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Working Paper

SINGLE CHANNEL GROUND AND AIRBORNE RADIO SYSTEM (SINCGARS)
AN/ARC-201 (ABN) MANPRINT EVALUATION

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SINCGARS ABN (AN/ARC-201) MANPRINT EVALUATION

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BACKGROUND

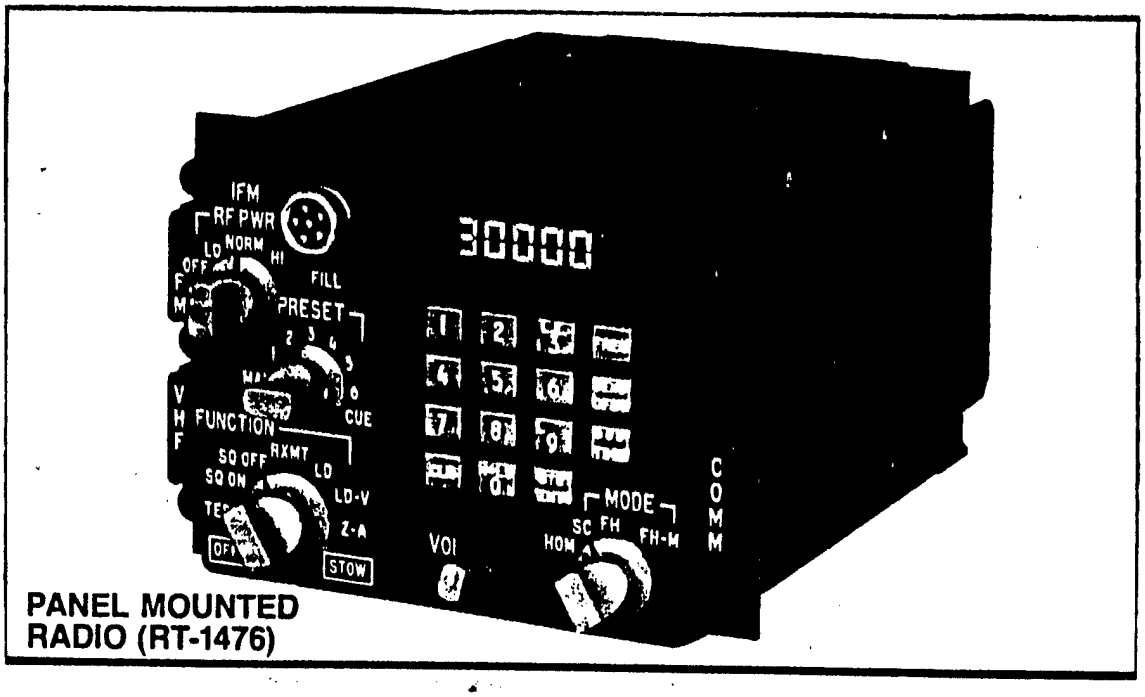
The AN/ARC-201 SINCGARS radio (ABN) is the aircraft counterpart of the ground SINCGARS combat net radio and is available in three (3) configurations. Two of these configurations were tested at Fort Sill, Oklahoma in the SINCGARS ABN Early User Test and Experimentation (EUTE) conducted during April and May of 1988 in conjunction with the SINCGARS Follow On Test and Evaluation (FOTE). The two ABN models--Panel Mounted Radio RT-1476 and Dedicated Remote Radio RT-1477 with Remote Control Unit C-11466--were installed in two UH-1 helicopters such that each aircraft had one copy of each model. A total of four ABN radios (two per helicopter) were installed and made operational. Six aviators were trained in operating the SINCGARS ABN by personnel from the Army Aviation Center, Fort Rucker, Alabama. The Army Research Institute (ARI), Fort Hood Field Unit, which supported MANPRINT efforts associated with the SINCGARS FOTE, was requested to conduct a preliminary MANPRINT evaluation of the SINCGARS ABN with primary concern for pilot workload.

