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ADVANCED COCKPITS FOR BATTLEFIELD HELICOPTERS - A SIKORSKY PERSPECTIVE

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The battlefield of the future will place new demands on rotary-wing aviation. The increasing sophistication and quantity of threat systems require the use of new tactics and systems. Increased detection capability and lethality of the threat along with air-to-air, nuclear/biological/chemical (NBC), laser and high energy weapons dictate nap-of-the-earth (NOE), day/night/adverse weather, highly coordinated operations. New cockpit technologies and designs are needed for the aircrew to effectively perform these strategies and employ their advanced avionics. Automation advances in flight control, navigation, communication, aircraft system management, control/display, search and targeting systems will provide us the tools to meet the cockpit demands of the 1990's battlefield but only through their judicious and tested application into a well integrated, man-machine system.

The role of the battlefield helicopter is changing. Evolving Army doctrine and tactics and threat capabilities place new demands on the design and application of rotary wing aviation. Major wars of attrition cannot be maintained. Emphasis is being placed on winning a war quickly to avoid a protracted stalemate.

The principal tactical goal will be to project an integrated combined armed force upon the threat, continuously placing him into unexpected situations and concentrating firepower at weak points throughout the enemy force structure. Adversary strengths will be avoided through maneuver and deception. Aggressive and offensively oriented actions which seize opportunities by responding more quickly and with greater agility than the threat are key. Quick reaction, coordinated firepower will place increased importance on rapid command, control, communication and intelligence (C3I) capabilities throughout the force structure.

The battlefield will no longer be linear with a continuous forward edge of battle (FEBA). Commanders will now have to consider their forward line of own troops (FLOT) as depicted in Figure 1. Units may work independently and may be cut off from support for several days at a time due to enemy situation or operational utility. These tactics and doctrine are representative of the U.S. Army's AirLand Battle 2000 concept and Army 21 refinement (See Figure 2). This doctrine emphasized "maneuver, strategic mobility, the highly lethal and fluid battlefield, emerging high technology, self-sufficient organization and the principles of initiative, depth, agility and synchronization" (Ref. 1). The role of the battlefield helicopter for scout, attack and utility duties will be critical to the success of such strategies.

The threat has also become more deadly through new tactics advanced technology and sustained numerical superiority. New roles for helicopters such as air-to-air engagements are expected (Ref. 2) along with improved C3I and independent actions. Their advances in targeting technologies severely limits our "see first" capability. The threat of nuclear-biological-chemical (NBC), laser and microwave weapon deployment as well as more lethal conventional systems place new demands on our survivability measures. Better sensors and improved tactics such as Nap-of-the-Earth (NOE) flight profiles must be used to counter this threat capabilities.

Limitations in the force structure call for single pilot operations with reduced maintenance personnel requirements. Higher levels of cockpit automation will be required and will significantly affect how we design our cockpits for the 1990s and into the 21st century.

New battlefield helicopter programs such as the US Army LHX and the European PAH-2 programs will be challenged to meet these demands and several "firsts" in cockpit design (see Fig. 3). They must be designed from the start for NOE operations for day/night/adverse weather conditions. We must provide increased ballistic protection to the aircrew from conventional weapons and significantly higher levels of reliability and redundancy in the avionics suite for operational availability and battlefield damage/fault tolerance. NBC and laser protection for the aircrew must be integrated into the cockpit and personal ensembles which do not adversely impair the crew's ability to fly and fight. The cockpit must be configured to provide a well blended mission, man/machine interface with highly sophisticated C3I networks, advanced target acquisition, recognition and designation sensor systems, advanced air-to-ground and air-to-air weapons as well as higher levels of automation to fly, navigate and manage the aircraft. Many levels of automation are mission driven, mandatory for not only single pilot configurations but for two place cockpits as well in scout/attack roles.

First, we must be able to fly safely in NOE environments. Despite advances in wire and other obstacle avoidance systems, improvements in external visibility over current battlefield aircraft are needed. As shown in Figure 4, we expect future cockpit designs to more closely match the visibility goals called for in current military specifications (Ref. 3). Observation/reconaissance and air-to-air mission functions also place significant operational importance on external visibility. The external visibility requirements must be established in concert with the airframe design to assess and trade off its characteristics with other critical factors such as ballistic and wire strike protection,

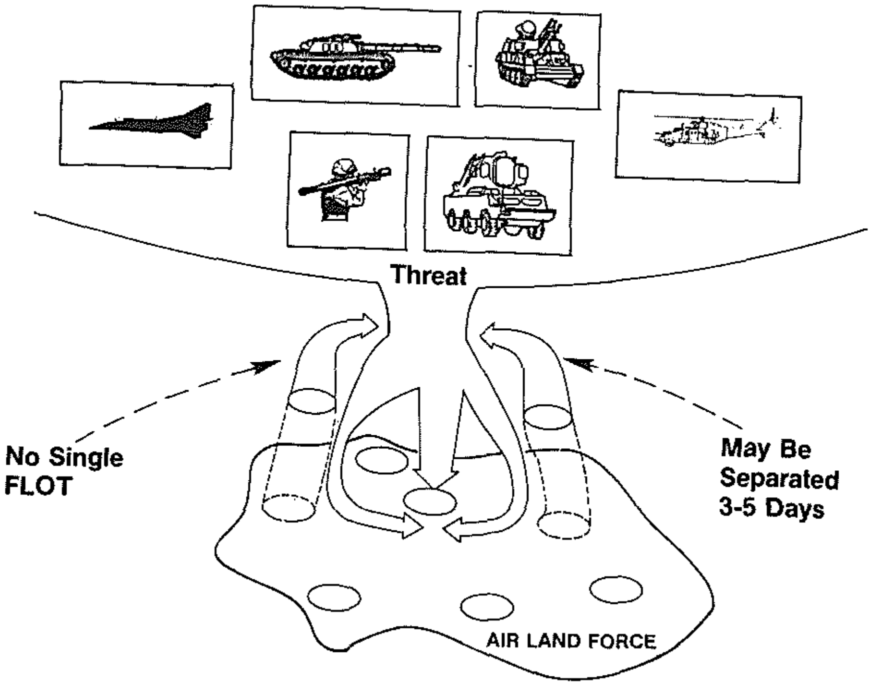
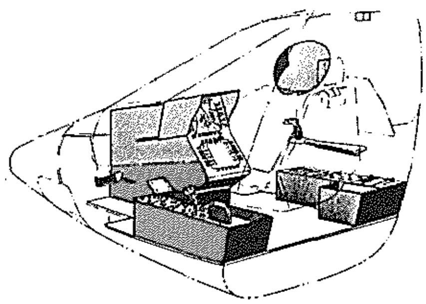


