3578

AD062 8596

AMRL-TR-65-152

01

FEASIBILITY OF USING HANDRAILS TO MOVE ALONG A SURFACE WHILE WEIGHTLESS

EDWIN H. SASAKI

3578

AUGUST 1965

20040218073

AEROSPACE MEDICAL RESEARCH LABORATORIES
AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

NOTICES

When US Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Requests for copies of this report should be directed to either of the addressees listed below, as applicable:

Federal Government agencies and their contractors registered with Defense Documentation Center (DDC):

DDC
Cameron Station
Alexandria, Virginia 22314

Non-DDC users (stock quantities are available for sale from):

Chief, Input Section
Clearinghouse for Federal Scientific & Technical Information (CFSTI)
Sills Building
5285 Port Royal Road
Springfield, Virginia 22151

Change of Address

Organizations and individuals receiving reports via the Aerospace Medical Research Laboratories automatic mailing lists should submit the addressograph plate stamp on the report envelope or refer to the code number when corresponding about change of address or cancellation.

Do not return this copy. Retain or destroy.

800 - January 1966 - 24-480-773

FEASIBILITY OF USING HANDRAILS TO MOVE ALONG A SURFACE WHILE WEIGHTLESS

EDWIN H. SASAKI

FOREWORD

This study was conducted by the Crew Stations Branch, Human Engineering Division, Behavioral Sciences Laboratory, Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, in support of Project 7184, "Human Performance in Advanced Systems," Task 718405, "Design Criteria for Crew Stations in Advanced Systems." This study was begun in June 1964 and completed in October 1964.

The author makes acknowledgement to Colonel Lloyd R. Hayes (retired), MSgt Charles W. Sears, and SSgt Estell P. Bunch for their invaluable assistance in monitoring the airborne tests.

This technical report has been reviewed and is approved.

WALTER F. GRETHER, PhD
Technical Director
Behavioral Sciences Laboratory
Aerospace Medical Research Laboratories

ABSTRACT

A preliminary investigation into the feasibility of using handrails as an aid to the astronaut in moving from one location to another within or outside a space vehicle was undertaken in a JC-131B zero-G airplane. Eight subjects wearing flying coveralls (one of whom also performed the tests wearing an inflated full-pressure suit) moved from one point to another aided by a single handrail or two parallel handrails. Eight conditions were investigated with the parallel handrails spaced from 6 to 36 inches apart and one with the single handrail. All subjects were successful in moving across the surface and turning around using both the single and parallel handrails. Motion picture films were taken to evaluate the body positions and ease of movement. The most common position appeared to be one in which the elbows and knees were slightly bent and the torso was nearly parallel to the surface. The parallel handrails spaced from 16 to 24 inches apart appeared to provide the greatest body stability.

SECTION I

INTRODUCTION

Future space missions will certainly require that the astronaut move from one point to another within the vehicle, or on its surface to a worksite, or from hatch to hatch. Although many concepts exist on techniques to aid the astronaut in moving from one location to another, one that appears particularly promising is the use of handrails. To investigate the feasibility of this technique, the following preliminary experiment was conducted.

SECTION II

METHODS

A 1-inch sheet of plywood (96 inches long by 48 inches wide) was bolted to the floor of the cabin of a JC-131B zero-G research airplane, so that the longitudinal centerline of the plywood surface made a 50° angle with the centerline of the airplane. A slot cut in the plywood at each end allowed installation of either a single handrail or parallel handrails that could be adjusted for distances from 6 to 36 inches apart. The handrails were smooth aluminum pipes, 1.25 inch in diameter and 84 inches long, with mounting blocks on each end that provided a 2-inch clearance between the bottom of the rail and the plywood surface.

Nine conditions were investigated: one in which a single handrail was used and eight in which two parallel handrails were spaced 6, 12, 16, 18, 20, 24, 30, or 36 inches apart. The conditions were randomly presented.

Eight subjects, well experienced in working under conditions of weightlessness in the zero-G research plane, participated in the experiment. The K-2B summer flying coveralls were worn by all subjects during the trials, and one subject repeated the experiment wearing the Air Force A/P-22S-2 full-pressure suit inflated to 3.5 psi.