SYSTEM DESCRIPTION

Each UH-1 aircraft housed one RT-1476/ARC-201(V) in the center console to the immediate left of the pilot and one Remote Control Unit, C-11466/ARC--201(V), in the center console to the immediate right of the co-pilot. The RT-1477, to which was cabled the Remote Control Unit, was mounted in the nose of the aircraft. Both radios operate in frequency hopping or single channel modes within the frequency range of 30-88 MHz VHF-FM and a capability of 2320 channels. Both radios accomodate voice and data, and include automatic retransmit, built-in homing, and built-in test. Both radios incorporate electroluminescent lighting (green) and a liquid crystal display. The front panel of the RT-1476 is slightly larger (146mm wide by 104mm high) than that of the RT-1477's Remote Control Unit (127mm wide by 102mm high). The panel color is olive drab, with all knobs and pushbuttons (keypad) medium gray. All labeling is etched and painted white. Both radios allow for six preset channels (single channel operation), with 5 and 10 kHz offset capability, or six preset nets (frequency hopping operation). The digital capability for both models is 16 kbps. The power output for either model is 10 watts nominal, and both models can interface with an AM-7189A/ARC 50 watt power amplifier. The RT-1476 was used only for communications with the tower, range control, and retransmission conditions. The RT-1477 was used for all test (EUTE) communications and conditions. Figure 1 provides a picture of panel configurations of the RT-1476 and Remote Control Unit of the RT-1477.

DATA COLLECTION CONDITIONS

The tasking and design of mission statements for helicopters were directed toward ensuring: (a) adequate coordination of aviation operation with ground (FOTE) operations; (b) full use of primary radio capabilities; and (c) radio operation under the widest possible range of conditions and aviation support



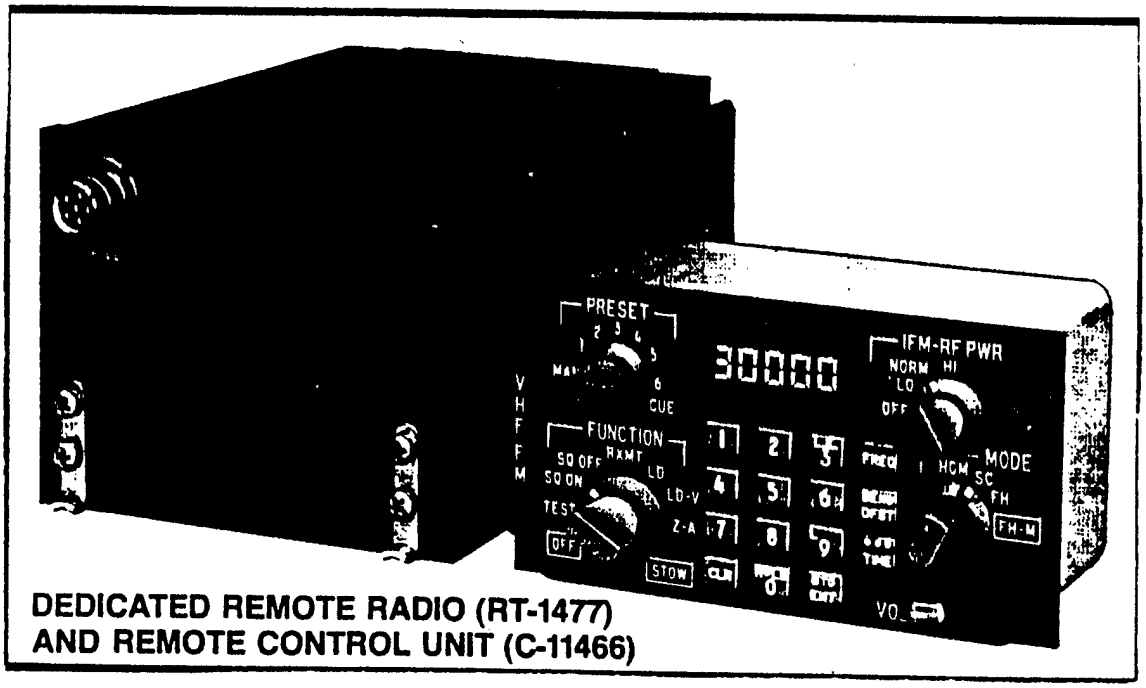


Figure 1. Panel configurations of RT-1476 and RT-1477 (Remote).

