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DEPARTMENT OF THE NAVY

OFFICE OF NAVAL RESEARCH 875 NORTH RANDOLPH STREET SUITE 1425 ARLINGTON, VA 22203-1995

IN REPLY REFER TO:

5720 Ser BD042/040 ONR FOIA 17-053 September 5, 2017

Mr. John Greenewald

Dear Mr. Greenewald:

This is the final response to your Freedom of Information Act (FOIA) request received by the Office of Naval Research (ONR) on July 11, 2017 and given the number 17-053 in our tracking system. You requested MDR, under the terms of Executive Order 12958, as amended, of the following document: Laser Eye Protection (U) dated April 1988. A copy of your request is attached to this letter.

ONR's records are maintained in accordance with the Department of the Navy Records Management Program Manual (SECNAV M-5210.1), the Department of Navy Standard Subject Identification Code Manual (SECNAV M-5201.2), and National Archives and Records Administration (NARA) guidelines. Not all records are permanent and some records may have been destroyed based on established disposition schedules. ONR does not maintain a central records room or consolidated records database.

Your request is considered granted in full. FOIA requests received by ONR are forwarded to the organization within ONR having cognizance over the subject matter of the request and a search is conducted of unclassified and classified records to identify responsive records. This request was reviewed by the Assistant Designated Federal Official (ADFO) for the Naval Research Advisory Committee (NRAC). The ADFO returned two responsive records containing fifty-five pages. A subsequent review was performed by Naval Air Warfare Center Aircraft Division (NAWCAD), authorizing release. These records are attached to this letter.

We have classified you as an "other" requester. As such, you are entitled to 2 free hours of search time and 100 pages of reproduction prior to any fees being assessed. Because your request did not exceed the reproduction fees there is no charge for this request.

If you have questions on any part of this letter, please address them to Mr. Michael Ferrari at (703) 696-4303 or <u>ONRFOIA@navy.mil</u>. Please reference ONR FOIA 17-053 in any correspondence discussing this case.

Sincerely,

Edward Orlowsky

Director

Management Services Division, BD042

Attachments:

As stated

Request Details Status: Assignment Determination Due Date: N/A Request Type: FOIA O (Never Started) Submitted Evaluation Assignment Processing Closed Request Details -Tracking Number: DON-NAVY-2017-008371 Submitted Date: 07/11/2017 Requester: Mr. John Greenewald Last Assigned Date: 07/13/2017 Organization: The Black Vault Fee Limit: \$15.00 Requester Has Account: Yes Request Track: Simple Email Address: john@greenewald.com Due Date: N/A Phone Number: 800-456-2228 Assigned To: Michael Ferrari (Office of Naval Research) Fax Number: 818-659-7688 Last Assigned By: Michael Ferrari (Office of Address: Naval Research) None City: State/Province: Zip Code/Postal Code: **Submission Details** Request Handling -Requester Info Available to No Request Perfected: No the Public: Appellate Authority: N/A Request Track: Simple Acknowledgement Sent Date: Fee Category: Unusual Circumstances ?: No Fee Waiver Requested: No 5 Day Notifications: No Fee Waiver Status: N/A Litigation: No **Expedited Processing No** * Litigation Court Docket Requested: Number: Expedited Processing Status: N/A Request Description -Short Description: N/A To whom it may concern, This is a request for a mandatory declassification review (MDR), under the terms of Executive Order 12958, as amended, of the following document(s): Laser Eye Protection (U) dated April 1988 - as listed here: https://www.nrac.navy.mil/reports_chronological.asp If you regard these documents as potentially exempt from disclosure requirements, I request that you nonetheless exercise your discretion to disclose them. Please release all reasonably segregable nonexempt portions of documents. Thank you for your time, and I look forward to your response! Sincerely, John Greenewald, Jr. FAX 1-818-659-7688 Description Available to the No Has Description Been No 0/2000 Public: Modified? Additional Information -Case #: N/A Name of Local Command: N/A Contract/Sol.#: N/A Limit Request To Clearly N/A

Releasable Info:

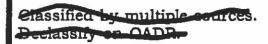
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REPORT OF THE

