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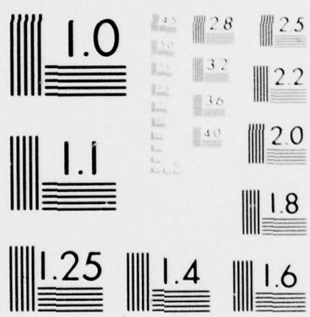

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NATIONAL BUREAU OF STANDARDS-1963-A

INTEGRATED AVIONICS CONTROL SYSTEM (IACS)

JUN 1978

*CHARLES A. PLECKAITIS, Mr., CARL J. GALANTI, Mr.,
ANTHONY S. SANTANELLI [redacted] GEORGE STECH, Mr.
US ARMY AVIONICS R&D ACTIVITY
FORT MONMOUTH, NEW JERSEY 07703

The concept of an Integrated Avionics Control System (IACS) in military aircraft has evolved from a significant increase in the number of electronic systems available for use on army aircraft today. A system such as IACS is needed for Army aviation because it reduces the crew workload, reduces demands on already crowded cockpits and makes new installation less difficult and less expensive.

Recently, considerable emphasis has been placed on reducing the cost of new avionics systems, thus the IACS program is being pursued under the design-to-cost concept. The design to unit production cost (DTUPC) essential requirement for this program is \$22.5K.

Currently Collins Avionics, Cedar Rapids and Grumman Aerospace, New York are under contract to the U.S. Army to develop an IACS for use in Army helicopters. The system weight is expected to be less than 30 pounds and the baseline system consist of five boxes. A primary control panel displays mode and frequency of controlled equipment, a secondary control panel provides a lesser capability for emergency uses, a status panel provides information for heads up viewing and the central control unit provides an interface between the remoted equipments, plus acts as a control for the 1553A data bus.

The following This paper ~~will~~ briefly discusses the Army approach to an integrated avionics control system. The background of the program is outlined, followed by a description of the overall IACS and its operation.

*PLECKAITIS, GALANTI, SANTANELLI, & STECH

The U.S. Army Avionics R&D Activity started an internal program in 1972 with a goal to develop a simple low cost integrated cockpit control/display system for use in army helicopters. The program guidelines established at that time were to:

1. provide control of the avionics equipment through a single integrated panel.

2. reduce aircrew workload.

3. increase avionics configuration flexibility.

The first of these guidelines is important because through the use of simple and clearly understood controls the aircrew could control a complement of avionics equipment with a minimum of training. Also, the workload of an aircrew is very high during helicopter missions and very little attention can be given to the avionics not directly involved with the aircraft flight operation. By using preset frequencies for communications equipments, the aircrew's workload is greatly reduced. Avionics flexibility is of particular importance with the introduction into the army inventory of new emerging electronic systems.

In 1974 an experimental model was designed, built, and evaluated. The result of this in-house program was the development of a integrated avionics systems specification in 1976 which served as a nucleus for the present engineering development program. Other guidelines that were included in this program were to minimize production cost, minimize maintenance, reduce weight, and have high reliability. The present program employs the design to cost concept to insure that IACS can be produced and supported economically by the Army. The contract calls for the delivery of eight fully qualified systems in October 1978 for formal flight and operational tests. The qualification test program will be conducted jointly by the contractors and the Army's test command and will include design verification, EMI and environmental tests and reliability, maintainability and human engineering demonstrations. The program will result in a complete production procurement package. One of the competing engineering development contractors will be selected for the initial production contract. Productions systems will be available early in 1982.

The basic IACS, which was recently nomenclatured by the Army as the AN/ASQ-166, consists of five units:

1. Primary Control Unit

2. Secondary Control Unit

3. Status Panel

4. Central Control Unit 1

5. Central Control Unit 2

See figure 1 for a block diagram of a typical IACS interconnection.

The primary control unit performs the following functions:

1. It displays mode and frequency information and other data on its front panel;

2. provides mode controls, display controls, and keyboard entry of data.

Since this panel will control up to ten avionics equipments, these equipments can now be remotely located in the aircraft avionics compartment. Control of such functions as the selection of preset frequencies and tuning to new frequencies is accomplished via the primary control front panel. The primary control unit has the following modes of operation:

1. IFF

2. COMM

3. NAV

4. Status

5. Index

Dedicated switches were retained for important functions as recovery of last frequency, guard, and zeroize of sensitive information.

