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ADVANCED FIGHTER TECHNOLOGY INTEGRATION PROGRAM AFTI/F-16

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ABSTRACT

The AFTI/F-16 Advanced Development Program is developing and flight validating advanced technologies which improve fighter lethality and survivability. The capability is achieved by the integration of mission task-tailored, digital flight controls with a director-type fire control system, and advanced target sensor/trackers. The Digital Flight Control System is the core technology. Integration of the systems forms the capability for automated maneuvering attack. Evaluation of automation, with respect to the weapon delivery task, is a key program thrust. Use is made of nonconventional aircraft control modes to achieve improved maneuverability and weapon line pointing. Careful attention is given to pilot/vehicle interface provisions. The AFTI/F-16 is now undergoing an extensive test program to provide the confidence necessary to transition the technologies for use on current and future fighter aircraft.

AFTI/F-16 PROGRAM DESCRIPTION

The overall objective of the AFTI/F-16 Advanced Development Program is to develop, integrate and flight test a set of technologies dedicated to improve fighter lethality and survivability. The AFTI/F-16 program permits individual development of technologies, criteria development, functional integration of the technologies, and benefit/penalty assessment in a manner that accelerates technology convergence at reduced cost. The payoff will be flight validated technology alternatives for future fighter aircraft in the critical, tactical environment of low altitude attack and air-to-air combat. (Figure 1).

The AFTI/F-16 development will be accomplished in two phases involving two periods of aircraft modification and two series of flight tests. The Digital Flight Control System (DFCS) is the core technology and as such is the primary technology development task in Phase I of the program. The DFCS development addresses flight path control and provides task-tailored, multimode control for operational versatility. The DFCS enables efficient use of 6 DOF decoupled aircraft control involving direct force modes and weapon line pointing. This part of the AFTI/F-16 program includes development of the demonstrator aircraft, with provisions for direct force control and weapon line pointing, cockpit development, avionics system integration, voice command evaluation and basic provisions for interface and installation of the Automated Maneuvering Attack System (AMAS) hardware. Approximately one year of flight testing (June 1982-May 1983) will be accomplished to assess and validate the Phase I technologies. In Phase II, automated maneuvering attack is the key thrust in demonstrating increased weapon delivery effectiveness and survivability. The DFCS is coupled with a director-type fire control system. Target sensors/trackers, helmet sight and weapons interface automation are added. A key thrust is the evaluation of automation with respect to weapon delivery tasks. It is the Automated Maneuvering Attack System phase where the "real world" validation of AFTI/F-16 technology integration is accomplished. Flight testing is planned for the summer of 1983 to fall of 1984 period.

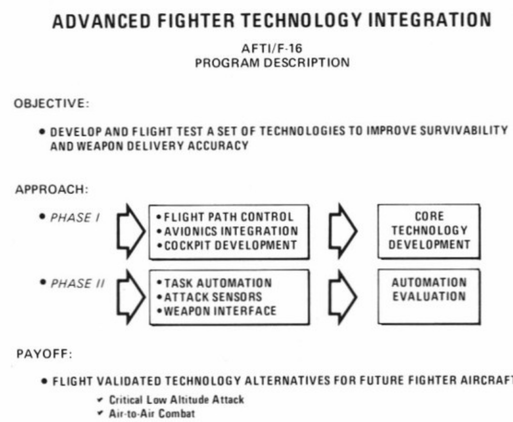

Figure 1

Figure 2 illustrates the AFTI/F-16 features. These features, how they are mechanized and how they will be utilized and evaluated on AFTI/F-16 are discussed at an overview level of detail in the remainder of this paper. The references cited at the end of the paper provide greater detail in their topic areas.

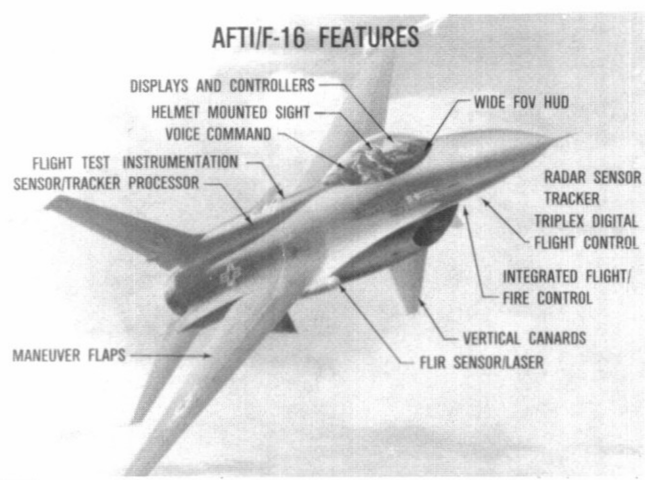

Figure 2

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Participants

AFTI/F-16 is a joint program involving the USAF, Navy and NASA, with General Dynamics, Fort Worth Division, the prime contractor. The AFTI/F-16 Advanced Development Program Office (ADPO) of the Flight Dynamics Laboratory, Air Force Wright Aeronautical Laboratories, is the responsible development organization and is thus responsible for all development, test and evaluation activities. The Naval Air Development Center provides funding and technical support to the ADPO; the Naval Air Test Center has provided a test pilot for simulation and flight test evaluation. The Air Force Armament Laboratory is funding and supporting Standard Avionics Integrated Fuzing development that will be flight demonstrated on the AFTI/F-16. NASA Dryden Flight Research Facility is providing significant manpower and facility resources in support of AFTI/F-16 development, operations and flight test. The Air Force Flight Test Center is the USAF designated Responsible Test Organization for the flight tests. A Joint Flight Test Organization (JFTO) consisting of personnel from the ADPO, AFFTC, TAC, NASA-DFRF, Navy and General Dynamics will conduct the flight test program at Edwards AFB and Nellis AFB.

