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Working Paper

HUMAN FACTORS EVALUATION OF THE SINCGARS ICOM RADIO

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HUMAN FACTORS EVALUATION OF THE SINCGARS ICOM RADIO

On 24-26 February 1987, the Army Research Institute (ARI Field Unit, Fort Hood) performed a human factors evaluation of the surface features and operating characteristics of the SINCGARS integrated-COMSEC (ICOM) radio. The evaluation, which took place at the developing contractor's (ITT) facility in Fort Wayne, Indiana, was invited by the SINCGARS Project Manager and coordinated with the U.S. Army Operational Test and Evaluation Agency.

The evaluation was not conducted in an operational setting; consequently, the observations presented in this report do not include findings based upon operator performance or comments, except that those findings from previous operational evaluations of the non-ICOM SINCGARS that appeared applicable to the ICOM version are included. Each observation is presented as a constructive guideline only and without cost-effectiveness considerations. Furthermore, some of the suggested possible improvements may not be entirely feasible or desirable for reasons pertaining to such factors as cost effectiveness, time constraints, incompatibility with other changes or features of the radio, etc. The intention is to facilitate the implementation of improvements in the current ICOM radio and the development of parallel or subsequent systems.

This report is subject to future incorporation of additions, deletions, and revisions.

FINDINGS

The findings are presented as observations organized into six sections: Operating Controls, Display, Labels, Connectors, Operational Procedures, and Miscellaneous. Each observation is accompanied by an impact assessment, comments, and suggested solutions. Reference may be made to Figure 1 (at the end of this document), which depicts the front panel of the SINCGARS ICOM radio.

Section 1: Operating Controls

1.01 **OBSERVATION:** The RF PWR switch can be set midway (on the "high points") between normal settings. (Cf. Observation 1.02.)

IMPACT: A specific violation of MIL-STD-1472C (par. 5.4.2.1.1.4.c). Display anomalies result from keying the handset when the control switch is set between normal stops: When the control is set between "M" and "HI," the signal strength display indicator shows a 3 x 7 dot matrix (indicating "HI"); when the control is set between "M" and "LO," the indicator may show either a 3 x 1 ("LO") matrix (bottom line) or a 3 x 3 ("M") matrix (bottom three lines). (Cf. Observation 2.02.)

COMMENTS/POSSIBLE IMPROVEMENTS: Improve the design of the switch to eliminate its ability to stop midway between intended settings. (The problem is not considered serious from a human factors perspective)

because, although possible, it is rather difficult to position the switch between settings. However, the suggested solution would serve to prevent curious operators from "experimenting" with the controls.)

1.02 **OBSERVATION:** The CHAN switch can be positioned between normal settings at the high points of resistance. (Cf. Observation 1.01.)

IMPACT: A specific violation of MIL-STD-1472C (par. 5.4.2.1.1.4.c). On the radio examined, the display reacted as follows:

When setting was between--	The display--
CUE & MAN	Flipped from "FILL 1" to "FILL 7" or vice versa (appropriate response).
MAN & 1	Showed "FILL 2" (inappropriate response).
1 & 2	Flipped from "FILL 1" to "FILL 2" or vice versa (appropriate response).
2 & 3	Showed either "30000," "FILL 2," "FILL 4," "FILL 6," or "FILL 7" (all inappropriate except for "FILL 2").
3 & 4	Showed "FILL 7" (inappropriate).
4 & 5	Showed "FILL 6" (inappropriate).
5 & 6	Flipped from "FILL 5" to "FILL 6" or vice versa (appropriate).

While the display is showing the inappropriate response, a frequency can be loaded into the inappropriately indicated channel.

COMMENTS/POSSIBLE IMPROVEMENTS: Same as for Observation 1.01.

1.03 **OBSERVATION:** The arrangement of channels on the CHAN switch and the corresponding display indications in the single-channel mode are as follows:

CHAN switch position---	Display
CUE	FILL 7
MAN	30000
1	FILL 1
2	FILL 2
3	FILL 3
4	FILL 4
5	FILL 5
6	FILL 6

IMPACT: The arrangement of channels on the CHAN switch does not have an intuitive correspondence to the display indications, which may be detrimental to ease of training and retention. (Cf. Observation 2.09.)

COMMENTS/POSSIBLE IMPROVEMENTS: The non-ICOM radio probably had a more satisfactory arrangement of channels on the channel selector (MAN, 1, 2, 3, 4, 5, 6, CUE). Apparently the arrangement was changed to comply with the general rule of thumb prescribing that the arrangement of controls should correspond to frequency of use. Regardless, the current "solution" appears to be worse than the original "problem." Two alternative suggestions for improvement are offered:

1. Change the order of channels back to the original order on the non-ICOM radio, and change the labeling as follows:

```

                                --|
                                C
                                |
                                3 4
                                |
                                2   5
                                |
                                1     6
                                |
                                MAN     CUE
                                |
                                --|

```

Use the following corresponding display indications (cf. Observation 2.08): "M FREE," "1 FREE," "2 FREE," . . . "6 FREE," and "C FREE." (The term "EMPTY" could be used instead of "FREE.")

2. Change the order of channels and the labeling to:

```

                                --|
                                C
                                |
                                4 5
                                |
                                3   6
                                |
                                2     MAN
                                |
                                1     CUE
                                |
                                --|

```

In the display, use "1 FREE" (or "1 EMPTY"), etc., as in the previous example.

Other arrangements/solutions might also be appropriate--the main consideration here is to create a close correspondence between the selector and the display, while retaining channel "1" as the primary communication channel. Frequency-of-use of channel positions is of secondary (and, here, minor) importance.

1.04 **OBSERVATION:** When the FCTN switch is set to "REM," after two or three seconds the display portrays the frequency in the CUE channel (regardless of where the CHAN switch is set).

IMPACT: Possible operator confusion.

COMMENTS/POSSIBLE IMPROVEMENTS: According to ITT, this problem is simply a "bug" in the first-generation ICOM radio which will not occur in subsequent versions.

1.05 **OBSERVATION:** The visual parallax distortion associated with the rotary controls on the ICOM radio (as on the non-ICOM radio) is considerable, especially for the FCTN switch.

IMPACT: It is difficult for the operator to determine visually the setting of the control if it is viewed from an angle. The problem would be exacerbated in low light. For example, the FCTN switch (which is very crowded with settings and labels) appears to be set at "REM" if the operator views the switch from as little as 15 degrees above and 15 degrees to the left of center when in fact it is set at "RXMT." Accurate readings are guaranteed only if the operator views the control panel from a fairly straight-on position.

COMMENTS/POSSIBLE IMPROVEMENTS: Control knobs should be designed to minimize visual parallax problems. Some modification of the knobs on the control panel of the ICOM could help (ref. MIL-STD-1472C, par. 5.4.2.1.1.3 & Figure 4), as might a reduction in the number of positions on the FCTN switch (cf. Observation 3.03, Comment).

1.06 **OBSERVATION:** The front panel controls (including the keyboard) are not illuminated for use in low-light or no-light situations. Operators of the non-ICOM radio have viewed this as a significant problem.

IMPACT: The lack of panel lighting makes it difficult or impossible for operators (especially of the backpack version) to manipulate controls effectively in the dark without some sort of external light source such as a flashlight, which may require a third hand as well as constitute a breach of security.

COMMENTS/POSSIBLE IMPROVEMENTS: Improvement appears to have been made in the readability of the controls with night-vision devices. Perhaps that is the most that can be expected under conflicting trade-off situations that constrain solutions to this problem. Ideally, the radio would have some sort of available panel lighting that would constitute a minimal security threat and require little in the way of battery power. (In vehicles the lighting would utilize vehicle power.)

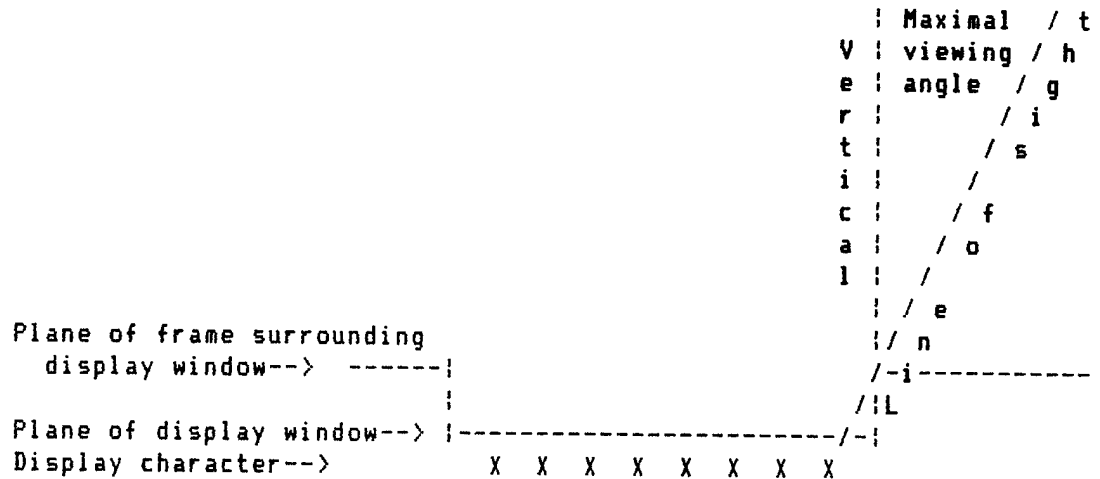
1.07 **OBSERVATION:** The volume control knob can be accidentally moved because of its lack of sufficient resistance to turning.