The subjects were instructed to grasp the rail (or rails) near one end when the weightless portion of the zero-G parabola was attained, to move along the surface using the rail, and to turn around when they reached the other end. This maneuver constituted one trial. They were told to remain at that end until the following parabola, at which time they were to return to the starting position in the same manner, again turning around when they reached the opposite end. This procedure was repeated for 18 trials. The subjects received no practice trials and were given no instructions concerning speed or technique of moving and turning around. All trials were photographed by a 16 mm motion picture camera. No measures of time or force were taken. When each subject completed the 18 trials he was asked to comment on any difficulties he may have had and to state which condition or conditions seemed to be the most comfortable.

SECTION III

RESULTS AND DISCUSSION

All the subjects were successful, on all trials, in moving from one position to another and in turning around. Furthermore, they were generally able to use their wrists in exerting sufficient torque on the rails to cancel any gross body rotation, e.g., heels-over-head. Only one subject (wearing coveralls), in one instance, did a handstand and then lost control when he stopped suddenly at one end (fig. 1), apparently having moved too rapidly. Except for this one case, all the subjects were able to maintain a fairly "good" body position/control as they moved and turned around. For most subjects, this good body position appeared to be one in which the elbows and knees were slightly bent and the torso was nearly parallel to the surface (figs. 2,3). However, one subject (wearing coveralls) consistently moved with his legs "tucked" as shown in figure 4.