missions. Air missions (tactical) under which data were collected included: reconnaissance, artillery target acquisition, convoy escort, air assault, evacuation, aerial resupply, air cover (simulated), battle surveilance, aerial photography, aerial command post, survey, transportation of VIPs, and communications relay (retransmission).

EVALUATION METHODOLOGY

Three methods of data collection were employed to support the MANPRINT evaluation of the SINCGARS ABN: observation, interview, and questionnaire. Each strategy is separately addressed below.

Observation. Observations of the radios and their operation were made by three persons: two trained data collectors who reported their observations on MANPRINT Problem Logs (DC Form 15) and an ARI research psychologist who reported observations on MANPRINT Special Operations Data forms. Both of these forms were relatively unstructured and problem-oriented. The two data collectors, a SSG and a PFC (OH-58 crew chief), received approximately 40 hours of TEXCOM and OTEA data collector classroom instruction which included a one-hour instructional block on MANPRINT (domains, orientation, concerns) and related data collection (DC Form 15). This instruction was provided by an ARI research psychologist.

Observations occurred during helicopter pre-flight and flight conditions associated with an operational test environment. Each helicopter on each mission carried one data collector seated so as to ensure unencumbered visibility of the two radios and provision of a headset to allow monitoring of all air-to-air and air-to-ground communications. These data collectors observed all test conditions of radio operation: single channel secure and nonsecure, frequency hopping secure and nonsecure, retransmission, start-up (cold start and full load), electronic remote fill (ERF), late net entry (LE), net transfer, homing, and communication under both jamming (ECM) and benign conditions. The total number of observational (data collection) hours for these data collectors was 65, 2 of which were night operations. Observation time of the ARI research psychologist was 10 hours, to include 2 hours of night operations.

Interview. Based on observational data recorded on MANPRINT Problem Logs (DC Form 15) and MANPRINT Special Operations Data forms, structured interviews were conducted with pilot-operators to validate, expand, or clarify observations and hypotheses generated by them. Additionally, pilot-operators were encouraged to volunteer comments, criticisms, concerns, or endorsements on the two models (RT-1476, RT-1477) they operated. These information exchanges were either recorded on previously noted forms or conveyed to the ARI research psychologist for further consideration or exploration.

Questionnaire. A 17-item (some with multiple response requirements) SINCGARS ABN Evaluation questionnaire was constructed based on MANPRINT concerns, with particular emphasis on pilot workload, and insight gained from interviews and observations as discussed above. This instrument largely required nominal or ordinal (rating) responses and contained sections on training, safety, and human engineering and workload. It was administered at the end of the EUTE

to the four primary pilots who flew the two SINCGARS ABN-equipped helicopters and collectively amassed 65 hours of flight time, 2 of which were night operations.

FINDINGS

Table 1 provides a summary of the most salient MANPRINT findings on the SINCGARS ABN based on observations made by the trained data collectors and ARI research psychologist and interviews of pilot-operators.

Pilots and co-pilots (N = 4) responded to items addressing training, safety, and human factors and workload on the SINCGARS ABN Evaluation. These aviators included two commissioned officers (CPT, 1LT) with MOSs of 15A and two warrant officers (CW2) with MOSs of 153B. A descriptive summary of their responses is provided in Tables 2 through 6.

