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U.S. ARMY HELICOPTER TECHNOLOGY INITIATIVES

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ABSTRACT

U.S. ARMY HELICOPTER TECHNOLOGY INITIATIVES

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This paper presents an overview of current and future technology initiatives sponsored by the US Army Aviation Research and Development Command (AVRADCOM). Formed in July 1977, AVRADCOM serves as the lead command for research, development, engineering, and initial procurement of current and future Army Aviation systems and subsystems (fig 1). Its major thrust is the orientation of technology to opportunities promising the greatest payoff and military user application while emphasizing effectiveness and affordability (fig 2). The objective is a total combat system approach to achieve maximum effectiveness from each component subsystem, developed in cooperation rather than in competition.

The command is anchored on a strong foundation of Army aviation technical experience and extensive research facilities (figures 3-8). These include resources for basic and applied aeronautical research performed by the Research and Technology Laboratories including the Aeromechanics Laboratory at Moffett Field, California, the Propulsion Laboratory in Cleveland, Ohio, Structures Laboratory at Langley, Virginia, and Applied Technology Laboratory at Fort Eustis, Virginia, as well as the Avionics Research and Development Activity at Ft. Monmouth, New Jersey. The spectrum of research capabilities also covers other electronics research and development, aviation unique weapons development, and qualification support for all project managed aviation systems. These presently include the Utility Tactical Transport Helicopter (BLACK HAWK) (fig 9), Advanced Attack Helicopter (AAH) (fig 10), Medium Lift Helicopter (CH-47D) (fig 11), Remotely Piloted Vehicle (RPV) (fig 12), Aircraft Survivability Equipment (ASE), and Navigation and Control Systems (NAVCON).

For management purposes it is usually convenient to categorize aviation sub-systems according to their technology area of expertise. The seven principle technical areas considered in this paper are aeronautical science, aircraft weapon systems, aviation electronics, propulsion systems, reliability/availability/maintainability, safety/survivability and structures technology (fig 13). The presentation will include examples of ongoing or about-to-begin efforts in each technical area and three technology demonstrators.

I AERONAUTICAL SCIENCE

This section will deal with the impact of tip shape on rotor design and the future role of ground based simulation in aviation systems research and development.

ABSTRACT cont'd

The advent of the swept tip on the BLACK HAWK and AAH, together with specialized shapes such as the OGEE tip for the UH-1H and Kaman tapered tip for the AH-1S, reflect the latest US design thinking (fig 14). Significant improvements in performance, reduced noise, better control of rotor loads, less vibration, and enhanced stability have already been realized, although mostly through trial and error efforts. At the US Army Aviation Research and Development Command's Research and Technology Laboratory, a strong effort is being made to understand the physical mechanisms of rotor noise generation, to develop better rotor design techniques. This work has resulted in the recent disclosure of a relatively simple analytical acoustic model which can be used to understand noise/performance trade-offs before the rotor is built. The model is currently being validated through a series of inflight and hover acoustic tests. A YO-3 "quiet" airplane has been instrumented with microphones on the wing tip and tail to be used as a flying platform for making inflight noise measurement. The data from these tests, along with the data being acquired in a new, anechoic hover test facility developed specifically for such purposes, appear to agree well with the analytical model.

The US Army, in cooperation with the National Aeronautics and Space Administration (NASA) at Ames Research Center, is developing a powerful moving base simular (fig 15). It will feature large amplitude, rate, acceleration, and motion combined with sophisticated computer generated imagery and displays. In preparation for this new capability a number of studies have been performed to define simular requirements for Army nap-of-the-earth operations. Once operational the simulator will become a principle tool for the definition of mission peculiar handling qualities requirements and for improving man-machine interface design.

II AIRCRAFT WEAPON SYSTEMS

Widespread introduction of the TOW, HOT, and soon the HELLFIRE missiles will significantly increase helicopter anti-tank lethality. This section will outline technology to counter lightly armored threats and the growing potential for air-to-air engagements. It is evident that the quantity of anti-tank aircraft being fielded by NATO forces offers a significant capability for engaging "soft targets," however, the use of guided missiles against lightly armored vehicles is costly and inefficient. Low cost terminal homing rocket systems and higher impulse gun systems are being developed in competition for these secondary target opportunities.

In the air-to-air threat arena, efforts are underway to refine targeting radars in the millimeter wave range to allow detection of enemy aircraft at survivable standoff ranges. We are also in the process of defining helicopter self defense weapons which provide the best combination of effectiveness and affordability. Consideration of air-to-air combat in the design of vehicles has resulted in emphasis being placed on reduced detectability, suppressed targeting signatures, and for components having greater ballistic tolerance.

III AVIATION ELECTRONICS

NOE operations introduce major complications in navigation, communications, obstacle avoidance and warning systems. Efforts to enhance aviation electronics technology include an Integrated Avionics Control System (IACS) and a Low Altitude Terrain Avoidance and Warning System (LOTAWS).

The Integrated Avionics Control System which is currently in engineering development employs digital multiplexed data bus architecture to centrally process, control and display communication, navigation, and identification (CNI) equipments (fig 16). IACS offers significant benefits in weight reduction, preset navigation/communication, system versatility and growth potential. It has recently been expanded to include Doppler and projected map display interface and control. The latter equipments provide navigation enhancement, especially at NOE altitudes. The IACS project is an initial step toward the development of digitally interfaced components connected via a standard multiplexed data bus. Advanced digital concepts being planned in aviation electronics include: multipurpose cockpit displays, multiplexed master monitor, status and advisory data, and energy management systems.

A recent breakthrough with a laser-doppler radar has provided the capability to detect ordinary noncurrent carrying field wire at sufficient range to permit evasive navigation or maneuvering. Efforts are now underway to reduce the weight and cost of such a system and hopefully to give it an expanded multifunction sensing role (fig 17).

