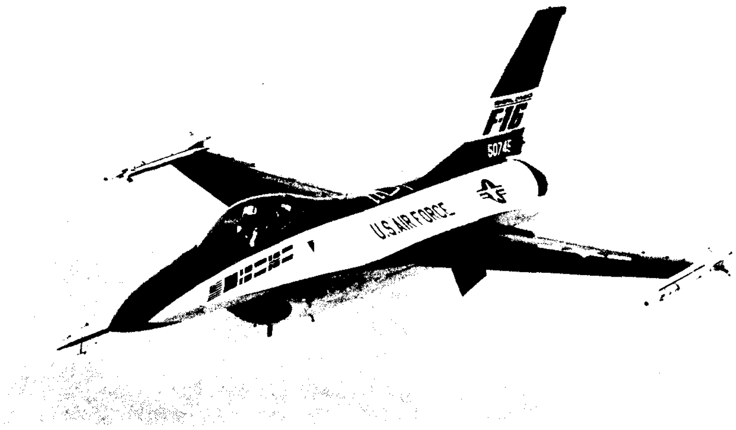
The aircraft has an extensive suite of multiplexed avionics subsystems. One of the unique aspects of the aircraft is its quadruple redundant fly-by-wire flight control system. The input to the system is a side stick controller on the right hand side of the cockpit which allows the pilot to fly the aircraft electronically through pressure induced on the side stick control.

The fire control radar allows the pilot to acquire both aerial and ground targets whose digitally synthesized symbology is then displayed to him on a heads-up display system, allowing him to maneuver and attack targets while retaining maximum visibility through the high bubble canopy. The stores management system allows the pilot to deliver his armament in any programmed sequence with exceptional accuracy. The aircraft also contains an inertial navigation system, UHF and VHF radios, and conventional position, navigation and instrument landing equipment.

Avionics Maintenance Concept

The modern, digitally implemented avionics suite of the F-16 aircraft logically requires complex testing capability for its trouble shooting and failure detection. The avionics system itself

F-16 AIR COMBAT FIGHTER



communicates through a MIL STD 1553 multiplexing bus. Built-In Test (BIT) systems in the aircraft report faults as they occur. These faults are stored in a table in the memory of the Fire Control Computer (FCC) on the aircraft. Upon the aircraft's return to base, this fault table in the computer can be read out by either the pilot or the ground crew for determination of what avionics maintenance may be required. Additional pilot reported failures are also the source of input for maintenance actions. The fault data can be displayed in the cockpit through the Fire Control Navigation Panel (FCNP). The maintenance technician, using tech data and a minimum of flightline ground support equipment, then removes the faulty avionic box, or Line Replaceable Unit (LRU), from the aircraft and processes the necessary forms to document the failure. He then installs a spare LRU to return the aircraft to service and verifies the functional integrity of both the subsystem and the aircraft. The LRU is then processed to the intermediate level of maintenance or directly to the depot for servicing as determined by a five digit code associated with the LRU, called a source maintainability/recoverability code. This coding is established by a process known as ORLA, or Optimum Repair Level Analysis.

The ORLA is a computer economic model designed to optimize the solution of a multivariable support level problem. The model takes a number of input variables and optimizes a multi-equation calculation to determine the output repair decision, which is a life-cycle-cost number representing the relative magnitude of the cost of implementing that level of maintenance. The general inputs and outputs of the ORLA model are given in Table I.

TABLE I

INPUTS	OUTPUTS
Failure Rate	Condemnation of LRU
Cost of Spares	Repair at Organization Level
Cost of Repair Labor	Repair at Intermediate Level
Labor Hours	Split Level Repair
Cost of Support Equipment	Other Combinations of Above Options
Maintenance of Support Equipment	
Stock Support Cost	
Training Cost	
Tech Data Cost	
Shipping Cost	

Three Levels of Maintenance

As implied by the ORLA discussion above, the F-16 employs a three level maintenance approach, organization, intermediate, and depot. The organizational level, or flight line maintenance, consists of those tasks oriented toward returning the aircraft to fully mission capable status. Removal and replacement of LRUs is the primary maintenance action related to avionic systems. The intermediate level of avionics maintenance is performed in the Component Repair Squadron, using the Avionics Intermediate Shop (AIS) and other intermediate level repair equipment.

