

REPORT NO. NADC-84115-60

12

AD-A150 464



20000804023

TIGHT RIBBON ARM PROTECTION (TRAP) FOR AIRCREWMAN EJECTION

Dan Lorch and Michael Schultz
Aircraft and Crew Systems Technology Directorate
NAVAL AIR DEVELOPMENT CENTER
Warminster, Pennsylvania 18974

JULY 1984

PHASE REPORT
AIRTASK NO. WO584001
Program Element No. 63216

DTIC
ELECT
FEB 20 1985
A

Approved For Public Release; Distribution Unlimited

**Reproduced From
Best Available Copy**

Prepared For
NAVAL AIR SYSTEMS COMMAND
Department of the Navy
Washington, DC 20361

DTIC FILE COPY

NOTICES

REPORT NUMBERING SYSTEM — The numbering of technical project reports issued by the Naval Air Development Center is arranged for specific identification purposes. Each number consists of the Center acronym, the calendar year in which the number was assigned, the sequence number of the report within the specific calendar year, and the official 2-digit correspondence code of the Command Office or the Functional Directorate responsible for the report. For example: Report No. NADC-78015-20 indicates the fifteenth Center report for the year 1978, and prepared by the Systems Directorate. The numerical codes are as follows:

CODE	OFFICE OR DIRECTORATE
00	Commander, Naval Air Development Center
01	Technical Director, Naval Air Development Center
02	Comptroller
10	Directorate Command Projects
20	Systems Directorate
30	Sensors & Avionics Technology Directorate
40	Communication & Navigation Technology Directorate
50	Software Computer Directorate
60	Aircraft & Crew Systems Technology Directorate
70	Planning Assessment Resources
80	Engineering Support Group

PRODUCT ENDORSEMENT — The discussion or instructions concerning commercial products herein do not constitute an endorsement by the Government nor do they convey or imply the license or right to use such products.

APPROVED BY:


E. J. GALLAGHER
CAPT, MSC, U.S. NAVY

DATE:

5 November 1984

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE				
1a. REPORT SECURITY CLASSIFICATION Unclassified		1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION/AVAILABILITY OF REPORT		
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE		Approved for Public Release; Distribution Unlimited		
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NADC-84115-60		5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION Aircraft & Crew Systems Technology Directorate	6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION		
6c. ADDRESS (City, State, and ZIP Code) Naval Air Development Center Warminster, PA 18974		7b. ADDRESS (City, State, and ZIP Code)		
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Naval Air Systems Command	8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER		
8c. ADDRESS (City, State, and ZIP Code) Washington, DC 20361		10. SOURCE OF FUNDING NUMBERS		
		PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.
		WORK UNIT ACCESSION NO.		
11. TITLE (Include Security Classification) Tight Ribbon Arm Protection (TRAP) for Aircrewman Ejection				
12. PERSONAL AUTHOR(S) Dan Lorch and Michael Schultz				
13a. TYPE OF REPORT Phase	13b. TIME COVERED FROM TO	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT 22	
16. SUPPLEMENTARY NOTATION				
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP		
			Ejection Seats, Aircrewman Safety, Limb Flail, Restraint, Arm Protection	
19. ABSTRACT (Continue on reverse if necessary and identify by block number)				
When an aircrewman ejects at high speed from a damaged aircraft the windblast (high Q force) can cause arm fractures and dislocations. These injuries may be so severe that he is unable to help himself survive after the parachute descent. The TRAP (TIGHT RIBBON ARM PROTECTION) was designed to provide ejection seat arm restraint; it consists of two nylon ribbons sewn onto either side of the crewman's parachute harness (either seat-mounted or torso harness mounted). Each of these pulls down off the crewman's shoulder and automatically tightens over his arm as the ejection seat moves up into the air stream. The crewman hooks up the TRAP to snubber lines as he connects into the aircraft restraint. Initial tests indicate that the TRAP system may be able to solve the arm restraint problem.				
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT		21. ABSTRACT SECURITY CLASSIFICATION		
☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTC USERS				
22a. NAME OF RESPONSIBLE INDIVIDUAL Ron Ronye		22b. TELEPHONE (Include Area Code)		22c. OFFICE SYMBOL