IV PROPULSION SYSTEMS

Propulsion systems have enjoyed very significant development in recent years as evidenced by the T700 engine system (fig 18), and the present advanced demonstrator technology engine (ADTE) program (fig 19). Two noteworthy advances in these programs are automated compressor manufacturing and the introduction of electronic fuel controls in small gas turbine engines.

The T700 features six axial flow compressor stages which are integral blade discs (BLISKS). The small geometry precludes separately machined blades and at the same time created BLISK manufacturing problems which required computer controlled automated machinery to overcome (fig 20).

Versatility, precision, and cost benefits of electronic versus hydromechanical fuel controls have been recognized in recent large turbine engines. This same technology is now being applied to small gas turbines in conjunction with the US Army's 800 horsepower ADTE program (fig 21). The command is also planning a Fuel Efficient Turboshaft Engine (FETE) Program. The variable capacity cycle and regenerative cycle are under consideration for the FETE. In the Variable Capacity Cycle, the basic arrangement of the gas turbine is retained. The difference in approach is that in throttling back for partial power operation, geometry changes are made to the compressor and turbine stators to prevent the compressor speed and pressure ratio from falling off. By this means, the most important keys to better fuel economy, high pressure ratio and gas temperature, can be preserved at partial power. This approach involves some increase in complexity and cost and some additional weight and volume, but the fuel savings can be in the range of 10-15% in the partial power range. The best engine cycle or combination of cycles will be determined following component tests for the variable capacity cycle concept.

V RELIABILITY/AVAILABILITY/and MAINTAINABILITY (RAM)

These are benchmarks for life cycle cost control. Characteristic of recent system programs are stringent numerical RAM requirements. Examples of supporting sub-system technology efforts are improved caution/warning systems and computer guided maintenance trouble shooting.

Examination of mission abort records reveals a disproportionately high number of false transmission chip detector indications. This problem is being addressed by development of improved oil filtration systems combined with "burn-off" chip detectors to minimize false indications.

A logic model (LOGMOD) has been developed exploiting large scale integrated circuitry and learning query theory which permits mechanics to trouble shoot systems on an optimized step-by-step basis (fig 22). The present models are confined to selected subsystems and components but the concept holds great promise and is being expanded.

VI SAFETY AND SURVIVABILITY

These are major design criteria for Army aircraft as dramatically evidenced by application of MIL-STD-1290 crashworthiness requirements. Efforts are currently focused on blast resistant composite structures and over-the-rotor targeting systems.

Small vehicles like the RPV cannot withstand nearby explosive detonation due to insufficient compression volume within or nearby the structure. Development of permeable or foam filled structures may offer a solution of this problem (fig 23).

The ability to conceal helicopters behind terrain or man-made obstacles while employing target acquisition systems has prompted the development of a mast mounted stabilized sighting system (MMS) (fig 24). First demonstrated on a UH-1 the MMS is now being considered for application to scout helicopters.

VII STRUCTURES TECHNOLOGY

The US Army is emphasizing application of fiber reinforced composite materials to airframes, rotor blades, and hubs. The objective of the airframe program is to demonstrate the use of advanced composite structures to increase survivability through enhanced crashworthiness and damage tolerance. Overall cost reduction will be achieved through reduced weight and improved manufacturing methods. This will provide confidence for early introduction of composite primary airframes in operational aircraft.

Composite rotor blades have been developed for the AH-1S and CH-47 (fig 25) and are planned for the UH-1H. The BLACK HAWK employs a composite tail rotor. Both the BLACK HAWK and Advanced Attack Helicopters utilize metallic and composite materials with advanced fabrication technology.

Perhaps the greatest potential payoff for composite material application is in the main rotor hub (fig 26). Current efforts include the design of a subscale multibladed articulated hub and a full scale elastomeric bearing hub.

VIII RESEARCH AIRCRAFT

To demonstrate new aircraft concepts, several research aircraft have been built and are being tested to document the new technology which they represent. This section will describe three such concepts.

The Advancing Blade Concept (ABC) aircraft (fig 27) demonstrates the advantages of speed and maneuverability possessed by a helicopter having coaxial, counter rotating rigid rotors that exploit the lift potential of the advancing blade.

The Rotor Systems Research Aircraft (RSRA) (fig 28) is essentially a flying wind tunnel that can be configured with wings, thrust engines or both, to permit mapping the entire range of rotor lift and propulsion capability.

The Tilt Rotor Research Aircraft (XV-15) (fig 29) will demonstrate the potential of the convertible aircraft for both commercial and military uses. By tilting its wingtip mounted prop-rotors, this aircraft takes off as a helicopter and converts to cruise as a fixed wing airplane.

In summary, there are exciting technology challenges in every area confronting today's helicopter developments. The requirement to extend life and improve the capability of our fielded fleet has demanded much innovation and encouraged rapid introduction of new ideas. The success of the BLACK HAWK and AAH is due, in large part, to their incorporation of recent helicopter research and engineering. New challenges loom large as we contemplate the Advanced Scout Helicopter (ASH) (fig 30), major systems variants such as Stand Off Target Acquisition System (SOTAS), and the as yet undefined weapons systems of the 1990's.

