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HUMAN ENGINEERING OF RADAR SET AN/SPN-12 (XN-1) RECOMMENDATIONS--ETC(U)
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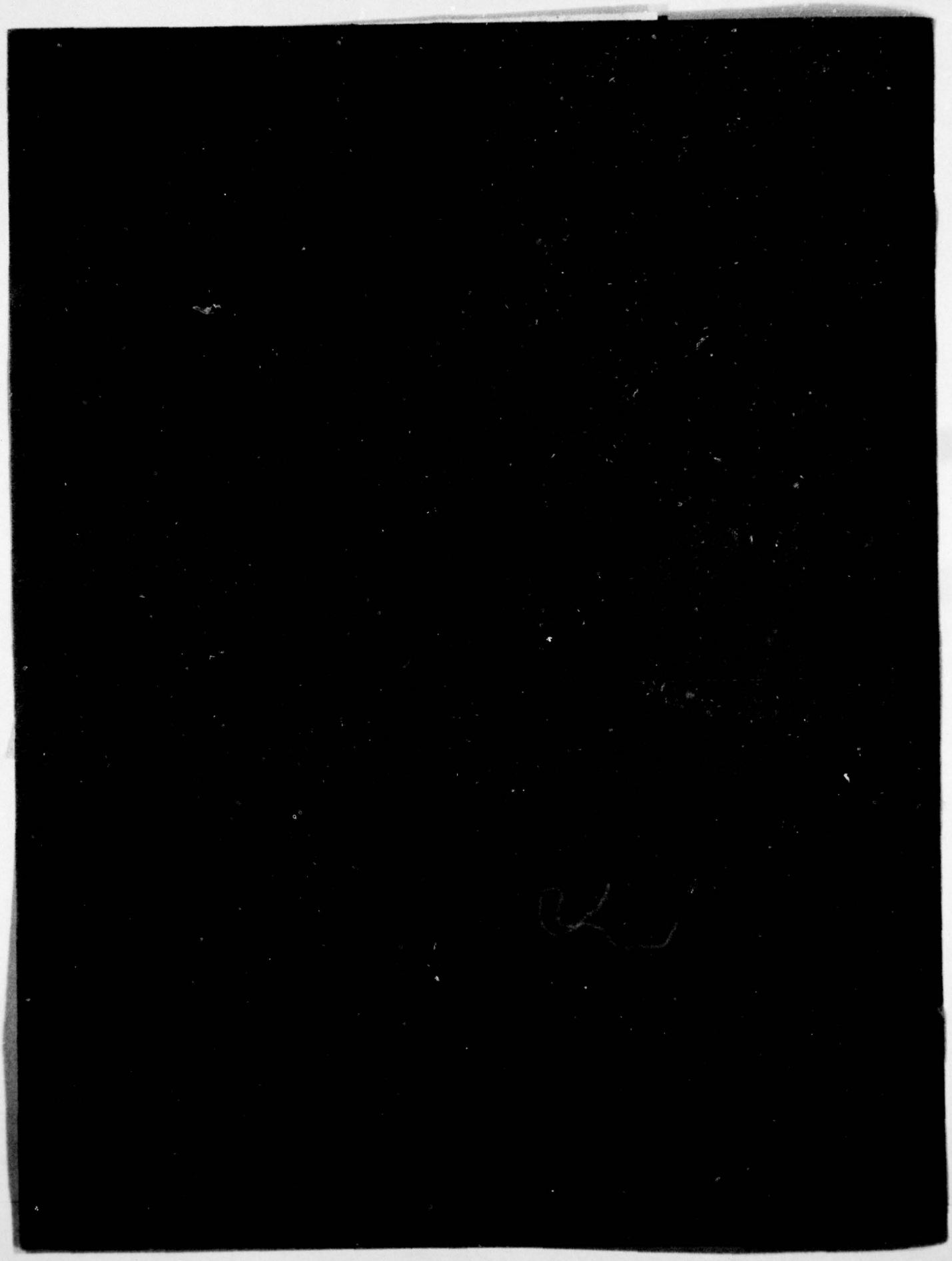