The secondary control unit provides a minimum capability for emergency situations. The specification requires it to control one FM, one AM radio, and an automatic direction finder as a minimum. This secondary unit is envisioned for use in cockpits for which space or funding does not permit a primary panel for each operator. The primary and secondary control units can be mounted either in the center console for a side-by-side helicopter or the side pockets for a helicopter with a tandem seating arrangement.

The status panel is a small lightweight one line display which provides frequency and mode status information for the transmitting radio. It is envisioned that the status panel will be installed as a heads-up type display near the brow of the instrument panel.

The central control units provide a means of interfacing the IACS (primary control, secondary control, and status panel) elements with the controlled CNI subsystems. For the initial deployment of this system in the 1982 to 1986 time frame, all subsystem equipments will be controlled through the central control units. However, beyond that time frame, new subsystem equipments will be designed to interface directly onto the data bus. The CCU also provides the function of bus controller for stand alone operation. However, the IACS is capable of operating as a subsystem of a larger bus system or in a dynamic bus allocation mode.

The intra IACS connections are through the use of a 1553A digital data bus. The use of a digital multiplex bus over conventional hard wiring as the means to exchange data between IACS and the controlled CNI equipments is in keeping with the overall goal of reducing aircraft complexity. Less wire and fewer connectors are required with the attendant savings in weight, improvement in reliability, and simpler wire routing in the aircraft. Digital transmission techniques provide a higher data capacity, self check on each transmission and reduced susceptibility to electromagnetic interference.

Human factors engineering (HFE) played a significant role in the design and fabrication of IACS. This involved the analysis of pilot operational procedures, system architecture design, man-machine function allocations, and the matching of operational requirements to available technologies. A basic objective of the HFE effort was to ensure not only that the man-machine interfaces of the system were sufficient for the intended operation and control functions of the equipment, but also that these control functions could be accomplished by the operator.

The human factors approach to accomplish the basic objective entailed the following tasks:

1. Identify all significant man-machine interactions required by the system.

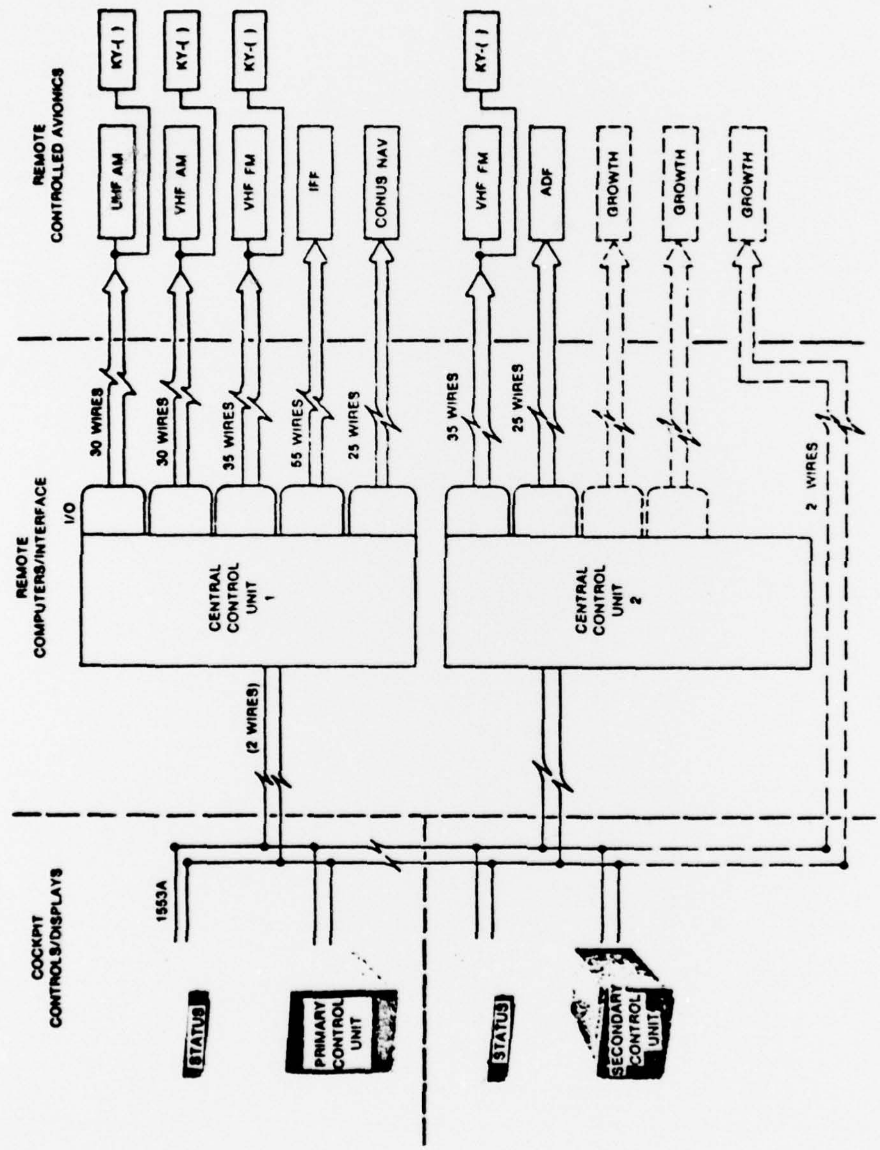


Figure 1. Integrated Avionics Control System AN/ASN-166

2. Determine mission and system characteristics which will influence operator performance during the above interactions.

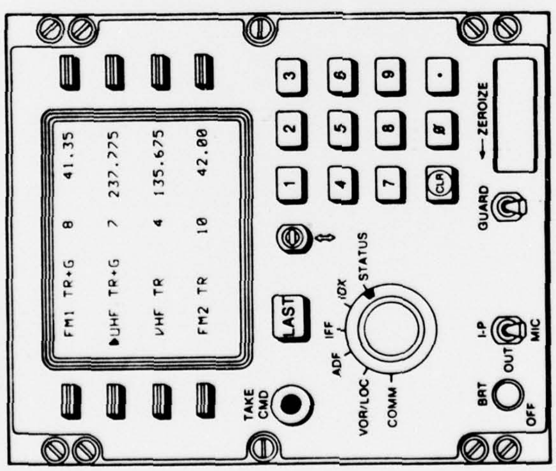
3. Provide and develop data to support trade studies, concept selection, and detailed design of equipment relating to the man-machine interface.

4. Conduct empirical studies to develop necessary operator performance data to support the above trade studies and design efforts.

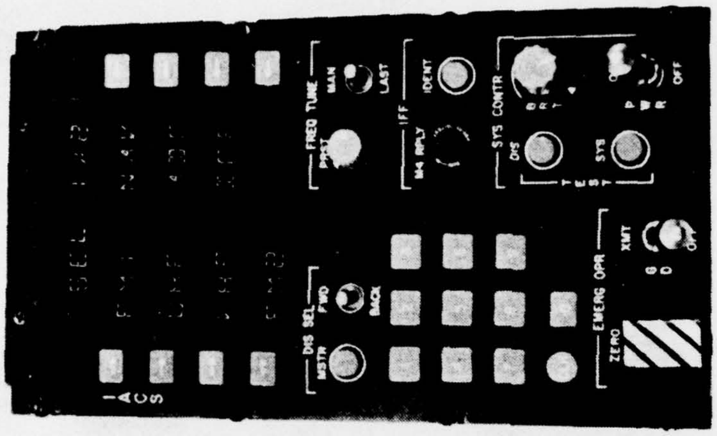
5. Conduct empirical studies to verify that chosen equipment designs will permit operator performance consistent with system and mission requirements.

Figure 2 shows the results of this HFE effort. The Primary Control Unit shown in Figure 2A was designed and built by Collins; and the one in Figure 2B, by Grumman. Both panels are multifunction control-display units that permit an operator to control a suite of CNI equipments. The displays (CRT in the Collins design and incandescents in the Grumman) are sun-light readable, are red for night-time viewing, are compatible with Night Vision Goggles, and are readable in a vibratory environment, such as encountered in rotary-wing flight. Both panels can be operated with gloves. In both panels, controls have been placed in close proximity to their related displays. This HFE principle is exemplified by the eight (8) line-select keys on either side of the display. These key switches give the operator direct access to the adjacent label/data lines on the display. It is also exemplified in the packaging of keyboard and display in the same box.

Both designs utilize an interactive or paging technique controlled completely by microcomputer software. In this approach, all available choices (e.g., the mode and frequency choices of a particular equipment) are displayed. Figure 3 shows a typical page. The operator makes a choice and selects, for example, FM 1 by actuating the line-select key to the left of the label. Immediately, a page labeled FM 1 appears, displaying frequency, channel, etc., see Figure 4. The asterisk to the left of SQT and CIP indicates that the pilot has selected these choices Squelch Tone, and Cipher. These actions illustrate another HFE principle: that verification and feedback are a necessary part of any control operation. For every control actuation, there is an immediate display response. Feedback requirements also apply to the actuation characteristics of the controls, themselves. Required actuation forces and switch detent characteristics, are an integral part of feedback information to the



A. Collins



B. Grumman

Figure 2. Primary Control Panels
(not to scale)

pilot, indicating that the switch has been actuated.