FIGURE 1 NONLINEAR BATTLEFIELD

- Agility
  - Strike at threat weaknesses, avoid threat strengths, concentrate decisive firepower at the critical time and place
- Initiative
  - Continuously create the opportunity to offensively seize the initiative. Make the threat respond to your lead
- Depth
  - Orient on the enemy in an expanded battlefield
- Time
  - Planning, decision making and execution of orders must anticipate enemy actions. Accelerated processing of information must allow U.S. forces to act faster than the threat can respond
- Synchronization
  - Unity of effort is critical. Wasted resources and efforts must be minimized. Concentrate firepower

FIGURE 2 ALB 2000/ARMY 21 PRINCIPLES

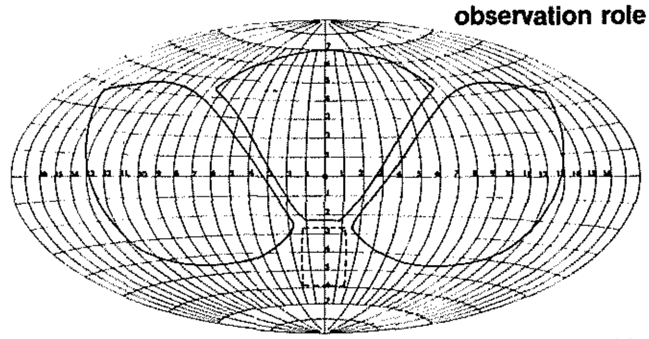


FIRSTS
Air to Air
NBC/laser protection
NOE operation
Single pilot

DESIGNED FOR
Visibility
Crew protection
Highly stable aircraft
Easy to learn & use

FIGURE 3 COCKPIT "FIRSTS"

- Safer NOE
- Better Scout/ observation role



- Tradeoff with
  - Protection
  - Airframe
- See Air-to-Air threat

FIGURE 4 EXTERIOR VISIBILITY GOALS

crashworthiness and aerodynamics. New techniques such as integrating armor within the aircraft structure and better conforming wing armor and new technologies in transparency materials offer encouraging projections for optimizing these often conflicting design goals.

The night/adverse weather operations place more difficult technological challenges on the cockpit design. The use of night vision goggles (NVGs) based on light intensification are low cost solutions for many situations, however they cannot provide adequate imagery under all conditions. Dark, overcast nights remain a problem with NVGs. Forward looking infrared (FLIRs) systems also have specific environmental limitations. The current fields of view (FOV) of the NVGs and Helmet Mounted Displays (HMDs) for FLIR imagery such as the Honeywell Integrated Helmet Display and Sight System (IHADSS) used on the AH-64 Apache and A-129 Mongoose attack helicopters are limited to approximately 30 to 40 degrees. This limits piloting techniques and mission critical tasks. Helicopter pilots can typically only perform the basic aircraft control exclusive of other responsibilities when flying with a restricted view of the outside world.

There are some prototype designs which address some of these problems. Integrated display/sensor systems such as the Honeywell Integrated Night Vision System (Ref. 4) and the GEC/Marconi NIGHTHELM system provide the capability to display FLIR or NVG imagery with symbology thus using the sensors in a complimentary manner. The Sperry Helmet Mounted Display System (Ref. 5) provides symbology to current NVGs but with very limited FOV and graphics. Very wide FOV for HMDs and associated night vision sensors will be needed for the battlefield helicopter pilot to perform his mission safely and effectively. Preliminary fixed base simulator tests at Sikorsky and U.S. Air Force experiments suggest that a 60° (vertical) x 90° (horizontal) FOV is the minimal desired FOV, but further tests are needed (Ref. 6, 7). FOV is not the only critical parameter for night vision displays or sensor systems. Resolution, sensitivity, gimbal configuration and response, flash protection, eye relief and helmet weight are just a few of the key design aspects that will have to be addressed as well.

Advanced helicopters will require a helmet systems that integrate wide FOV display capability, noise reduction for intercom/radio/voice recognition systems as part of or compatible with chemical defense ensembles and laser protection systems. Current NBC masks significantly impact pilot visibility and comfort with marginal compatibility with fielded aviator helmets. Even advanced developments such as the US Army's HGU-56 helmet or XM43 mask programs do not fully meet these needs. The use of voice recognition systems will require either significantly better noise cancelling microphones or reduction of the ambient noise levels. Integrated helmet designs such as shown in Figure 5 provides the required noise reduction as well as lower overall HMD weight and potential NBC protection.