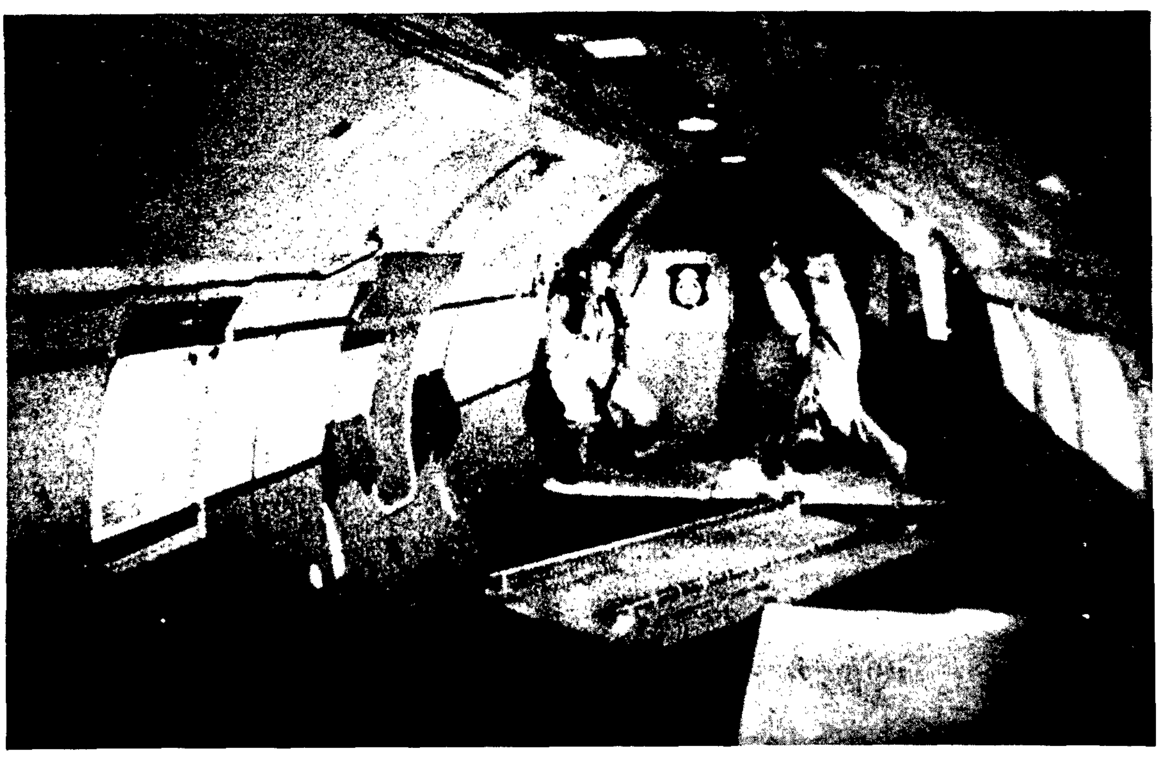
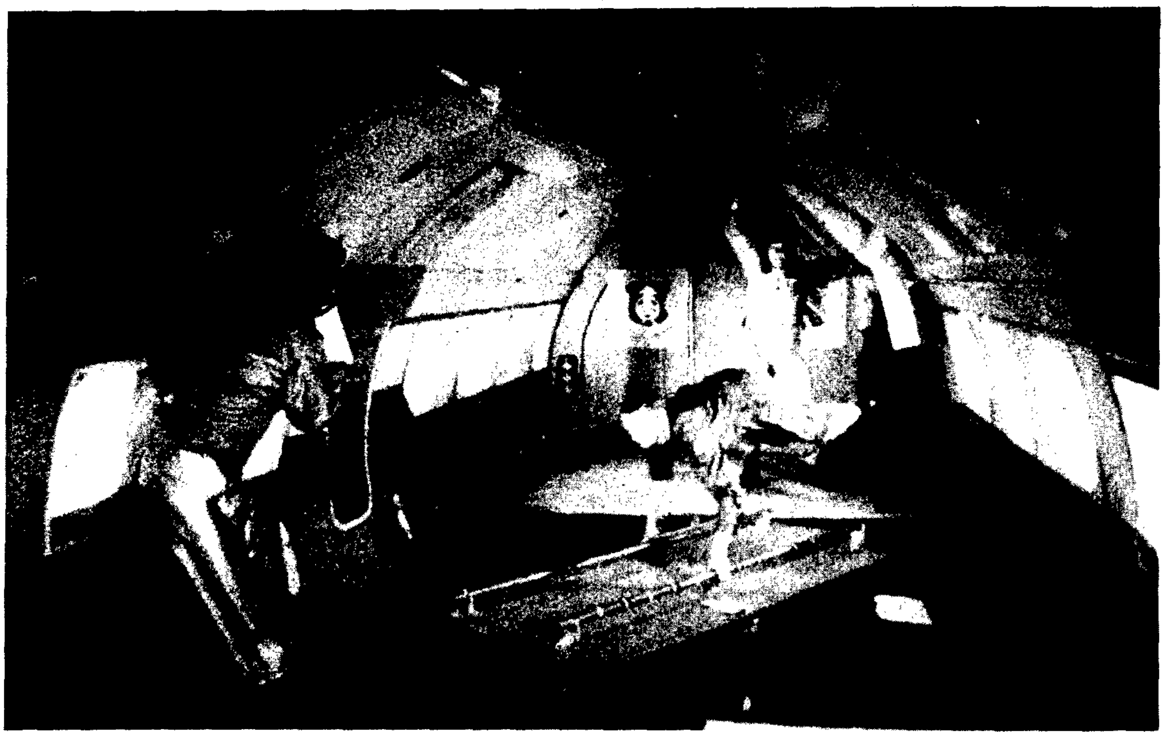
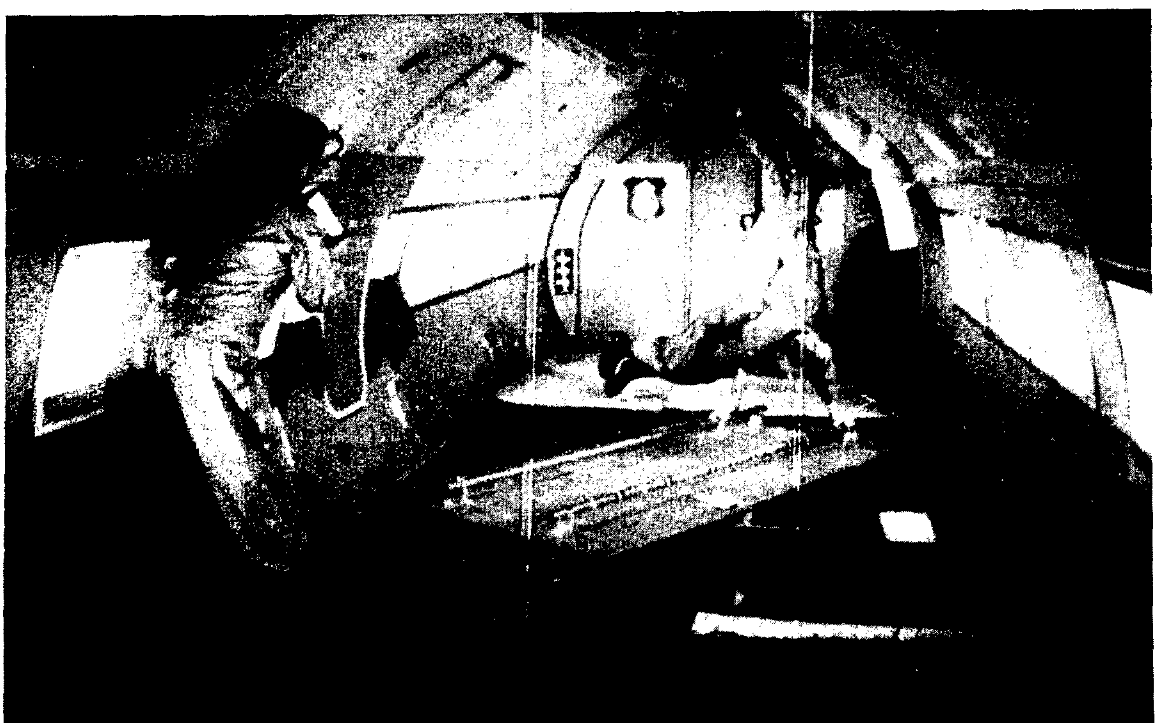