DD FORM 1473, 34 MAR

82 APR edition may be used until exhausted.
All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

NADC-84115-60

LIST OF FIGURES

Figure		Page
1	Crewman Ready to Enter Aircraft; Front View	2
2	Back View of TRAP Ribbons Sewn Onto MA-2 Harness	3
3	Side View of TRAP System Sewn Onto MA-2 Harness	4
4	Crewman Seated Before Hooking Up Snubber Lines to Sliding Rings	5
5	Crewman Hooking Up Snubber Line to Sliding Ring	6
6	Crewman Looking Aft with TRAP Snubber Lines Connected	7
7	TRAP Ribbons Deployed Over Arms; Front View	8
8	TRAP Ribbon Deployed Over Arm; Side View	9
9	Side View of TRAP Ribbon Deployed Over Left Arm	10
10	Routing of TRAP Ribbon; Pointing Out Free Sliding Ring	11
11	Sequence Showing TRAP Lanyards Pulled Manually From Below Seat	12
12	Fifty Percentile Dummy With TRAP Snubber Lines Connected	13
13	TRAP Deployed After Ejection Test #3 (Front View)	14
14	TRAP Deployed After Ejection Test #3 (Side View)	15

BACKGROUND

Limb flail injury is one of the most common major injuries resulting from high speed ejection. The wind blast that strikes the aircrewman can twist and bend his arms and legs causing fractures and dislocations which prevent him from performing vital survival functions after he descends to the ground or into the sea (ref. 1).

Although many current (1984) U.S. Navy Ejection seats are equipped with a leg restraint system, none is equipped with arm restraint.

During the past decade many attempts have been made to develop a passive arm restraint, one that automatically works during ejection and requires no hookups by the aircrewman (ref. 2). These systems have shown some degree of success, but all require some modification to the ejection seat.

The purpose of this development was to determine if it is possible to design an arm restraint that is harness mounted, requiring little or no modification to the seat.

To simplify the design, the same type snubber line arrangement used for the leg restraint would also be used to pull in the arms. This was to be an active system requiring the aircrewman to hook up. After the initial hookup, the system entraps the arms automatically as the ejection seat begins to move.

The acronym for this system is 'TRAP,' which stands for 'Tight Ribbon Arm Restraint.'

DESIGN APPROACH

The most effective way to limit arm motion is to restrain both major bone linkages—the humerus and the radius. After trying several different ways to accomplish this it became evident that the simplest way was to stitch nylon ribbon to either side of the MA-2 Torso Harness (figs. 1 through 6). Each ribbon was stitched at two locations and reeved through two steel slip rings. One of these rings was sewn to the shoulder strap while the other, which was Velcroed on top of the first, was left free to slide along the loop once it pulled free of its Velcro tab. The ribbons then pull free of the shoulder epaulets, tighten on the upper arms and trap the forearms against the crewman's legs (figs. 7 through 14). Later, during seat/man separation, the snubber lines must be released when the Emergency Harness release Handle is pulled.

Because this system is harness mounted it can be configured to either a torso harness or seat-mounted harness. The ejection seat must be slightly modified by the addition of snubber blocks (similar to the leg restraint snubber blocks) to the front edge of the seat bucket, and snubber line cutters. The system is designed for center-pull ejection actuation. For best entrapment, the hands should be on the firing handle or on top of the thighs. But the system will entrap the arms when they are on the flight controls.

DEPLOYMENT TESTS AND RESULTS

Two series of tests were conducted with the TRAP restraint to observe its deployment: (1) Static Pull Tests, (2) Ejection Tower Tests. All tests were done using a GRU-7 (Martin-Baker) ejection seat which was modified with two additional snubber blocks (similar to the leg line snubber blocks) located on the lower forward edge of the seat.