Significant increases in cockpit automation will be required of future battlefield helicopters for several reasons. The foremost reason, of course, is the reduction of crew workload, especially for such ambitious concepts as the single seat Scout/Attack (SCAT) configuration of the LHX. The other dominant reason for automation is the speed required to search for, identify and counter the threat. This requirement is independent of crew size.

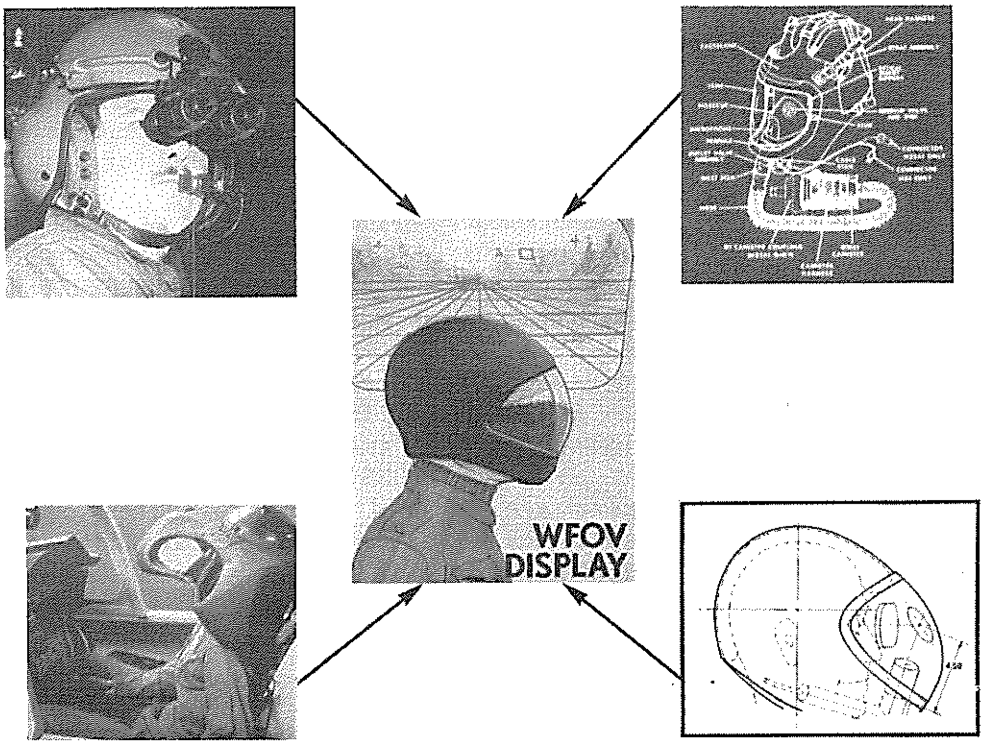


FIGURE 5 ADVANCED INTEGRATED HELMET DESIGN

PLANNING

- Site selection
- Phase lines
- Select ordinance
- Target priorization
- Alternative mission planning

AIRCRAFT MANAGEMENT

- System health
- Fuel consumption
- Fuel management
- Performance checks
- Start procedures
- Stop procedures
- Electrical system management
- Consumables management
- Maintenance
- Emergency procedure displays

NAVIGATION

- Route planning (contour/cruise)
- Route following
- Route planning (NOE)
- Time management
- Map orientation
- True ground speed
- True ground heading
- Navigation hazards
- Approach information
- Aircraft range
- Weather detection
- Arrival times
- Flight to homing beacon

FLIGHT CONTROLS

- Cruise
- Hover-to-cruise
- Cruise-to-hover
- Hover
- Return-to-a-point
- Reposition during hover
- Approach to land
- Approach to land (MLS)
- Stability augmentation
- Yaw stability
- Coordinated turns
- Rotor speed control
- Obstacle avoidance
- Contour flight control
- NOE flight control
- Touchdown
- Takeoff
- Autorotation
- Takeoff without hover
- Running landing
- Landing without hover

COMMUNICATIONS

- Selection of radios
- Frequency assignments
- Secure communications
- Volume and squelch adjustment
- Message management and storage
- Tuning and ID NAV aids
- Area coordination
- Transponder control
- Retransmission control

WEAPONS

- Receive handoff
- Launch positioning
- Fire point locating
- Hellfire launch setup
- Coordinate Hellfire launch
- Aim and fire flex gun
- Air-to-air engagements
- Stores management
- Weapon selection
- Weapon arming/disarming

RECONNAISSANCE

- Threat warning
- Target identification
- Range finding
- Target location (map)
- SPOT reports
- Call for fire
- Artillery adjustment
- Tactical air adjustment
- Target handoff
- Pop-up
- Target location (visual)
- Damage assessment

FIGURE 6 CANDIDATE FUNCTIONS FOR AUTOMATION

The first step toward cockpit automation is the identification of candidate functions (See Fig. 6). The next step is to assess the impact of automation based on several attributes. The first three factors are directly related to pilot workload: task difficulty, frequency of use and automation burden. While automation may solve the problem, it may present new problems of its own. Some automation functions require set-up, data entry or cognitive decision-making with considerable effort before or during the flight.

The next set of factors relate to the machine side of the automation question. The first function is referred to as "self-healing". This is the ability of the system to be replaced or backed up in the case of system failure. Some systems may be capable of automatically determining that a failure has occurred, identifying the failure and reassigning the function to another or redundant device. Some systems must be "healed" by the pilot assuming responsibility for the task. The next characteristic to be considered is that of failure consequence. A candidate system is evaluated according to its criticality and impact on the mission should the system fail.