NAVAL RESEARCH ADVISORY COMMITTEE PANEL

ON

LASER EYE PROTECTION



APRIL 1988

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SECTION I

EXECUTIVE SUMMARY (U)



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EXECUTIVE SUMMARY (U)

- (U) The Naval Research Advisory Committee (NRAC) Panel was requested to undertake a rapid review of the laser threat to Navy and Marine Corps aviation to reassess the threat, the adequacy of Operational Requirements (OR) to develop means to protect against it, to review present Navy protection programs and the Research and Development (R&D) organization, and to make recommendations for broader R&D leading to the development of protection against the emerging frequency agile threat. The Terms of Reference (TOR) are included as Appendix A.
- (U) The panel membership, included as Appendix B, contained members with engineering, research, and medical backgrounds and was assisted by the Navy in-house R&D community. The panel drew the conclusions and made the recommendations described below. The (Acting) Assistant Secretary for Research, Engineering and Systems (ASN (RE&S)) signed three tasking letters in response to this panel's recommendations. These are also included in the Appendices.
- (U) There are a variety of friendly and hostile lasers currently developed by military forces in the form of laser range finders and designators. Some of the Soviet lasers may have power levels unwarranted by range finder or designator applications, but it is not known whether these are intended as anti-personnel weapons. Laser radiation has been experienced by U.S. flight crews flying reconnaissance missions. While there are several different damage mechanisms (discussed in this report), present lasers can cause eye damage at ranges up to a few miles. However, they can cause a "dazzle" effect at greater ranges (particularly at night) when illumination of a cockpit and the scattering of light results in the inability of the crew to perform its mission and can result in the loss of the aircraft. The panel concluded that the laser threat is growing and whether intentionally used as anti-personnel weapons or causing damage only accidentally, lasers must be considered a growing anti-personnel threat against which protection should be provided. The naval aviators most exposed to this threat are the air-to-surface attack aircraft and the Marine aircraft and helicopter crews supporting ground combat.
- (U) While early deployed lasers operated predominantly at only two wavelengths, the number of wavelengths used is now proliferating. It is expected that a tunable (frequency agile) laser threat will also develop soon. The present program to protect naval aviators from the laser threat is based on developing helmet visors or goggles which have narrow band spectral line rejection filters at the threat laser wavelengths, attenuating incident laser energy at these wavelengths, thus preventing laser radiation from damaging eyes. The panel reviewed the OR of the Navy and of the other services and found them to be similar and the R&D effort well

coordinated. The OR called for protection at two wavelengths. The OR did not address the frequency agile threat, nor protection from the "dazzle" effect, and did not address the possibility of providing protection by evoking aircraft sensors to warn of laser illumination and the reflexive application of eye protection for the crew. The panel recommended changes in the OR to correct these deficiencies, and these changes were made.

- (U) The technical approach used to protect against fixed frequency lasers cannot be applied to protection from the agile threat or even to the protection from a larger number of fixed frequency threats. As more band rejection filters are built into a sandwich, transmissivity of the visor at other wavelengths decreases also, making it unusable at night and limiting its utility in the daytime. In addition, the level of attenuation provided by visors at present laser wavelengths is only adequate against laser powers used at present and may not be adequate against higher power Soviet lasers, should these be intended as anti-personnel weapons. There are other mechanisms that may be effective against the agile threat. Among these are the optical limiters that restrict the intensity of light they transmit and the intensity activated optical shutters that make the visor momentarily nontransparent when illuminated by strong laser light. The investigation of these mechanisms is still in an early stage (6.1 and 6.2). The panel identified a list of possible physical mechanisms from which the more promising need to be pursued to develop protection against the The panel also recommended the initiation of agile threat. system level laser protection approaches which involve the use of sensors on the aircraft as part of the laser protection This can provide illumination sensing and analysis program. capability on the aircraft prior to the illumination of the The time so gained can be used to initiate crew itself. reflexive protection measures and pilot illumination evasion. Recommendations to increase the 6.2 funding to provide for this research were made and the funds were provided in the FY 88 budget.
- (U) The panel reviewed the Navy organization for R&D for laser eye protection for aviators and found the organization and the Navy laboratory support and leadership excellent. It must be pointed out, however, that as laser protection moves from the protection of eyes of aviators by visors to systems solutions involving the aircraft and its sensor system, the R&D management of the laser protection program may have to be broadened.
- (U) The panel identified priority intelligence collection requirements against the laser threat. The ASN (RE&S) signed a letter to initiate such increased intelligence collection and efforts are underway to carry out these tasks.