MISSION

CONDUCT RESEARCH AND DEVELOPMENT TO:

1. PROVIDE MAXIMUM AFFORDABLE TECHNOLOGY FOR ARMY AVIATION SYSTEMS
2. INCREASE RELIABILITY, AVAILABILITY AND MAINTAINABILITY
3. ENHANCE SAFETY, SURVIVABILITY AND OPERABILITY
4. IMPROVE AIRCRAFT WEAPONIZATION AND AVIONICS INTEGRATION

INITIATE THE MATERIEL ACQUISITION PROCESS BY:

1. ACCOMPLISHING FIRST PROCUREMENTS
2. DEMONSTRATING EQUIPMENT SUITABILITY

SUPPORT MATERIEL READINESS WITH:

1. TECHNICAL IMPROVEMENTS FOR FIELDED SYSTEMS
2. REDUCED COST OF OWNERSHIP

FIGURE 1
AVRADCOM MISSION

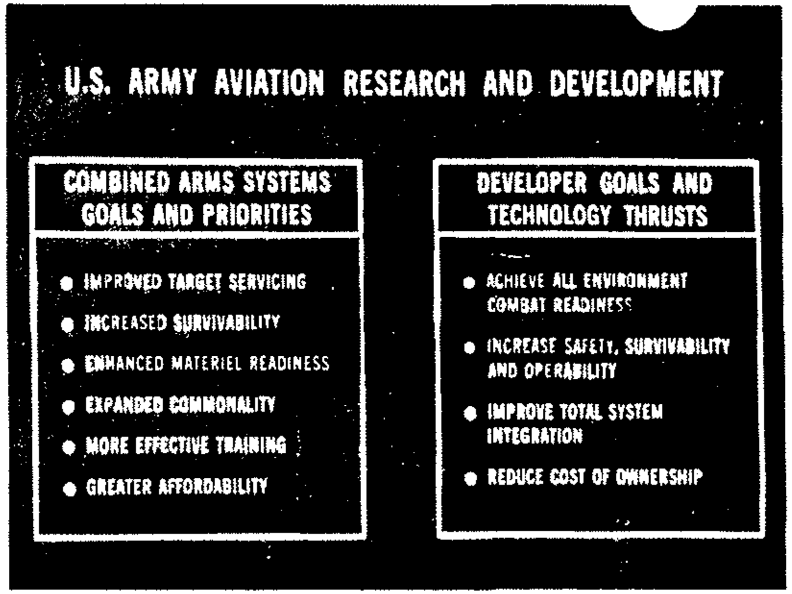


FIGURE 2
USER NEEDS/DEVELOPER GOALS

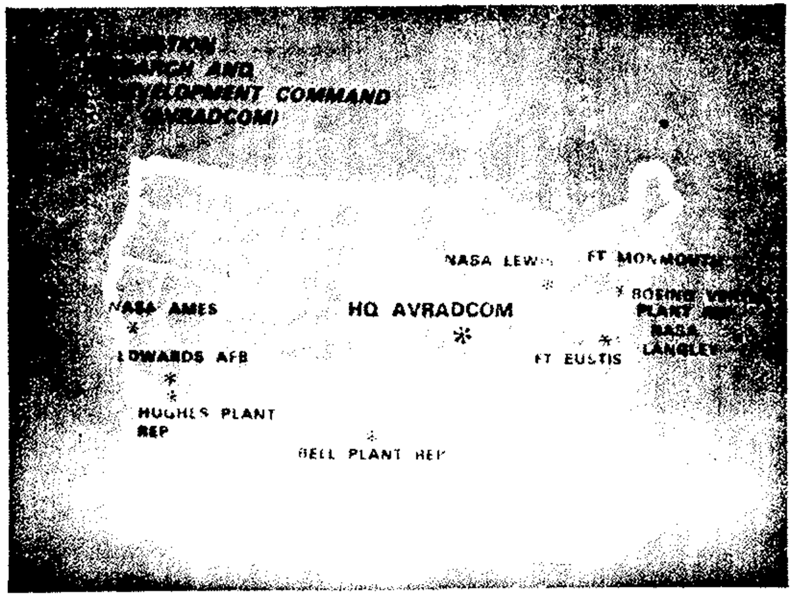


FIGURE 3
NATIONWIDE FACILITIES

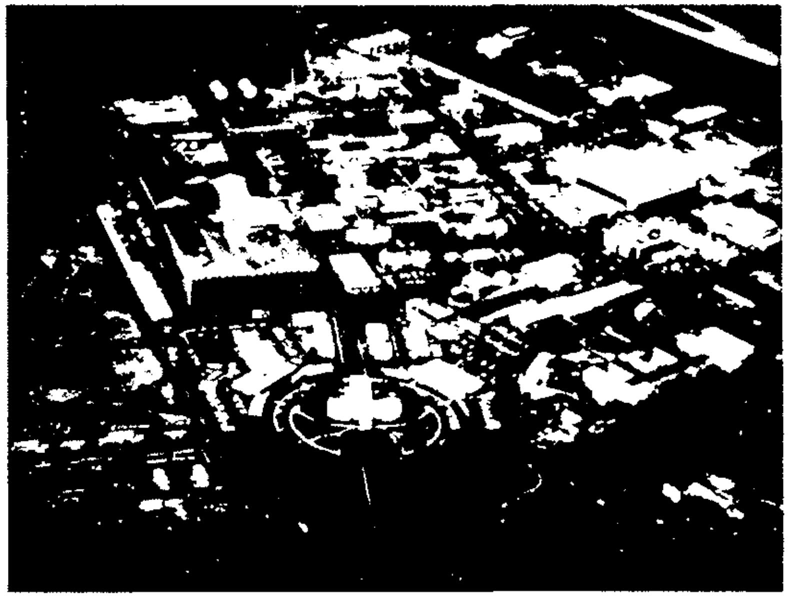


FIGURE 4
AEROMECHANICS LAB, MOFFETT FIELD, CA.

FIGURE 5
PROPULSION LAB, CLEVELAND, OH.