IMPACT: Accidental movement to a minimum or near minimum setting may render reception inaudible. Inadvertent maximum settings could breach noise discipline in tactical situations or hurt the operator's ears. Because the radio may not be receiving signals much of the time, the effect of accidental movement of the volume control may not be immediately apparent. This problem is aggravated by the lack of meaningful level markings (cf. Observation 3.19).

COMMENTS/POSSIBLE IMPROVEMENTS: Increase the control's resistance to movement.

Section 2: Display

2.01 **OBSERVATION:** The maximal viewing angles for the ICOM display were measured by taking the angle between a vertical line from the plane of the display frame at the edge of the display window and a line of sight in the horizontal plane slanting away from the vertical line to the point where the edges of the characters began to be occluded from view, as in the following illustration for viewing the display from the right side:



The maximal viewing angles determined by this method were the following (they are approximate):

- 30 degrees from the top of the display
- 27 " bottom "
- 30 " right "
- 30 " left "

IMPACT: The nominal maximal viewing angles are improved over the non-ICOM radio (for which they were approximately 12 degrees above and below, 20 degrees to the left, and 25 degrees to the right). The improvement is, however, much greater than the nominal values would indicate because of the change from a five-character, seven-segment LED to an eight-character (seven used), 5 x 7 dot matrix LED. The dot matrix allows much greater detail in the display characters, thus making them considerably more distinct from one another even if the entire character is not visible because of extreme viewing angle. Furthermore, the first and eighth characters of the display (which graphically indicate signal strength and low battery condition, respectively) are not used for alphabetical or numerical messages, and the seventh character is not used at all; therefore the effective readability of the display (for alphanumeric prompts and feedback) from extreme side-viewing angles is greater than that indicated by the nominal values given. When the first, seventh, and eighth characters are not considered, the effective angles for viewing from the left and right are approximately 62 and 82

degrees, respectively. Thus, while the top and bottom angles are still somewhat restricting, the side angles are not.

COMMENTS/POSSIBLE IMPROVEMENTS: The fact that the display characters are considerably inset from the surface of the display limits the maximal viewing angles. Design efforts should attempt to minimize this inset. The bottom viewing angle (27 degrees) could possibly be widened by tapering the top edge of the frame around the keypad. (Of course, nighttime security considerations tend to work in opposition to viewing considerations, and in some situations there may be reasons to minimize rather than maximize viewing angles.)

- 2.02 **OBSERVATION:** When the RF PWR selector is set to "HI" and the handset is keyed, the signal strength indicator flashes a "4" immediately followed by a 3 x 3 dot matrix.

IMPACT: The signal should show a 3 x 7 matrix for the "HI" setting. Operators would be confused by this erroneous feedback.

COMMENTS/POSSIBLE IMPROVEMENTS: According to ITT, this problem is a "bug" in the first-generation ICOM that will not exist in future versions.

- 2.03 **OBSERVATION:** Moving the FCTN switch from "OFF" to "Z-FH" produces a momentary display flash composed of full and partial matrices that are not meaningful to the operator.

IMPACT: The operator may interpret the flashes as indicating a possible radio malfunction.

COMMENTS/POSSIBLE IMPROVEMENTS: According to ITT, this problem is a "bug" in the first-generation ICOM that will not exist in future versions.

- 2.04 **OBSERVATION:** During the self test (FCTN switch set at "TST"), the top row of pixels in the display occasionally failed to light when they should--perhaps five percent of the time.

IMPACT: Operators might be confused. While the anomaly would seem to suggest a malfunction of some sort, apparently no operational consequences arise from it.

COMMENTS/POSSIBLE IMPROVEMENTS: This is probably another "bug" in the display. ITT should ensure that it does not appear in future ICOM radios.

- 2.05 **OBSERVATION:** During the self test (FCTN switch set at "TST"), the display shows a row of "8's," then a row of "inverted 8's," so that the operator can confirm that all pixels in the display are working.

IMPACT: Unnecessary complication of procedure.

COMMENTS/POSSIBLE IMPROVEMENTS: It would be simpler, more efficient, and perhaps more conducive to accurate operator observation simply to display all pixels at a time (a row of eight 5 x 7 matrices) rather than in two different sets, one of which (the "inverted 8's") is composed of complicated, non-standard characters. (This solution may be infeasible if, as ITT maintains, the use of all eight display positions at the same time would tend to overload the electrical circuits involved [cf. Observation 2.11, Comment]). Alternatively, the first four display positions could be displayed first, followed by the last four; which would eliminate the problem of lightning all positions at once and still provide easily scrutinized characters.)

- 2.06 **OBSERVATION:** With the MODE switch set at "FH" and the FCTN switch set at "LD," the display is supposed to indicate an empty "manual" channel with the term "COLD." Instead, the display shows "CO1D." (Cf. Observation 2.23.)

IMPACT: Operator confusion.

COMMENTS/POSSIBLE IMPROVEMENTS: According to ITT, this problem is a "bug" in the first-generation ICOM that will not exist in future versions.

- 2.07 **OBSERVATION:** In the single-channel mode, an empty manual channel is indicated in the display as "FILL 0," but in the frequency-hopping mode as "FILL."

IMPACT: To be consistent with other current display messages, the term should be "FILL 0" (although cf. Observations 2.08 & 2.11, Comment). The inconsistency may lead to operator or trainee confusion.

COMMENTS/POSSIBLE IMPROVEMENTS: Terminology should be consistent across operating modes.

- 2.08 **OBSERVATION:** Certain shortcomings in the non-ICOM radio resulting from the limitations of the seven-segment, five-character display, appear to have been unnecessarily carried over into the ICOM radio. E.g., the term "FILL" is used to designate an empty channel (a channel in which no frequency or hopset has been loaded; cf. Observation 2.11, Comment.)

IMPACT: The versatility of the new display is not always exploited with maximal effectiveness, thereby not alleviating to the extent possible the cognitive load on the operator and trainee.

COMMENTS/POSSIBLE IMPROVEMENTS: The term "FILL," for example, could be replaced with "EMPTY" or "FREE," both of which would better denote the condition of a channel with no frequency or hopset. "FILL" is, inappropriately, a command rather than a description of a state, as it should be. The versatility of the new display should be capitalized upon to make the trainee's and operator's jobs as simple as possible.

2.09 **OBSERVATION:** The display uses the numeral "7" to denote the "cue" channel. (Cf. Observation 1.03.)

IMPACT: The lack of intuitive correspondence between the name of the channel ("manual") and its symbolic representation adds an unnecessary complication to training and operation by requiring the soldier to learn a correspondence that should have been obvious in the first place.

COMMENTS/POSSIBLE IMPROVEMENTS: The cue channel should be represented in the display with the letter "C" or the term "CUE." (The former may be the better choice because it has fewer characters; cf. Observation 2.11.)

2.10 **OBSERVATION:** The display employs a "0" to refer to the so-called "manual" channel. (Cf. Observation 1.03.)

IMPACT: Analogous to impact of Observation 2.09: an unnecessary complication.

COMMENTS/POSSIBLE IMPROVEMENTS: If the term "manual" is to be retained (cf. Observation 3.13), it should be symbolized in the display with the abbreviation "MAN," as it is on the channel selector, or the letter "M." The latter may be more efficacious because it has fewer characters (cf. Observation 2.11).

2.11 **OBSERVATION:** Display messages on the ICOM radio consist, potentially, of eight characters; yet only seven of the display spaces are used.

IMPACT: The versatility of the display is not maximally exploited, which limits the number and variety of display prompts and feedback messages that can be presented to the trainee or the operator. (Cf. Observation 2.08.)

COMMENTS/POSSIBLE IMPROVEMENTS: The display prompt "M EMPTY," for example, would be possible if seven of the eight display position were utilized. "MAN EMPTY" would not be a candidate because it requires nine spaces. "MAN FREE" would be possible if the first, seventh, and eighth display characters (normally not used for alpha characters) were used. There would not appear to be any significant detrimental effect from using at least seven of the eight possible characters. ITT maintains, however, that using all eight characters at the same time creates too much of a load on the electrical system. It may still be feasible (and, if feasible, desirable) to use all eight spaces as long as not more than seven were employed at the same time.