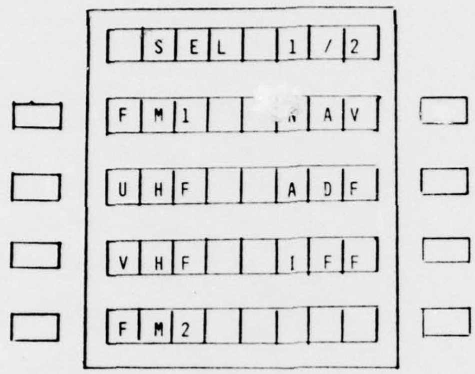


Figure 3. Typical CNI Select Page

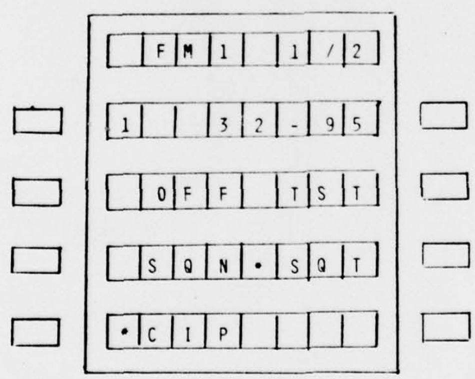


Figure 4. Typical FM 1 Page

Each piece of equipment has one or more pages showing all the control/display functions of the conventional control head. Also, each piece of equipment has been given 10 preset channels in which frequencies can be stored for future use. A control on the PCU allows the pilot to automatically tune any selected radio to a predetermined channel. For example, look at Figure 5, which shows a VHF control page. Notice the label CH-8 on the first line and the frequency, 141.675 below it. The pilot can select another channel with its associated frequency merely by actuating a rotory switch on the PCU. By rotating the switch to the right, channels are increased and vice versa. To change a frequency, the pilot types in a new frequency with the keyboard. This new frequency appears within the brackets at the bottom of the display. Then he pushes the line key next to the old frequency on the second line. Immediately the new frequency appears, indicating that the VHF radio is tuned to that frequency.

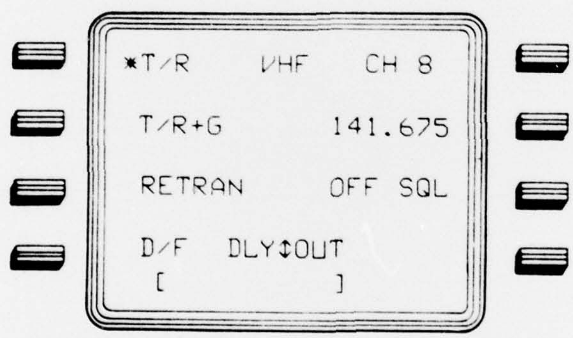


Figure 5. VHF Control Page

The pilot does not have to cycle through different pages to determine the operating frequencies of his radios. Figure 6 shows a Status Page on which his four (4) primary radios and their current operating channels and frequencies are displayed. The asterisk indicates that the ICS is at the FM 1 position, ready for transmission. To transmit on UHF, the ICS is switched to UHF position. The asterisk leaves FM 1 and appears at UHF. Thus, the pilot knows the status of his radios at a glance.

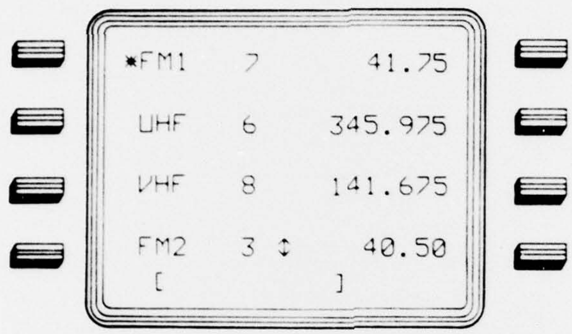


Figure 6. Status Page

As an illustration of a typical IACS aircraft installation (Figure 7) let's look at the AAH pilot station with conventional COMM, NAV, and IDENT control/display units (these are shown crosshatched). We have installed an FM with a security key, an UHF, and a VHF radio with space, weight, and power provisions for additional security keys, an IFF and an ADF.