(U) In conclusion, the panel found the threat to be growing rapidly and the need for R&D for protection from the agile threat to be of great importance. The panel is pleased that its recommendations were acted upon rapidly and commends the Navy laboratory personnel for its strong technical leadership in this important area for the Navy.

TERMS OF REFERENCE FOR LASER EYE PROTECTION

- BACKGROUND
- PROBLEM
- TASKS
 - REVIEW CURRENT R&D LASER EYE PROTECTION PROGRAMS
 - VALIDATE CURRENT AND PROJECTED THREAT
 - REVIEW REQUIREMENTS FOR COCKPIT COMPATIBILITY, NIGHT VISION, AND MANUAL DEXTERITY
 - DETERMINE STATUS OF OPERATIONAL REQUIREMENTS TO COUNTER THE THREAT
 - IDENTIFY NAVY ORGANIZATIONAL RESPONSIBILITIES
 - ASSESS INDUSTRIAL AND ACADEMIC TECHNOLOGY BASES
- GOAL
 - DEVELOPMENT OF RECOMMENDED COURSES OF ACTION TO ACHIEVE/ACCELERATE AN AGILE (MULTI-FREQUENCY) LASER EYE PROTECTION CAPABILITY

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FIGURE 1.

TERMS OF REFERENCE FOR LASER EYE PROTECTION (U)

BACKGROUND (U)

(U) Thousands of lasers are currently deployed for various purposes (e.g., rangefinding and target designation) and could be used against personnel to cause either temporary or permanent eye damage. Of particular concern is the fact that future laser devices could operate anywhere in the visible, near infrared and far infrared bands. The present Navy/Marine Corps program to provide laser eye protection consists of three elements: two directed at discrete wavelength protection and the third, longer term effort under development, against the entire agile laser band.

PROBLEM (U)

 (U) Laser eye protection devices are wavelength dependent and multiple devices cannot normally be used concurrently. Additionally, cockpit display and visual requirements

SECTION II
BRIEFING CHARTS

greatly inhibit protection device versatility. A need exists for a generic laser eye protection device that places no limitation on personnel performance.

O (U) Navy participation in the development of protection against the entire agile laser band is minimal and only leads to a full capability in 1998.

TASKS (U)

- (U) The following subjects and tasks will be reviewed and/or accomplished.
- (U) Review current Navy and DOD R&D laser eye protection programs.
- (U) Validate current and projected threat. Specifically, review potential present and future laser devices capable of use against personnel.
- 3. (U) Review requirements for cockpit compatibility, night vision, and manual dexterity.
- 4. (U) Determine status of OR to counter the threat.
- 5. (U) Identify Navy organizational responsibilities for laser eye protection.
- 6. Assess industrial and academic technology bases.

GOAL (U)

(U) To develop recommended courses of action to achieve/ accelerate an agile (multi-frequency) laser eye protection capability.

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PANEL MEMBERSHIP

* DR. GEORGE S. SEBESTYEN - PANEL CHAIRMAN PRESIDENT DEFENSE SYSTEMS, INC. MR. LARRY BLAIR LOS ALAMOS NATIONAL LABORATORIES VADM E. A. BURKHALTER, USN (RET) PRESIDENT, BURKHALTER ASSOCIATES DR. JAY ENOCH UNIVERSITY OF CALIFORNIA, BERKELEY DR. MICHAEL FELD MASSACHUSETTS INSTITUTE OF TECHNOLOGY MR. HARVEY S. FROMER GRUMMAN AIRCRAFT SYSTEMS DIVISION DR. URSULA J. GIBSON UNIVERSITY OF ARIZONA MR. WILLIAM R. GRAVER ANALYTIC DECISIONS INC. DR. HERSHEL W. LEIBOWITZ PENNSYLVANIA STATE UNIVERSITY DR. ALEXANDER L SLAFKOSKY PRIVATE CONSULTANT (FORMER CHIEF SCIENTIST USMC) CDR E. D. POPE - PANEL EXECUTIVE SECRETARY OFFICE OF ASSISTANT SECRETARY OF THE NAVY (R,E&S)

FIGURE 2.