Another important attribute is the risk associated with the development of the automation device. The U.S. Army has provided a nominal scale for classifying risk for advanced programs based on hardware maturity (see Fig. 7). While such factors as system integration, software development or avionics architecture design do not conveniently fit into these classifications, this scale has been useful for qualitative comparisons of the risks associated with alternate automation approaches. An often overriding factor is cost. This is not only the development cost and eventual unit cost, but also the operating and support cost as well.

Risk Category	Level (Qualitative)	Description
0	Very Low	Equipment in production and approved for service. No environmental restrictions, multi-source
1	Low	Few problems (solutions are in-work) • Critical functions in MIL qualified configuration requiring modifications • Prototype/Engr. model flight tested • Extensive lab demos
2	Low-Moderate	Advanced brassboard; prototype package, some environmental limitations
3	Moderate	Preliminary brassboard; critical functions lab demo, problem areas quantified, prelim packaging
4	High	Breadboard of critical functions; application problems identified qualitatively
5	Very High	Concept formulation: Paper design with analyses, research lab demo

FIGURE 7 RISK ASSESSMENT SCALE

Obviously, the allocation of functions between man and machine must also consider their unique processing attributes, matching them for optimal performance. For example, computers are rather dumb but extremely fast, impervious to fatigue and can handle large amounts of encoded data. Continuous calculations of navigation, aircraft performance parameters and system health monitoring are excellent tasks for the machine. Conversely, man is an excellent adaptive decision maker and discriminator. Final visual identification of targets and adaptive tactics decisions are examples of tasks best performed by the man in the loop. These examples may seem contradictory to the aforementioned need for automated target recognition. While it is considered that the large volume searches required in the battlefield of tomorrow and the extremely short timelines to respond to the threat are best met by machine, the final confirmation and decision to launch a weapon is best accomplished by he who is responsible, the pilot.

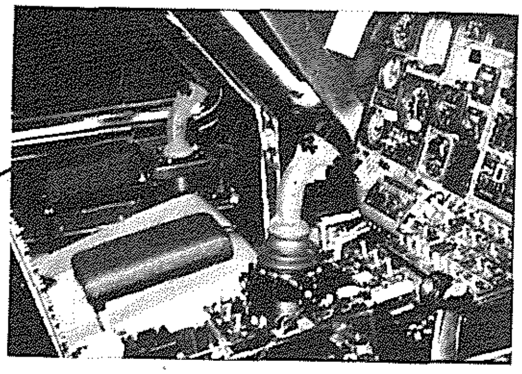
There is no one attribute that singly determines what function shall be automated, rather it is a tradeoff between these attributes to maximize mission effectiveness within a given program's constraints.

There are specific functions that our current studies indicate that will have significant increases in the level of automation in 1990's. We look for cockpit automation advances in flight control, navigation, communication, aircraft system monitoring and maintenance, sensor and weapon management as well as improved crew interface systems to effectively interact and control these functions.

We expect more stable, easier to fly aircraft due to the capability to "tailor" the flight controls via digital fly-by-wire/light systems. When coupled to more reliable and accurate sensors, pilot unburdening, particularly in hover hold, can be greatly enhanced. Hover hold performance of three meter RMS horizontally and less than one meter vertically for 2 to 3 minutes in gusty winds are being projected for the next generation battlefield helicopter. The use of multi-axis flight controllers are expected to free up the pilot's left hand from the collective control even in NOE. With the left hand "free", single pilot operations are easier to achieve and more comfortable to perform. Preliminary tests of a variable stability fly-by-wire flight control system using multi-axis flight controllers have been underway at Boeing Vertol under the Advanced Digital Optical Control System (ADOCS) program (Ref. 8), NASA-Ames (Ref. 9) and at Sikorsky.

We successfully flew a fly-by-wire system on an experimental S-76 in the summer of 1984 as a preliminary testbed for advanced control law development. As shown in Figure 8, we flew various flight control configurations including four axis sidearm only (4+0), sidearm plus collective (3+1), sidearm plus collective plus force pedals (2+1+1) as well as a "slide" collective and force and limited displacement sidearm controllers. Though the flight control laws were not optimized and digital engine control was not installed, the four axis control was reported to be preferred for all but a few situations. Single axis collective control was considered desirable for high performance turns, autorotations and other conditions where precise power control is required. These tests will be expanded late this year in our single pilot research vehicle shown in Figure 9.

Navigation has been frequently identified as a prime workload driver in NOE environments (Ref. 10). Knowing one's absolute location as well as relative



- 2 4 axis controllers
  - Force
  - Limited displacement
- Force pedals
- "Slide" collective
- 2+1+1, 3+1, 4+0 configurations

