NASA Technical Memorandum 101053 USAAVSCOM Technical Report 88-A-009

AH-1S Communication Switch Integration Program

Loran Haworth, Zoltan Szoboszlay, Robert Shively, and Frank J. Bick

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US ARMY AVIATION SYSTEMS COMMAND
AVIATION RESEARCH AND TECHNOLOGY ACTIVITY

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SUMMARY

The C-6533/ARC communication system as installed on the test AH-1E Cobra helicopter was modified to allow discrete radio selection of all aircraft radios at the Cyclic Radio/intercommunication system switch. The current Cobra-fleet use of the C-6533 system is cumbersome, particularly during low-altitude operations. Operationally, the current system C-6533 configuration and design requires the pilot to estimate when he can safely remove his hand from an active flight control to select radios during low-altitude flight. The pilot must then physically remove his hand from the flight control, look inside the cockpit to select and verify the radio selection and then effect the selected radio transmission by activating the radio/ICS switch on the cyclic. This condition is potentially hazardous, especially during low-level flight at night in degraded weather. To improve pilot performance, communications effectiveness, and safety, manprint principles were utilized in the selection of a design modification. The modified C-6533 design was kept as basic as possible for potential Cobra-fleet modification. The communications system was modified and the design was subsequently flight-tested by the U.S. Army Aeroflightdynamics Directorate and NASA at the NASA Ames Research Center, Mountain View, California. The design modification enables the Cobra pilot to maintain "hands-on" flight controls while selecting radios during nap-of-the-Earth (NOE) flight without looking inside the cockpit which resulted in reduced pilot workload ratings, better pilot handling quality ratings and increased flight safety for the NOE flight environment.

INTRODUCTION

The United States Army Aviation Systems Command (AVSCOM) requested the United States Army Aeroflightdynamics Directorate (AFDD) to study and evaluate Army Suggestion HA 80/85 (appendix A). The Army suggestion referred to the modification of the AH-1 Cobra helicopter fleet cyclic radio/intercommunications system (ICS) switch (fig. 1) so that available aircraft radios could be selected at the cyclic radio/ICS switch by using the pilot's thumb.

The radio/ICS switch is used for radio transmissions and internal helicopter communications. Currently only two of the four possible cyclic radio/ICS switch positions are used, and discrete radio selections can only be accomplished by rotation of the transmit-interphone selector on the Cobra helicopter C-6533 Interphone Control Panel (ICP, fig. 2). During maneuvering flight in the nap-of-the-Earth

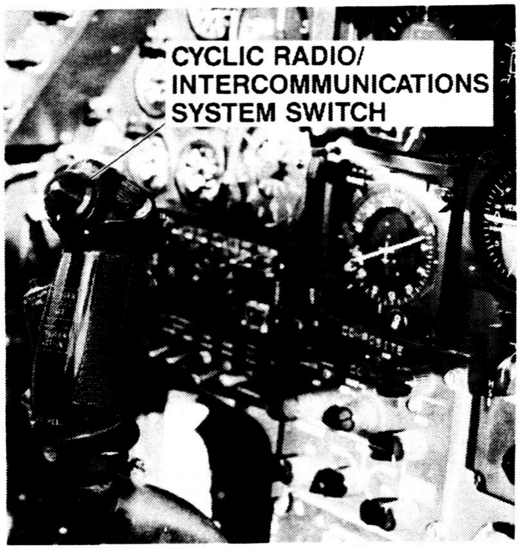

Figure 1.– Cyclic radio/intercommunications system switch.

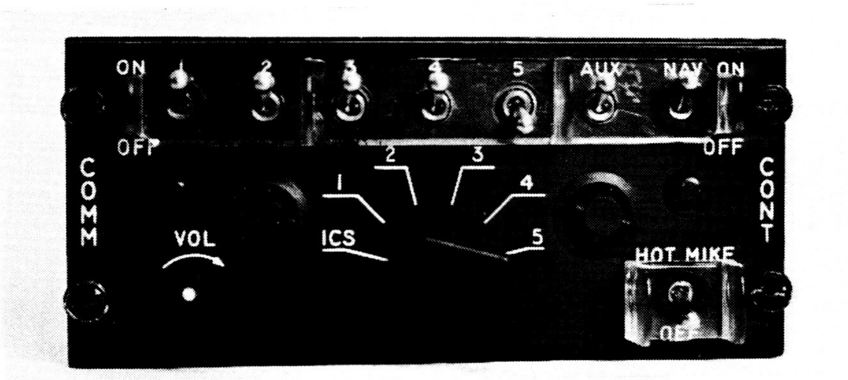

Figure 2.– C-6533 interphone control panel (ICP) which shows the transmit-interphone selector.

(NOE) environment, Cobra pilots must remove one hand from an active flight control to select radios at the ICP. This interferes with their ability to conduct timely communications and/or fly the aircraft, especially during night operations with night-vision goggles. Figure 3 shows the rear cockpit location of the cyclic radio/ICS switch, floor microphone, flight controls, and the ICP. Figure 4 further demonstrates the current fleet operation of the Cobra C-6533 ICP.

After initial review of Army Suggestion HA 80/85 (appendix A) by U.S. Army Cobra pilots, it was predicted that discrete selection of multiple aircraft radios at the cyclic radio/ICS switch could reduce the pilot's workload and enhance flight safety. Discrete radio/ICS selection at the cyclic would increase the pilot's ability to conduct timely radio/ICS selections without removing his or her hand from a flight control. While a second crew member may be able to perform some communications tasks, conditions often exist where the second crew member is not always available to perform that function on a timely basis because of other pilot tasking such as navigation and targeting. Transfer of the flight controls to the other crew member during high workload conditions such as NOE flight at night often leads to confusion as to who is controlling the aircraft (ref. 1). The tandem seating arrangement of the Cobra cockpit

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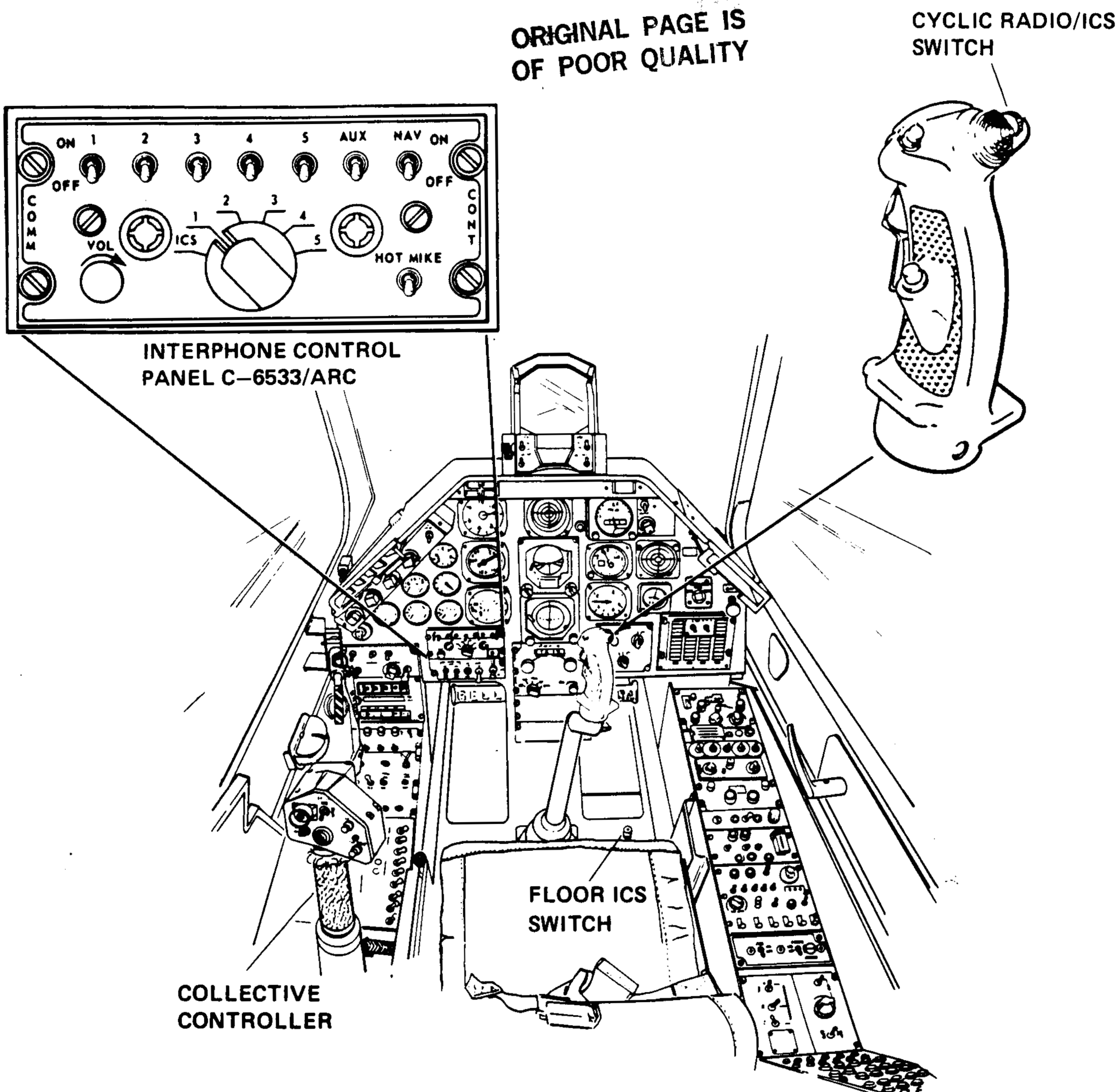
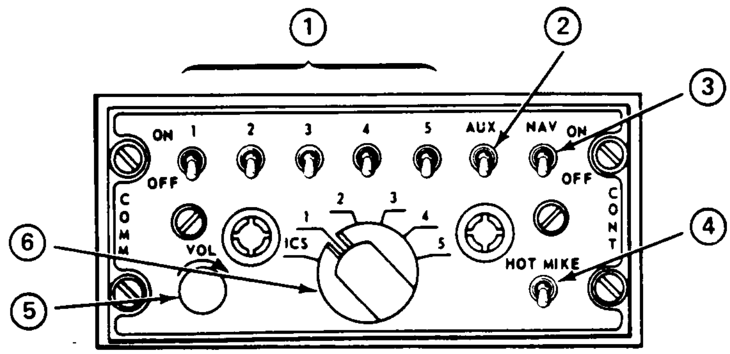


Figure 3.– Location of cyclic radio/ICS switch floor ICS switch flight controls. ICP.

decreases nonverbal communications which degrades crew coordination and increases the length of time required to relay communications to the other crew member.

The United States Army Safety Center indicates that several accidents and incidents have been attributable to pilot actions associated with communications or similar actions. These include removal of the hand from an active flight control during flight, looking inside the cockpit to select radios or other aircraft equipment, and lengthy communication time delays. It was felt that a successful communications modification would lead to personnel and material savings far in excess of the cost of modification.



CONTROL/INDICATOR	FUNCTION
1. Receiver Switches	Connect (ON) or disconnect (OFF) communications receivers from the headsets.
1 – VHF/FM ARC-114A	
2 – UHF ARC-116 or ARC-164	
3 – VHF/AM ARC-115	
4 – Not Used	
5 – Not Used	
2. AUX Receiver Switch	Connects (ON), or disconnects (OFF), VOR set receiver ARN-123(V)1 from the headset.
3. NAV Receiver Switch	Connects (ON), or disconnects (OFF), ADF navigation receiver ARN-89B from headset.
4. HOT MIKE Switch	Permits hand-free intercommunications with transmit-interphone selector in the ICS position.
5. VOL Control	Adjusts volume from receivers. Adjusts intercommunications volume.
6. Transmit-Interphone Selector	Selects transmitter to be keyed and connects microphone to transmitters.
1 – VHF/FM ARC-114A	
2 – UHF ARC-116 or ARC-164	
3 – VHF/AM ARC-115	
4 – Not Used	
5 – Not Used	
ICS	Connects the microphone to the intercommunications system only, disconnecting microphone from transmitters.

Figure 4.– Current operation of the Cobra C-6533 ICP.

Previous attempts at modifying the cyclic radio/ICS radio switch on the Army Silver Eagles OH-6 aircraft, as mentioned in Army suggestion HA 80/85, were reviewed. It was determined that drawings were not published for the Silver Eagles OH-6 cyclic switch modification and the verbalized method of modification would not be practical for an aircraft used in combat because of the possible failure modes. Other examples were also studied such as the AH-64 arrangement, but were not found to be practical for this level of modification.

To effect a simple and reliable modification of the Cobra radio/ICS switch that could be used by the Cobra fleet as suggested, a detailed study and design modification of the ICP, ICS, and pilot's cyclic switch was indicated. Several design iterations to meet the objective of using the radio/ICS switch for discrete radio selection are shown in appendix B; however, many of the designs were not appropriate because of potential pilot negative habit transfer.

To adequately study and evaluate Army suggestion HA 80/85, a flight-project test plan titled "Communications Switch Integration Program (CSIP)" (Letter to OA/Chief, Ames Research Aircraft Operations Division dated 25 Sep 87, subject "Aircraft Flight Project Request for Communications Switch Integration Program (CSIP)" from CPT Haworth, Flying Laboratory for Integrated Test and Evaluation (FLITE) Cobra programs manager, U.S. Army Aeroflightdynamics Directorate) was submitted to AFDD, NASA Ames and AVSCOM. The CSIP test plan was approved 25 January 1988 and the CSIP airworthiness release was approved by the Ames airworthiness engineering branch on 3 December 1987.

Test Objectives

The first objective of the CSIP was to initially study, perform paper evaluations and then complete a breadboard design modification of the interphone control electronics (C-6533) and system wiring to allow all four Cobra cyclic communications switch positions to be used. The second objective was to determine the suitability of using the Cobra Cyclic Radio/ICS for discrete aircraft radio selection and transmission. The interphone control electronics design was directed at ease of modification for possible fleet modification, reliability, pilot acceptance and minimization of any adverse man-machine interaction problems such as those habits carried over from previous Cobra communications control methods.

Description

The test FLITE AH-1E is equipped with a two-place (pilot and gunner) tandem seat and a single-engine aerial-weapon platform using a single, two-bladed-teetering, K747 main rotor and two-bladed tail rotor (fig. 5). The maximum gross weight of the helicopter is 10,000 lb. Power is provided by a Lycoming T-53-L-703 free turbine engine rated at 1800 horsepower, flat-rated to 1485 shaft horsepower (SHP) by reduction gears and to 1290 SHP by the transmission. The aircraft has been modified with the addition of the Pilot Night Vision system (PNVS) and the addition of a laser reflector as shown in figure 6. The airworthiness release for the installation of the PNVS restricts the aircraft forward speed to 150 knots-indicated airspeed (KIAS) and a pressure altitude of 11,000 ft. A more complete description may be found in the operator's manual (ref. 2) and the PNVS operators manual (ref. 3). The C-6533 ICP, ICS and pilot's cyclic radio/ICS switch were representative of the AH-1 Cobra fleet aircraft prior to modification of the system for the CSIP test.

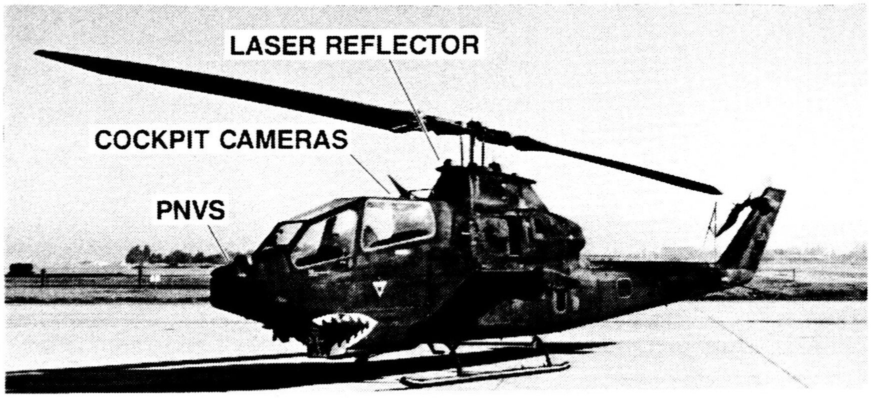


Figure 5.– The AH-1E Cobra helicopter.