DIGITAL FLIGHT CONTROL SYSTEM

A digital flight control system (DFCS) is the core technology in AFTI/F-16. DFCS combines the magnitude increase in flight control capability with physical characteristics which are attractive for small, fighter aircraft applications; i.e., capability growth without compromise (volume, weight, performance, cost) to the aircraft. This increase in capability allows maximum exploitation of flight/fire control and other subsystem integration, with growth provisions for capability evolution that is typical of multi-role ("swing") fighter aircraft. The AFTI/F-16 flight control system represents a significant advancement in state-of-art and is applicable to both current and new fighter aircraft.

When we speak of DFCS, more is inferred than a set of computers, controllers, sensors and integrated servo-actuators typical of a fly-by-wire flight control system. The DFCS phase of the AFTI/F-16 is in itself the development of a total integrated system. Development thrusts include: (a) task-tailored multimode control laws incorporating decoupled direct force and weapon line pointing features; (b) triplex asynchronous digital fly-by-wire using Bendix BDX-930 processors; (c) advanced redundancy management techniques, making maximum use of digital concepts (minimizes hardware), which provide essentially 2 fail-operate capability. The requirement is to meet or exceed a loss of control reliability of 1×10^{-7} failures/flight hour and a mission abort reliability of 1×10^{-5} aborts/flight hour; (d) integrated crew station using multipurpose displays and controls; (e) modular software for ease of development, test and integration; and (f) maximum integration of flight controls and other aircraft systems through digital data bus interlacing of subsystems including fire control, mission avionics and associated displays.

The advantages gained through the digital flight control system are illustrated in Figure 3; discussion in following sections will further detail the AFTI/F-16 control law development and subsystem integration. A key point to this Figure is that as requirements for enhanced system performance grow, life cycle costs clearly favor the digital system (F-16 example shown). The payoff of enhanced performance on the F-16 can be gained with reduced hardware volume (compared to analog hardware) - a significant factor in fighter aircraft.

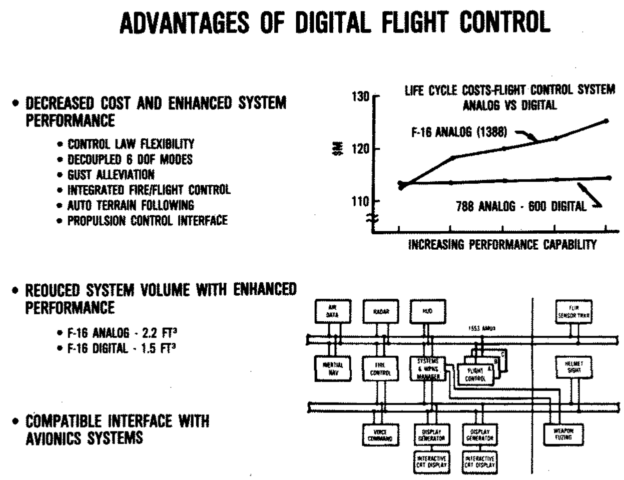

Figure 3

Advanced Control Modes

One area of "enhanced performance" in AFTI's DFCS is a key technology thrust of the program. AFTI/F-16 will apply new control degrees of freedom to the fighter air-to-air and air-to-surface attack tasks. In a previous flight test program, the Control Configured Vehicle (CCV) YF-16 Advanced Development Program, the concept of decoupled six degree-of-freedom (6 DOF), flight path control was successfully demonstrated. This 87 flight, 125 flight hour test program demonstrated that the ability to independently control vehicle translational and rotational degrees-of-freedom (Figure 4) by employing independent control surfaces for each response axis can create unique maneuvering capabilities: direct lift and sideforce, fuselage elevation and azimuth pointing independent of flight path, vertical and lateral translation, and quicker and more precise maneuvering control (maneuver enhancement and gust alleviation). However, the CCV YF-16 program was just the initial step in validation of the decoupled control mode potential. CCV YF-16 flight testing clearly showed the need for improved mechanization and automatic versus manual control. Guidelines were to (1) increase automatic operations, (2) simplify pilot controllers, and (3) task-orient controller gradients, mode authorities and dynamic response characteristics. AFTI/F-16 is heeding these recommendations and has undertaken an intense effort to develop task-tailored conventional (standard) and 6 DOF control laws in a digital flight control system. AFTI/F-16 carries the development of this "new way to fly" from a concept demonstration to a validation of combat effectiveness.