Figure 1. Subject in Handstand Position at the End of the Handrails



TRANSLATION



TURN-AROUND

Figure 2. Subject (Wearing Flying Coveralls) in "Good" Body Position

TRANSLATION

TURN-AROUND

Figure 3. Subject (Wearing Inflated Full-Pressure Suit) in "Good" Body Position

Figure 4. Subject Moving with His Legs "Tucked"

Based on an evaluation of the film, the single rail and parallel rails with 6- or 12-inch separations appeared to offer the least body stability in terms of roll oscillations about the handrails. Once a subject's body started to sway, he had difficulty stopping and, in a few cases, some subjects could not stop the oscillations before hitting the surface (fig. 5). The subjects, themselves, may not have started their bodies swaying, rather, the airplane may have induced the oscillations.

All subjects (including the subject wearing the inflated pressure suit) reported that the 16- to 24-inch separations felt the most comfortable. These conditions were probably more comfortable because they were close approximations of the subjects' shoulder breadths.

Only the subject wearing the inflated full-pressure suit reported that the 30- and 36-inch separations were definitely uncomfortable. The subject had to "fight" the restraint of the pressure suit to extend his arms out to the two rails. In addition, the pressure suit helmet restricted the subject's view so that he could see only one rail at a time, and then, only when he turned his head to one side.

In summary, this investigation must be considered preliminary, primarily because of its qualitative nature and the small number of subjects. However, the experiment does demonstrate the feasibility of an astronaut using two parallel handrails, but not a single handrail, to move from one position to another within the space vehicle or on its surface. Furthermore, the experiment suggests that a satisfactory spacing, at least for shirt-sleeved subject, is in the range from 16 to 24 inches between rails.