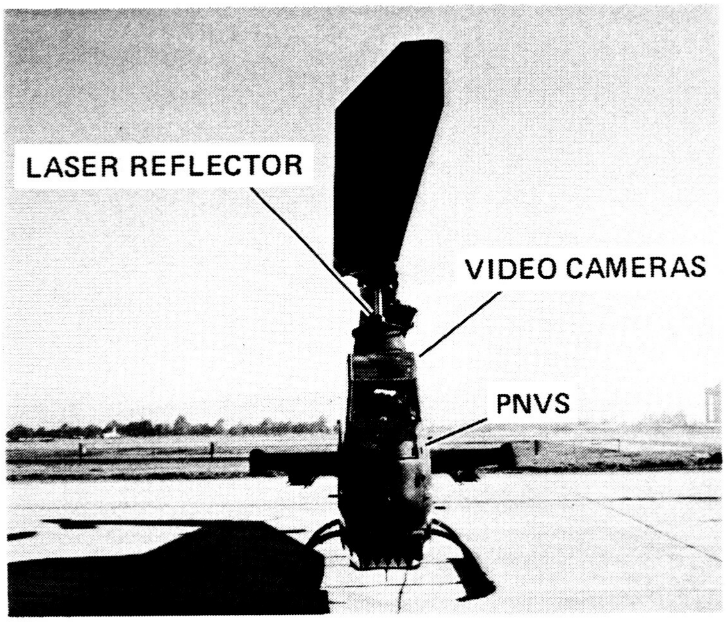


Figure 6.– The PNVS and laser reflector on the Cobra.

The ICP electronics were modified as described in appendix C. This design modification was only selected after several design iterations with engineers, avionics technicians, and pilots to arrive at a design that was acceptable to the user. At the same time the design was kept at a level that would readily allow the Army to retrofit the existing Cobra fleet.

For the purpose of this investigation Army/NASA engineers and researchers provided a proof-of-concept breadboard design shown in photos in appendix C. Essentially the suggested modification included the build of a small interface box that would mate to the communications control box C-6533 (fig. 7) and minor rewiring of the C-6533 box. Detailed information on the breadboard design to include estimated labor is available in appendix C however; AFDD is not the appropriate agency to provide detailed information on cost of modification and other logistics information related to implementation of such a design modification for the Cobra fleet.

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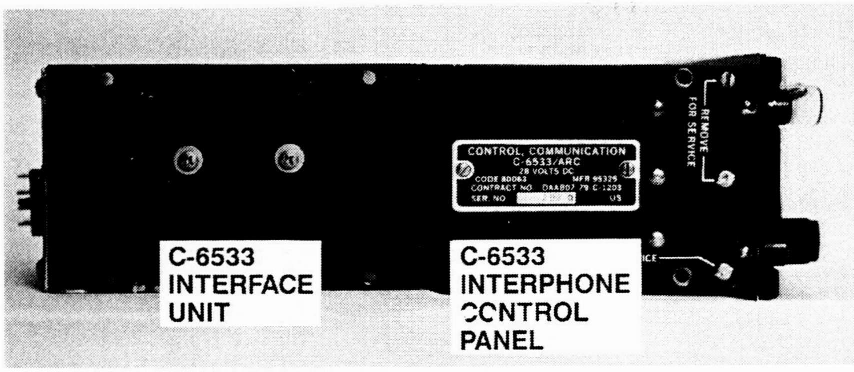

Figure 7.– Interface box.

The selected design modification for the CSIP evaluation is called Option five (fig. 8b). This modification allows the pilot to select a discrete radio and key (push-to-talk) the radio at the same time. This means the pilot can select and key his intended radio without removing his hand from an active control stick. Use of the Transmit-Interphone Selector switch with the Foot switch and Hot Mike switch with Option five was not affected. Only the rear cockpit was modified for this proof of concept evaluation.

Test Scope

The CSIP testing was conducted in five phases. Phase I involved selection of possible design iterations shown in appendix B. Functional ground tests (Phase II) were performed in the hangar and on the ramp area at NASA Ames, California during 15 January to 18 January 1988 after selection of the preliminary design and subsequent modification of the C-6533 system. Pilot ground evaluations were conducted in the cockpit at NASA Ames (Phase III) between 18 January to 22 January 1988. Pilot-in-the-loop flight evaluations at Navy Crows Landing and Moffett Field California (Phase IV) occurred between 22 January 1988 and 3 March 1988. Air Traffic Control flight trials (Phase V) were performed from 3 March to 20 April 1988 in the local Moffett Field flying area. A total of 34 flights and 59.6 flight hours were flown with the modification.

The AFDD and NASA at Ames Research Center had overall responsibility for conduct of the test to include range tracking instrumentation. The U.S. Army Test and Experimentation Command (ATEC) at Ft. Ord and Ft. Hunter Liggett, California instrumented the test aircraft with two internal video cameras, recorders and time-code generators. The AFDD provided funding, avionics design and modification, researcher, pilot, technical and engineering support as required. NASA Ames supplied maintenance, fuel and oil, pilot and operations support. AVSCOM requested the research and furnished general test object guidance.

The test aircraft was operated within the limitations of the operator's manual as amended by the PNVS and CSIP airworthiness releases (refs. 2 and 3; appendix A). Average flight test conditions for Phase IV flight tests are shown in table 1.

Test Methodology

<u>Phase I design selection and modification</u>– Avionics, aircraft maintenance, safety, engineering and Cobra flight personnel initially considered five possible design options shown in appendix B that would

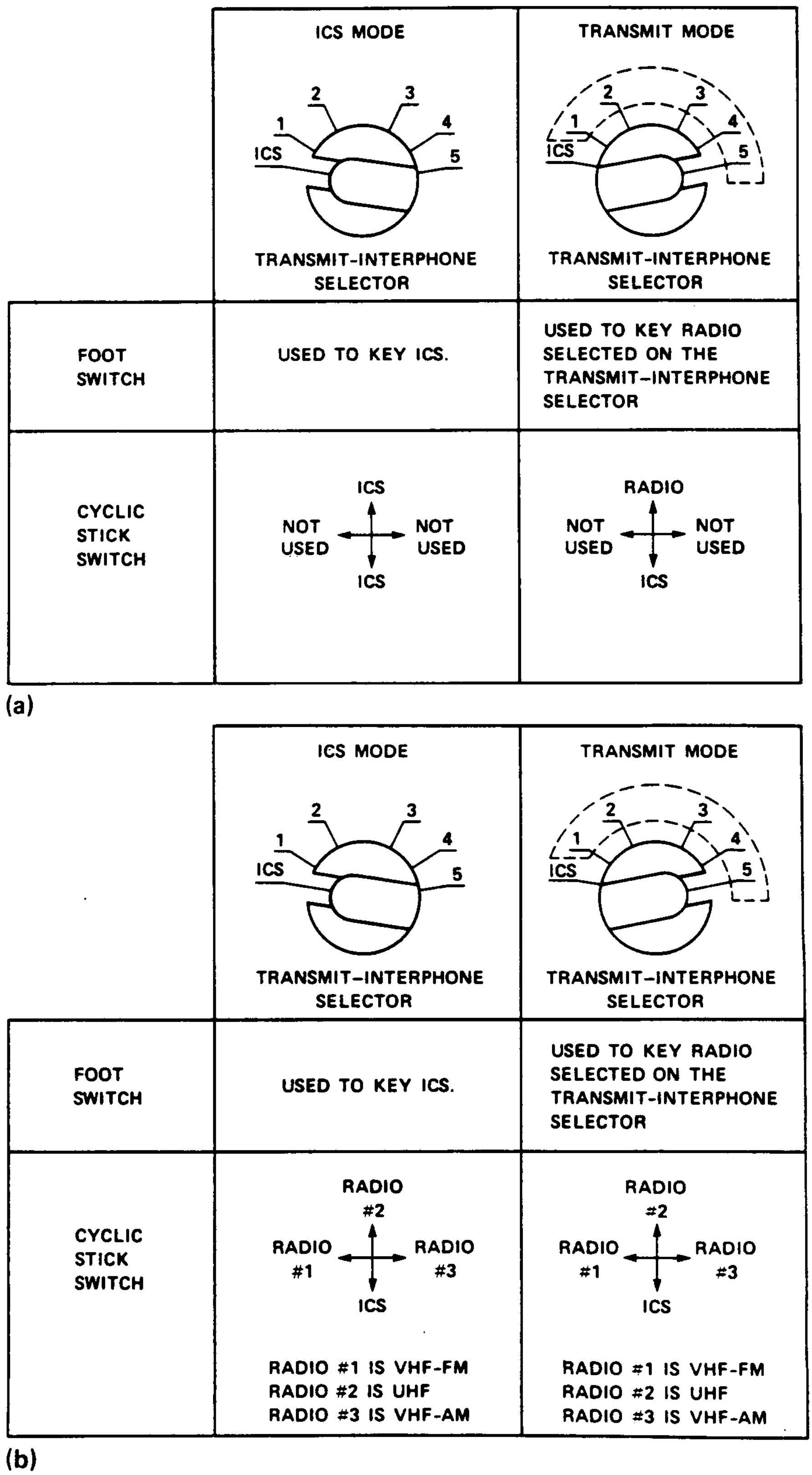

Figure 8.– Communication C-6533 ICP switch modes. a) Original configuration; and b) Option five configuration.

TABLE 1.– FLIGHT TEST CONDITIONS (PHASE IV).

Flight date	Average temperature (C)	Pressure altitude (ft)	Wind speed/ direction (knots/deg)	Flight time (hr)
3 Feb 88	12	60	11/337	3.8
4 Feb 88	13	300	05/032	3.0
5 Feb 88	12	400	06/165	4.4
5 Feb 88	14	370	05/156	3.3
8 Feb 88	17	270	10/335	4.3
10 Feb 88	20	240	21/310	3.3
11 Feb 88	16	270	03/100	3.4
16 Feb 88	17	30	32/309	4.1
3 Mar 88	15	140	13/230	4.8

Average gross weight – 8125 lb
Average center of gravity – 195.1

allow functional use of all four cyclic radio/ICS switch positions. Operational pilots were asked to do a paper evaluation of each option and provide guidance as to the best option. Personnel involved with the engineering effort recorded the modification endeavor for future use in estimating time, man hours, and materials required.

Phase II functional ground checks– After modification the avionics, safety, and engineering personnel performed standard operations checks of the system during ground operation. Checks of the modified system were also made to ensure that the system design would functionally operate as specified and without electrical interference with onboard aircraft systems.

Phase III pilot ground evaluations– During phase III experienced pilots were asked to perform radio switching tasks using the present/original Cobra communications design (fig. 8a) and the modified design (fig. 8b) (Option five) during ground based simulation in the aircraft cockpit. The Phase III pilots completed a series of five separate radio changes for each of the two configurations. The pilots subsequently rated the workload on the Bedford scale (Rascoe, A. H.: Practical Assessment of Pilot Workload. Advisory Group for Aerospace Research & Development O GRAPH" #282, 1987, pp. 78-82; fig. 9), a 10-point tree-structure scale that is based upon spare capacity.

This phase of research evaluated workload levels without the effects of prior learning (i.e., negative transfer) by using a pilot population not rated in the Cobra Helicopter. Later Phase IV flight maneuver tasking by necessity required experienced Cobra pilots. These experienced pilots were already predisposed toward the original communications configuration.

Phase IV pilot flight evaluation– Established AH-1 Cobra Aircrew Training Maneuvers (ATM) (Aircrew Training Manual, FC 1-213, Attack Helicopter, U.S. Army Aviation Center, Fort Rucker, Ala., September 1984) were used throughout the flight evaluation where possible. Target maneuver performance standards are shown in appendix D. Maneuvers and methods are briefly discussed in the results and discussion section of this report.

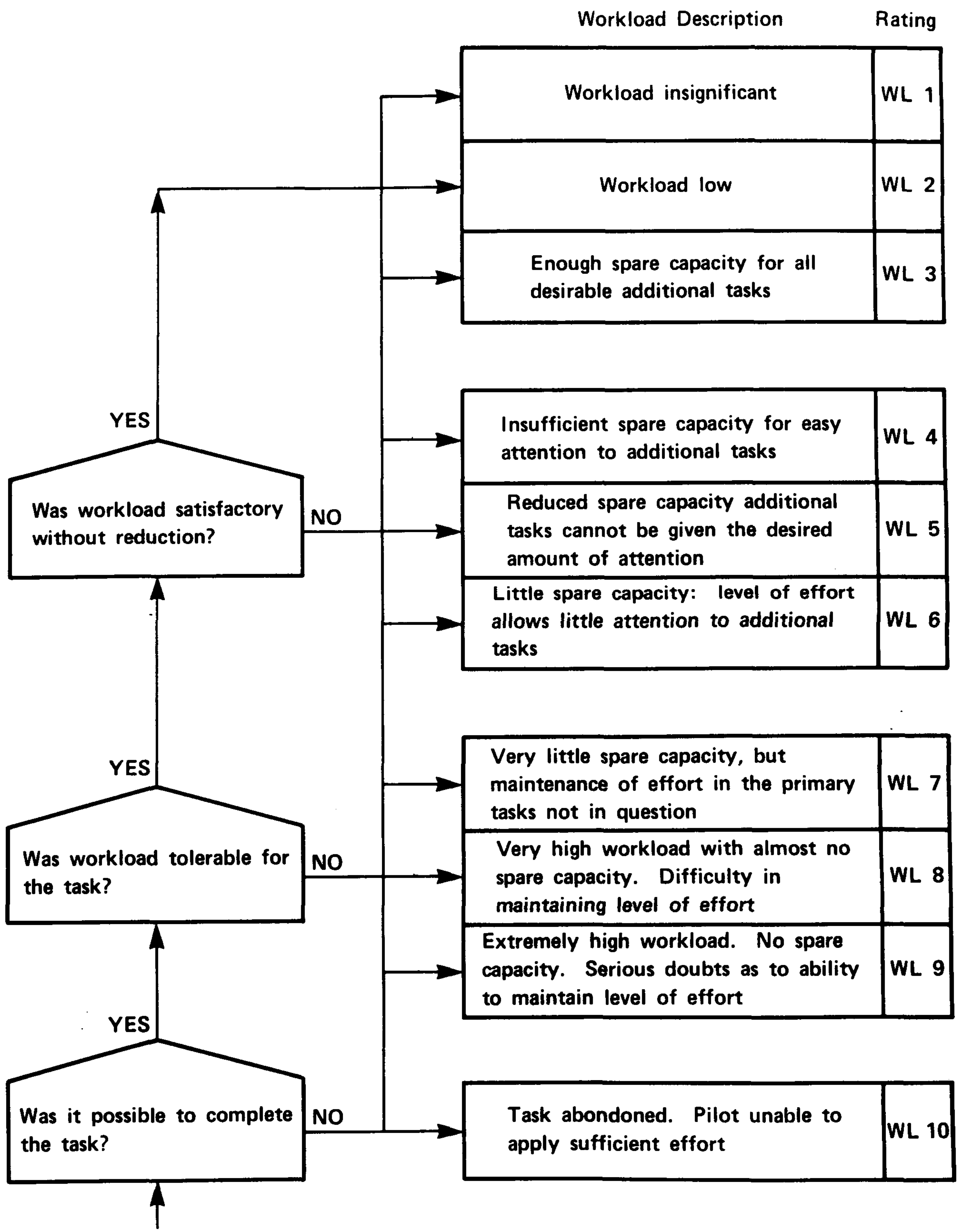

Figure 9.– The Bedford Workload Rating Scale.

During Phase IV Cobra pilots performed specified flight maneuver tasks shown in appendix D while performing radio switching tasks described in the following paragraphs under conditions shown: 1) flight maneuver task without radio switching tasks (maneuver condition), 2) maneuver task plus radio switching tasks using the present Cobra communications system (original condition), and 3) maneuver task using the modified communications switching design (Option five). Orange road construction cones were placed at specified locations on the Crows ramp area for visual reference during hover maneuvers. Flight tasks chosen for the test reflected hover, low-airspeed, and up-and-away flight maneuvers.

Phase V air traffic control– At the completion of detailed flight trials performed during Phase IV, local Army and NASA pilots were asked to continue operating with the modification. This phase was used to assess additional reliability and usability questions outside the structured test flight environment during flight in the air traffic control environment. Subjective pilot comments were gathered at the end of this phase.

Radio selection scenario– The radio-selection scenario task was such that the pilot was instructed to transmit a simple standard phrase on a primary radio, select a specified alternate radio, transmit the standard phrase and then reselect the primary radio and transmit. This may simulate one of many situations where the pilot may communicate with team aircraft on a primary radio, then switch to air traffic control or coordinating units and later return to the primary radio to give further instruction to team aircraft. Since pilots normally fly with a primary radio already selected pilots were allowed to initially select the primary radio prior to start of the flight maneuvers under the original configuration test condition. Prior selection of the first radio for the original condition would make the test results more conservative when comparing the original system to the modified system design since the pilot would not have to make an initial radio selection prior to transmission.

The amount of time allotted for completion of the communications switching tasks was somewhat dependent upon the length of time for completion of a maneuver set at a moderate level of aggressiveness. While the pilot may not ordinarily transmit three times during a brief time span associated with certain maneuvers the time pressure demonstrated ease of use associated with each configuration and the ability of the pilot to perform communications/radio selection tasks during maneuvering flight. When the pilot was not under time pressure because of the nature of the maneuver such as stabilized hover, the pilot was instructed to complete the communications task as soon as possible.