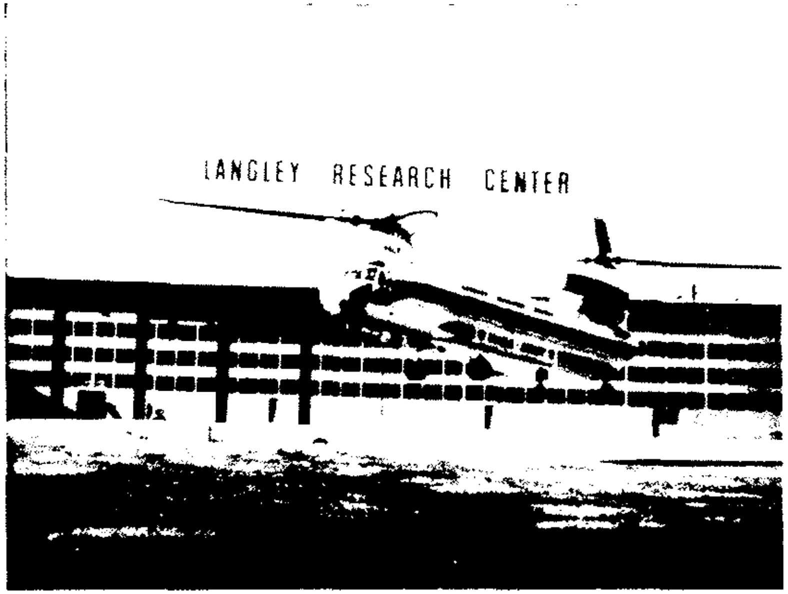
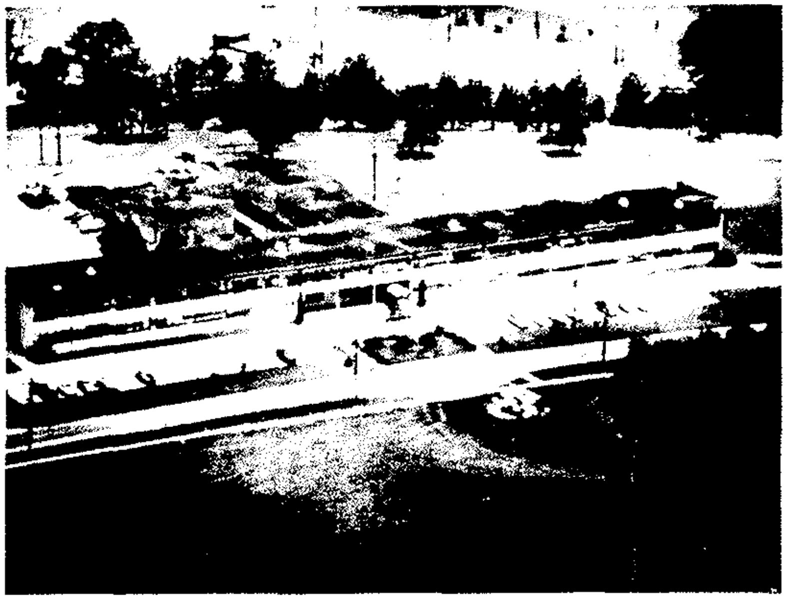


FIGURE 6
STRUCTURES LAB, LANGLEY, VA.



F[illegible]RE 7
[illegible]ED TECHNOLOGY LAB, FT. EUSTIS, VA.

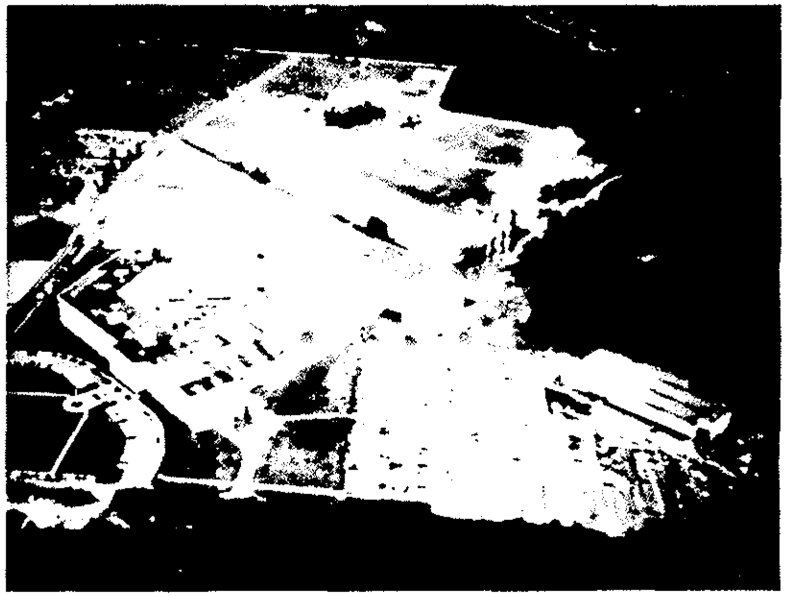


FIGURE 8
AVIONICS R&D ACTIVITY, FT. MONMOUTH, NJ.