Table 1

SINCGARS ABN Observational Data

Observation	MANPRINT Domain*	Interview Validation
Cold start procedures are sufficiently complex and labor-intensive to require completion during pre-flight operations.	HFE T	Yes
Pushbuttons may be too close together to allow effective manipulation while wearing gloves.	HFE	No
Workload is maximized during RT start-up (cold start) and when problems arise in receiving or storing an ERF.	HFE T	Yes
Display visibility from various pilot angles appears adequate.	HFE	Yes
Display washout from direct sunlight appears minimal.	HFE	Yes
Occasional operator confusion was evidenced during cold start, ERF, and retrans--required coaching from co-pilot.	T	Yes
Generally, pilot operated RT-1477 and co-pilot operated RT-1476--retrans requires coordination of both RTs.	M HFE	N/A
MODE knob came loose (RT-1477).	HFE	Yes
Use of the secure condition for transmitting seems to reduce the quality of receptions.	HFE	No
Any complex process, such as ERF, which requires appreciable vigilance (looking down) produces neck muscle fatigue--helmet weight strains neck.	HFE S	Yes
PRC-12 (RT-524) sound quality and comparative volume were appreciably higher than SINCGARS in single channel mode--"sounds louder and more clear" (pilot comment)	HFE	Yes

Table 1 continued

Panel configurations may induce negative transfer--MODE select positions on RT-1476 are ordered similar to RT-1477 but are rotated about 35 degrees.	HFE T	N/A
Knob placements on panels are different --3 on left and 1 on right side of RT-1476 while 2 on left and 2 on right of RT-1477.	HFE	N/A
Top left control on RT-1476 is RF PWR, while top left on RT-1477 is PRESET.	HFE	N/A
Electroluminescent lighting is adequate and effective in illuminating controls and settings.	HFE	Yes
Electroluminescent lighting is much brighter than all other panel or control lighting.	HFE S	Yes
Accidental movement of MODE selector knob to FH-M (Master) causes loss of time synchronization with other stations, operator confusion, and disrupted communication (must get ERF or time setting).	HFE T	Yes
Frequency Hopping Master setting on MODE selector needs a lockout to minimize accidental selection.	HFE	N/A
Internal control lighting reflects on windshield at night directly above pilot's normal field of vision and is an attentional distractor.	S HFE	Yes
Electroluminescent lighting color (green) is different from all other crewstation lighting (red)--should be uniform.	HFE	N/A
Radios "ON" while cranking helicopter become prone to voltage spikes and tripping of circuit breaker.	T	Yes

* (MANPRINT domain key: HFE = Human Factors Engineering, T = Training, S = System Safety, M = Manpower)

Table 2

SINCGARS ABN Training Evaluation

Item Content	Frequency of Mention
Mean hours of hands-on training reported = 6	
Mean hours of lecture training reported = 8	
Mean hours of flying time using SINCGARS = 26	
Content not provided but needed:	
Correlation between KY-58 and SINCGARS RT	3
More retransmission classroom experience	2
Frequency Hopping Master MODE operation	2
Loading or changing Net ID	2
Rating of length of training:	
About the right length	4
Content areas needing more training time:	
Active late entry (LE)	3
Procedures in general on NCS operations	1
None	1
Content areas needing less training time:	0

Table 3

SINCGARS ABN Safety Evaluation

Item Content	Response
Present crew station problems associated with configuration or operation of SINCGARS ABN?	No = 2 Yes = 2*
* Mixing green and red lights in cockpit doesn't allow proper dimming (1)	
* During night operations, SINCGARS green lights were too bright--O.K. if with green or NVG modification (1)	
Potential crew station problems associated with configuration or operation of SINCGARS ABN?	No = 3 Yes = 1*
* Potential exists for fixation inside cockpit of crew if newly trained	
Injury sustained while operating SINCGARS ABN?	No = 4 Yes = 0

Table 4

ABN Comparison with Current Equipment

Operation/Function	Attempted	Difficulty Rating*	Task Conflict
Turn on RT	4 Yes, 0 No	3.3	0 Yes, 4 No
Enter frequency	4 Yes, 0 No	4.0	0 Yes, 4 No
Enter a net	4 Yes, 0 No	3.8	0 Yes, 4 No
Change frequency	4 Yes, 0 No	4.5	0 Yes, 4 No
Go secure	4 Yes, 0 No	4.0	0 Yes, 4 No
Radio check	4 Yes, 0 No	3.5	0 Yes, 4 No
Do retrans	4 Yes, 0 No	3.8	0 Yes, 4 No

* Scale extended from 1 = "much more difficult" through 3 = "about the same" to 5 = "much less difficult."