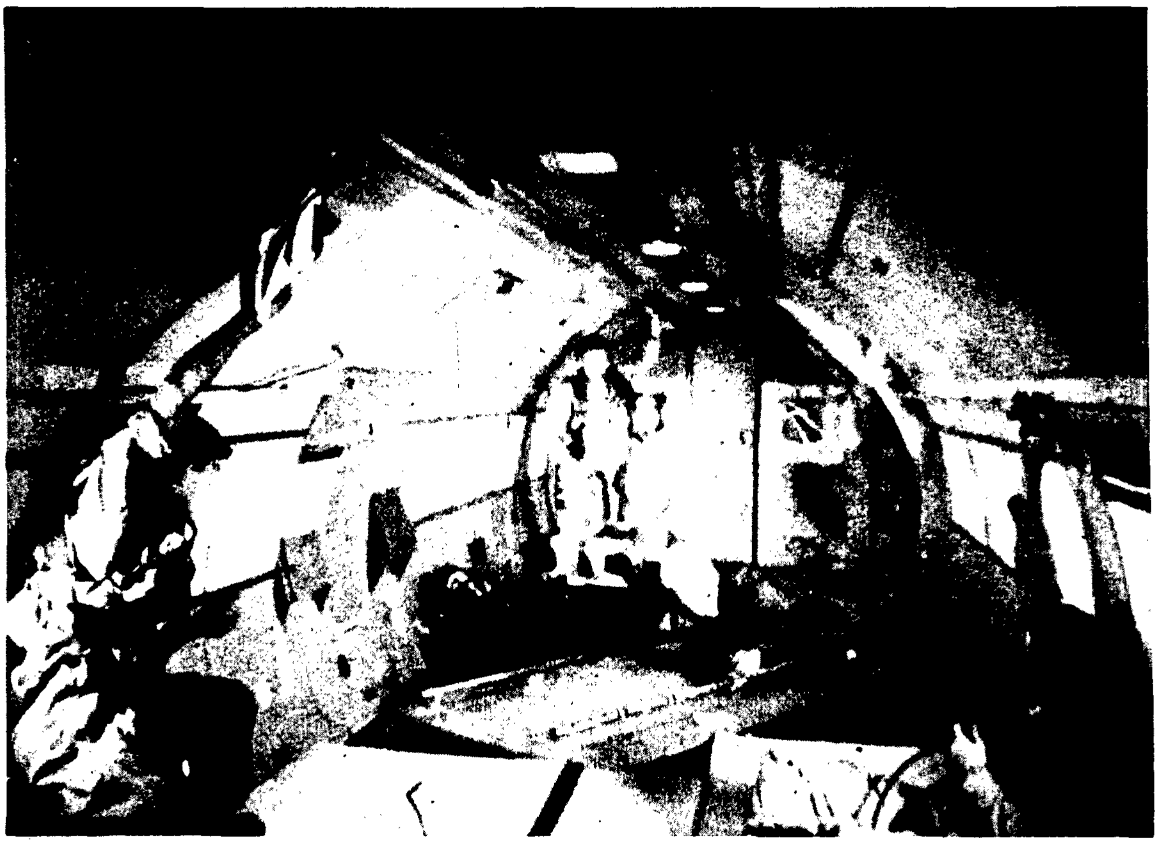


Figure 5. Subject Hitting the Surface While Moving

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

ORIGINATING ACTIVITY (Corporate author) Aerospace Medical Research Laboratories, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson AFB, Ohio	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP N/A

3. REPORT TITLE

FEASIBILITY OF USING HANDRAILS TO MOVE ALONG A SURFACE WHILE WEIGHTLESS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report, June 1964 - October 1964

5. AUTHOR(S) (Last name, first name, initial)

Edwin, H. Sasaki

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1965	6	none

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO 7184	AMRL-TR-65-152
c. Task No. 718405	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. AVAILABILITY/LIMITATION NOTICES

Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Aerospace Medical Research Laboratories, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson AFB, Ohio

13. ABSTRACT

A preliminary investigation inot the feasibility of using handrails as an aid to the astronaut in moving from one location to another within or outside a space vehicle was undertaken in a JC-131B zero-G airplane. Eight subjects wearing flying coveralls (one whom also performed the tests wearing an inflated fullpressure suit) moved from one point to another aided by a single handrail or two parallel handrails. Eight conditions were investigated with the parallel handrails spaced from 6 to 36 inches apart and one with the single handrail. All subjects were successful in moving across the surface and turning around using both the single and parallel handrails. Motion picture films were taken to evaluate the body positions and ease of movement. The most common position appeared to be one in which the elbows and knees were slightly bent and the torso was nearly parallel to the surface. The parallel handrails spaced from 16 to 24 inches apart appeared to provide the greatest body stability.

DD FORM 1 JAN 64 1473

AF-WP-B-AUG 64 400

Security Classification

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Weightlessness, Space technology Maneuverability Aids Human Performance Pressure Suits Coveralls JC-131B zero-G aircraft						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2*a*. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2*b*. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7*a*. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7*b*. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8*a*. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8*b*, 8*c*, & 8*d*. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9*a*. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9*b*. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through ____________ ."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through ____________ ."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through ____________ ."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS), (S), (C), or (U)*

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.