FIGURE 8 SIKORSKY SIDEARM FLIGHT CONTROLLER TESTS

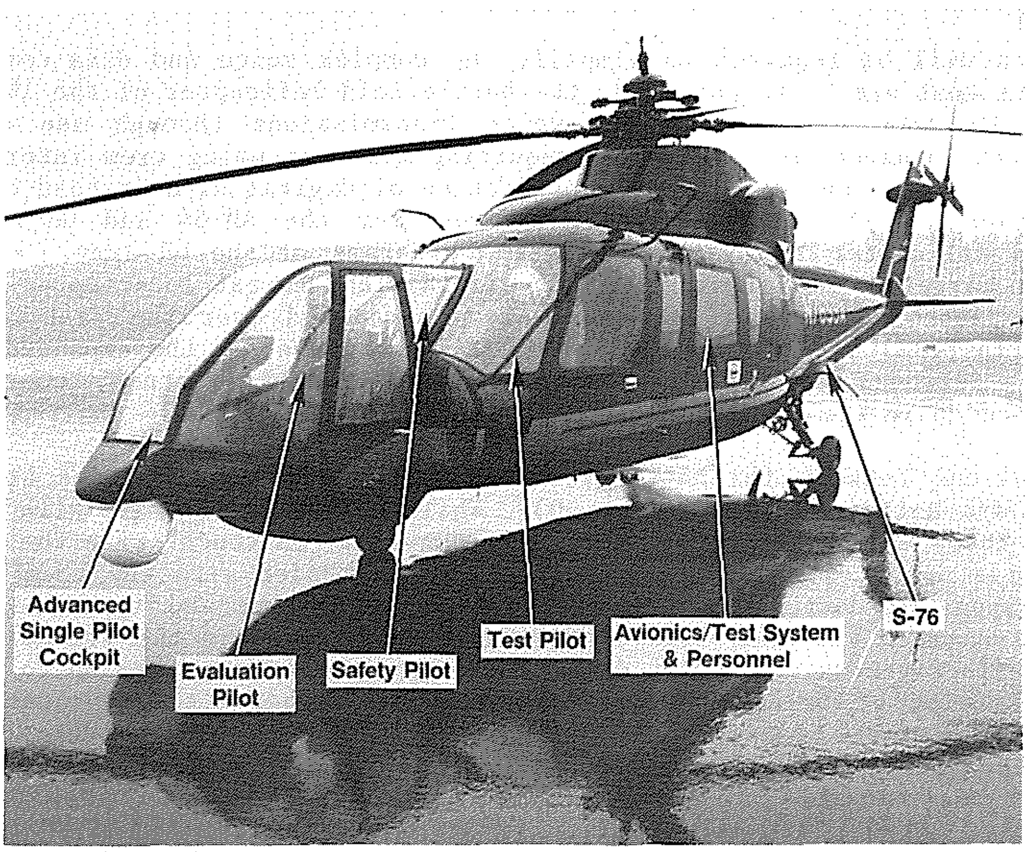


FIGURE 9 SIKORSKY SINGLE PILOT EXPERIMENTAL RESEARCH HELICOPTER

position to other troops and threats are significant components of overall *situation/battlefield awareness*. Current *navigation systems require periodic* updates to maintain absolute positioning accuracy. To meet the anticipated accuracies require for the near-term battlefield, either cooperative navigation aids or frequent overflys of known geographic points or other manually performed updates will be needed. If full mission capability is expected of the aircrew, particularly single pilot cockpits, cooperative navigation sources are need. Such systems as the Global Positioning System (GPS) and the enhanced versions of the Position Location and Reporting System (PLRS) are expected to unburden the aircrew of the navigation update responsibility. In the event of onboard failures, data links between team elements can exchange absolute navigation parameters. Other onboard systems such as inertial platforms using ring laser gyros and even doppler *subsystems can serve as secondary, backup* sources as well as providing short term navigation and hover hold inputs.

Digital map technology holds much promise for the near-term and future battlefield helicopter. The digital terrain and cultural feature data base enables the flexible presentation of navigational information to the aircrew without the limitations of projected imagery or display video via a remote map reader. Variable map scales and "de-clutter" modes are available with the digital map without optical limitations or specially prepared paper maps to be converted to film strip. The digital terrain data base, when coupled with a radar altimeter and appropriate terrain correlation algorithms, can serve as an alternate precise navigation source. It also can provide a passive terrain/obstacle avoidance data, albeit predetermined.

Automation will be required to simplify the complex voice and data communication tasks that are anticipated for the battlefield helicopter of the 1990s and *beyond. We hope to minimize* the voice transmissions through use of more digital data communication without requiring time-consuming crew interaction. We are starting to see the initial application of digital data instead of voice transmission in the target handoff systems for the AH-64 and OH-58D AHIP (Advanced Helicopter Improvement Program) programs of the US Army. With the Automatic Target Handoff System (ATHS), aircraft and threat location as well as certain weapons parameters and cues are transmitted over the Tactical Fire Control (TACFIRE) network via FM radio data links. We see the expanded use of such C3I networks as critical to perform the rapid response, coordinated attacks needed in the battlefield of the future.

Communications between the *battlefield helicopter and various force structure* elements are anticipated (see Fig. 10). While not every aircraft will have to maintain these extra-team links, the team must stay "in touch" with the rest of the outside world, providing the battlefield commander with the team's location, weapons loadout, and fuel status. Threat number and type and battle damage assessment via such data links will greatly enhance the friendly force overall effectiveness. The C3I data to the team will keep them up to date on the disposition of friendlies and threats, thus reducing their vulnerability and improving their response to the threat. Obviously, these data must be transmitted secure from interception and disruption. New developments such as Single Channel Ground and Airborne Radio System (SINCGARS), the Have Quick program, the Joint Tactical Information Distribution System (JTIDS) and enhanced PLRS networks are expected to meet these needs.