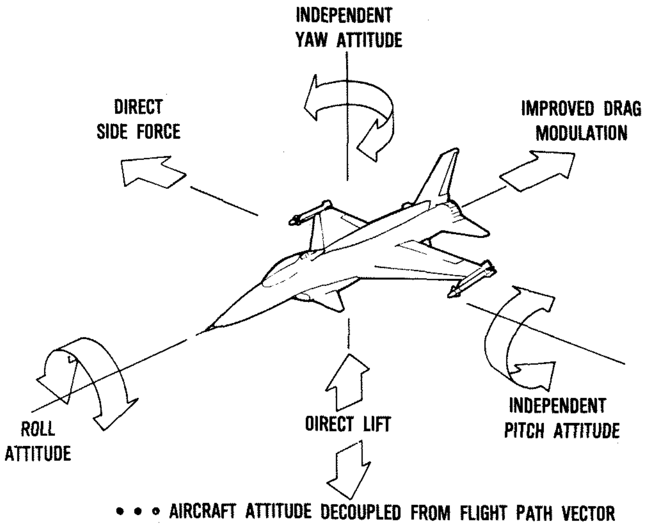

Figure 4

Control Law Development

AFTI/F-16 will demonstrate improved flight path control through enhanced flying qualities and the new degrees of control freedom. Today's non-multimode flight control systems are compromises that provide reasonably acceptable flying qualities over the aircraft's full operating envelope. In analog systems, provisioning of extensive multimode features is precluded because of the volume of hardware components and resulting reduction in system reliability. Now, the speed and computational power of digital processors allow magnitude increases in control capability within equivalent space for single mode analog equipment.

On the F-16A, a single control mode is used throughout the flight envelope. In contrast, the AFTI/F-16 has four standard modes: Normal, Air-to-Air Gun, Air-to-Surface Gun and Air-to-Surface Bombing (Figure 5). The AFTI/F-16 normal mode has specific improvements from that of the F-16; it is tailored for takeoff, landing and secondary mission tasks. The combat modes are entirely unique to the AFTI/F-16. As shown in Figure 5, for each standard mode there is an associated, decoupled control mode. Thus, eight distinct operational flight modes are selectable from the DFCS.

These normal and combat modes provide flying qualities task-tailored to the particular mission segment. The normal mode is primarily tailored for good handling qualities in the cruise, power approach and takeoff phases of flight. It is designed to provide gust smoothing and reduction in pilot workload during such tasks as formation flight and air refueling. The air-to-air and air-to-surface gun combat modes primarily are tailored for rapid maneuvering and precise control of the weapon line for gunnery accuracy; pitchrate feedback predominates in these modes. In the bombing mode, precise control of the flight path vector and automatic gust alleviation are required for bombing accuracy; normal acceleration feedback predominates in this mode design. A note of caution must be made regarding the nomenclature of standard and decoupled control modes in order to prevent misunderstanding of the AFTI/F-16 application of CCV, 6 DOF control. All of the standard modes (Figure 5) employ automatic blending of direct force control. Direct lift is automatically blended with each of the modes to provide gust alleviation and response quickness (maneuver enhancement). Here too, different blendings of gust alleviation serve to either stabilize the weapon line (air-to-air) or improve ride qualities (air-to-surface). Another closed loop implementation is where the canards are used with the rudder in the yaw stability augmentation system mechanization. Direct sideforce (flat turn) is also provided for all the standard combat modes by pilot inputs through the rudder pedals. Drag modulation is a unique feature that uses snowplowing of the canards with speed-brakes in up-and-away flight, and for speed stability with angle-of-attack change in landing approach.

In the DFCS, the decoupled fuselage pointing and translation modes are pilot selectable and manually controlled; the pointing modes are used for precise attitude control while translation applies to precise flight path control.

In addition to the standard and decoupled control modes that task-tailored flying qualities, many pilot-assistance features are provided by the DFCS control system including angle-of-attack limiting, load factor and structural limiting, and departure/spin prevention.

Two other control "modes", Reconfiguration and Independent Backup Unit (IBU), are shown in Figure 5. Pitch and lateral-directional control law reconfiguration, schemes have been developed to enhance the two-fail operate design of the triplex DFCS. Upon detection of second-like sensor failures, the FLCCs will execute alternative control laws using other sensor inputs.

An analog Independent Backup Unit (IBU) is resident in each flight control computer. This provides emergency flight control capability for a safe return to base and landing in the event of digital flight control computer complex failure (e.g. - undetected generic software fault failing all three computers).

AFTI/F-16 Control Law Multimode Structure

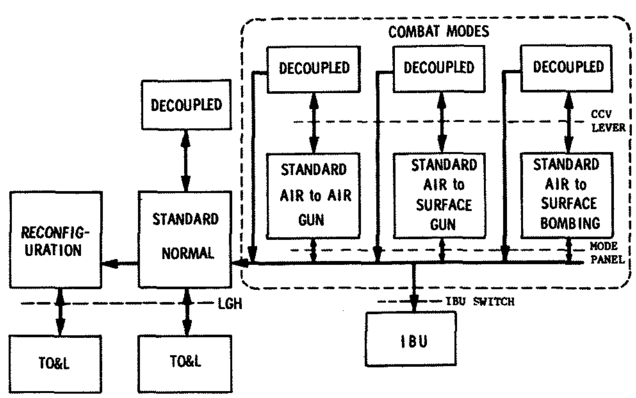

Figure 5

The task-tailored, conventional and decoupled and multimode control features just described will all be evaluated in the DFCS phase of flight testing. Other automatic control capabilities will be demonstrated in the Automated Maneuvering Attack System (AMAS) phase of testing. In the AMAS phase, the fire control system will be coupled to the flight control system for the realistic capability to accomplish maneuvering weapon delivery. Conventional and decoupled control modes can be automatically commanded to null weapon aim error. Similarly, terrain following, terrain avoidance, collision avoidance, propulsion coupling are typical candidates (not in current AFTI/F-16 program) for future coupling with DFCS control laws.