ABSTRACT

The AN/SPN-12 is a doppler principle radar which is used in determining true air speed of planes landing on a carrier. This report concerns the problem of presenting information about true air speed to the Landing Signal Officer (LSO). It had been determined previously that this information should not be presented visually because the LSO must keep his gaze fixed on the approaching plane at all times. Therefore, it was decided to consider use of audition. Thought was given both to voice communication and to automatic audio indication. It was recommended that:

a. the decktalker or the Assistant LSO read the speed indicator and communicate true air speed to the LSO by speech whenever speed is outside tolerance limits for landing.

b. this procedure be initiated at once in all existing installations.

c. a true air speed indicator of the counter type be used to facilitate quantitative readings.

d. if it is decided to further develop an automatic audio indication system, the audio presentation as now proposed should be revised and accepted only after extensive development and operational testing.

PROBLEM STATUS

This is an interim report; work on this problem is continuing.

AUTHORIZATION

NRL Problem 36R13-09 (Bureau Request S-1561)

GENERAL BACKGROUND INFORMATION

1. The Radar Set AN/SPN-12 (XN-1) is a CW radar utilizing the doppler principle to obtain data for measuring the true air speed of aircraft making a landing approach on an aircraft carrier. When making carrier landings, the aircraft make their downwind approach to the carrier at regular intervals and at landing altitude off the port beam parallel to the carrier. About 600 yards aft of the ship, the planes make an 180 degree turn and make their final approach. This final approach is called "The Slot." It is in this brief period of about 20-30 seconds that the planes are tracked by means of an optical gunsight by the radar receiver-transmitter operator. While the plane is "In The Slot," the Landing Signal Officer (LSO) communicates corrections of altitude, wing position and speed to the aircraft by means of his handflags.

2. The radar obtains the relative speed between the aircraft and the radar set by comparing the transmitted signal frequency with frequency of the echo. This relative airspeed is converted to true air speed by means of a wind velocity correction. This true air speed is fed into the true air speed indicator dial and an Esterline-Angus recorder for permanent record. The true air speed goes through the synchro amplifier and from thence to four remote indicators located in strategic places in the ship. The most important indicator is the one located at the LSO's station.

FUNCTION OF THE LSO

3. The LSO is situated on a platform just off the port aft portion of the flight deck. His brightly colored coveralls and signal flags outlined against a dark canvas wind screen, are clearly visible to the pilots. The LSO ordinarily judges the speed of the incoming plane from its attitude (i.e., the tilt of the plane or angle subtended between the tail surfaces and the wing surfaces). In night operations, three differently colored lights are contained vertically in a compartment recessed into the leading edge of the wing. The light that shows in the aperture depends upon the attitude of the plane, thus giving the LSO an indication of the speed of the plane. The correct landing speed depends upon the type and loading

characteristics of the plane. The LSO's judgment of speed of approach is important because if the plane lands too fast it may crash into the barrier. If the speed is too slow, the plane may stall and dive into the fantail or into the ocean. The SPN-12 radar will serve as a check on the LSO's judgment, and it is hoped, reduce the accident rate of carrier landings due to miscalculations of aircraft landing speed.

4. The LSO also communicates corrections of wing tilt and of altitude of the plane above the flight deck. These additional corrections are unrelated to the present discussion and will not be gone into at the present time. They do complicate the task of the LSO to the extent that he cannot very often remove his gaze from the aircraft.

FUNCTIONS OF OTHER PERSONNEL AT THE LSO STATION

5. In addition to the LSO, there are three other men at the station who assist him in his duties:

a. The Assistant LSO. This officer has also graduated from the LSO School at Pensacola, but he has not qualified as a full-fledged LSO because of lack of experience. The Assistant LSO becomes an LSO after he has completed four cruises. This additional training is usually accomplished in about a year after graduation.