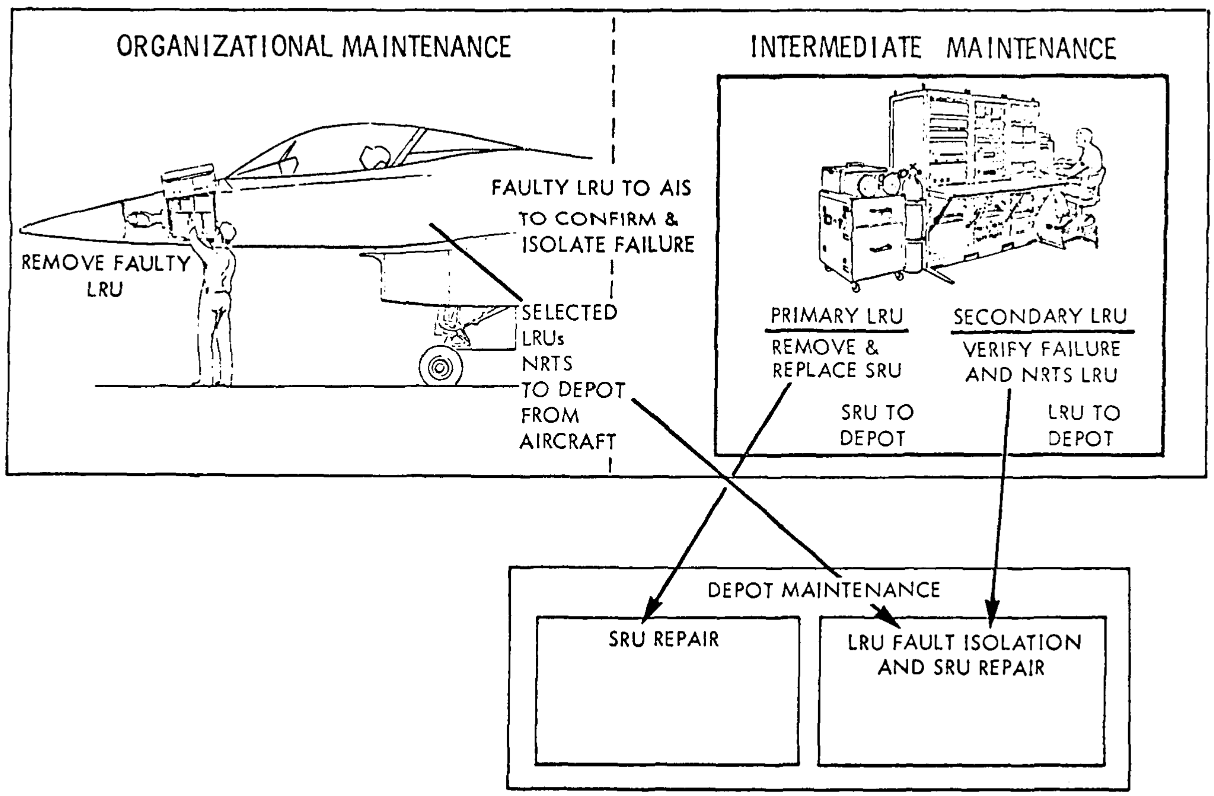
The Avionics Intermediate Shop (AIS) is a set of four automatic test consoles, interface test adapters, and software necessary to troubleshoot those LRUs repaired at the intermediate level. The LRU is connected to the automatic test equipment by means of the interface test adapter, a patch panel that has the specific connectors required to interface with the avionics LRU. The task of the Avionics Intermediate Shop is to confirm the failure and fault isolate to the circuit card (called an SRU) within the LRU. (For additional detail, see the companion article on the F-16 AIS.) The SRU is removed and a spare is installed. The LRU is then performance tested to verify the repair action.

The third level of maintenance is the depot level. The SRU from the intermediate level in most cases is returned to the depot where it is in turn fault isolated on depot automatic test equipment in order to determine the faulty components on the circuit card itself. (The depot test equipment is also discussed in detail in a companion article.) Those LRUs which either cannot be repaired at the intermediate level due to equipment failure or other factors, or those designated by the ORLA process for depot repair are also returned to the depot.

The combination of organization, intermediate and depot level repair of both LRUs and SRUs was arrived at after extensive analysis and trade studies conducted by General Dynamics. There were many iterations of life cycle cost models which arrived at the current mixture of repair levels. These studies concluded that there was indeed a least cost mix somewhere between repair completely at the depot and a total field repair concept. In general, those LRUs that were found to be most economically repaired at the base level were those LRUs of high complexity and high cost. The lower demand and low cost LRUs, i.e., the simpler, more reliable electronics systems, are more economically repaired through a return to depot concept, because it is cheaper to buy spares and "fill the pipe" than it is to field and maintain the support equipment.

The capability of the AIS consoles themselves was determined by an aggregate group of all of the avionic LRUs associated with the F-16 aircraft. The initial investigation revealed

F-16 MAINTENANCE CONCEPT



that 95% of the development and production costs associated with the capabilities for over 100 F-16 LRUs rested in approximately 40 of the higher cost LRUs. Once the investment was made in the test capability for the complex LRUs associated with the aircraft, the capability to test the simpler LRUs was inherent in the investment. Each of the over 100 LRUs was then subjected to the previously discussed Optimum Repair Level Analysis to determine whether it would be repaired in the field or at depot level, using the same automatic test equipment at both locations where cost effective.

EPG Maintenance Concept

Because of their desire for maximum self sufficiency at the base level, the European Participating Governments have adopted a slightly different maintenance concept with respect to the Avionics Intermediate Shop. As previously explained there are some LRUs assigned for testing on the Avionics Intermediate Shop equipment for the United States only at depot level. This capability for the EPGs (the additional Interface Test Adapters and software) will be placed at each F-16 operating base in order to retain their local flexibility to repair LRUs on station.

Summary

The avionics maintenance concept development for the F-16 is an iterative process. Decisions are made based on the best economic approach, yet test capability is retained that allows a reversal in those instances where the phased maturation of the weapons system dictates the change. The F-16 will carry the defense forces of many countries into the next century, and the development of a workable maintenance concept is a critical element of logistics support planning for ensuring that defense capability.