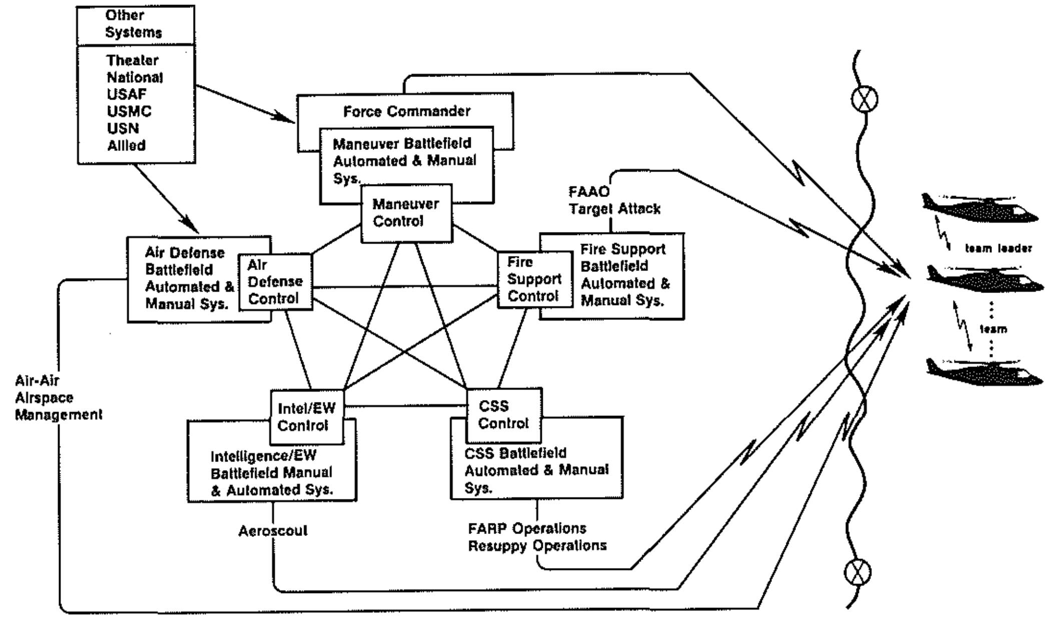


FIGURE 10 FUTURE BATTLEFIELD HELICOPTER C3I LINKS

Voice transmission will still be often used, but we must reduce the workload associated with the steps to perform it. "Hands on" radio control for radio and channel selection via collective/cyclic grip switches such as being used on the OH-58D have helped (Ref. 11) but further improvements through the use of voice recognition systems should further reduce cognitive and manual workload. Through the use of voice control, we can reduce the use of cyclic/collective grip switches which can cross-couple flight control inputs. We also can reduce the mental tasks associated with remembering which radio and channel/frequency to use. For example, a pilot can call for "COMMAND POST" on a voice recognition system which is programmed for a prestored radio and channel.

Part of the workload reduction of these systems is, in part, accomplished by shifting the tasks from the time during the mission to pre-mission. The use of data loaders for helicopters is not new. Magnetic tapes are used to load in mission data into the U.S. Navy's LAMPS III SH-60B SEAHAWK helicopter (See Fig. 11) and are planned for the U.S. Navy's CV HELO (SH-60F). We do not envision aircrews hacking away at a mission planning terminal, entering numerous large data strings. We do see pre-stored templates of communications protocol, pre-established waypoints, fuel and weapons loadout as well as disposition of threats and friendlies within the mission planning stations, ready for final mission data entry by command post, intelligence or aircrew personnel just prior to departure. Post-mission data, such as battle damage assessment, reconnaissance and maintenance information, will be electronically stored and transmitted to reduce the "paper burden".

FIGURE 11 SEAHAWK® SH-60B

We previously mentioned the application of machines to perform aircraft system health monitoring. Machines can do those functions much faster, more accurately, without fatigue, then can the aircrew. As more and more sensors are provided for such monitoring, the better the machine can assess the status of the aircraft's many subsystems and provide that information to the pilot. We can integrate data from multiple sources and provide the results in a simpler manner to the aircrew. Performance margins for power, endurance and range are prime candidates for such integration. We look for this "information fusion" to be a major pilot workload reducer.

Near-term scout and attack helicopters will begin to rely more on automated features of the target/threat detection and acquisition sensor systems and the weapons management functions. As previously mentioned, some of the automation features are needed to find and counter the threat fast and accurately enough to be effective, independent of crew size. Considerable progress in automatic target recognition system (ATRs) is being made, particularly with Forward Looking Infrared (FLIR) imagery. The area that holds much promise to reduce the false alarm rate and improve the recognition accuracy is a technology referred to as "sensor fusion." Theoretically, sensor fusion calls for the use of information coming from several sources to be "fused" into a "best guess" response. Data from FLIR, Radar, Radio Frequency Intereferometer (RFI) and even Laser Radar sensors as well as C3I data are being considered in algorithm development.

While significant detection and recognition performance have been achieved for fixed wing air targets with Radar, current ATR and sensor fusion programs for rotary wing applications are designed to recognize predetermined "military targets of interest", i.e. predominately ground vehicles. Recognition is limited to tracked versus wheeled, tank, truck, APC or air defense vehicles. The scout and observation roles are and will continue to use imaging sensors for many non-vehicular subjects of interest such as infantry troop concentrations, bridges, buildings, vehicle tracks, artillery fire adjustment and battle damage assessment. For these sensor applications, manual techniques with limited automatic function such as preselected sensor scan patterns and pointing will still require visual search by the aircrew. Other limited automation can be provided in the control and setup of the sensors such as gain, contrast and threshold levels as well as tracking of ground stabilized, contrast lock and laser illuminated targets.