Now, by way of contrast, let's look at the same station with an IACS installation (Figure 8). The IACS Primary Control Unit not only provides all the control functions of the equipments removed from this cockpit but the pilot also has control over the co-pilot/gunners FM radio and security key and CONUS NAV (VOR/ILS/MARKER BEACON) if the aircraft is so equipped.

In addition, a status panel displaying COMM mode, channel, and frequency is available which can be mounted near the top of the instrument panel so as to provide a nearly heads-up type display.

It can be readily seen that the above examples show how the concept of integrating a control/display unit with a microprocessor provides the pilot with a viable solution to the problems of increased

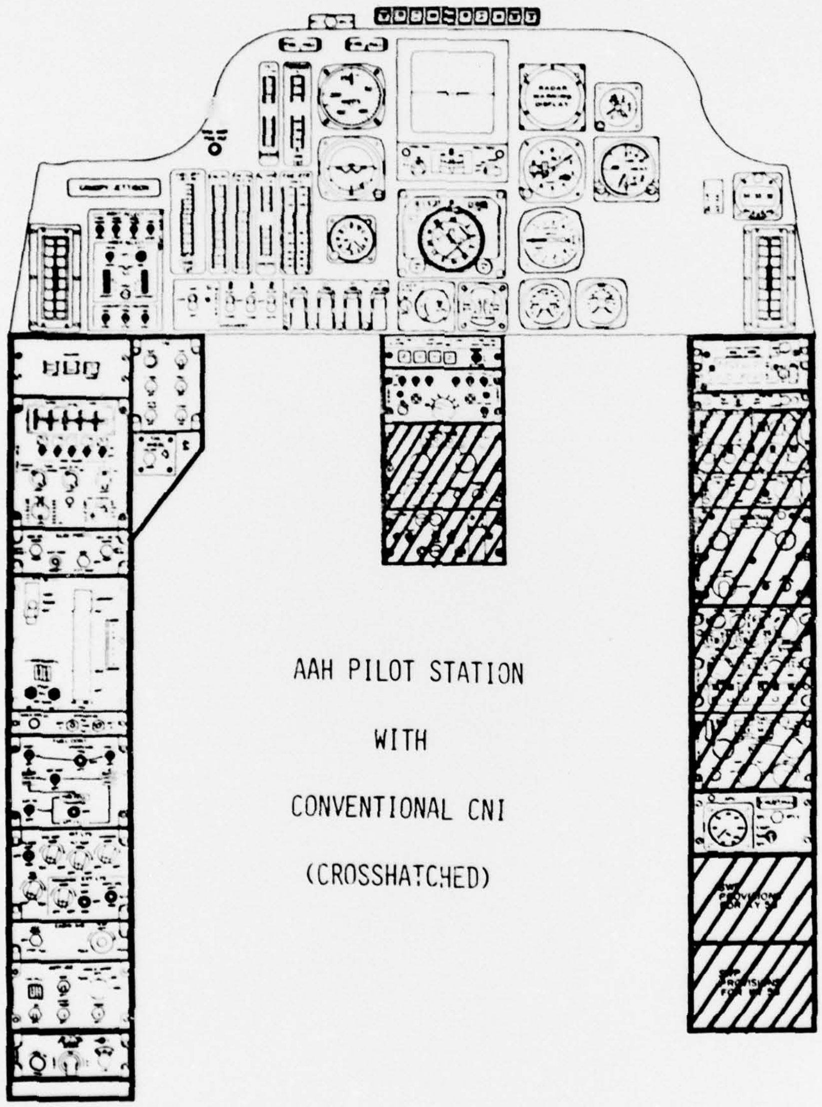


Figure 7. AAH Pilot Station (Conventional)