FIGURE 9
UH-60 BLACK HAWK HELICOPTER

FIGURE 10
YAH-64 ADVANCED ATTACK HELICOPTER

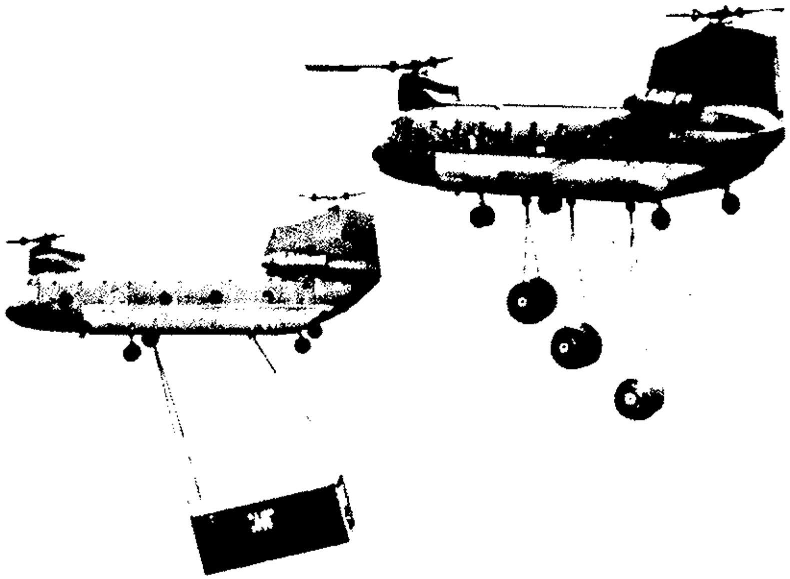


FIGURE 11
CH-47 MEDIUM LIFT HELICOPTER

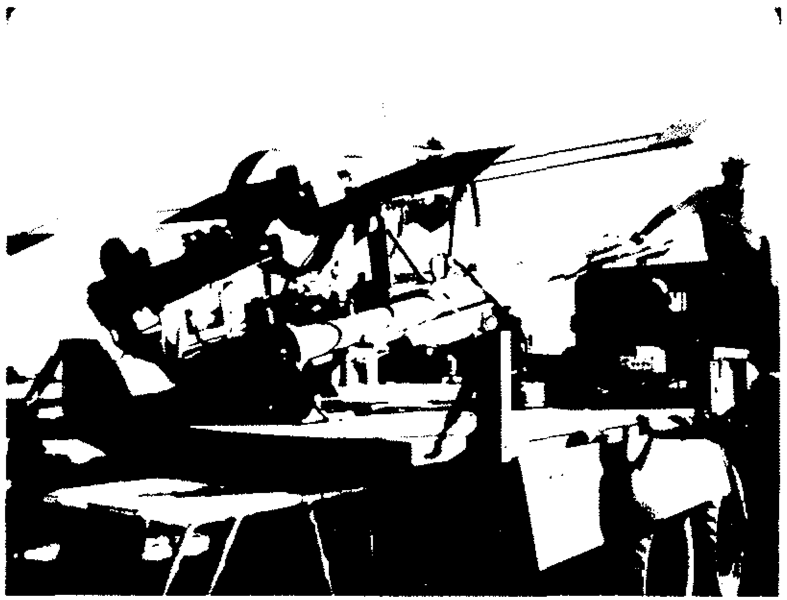


FIGURE 12
REMOTELY PILOTED VEHICLE (RPV)