We anticipate that many of the weapons management functions in future battlefield helicopters will be automated. Specifically, the cueing from the targeting sensors, preliminary weapons assignment for a given target as well as target firing/designation priority and coordination within a scout/attack team can be highly automated. Integration of fire and light control systems is very likely means of unburdening the pilot. Knowing where the target is via the targeting sensors, weapons characteristics and constraints, the location and state of aircraft and the capability to provide flight guidance or even directly coupled control, we can improve system performance with reduced pilot effort. A limited example of this technology is the TOW launch constraints flight coupler on the Hughes 530MG (Ref. 12). The automation of these functions will have to be designed to assist and guide the pilot, permitting him to easily accept or reconfigure with ultimate launch authority. This approach is required to meet the positive identification prior to weapons launch requirements and to give the pilot the flexibility to employ his weapons for the best tactical success which may or not be programmed into the fire control algorithms.

These advances in cockpit will greatly reduce aircrew workload but only if a well integrated man/machine interface is provided so that the aircrew can control and interact with those functions effectively. New control/display systems will greatly aid the crew/aircraft "I/O" problem. "Glass" cockpits are becoming more and more prevalent in rotary wing applications as seen in the A-129 Mongoose, OH-58D AHIP and HH-60D Night Hawk. That technology provides us the means to not only provide information to the crew in a fewer number of displays, but more importantly, to use such techniques as "display by exception" and "information fusion" to make the crew's job less complex and simpler to perform.

A candidate crew I/O configuration for a single pilot battlefield helicopter of the 1990s is shown in Figure 12. The WFOV Helmet Mounted Display will enable the pilot to keep "heads out" for a large majority of the mission. The sidearm controllers and associated flight control laws make the piloting tasks easier to perform and more comfortable then current cyclic/collective configurations.

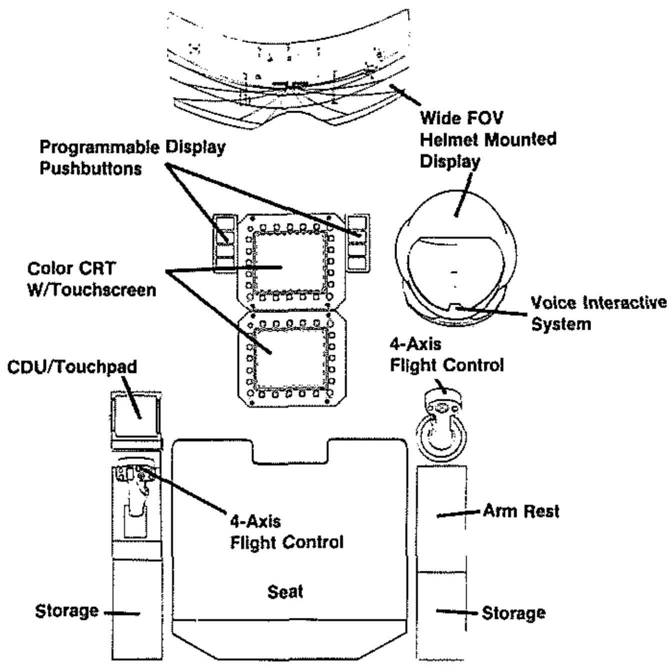


FIGURE 12 ADVANCED CREW I/O

We are looking to provide "hands on" control but limited to mission critical functions. We need to minimize the negative impact of grip-mounted switches and controls on flight control precision by careful anthropometric grip and switch design. We also must avoid the "piccillo player's syndrome" caused by putting to many secondary devices on the stick grips. The application of voice interactive systems (VIS) will mitigate this situation. As previously described, VIS will enable direct selection of desired modes and functions without the typical chain of paging, menuing or moding steps prevalent with many advanced control/display systems.

Two large screen color CRT displays are provided on a centrally located console to show tactical situation (primary navigation, map and mission information) and system management (aircraft system health, communication and weapons) data.

The color capability significantly simplifies the interpretation of the data presentation, particularly the map with overlays of threat/friendly force locations, waypoints, course lines, etc. We look for CRT technology (as opposed to flat panel technology) advances in display size, brightness, contrast enhancement filters, and resolution to meet the demanding high and very low ambient light conditions of the battlefield of the 1990s. NVG compatibility will still be required which provides another technical obstacle to overcome.

Touch sensitive screens will be used to ease pilot manual selection of desired functions as will as replacing current cursor controls. Resolution and accuracy of the touchscreens versus operational requirements may also require new concepts. One approach is to provide a separate stowable touchpad which does not directly overlay the display but provides the same capability. A flat panel display behind the touchpad could provide a low power display for system startup and readily assessable data entry device.

Programmable display pushbuttons (PDPs) provide a flexible means for manual mode selection without using valuable CRT area typically used for map or sensor imagery. PDPs use a small flat panel display with a touch sensitive screen or attached to a mechanical switch assembly. Essentially, multiple groups of PDPs are used in lieu of another CRT display and associated display generator hardware. The two CRT/PDPs center console provides more than adequate display surfaces for most rotary wing missions while having minimal impact on external visibility and excellent crashworthiness characteristics.

We do not envision that the future cockpits of battlefield helicopters will be completely devoid of typically dedicated controls. Due to safety requirements, such functions as master arm, jettison, emergency landing gear or fire extinguisher controls should have separate control devices. For convenience of operation, dimming cockpit lighting or adjusting headphone volume can best be done with a control that is easy to reach and use. We must also consider the need for adequate storage space for personnel gear, provisions and emergency equipment that will be still required for field, remote site operations.

Sikorsky is preparing for the cockpit design of the battlefield helicopters of the future by developing and applying the needed techniques and tools today through a multistage approach. The first stage is detailed analysis of the mission/task requirements, the threat capabilities, battle doctrine of the threat and how they will be used within the friendly force structure. We then develop preliminary designs to satisfy the resultant functions based on extensive tradeoffs which are weighted toward the overall program goals. This entails the interaction of mission requirements, airframe capabilities, human factors analysis, and technology protections/risk assessments for given avionics and cockpit design applications.