The order of radio selection presentation and specific communications configuration was randomized. The necessary radio selection prompting was provided by the safety/researcher pilot in the front seat of the Cobra. Each particular flight maneuver for a specified pilot was repeated for each of the three conditions above at the same environmental conditions for comparison purposes.

Data recording– The Handling-Qualities Rating Scale (HQRS) (ref. 4) shown in figure 10 and the Bedford Workload Rating Scale (BWRS) were used to supplement pilot's qualitative comments. Flight test data were recorded by hand, laser position tracker and by three video cameras. The laser tracker (fig. 11) is operated by NASA Ames at the Navy Crows landing facility. Two video cameras were located inside the pilot's cockpit area (fig. 12). One internal camera and recorder video recorded the collective, cyclic controller movements, cyclic switch and cockpit instruments. The other internal camera was focused outside the aircraft looking forward of the aircraft to record maneuver information. Time-code generators and other video support equipment were located in the Cobra ammunition bay (figs. 13 and 14). An additional video camera is permanently mounted on the laser tracker that recorded maneuver and tracking information during laser lock-on. All instrumentation was time-coded for data reduction purposes.

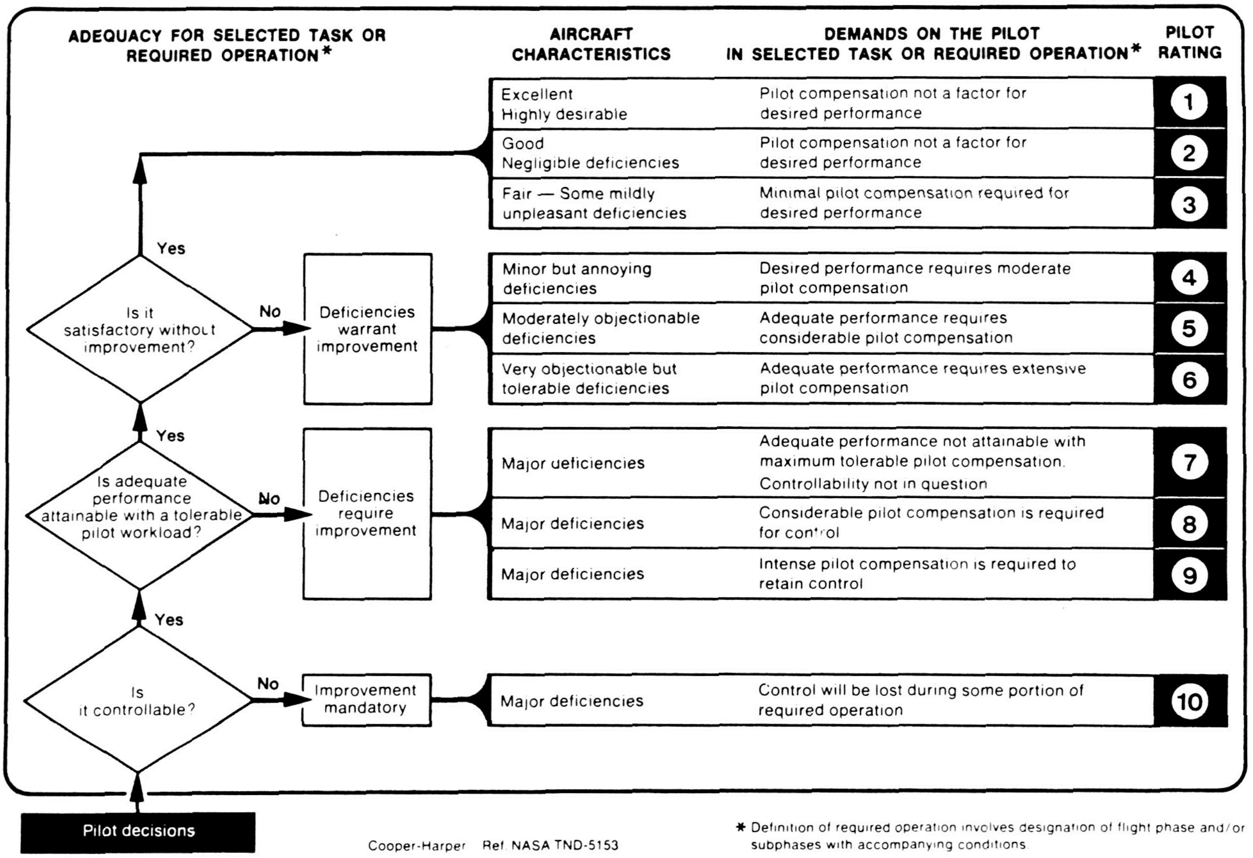

Figure 10.– The Handling-Qualities Rating Scale.

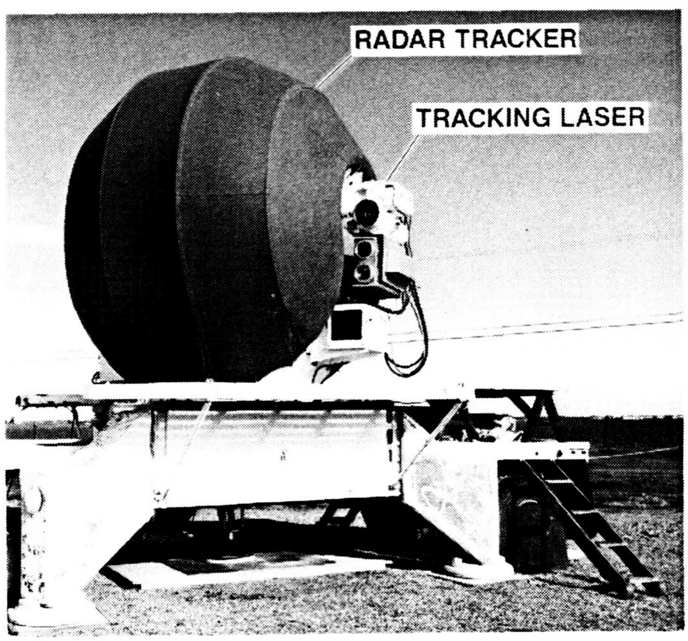

Figure 11.– Laser tracker.

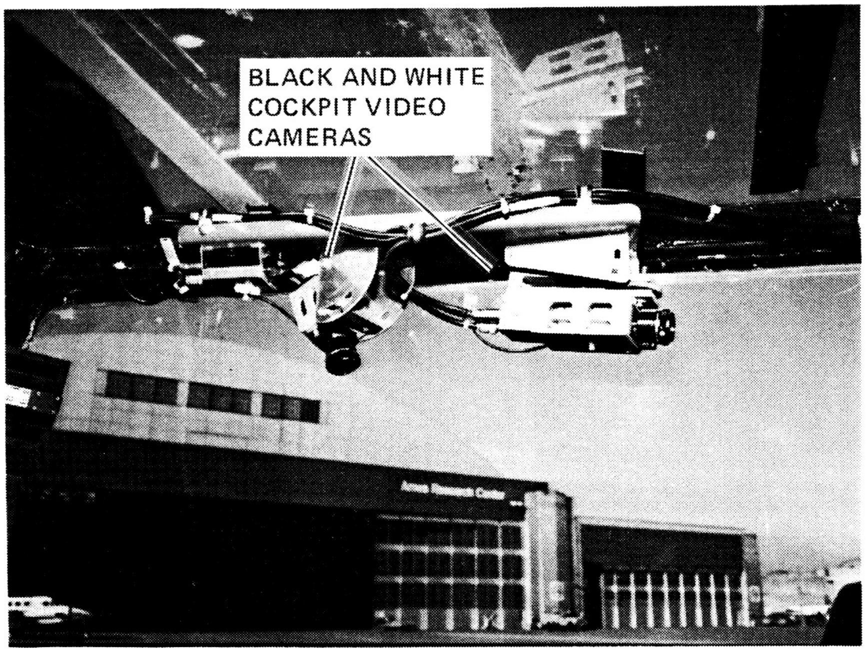

Figure 12.– Two cockpit video cameras.

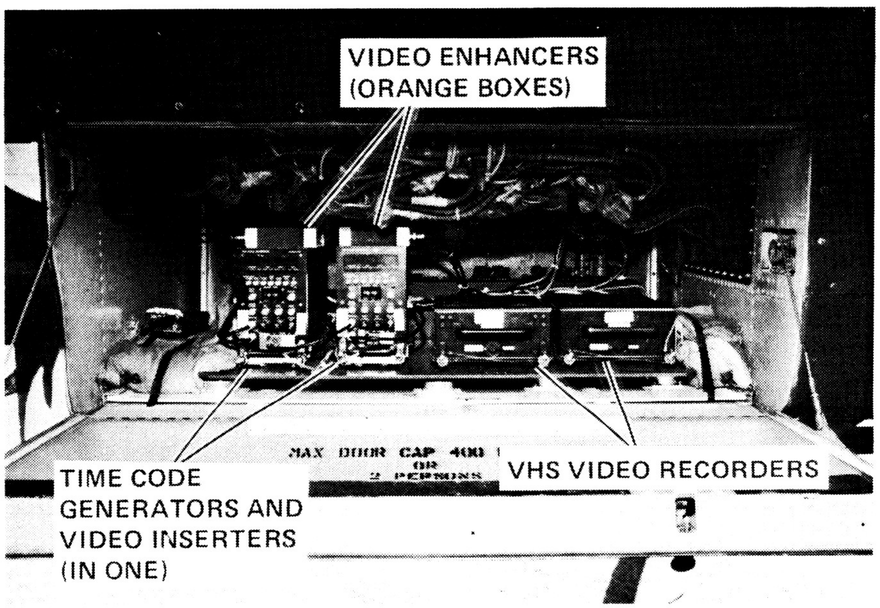

Figure 13.– Time-code generators and video support equipment; view 1.

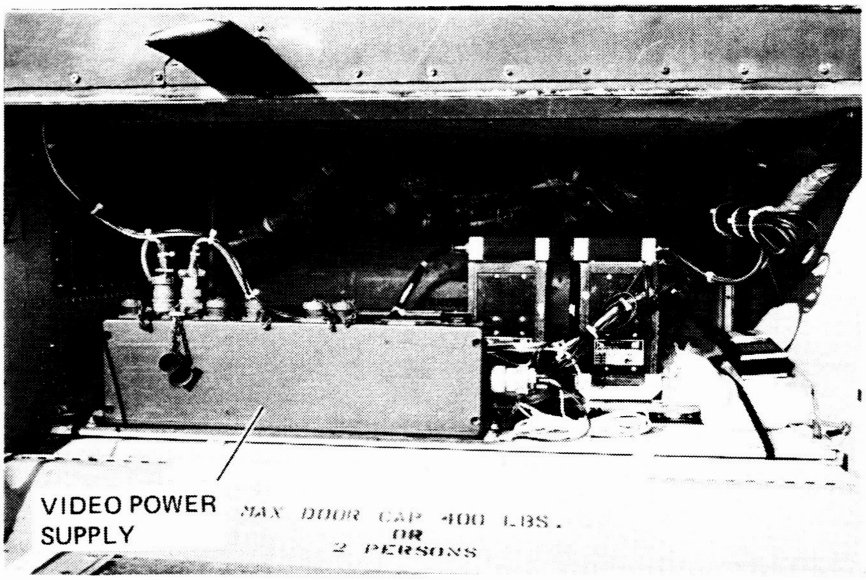

Figure 14.– Time-code generators and video support equipment; view 2.

Pilot maneuver instructions– The subject pilot was instructed to perform each maneuver at a moderate level of aggression and to always perform the maneuver to the specified target maneuver standardization criteria shown in appendix D. Where radio selection interfered with the pilot's ability to fly the aircraft to specified flight maneuver standards the pilot was instructed to first fly the aircraft at the same moderate level of aggression and then complete the communications selection process as time was available during the maneuver. All recorded information was compared between communication conditions for each pilot under the same environmental surroundings. Of particular interest, in addition to the pilot subjective and maneuver performance data, was the length of time between communications when the pilot was involved with flight of aircraft and could not readily or safely remove his hand from the collective controller.

RESULTS AND DISCUSSION

General

The evaluation of the cyclic communications switch integration was conducted in five phases. Phase I involved a paper evaluation of possible options. Phase II was conducted on the ground to functional check the communications modification. Phase III was designed as ground-based pilot tasking prior to study preliminary pilot acceptability and operational communications reliability. Phase IV examined pilot flight maneuver and communications performance, modification reliability, and pilot acceptance during inflight maneuvers at Moffett Field, California and Navy Crows Landing. Phase V involved operation of the aircraft and communications system during normal air traffic control operations and further assessed pilot acceptance of the modification along with reliability and performance.

Phase I Design Modification Selection

Initially three design options were presented to pilots on paper to evaluate. The options were based on ease of modification while still allowing the pilot the ability to discretely select radios at the cyclic radio/ICS switch as discussed in Army suggestion HA 80/85 (appendix A). These three options required a small interface unit and additional cyclic wiring but did not require a modification of the C-6533 ICP. However, the first three options were considered inadequate due to probable negative habit transfer between the present Cobra communications configuration and the proposed configuration. After conferring with the operational pilots two more options were considered. Both additional options (four and five) required minor modification of the C-6533 unit which project personnel were attempting to avoid so that possible fleet modification would be easier and less expensive. After further evaluation Option five was considered as the only acceptable option by pilots and researchers since this option would allow easy progression from the current configuration to the new system.

Phase II Functional Ground Checks

Function checks of the system were completed without incident. The system operated as specified after installation and did not create any noticeable electronic emissions or interference.

Phase III Ground Testing

Ratings were obtained from pilots that were not qualified in the Cobra helicopter to reduce selection predisposition. The pilots proceeded through a series of five separate radio-change setting in the cockpit using both the original and modified systems. Ratings were then obtained using the BWRS. The results showed pilots clearly rated the modified system better for reducing workload. The mean rating for the original system on the BWRS was 2.6, while the proposed system had a mean of 1.4. This difference was significant, $F(1,4) = 20.2$, $p < 0.01$.

Phase IV Flight Maneuvers

General– Pilots were instructed to maintain the same level of aggression when performing the same maneuver across all communications configurations. As shown in table 2 maneuver time was nearly constant for each set of identical maneuvers indicating the pilot's capability to hold this variable constant and replicate the same level of time-maneuver aggression.

On several occasions pilots using the original system were unable to complete the communications task during the maneuver as indicated in table 2. All pilots using the modified system were able to complete the communications tasking while performing all test maneuvers. The radio switching completion time for the original system of those who were able to complete the communications tasking was approximately twice that of the pilots using the modified system. This indicated greater communications effectiveness when using the modified switching configuration. Increased effectiveness helps eliminate problems experienced with delayed communications when the pilot is required to maintain "hands-on controls" during flight in the nap-of-the-Earth (NOE) environment.

The BWRS were gathered from Cobra qualified pilots after each maneuver and radio-switching task. The mean BWRS across all pilots and maneuvers are shown in figure 15. Higher BWRSs shown

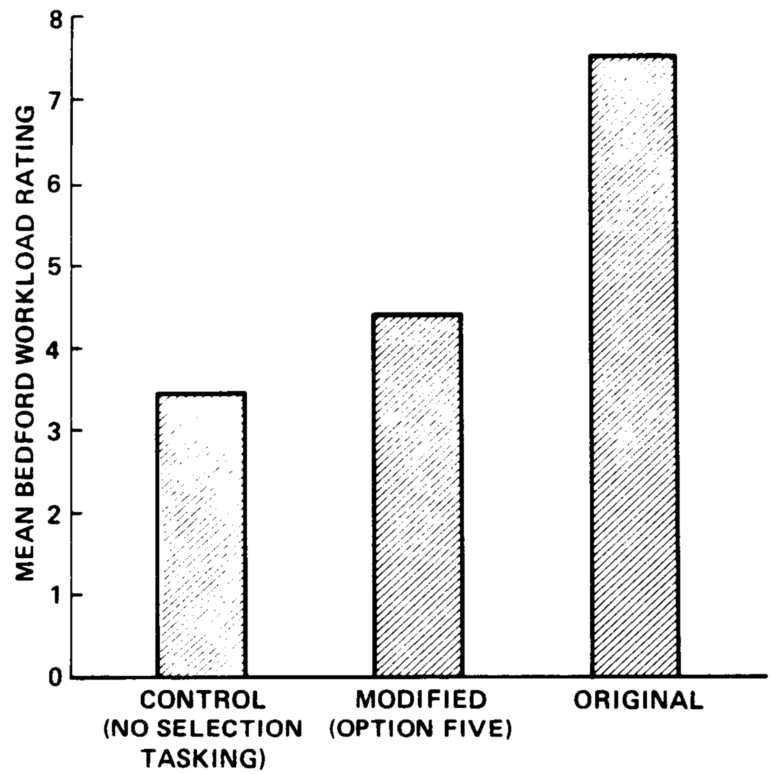

Figure 15.– Switching conditions.

for the original condition are indicative of the pilots' difficulty in completing radio switching tasks using the current Cobra switching configuration under conditions tested. The lower workload ratings associated with the modified condition are indicative of the ease of use of the modified system by pilots during flight maneuvering.