Avionics Integration

A highly integrated avionics and flight control system architecture has been designed for the AFTI/F-16. Figure 6 illustrates this DFCS/Avionics system. The DFCS (comprised of a Flight Control Computer (FLCC) complex and controllers, inertial sensors, Flight Control System Control Panel and actuators) interfaces with avionics system elements that provide the means for DFCS mode control and status display. These elements include: (1) two interactive multipurpose displays (MPDs), (2) two programmable display generators (PDGs), (3) dual redundant stores management set (SMS) central interface unit (CIU), (4) redundant multiplex (MUX) data buses and (5) primary and backup MUX bus controllers. The serial-digital, dual redundant, time-division multiplex data bus (AMUX) is the communication link between the avionics subsystems and the DFCS. The DFCS responds as a remote terminal on this MIL-STD-1553 data bus; mode selection commands, air data and inertial data are received and flight control system status information is transmitted via the AMUX. The bus interface is designed so that no failure outside the DFCS will cause an internal malfunction. The redundant avionics bus (AMUX), display bus (DMUX) Stores Management Set (SMS) and Multipurpose Display (MPD) sets provide complete dual redundant command and data paths between the pilot and DFCS.

The F-16 avionics architecture was designed to partition subsystems functions and through careful interface definition forces avionics software problems to the subsystem level. Hardware and software is modularized rather than combined into a larger, more complex computer system. The transition from F-16 to AFTI/F-16 takes advantage of this partitioning for software development. Addition of the display bus (DMUX) doubles the data communication capability and facilitates the addition of subsystems with high bandwidth data requirements. The result is a core digital avionics system with the logical partitioning and standard interfaces to readily accommodate and integrate additional sensors, weapons and functions.

Pilot/Vehicle Interface

Usable application of the advanced control modes requires very careful attention be given to the pilot/vehicle interface. Considerable effort has been expended to provide AFTI/F-16 with controllers and displays that will keep pilot workload level acceptable for the mission tasks. Figure 7 illustrates the AFTI/F-16 cockpit layout and unique controllers and multipurpose displays.

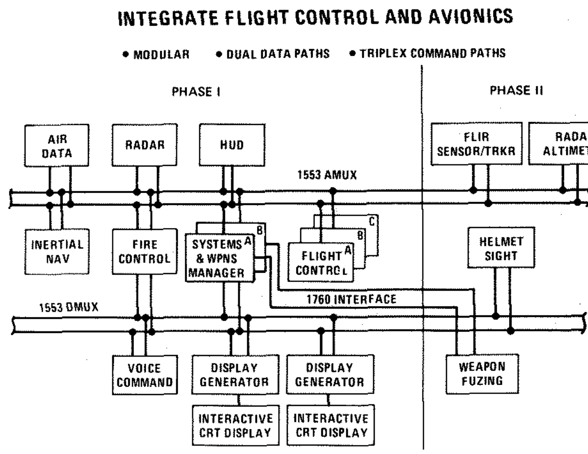

Figure 6

Primary, manual pitch and roll command are provided through the limited-displacement F-16 sidestick controller. It has been modified to provide additional switch functions: engage/disengage control of the independent backup system (IBU), decoupled control modes and Automated Maneuvering Attack System (AMAS). Based on CCV YF-16 flight experience, effort was made to logically separate manual command of coupled and decoupled control modes. To do this, a twist grip throttle controller was designed to provide manual pitch pointing and vertical translation control. Rudder pedals provide normal yaw control and, when selected, manual lateral pointing, translation and sideforce control.

Interactive Multipurpose Displays (MPDs) provide pilot communications with avionics subsystems and the DFCS. Action of the bezel mounted pushbuttons: (1) allow preset selection and change of control modes, weapon options and decoupled options; (2) provide in-flight test data presentation; (3) provide fault lists (failure locations) and allow selective pilot reset of DFCS faults; and (4) provide for pilot and maintenance level preflight testing. Along with the overlay displayed alphanumeric text, radar and other sensor video are displayed as an underlay on the MPDs. Location of video and alphanumeric data display is pilot selectable to either left or right MPD.

A new, wide-field-of-view Head-Up-Display (HUD) provides for display of critical flight reference information, weapon aiming and fire control system symbology; the instantaneous field-of-view is 15 x 20 degrees as compared to the F-16's 9 x 13 degrees. The HUD Electronics Unit has growth potential for raster capability (video display on HUD).

The MPD controls provide great flexibility in the pilot/vehicle interface. However, to reduce high pilot workload for combat operations, mission mode select buttons are located on the face panel of the HUD. These four switches provide one button selection of the aircraft configuration for normal, air-to-air gunnery, air-to-surface gunnery, and bombing modes. One switch action sets a preselected configuration of flight control mode, decoupled options, fire control mode, weapon(s) and arming, radar mode, Forward-Looking-Infrared (FLIR) sensor mode, sensor video and display symbology. If a change in preselected option is desired (e.g.-weapon selection) the pilot can then return to the MPD control and quickly modify the configuration selection.