The second stage is to take the preliminary concepts from paper design to mockups and part-task simulators. Part-task simulation of the preliminary design allows visualization to the man-machine interface and preliminary workload assessments and early pilot feedback on generalized approaches to control/display techniques and procedures (See Fig. 13). At Sikorsky, our Part-Task Simulator is located in our Human Factors Laboratory and consists of a Megatek computer graphics system which is capable of full color, high resolution displays, a PDP 11/34 for simulation control and several support peripherals including a variety of voice recognition and speech synthesis systems, touchpads, sidearm controllers and grip switches. Control/display moding techniques and formats are tested out in the Part-Task Simulation prior to evaluation in our Fixed Base Simulator for engineering development.

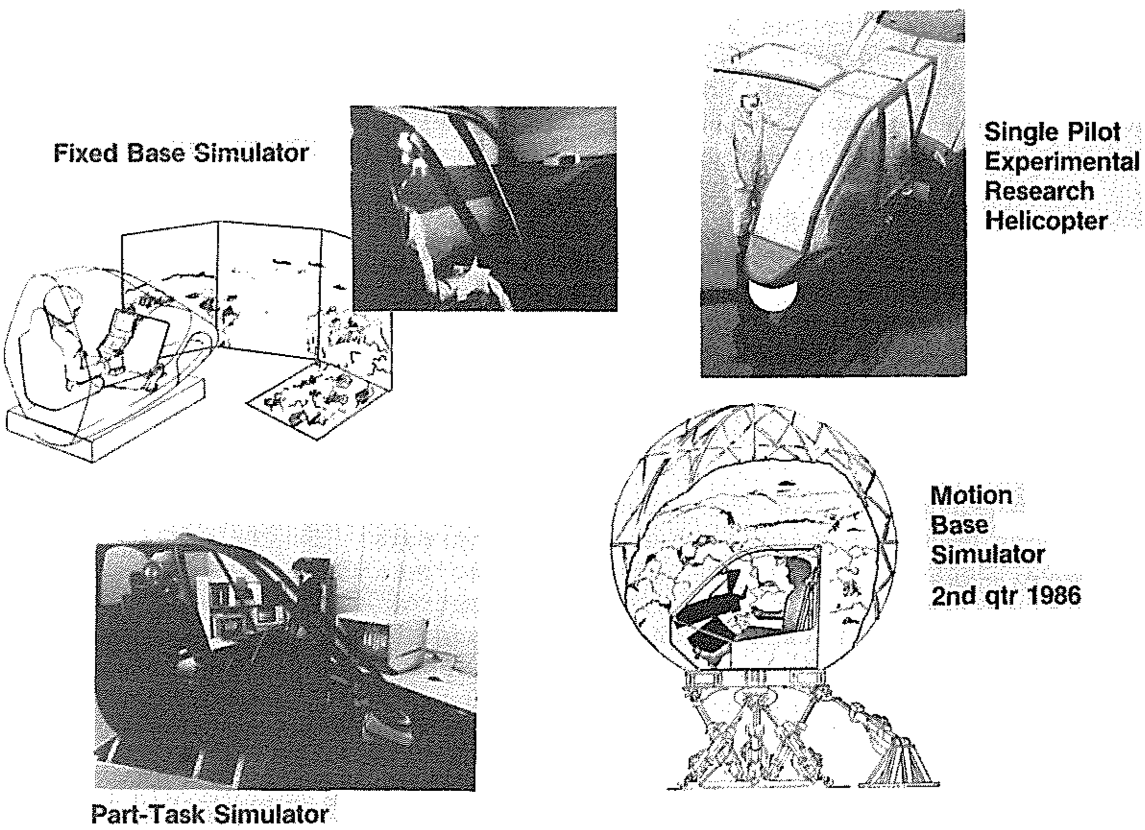


FIGURE 13 SIKORSKY COCKPIT RESEARCH TOOLS

The Fixed Base Simulator provides a high fidelity simulation of the aircraft dynamics and control laws, the visual "outside world", aircraft avionics and mission equipment package and the cockpit environment. It consists of a Reddifusion SP3T visual system, PDP 10 and SEL 32/870 computers, "hot bench" avionics along with several cockpit cab configurations. We plan to extend our full mission simulation capability next year with our Motion Base Simulation (MBS). The MBS will have a Singer-Link six degree of freedom motion system with a state of the art visual system from General Electric called COMPUSCENE IV.

The final stage is flight testing of critical or high workload tasks in the unique Sikorsky single pilot experimental research helicopter (Fig. 9 and 13). It is an S-76 modified with a single pilot cockpit added to its nose. Its layout permits the evaluation pilot to fly realistic flight profiles using a sophisticated avionics suite to simulate advanced technology applications. The evaluation copilot and test manager can monitor and simulate external events and conditions presented to the pilot. The aircraft has space and load capability to carry the equipment and personnel to simulate the mission environment yet provide highly maneuverable, agile aircraft performance. The safety pilot performs his function unburdened by test monitoring or simulation demands. This configuration enables the aircraft to truly be used as a simulator and not just a demonstrator.

The demands on the cockpit designer are extensively greater than in the past. If we are to meet those challenges effectively, we need to be open to new techniques and tools for development as well as to the technologies that offer the means to extend performance of the battlefield helicopter. It will be through the judicious application of these advances with the pilot in mind from inception will we be able to integrate them into a highly effective mission man/machine system.

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