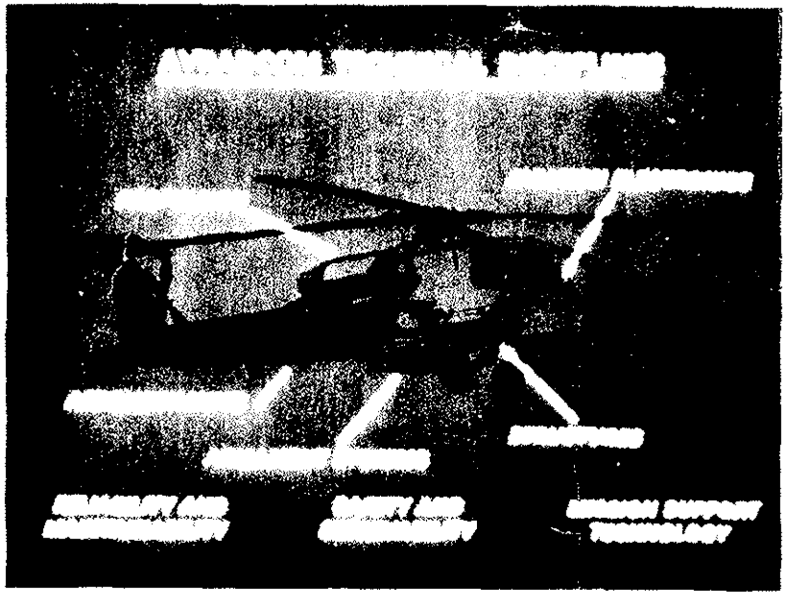


FIGURE 13
AVRADCOM TECHNICAL DISCIPLINES

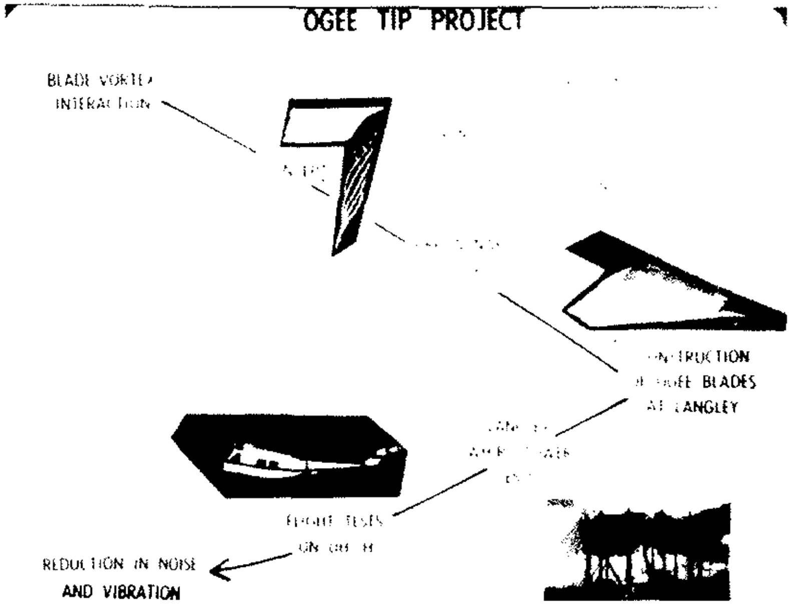


FIGURE 14
OGEE TIP

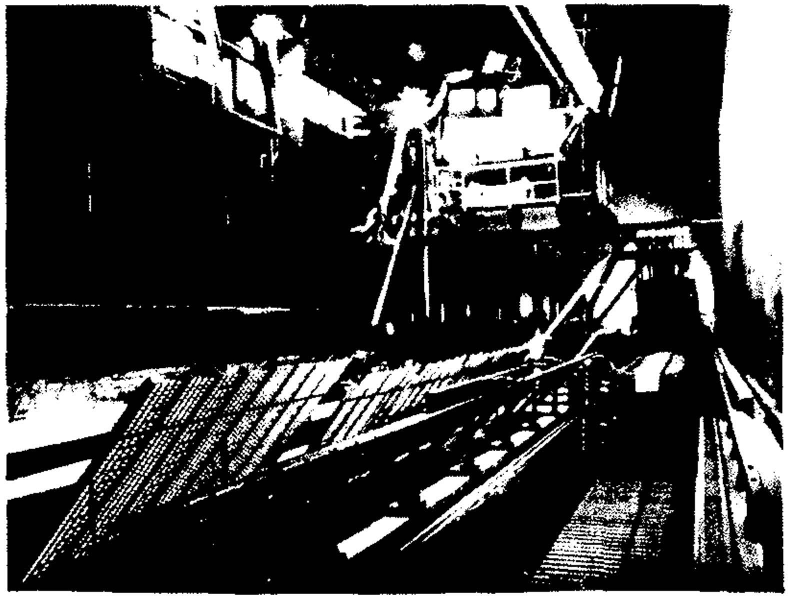


FIGURE 15
NAS IGHT SIMULATOR
FOR ANCED AIRCRAFT

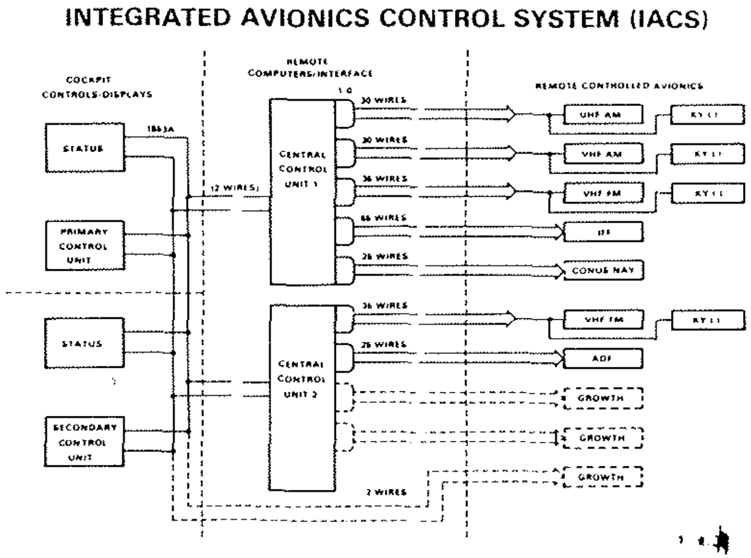


FIGURE 16
INTEGRATED AVIONICS CONTROL SYSTEM (IACS)