2.12 **OBSERVATION:** The display indication for the so-called "late-entry" status is the capital letter "L" shown in the second character position before the hopset ID (e.g., "LF123"). Lockout IDs (if used) are represented in the display as "L123," "HL123" ("hold lockout #123"), or HLDⁿ ("retrieve lockout n"--cf. Observation 2.13). On the other hand, the keyboard designation for "late entry" is "L.E." (cf. Observation 3.10); the designation for "lockout" is "L."

IMPACT: These representations ("L," "LF," "HL," "HLD^L," and "L.E.") lack distinctiveness and present a confusing array of obstacles to the trainee.

COMMENTS/POSSIBLE IMPROVEMENTS: There are problems with the term "late entry" as it is used in the non-ICOM Operator's Manual and as taught in training classes (cf. Observations 3.09 & 3.10). However, if the term is to be retained as it is presently used (it is recommended that it not be so retained), the above confusion among abbreviations might be lessened by using "LE" (for "late entry") in the display as a superscript; i.e., as in "L^EF123." Of course, this display message requires six characters, as opposed to five. Perhaps character space seven could be utilized in this instance (cf. Observation 2.11). Similarly, lockout IDs (if used) could be represented in the display as "L^OF123" or "L^KF123" (cf. Observation 3.12).

- 2.13 **OBSERVATION:** The display messages "HLD _," "HLD n," "HLD^L_" and "HLD^Ln" are apparently representations of the old "H·LD" key on the non-ICOM radio (or at least highly reminiscent of it). Thus, it is not clear whether they are meant to imply "hold/load" or simply "hold." (Either way, they are probably internalized by the operator merely as "hold.") The corresponding key on the ICOM radio says only "LOAD" (cf. Observation 3.04). Furthermore, the concept "hold" is represented in other display messages by the single character "H" (in "HFnnn" and "HLnnn").

IMPACT: Considerable confusion and inconsistency has to be overcome by the trainee, which is expected to detract from the retention of operational skills and knowledge.

COMMENTS/POSSIBLE IMPROVEMENTS: The function of the key that generates the "HLD . . ." messages is sometimes to recall from memory and at other times to load information from an external source. It would probably be an improvement to move the function (it is currently collocated with "0") to a non-numeral key with a new, more appropriate label. Corresponding display messages might be more effective if they employed superscript characters, as in "HLD^L_" etc.--although the "hold" terminology should probably be discarded altogether and replaced by the terms "load" and "recall," as appropriate (cf. Observation 3.04).

- 2.14 **OBSERVATION:** In some instances the display uses a hyphen between characters (e.g., "AD-1," "AD-2," "CT-n"). In other instances a space is used in place of the hyphen (e.g., "CH n," "CLR n," "HLD n," "STO n").

IMPACT: The presence of the hyphen in the first instances but not in the second connotes a distinction between the situations that may be superfluous and may lead the naive trainee to question whether the hyphen is a minus sign or a hyphen. At any rate, it appears to be an unnecessary inconsistency.

COMMENTS/POSSIBLE IMPROVEMENTS: Eliminate the hyphens. Use spaces. (But see Observation 3.18, Comment [note j].)

2.15 **OBSERVATION:** The display uses "FQMER" to indicate an error status when the operator attempts to load a four-cell hopset into the ICOM radio.

IMPACT: This acronym, which stands for "frequency management error" is too esoteric for operators who will, most likely, encounter it only infrequently.

COMMENTS/POSSIBLE IMPROVEMENTS: Use a more meaningful prompt, such as "LD ERR," "LOAD ERR," or other appropriate term. (Cf. Observations 2.11 & 2.16, Comment.)

2.16 **OBSERVATION:** The term "ERROR" appears in the display both when the ECCM module is missing in the frequency-hopping mode and when the COMSEC switch is set at "RV" with the CHAN switch on "CUE" or "MAN."

IMPACT: The display feedback does not distinguish between the two error conditions; hence it is not as informative to operators as it could be.

COMMENTS/POSSIBLE IMPROVEMENTS: To distinguish between the two error conditions and to be consistent with the solution suggested for Observation 2.15, use "ECCM ERR" or the like for the missing-ECCM problem and "CHAN ERR" or the like for the wrong-channel problem. (Cf. Observation 2.11.)

2.17 **OBSERVATION:** The meaning of the display feedback message "E...D," which appears during the self test, is obscure and, with respect to the "D," inappropriate.

IMPACT: The self-test is more difficult to learn and interpret than necessary.

COMMENTS/POSSIBLE IMPROVEMENTS: The appearance of the "E" during the self test implies the presence in the radio of an ECCM module. The "D," however, which indicates the presence of a data module, is inappropriate because the data module will be an integrated component of the ICOM radio. ITT reports that "D" will be replaced by "C," which will indicate the (optional) presence of the COMSEC module. Even so, the display message "E...C" will be more cryptic than necessary. The new, enhanced display (cf. Observation 2.11) should be capable of presenting, serially, messages such as "ECCM IN" (or "NO ECCM") and "CMSC IN" (or "NO CMSC").

2.18 **OBSERVATION:** The meaning of the "FAIL 3" display message, which may appear during initialization (i.e., the memory test; function switch set to "Z-FH"), is unnecessarily cryptic.

IMPACT: It is more difficult than necessary for the trainee or operator to remember the meaning of the message.

COMMENTS/POSSIBLE IMPROVEMENTS: The message is intended to indicate that the ECCM memory (RAM) has not been appropriately zeroized. It

should be possible to present the message more meaningfully--for example, "NO ZERO," "MEM ERR," "FAIL Z," "NO INIT" (cf. Observation 3.03), or the like. The numeral "3" provides no intuitive meaning to the operator. The same sort of comments would apply to any other "FAIL n" messages.

- 2.19 **OBSERVATION:** The connotation of the display feedback message "GOOD," which follows initialization (function switch set to "Z-FH"), is ambiguous. (Cf. Observation 3.03.)

IMPACT: With the non-ICOM radio, operators tend to ignore the memory test (initialization) during start-up procedures and proceed directly to the "TST" position of the switch. As a consequence, false "FAIL" messages are sometimes displayed. Operators are not sufficiently aware of the "memory test" (initialization) function. The same would be true for the ICOM radio.

COMMENTS/POSSIBLE IMPROVEMENTS: Clarification of the import and purpose of the initialization/memory-test function needs to be emphasized during operator training and incorporated into the Operator's Manual. In addition, the feedback term "GOOD" should be replaced with a term more directly informative, such as "CLEARED," "ZEROED," "INIT OK," etc.

- 2.20 **OBSERVATION:** A single-channel frequency is "loaded" (without the use of the LOAD key--the "loaded" terminology comes from the non-ICOM Operator's Manual, pp. 2-34, 35) by pressing the number keys to display the appropriate frequency. The frequency is then stored with the STO (store) key, and the display blinks and displays the stored frequency just as it was displayed prior to pressing the STO key.

IMPACT: The feedback to the operator indicating completion of the procedure (display blink) is cryptic. If the trainee/operator does not see the blink (or does not remember its significance), the completion of the procedure remains unconfirmed, or at least tenuous.

COMMENTS/POSSIBLE IMPROVEMENTS: The display should confirm that a frequency has been stored by showing an appropriate term such as "STORED," "STO'D," "DONE," "ENTERED," "ENT'D," or the like. (Cf. Observations 2.22 & 3.18, Comment [note p].)

- 2.21 **OBSERVATION:** During the process of loading information (COMSEC variable, hopsets, lockouts) the LOAD key produces the display message "LOAD" during the loading process.

IMPACT: The message is misleading because it is in the form of a command prompt rather than a description of an ongoing process. It adds a learning/retention burden on the trainee or operator.

COMMENTS/POSSIBLE IMPROVEMENTS: Change the display term "LOAD" to "LOADING," "LD'ING," "WAIT," or other appropriate message.

2.22 **OBSERVATION:** After loading a TRANSEC, lockout, or hopset into the radio, the display confirms by blinking "STO x" ("x" is either "T" [for TRANSEC] or "n" [for channel]).

IMPACT: "STO x" is inappropriate because it is a command prompt rather than a confirmation. It is an unnecessary ambiguity that compounds operator training.

COMMENTS/POSSIBLE IMPROVEMENTS: Change "STO x" to something like "DONE," "STORED," "STO'D," "ENTERED," "ENT'D," or the like. (Cf. Observation 3.18, Note "1," which deals with loading the time variable.)

2.23 **OBSERVATION:** The term "COLD" appears in the display when the CHAN switch is set on "MAN" in preparation for a so-called "cold start."

IMPACT: To trainees, the metaphor "cold" may have little appropriate meaning. Consequently, they may find the concept difficult to assimilate and retain. (Operators appear to have had some trouble with the concept in the past in connection with the non-ICOM radio and the non-ICOM Operator's Manual where the concept is treated rather abstrusely.)