The main function of the Assistant LSO is to observe the LSO and improve his own technique. He will land planes under the supervision of the LSO, when the latter desires relief. The Assistant LSO ordinarily stands behind the LSO on the platform.

b. Two enlisted talkers.

(1) The decktalker watches the flight deck and informs the LSO of its condition. A plane cannot land on the flight deck until the deck is clear of the previously landed plane and the two barriers have been returned to its upright protective position. The sequence of events after landing is as follows: The plane has its landing hook released from the arresting gear by deck personnel. The cable barriers and the arresting cables are then lowered level with the flight deck, the pilot guns his engine and passes the barriers which are then returned to the upright position. The next plane is then ready to be landed.

The decktalker keeps the LSO informed about the deck condition. If the deck is not ready to receive the next plane, he will say "Foul Deck." If it is ready, he will say "Clear Deck." The decktalker must anticipate the condition of the deck at the time when the next plane will land and convey this information to the LSO in time for him to give the wave-off signal if necessary. If he does not think the deck will be clear when the next plane will land, he yells "No Chance." The LSO will then give the incoming plane a wave-off. If the decktalker thinks the deck will be clear he yells "Keep Him Coming" until the deck is clear; then, he yells "Clear Deck." The decktalker receives information from the Flight Control Bridge about deck condition, plane conditions (e.g., fuel low) and emergency operations over a telephone headset.

(2) The planetalker observes the incoming planes through binoculars and checks to see that the planes' flaps, landing gear and hook are down. If they are down, he says "All Down." This man observes the planes just before they enter the "Slot" and conveys the information at that time.

The two talkers are ordinarily situated on a catwalk in front of the LSO platform and about four feet below it.

THE PRESENT SPN-12 REMOTE TRUE AIR SPEED INDICATOR LOCATED AT THE LSO PLATFORM

6. This indicator is located just aft of the LSO platform, level with the flight deck next to the wind direction and speed indicator. It is tilted approximately 30 degrees from the horizontal and can be read easily by the LSO and the Assistant LSO. However, it is impossible to read the indicator and observe the approaching aircraft simultaneously. Most LSO's refuse to use the True Air Speed Indicator because in order to do so they would have to remove their fixation from the airplane while it is in the Slot, the most important part of the approach. LSO's also report that the indicator itself is difficult to read and is, therefore, seldom used in the field. It consists of a five inch, black, semicircular dial with white numerals every 10 knots, with a range from 50 to 150 knots. The dial is subdivided by a line marker for every knot with a longer marker every five knots. The pointer is a white, broadheaded arrow that can obscure the numerals of the dial because these numerals are mounted within the line markers.

NOISE LEVEL AT THE LSO PLATFORM

7. The noise level at the LSO platform does not interfere with the necessary voice communications in landing operations as presently

constituted. Ordinary conversation can be understood at distances up to ten feet away from the LSO most of the time. Voice communication is impossible only when a plane has taken a waveoff and is gunning his engine in order to gain air speed, and so passes directly over the LSO at a low altitude. This period lasts from 2-3 seconds. Communications are not necessary at this time anyway, because the next plane has not yet entered the Slot. Shouting is necessary when the plane on deck guns his engine in order to clear the landing area for the next plane. At this time, the deck-talker who is about six feet from the LSO has no difficulty in communicating the deck condition to the LSO. The LSO usually repeats the information in order to indicate that he understood the message.

THE FUNCTION OF THE SPN-12 AT THE PRESENT TIME

8. At the present time, the SPN-12 is not being used by most LSO's for the following reasons:

a. Lack of training in its use with the resultant lack of confidence in it.

b. No adequate visual means of giving the information to the LSO without having him remove visual fixation from the aircraft.

c. The information is only necessary in abnormal circumstances since under normal conditions he can judge the speed of the aircraft adequately.

d. The complexity of the LSO's task gives him a multitude of other things to do, and thus reduces the amount of time he can devote to speed of approach information.

e. Usually an LSO will only have to land types of aircraft with which he is familiar. Under normal circumstances, his judgment is sufficiently accurate for him to land aircraft safely.