Table 5

Evaluation of ABN Characteristics

Characteristic	Rating*
Readability of control labels	6.0
Readability of display	6.3
Volume control sensitivity	3.0
Squelch sensitivity	5.0
Recognizing knob position	5.3
Connecting or disconnecting cabling	4.5
Lighting of panel	6.0
Recognizing on-off status	4.3
Using keypad	6.0
Recognizing displayed alphanumerics	6.3
Using MODE selector	6.0
Dim sensitivity	3.0
Clarity of transmissions	6.5
Tension/resistance on knobs	5.8
Spacing of controls	5.8
Location of fill connector	4.3
Ability to reach all controls with ease	Y = 4, N = 0
Ability to see all controls with ease	Y = 4, N = 0
Ability to operate all controls with ease	Y = 4, N = 0

* Scale extended from 1 = "extremely poor" through 4 = "generally adequate" to 7 = "extremely good."

Table 6

Evaluation of ABN Operations

Operation/Function	Attempted	Difficulty Rating*	Task Conflict
Load net ID	4 Yes, 0 No	3.0	2 Yes, 1 No
Load HOPSET	4 Yes, 0 No	4.0	0 Yes, 3 No
Late entry (LE)	4 Yes, 0 No	4.0	0 Yes, 3 No
Respond to cue	4 Yes, 0 No	4.3	0 Yes, 3 No
Load time (TOD)	4 Yes, 0 No	3.9	0 Yes, 3 No
Use FH mode	4 Yes, 0 No	4.3	0 Yes, 2 No
Receive ERF	4 Yes, 0 No	4.3	0 Yes, 3 No

* Scale extended from 1 = "very difficult" through 3 = "not easy, not hard" to 5 = "very easy."

The four aviators, representing a collective 105 hours of flying experience with the SINCGARS ABN, were asked to rate the overall workload associated with operating the SINCGARS radio compared with current communications systems and procedures. The rating scale ranged from 1 = "very much increased" through 4 = "about the same" to 7 = "very much decreased." They were also asked to indicate the single task which was the largest contributor to any increased workload reported. Three rated the SINCGARS ABN workload as "somewhat increased" (3) and one rated it "about the same" (4). Of those indicating an increased workload, all identified receiving and loading an ERF (electronic remote fill) as the single largest contributor to workload.

CONCLUSIONS AND RECOMMENDATIONS

The reported findings evolved from an EUTE. A testing effort of this type must be regarded as exploratory and typically has appreciable limitations, particularly in regard to small samples both of personnel and equipment. Respecting these conditions, the following summary conclusions are provided:

- The SINCGARS ABN training provided aviators appears appropriate in length.
- The SINCGARS ABN training needs to include information and experience on the KY-58 interface, Frequency Hopping Master Mode operation, and loading net IDs.

- SINCGARS ABN operational efficacy would likely be increased by more intensive training on several procedures: cold start, responding to an ERF, and retransmission. Through such training, workload should be reduced.

- Display and control visibility appears quite adequate, though the color and brightness of lighting needs investigative attention relative to distraction and safety hazard.

- The potential for some negative transfer between operating both radios (RT-1476 and RT-1477) exists and should be further investigated.

- While the volume and clarity of transmissions with the SINCGARS ABN were not criticized by aviators, there was sufficient evidence of unfavorable comparisons with that of current radio equipment to warrant investigation.

- The sensitivity of both volume and dim controls was seen as somewhat substandard.

- Pilot workload associated with operating the SINCGARS ABN compared with current communications equipment is viewed as slightly increased. However, there is a strong suggestion that this increase, which revolves around a few tasks or situations as noted, could be resolved through more concerted attention (particularly hands-on experience) in training.