NADC-84115-60



Figure 1. Crewman Ready to Enter Aircraft; Front View

NADC-84115-60



Figure 2. Back View of TRAP Ribbons Sewn Onto MA-2 Harness

NADC-84115-60



Figure 3. Side View of TRAP System Sewn Onto MA 2 Harness



Figure 4. Crewman Seated Before Hooking Up Snubber Lines to Sliding Rings

NADC-84115-60



Figure 5. Crewman Hooking Up Snubber Line to Sliding Ring

NADC-84115-60



Figure 6. Crewman Looking Aft with TRAP Snubber Lines Connected

NADC-84115-60



Figure 7. TRAP Ribbons Deployed Over Arms; Front View.



Figure 8. TRAP Ribbon Deployed Over Arm; Side View

NADC-84115-60



Figure 9. Side View of TRAP Ribbon Deployed Over Left Arm

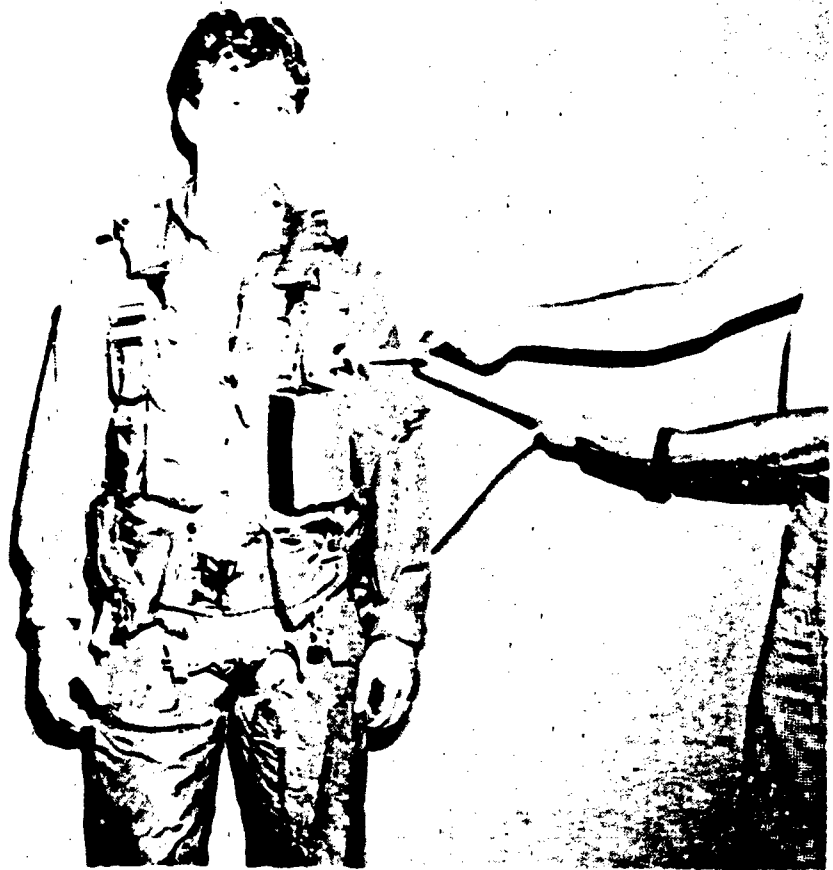


Figure 10. Routing of TRAP Ribbon; Pointing Out Free Sliding Ring