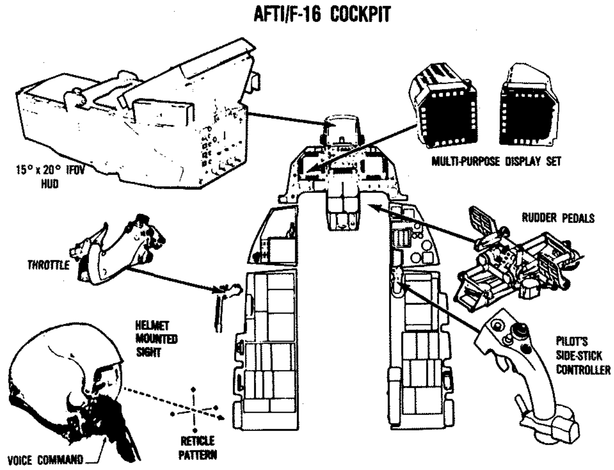

Figure 7

Voice Command

Another dimension to interactive pilot/vehicle interface is through voice command. Careful attention was given in designing hands-on controllers for AFTI. However, the number of switches and functions (Figure 8) have reached the limit of reasonable operability. Voice can be the next threshold in cockpit operation, giving the fighter pilot a true head-up, hands-on control capability and reducing or redistributing pilot workload. It can enhance the all-weather and/or night attack mission and may be a key to single-seat operation of a fighter on these missions. *Voice command will be initially evaluated during* DFCS flight testing. The purpose is to establish the effects of the airborne environment and extend the state-of-art for the technology to fighter aircraft. Avionics architecture provides potential access and control of all avionics systems interfaced on the multiplex buses.

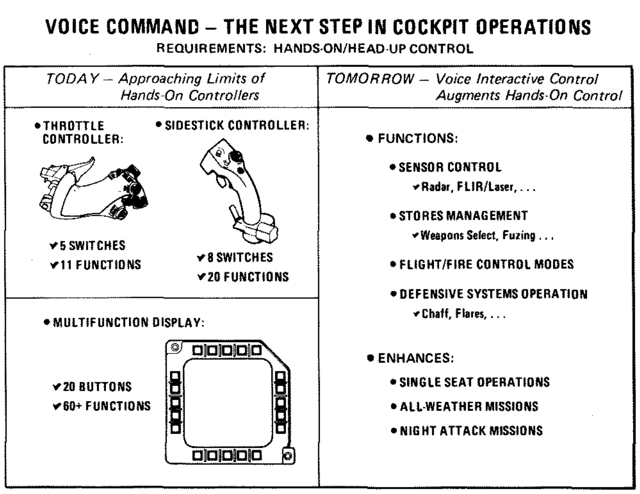

Figure 8

AUTOMATED MANEUVERING ATTACK SYSTEM

Phase I - DFCS, as described in the preceding Section, constitutes the core technology and vehicle development phase of AFTI/F-16. In Phase II, task automation as applied to the fighter mission is evaluated. Development of AFTI/F-16's Automated Maneuvering Attack System (AMAS) is both a *major technology thrust* and a product exploitation of the core digital avionics system capability. Through software integration, the attack sensors, fire control, flight control, pilot vehicle interface and weapons interface are integrated into the AMAS (Figure 9). The aim is to free the pilot to concentrate on target acquisition,attack planning and threat avoidance, with the automated system working the flight trajectory and attitude control tasks.

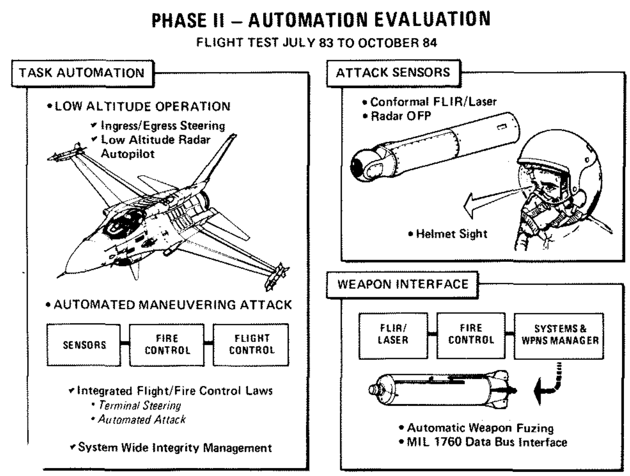

Figure 9

The AFTI/F-16 has the integrated systems to demonstrate precision, low altitude air-to-surface maneuvering attack and all-aspect air-to-air engagement. Figure 10 illustrates a maneuvering attack scenario. It is noted that the ingress/egress navigation problem is not a primary AFTI program objective: emphasis is given to the terminal attack. The AMAS system is designed such that flight path control from engagement on ingress through weapon release and into egress, can be fully automatic. However, the pilot can intervene at anytime, adjusting either ground track or altitude profile of the delivery to suit terrain or threat conditions. He can also select semi-auto and manual control options. The AMAS enables accurate weapon delivery while maneuvering. Bombs can be delivered from level, diving or lofted turning attack that provides standoff distance from the target and minimizes exposure time to ground threats. The measure of merit is in survivability improvement for the attacker aircraft while achieving equivalent weapon delivery accuracy during AMAS maneuvering compared to the baseline F-16 aircraft while not maneuvering.

In air-to-air, a 360° gun employment envelope is available (Figure 11); high line-of-sight (LOS) rate and front quarter engagements become realistic. A 3:1 increase in firing opportunities during