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PANEL MEMBERSHIP (U)

POTENTI. AVIATORS MISSION	AL LASER	THREAT TO THE PROBABILITY OF ENCOUNTERING THREAT	PROBABILITY OF IMPACT ON MISSION DAY NIGHT	PRIORITY FOR
ATTACK (AIR- TO-GROUND)	A-8 A-7 AV-8 A-18	HIGH	MED HIGH	1*
FIGHTER (AIR- TO-AIR)	F-14 F-18	LOW	LOW LOW	3
AEW	E-2	LOW	FOM FOM	4
JANHING	EA-68	Low	FOM FOM	4
ASW	S-3 P-3 H-2 SV-2: H-3 SH-6		MED HIGH	2
INTELLIGENCE	EA-38 EP-3	FOM	FOM FOM	•
HELICOPTER (GROUND SUPPORT FOR MARINES)	CH-45 MY-2 CH-33 OV-1 UH-1 HH-5 AH-1H	9	нон нон	1.
CODWOD	C-2 CH- C-130 etc.		LOW LOW	4
WHILE THESE TY			ST PRIORITY, THE INHE	RENT MISSION

FIGURE 3.

POTENTIAL LASER THREAT TO THE NAVAL AVIATOR/MARINE PILOT (U)

UNCLASSIFIED REPRESENTATIVE POTENTIAL THREAT - FRIENDLY AND HOSTILE LASERS

				125,000	PULSED	7		NO. OF	MENTA DE	PLOTED S	HOBILE P	LATFORM
TYPE OF LASER	WAYELDESTH (µm)	CW AVQ POWER [W]	EMERGY (J)	PULSE WIDTH (µs)	PEAR POWER (W)	REP RATE (DDS)	AVO	1887	1989	1981	1993	1091
æ,	18.6"											
ca	6.2*		1				1				1	
20"	1.0*				1		1 1			1		
107	2.7*								i .	l		
rotavg	1.8*				ľ		1	l. i				1
MP1YAG	1.1	1.30X10 ⁴	1.4X10 4	19	.4810	4	2-10X1d			10	**	
ALEXAMORITE	6.81-6.75 (TUMABLE)	_	10-103	400	1-2270	180	0-20X10	18	20	**	100	200
anuary .	.40		-10Z10	100	1-10210	1	0-10210		10	44	100	168
DIE	T.9-0.40	12-100	200-1000	10	0-10X10	6.0	1.5-0210	1	22	48	100	150
(DHE)DAY: CH	0.01	1-16X10	1-2.02.2		1-4.0Z10	•	1.1421					1
109 1091		1-10E10							18	**	200	***
CN YAPOR	0.60-8,61		1-18	0.00	9-20X10 ⁷	0-18218 ³		Ki .			- 19	
AR 10H	0.49	-6210°						10		100	158	180
DHT) DAY: 0H	6.38*									39051	-	
CICHIDI	4,38-9,10*						1		1			0.0
* <u>.</u>	8.34*				1		, l					

^{*} ADSOLATE PROTECTION PROVIDED BY COCKPIT CAMOPT AND/OR PLOT VISOR-GOOGLES.

NUTTE PERFORMANCE PROMETED TO 1993 THE SHARE ON PRINCIPS REALEST AND THE AREA

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FIGURE 4.