The ability to select and key a selected radio while maintaining "hands-on flight" has definite safety implications. Many situations have existed where an aircraft has sustained flight control problems caused by combat or other damage and the pilot cannot afford removing his hand from a flight control to communicate with other team aircraft or emergency facilities. Another condition that exists because of the operational need to fly in degraded weather conditions at night is the possibility of entering inadvertent Instrument conditions. Obviously it would be helpful to select radios without inducing vertigo by searching inside the cockpit or having to remove one's hand from the flight control to communicate. The ability to select radios while maneuvering will also reduce the need to transfer flight controls to the other pilot; transferring flight controls has led to reported misunderstanding of who was flying the aircraft.

Pilots reported a feeling of increased safety and reduced workload using the modified communications configuration. Reported pilot workload was higher using the original configuration in comparison to the modified configuration because of the following:

a. Requirement to look inside the cockpit and/or to feel inside the cockpit to find the communications switch during eyes-out flight at low altitude

b. Additional mental workload associated with time estimation as to when and how long the pilot could safely remove his hand from a flight control to effect a radio selection during low-altitude maneuvering

c. Physical reaching requirement

d. Sudden required reentries back to the flight controls after aircraft altitude abruptly deviates from the expected course during flight

e. Inadvertent flight control inputs when returning the hand back to the controls causing the aircraft to deviate from intended path

f. Selection of the incorrect radio with the left hand because of time pressures in maneuvering flight and the competing need for the same hand to be at two locations at the same time

Hovering Flight

General– Hovering flight was conducted on the Crows Landing ramp area. As predicted, maneuvers requiring nearly constant use of the collective competed with the pilot's ability to select radios when using the original communications system. Pilots using the original system were unable to complete the communications task when maneuvers required a high frequency or constant use of collective control stick.

Aircraft position data obtained from the laser tracker indicated a slight trend toward more ground drift when using the modified switch configuration during stabilized hover and out-of-ground effect hovering turns. Slightly increased ground drift indicated inadvertent movement of the cyclic control during activation of the radio/ICS switch because of the unfamiliarity of the pilot with physical use of the radio/ICS switch in the lateral directions, higher than optimal radio/ICS switch spring forces, location of the switch and the direction of switch activation. Another possible contribution to increased movement was lack of visual feedback cues indicating movement during hovering flight on the flat ramp area. Orange marker cones were provided on the ramp for position information, but were not sufficiently adequate for precision hovering flight. Horizontal aircraft movement during switch activation was also confirmed verbally by subject pilots who reported inadvertent lateral inputs in the lateral control system (lateral cyclic) during the earlier stages of flight until they became more accustomed to the modified switch configuration. These maneuvers should be flown in an operational context to determine if the increase in horizontal ground drift is significant for operational flight.

Increased vertical drift was predicted because of removal of the hand from the collective to select radios at the interphone panel when using the original communications system. Subjective data collected during hovering flight indicated decreased performance and higher workload in vertical axis control during maneuvers that accompanied use of the original system.

The safety pilot recovered the aircraft on two occasions during hovering flight when using the original system. Two pilots inadvertently made downward step inputs to the collective control near the ground while trying to rapidly return their left hand from the ICP radio selector to gain vertical control. Another recovery was made by the safety pilot when one pilot did not accurately estimate loss of altitude during a slalom course maneuvering as the pilot was reaching to make a radio selection.

Takeoff to hover– During takeoff to hover the pilot was required to start the maneuver with collective full down and aircraft heading into the wind. The maneuver was completed when the pilot reached stable hover at an altitude of 3 ft. During the takeoff to hover the pilot was asked to complete the radio switching task prior to reaching stable hover. The average length of the maneuver was 10 sec. None of the pilots were able to complete the communications task while performing takeoff to hover using the original communications system. Lack of completion was due to the necessary collective control inputs that interfered with use of the left hand for the communications selection task and also the limited maneuver time.

The average HQRS and pilot workload ratings for the original configuration were 5.7 and 10 respectively. The average HQRS for the modified configuration was 3.3 with workload rated at 4.7. Laser tracker information indicated only very minimal difference in drift during takeoff to hover between communications configurations with a slightly higher maximum hover height when using the original configuration. Communication results indicate that it would be difficult for the pilot to respond and transmit over more than one radio during liftoff to a hover using the original configuration. The ability to even key one radio when using the original system is due to the fact that the first radio is already selected prior to the task. (See Radio Selection Tasks for explanation, appendix D.) The need to transmit over more than one radio during liftoff sometimes exists when transferring radios from ground to tower or when informing team aircraft of takeoff to hover during communications with the tower or ground control.

Stabilized hover– Pilots were instructed to maintain a hover altitude of 3 ft and to stabilize hover into the wind for a period of 30 sec. After collecting data in a headwind condition the pilot was instructed to hover the aircraft with a tailwind when winds were greater than 5 knots. Data taken during stabilized hover into a headwind indicated only small differences between configurations. Since the maneuver was essentially a stable maneuver requiring very little collective action and little time constraint, it was relatively easy for the pilot to remove his hand from the collective to make radio selections. Average time for communications tasks during hover with headwind was 10 sec for the original configuration and 6 sec for the modified configuration. However, hovering with a tailwind required almost constant flight-control action thus lengthening the time between radio selections.

Laser tracker data indicate a trend for slightly more horizontal movement over the ground when using the modified system during hover as shown in table 2. This is primarily due to activation of the cyclic in the lateral direction during radio selection tasks. Pilots verbally reported slight inadvertent lateral control actions during lateral-switch activation and indicated that inadvertent movements decreased after becoming accustomed to the new activation modes. These deviations were difficult to visually recognize during hover on the landing ramp, but were evident from laser tracker information.

The data collected on three pilots indicate that the pilots could not adequately perform the stabilized tailwind hover maneuver when attempting to communicate using the original system. An average HQRS of 7.3 as recorded under the original configuration indicates that pilots were unable to maintain the requested flight task standard during hover with a tailwind while those using the modified configuration were able to hover the aircraft within maneuver tolerances during the communication switching tasks. When required to hover in a tactical operation with a tailwind or crosswind, the pilot will find it difficult to select radio channels using the original communications system especially when the aircraft is near obstructions.

During stabilized hover into a headwind, the pilot can effectively operate the radio selector switch; however, wind disturbances will require the pilot to more actively control the aircraft. When this occurs

TABLE 2.– COMMUNICATIONS-SWITCH-INTEGRATION PERFORMANCE MEASURES

Maneuver and option	Handling quality (average)	Bedford workload (average)	Maneuver time (sec, average)	Radio selection/ communications time (sec, average)	Delta R* Horizontal	Delta Z* Vertical
Takeoff to hover						
Maneuver	2.8	2.5	10	NA**	NA	NA
Option five	3.3	4.7	12	6	0.6	NA
Original configuration	5.7	10.0	10	NC†	0.7	NA
Stabilized hover						
Maneuver	3.0	2.8	32	NA	NA	NA
Option five	3.2	2.8	33	6	1.2	0.1
Original configuration	3.8	4.5	31	10	0.1	0.5
Stabilized hover with tailwind						
Maneuver	5.7	5.0	30	NA	NA	NA
Option five	6.0	5.2	31	DD††	0.5	0.6
Original configuration	7.3	8.0	32	NC	1.8	1.1
Land from hover						
Maneuver	2.8	2.5	12	NA	NA	NA
Option five	3.8	5.5	12	4	0.2	NA
Original configuration	5.5	10.0	11	NC	0.4	NA
Bob up						
Maneuver	3.2	2.7	14	NA	NA	NA
Option five	4.0	4.0	16	5	0.7	NA
Original configuration	4.5	7.0	14	NC	0.4	NA
Out-of-ground-effect hovering turn						
Maneuver	4.2	4.3	28	NA	NA	NA
Option five	4.7	5.0	28	6	5.9	1.1
Original configuration	5.8	6.3	29	10	0.6	1.0
Bob down						
Maneuver	3.2	3.5	14	NA	NA	NA
Option five	3.8	4.2	14	5	0.6	NA
Original configuration	5.8	7.7	15	NC	2.9	NA
Maximum performance takeoff						
Maneuver	3.0	2.7	16	NA	NA	NA
Option five	3.3	3.7	18	6	NA	NA
Original configuration	3.3	6.7	17	NC	NA	NA
Acceleration and deceleration						
Maneuver	3.5	3.7	18	NA	NA	NA
Option five	3.8	4.0	17	5	NA	1.6
Original configuration	5.2	8.2	23	NC	NA	0.7

TABLE 2.– CONCLUDED.

Maneuver and option	Handling quality (average)	Bedford workload (average)	Maneuver time (sec, average)	Radio selection/ communica-tions time (sec, average)	Delta R* Horizontal	Delta Z* Vertical
Lateral unmask						
Maneuver	3.3	3.7	15	NA	NA	NA
Option five	3.8	4.3	15	5	NA	1.0
Original configuration	5.7	7.5	16	NC	NA	0.6
Rearward flight						
Maneuver	4.2	4.2	21	NA	NA	NA
Option five	4.3	5.0	20	6	NA	0.8
Original configuration	6.4	8.2	20	NC	NA	1.1
Slalom course						
Maneuver	4.8	5.2	75	NA	NA	NA
Option five	4.8	5.6	71	11	NA	NA
Original configuration	7.0	8.6	69	17	NA	NA

*Delta R and Z = the average deviation from the starting point in feet as compared to the baseline maneuver.
**NA = not applicable.
†NC = one or more pilots were not able to complete communication task.
††DD = data drop.

the pilot will perform communications/radio selection tasks more effectively with the modified system since he does not have to take his hand off an active flight control.

Landing from hover– Pilots were instructed to land the aircraft from a stabilized 3-ft hover. The maneuver was considered complete after landing and when the collective was placed full down. As with the takeoff-to-hover maneuver, the maneuver time was brief (approximately 11 sec). None of the pilots were able to complete the communications switching tasks using the original communications system. All pilots were able to complete the communications switching tasks easily using the modified system. Communications tasking under the modified configuration (Option five) lasted 4.34 sec. During one exercise, the safety pilot recovered the aircraft as the subject pilot came close to unexpectedly touching down. The recovery occurred when the subject pilot was performing communications switching tasks using the original configurations and the pilot's hand was off the collective. Information collected during landing from a hover demonstrates the increased communications effectiveness and increased flight safety when the pilot communicates using Option five during touchdown.

Bob-up (simulated unmask)– A simulated, unmasked bob-up maneuver was made from an original hover altitude of 3 ft to an altitude of 50 ft. The maneuver was started and finished with stabilized hover at the specified altitudes. Three pilots were unable to complete the communications tasks using the original communications system while all six pilots completed the communication tasks with the modified system.

Pilots reported the modified communications configuration as being easy to use with an enhanced level of comfort since the pilot could constantly maintain his hand on the collective. By remaining on the collective control pilots predicted that they could easily terminate the bob-up at any point during the vertical ascent. The hands on collective capability is important during bob-up especially when operating in conditions where the aircraft is power or tail-rotor limited and may have to be recovered during bob-up. In addition, from a tactical point of view it may be important to rapidly stop the bob-up sequence if unexpectedly exposed to threat. Use of two radios during bob-up maneuvering as demonstrated by the present communications scenario would not be unusual especially when the pilot is performing a targeting function in concert with a ground battle commander and wing aircraft.

Out-of-ground-effect hovering turn– A left 360° hovering turn was performed at a hover altitude of 50 ft. The maneuver was started and finished at a stable hover with heading into the wind. Laser tracker information indicated slightly more horizontal displacement using the modified communications system in comparison to maneuver performance without communications tasking and the original system. This most likely indicates the same phenomena as during stabilized hover.

Subjective assessments indicate a slightly higher workload for the original configuration compared to the modified configuration. The average maneuver length was 28 sec with the communications task for the original configuration lasting 10 sec and the modified configuration lasting 6 sec. Enough time was available to easily complete the communications task using either configuration.

Bob-down (simulated remask)– The pilot was instructed to bob the aircraft down from a stabilized 50-ft hover to a 3-ft hover. The maneuver was completed when the hover was stabilized at 3 ft. Half of the pilots were not able to complete the communications tasking using the original communications system during bob-down. Pilots indicated difficulty since it was felt that aircraft safety could be compromised if they tried to switch radios using the original configuration during vertical descent and recovery near the ground. Pilots were able to complete the communications task during bob-down using the modified system with relative ease. Pilots also indicated that they were much more at ease flying the aircraft and communicating when using the modified system since they did not have to remove their hand from the collective. Average time to complete the radio selection task was 5 sec for the modified configuration.

Low-Speed Maneuvering

General– The following low-speed maneuvers were primarily performed on the large ramp area and on inactive runways at Crows Landing. These maneuvers simulated low-speed maneuvers conducted in low-altitude mission environments.

Acceleration and deceleration– Accelerations and decelerations were performed at an altitude of 50 ft. The distance between stop and start points was 400 ft. The average maneuver time was 18 sec. One-third of the pilots were unable to complete the communications selection procedure using the original configuration because of the active use of the collective controller during the acceleration and deceleration. The average time to communicate using the modified configuration was 5 sec. Communications tasks with the original configuration were performed during a short period of time between the acceleration and deceleration maneuver. This created a situation where the pilot was rapidly moving his hand to make radio selections and errors were made in the manual selection process. All radio selection tasks were accomplished under the modified configuration. Laser tracker data indicated only small differences in maneuver altitude variation between communications configurations.

Lateral unmask and remask– The aircraft was flown laterally between two runway lights. The distance between start and stop points was 200 ft. Hover altitude was 20 ft. The average maneuver time was 15 sec. Two pilots were unable to complete the communications selection task using the original communications system and workload was considerably higher when compared to the modified system. All pilots completed the communications task and the average time for completion of the task for the modified system was 5 sec. Both HQRS and BWRS data indicated higher workload and decreased performance with the original configuration.

Rearward flight– Pilots were instructed to hover rearward 400 ft at a hover altitude of 20 ft. The average maneuver time was 21 sec. More variation was shown in the vertical axis under the original configuration condition when compared to the other conditions. Two pilots were unable to complete the communications tasks using the original communications system. All pilots completed the communications tasking using the modified system at an average time of 6 sec. Again both HQRS and BWRS ratings were higher indicating higher workload and decreased performance using the original option. Pilots complained about the need to look inside the cockpit to use the original switching configuration during rearward flight since aircraft heading and the rearward course could not be actually tracked when the pilot looked inside to select radios.

Slalom course with vertical maneuvering– The slalom course distance from start to finish was 2000 ft. Pilots were required to fly a slalom maneuver between runway lights that were spaced 200 ft apart. To help simulate NOE operation the pilot was required to change aircraft altitude 20 ft between each light. Maneuver time was approximately 72 sec. Since the maneuver lasted more than 30 sec the pilot was asked to perform the communication selection tasks twice for better radio selection tasking assessment.

Subjective pilot comments indicated that pilot workload was very high when using the original configuration and interfered with the ability of the pilots to maneuver precisely, even when the maneuver standards were emphasized. Pilots reported that they could only safely make a communication selection with the left hand during vertical climbs and not descents. One pilot experienced difficulty when trying to make a radio selection with the left hand during a descending right turn as the aircraft descended faster than planned. The pilots experienced the additional mental workload of estimating when and how long they could remove their hand from the collective to perform communications tasking. Laser tracker information was unusable for this maneuver since laser lock-on was broken by the side to side maneuvering which masked the laser tracker during the slalom course runs.

Pilots were unable to perform radio switching tasks under the original communications configuration during simulated NOE flight without reducing flight performance. The requirement to remove one hand from the flight control to select radios during active maneuvering flight means that the pilot will most likely have to compensate by reducing his flightpath workload in order to select radios. The pilot may decide to stop and hover, slow his airspeed or allow greater deviations in the vertical axis to select radios for communications.

Maximum performance takeoff (simulated terrain flight takeoff over barriers)– The takeoff was performed from the ground with the collective full down. During takeoff the pilot was asked to maintain a 40-knot attitude and maintain power 10% to 15% above hover power. Communication tasking was stopped once the pilot leveled the aircraft at 100 ft. The maneuver length was approximately 17 sec. As with other maneuvering, workload was higher using the original configuration; however, observed maneuver performance was essentially the same.

Terrain flight approach– The simulated terrain flight approach was performed from 100 ft at an approach angle of approximately 5 to 8°. The maneuver ended with a smooth and controlled termination to the ground. The maneuver length did not require constant utilization of the collective once the aircraft was on the approach angle to the point of intended landing. This allowed the pilot adequate time to easily select radios during the descent.