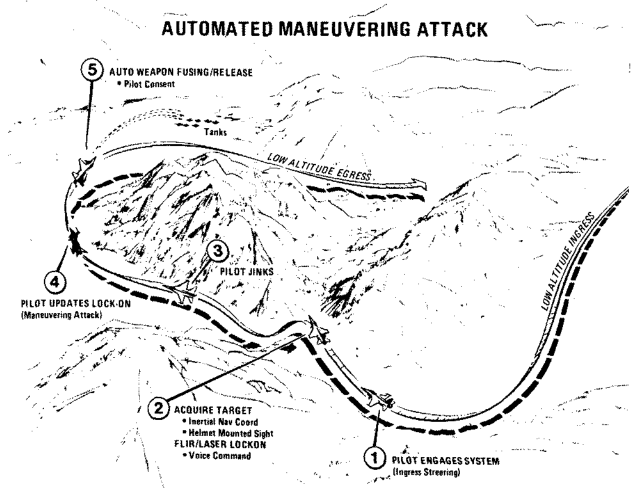

Figure 10

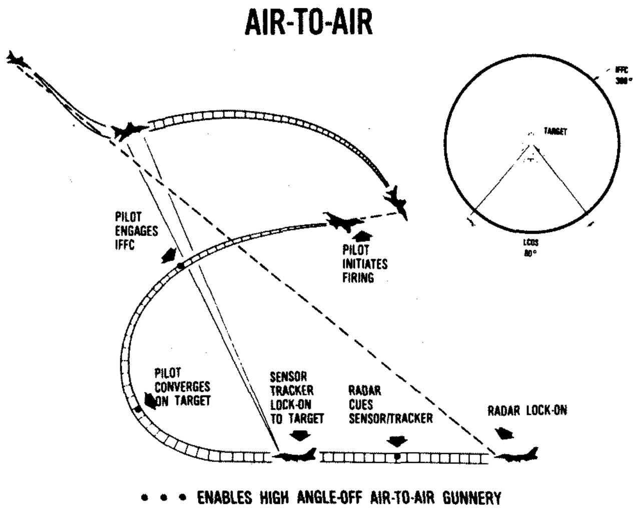

Figure 11

an aggregate of high angle off (front quarter), high LOS rate and dynamic tail chase encounter is anticipated.

AFTI/F-16 AMAS is nearing the Critical Design Review stage of development; flight testing will be in summer of 1983. Analysis and simulation is continuing in order to refine the AMAS design and mechanization to be flight tested. The pilot/vehicle interface is being evaluated for pilot acceptance, system control and display effectiveness. Automated weapon delivery profiles for different attack scenarios are being evaluated with piloted simulations; delivery accuracy will be measured and threat avoidance assessed. Since the AFTI/F-16 AMAS is not yet fully defined, the discussion that follows will cover key "parts" of AMAS and will point up the intended mechanization approach, unique AFTI/F-16 features and concepts of mission application.

Integrated Flight/Fire Control

Figure 12 conceptually illustrates Integrated Flight/Fire Control (IFFC). Radar and FLIR/Laser sensors are used to establish the target motion (angle and angle-rate) and measure the target range vector (range and range-rate). The director fire control system processes this target state data with own-ship state data to accurately predict target future position. This information is passed to the HUD to provide planning and situation displays to the pilot.

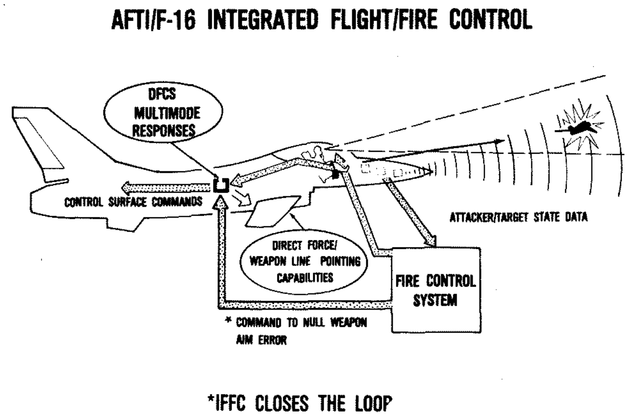

Figure 12

In addition, a control loop is closed between the fire control system and flight control system. This IFFC coupler can automatically control the aircraft to establish a weapon launch trajectory (e.g. - gunline or bomb fall line) that will intersect the predicted future target position. Control options including conventional, direct force and fuselage pointing, will be selectable. A goal of AFTI/F-16 is to measure and validate the benefits of direct force and pointing. The comparison will be between the best possible "conventional" control system (i.e., DFCS "standard" modes) and the DFCS 6 DOF options.

Sensor/Tracker

The key to IFFC is knowing precise target location. On AFTI/F-16, measurement of target location can be performed through either radar or FLIR/Laser tracking/ranging. In addition, the inertial navigation unit (INU) can provide prelocated target coordinates for bombing; or, the helmet sight can be used to set a target location in the INU.

The AFTI/F-16 AMAS sensor/tracker is being procured by General Dynamics from Westinghouse Corporation. It incorporates a modified common module FLIR and a modified Pave Spike Laser. The video tracker features area and centroid correlation for air-to-surface and centroid with auto-acquisition for air-to-air. Three fields of view (5.4/2.4/1.2 Deg) are pilot selectable. The sensor head is approximately 10 inches in diameter and weighs about 250 pounds.

Figure 13 illustrates the dual sensor/tracker configuration selected for AFTI/F-16. The wing-strake location provides a rigid sensor mount for good boresight control and can meet the desired field-of-regard. Keeping the sensor head diameter small minimizes drag penalty to the aircraft. Data show 50 to 80 percent less drag than equivalent pod-type systems across the Mach range. This is of significant importance for a "swing" fighter, especially a small aircraft that is less tolerant to aerodynamic drag growth. Air-to-surface weapon system capability can be maintained without significantly degrading air-to-air combat performance. An additional feature of the configuration is that no stores stations are lost to sensor carriage.