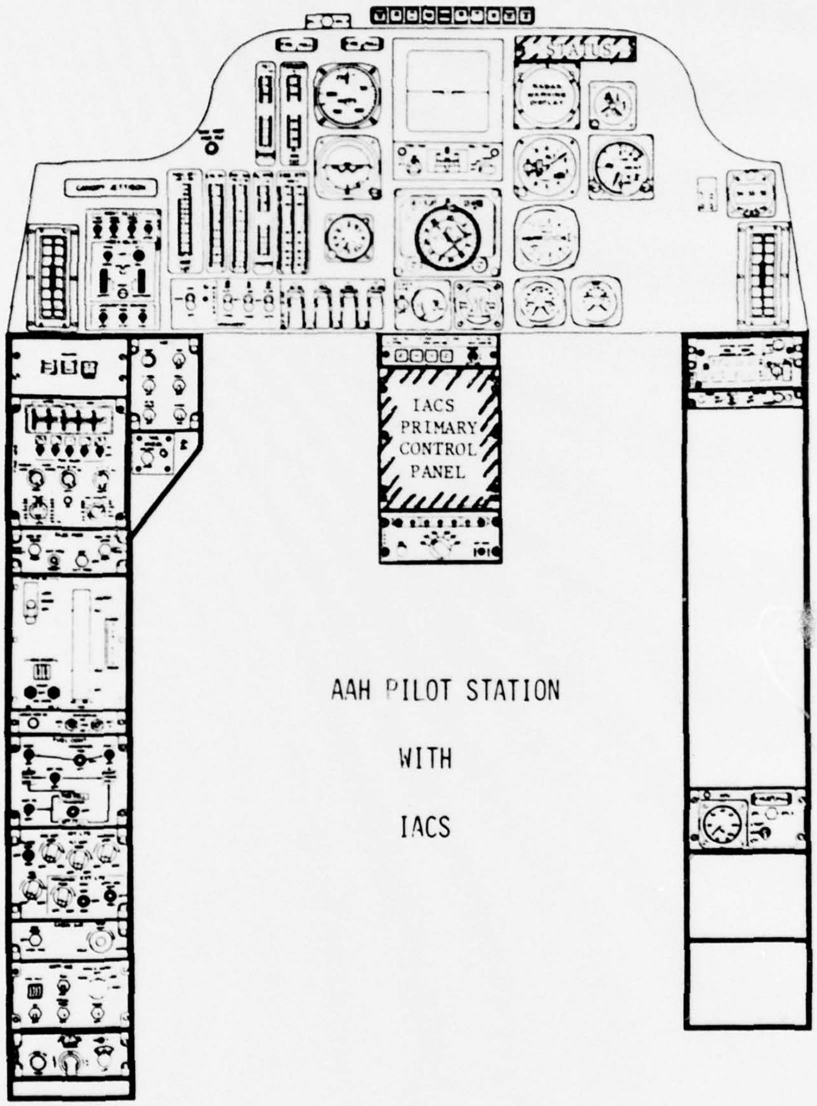


Figure 8. AAH Pilot Station With IACS

workload and decreased cockpit real estate that characterizes modern rotary-wing aircraft today. Through the use of IACS the pilot will be able to operate the helicopter more efficiently while keeping a visual reference on a single integrated control panel for information on the aircrafts avionics posture.

IACS is the Army's first application of the new technologies of digital data buses, microprocessors and integrated controls and displays. It is the first step toward a totally integrated digital aircraft. IACS has been designed to operate as a stand alone system or as part of a total aircraft MIL-STD-1553 multiplex system. A future total aircraft multiplex system could include the avionics, electrical power control and distribution, flight controls, aircraft warning indicators, instruments, fire control and stores management and diagnostics for checkout and maintenance. Such an overall integrated aircraft system would provide for: improved cockpit management; reduced aircrew workload; significant reduction in aircraft wiring weight; considerable flexibility in placement of equipments; intercommunications between various subsystems without costly interface; and more effective and yet simpler diagnostic maintenance. Even though our strategy is evolutionary, so we do not obsolete our inventory of current avionics, the overall result is a revolution in the design of future army cockpits.

Glossary of Terms

AAH - Advanced Attack Helicopter
ADF - Automatic Direction Finder
AM - Amplitude Modulation
CCU - Central Control Unit
CIP - Cipher
CNI - Communication, Navigation, Identification
COMM - Communication
CONUS Nav - Continental US Navigation
CRT - Cathode Ray Tube
D/F - Direction Finder
DTUPC - Design to Unit Production Cost
EMI - Electromagnetic Interference
FM - Frequency Modulation
ICS - Intercommunication System
Ident - Identification
IFF - Identification Friend or Foe
ILS - Instrument Landing System
NAV - Navigation
PCU-Primary Control Unit
Retran - Retransmission
SCU - Secondary Control Unit
SEL - Select
SQN - Squelch Noise
SQT - Squelch Tone
T/R - Transmit-Receive
T/R & G - Transmit-Receive plus Guard
TST - Test
UHF - Ultra High Frequency
VHF - Very High Frequency
VOR - VHF Omnidirectional Range