Up and away flight– As predicted, straight and level flight, right turns around a ground point, climbs, descents, and right climbing and descending turns as described in appendix D demonstrated little difference between HQRS and workload. Since these maneuvers do not require constant use of the collective in flight the radio switching tasks were easy to perform when using either configuration.

Phase IV—Flight in air traffic control environment– No other significant comments were gathered during flight in the air traffic control environment. Pilots generally felt that the modified radio/ICS switching configuration was easier to use than the original switch configuration and recommended Cobra fleet modification.

Radio-selection retention– Researchers predicted a decreased pilot ability to recall the last selected radio when using the modified configuration in comparison to the original configuration. The selector switch on the ICP always retains the last selected position whereas the modified configuration does not. At random points during flight the pilots were tested on their ability to remember the last radio selected. Pilots did not demonstrate a decreased capability to remember the last selected radio during flight since they were able to associate a particular radio to their last conversation. However, researchers still estimate a slightly decreased capability for retention of the last radio selected.

Pilot comments– Pilot comments were recorded and are presented in appendix E. They indicated a strong preference for the modified communication system. According to the pilots, the modified system reduced pilot workload, increased pilot maneuver and communications performance, and enhanced flight safety. Pilots also predicted a significant benefit during night NOE operations with night-vision goggles since the pilot would not have to look under the goggles inside the darkened cockpit to select a radio. Pilots indicated that the switch spring tension should be reduced in the lateral direction.

CONCLUSIONS

General

The following conclusions were reached upon completion of the CSIP testing:

a. The modified communication configuration indicates significantly better aircraft handling qualities and reduced pilot workload during low-altitude maneuvering flight when compared to the original configuration.

b. The modified communications configuration permits the pilot to leave his hand on the collective during communication/radio selection tasking. It is estimated that flight safety and flightpath performance would be greatly enhanced during aircraft operation in the NOE environment with the modified configuration.

c. Situation awareness and flight safety is increased with the modified communications configuration since the pilot does not have to look inside the cockpit to visually verify a radio selection in the NOE heads-out operational environment.

d. The modified communications configuration increased communications effectiveness.

e. The modified communications configuration demonstrated an increased capability to communicate and fly during degraded flight control situations and during incapacitation of the other crew member.

f. The modification proved reliable, functional and free of electromagnetic interference during the period of the flight test.

Problem Areas

The following problem areas associated with the communications modification were identified, but not corrected:

a. Tendency for slightly increased ground position drift during activation of the radio/ICS in the lateral direction owing to the cyclic switch spring forces (Hover Flight section).

b. Probable negative habit transfer regarding use of the modified radio/ICS until appropriate training has occurred (Stabilized Hover section).

c. While not demonstrated during flight testing it is predicted that there will be a slightly diminished pilot ability to recall the last selected radio since the modified switch does not retain the last radio position when compared to the original configuration (Radio-Selection Retention section).

d. While not documented during flight test it is predicted that pilots may on occasion inadvertently transmit over a selected radio without the appropriate audio receiver being selected. The pilot should rapidly recognize that the radio receiver has not been selected since the normal audio feedback (side tone) will not be present during transmission. The auditory feedback characteristic is very similar to the original system when the pilot accidentally transmits without turning on the selected radio.

Recommendations

The following recommendations are made:

a. The appropriate agency should direct study requirements to determine logistic concerns and appropriate solutions for installation of the communications modification (Option 5) in fleet aircraft.

b. Continue operational testing of the modified communications configuration at organizational flight test units such as the U.S. Army Engineering Flight Activity at Edwards Air Force Base and the Aviation Flight Test Facility at Ft. Rucker, Alabama.

c. Decrease lateral spring tension on the cyclic radio/ICS switch to avoid inadvertent control inputs to the control system when activating the cyclic radio/ICS switch (Hover Flight section).

d. Establish cost and schedule estimates for implementation of modification Option 5.

e. Continue to study identified and predicted problem areas sited and determine if these areas are significant to operational flight.

f. Modify the present Cobra communications system as soon as possible after steps a through e above are completed to allow for discrete radio selections at the pilot's radio/ICS switch.

g. Investigate possible integration of the modified communications system (Option 5) into the UH-1H fleet aircraft.

REFERENCES

1. Mitchner, Marvin E., Jr. (ed.): Aircrew Coordination and Communication. Flight Fax, vol. 16, no. 27, Sept. 1988.

2. Operator's Manual. Army Model AH-1S (MOD) Helicopter, Headquarters, Department of the Army, TM-1520-234-10, November 1976.

3. Operator's Manual Supplement. Army Model TH-1S (PNVS) Helicopter, Headquarters, Department of the Army, TM-1520-234-10 Supplement, July 1984.

4. Cooper, G. E.; and Harper, R. P.: The Use of Pilot Rating in the Evaluation of Aircraft Handling Qualities. NASA TN D-5153, 1969.

APPENDIX A

INTRODUCTION

The following suggestion HA 80/85 was submitted through Army channels for investigation, evaluation and report as to possible adoption or rejection. The suggestion proposed redirecting the functional application of the cyclic radio/ICS switch to enhance safety and increase communications effectiveness. However, to implement the suggestion a detailed avionics analysis had to be accomplished. Careful consideration of the suggestion was made by designated Army personnel who determined that the suggestion warranted prototype hardware evaluation.

After careful study five separate design iterations were drafted for consideration. During manprint studies only one design was considered appropriate for hardware and flight evaluation as discussed in the main text of this report.

For use of this form, see AR 672-20, the proponent agency is Office of the Deputy Chief of Staff for Personnel.

TO: (Include ZIP code)	FROM: (Include ZIP code)
4th Bde, 3rd AD ATTN: AETFOK-XO (MAJ Clapp) APO 09165	Hanau MILCOM ATTN: CPO-IA APO 09165-0021
1. SUGGESTION TITLE Rewiring of the Radio/ICS Switch in the AH-1S(MC) Helicopter	2. SUGGESTION NUMBER HA 80/85

3. ACTION TAKEN OR RECOMMENDED

- a. APPROVED FOR ADOPTION ☐ TOTALLY ☐ PARTIALLY OR WITH MODIFICATION (Explain in item 4)
  - DATE SUGGESTION WAS OR WILL BE PUT INTO EFFECT
  - ☐ ALSO RECOMMEND CONSIDERATION FOR WIDER APPLICATION AS INDICATED IN ITEM 4
- b. ALREADY IN USE OR UNDER CONSIDERATION (Explain in item 4 indicating whether this suggestion contributed to the action in any way)
- c. NOT APPROVED FOR ADOPTION FOR REASONS SHOWN IN ITEM 4
- d. RECOMMEND ADOPTION, BUT APPROVAL NOT WITHIN JURISDICTION OF THIS OFFICE. REASONS FOR RECOMMENDATION ARE CONTAINED IN ITEM 4.
- e. NOT RECOMMENDED FOR ADOPTION FOR REASONS SHOWN IN ITEM 4
- f. OTHER (Specify in item 4)

4. REASONS FOR ACTION TAKEN OR RECOMMENDED (If more space is needed, continue on reverse)

1. Reference: Para 2-4, Chapter 2, AR 672-20, and USAREUR Suppl 1, thereto.

2. Forwarded for investigation, evaluation and report as to possible adoption or rejection is suggestion # HA 80/85 . In accordance with reference 1., above, suggestion should be evaluated as expeditiously as possible using DA Form 2440 (Suggestion Evaluation - 4 copies attached). When it is determined that evaluation can not be completed within 30 days after receipt of the suggestion, it is required that the suggester will be so informed by the Incentive Awards Office. You are, therefore, requested to return your evaluation by 17 Mar 87 or to give an interim progress report either in writing or by telephone by the same suspense date.

5. BENEFITS (Complete for all suggestions adopted or recommended for adoption)

- ☐ a. TANGIBLE (Show actual or estimated dollar savings in terms of man-hours or personnel spaces; estimated savings based on increased output; and/or materials, equipment or other resources saved; for the first year subsequent to adoption. Indicate cost of conversion and net first year savings)
- ☐ b. INTANGIBLE (Describe effect on operations, health, safety, welfare, or morale; and number of people and specific organizations affected. Based on criteria in AR 672-20, indicate whether significance is considered moderate potential value, substantial potential value, high potential value, or exceptional potential value and whether application is limited, extended, broad, or general)

3. If the suggestion is considered desirable and practical but cannot be adopted locally DO NOT RETURN SUGGESTION TO THE INCENTIVE AWARDS OFFICE but forward it with your evaluation on DA Form 2440 directly to the next echelon office of primary interest having jurisdiction over the subject matter. In this case a copy of your evaluation will be furnished the Hanau Area Civilian Personnel Office, ATTN: Incentive Awards, APO 09165, as advice of the suggestion referral.

3 Encls
1 - Resubmitted Case File Suggestion #HA 80/85
2 - DA Form 2440 (in quad)
3 - Guide to calculate awards

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6. DATE	7. NAME, TITLE, & TELEPHONE EXT OF EVALUATOR	8. SIGNATURE & TITLE OF RESPONSIBLE OFFICIAL
17 Feb 87		E. ENGEL, Inc. Awards Admin. ETS 322-8244 [signature]

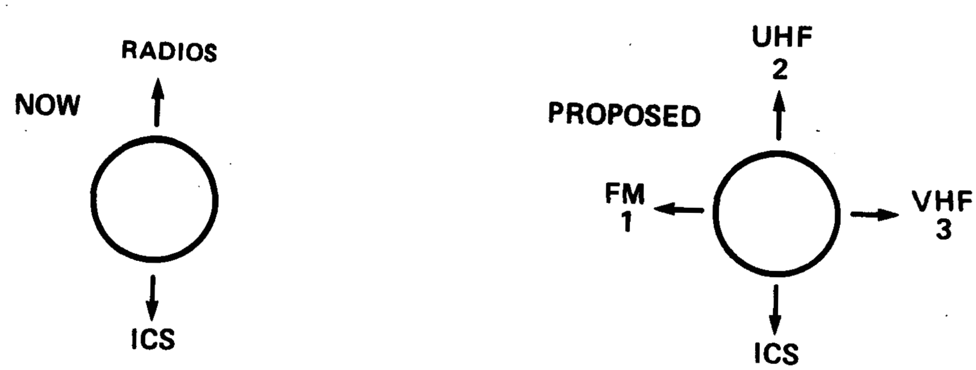
DA FORM 1 JUN 72 2440 EDITION OF 1 JUN 61 IS OBSOLETE.

Rewiring of the Radio/ICS Switch in the AH-1S(MC) Helicopter | HA 80/85
15. SUGGESTION NUMBER

18. DESCRIPTION (Describe the Current Situation and your Suggestion for change or improvement. Include where and how it can be used, and identify estimated tangible/intangible benefits which would result from adoption.)

At present there is a four position switch (the 'Chineese' hat) on both the pilot's and the gunner's cyclic grips which are not being fully utilized. Only the forward and rearward positions are being used; the forward for transmitting on the radio selected by the transmitter select switch on the Intercommunications Set (ICS) C-6533 or C-1611, and rearward for intercommunications between the two crew positions. The other two positions are unused. I propose that the switch be rewired in the following, or a similar, manner. Left would be for transmitting on the Number 1 (FM) radio, forward for the Number 2 (UHF) radio, right for the Number 3 (VHF) radio and rearward for the crew intercom position. The advantage of this is that it allows the crewmembers to communicate much more efficiently and effectively on any of the radios installed in the aircraft. This is accomplished through the elimination of the need for the crewman to take his hand off the flight controls to switch the radio selector on the ICS panel. This not only provides easier communications on numerous radios, but also increases safety by eliminating the need for taking one's hand off of a flight control while flying in a terrain flight mode or while at a hover as is now necessary. The rewiring of the switch can be done. It was done in the 1970's by the Army's Precision Helicopter Demonstration Team, the Silver Eagles which modified its aircraft, the OH-6 Cayuse.

SUGGESTION FINISHED? Refer to Instruction Numbers 2 & 3 on reverse side of this set.
NEED MORE SPACE? Reverse entire set. Pull out long carbons. Reverse and reinsert long carbons. Continue under Item 18.



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APPENDIX B

DESIGN ITERATIONS

The following design iterations were evaluated by experienced Cobra crew members and technical experts prior to hardware and flight evaluation. Based upon these evaluations the Option 5 design shown in figure B-5 was chosen for evaluation as described in the text of this report.

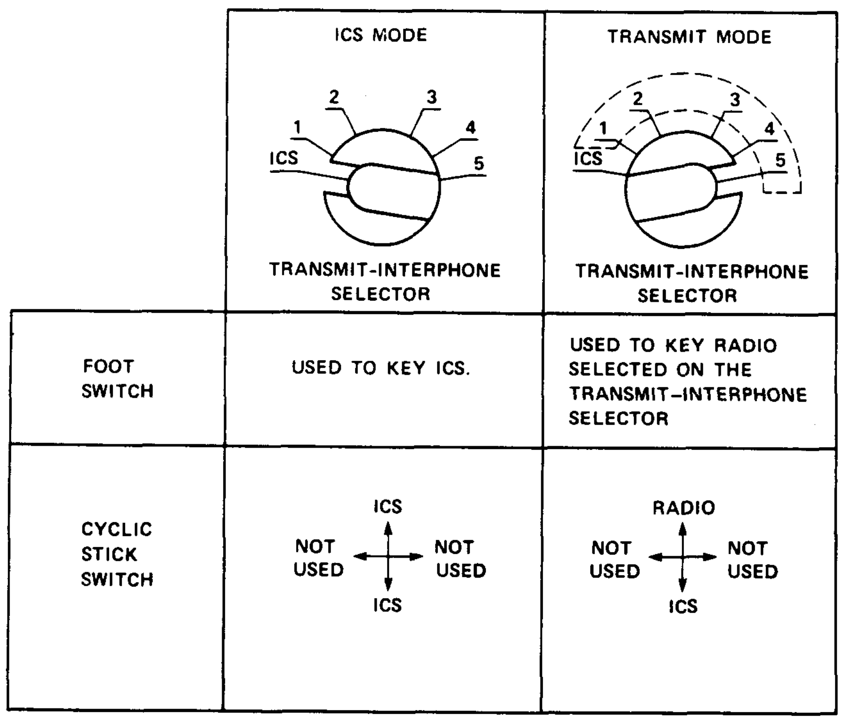

Figure B-1.– Original configuration.

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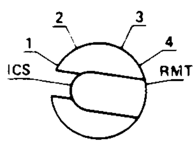
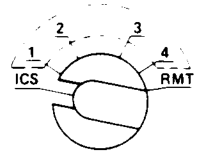
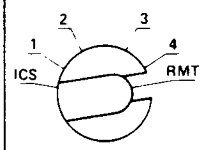
	ICS MODE	TRANSMIT MODE	REMOTE MODE
	 TRANSMIT-INTERPHONE SELECTOR	 TRANSMIT-INTERPHONE SELECTOR	 TRANSMIT-INTERPHONE SELECTOR
INTERPHONE CONTROL PANEL	ALL FUNCTIONS REMAIN UNCHANGED. REF. TM 55-1520-236-10 FIGURE 3-3.	ALL FUNCTIONS REMAIN UNCHANGED. REF. TM 55-1520-236-10 FIGURE 3-3.	TRANSMIT-INTERPHONE SEL. REMOTED TO CYCLIC STICK. ALL OTHER FUNCTIONS REMAIN UNCHANGED.
FOOT SWITCH	USED TO KEY ICS.	USED TO KEY ICS.	USED TO KEY ICS.
CYCLIC STICK SWITCH	ICS (up) ICS (left) ICS (right) ICS (down)	RADIO (up) RADIO (left) RADIO (right) ICS (down) RADIO IS SELECTED BY TRANSMIT-INTERPHONE SELECTOR.	RADIO =2 (up) RADIO =1 (left) RADIO =3 (right) ICS (down) RADIO =1 IS VHF-FM RADIO =2 IS UHF RADIO =3 IS VHF-AM

Figure B-2.– Option 1.

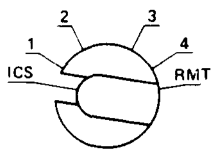
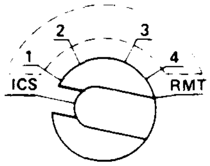
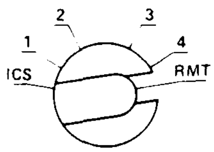
	ICS MODE  TRANSMIT-INTERPHONE SELECTOR	TRANSMIT MODE  TRANSMIT-INTERPHONE SELECTOR	REMOTE MODE  TRANSMIT-INTERPHONE SELECTOR
INTERPHONE CONTROL PANEL	ALL FUNCTIONS REMAIN UNCHANGED. REF. TM 55-1520-236-10 FIGURE 3-3.	ALL FUNCTIONS REMAIN UNCHANGED. REF. TM 55-1520-236-10 FIGURE 3-3.	TRANSMIT-INTERPHONE SEL. REMOTED TO CYCLIC STICK. ALL OTHER FUNCTIONS REMAIN UNCHANGED.
FOOT SWITCH	USED TO KEY ICS.	USED TO KEY RADIO.	NOT INTENDED TO BE USED IN THIS MODE. SYSTEM WILL BEHAVE AS IF A RADIO WAS KEYED, BUT NO RADIO WILL TRANSMIT.
CYCLIC STICK SWITCH	ICS (up) ICS ◄ ► ICS ICS (down)	RADIO (up) RADIO ◄ ► RADIO ICS (down) RADIO IS SELECTED BY TRANSMIT-INTERPHONE SELECTOR.	RADIO =2 (up) RADIO =1 ◄ ► RADIO =3 ICS (down) RADIO =1 IS VHF-FM RADIO =2 IS UHF RADIO =3 IS VHF-AM

Figure B-3.– Option 2.