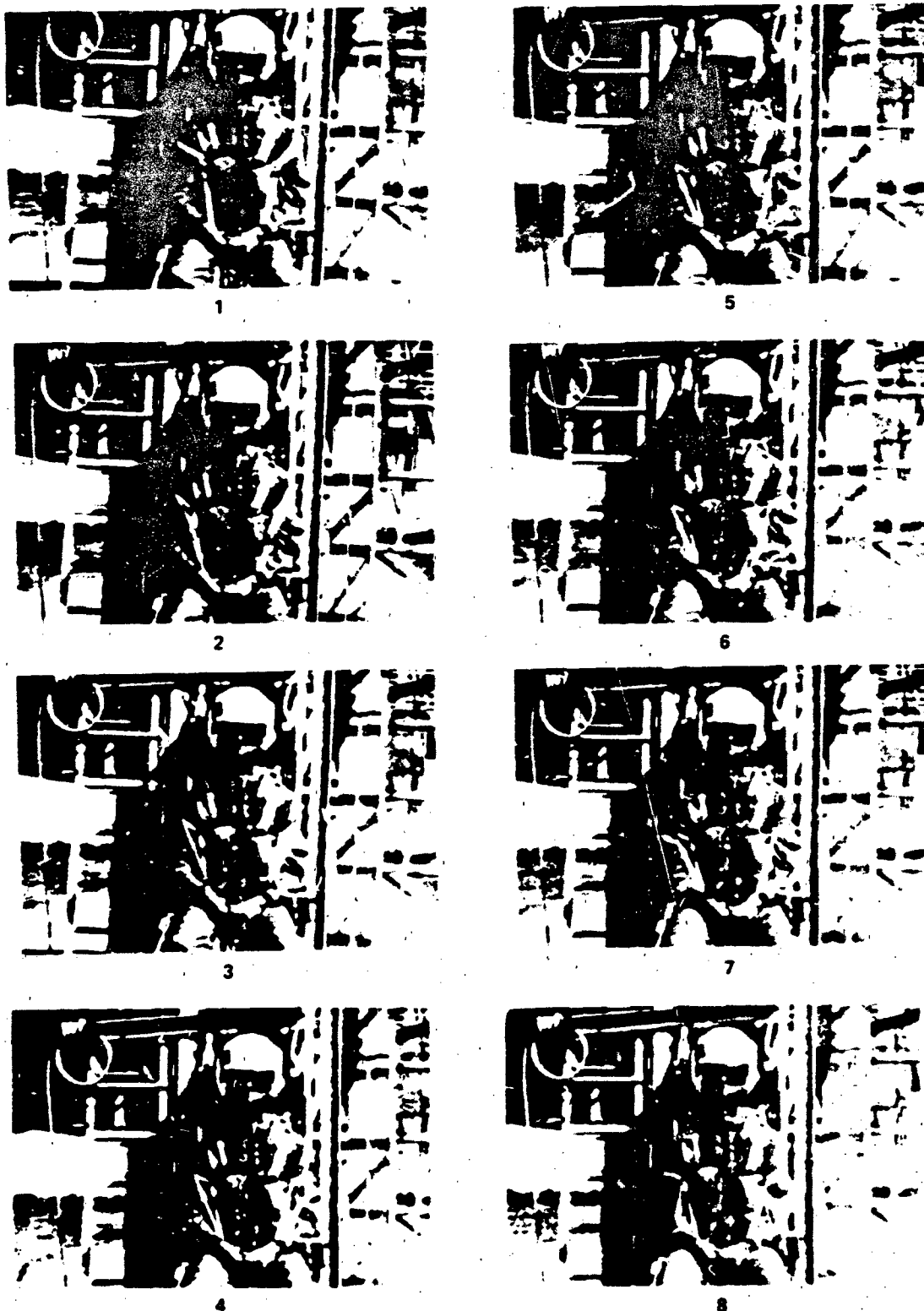


Figure 11. Sequence Showing TRAP Lanyards Pulled Manually From Below Seat



Figure 12. Fifty Percentile Dummy With TRAP Snubber Lines Connected

NADC-24115-60



Figure 13. TRAP Deployed After Ejection Test #3 (Front View)



Figure 14. TRAP Deployed After Ejection Test #3 (Side View)

NADC-84115-60

The Static Pull Tests were conducted using a fifty percentile subject (seated height) with the seat fixed on the NADC Ejection Tower (fig. 11). The TRAP snubber lines were pulled manually by an assistant. The test subject placed his hands in several positions while the TRAP was deployed. About ten tests were conducted, all of which demonstrated that the TRAP ribbons deployed over the crewman's arms and securely restrained them.