AMAS maneuvering weapon delivery places severe requirements on the sensor/tracker suite used for both air-to-air and air-to-surface attack. At least a full forward hemisphere field-of-regard is desirable for off-boresight target acquisition. Single sensor/tracker locations (other than the aircraft's nose) will have blanking by assorted aircraft parts that severely limit combat flexibility. The multiple sensor approach provides overlapping fields-of-regard and then as blanking of one is encountered, tracking control is handed off to one that is not blanked. Funding limitations prohibited provisioning of dual sensor/trackers on the AFTI/F-16. For the technology demonstration, a single sensor/tracker mounted in the right wing strake will suffice.

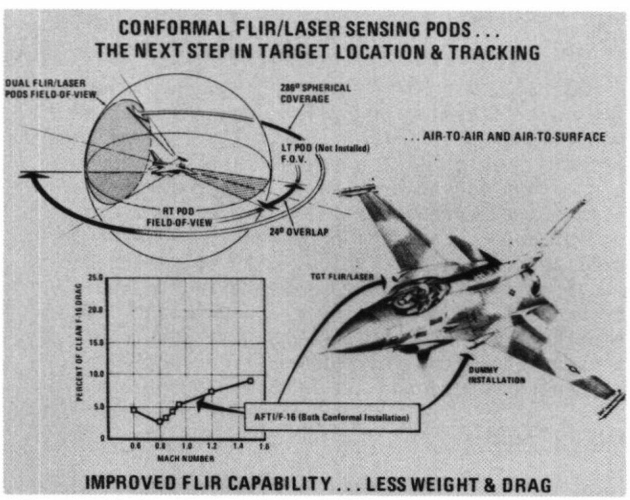

Figure 13

Helmet Sight

A significant part of the AMAS system is a helmet sight that will enable rapid head-up and hands on off-boresight target designation for the radar and FLIR/Laser sensors and INU. This feature is considered essential in order to reduce pilot workload to a level where the AMAS weapon delivery can be effectively accomplished in a single-seat fighter. The pilot need only look at the target of interest, push the "designate" button on his sidestick controller, the sensors will slew to the designated direction and he can expect a coarse sensor lock-on (target can be found within the sensor video field-of-view). Precise correction to target designation would then be made through a throttle-mounted cursor control or voice command with MPD sensor video. Reverse cueing of target location (e.g. - locked on radar or INU data) is also possible with the helmet sight to assist the pilot in visual acquisition of the target.

Weapons

It is essential that weapons be considered in full view of the total set of pilot-weapon delivery system interfaces. This is true if the weapon be a gun, conventional (unguided) bomb or munition dispenser, or guided munition. AFTI/F-16 with the AMAS approach is focusing the concept of weapon integration. As a result, the gun becomes a reliable, all-aspect air-to-air weapon where automation of the terminal tracking problem multiplies kill probability. Now the gun becomes a cost-effective companion weapon with the guided missile. In air-to-surface attack, the AMAS is expected to give precision delivery making the conventional bomb a cost-effective companion weapon with the guided munition (e.g. - Laser Guided Bomb, Mavericks).

In addition to the gun and training bomb (BDU-33), AFTI/F-16 will flight demonstrate delivery of an unguided Wide Area Anti-Armor Munition (WAAM). In a joint AFWAL/Flight Dynamics Laboratory and AF Armament Laboratory effort, Standard Avionics Integrated Fuzing (SAIF) will be demonstrated. Active control of a digitally fuzed WAAM tactical munition dispensor (TMD) is accomplished where fuze settings are automatically updated up to the moment of weapon release rather than being pre-set at takeoff. With the WAAM TMD this provides an expanded release envelope, more flexible dispersal pattern (area density) control of the sub-munitions, and reduced pilot workload for better delivery accuracy. SAIF facilitates use of the WAAM during AMAS delivery profiles and provides AFTI/F-16 with a tank-killing type weapon for demonstration (Figure 14).

Of key significance in this SAIF development is the establishment of a MIL-STD-1553 interface in the weapon. MIL-STD-1760 is being applied for electrical interface interoperability. This standardization of interfaces enables the integrated weapons concept to be readily applied to future weapons - simple or complex.

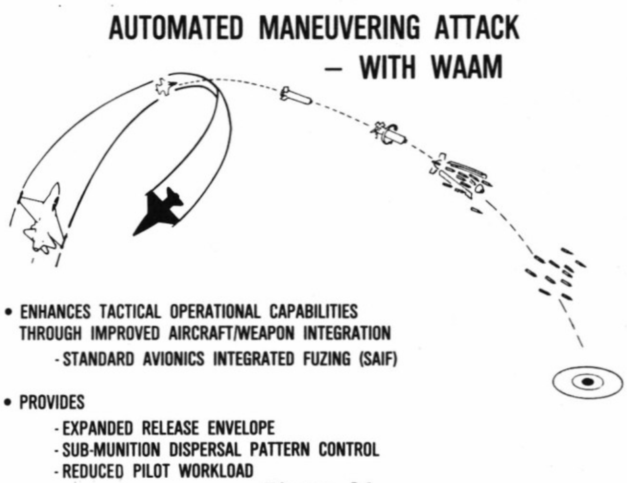

Figure 14

Mechanization

Development of the AMAS on the AFTI/F-16 is more than design of the automated function. For every task automation feature, human factors must be given careful attention. The design challenge is not only to enable the automation but also to give the pilot awareness and confidence in the automatic system's operation. Pilots properly hold a "show me" attitude to automated systems and confidence will only be gained through flight demonstrated results.