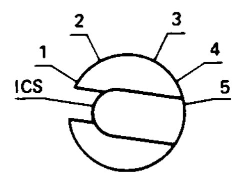
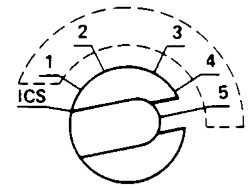
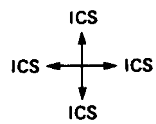
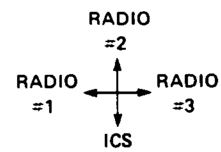
	ICS MODE	REMOTE MODE
	 TRANSMIT-INTERPHONE SELECTOR	 TRANSMIT-INTERPHONE SELECTOR
INTERPHONE CONTROL PANEL	ALL FUNCTIONS REMAIN UNCHANGED. REF. TM 55-1520-236-10 FIGURE 3-3.	TRANSMIT-INTERPHONE SEL. REMOTED TO CYCLIC STICK. ALL OTHER FUNCTIONS REMAIN UNCHANGED.
FOOT SWITCH	USED TO KEY ICS	USED TO KEY ICS
CYCLIC STICK SWITCH	 ICS (up), ICS (left), ICS (right), ICS (down)	 RADIO =2 (up), RADIO =1 (left), RADIO =3 (right), ICS (down) RADIO =1 IS VHF-FM RADIO =2 IS UHF RADIO =3 IS VHF-AM

Figure B-4.– Option 3.

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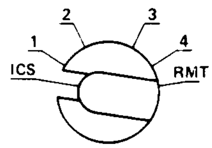
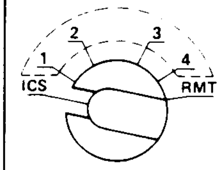
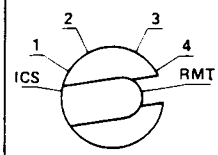
	ICS MODE	TRANSMIT MODE	REMOTE MODE
	 TRANSMIT-INTERPHONE SELECTOR	 TRANSMIT-INTERPHONE SELECTOR	 TRANSMIT-INTERPHONE SELECTOR
INTERPHONE CONTROL PANEL	ALL FUNCTIONS REMAIN UNCHANGED. REF. TM 55-1520-236-10 FIGURE 3-3.	ALL FUNCTIONS REMAIN UNCHANGED. REF. TM 55-1520-236-10 FIGURE 3-3.	TRANSMIT-INTERPHONE SEL. REMOTED TO CYCLIC STICK. ALL OTHER FUNCTIONS REMAIN UNCHANGED.
FOOT SWITCH	USED TO KEY ICS.	USED TO KEY RADIO.	USED TO KEY ICS.
CYCLIC STICK SWITCH	ICS (up), ICS (left), ICS (right), ICS (down)	RADIO (up), RADIO (left), RADIO (right), ICS (down) RADIO IS SELECTED BY TRANSMIT-INTERPHONE SELECTOR.	RADIO =2 (up), RADIO =1 (left), RADIO =3 (right), ICS (down) RADIO =1 IS VHF-FM RADIO =2 IS UHF RADIO =3 IS VHF-AM

Figure B-5.– Option 4.

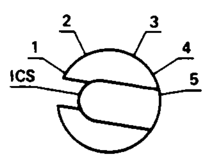
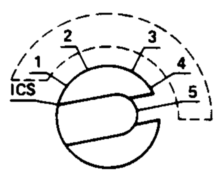
	 TRANSMIT-INTERPHONE SELECTOR	 TRANSMIT-INTERPHONE SELECTOR
INTERPHONE CONTROL PANEL	ALL FUNCTIONS REMAIN UNCHANGED. REF. TM 55-1520-236-10 FIGURE 3-3.	ALL FUNCTIONS REMAIN UNCHANGED. REF. TM 55-1520-236-10 FIGURE 3-3.
FOOT SWITCH	USED TO KEY ICS.	USED TO KEY RADIO SELECTED ON THE TRANSMIT-INTERPHONE SELECTOR
CYCLIC STICK SWITCH	RADIO #2 (up), RADIO #1 (left), RADIO #3 (right), ICS (down) RADIO #1 IS VHF-FM RADIO #2 IS UHF RADIO #3 IS VHF-AM	RADIO =2 (up), RADIO #1 (left), RADIO =3 (right), ICS (down) RADIO =1 IS VHF-FM RADIO =2 IS UHF RADIO =3 IS VHF-AM

Figure B-6.– Option 5.

APPENDIX C

DETAILS OF ELECTRICAL DESIGN

Figure C-1 shows the basic block diagram of the modification to the C-6533/ARC communication system for design Option 5 (fig. B-5). The modification to the system requires the following actions to be completed:

a. Fabrication of an interface unit.

b. Modification of the C-6533/ARC communication panel.

c. Attachment of the interface unit to the C-6533/ARC communication panel.

d. Removal of one wire from the base of the cyclic stick.

e. Addition of three new wires from the base of the cyclic stick to the interface unit.

Modification of C-6533 Control Panel

The following discussion references figure C-2a, b, and c. Figure C-2a of the drawing details the modification to the existing communication control panel C-6533/ARC. Three modifications are listed on that drawing:

a. Remove wire from Terminal 2 of switch S1A-Front and connect to pin JJ of connector J1 (figs. C-3 and C-4).

   This modification brings the transmitter audio out signal to pin JJ (a spare pin) for the interface unit to use. This is necessary so that the transmit audio out signal goes into the interface unit even when the transmit-interphone selector switch is in the ICS position.

b. Add a new wire from pin NN of connector J1 to terminal 2 of assembly VR1 (protective device and filter assy., fig. C-5).

   This modification provides a direct radio key input, bypassing the transmit-interphone selector switch.

c. Remove wire from terminal 9 of switch S1B-REAR. Insulate and secure wire.

   Remove wire from terminal 7 of switch S1A-REAR. Insulate and secure wire.

   Add a new wire from terminal 9 of switch S1B-REAR to terminal 7 of switch S1A-REAR.

   This modification is necessary so that when the cyclic stick switch is used for a radio selection, the radio selected with the transmit-interphone selector will not be keyed also.

Modification of Aircraft Wiring Harnesses

Included on the first sheet of the drawing set is the modification to the aircraft wire harness:

a. Unsolder wire 1C6533-2B22 from pin L of connector 4A3J1 (Pilot's Cyclic Stick Disconnect).

   Removing this wire disconnects the forward position of the cyclic stick switch from the footswitch.

b. Add three new wires from pins K, G and L of the pilot's cyclic stick disconnect (4A3J1) to the new connector (J2) of the interface unit.

   These wires correspond to the left, forward and right positions of the cyclic stick switch.

Interface Unit

The interface unit is shown in figure C-6 with the cover removed. Figure C-7 shows the interface unit attached to the C-6533/ARC Control Panel. A single top and bottom cover is attached to both units for greater strength. Figure C-8 shows the back side of the interface unit.

The interface unit contains only six relays and nine diodes (fig. C-2b). The function of three diodes (D11, D12 and D13) is the same as diode CR9 of the C-6533/ARC Control Panel. They prevent a ground on the key radio output lines from keying the radio circuits inside the panel. The other six diodes are protection devices for the six relay coils.

The six relays work in pairs. Relays K1 and K2 are energized when channel 1 is selected for transmission. Relays K3 and K4 are energized when channel 2 is selected. Relays K5 and K6 are energized when channel 3 is selected. Two more pairs of relays could have been added for channels 4 and 5, but were not added since only three positions were available on the cyclic stick switch.

Relays K1, K3, and K5 route the transmitter audio out signal to only the one selected radio. These relays serve the same function as the S1A-FRONT part of the Transmit-Interphone Selector Switch. The main reason for sending the signal to only one receiver is to allow the other radios to still function if one radio's transmit audio line shorts to ground.

Relays K2, K4, and K6 have two functions. One is to send the key signal (a ground) to the selected radio. The other function is to provide a key signal into the C-6533/ARC Control Panel when any of the three radios have been selected on the cyclic stick, or by the footswitch.

Notice on the drawing that the key radio outputs on the C-6533/ARC Control Panel do not go directly out into the wiring harness, but are used to energize the appropriate relay pair in the interface unit. These lines are used only with the foot switch to allow the foot switch to key whichever radio is selected on the transmit-interphone selector switch.

Sheet 3 (fig. C-2c) of the drawing set is the parts list for the interface unit.

Time Estimate for Modification

Only the aft cockpit was modified for the test. The amount of time it took to modify the system is listed below:

3 hr to modify the C-6533/ARC Control Panel.

20 hr to perform the electrical wiring in the interface unit

2.5 hr to modify and fabricate the aircraft wiring harnesses

Alternative Designs

If all the transmitter audio lines are tied together, then the interface unit will no longer be needed, and changes to the C-6533/ARC will not be required. This design is not suggested since neither pilot will be able to transmit on any of the radios connected to the communication system if a short circuit occurs on any of the transmit audio lines.

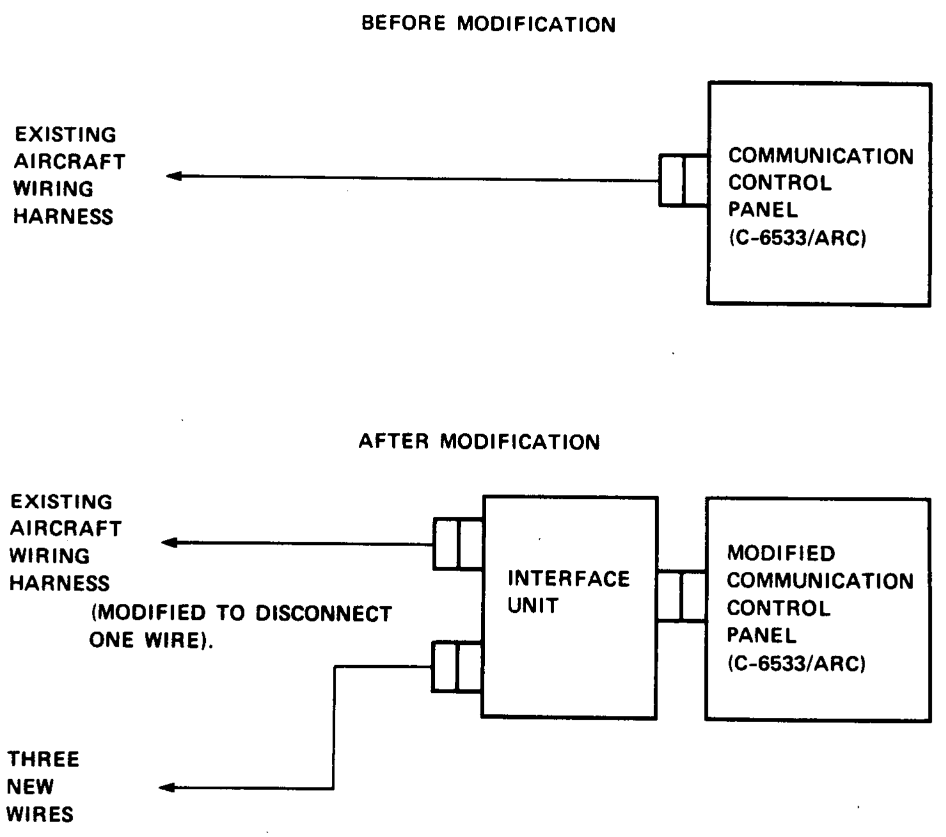


Figure C-1.– Modification of communication system for design option 5.

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CHANGES TO COMMUNICATIONS CONTROL PANEL C-6533/ARC

1.) DIRECT AUDIO OUTPUT

REMOVE WIRE FROM TERMINAL 2 OF SWITCH S1A-FRONT. EXTEND WIRE TO PIN JJ OF CONNECTOR J1.

2.) KEY RADIO - DIRECT INPUT

ADD A NEW WIRE FROM PIN NN OF CONNECTOR J1 TO TERMINAL 2 OF ASSEMBLY VR1 (PROTECTIVE DEVICE AND FILTER ASSY.)

3.) TRANSMIT SELECTOR INPUT

REMOVE WIRE FROM TERMINAL 9 OF SWITCH S1B-REAR. INSULATE AND SECURE WIRE.

REMOVE WIRE FROM TERMINAL 7 OF SWITCH S1A-REAR. INSULATE AND SECURE WIRE.

ADD A NEW WIRE FROM TERMINAL 9 OF SWITCH S1B-REAR TO TERMINAL 7 OF SWITCH S1A-REAR.

CHANGES TO AIRCRAFT WIRING HARNESSES

MODIFICATION OF PILOT'S COCKPIT:

1.) UNSOLDER WIRE 1C6533-2B22 FROM PIN L OF CONNECTOR 4A3J1 (PILOT'S CYCLIC STICK DISCONNECT) INSULATE AND SECURE WIRE.

2.) ADD THREE NEW WIRES FROM PINS K, G AND L OF THE ABOVE CONNECTOR TO PLUG P2 OF THE PILOT'S C-6533 INTERFACE UNIT.

FOLDOUT FRAME

FOLDOUT FRAME

LTR	ZONE	DESCRIPTION	DRAWN	APPROVED	DATE
		REVISIONS			

DRAWN Z. SZOBOSZLAY 11/30/87	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ENGINEER Z. SZOBOSZLAY 11/30/87	AEROFLIGHTDYNAMICS DIRECTORATE US ARMY AVIATION RESEARCH & TECHNOLOGY ACTIVITY
APPROVED [signature] 12/1/87	AMES RESEARCH CENTER MOFFETT FIELD, CALIFORNIA 94035
APPROVED	DRAWING TITLE 3 CHANNEL COMMUNICATION SYSTEM MODIFICATION C-6533/ARC AH-1S 77-22768
AIRWORTHINESS	SIZE D FSCM NO. 25307 DRAWING NO. A7730-8707-E1
	SCALE WEIGHT SHEET 1 OF 3

NEXT ASSEMBLY	USED ON
A7730-8707 M	77-22768
A7730-8707-E1	77-22768
APPLICATION	

Figure C-2a– Three channel communication system modification C-6533, sheet 1.

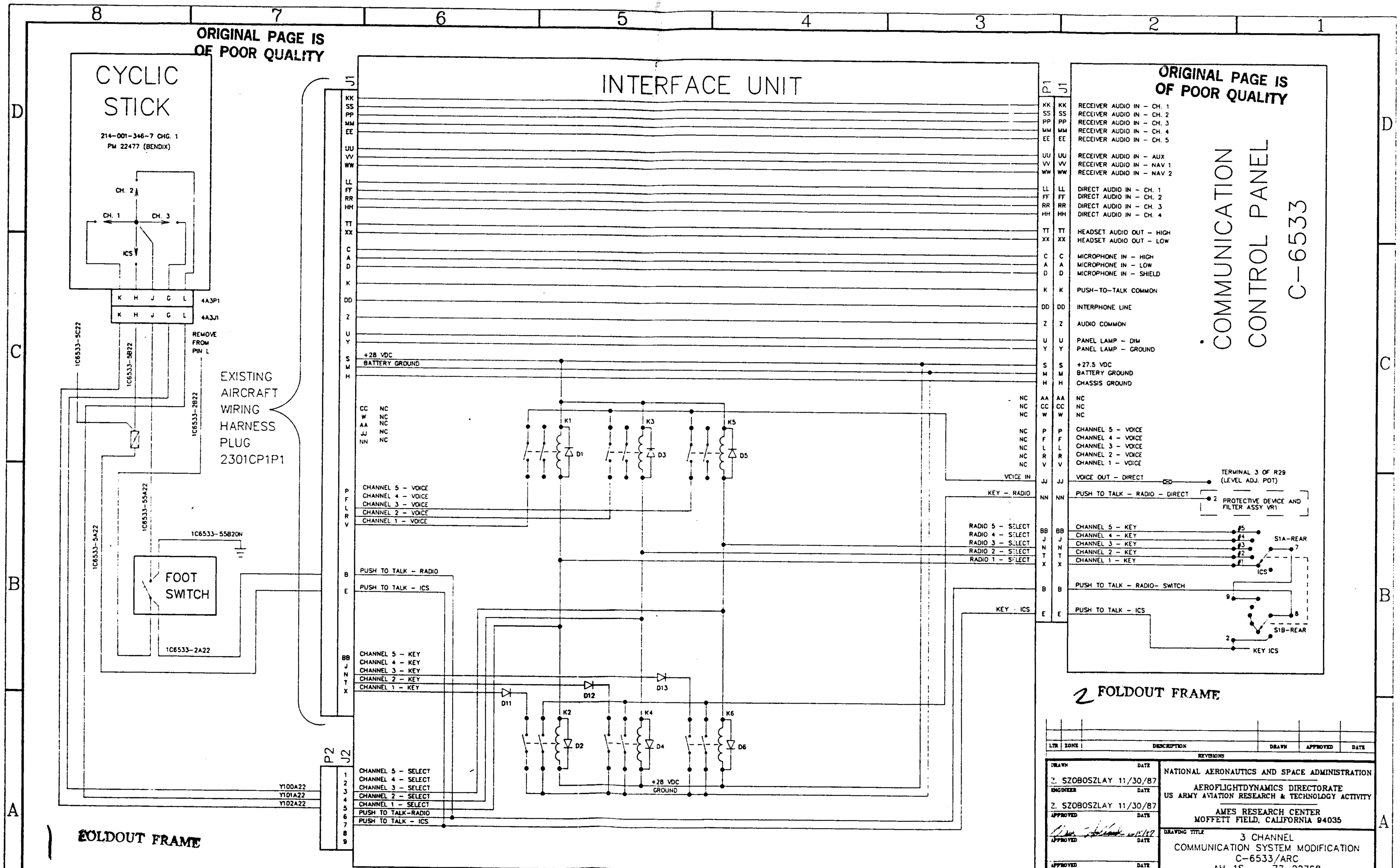

Figure C-2b.– Three channel communication system modification C-6533, sheet 2.