COMMENTS/POSSIBLE IMPROVEMENTS: Literal terms are normally more informative than metaphors in situations like this. The names for procedures or operational states (as well as all other operational terms) should, to the extent possible, be immediately understandable to the trainee; the terms should not themselves constitute additional learning tasks. Replace the term "cold" (and similar terms such as "local fill") with terms, phraseology, or explanations that directly assist the new operator in understanding the concepts and procedures involved.

Section 3: Labels

3.01 **OBSERVATION:** The label "RF PWR" on the power switch is unnecessarily specific and abbreviated.

IMPACT: The label, while it should be clear to the minimally trained operator, does, nevertheless, present an unnecessary learning task in its use of the abbreviation "RF."

COMMENTS/POSSIBLE IMPROVEMENTS: Simplify the label by changing it to "POWER."

3.02 **OBSERVATION:** All controls and connectors except the function switch are labeled at the top. The function switch is labeled at the bottom.

IMPACT: The switch position labeling at the top of the function switch, i.e., "!-SQ-!", could be mistaken by the naive trainee as a label for the switch itself because it follows exactly the format of the label for the MODE switch and is analogous to the labels on the power and channel switches. (Cf. Observation 3.21).

COMMENTS/POSSIBLE IMPROVEMENTS: Perhaps the FCTN switch label could be moved to the top as follows:

```
!--FCTN--!  
SQ SQ  
ON OFF .
```

A less ideal solution would be to leave the "FCTN" label at the bottom of the switch, but label the squelch positions as shown.

3.03 OBSERVATION: The "Z-FH" position label on the function switch indicates neither the "initialize" (i.e., memory test) function of that switch position nor the zeroing of single-channel information and time. (Cf. Observations 2.18 & 2.19.)

IMPACT: The purpose of this switch position is not well understood by operators of the non-ICOM radio, which bears the similar label "Z-A." There may be a tendency for operators to ignore the initialization during start-up procedures. They may think that the key zeros frequency-hopping information only. Greater confusion about this issue is expected to be evident with the ICOM radio because of the additional zeroizing function on the COMSEC switch.

COMMENTS/POSSIBLE IMPROVEMENTS: All functions of a control should be indicated by appropriate labeling--in this respect, the current label is unsatisfactory. Perhaps a better label for this switch position could be found. Some suggestions are: "M-TST" (memory test), "INIT" (initialize), and "INIT/Z" (initialize/zero). If there were sufficient room (as there might be if some of the control's functions were transferred to the keyboard or other locations--cf. Observation 6.01), better possibilities, such as follow, might exist:

```
INIT/ZERO , INIT/ , M-TST/ZERO , ZERO/ .  
ZERO M-TST
```

If the abbreviation "TST" were used in the label (as in some of the examples given), then the self-test position label ("TST") would have to be modified to distinguish it from the memory-test/zero position--it might be changed to "CIR TST" (circuit test), "SLF TST," "BIT," or the like.

3.04 OBSERVATION: The label "LOAD" on the zero (0) key does not sufficiently describe the function of the key often used to "recall" information from permanent memory. (Cf. Observation 2.13.)

IMPACT: The usage of the key may be more difficult than necessary for operators to learn and remember.

COMMENTS/POSSIBLE IMPROVEMENTS: Because the key "recalls," as well as "loads," it may be appropriate to move the function to a non-numbered key where there would be room to provide a label such as:

!RECALL!
! LOAD !

(Cf. Observation 3.18, Comment [note g].)

- 3.05 **OBSERVATION:** The acronym "HUB" used on the "hold-up" battery cover has undesirable connotations (as "hub" in "hubcap").

IMPACT: This is an awkward use of labeling that tends to interfere with the proper interpretation of the label, especially for the trainee.

COMMENTS/POSSIBLE IMPROVEMENTS: Because there is ample room on the battery cover, a better, more informative label for the hold-up battery cover might be:

HOLDING , HOLD-UP , H-BATT ,
BATTERY BATTERY

or the like.

- 3.06 **OBSERVATION:** There is no indication on the radio that the hold-up battery is to be installed with the negative terminal pointing outward.

IMPACT: The battery may be installed backward, which would prevent proper contact.

COMMENTS/POSSIBLE IMPROVEMENTS: Astute operators should be able to deduce the proper orientation of the battery from the physical construction of the cover, but the battery can be installed backward. Ideally, the design should prohibit improper installation. A satisfactory solution would be the inclusion of labeling on the surface of the panel, but underneath the battery cover, informing the operator that the negative pole of the battery should point outward: "NEG OUT," or the like.

- 3.07 **OBSERVATION:** ITT reports that the labels on the front panel of the radio will be embossed rather than engraved because of the expense involved in painting engraved labels.

IMPACT: The paint on the raised labels will be exposed to excessive wear. Worn-off paint would make the labels even more difficult to read in low-light situations.

COMMENTS/POSSIBLE IMPROVEMENTS: Slightly depressed labels should protect label paint and resist collection of dirt.

- 3.08 **OBSERVATION:** The scanning function is not indicated by a label.

IMPACT: Operators will be forced to remember the scan procedure with no machine prompt.

COMMENTS/POSSIBLE IMPROVEMENTS: Unless there are overriding considerations, all functions should be represented by a label on the appropriate control, regardless of the frequency of usage.

- 3.09 **OBSERVATION:** The abbreviation "L.E." on the keyboard (on the "3" key) denotes "late entry," which appears to be a misnomer because the purpose of the procedure to which it refers (according to the non-ICOM Operator's Manual, p. 2-59) is to regain lost or suspended communication with a net, not to enter a net late. The procedures for a bona fide late net entry (cue and ERF) are completely different (Operator's Manual, pp. 2-59, 60).

IMPACT: The purpose of the procedure is not well understood by operators. The procedure is difficult to teach to trainees, who must learn that "late entry" procedures are not used for bona fide late net entry. This problem may have a significant negative impact on training and retention.

COMMENTS/POSSIBLE IMPROVEMENTS: Terminology in this area needs clarification. The term "late entry" should be used only in its literal sense, which is the late "entering" (not "reentering") into an operating net via cue/ERF procedures. That is, "late entry" occurs after a previously appointed, previously expected, or normal entry (not reentry) time. The term "late entry" should not be used to describe the situation in which the operator is attempting to reenter a net with which communication had been previously established but for some reason was lost or suspended. In the latter situation, the concept of "resynchronization" should be useful as a descriptor, especially in view of the fact that the operational procedure specified for that circumstance involves a resynchronization of the time variable between the "lost" station and the operating net. Because the term is familiar to trained operators, the abbreviation "SYNC" would be a likely candidate to replace the confusing "L.E." on the keyboard (but note also Observation 3.10).

- 3.10 **OBSERVATION:** The so-called "late-entry" function (resynchronization function--cf. Observation 3.09) is not indicated on the key that is used to initiate the function (the "FREQ" key). Likewise, the label "L.E." on the "3" key is inappropriate because that key is not used to initiate the function.

IMPACT: Operators may forget how to enter the so-called "late entry" mode. Because the "3" key has the label "L.E." on it, the natural tendency is to press L.E. first, rather than FREQ. Because of these complications and those discussed in Observation 3.09, operators tend to ignore this convenient and relatively safe method of reestablishing communications.

COMMENTS/POSSIBLE IMPROVEMENTS: All controls should be labeled for the functions that they initiate. The FREQ key, however, is already overworked, so the solution would not be to add a label for the resynchronization function to it. A better solution would be to establish a different procedure altogether--e.g., initiate the function with an

appropriately labeled key (other than the FREQ key). (The display would respond with something like "SYNC OFF".) Then press a change-state key (e.g., "CHG") to enter the resynchronization mode (cf. Observation 3.18, Comment [notes g & f]). (The display would then show "SYNC ON".)

- 3.11 **OBSERVATION:** The FREQ key is used to identify previously stored lockouts, yet there is no indication of this function on the key. The label "L" (for "lockout") on the "9" key is confusing at this point because that key is not used in the lockout identification process.

IMPACT: Operators may forget how to identify lockouts stored in the radio. Trainees may forget which key controls the function. The entire process of loading, storing, retrieving, and identifying lockouts is liable to confusion and misunderstanding.

COMMENTS/POSSIBLE IMPROVEMENTS: Because the FREQ key is overworked, the solution is not to add a label for lockouts to it. Initiation of the lockout-identification function should be moved to another appropriately labeled key (cf. Observation 3.12).

- 3.12 **OBSERVATION:** The meaning of the label "L" on the "9" key is unnecessarily cryptic.

IMPACT: The label, as is, contributes to the confusion among terms and abbreviations used for "lockouts" and "late entry" discussed in Observation 2.12.

COMMENTS/POSSIBLE IMPROVEMENTS: On the keyboard, lockouts could perhaps be better represented by "LOCKOUT," "L-OUT," "LK-OUT," etc. (i.e., some indication that is more informative than "L"). The point is that an attempt should be made (not necessarily as illustrated here) to make the designations for lockouts and "late entry" as meaningful as possible (both in the display and on the keyboard) and to ensure that the distinction between them is clear. (Cf. Observation 3.18, Comment [notes f & g].)