9. A system of obtaining and communicating more accurate speed of approach information is becoming increasingly necessary as the speed of aircraft landing on carriers becomes greater and the types of airplanes more diversified. The system of guiding aircraft into carrier landings by the LSO is only an interim system. Automatic carrier approach and landing systems are being developed that will supplant the present method. But it is felt that a number of years will pass before this development is in actual use.

SUGGESTIONS FOR THE USE OF THE SPN-12 IN NONAUTOMATIC APPROACH AND LANDING CONTROL

10. The following changes in the use and design of the SPN-12 Remote True Air Speed Indicator are indicated by the preceeding operational analysis:

a. The type of presentation of the speed of approach information should be changed. It is suggested that a counter type presentation be used. True air speed should appear in a large window. This window should have a vertical extension above and below the horizontal window, the unit digits to appear in this extension, so that the unit above and the unit below will appear above and below the correct center unit. The numerals should be as large as the housing permits. Window type presentations can be read more accurately and quicker than dials when the quantity read does not change drastically. The numerals should be white on a black background, transilluminated for easy nighttime reading, with a knob regulating the light intensity.

With a counter type of presentation, it would be necessary to use a shutter which automatically covers the numbers whenever the information presented is inaccurate, but this shutter is difficult to mechanize. The shutter is unnecessary on the present dial type of presentation since the pointer is made to move to the zero position behind a shield when information is inaccurate. If the difficulty of mechanizing a shutter for the counter should prove insurmountable, and it is necessary to use a dial presentation, then it is suggested that the present dial be improved. The numerals should be engraved outside the graduations so that they will not be obscured by the pointer. The unit graduations should be shortened, retaining the same size of numbers and of 5 and 10 unit graduations. A movable bug and two line markers should be placed on the outside of the dial, along with two adjustable markers. The LSO can then set the bug at the optimum landing speed and the two line markers at the maximum and minimum landing speed for the particular aircraft that he is landing.

b. Instruction in the use of the SPN-12 should be included in the curriculum of the LSO School. Information on the use of the SPN-12 should be disseminated to all ships having this equipment. This will give LSOs confidence in its use.

c. Check-reading the SPN-12 Remote Air Speed Indicator should become part of the Assistant LSO's job. The Assistant LSO has sufficient time and

is in an excellent position to observe the Indicator and to communicate with the LSO if the aircraft is outside speed tolerance limits. He is directly in back of the LSO and should have no difficulty in communicating this information. If this check-reading is included in the Assistant LSO's regular duties, and its importance stressed in LSO school, the SPN-12 will be used to a greater extent in the future. In addition, the SPN-12 will become a teaching tool and will probably reduce LSO training times. In training, the embryo LSO can check his estimation of approach speed against a criterion and correct his judgment accordingly. The SPN-12 will also prove extremely useful in emergency situations.

In cases where no Assistant LSO is available, the planetalker can be stationed in back of the LSO on the platform. Before the aircraft is in the Slot he can give the condition of the landing gear. After the aircraft is in the Slot and the SPN-12 is tracking him, he can check-read the Remote Air Speed Indicator. No difficulty is anticipated in this type of operation.

AN ALTERNATIVE METHOD OF PRESENTATION OF TRUE AIR SPEED TO THE LSO

11. It has been suggested by Raytheon field engineers that this information can be conveyed to the LSO by means of a non-verbal auditory signal. This signal would consist of a reference tone at midrange frequency and a comparison tone, varying in frequency in proportion to the speed of the aircraft above or below the optimum landing speed for that type of airplane. The LSO would hear a dash-dot pattern, the dash representing optimum landing speed, and the dot representing the actual speed of the aircraft. If the plane is landing within the speed limits, the tone would be continuous; there would be no difference in frequency. This signal would be presented to one ear of the LSO by means of a single earphone, receiving the signal over a miniature receiver attached to his belt. The signal would be transmitted over a wireless coupling from a low-power oscillator.