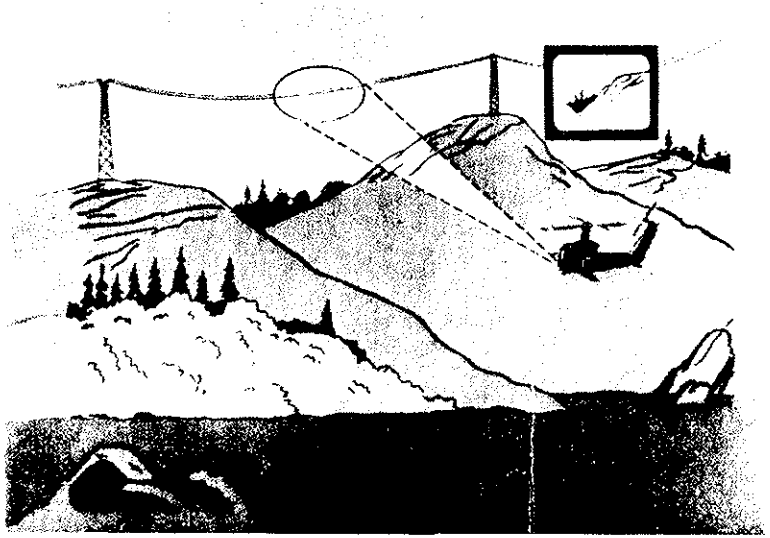


FIGURE 17
LASER WIRE DETECTION SYSTEM

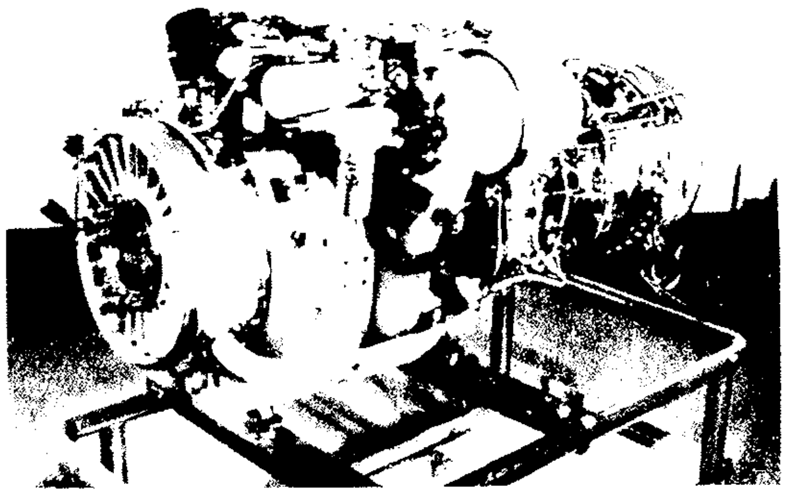


FIGURE 18
T700 ENGINE

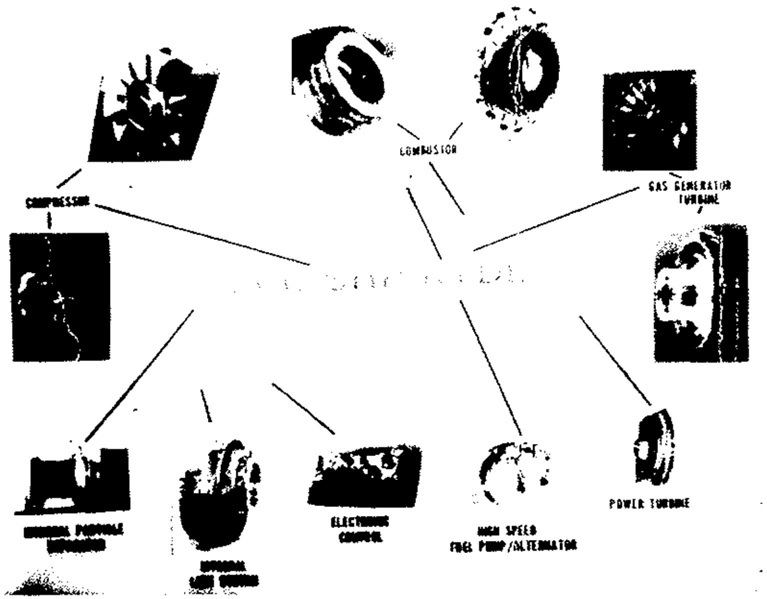


FIGURE 19
ADVANCED TECHNOLOGY DEMONSTRATOR ENGINE (ATDE)

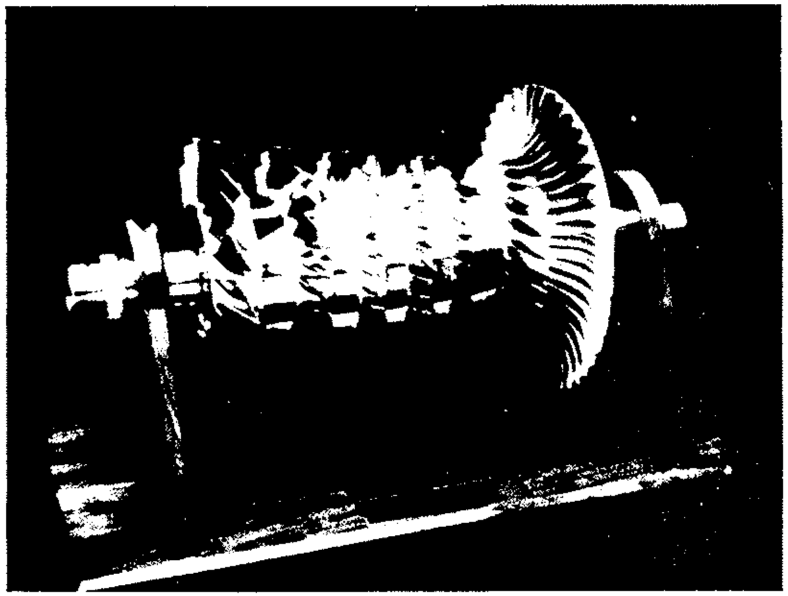
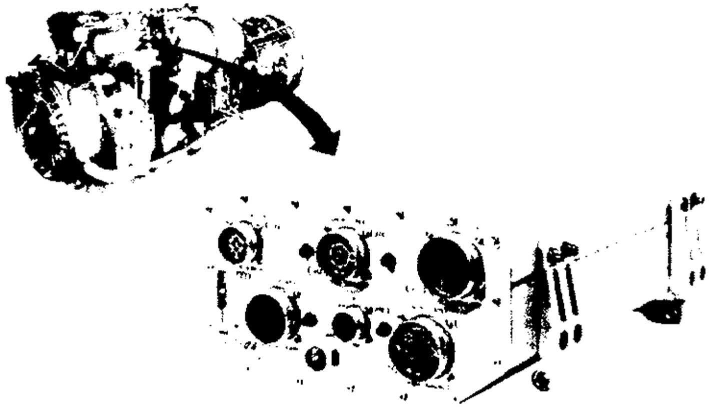


FIGURE 20
INTEGRAL COMPRESSOR BLADE/DISK (BLISK)