- 3.13 **OBSERVATION:** The term "manual" (as in "MAN channel"), used to designate the digital-channel position on the CHAN switch, is a misnomer in that it implies that this channel, unlike the other seven, is somehow not automatic (i.e., operated manually). This distinction appears to be entirely superfluous, having no bearing on the operating features of any of the channels.

IMPACT: Even seasoned operators are confused about the purpose, proper usage, and nature of the "MAN" channel.

COMMENTS/POSSIBLE IMPROVEMENTS: The term should be replaced with an appropriate and informative designator that connotes the administrative characteristics of the channel; e.g., "ADMN," "ADMIN," or other appropriate term. Provide additional operator training on this topic.

3.14 **OBSERVATION:** The virgule in the label "FH/M" is not consistent with the meaning of the label or with the analogous label "Z-FH" on the FCTN switch. (Cf. Observation 3.03.)

IMPACT: The slant bar denotes alternatives. The hyphen denotes subordination. The latter is the correct choice for the present situation.

COMMENTS/POSSIBLE IMPROVEMENTS: Change "FH/M" to "FH-M."

3.15 **OBSERVATION:** In general radio parlance the meaning of the term "send" is "transmit"; i.e., "send" refers to any transmission at all and implies no limitation regarding type. The SINCGARS radio, however, employs "send" in a non-standard manner, reserving it for the transmitting of "electronic remote fills" (ERFs).

IMPACT: The trainee must learn that "send" does not mean "transmit" in its general sense, but "transmit ERF."

COMMENTS/POSSIBLE IMPROVEMENTS: Change the label "SEND" on the keyboard to "ERF," which has the precise meaning intended and is thoroughly familiar to all operators with minimal training. (Cf. Observation 3.18, Comment [note n].)

3.16 **OBSERVATION:** The combination of upper case and lower case letters on the SEnd OFST key serves no purpose.

IMPACT: Trainee confusion.

COMMENTS/POSSIBLE IMPROVEMENTS: The upper/lower case combination is apparently an accidental "holdover" from the non-ICOM radio, which was incapable of displaying upper case "N's" and "D's" in the display. One solution would be to change to upper case. A better solution would change the labeling on the key to "ERF" instead of "SEND" (cf. Observation 3.15).

3.17 **OBSERVATION:** The change-sign function (+/-), used for entering negative frequency offsets, is not indicated on the key that controls it (the SEnd OFST key).

IMPACT: The method of entering negative offsets is confusing to the trainee and may tend to be forgotten by operators who do not use the radio frequently.

COMMENTS/POSSIBLE IMPROVEMENTS: The entire offset function would be better moved to a different key and controlled as suggested in Observation 3.18, Comment (notes c & k). Failing that, indicate the +/- function on a key (but not the SEnd OFST key).

3.18 **OBSERVATION:** The labeling and corresponding arrangement of functions on the keyboard, while better than that of earlier versions, remains incomplete and confusing in certain ways (some of which are indicated in the observations discussed above).

IMPACT: The keyboard, as is, does not minimize the trainee's learning and retention requirements. In this respect, it would appear amenable to considerable improvement, with an attendant payoff in the areas of training and learning decay.

COMMENTS/POSSIBLE IMPROVEMENTS: The following is one of perhaps several keyboard arrangements that might constitute significant improvement. It is suggested that consideration be given to the notion of incorporating some such changes in the current SINGARS ICOM. (See notes below.)

----- * COMSEC CHANGE FREQ/ 1 2 3 STATUS -----	----- SCAN SYNC LOCKOUT CLEAR 4 5 6 (oo) -----
----- BATT CK DATA OFFSET TIME 7 8 9 (ooo) -----	----- CALL ERF RECALL/ ENTER REMOTE 0 LOAD -----

Notes:

a. **ASTERISK (*):** The asterisk replaces "ASE" as a symbol that, with appropriate training, may be less confusing to the operator.

b. **COMSEC:** The "COMSEC" key displays the ID of the current COMSEC variable. Available IDs are cycled in the display with the CHANGE key.

c. **CHANGE:** The CHANGE key could be used for at least five purposes: to cycle through available data rates, offsets, COMSEC IDs, ASE (*) status, and resynchronization status.

d. **FREQ/STATUS:** The function of the FREQ/STATUS key is limited to activating the display to show frequencies, hopsets, lockouts, and current states such as resynchronization status. (Cf. Observation 3.10.)

e. SCAN: The scanning function is initiated with the SCAN key (rather than, as previously, with the STO key). (Cf. Observation 3.08.)

f. SYNC: Resynchronization (previously "late entry") is initiated with the SYNC key and turned "ON" or "OFF" with the CHANGE key. If the operator keys the radio while in sync mode, the display could provide a reminder such as "WAIT 30" to remind the operator to wait thirty seconds before trying to contact the net again. (Cf. Observation 3.10.)

g. LOCKOUT: The LOCKOUT key displays (cycles through) the IDs of lockout sets currently in the radio. If none, display could show "NO L-0" or some analogous feedback message. To retrieve a lockout prior to an ERF, the operator would press RECALL/LOAD (the display would show "RCL?," or the like) and LOCKOUT (the display would show the lockout ID of the current channel). (Cf. Observations 3.11 & 3.12.)

h. CLEAR: There would always be a requirement for the operator to press the CLEAR key twice, with a mandatory wait between presses (at least two seconds) while the display flashes the query "CLEAR?" (or the like). (Cf. Observations 5.06 & 5.07).

i. BATT CK: "BATT CK" could also be "BATTERY." Regardless, cf. Observation 5.12. This function is removed from the BATT CALL key to avoid ambiguity of labeling (cf. note m, below).

j. DATA: The DATA key would turn the data switch on and off. Changes in data rate would be accomplished with the CHANGE key while the data switch is on. If the data switch has been off and the DATA key is pressed, the display might show "DATA OFF." If the DATA key is pressed again before the display turns off, the switch would be turned on and the smallest data rate ("DR 75"), or perhaps the rate last used (e.g., "DR 16000"), would be displayed. The CHANGE key would then select the desired rate if that rate is not displayed. (The analogue data-rate settings could be displayed as "DR A1" and "DR A2." Cf. Observation 2.14.)

k. OFFSET: The OFFSET key would display the current value of the offset: "OFST -10," "OFST 0," etc. The offset value would be changed with the CHANGE key. (Cf. Observations 3.17 & 5.08.)

l. TIME: Pressing TIME repeatedly would cycle the display through day, hours/minutes, and minutes/seconds. The display would show, successively: "DAYXX," "HXX MXX," and "MXX SXX." The procedure for setting time would be as follows (or a similar variant):

Press	Display	Comment
TIME	DAYXX	(Current day)
1	DAY01	
ENTER (optional)	DONE	(Current HH MM SS unchanged)
TIME	MXX	(Current hour)
7	M07	
ENTER (optional)	DONE	(Current DD MM SS unchanged)
TIME	M07 MXX	(Current minute)
3	M07 M03	
0	M07 M30	
ENTER	DONE	(Current DD HH unchanged; SS set to 00)

(Cf. Observation 5.08.)

m. CALL REMOTE: Pressed to signal the SRCU. (Cf. note i, above.)

n. ERF: Transmits electronic remote fill. (Cf. Observation 3.15.)

o. RECALL/LOAD: For retrieving from permanent memory and loading variables (hopsets, etc.). (Cf. Observation 3.04.)

p. ENTER: For storing information in permanent memory. The display would require operator confirmation if pressing the enter key would cause previously stored information to be overwritten. (A confirmation procedure such as that suggested for the CLEAR key might be considered --see note h, above.) The term "enter" replaces "store," although the latter would also be acceptable.

3.19 **OBSERVATION:** The crescent scale on the "DIM" and "VOL" (volume) controls have no reference marks on the panel.

IMPACT: The scales are essentially useless as they are. The controls cannot be preset to a specific level, which is an especially desirable feature for the manpack version where it may be important to avoid inadvertent exposure from unintended brightness or volume levels.

COMMENTS/POSSIBLE IMPROVEMENTS: Redo the labeling on these controls. Appropriate labels could be expressed in a number of different formats. However, if the crescent scale is to be retained, it should be moved from the knob to the face of the panel and reversed in orientation; a reference mark and shape coding should then be incorporated into the knob design. A better solution might consist of a shape-coded knob with several discrete reference marks on the panel so that the operator can easily preselect desired settings.

3.20 **OBSERVATION:** The labels on the COMSEC switch are too cryptic.

IMPACT: Operator learning and retention will be impeded.

COMMENTS/POSSIBLE IMPROVEMENTS: The amount of space around the control is small; perhaps something like the following could be implemented within the limits of the available space:

```
      |--COMSEC--|  
      TM-DEL  
      _CYPH      REM-LD  
      |PLN|      |Z-CMSC|
```

The label "REM-LD" is meant to denote "remote load" and replaces "RV," which it is understood stands for "receive variable."