PARTS LIST

ITEM NO.	QTY	PART NO.	DESCRIPTION/NOMENCLATURE
	1	A7730-8707	CHASSIS, INTERFACE UNIT
		MIL-W-16878E/4A - 22AWG	WIRE, USE FOR INTERNAL WIRING OF INTERFACE UNIT
J1	1	42-20P	RECEPTACLE, INTERFACE UNIT, J1
P1	1	42-20S	PLUG, INTERFACE UNIT, P1
J2	1	M24308/2-1	RECEPTACLE, INTERFACE UNIT, J2
P2	1	M24308/4-1	PLUG, INTERFACE UNIT, P2
P2	1	DE44994 (ITT)	CABLE CLAMP, INTERFACE UNIT, P2
K1-K6	6	M39016/22-004M	RELAY 2A CONTACT, 26.5 VDC COIL
D1-D6	6	1N4247	DIODE
D7-D10			NOT USED ON THIS DRAWING
D11-D13	3	1N4247	DIODE

FOLDOUT FRAME

FOLDOUT FRAME

DRAWN	Z. SZOBOSZLAY 11/30/87
ENGINEER	Z. SZOBOSZLAY 11/30/87
APPROVED	[signature] 12/1/87

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AEROFLIGHTDYNAMICS DIRECTORATE
US ARMY AVIATION RESEARCH & TECHNOLOGY ACTIVITY
AMES RESEARCH CENTER
MOFFETT FIELD, CALIFORNIA 94035

DRAWING TITLE: 3 CHANNEL COMMUNICATION SYSTEM MODIFICATION C-6533/ARC AH-1S 77-22768

SIZE D | FSCM NO. 25307 | DRAWING NO. A7730-8707-E1 | SHEET 3 OF 3

Figure C-2c.– Three channel communication system modification C-6533, sheet 3.

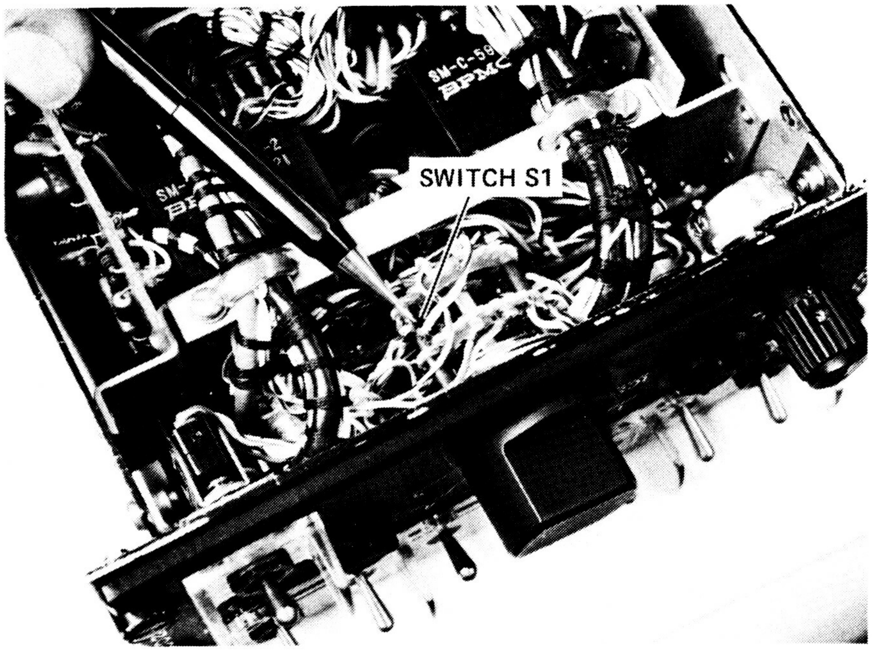

Figure C-3.– Location of switch S1.

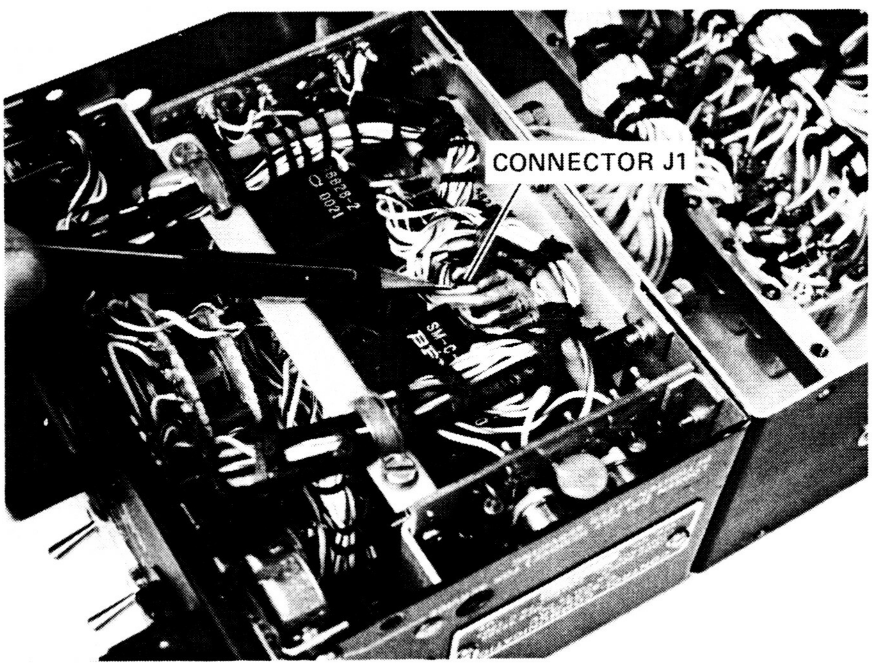

Figure C-4.– Location of connector J1.

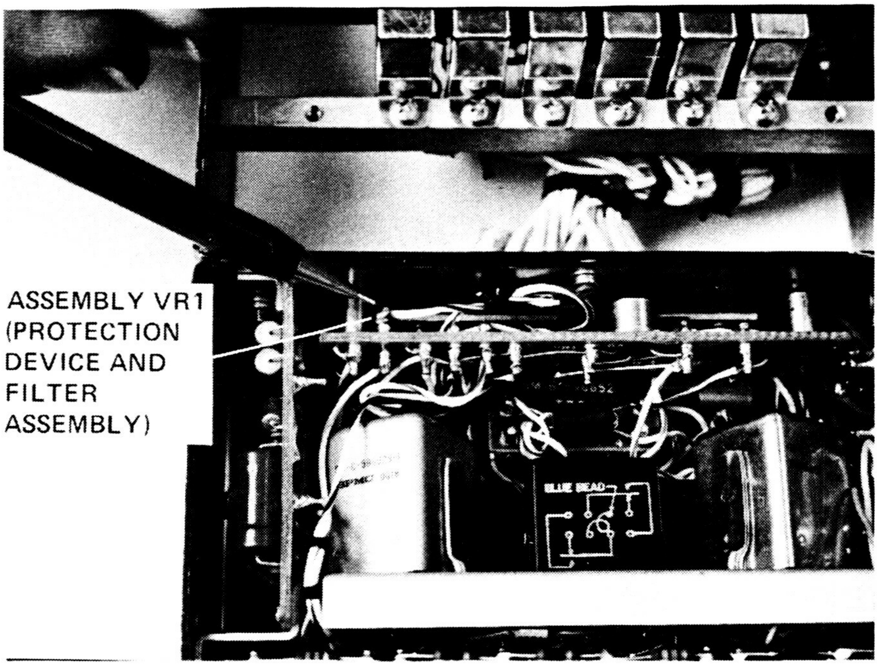

Figure C-5.– Location of assembly VR1.

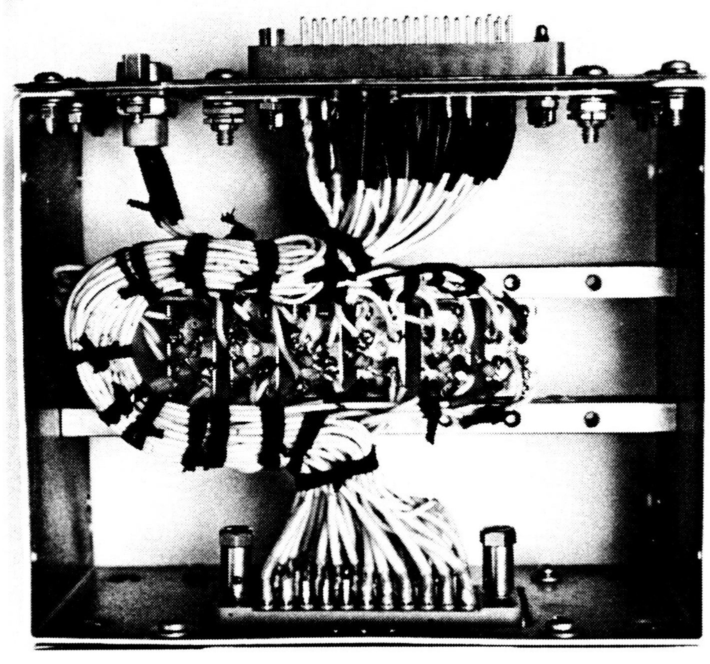

Figure C-6.– Interface unit.

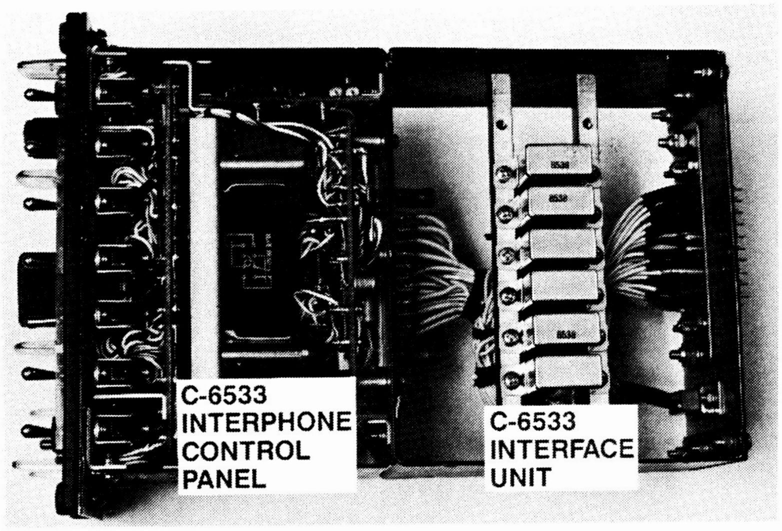

Figure C-7. Interface unit attached to control panel.

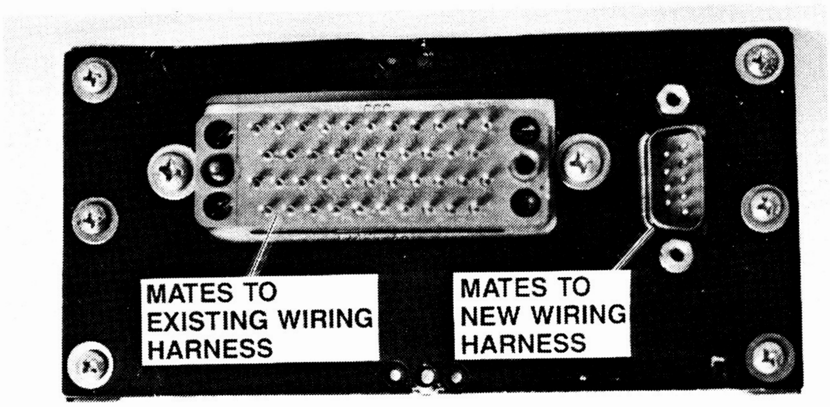

Figure C-8. Backside of interface unit.

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APPENDIX D

STANDARD SET OF MANEUVERS/TASKS

Maneuver Instructions

The development of standard set of flight maneuvers relied primarily on the current Army Attack Helicopter Aircrew Training Maneuver (ATM) guide (Army Field Circular No. 1-213). In that document, specific flight tasks are defined, including qualitative and quantitative performance standards for each task. Performance of the flight task was measured during the accomplishment of a defined auxiliary communications mission task. Specifically, the pilot conducted flight maneuvers while communicating. The flight tasks (table D-1) used in this experiment were categorized as hover, takeoff and landing, up and away flight, and low-speed maneuvering. Standard atmospheric data were recorded during each test run to include frequent monitoring of wind changes. Pilots were instructed to place first priority on maintaining the desired flight maneuver performance standards with the radio selection/communications tasks having secondary priority. Pilots shall also be instructed to call the stable and the start and end points of each maneuver over the ICS and to not let the communications tasks interfere with these calls. The number of flight maneuvers may be reduced based upon pretest and test experience and time available for completion of the investigation. All maneuvers should be accomplished with a moderate level of aggression where applicable.

Radio Selection Tasks

Radio selection tasks were interjected at specified maneuver points during performance of the flight tasks. The radio switching task consisted of switching from one radio to another radio and then back to the original radio. This simulated a common field situation where the pilot is communicating over a primary radio frequency, leaves the primary radio to transmit over another radio and then returns to the primary radio. For testing purposes the radio selection task required the pilot to select the appropriate radio and to communicate the one digit number (#) representing the selected radio by saying transmit (#) twice as each radio is selected. The pilot was expected to start the communications task as soon as the maneuver starts and is expected to complete the task as soon as possible. The radio selection communication task was repeated twice for those maneuvers that extend beyond 30 sec in length. The communications task was interrupted by flight-test completion. Pilot communications were clear and distinct. To lessen the communications workload so that the physical switching mechanism can be studied the communications part of the task was kept simple and standardized. The selections were also prebriefed by the safety pilot or the test-ground controller just prior to each maneuver, thereby reducing the workload associated with listening and understanding spoken communications.

An additional but separate switching task of turning on the radio receiver of the alternate radio selected for transmission was conducted to compare pilot performance, workload and comments on each switching option. Presently the pilot also receives communications when the interphone selector switch is placed to the selected radio for transmission. Option 5 requires the pilot to turn on the receiver switch at the interphone control panel for incoming communications. This task was not performed since it was estimated that the workload associated with turning on the receiver was similar to selecting a radio with the original option.

The radio selection task was planned to be identical for each design condition and specific flight maneuver for comparison purposes. During the course of the evaluation the pilot was tested on his ability to recall which radio he most recently transmitted over after completion of the maneuver task.