ELECTRONIC FUEL CONTROL

FIGURE 21
ELECTRONIC FUEL CONTROL

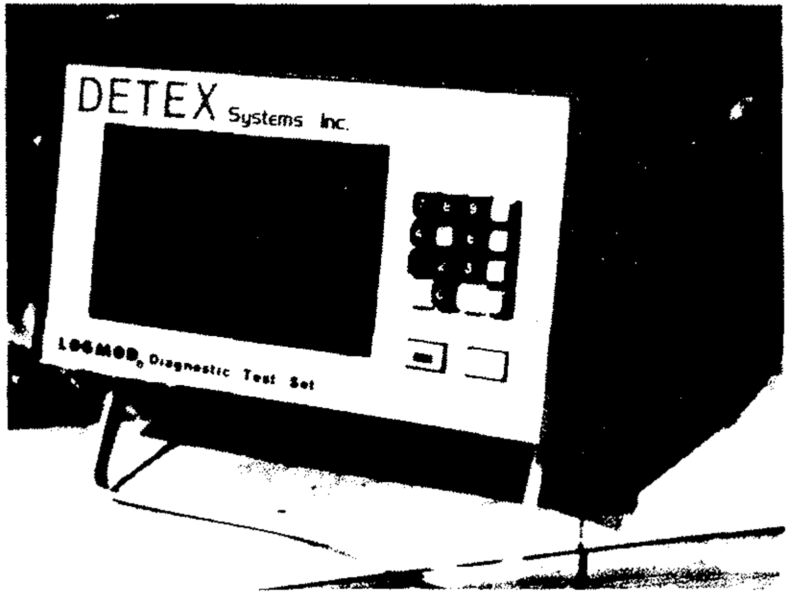


FIGURE 22
LOGIC MODEL

FIGURE 23
CEWIND RPV

FIGURE 24
MAST MOUNTED SIGHT

FIGURE 25
CH-47 BLADE

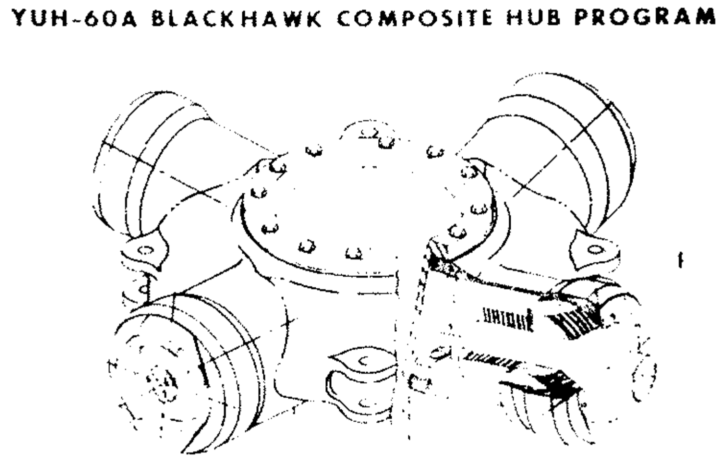


FIGURE 26
UH-60 HUB

FIGURE 27
ADVANCING BLADE CONCEPT

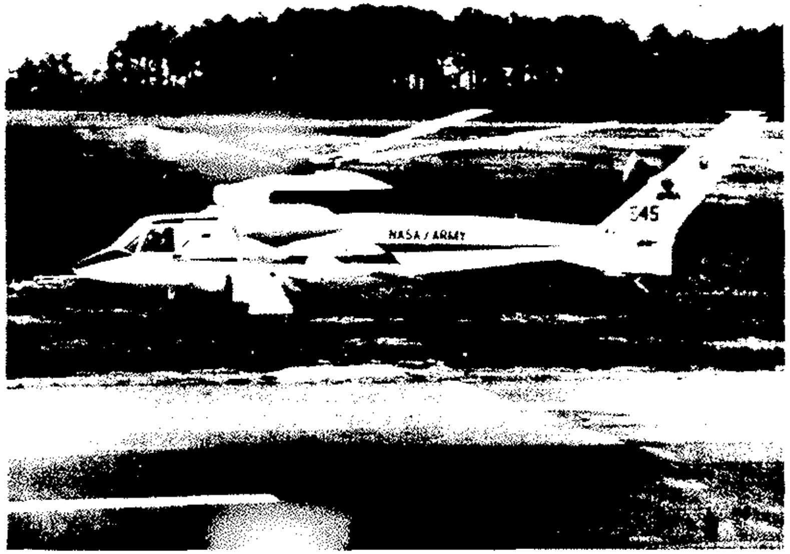


FIGURE 28
ROTOR SYSTEMS RESEARCH AIRCRAFT

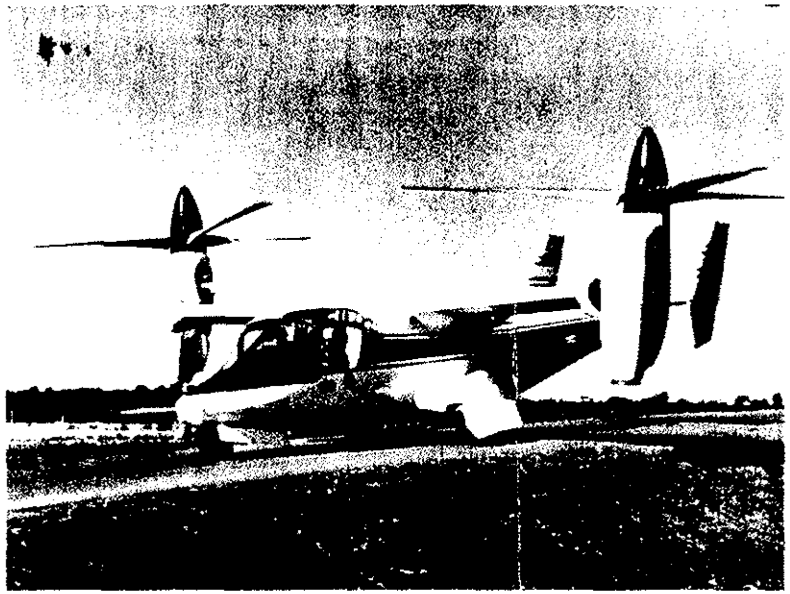


FIGURE 29
XV-15 TILT ROTOR RESEARCH AIRCRAFT

FIGURE 30
ADVANCED SCOUT HELICOPTER