3.21 **OBSERVATION:** The "COMSEC" label has no reference lines like those of the labels "CHAN," "RF PWR," "MODE, and "FCTN."

IMPACT: An unnecessary inconsistency.

COMMENTS/POSSIBLE IMPROVEMENTS: Add the lines, as in the illustration in Observation 3.20.

Section 4: Connectors

4.01 **OBSERVATION:** Operators have complained about the number of cable connections required for vehicular configurations of the non-ICOM SINCGARS.

IMPACT: The multiplicity of cables is alleviated to some extent in the ICOM radio because of the integrated COMSEC feature. Unnecessary cabling would be expected to add to the unreliability of a system.

COMMENTS/POSSIBLE IMPROVEMENTS: The number of connections that operators are required to make should always be minimized to the extent possible. This can be accomplished in great part by the appropriate design of installation components (vehicle mounts, etc.) which would make connections automatically with installation of the radio.

4.02 **OBSERVATION:** The connectors on the control panel of the non-ICOM radio have been notorious for the difficulty encountered in trying to plug cables into them--partially because of the lack of access space and partially because of the poor design of the connectors themselves (cf. Observation 4.03). The same is true of the ICOM. For example, it is next to impossible to connect the handset to the audio connectors without first lubricating the plug on the handset.

IMPACT: Cable connecting will often require excessive time. (Operators of the non-ICOM radio [and their instructors] have used saliva as a lubricant--a practice that might present a problem in extremely cold weather.)

COMMENTS/POSSIBLE IMPROVEMENTS: Provide connectors and plugs that are easily assembled and disassembled.

4.03 **OBSERVATION:** The alignment keys on the protective caps for the audio and retransmission receptacles are difficult to engage. It is cumbersome to install the caps--even though the caps are coded with external depressions indicating the location of alignment keys in the caps. (There is no corresponding coding on the receptacles.) The problem is compounded by the proximity of the connectors and the panel railings.

IMPACT: Installation of the caps is unnecessarily time consuming. The caps may not be appropriately utilized.

COMMENTS/POSSIBLE IMPROVEMENTS: All connectors and caps should be designed for ease of use. (Cf. Observation 4.02.)

4.04 **OBSERVATION:** The sponge-like inserts (which act as retainers) in the connector caps are easily removed.

IMPACT: If a retainer is lost, the cap easily falls off the connector.

COMMENTS/POSSIBLE IMPROVEMENTS: Provide caps with retaining mechanisms that will not be lost.

4.05 **OBSERVATION:** Connector caps are attached to the radio with braided cord crimped into a swivel on top of the cap.

IMPACT: The caps, when not in use, dangle loosely from the front panel where they can be easily yanked from the radio and lost. The cords can be snagged by underbrush, etc. and get entangled with each other. They also can swing under the radio when the radio is set down, thus subjecting the caps to possible damage from the impact of the radio on them.

COMMENTS/POSSIBLE IMPROVEMENTS: Provide a more durable, less unwieldy method of attaching the caps to the radio.

Section 5: Procedures

5.01 **OBSERVATION:** According to ITT, the radio setup for loading the COMSEC variable into the "first-generation" ICOM radio includes setting the MODE switch to FH (or FH/M). The procedure will not work if the switch is set to SC.

IMPACT: There would seem to be no compelling reason, at least from the operator's point of view, why the MODE switch should have anything to do with the loading of a COMSEC variable. It adds an enigmatic step to the procedure which hinders learning and retention.

COMMENTS/POSSIBLE IMPROVEMENTS: The requirement that the MODE switch be set to a particular setting for loading the COMSEC variable should be eliminated, as, according to ITT, it will be in the second-generation ICOM.

5.02 **OBSERVATION:** The radio setup for loading a COMSEC variable requires that the data key be switched to off (or AD-1); otherwise the COMSEC alarm will not be heard.

IMPACT: The reason for this requirement may not be immediately apparent to (or well remembered by) the operator.

COMMENTS/POSSIBLE IMPROVEMENTS: Ideally, a display prompt should assist the operator in avoiding the problem. Additionally a display message should accompany the alarm to provide redundancy.

5.03 **OBSERVATION:** It is presumed that the "load and store" procedure for storing a TRANSEC variable in the ICOM radio is the same as that used with the non-ICOM radio. That being the case, the following observation is relevant: The "load and store" procedure consists of pressing a single key (the LOAD key) after the correct switches have been set and the fill device connected. The STO key is not to be used even though the display "beeps" and momentarily shows "STO T" after the LOAD key has been pressed. The operator's procedure for storing an additional TRANSEC variable in the holding memory is the same--the single key "LOAD" is pressed. (Cf. Observation 5.04.)

IMPACT: A natural mistake here would be to press the STO key, either instead of or in addition to the LOAD key. In attempting to store an additional TRANSEC variable in the holding memory, use of the STO key will erase the TRANSEC variable stored in permanent memory.

COMMENTS/POSSIBLE IMPROVEMENTS: The loss of stored information appears to have been a significant problem with the non-ICOM radio in past operational evaluations. Perhaps the sort of problem cited here has been contributory. The ICOM radio should be provided with overwrite protection so that unintentional deletion of stored information is made highly improbable (cf. Observation 3.18, Comment [note p]).

5.04 **OBSERVATION:** The "load and store" procedure for loading a hopset (in the "local fill" situation), in contrast to the procedure described in Observation 5.03 for TRANSECs, involves pressing two keys--LOAD followed by STO (and the channel number). The two procedures are inconsistent.

IMPACT: The tendency to use the STO key erroneously when loading a second TRANSEC variable (cf. Observation 5.03) is perhaps enhanced by its required use when loading hopsets.

COMMENTS/POSSIBLE IMPROVEMENTS: Loading and storing procedures should be consistent from task to task so that the cognitive requirements for the operator are minimized. The terms "load" and "store" should be clearly and distinctly defined and operationalized.

5.05 **OBSERVATION:** Clearing a single-channel frequency requires that the CHAN switch be set on the channel being cleared. Clearing a frequency hopset, on the other hand, requires that the CHAN switch not be set on the channel being cleared.

IMPACT: The two procedures are, from the operator's or trainee's point of view, inconsistent. They are more difficult to learn and remember because they can be confused with each other.

COMMENTS/POSSIBLE IMPROVEMENTS: If possible, the two procedures should be made alike--which would imply making it possible to clear the hopset on the current channel (although additional protection against accidental clearing should be introduced here as well as elsewhere--cf. Observation 3.18, Comment [notes h & p]).

5.06 **OBSERVATION:** The procedure for clearing a single-channel frequency involves pressing the following keys in order: **FREQ, CLR, 0, STO.** On the other hand, the procedure for clearing a frequency hopset is simply: **CLR, [channel number].**

IMPACT: It is a simpler matter to reload a lost single-channel frequency than a lost frequency hopset; yet, as indicated, it is much easier to accidentally clear a hopset than a single-channel frequency. Because the clear key requires no confirmation from the operator before information is cleared, losing information accidentally is made more probable. (Cf. Observation 3.18, Comment [note h].)

COMMENTS/POSSIBLE IMPROVEMENTS: Change both the single-channel and hopset clearing procedures to something like the following:

Press	Display
CLR [channel #]	CLR _ CLR FFn? (or "CLR SCn?," depending on the position of the MODE switch; "n" is channel #; display flashes query [minimum two seconds] until operator responds)
CLR	DONE

5.07 **OBSERVATION:** The clear function is not effectively utilized; the manual clearing of the display before entering new data is an unnecessary step.

IMPACT: When the operator wishes to enter or change single-channel frequencies, frequency offsets, or time-of-day, the **FREQ, SEnd OFST, or TIME** key is pressed. Correspondingly, this action displays the currently stored frequency, offset, or time data. Then the **CLR** key must be pressed to replace the displayed information with a blank-line prompt. The operator then keys in the required new data (fills in the blanks) and stores them. In the sequence just described, the **CLR**-key step appears to serve no useful purpose. It neither informs the operator of anything not already known nor adds significant protection against accidental loss of information. Consequently, it appears to be an unnecessary complication and a waste of time.

COMMENTS/POSSIBLE IMPROVEMENTS: For all practical purposes, the frequency, offset, and time procedures would be more efficient if the **CLR**

step were simply omitted, as in the following example (note that the zero is entered automatically):

```
Key:  FREQ      4      6      2      5      STO
Display: 30000  4....  46...  462..  46250  46250
                                             \\!//
                                             //!\
                                             [blink]
```

A better sequence would include an overwrite protection step:

```
Key:      "      "      "      "      "      STO      STO
Display:  "      "      "      "      "      46250  DONE
                                             \\!//
                                             //!\
                                             [rapid
                                             flash]
```

The flash should occur at a rate of about one per second, remaining on each time long enough for the display to be read. A minimum of two flashes should be required before the next step is enabled. (Or, the flashing frequency could alternate with the prompt "STORE?" or equivalent--cf. Observation 3.18, Comment [note p].)