TABLE D-1.– FLIGHT TASKS AND QUANTITATIVE PERFORMANCE CRITERIA

Task	Desired performance standards

Hover (initial hover heading is into the wind unless specified otherwise)

Takeoff to hover
- Start maneuver with collective full down
- Vertical ascent to specified hover altitude of 3 ft ±1 ft
- Maintain heading ±10°
- Drift not to exceed 1 ft
- Maneuver complete when stable hover called by pilot

Stabilized hover
- Maintain appropriate hover altitude of 3 ft ±1 ft
- Drift not to exceed 3 ft
- Maintain heading ±10°
- Stabilize hover with wind from the front and again from the rear quadrant
- Start maneuver when pilot calls stable and end maneuver at 30 sec

Landing from hover
- Initial hover altitude of 3 ft
- Drift not to exceed 1 ft
- Maintain heading ±10°
- Perform smooth and controlled descent and touchdown
- Maneuver is completed when collective is full down

Bob-up (simulated unmask)
- Maintain heading ±10°
- Initial hover altitude 3 ft ±2 ft
- Moderately aggressive for conditions
- Bob-up altitude 50 ft ±5 ft
- Position drift ±3 ft
- Maneuver starts when pilot is stable at 3 ft and stops when stable at 50 ft

Out-of-ground-effect hovering turn
- Maintain hover altitude of 50 ft ±5 ft
- Drift not to exceed 3 ft from pivot point
- Constant rate of turn around vertical axis not to exceed 90° in 4 sec
- Left turn of 360°
- Moderate level of aggression for conditions
- Start and stop maneuver at stable hover

TABLE D-1.– CONTINUED.

Task	Desired performance standards
Bob-down (simulated remask) • Maintain heading ±10° • Initial altitude 50 ft ±5 ft • Return to hover altitude of 3 ft ±2 ft • Moderately aggressive for conditions • Position drift ±3 ft • Complete maneuver with stabilized hover	
<u>Takeoff and Landing</u> (takeoff and landings into direction of the wind or as dictated by traffic pattern)	
Maximum performance takeoff (simulated terrain flight takeoff) • Perform power checks • Takeoff from the ground • Maintain heading ±10° • Maintain ground track • Maintain 40-knot attitude • Maintain power 5 to 8 psi at 10 to 15% above hover power, respectively, during climb out • Momentarily transition to level flight at 100-ft AGL	
Terrain flight approach • From 100-ft AGL start constant approach angle of 5 to 8° • Maintain rate of closure not to exceed speed of brisk walk • Maintain heading ±10° last 50-ft altitude prior to landing • Maintain desired ground track • Make a smooth and controlled termination to the ground	
<u>Low speed</u>	
Acceleration and deceleration • Maintain heading ±10° • Maintain altitude of the tail rotor at 50-ft AGL ±5 ft • Accelerate to desired airspeed and decelerate to full stop at the selected location ±50 ft • Distance between stop and start points is 400 ft	
Lateral unmask and remask • Initial stabilized hover condition of 20 ft • Maintain skid height of 20-ft AGL ±2 ft • Maintain heading ±10° • Hover aircraft laterally to the right between two points selected on the ground • Simulate lateral unmask from point one and remask at point two • Maneuver should be performed at a moderately aggressive level • Distance between start and stop points is 150 ft	

TABLE D-1.– CONCLUDED.

Task	Desired performance standards
Rearward flight • Initial stabilized hover condition of 20 ft • Maintain skid height of 20 ft AGL ±2 ft • Maintain heading ±10° • Accelerate to an estimated 15 knots rearward and then decelerate to arrive at a stabilized hover condition at 20-ft AGL • Distance between start and stop points is 400 ft	
<u>Slalom course</u>	
Slalom course with vertical maneuvering • Maintain vertical altitude changes of 20 and 40 ft as specified along course ±5 ft • Maintain airspeed 40 knots along course ±5 knots • Maintain direction trim • Start when pilot calls stable and end maneuver in 60 sec	
Right turns around ground point • Maintain altitude of 400 MSL ±50 ft • Airspeed of 80 knots ±5 knots • Directional trim • Average bank angle of 30° • Make two complete turns around ground point • Read data during second turn	
Climbs and descents • Maintain airspeed 90 knots ±5 knots • Heading ±3° • Vertical rate of 1000 ±100 fpm • Directional trim • Climb or descent of 500 ft	
Right climbing/descending turns • Maintain airspeed 90 knots ±5 knots • Specified vertical rate ±100 ft • Directional trim • Climb or descent of 500 ft • Bank angle of 45° should be established during turn recover from maneuver at end of climb or descent • Start maneuver as pilot starts the turn and descent or climb	

APPENDIX E

PILOT COMMENTS

The following pilot comments were collected immediately after pilots completed individual data flights. Instructions to pilots are shown in appendix E and pilot comments were recorded as written by each pilot. Question marks indicated that the pilot was not sure of the question or the comment was not readable.

PILOT DEBRIEF

COMMUNICATIONS SWITCH INTEGRATION PROGRAM
CSIP

INSTRUCTIONS TO PILOTS: The cyclic radio/ICS switch at the pilot's station has been modified to provide selection of the FM, UHF, and VHF radios and ICS from the radio/ICS switch. The original (fleet standard) floor communications switch, transmit-interphone selector and the radio/ICS switch utilization is demonstrated in Figure One. Figure Two shows the current radio/ICS modification. All pilots are encouraged to exercise the modified switch for radio selections and to make comments regarding use of the switch. Please make qualitative comparisons to the original fleet communications configuration where possible. Comments on the following subject areas are requested when and where appropriate. Each number shown indicates a particular pilot.

LOCATION OF THE RADIO/ICS SWITCH

1. The location of the interphone panel switch in the front seat of the COBRA is a joke. Down between your legs like on the front of the modified Cobra. It's hard to see and hard to switch. This new mod on the cyclic stick is ideal.

2. Good location on the cyclic grip allows hands on operation of the flt controls during flt critical maneuvers.

3. Good – Easy to use once you get some practice.

4. Acceptable. Previous experience using the chinese hat switch for communications made it quite easy to adapt to the location.

4. Maybe I've gotten used to the location since this was my second flight. Location was not a problem.

5. Little high on cyclic grip, however, this switch is already being used for radio/ICS selection so no worse.

6. A bit too high to reach. You must reposition your hand – up – to reach switch – awkward. Don't delay fielding for this.

SWITCH SPRING TENSION

1. Should be sufficient to not allow inadvertent activation but not enough to cause flt control movement during transmission.

2. Adequate. Force may be a little on the high side – all directions.

3. O.K. – I saw no problems.

4. Almost unacceptable at first when transmitting on #1 or #3. #2 was acceptable at first because of prior experience. As the flight went along the tension required seemed to diminish.

4. Spring tension for the #1 position seemed excessive. Had to work hard not to induce a left cyclic input when trying to activate the #1 switch.

5. Little too much spring tension toward each side – the one and three position, however switch is very usable.

6. Tension should be reduced if done easily otherwise o.k. Don't delay fielding for this.

SHAPE OF THE CYCLIC RADIO/ICS SWITCH

1. Same as original.

2. Do not like the feel of the top point on the coolie switch.

3. O.K. – seemed to be satisfactory.

4. Acceptable. Previous experience with the chinese hat had a lot to do with adapting to switch.

4. Not a problem.

5. Have seen better for thumb switch, again however the switch is very usable.

6. Rocker style switch would be easier to use.

SWITCH ACTIVATION FOR EACH AXIS OF MOVEMENT

1. Identical to previous ICS and radio, so not difference to train up for.

2. Switch is a little awkward to use in the lateral directions.

3. O.K. – I did not see any problems such as inadvertent control inputs.

4. ICS and #2 were not problem. Initially the force required to activate #1 and #3 seemed excessive. As the flight continued, the force required to activate these positions didn't seem noticeable.

4. The #2 position was not a problem. The #1 and #3 position seemed to require extra effort.

5. Seems usable during all flight maneuvers looked at – In other words each axis can be activated, but some control positions make activation slightly harder than others.

6. Difficult to transmit on 1 & 3 initially, but easily learned.

INADVERTENT FLIGHT CONTROL INPUTS

1. None.

2. Slight lateral stick movements during hover tasks.

3. (above) will depend on control sensitivity from aircraft to aircraft.

4. Initially, activating #1 and #3 resulted in an inadvertent input to lateral cyclic. This inadvertent input decreased as I became more used to activating the switch.

4. Spring tension for the #1 position seemed excessive. Had to work hard not to induce a left cyclic input when trying to activate the #1 switch.

5. None with option five. However with the original option I sometimes made inadvertent control inputs to the collective when I had to rapidly get back into the vertical axis control loop.

6. Minimal – same as original.

PILOT WORKLOAD

1. Reduces greatly especially NVG.

2. Reduced workload.

3. Much reduced in many cases during the evaluations.

4. As ratings indicate, workload seemed to significantly increase with each task assigned and the maneuver required. Communicating while coming up to a hover just didn't allow much time to accomplish the communications task especially in the original configuration.

4. In configuration 5, you had to <u>think</u> about when selection was required and which way to activate the switch.

5. Option five greatly reduces physical and mental workload during maneuvers that require constant collective control. Can also reply on radios considerably faster.

6. Significant reduction while hovering near the ground/obstacles. Much quicker response when working 2 frequency. Can keep eyes outside cockpit.

HABIT TRANSFER

1. Good habit transfer as AH-1 pilots are used to talking with ICS switch.

2. Easy to master.

3. Took some time to "feel at home" with the new setup – but now I prefer it.

4. In configuration #5, the more I used the chinese hat the more I feel comfortable with its use.

4. Having to transfer between the original configuration and Option 5 during each repetition requires considerable mental work. I wonder if my ratings or comments would change if I did all the tasks during the flight in one configuration only. Then on a second flight?

5. Some initial negative habit transfer remembering use of the four positions that is the pilot may tend to broadcast over the #2 position for all radio.

6. Not a problem. Occasionally transmitted on 2 instead of 1 or 3. Corrected by second flight.

TRAINING IMPLICATIONS

1. Minimal training would be required.

2. All Army aircraft are different. Should pose little problems in training to use the system switch.

3. No problem here – Pilots can be trained to use "Option 5" in a short time.

4. None.

4. None.

5. Easy to train pilots due to option five design.

6. A simple 30 minute class by unit IPS + a decal for instrument panel as a reminder.

ABILITY TO RECALL LAST TRANSMITTED RADIO

1. No problem. If you forgot it's easy to just retransmit on the old one you would have to reach and switch.

2. Forces a mental workload during the test. Actual operations should not pose a problem. Pilot will know who he is talking to.

3. Not as good – but is this an operational requirement? What is important is using the right one when needed.

4. Depended mainly on the difficulty of the flight maneuver required. This was clearly evident in the slalom course where considerable attention had to be used watching airspeed and altitude.

4. When workload required to do the maneuver was high (slalom course) thinking about what your last transmission was proved to be difficult.

5. Did not experience any problem.

6. Not a problem. Use different radio for different type units – ground units – air-to-air – ATC – CO Ops.

RADIO RECEIVER SWITCH ON PRIOR TO RADIO TRANSMISSION

1. No problem. If you forgot it's easy to just retransmit on the old one you would have to reach and switch.

2. Switches are usually on anyway.

3. I feel that this has not changed – you switch on receivers that must be monitored in either option.

4. Cut down an extra task which helped with workload.

4. Made first transmission easy. If one started in the original configuration in ICS. The task would have added difficulty.

5. If the receiver switch is not on very little side tone will be present, thus providing a cue to the pilot that the receiver switch is not on.

6. Normally fly with switches up on radios I'm using. Turn off only if background static is too bad.

CONFIGURATION INTERFERENCE

1. With minimal training pilots would become 100% proficient with the modified system.

2. None.

3. (?)

4. There was some remembering required to make sure you were executing the correct configuration. A couple times I found myself selecting transmit position #1 on the cyclic chinese hat when I really wanted to use configuration.

Mental work was required to remember what configuration you were in.

5. None experienced.

6. ?

CREW MEMBER INTERACTION

1. It would allow the crewman not on the controls to do other tasks he would normally have to stop to talk on the radio especially NOE and NVG.

2. No problem.

3. Seemed to go O.K. during evaluation flights – ICS position worked fine.

4. No particular problem.

4. No problem.

5. (Option five) None experienced, better at times since the pilot doesn't have to reply on the other pilot to make an explained transmission.

6. ?

MANEUVER PERFORMANCE

1. Not degraded using new mod.

2. Increases performance.

3. In many cases, maneuver performance was significantly improved.

4. An overall comment would be that my performance was better with configuration #5. The major factor was that I did not have to remove my hand from the collective during the maneuvers as I did for Configuration #1.

4. Doing the maneuver was the priority. Performance degraded as workload increased.

5. Much better with Option five when doing maneuvers requiring constant vertical control action.

6. Significant improvement on low altitude performance. No major improvement at altitude.

COMMUNICATIONS PERFORMANCE

1. Quick, efficient, without wondering which radio the ICS is up.

2. Increases performance.

3. Obviously improved and significantly more efficient.

4. Deteriorated with increased difficulty of the flight maneuver performed. Executing the flight maneuver safely and correctly was the top priority and the communications tasks were done when it was safe to do so.

4. Did it when I could. Executing maneuver took priority.

5. Much better with option five. I do not have to program when to remove my hand from the actual vertical controller (controller) so transmissions can be made faster and responded to faster.

6. Can miss communications if toggle switch is down. Response time is quicker.

SWITCHING PERFORMANCE

1. Worked great.

2. No problem.

3. Significantly improved. Switching (from radio to radio) time was reduced.

4. Configuration #5 was significantly easier than the original configuration. This was most clearly evident when the maneuver required significant excursions with collective. Having to take your hand off the collective to switch radios impacted performance.

4. Mental work required to switch between configurations.

5. Much better with Option five.

6. Original switch requires pilot to look inside A/C at rotary switch. Controllability is reduced as is safety. Original switch guard you will receive frequency you are talking on. Mod hears only if toggle switch is

ELECTRO MAGNETIC PROBLEMS DURING GROUND OR FLIGHT TEST

1. None detected.

2. None noted.

3. None noted.

4. None noted.

4. None observed.

5. None noted.

6. None noted.

FLIGHT SAFETY

1. Greatly enhances crew safety. Letting the aviator on the controls have access to radios without releasing the controls during critical modes of flight.

2. Increases by allowing the pilot more time during time critical flight tasks. Switch will increase safety and mission effectiveness during NOE and hover/low level tasks by allowing the pilot hands on flt control while performing secondary commo tasks.

3. Improved – Primarily due to elimination of requirements to take hands off primary flight controls while maneuvering near the ground.

4. As the difficulty of the maneuver increased flight safety became the first priority.

4. No problem.

5. Much better with Option five since I don't remove my hand from an active flight controller.

6. Many hovering maneuvers could not be completed on original switch. Safety precluded removing your hand from the collective. No safety problems with modified switch. Looking inside at rotary switch.

OTHER COMMENTS

1. This would greatly increase the safety and reduce pilot workload especially during NVG flt.

2. None.

3. This experiment effectively demonstrated the operational advantages of "Option 5."

4. Has any thought been given to placing a switch on the collective? I'm only thinking of a configuration #5 application and not the original application.

4. None.

5. Option five enhances safety since the pilot doesn't have to remove a hand from active flight control.

6. While hovering is a problem. Possible not to monitor guard frequency when single pilot one radio could be left on "guard" in hostile situations. In an emergency you could always transmit on "guard" without removing hands from controls.

RECOMMENDATIONS

1. This modification be introduced to the field as soon as possible.

2. Modify AH-1 fleet with switch design (priority). Look into a better switch shape/feel that has a four axis switch capability (secondary if funding permits) but should not delay the effort.

3. The Army's practice of labeling radios with numbers instead of function has always bothered me.

4. Has any thought been given to placing a switch on the collective? I'm only thinking of a configuration #5 application and not the original application.

4. None.

5. – Ask Ft. Rucker to use device during Ram data testing at AVN board.
   – Have selected Army units use switch. Look at use by IMC Cobra developers.

6. a. AVSCOM engineers review design and develop design not requiring modification to ICS box.
   b. Mod entire AH-1 fleet ASAP and check feasibility on other A/C.

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15. Supplementary Notes

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16. Abstract

The C-6533/ARC communication system as installed on the test AH-1E Cobra helicopter was modified to allow discrete radio selection of all aircraft radios at the Cyclic Radio/intercommunication system switch. The current Cobra-fleet use of the C-6533 system is cumbersome, particularly during low-altitude operations. Operationally, the current system C-6533 configuration and design requires the pilot to estimate when he can safely remove his hand from an active flight control to select radios during low-altitude flight. The pilot must then physically remove his hand from the flight control, look inside the cockpit to select and verify the radio selection and then effect the selected radio transmission by activating the radio/ICS switch on the cyclic. This condition is potentially hazardous, especially during low-level flight at night in degraded weather. To improve pilot performance, communications effectiveness, and safety, manprint principles were utilized in the selection of a design modification. The modified C-6533 design was kept as basic as possible for potential Cobra-fleet modification. The communications system was modified and the design was subsequently flight-tested by the U.S. Army Aeroflightdynamics Directorate and NASA at the NASA Ames Research Center, Mountain View, California. The design modification enables the Cobra pilot to maintain "hands-on" flight controls while selecting radios during nap-of-the-Earth (NOE) flight without looking inside the cockpit which resulted in reduced pilot workload ratings, better pilot handling quality ratings and increased flight safety for the NOE flight environment.

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