Three Dummy Ejection Tests (fifty percentile dummy) were conducted to determine if TRAP would work under ejection acceleration (figs. 12 through 14). For the first test the snubber lines were attached to the 'floor' with 100 pound break-away cord. High-speed movies showed that there was too much friction between the snubber lines and the snubber blocks; the right side of the TRAP deployed over the arm (but not tightly), and the left side never deployed.

For the second ejection a 200 pound break-away cord was used. Both sides successfully deployed but were not very tight over the arms.

For the third ejection a 400 pound break-away cord was used. Again, both sides successfully deployed over the dummy's arms but with little tension; the break-away cords were still too low in strength.

No further tests were conducted since these tests demonstrated that the TRAP system can deploy during ejection acceleration and with the proper break-away cord, effectively restrain the arm.

CONCLUSIONS

1. The TRAP system appears to be a simple and effective way to protect an aircrewman's arms from the damaging effects of high Q windblast; it can be designed to immobilize both the upper and lower arm until seat/man separation takes place.
2. Although flight testing has not been conducted, it appears that the TRAP system could be used in the aircraft with no degradation of aircrew performance.
3. At least a 600- to 800-pound shear rivet should be used on each floor attachment to ensure adequate tensioning of the TRAP snubber lines.

RECOMMENDATIONS

1. The TRAP system should be refined for operational use, then tested as follows:
 - a. Ejection tower tests at NADC with dummies and live subjects to determine the best value breaking strength for the snubber line shear pins.
 - b. High Q Windblast dummy tests at Dayton T. Brown Company.
 - c. Technical Evaluation at the Naval Air Test Center for aircrewman acceptance of ingress or egress from the cockpit.
 - d. Seat/man separation tests at NADC with dummies to assure that there are no hang-ups.
 - e. Evaluation by at least two Fighter/Attack Squadrons for aircrewman acceptance.
 - f. High-Speed Ejection test at the Naval Weapon Center to verify that the complete system will function under actual high-speed ejection conditions.
2. The TRAP system should be tested together with the 'Y' strap (ref. 3) which is used for improving negative Gz restraint. Both of these 'fixes' to the MA-2 harness should be evaluated together to assure compatibility.

NADC-84115-60

ACKNOWLEDGMENTS

Special thanks are due to Rod Pursell, a qualified technician, for his support in the fabrication of the TRAP system onto the MA-2 Torso Harness.

NADC-84115-60

REFERENCES

1. A Summary of Navy Air Combat Escape and Survival, Final Report, Martin G. Every, Office of Naval Research Contract N00014-72-C-101, Task No. NR105-667, February 1977.
2. Passive Arm Restraint Curtain (PARC) For Navy Aircraft Ejection Seats, Thomas J. Zenobi, Naval Air Development Center Report No. NADC-83138-60, November 1983.
3. Improving In-flight Negative Gz Restraint for Aircrewmembers, Dan Lorch, Naval Air Development Center Report No. NADC-84114-60, August 1984.

DISTRIBUTION LIST

REPORT NO. NADC-84115-60

	No. of Copies
Naval Air Systems Command (00D4)	
Washington, DC 20361	8
(2 for retention)	
(1 for AIR-531)	
(1 for AIR-5312)	
(2 for AIR-5315)	
(2 for AIR-310H)	
Naval Safety Center, Norfolk, VA 23511	3
Naval Air Test Center, Patuxent River, MD.	3
(Code SY-711)	
6570 AMRL/DAL Library, Wright Patterson AFB, Ohio 4531	3
U.S. Army Aeromedical Research Lab, Fort Rucker, ALA	3
AFFDL, Wright Patterson AFT (Life Support SPO) Ohio 4531	3
Department of Army, Applied Technology Lab, Ft. Eustic, VA 23604	3
(Attn: DAVDL-EV-ASV)	
Division of Aerospace Pathology, Washington, DC	3
Naval Weapons Center, Advanced Design Group, E.I. Branch (Code 6411)	
China Lake, CA 93555	3
Defense Technical Information Center	
Cameron Station, Bldg. 5	
Alexandria, VA 22314	12
NADC	63
(3 for 8131)	
(60 for 6011 -- Dan Lorch)	