The proper function for the CLR key should be to clear the memory in a dual-step procedure like the following:

```
Key:  FREQ      CLR      CLR
Display: 46250  \\!//
                                             46250  DONE
                                             //!\
                                             [rapid
                                             flash]
```

(Or, the flash could alternate with the prompt "CLEAR?" or equivalent--cf. Observation 3.18, Comment [note h].)

5.08 OBSERVATION: The frequency-offset prompt ("--") implies that a two-digit response is required.

IMPACT: An attempt to enter "05" for a 5 kHz offset will not only fail to establish a 5 kHz offset, it will also erase any previously entered offset by entering "00" instead. This procedure is inconsistent with that for entering time-of-day, where, for example, "five minutes" must be entered as "05." To establish a 5 kHz offset, the operator must ignore the two-digit request and enter the single digit "5." If the operator carelessly enters "05" instead, single-channel communications will be lost until the error is detected and corrected.

COMMENTS/POSSIBLE IMPROVEMENTS: If the method of entering offsets is not changed completely, as suggested in Observation 3.18, Comment (notes c & k), then, to establish a 5 kHz offset, the operator should be able to enter either "0" or "5" as the first digit. If "0," the radio should wait for the second digit and allow either another "0" (to erase any previous offset) or a "5" (which would overwrite any previous setting). If "5" is entered as the first digit, then no second digit should be allowed. (If "1" is entered as the first digit, the second digit ["0"] should be automatically entered by the radio to establish a 10 kHz offset.)

- 5.09 **OBSERVATION:** There has been some indication in the past that operators were less than optimally familiar with troubleshooting procedures.

IMPACT: Operators may waste more time than necessary applying illogical solutions or inefficient procedures to problems encountered.

COMMENTS/POSSIBLE IMPROVEMENTS: Operators may benefit from additional troubleshooting training so that they are prepared to apply a logical sequence of remedial procedures upon encountering an operational problem. Operator manuals should contain a section that lists possible problems and clearly indicates the appropriate procedure to be followed in each case.

- 5.10 **OBSERVATION:** In a recent evaluation of the non-ICOM radio, one of the operators complained that the cue signal caused confusion within the net ("may get people lost switching back and forth"). The extent of this problem is not known. To the extent that it exists with the non-ICOM version it is expected to exist with the ICOM version.

IMPACT: May precipitate a loss of communication among net members.

COMMENTS/POSSIBLE IMPROVEMENTS: This observation may signify insufficient training in cue procedures. It may also imply a need for a more versatile cue capability such as the option to cue a single receiver (NCS) rather than the entire net.

- 5.11 **OBSERVATION:** The Operator's Manual for the non-ICOM radio states that the radio should not be turned off if the ambient temperature drops below +20 degrees Fahrenheit. Otherwise, the presets may be lost. It is assumed that this comment would also apply to the ICOM version.

IMPACT: If the operator allows the radio to become cold, communication may be precluded.

COMMENTS/POSSIBLE IMPROVEMENTS: The Operator's Manual discusses this problem in a section near the end of the manual called "Operation Under Unusual Conditions." The necessity of operating in temperatures below +20 degrees Fahrenheit should not be considered unusual. If the probability of losing presets is significant at temperatures below +20, certainly the importance of keeping the radio warm should be greatly

stressed during operator training. ITT is currently examining this issue.

- 5.12 **OBSERVATION:** The validity of the battery-low indication is dependent upon the accuracy of manually stored information (indicating when the battery was installed in the radio). The requirement for operators to log battery amp-hours is probably ill-advised. It is unlikely that the requirement will be met to a satisfactory degree.

IMPACT: The battery-low indication is not a reliable indicator. The operator will have insufficient or inadequate warning of the imminent failure of the battery; communications may be lost, interrupted, or otherwise degraded.

COMMENTS/POSSIBLE IMPROVEMENTS: Scrap the requirement for operators to keep track of battery life manually. Ensure that fresh batteries are always available. If feasible, devise an automatic warning of imminent battery failure--if the amount of time remaining would allow the operator to exchange batteries without a a totally unexpected interruption of communication. If it is a high priority for the operator to be able to ascertain remaining battery life, additional consideration should be given to utilizing a different kind of battery.

- 5.13 **OBSERVATION:** The battery housing box on the non-ICOM radio has four spring clips for securing the box to the radio. The clips are easy to close, and they appear to provide a very secure attachment; however, they are difficult to impossible (depending on the operator) to open without some sort of leverage tool (such as a screwdriver)--cf. Observation 6.06.

IMPACT: Unresolved, the problem would extend the time required to change the battery because the operator would have to locate and apply an appropriate tool.

COMMENTS/POSSIBLE IMPROVEMENTS: Redesign the battery housing attachments. Provide clips that open easily without a tool but remain secure when in place. (ITT reports that redesign efforts currently underway will eliminate this problem from the ICOM radio.)

- 5.14 **OBSERVATION:** Undue force is required to tighten and untighten the screws that secure the hold-up battery compartment cover.

IMPACT: Using a penny (the edges of which will suffer significant damage as a result) as a tool, the time required to remove and replace the cover is approximately 3.25 minutes. (Inserting the battery should add less than five seconds.)

COMMENTS/POSSIBLE IMPROVEMENTS: Such a potentially simple operation should require much less time. The method of attaching the battery cover should be reexamined (cf. Observation 5.16, Comment).

5.15 **OBSERVATION:** The screw wells on the cover of the hold-up battery cover are too small.

IMPACT: Some of the tools that may be used to change the battery (coins, etc.) will scratch the paint off the edge of the screw wells.

COMMENTS/POSSIBLE IMPROVEMENTS: Cf. Observation 5.16, Comment.

5.16 **OBSERVATION:** A tool is required to change the hold-up battery. The slots in the screw heads of the hold-up battery cover are not wide enough to accommodate the edge of a nickel or a quarter.

IMPACT: The required tool may not be available when it is needed.

COMMENTS/POSSIBLE IMPROVEMENTS: The radio operator should not have to use tools for any normal operational procedure. Possibly a knurled screw in cap with a retainer on it would help solve the hold-up battery cover problems (cf. Observations 5.14, 5.15, & 6.01-6.03).

Section 6: Miscellaneous

6.01 **OBSERVATION:** The cover for the "hold-up" battery compartment uses an unfortunately large amount front panel space.

IMPACT: Space that was badly needed to alleviate the crowding of controls on the non-ICOM radio is occupied on the ICOM radio by what may be an unnecessarily large cover.

COMMENTS/POSSIBLE IMPROVEMENTS: The design of the battery compartment cover was the subject of intense consideration, according to ITT. Perhaps it cannot be improved upon (cf. Observation 5.16, Comment). Nevertheless, it appears to occupy more space on the control panel than would seem justified by the infrequency of its use. (The space could be better employed, perhaps, by an additional column of keys on the keypad to which various functions could be transferred from control knobs--cf. Observation 3.03.)

6.02 **OBSERVATION:** The screws used for attaching the hold-up battery cover have washers whose apertures are too large.

IMPACT: The washers do not seat themselves symmetrically around the screw shafts. The lower washer can hang below the edge of the cover.

COMMENTS/POSSIBLE IMPROVEMENTS: Use appropriate washers. But see Observation 5.16, Comment.

6.03 **OBSERVATION:** The cover for the hold-up battery and the screws that secure it are not captive (attached to the radio) when the battery is being replaced.

IMPACT: The cover and screws could be lost, especially in the backpack configuration of the radio.

COMMENTS/POSSIBLE IMPROVEMENTS: The cover should be an integral part of the radio that does not become detached during battery replacement. Redesign accordingly (cf. Observation 5.16, Comment).

6.04 **OBSERVATION:** Certain features of the front panel of the radio are unnecessarily reflective.

IMPACT: The visibility of the radio itself at nighttime is not minimized, which may be of some concern in the backpack configuration. The unnecessary reflectance adds to the cluttered aspect of the panel.

COMMENTS/POSSIBLE IMPROVEMENTS: The reflective quality of certain labeling is necessary in operating controls. Other reflectance should be minimized. Examples of sources of possibly unnecessary reflectance are: the white paint on the label of the holding battery cover (the cover is used infrequently and is not an operational control) and on other non-essential label components ("ANT," "CHAN," "RF PWR," "MODE," "FCTN," "SIG" [and its scale], "HUB LOW," "COMSEC," "VOL," "AUD/FILL," and "AUD/DATA"); the unpainted screws that retain the holding battery cover; the locking rings on the connectors; and larger than necessary switch and switch position labels. Some consideration should be given to leaving the white paint off all but necessary labels and painting other shiny components the same color as the panel face. This would have the added advantage of lessening the cluttering on the panel.

6.05 **OBSERVATION:** The radio has no carrying handle.

IMPACT: The radio is extremely difficult and awkward to carry with one hand.