In the AMAS design, meticulous attention is being given to system wide failure management. The integrated flight/fire control (IFFC) mechanization in AMAS can be viewed as an outer-loop control mode of the DFCS; simplistically, it can be considered as an auto-pilot type mode. Command and guidance signals are received and passed by the flight control system to accomplish the automatic weapon delivery flight profile. It most certainly is a high performance mode and one that requires high system integrity when operating at high speeds (500-600K) at 200-300 foot altitudes. The key to this system integrity is again the triplex redundant, dual fail safe DFCS. The IFFC coupler, authority limiter (e.g. - roll rate and g limits can be automatically set) and integrity management functions are accomplished within the DFCS computer complex. Dual MUX Buses and combinations of sensor data form the elements necessary for fail safe redundancy. System Wide Integrity Management software in the Flight Control Computers (FLCCs) will perform internal tests of each system component to status the "health" of the AMAS to insure fail safe operation. Safe ground clearance parameters are continuously calculated by the FLCCs to form an inertial floor - the AFTI/F-16 will know where up is. Automatic fly up is provided in the integrity management and ground avoidance functions. The limiting factor in terms of mission reliability becomes the attack sensors (radar, FLIR, Laser) themselves; this area of avionics architecture and sensor redundancy is one that needs further technology development.

A radar altitude-hold autopilot mode will be mechanized with the DFCS and the F-16 radar operating in an air-to-ground ranging mode. A radar altimeter would also be used to measure current altitude with full (360 degree) roll attitude capability, and crosscheck the ranging radar data; combined, the data can be used to smooth the altitude-hold profile. The purpose of this autopilot mode is also to reduce pilot workload, allowing the pilot to pay additional attention to target acquisition during ingress, in the Edwards/Nellis AFB flight test environment. This is not a full terrain-following system. However, we consider automatic terrain following/terrain avoidance to be an important requirement, and another critical technology need, for operational employment of AMAS with night/allweather attack capabilities.

In AFTI we are expending considerable effort to provide predictive displays such that the pilot will know the current "intent" of the automatic system. HUD symbology has been designed to provide both the altitude profile and horizontal situation that is being computed in real-time during an automated maneuvering attack profile.

A goal in implementation of the AMAS is to maintain a manageable pilot workload to a point where the maneuvering delivery and all-aspect encounter concepts become viable to an average line pilot in a single seat aircraft. In AFTI/F-16, the helmet sight will assist in finding the target and making a first pass attack; having designated a target, it can provide cueing for acquisition during a re-attack. With the wide FOV HUD, near eye level multipurpose displays and hands-on controllers, less head-in cockpit attention is required. The radar altitude-hold autopilot will reduce the need for pilot attention to flight path control while accomplishing sensor lockup to target. With AMAS sensor/tracker lockup, attention can be given to survival flying to the terminal point of automatic weapon delivery. The IFFC fire control algorithms will enable automatic ordinance delivery with accuracy during the maneuvering delivery profiles. Voice command is a feature that we expect to demonstrate as a means of further reducing hand-switching in the cockpit; synthesized voice alert and system status response is anticipated to be a useful voice feature in AMAS. This emphasis on reduction of pilot workload is absolutely essential to the successful validation of the AFTI/F-16 technologies and to achievement of the goals: improved weapon delivery and survivability. It is particularly critical for single seat attack aircraft operating in an environment where they can survive - LOW.

SUMMARY

A description of the AFTI/F-16 program has been presented with features and capabilities highlighted. The technologies are squarely aligned with our future fighter requirements. The program is focusing an integrated systems approach-- the focal point for aircraft automation (Figure 15).

COMBAT AUTOMATION

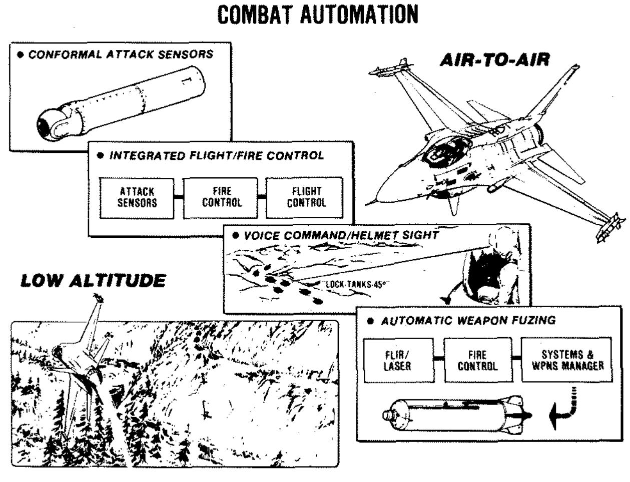

Figure 15

A key problem, compounded by night and in-weather attack requirements, is pilot workload. We do not claim to be solving all of the pilot/vehicle interface problem, but AFTI is charging head-on into the area. Voice command, helmet sight, displays and predictive symbology illustrate this AFTI/F-16 emphasis.

The AFTI/F-16 payoffs anticipated are:

OPERATIONAL CAPABILITY -

- Digital Flight Control: Decreased Cost/ Enhanced Performance
- Automated Maneuvering Weapon Delivery
- Enhanced Single Seat Attack
- All Aspect A-A Gunnery

SURVIVABILITY IMPROVEMENTS -

- Low Altitude Automated Attack - Key to Survivability in Multiple Threat Environment

FLEXIBILITY -

- Integrated Avionics Facilitates Adding New Capabilities
- Exploits Complementary New Weapon Technologies
- Significant Growth Potential in Testbed Capabilities

TRANSITION POTENTIAL -

- Direct Application to Next Generation Fighter And/Or Major Update of Current Fighters
- Critical Demonstration Leading to Automated Night Attack

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