12. The advantages[+] of this system over the suggested method, are as follows:

a. Information about landing speed is presented continuously rather than intermittently.

[+] It has been stated that this system saves one man. This is not necessarily true since the planetalker or the Assistant LSO could perform speed-talking duties.

b. The amount of verbal communication required is reduced.

c. Possible advantage in that repeated presentation of air speed will help LSO improve his visual judgment. This would be more useful in training than in tactical use.

13. Compared to the suggested system, the auditory non-verbal method contains the following disadvantages:

a. A man at the oscillator has to change the limits of speed tolerance for different types of aircraft. He will occasionally forget this and leave the equipment incorrectly set, giving LSO false information.

b. The presence of the stimulus and the covering of one ear with an earphone will reduce the auditory acuity of the LSO. This may introduce some error in discriminating the verbal signals of the plane and the decktalkers.

c. The wearing of a headset and carrying a radio receiver will probably be physically annoying for the LSO.

d. The additional equipment presents problems of maintenance, calibration and susceptibility to failure.

e. The function of the Assistant LSO as a filter is eradicated. Under the speed talker system, the Assistant LSO only gives the necessary danger information. Under ordinary circumstances, i.e., when the plane is within tolerated landing speed, the Assistant LSO gives no signal. Further, in the non-verbal system, the judgment of the Assistant LSO is not added to the judgment of the LSO in cases where there may be conflict between radar information and plane attitude true air speed information.

f. The non-verbal method of presentation does not give the LSO any absolute indication of the amount that the approaching aircraft is above or below the limits of speed tolerance.

g. The mechanical equipment costs more than would be the case in the verbal system.

In the considered opinion of the Psychology Branch these disadvantages of the proposed non-verbal method outweigh the advantages gained by this method.

FUTURE DEVELOPMENT OF A NON-VERBAL AUDITORY SYSTEM

14. If it is decided to continue development of a non-verbal system, it should satisfy the following requirements:

The Stimulus Requirements of the Signal

a. The signal must indicate:

1. Area of excessive air speed,
2. Area of insufficient air speed,
3. The area of optimum air speed,
4. The relative degree of departure from critical air speeds, above or below the optimum,
5. The degree of approach to critical air speeds.
6. The system must operate in conjunction with other auditory transmitters (i.e., decktalkers).

b. The system must indicate equipment not operating.

c. The system must be capable of handling several air speed ranges without introducing other differentiating stimuli. The optimum air speed range should be adjustable for different types of aircraft.

15. If an auditory non-verbal method is considered necessary, it is believed that the following system of information presentation fulfills the requirements given above. This is only one of a number of possible methods that might be used.

a. Basic stimulus should be a tone that rises in pitch from 800 cps to 4000 cps.

b. Low and high speed danger points should be indicated by interruption of tone at 1200 cps and 3600 cps.

c. Optimal speed stimulus -- an uninterrupted tone which varies in frequency over the optimal speed range proportional to speed.

d. Degree of departure from critical high or low should be indicated by:

(1) frequency variation proportional to speed, with interruption in danger areas; and

(2) increasing rates of interruption above and below optimum level.

Note: Method (1) would be simplest electronically, but method (2) would convey the information more effectively.

e. The LSO will learn when the airplane's speed is approaching or at the critical transition between optimum and danger areas.

f. True air speed information would be channeled through a single phone or by monaural bone conduction apparatus. The connection of the LSO to the source must be by non-wire means, probably by means of a low power AM transmitter.

g. The working intensity of the earphone should be controllable so that the LSO can obtain the best S/N ratio, depending upon the noise level on the deck.

h. Operation in competition with speech frequencies, while a disadvantage, can be compensated for by volume control and frequency choice as above.

i. Apparatus casualty will be indicated by lack of any signal when an aircraft is in the slot.

16. If the above system is considered feasible, it is recommended that it be given a thorough testing at LSO School by experienced LSO's before it is installed aboard ship.

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