COMMENTS/POSSIBLE IMPROVEMENTS: According to ITT, there appears to be enough available space in vehicular mounts to allow a folding handle to be attached to the right side of the radio. Such a handle would be of significant use to installers and maintenance personnel as well as others.

6.06 **OBSERVATION:** The main battery for the non-ICOM radio and, presumably, the first-generation ICOM radio, is not integral to or secured within the battery box.

IMPACT: The battery, including its electrical connector, is susceptible to damage from dropping when the housing is removed for battery exchange. The battery can fall out or be removed at an angle, which exerts a twisting or bending force on the receptacle.

COMMENTS/POSSIBLE IMPROVEMENTS: The battery should be protected from accidental damage caused by dropping or inappropriate removal by ensuring that it cannot be removed from the radio at an angle. This could be accomplished by providing alignment keys on the housing and by securing

the battery within the housing so that the housing and the battery must be removed as a unit--and subsequently separated for battery exchange; cf. Observation 5.13. (ITT reports that redesign efforts currently underway will eliminate this problem from the ICOM radio.)

- 6.07 **OBSERVATION:** On the non-ICOM radio, and presumably on the first-generation ICOM radio as well, the clips that secure the main battery box to the radio spring open with great force.

IMPACT: The operator who is able to spring open the clips without a tool may sustain a very painful blow to the fingers.

COMMENTS/POSSIBLE IMPROVEMENTS: Same as for Observation 5.13. (ITT reports that this problem is currently being addressed.)

- 6.08 **OBSERVATION:** The radio in its backpack configuration is difficult to balance for operating on the ground.

IMPACT: An inconvenience.

COMMENTS/POSSIBLE IMPROVEMENTS: It might be feasible to modify the backpack frame so that it could be used as a prop for the radio.

- 6.09 **OBSERVATION:** Some of the screws on the front panel of the radio have standard slotted heads. The rest are Phillips screws.

IMPACT: Because standard screw heads (especially the slotted type) are easily removed, they allow the well-meaning or curious operator to attempt unauthorized "maintenance."

COMMENTS/POSSIBLE IMPROVEMENTS: Use a less common screw head (e.g., allen) because it would require a less commonly available tool.

- 6.10 **OBSERVATION:** The front panel violates the general principal that a more frequently used control should not be positioned on the left side of the panel.

IMPACT: Right-handed operators, which constitute the majority, must reach farther; manipulation of the controls on the left is somewhat more awkward than it would be if they were farther to the right. This problem is not considered serious.

COMMENTS/POSSIBLE IMPROVEMENTS: For future reference the following comments may be appropriate: Assuming the same switches and controls, a better panel design would probably place the COMSEC and MODE switches on the left side along with the holding battery compartment (if the compartment were to be on the front panel at all [cf. Observation 6.01]). The power, channel, and function switches would be on the right. Ideally, the volume and dim switches would also be on the right --the volume switch near the AUD connectors, the dim switch near the display (without obstructing the view). The keyboard should remain centrally located.

DISCUSSION AND CONCLUSION

When the new SINCGARS ICOM radio was in the planning stages, it was considered desirable for several reasons to make it as similar as possible to its predecessor, the non-ICOM version. The reasons were, presumably, to minimize costs, to simplify production and logistics, and to facilitate the transfer of training both for operators and maintenance personnel. Consequently, many of the findings presented above for the ICOM radio are carry-overs from the non-ICOM version.

However, the production of the non-ICOM radio has now been limited to a very small percentage of the originally planned number. On the other hand, the number of ICOM radios is expected to reach perhaps 20 times the number of non-ICOM radios. Hence, the argument for making the ICOM radio similar to the non-ICOM radio becomes much less compelling, and the opportunity to make cost-saving changes becomes much more available.

The most promising area for realizing substantial life-cycle savings is probably in the area of operator training. The current training requirement for the SINCGARS radios is far greater than that for the family of radios that SINCGARS is replacing--perhaps five to ten times as great! Multiplied over many thousands of soldiers for many years, the additional cost of training SINCGARS over the current radios is, in absolute terms, gargantuan.

There are two ways to facilitate training: (a) to maximize the effectiveness of the training program itself, and (b) to make operation of the radio as easy to learn and remember as possible.

Regarding the first method: No formal training evaluation of the ICOM or non-ICOM has occurred to date; although it is planned in connection with the upcoming SINCGARS FOT & E scheduled for February 1988. Informal observations by human factors personnel of operator training conducted in connection with previous operational tests would, however, suggest that training time can be substantially lessened through the effective design of training courses. In addition, the operator's manuals currently available for the non-ICOM radio have been formally evaluated and found to be capable of great improvement. It is anticipated that the lessons learned will greatly improve the documentation being produced for the ICOM version.

Regarding the second method: It is precisely in the area of training (and retention--i.e., reducing needs for retraining) that many of the changes suggested in the findings of this report would have their greatest impact. Although significant training-related improvements have already been incorporated into the radio (primarily through feedback and display enhancement), the findings presented above attest to the fact that there is still considerable room for improvement. A problem often encountered in this connection is that many of the findings cited, when taken by themselves, appear to be rather inconsequential--as they may be in some instances. Hence, they do not seem deserving of attention. It is important, however, to consider the findings collectively and what their cumulative impact on training and operating might be when multiplied by the same thousands of soldiers and number of years in the radio's life cycle mentioned above.

The SINGARS ICOM radio is in an early enough stage of development not to preclude substantial changes. Of course, as is always the case, changes involve cost--in time as well as money. The predicament here is one that is commonly encountered: Can we dedicate the necessary effort, time, and money now in order to save what may be substantially more in the future? Often, the question is answered negatively--by default (through unwillingness to consider the issue)--or because we literally do not have the means--or because the future seems so comfortably remote that we can put it out of mind.

The Army needs a radio now, and this report does not pretend to evaluate the trade off between accepting the SINGARS ICOM with minimal changes and devoting the necessary resources for incorporating more substantial changes. It is suggested only that the issue be carefully considered from a perspective that incorporates a particular concern for long-term cost effectiveness.

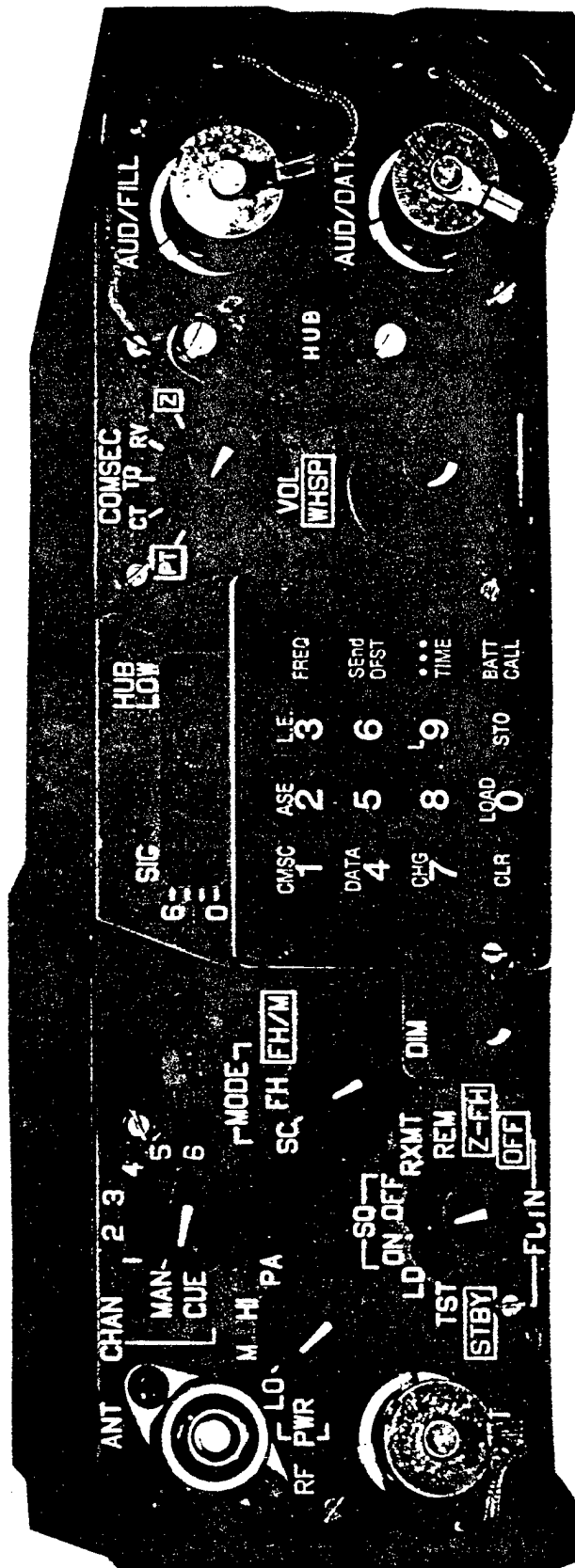


Figure 1. Front panel of the SINGGARS first-generation Integrated COMSEC (ICOM) radio.