REPRESENTATIVE POTENTIAL THREAT - FRIENDLY AND HOSTILE LASERS (U)

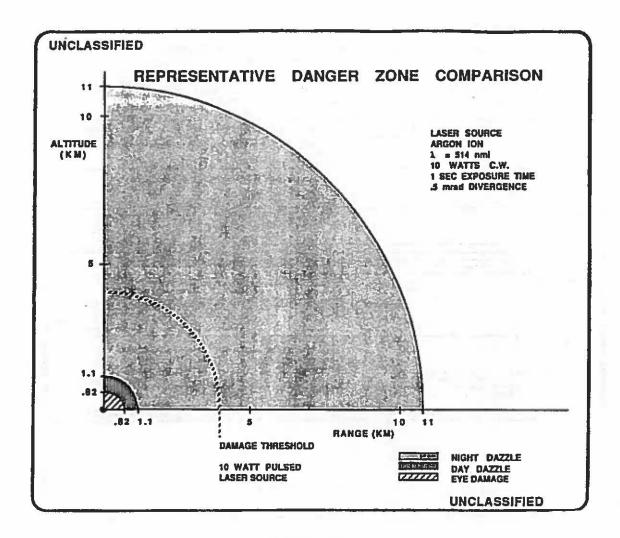


FIGURE 5.

REPRESENTATIVE DANGER ZONE COMPARISON (U)

- o (U) Dazzle is the loss of visual function caused by excessive light in the eye. The light profile is characterized by both temporal and spatial nonuniformity of illumination.
- o (U) The most significant near term threat to the successful completion of a naval aviator's mission is laser-induced night dazzle.
- o (U) Day dazzle and eye damage can become a more significant threat at higher power levels and for pulsed laser sources.

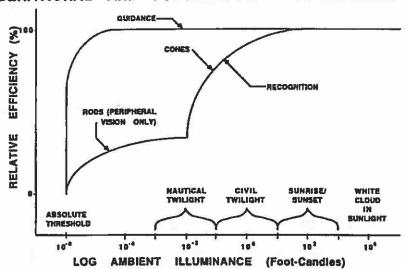
COMPITION	CORNEA AND OCULAR MEDIA	AGE AND/OR	FUNCTIONAL VISU RETHAL BUT PERPHERAL BUT PER		BAZILE & EFFECT ON
ACCIDENTAL EXPOSURE (RANGING, etc.)	AES' IN SHOUL OU FOND MVAS- FEMBRAS		MOST PROBABLE FOR PLOT	LESS LIKELY POR PROT	PERHAPS
PURPOSEFUL EXPOSURE (ANTI- PERSONNEL)	LESS LIKELY THAN RETHAL	G-SWITCHED LASER MAYARS	HERE, PIRST PULSE IS TO GAM ATTEN- TION - MAY NOT BURNL SECOND PULSE IS DIRECTED AT CENTER	DESIGNED OFTEN FOR THIS LESION	YES, A CHEAN SMPLE OPTION
DAY		12000 1000	LESS DISTRACTING. MAY STRL. RE ABLE TO PUNCTION	MUST NOT RESCRECT EYE TO LEGK AT SOURCE	SOMEWHAT DISTURBING
PART			MORE DISTRACTING, MAY STILL BE ABLE TO FUNCTION	MUST NOT REDIRECT EYE TO LOOK AT SOURCE	FARTICULARLY DIS- ORIGITING, CAM CAUSE MABILITY TO FUNCTION
WAYELENGTH BAND	UV YES VISIBLE NEAR IN FAR IN YES	VES	YES	YE.	SOME PLUORESCENCE VES
O-SWITCHED		PARTICULAR HAZARD	MOST PROBABLE		
Polsto		- Magazina	MOST PROBABLE SITE	LOW PROGRAMATY PIRST EXPOSURE, POSSIBLE AFTER GAMENO ATTENTION	EMPLE PULSE HAS LITTLE ADAPTIVE EFFECT, MAY BUSTUM BY EMSTRACTIONS
(1			LANGER SURM AREA THAM RETHIAL MAGE SIZE, PROBABLE PRIST INTERCEPT	POSSIBLE AFTER GAMENG ATTENTION	PARTICULARLY DISTRACTING
THE POR RESPONDES	OFTEN HOT AWARE OF EXPOSURE, PAINFUL	(PICOSECONDS)	(MICORECONDE) ANGATTA MONE	IF NOT MITTAL SITE, ABOUT 300 MILLISTCOMOS FOR RESPONSE	TIME IS AVARABLE FOR AVERSION OR RESPONSE

FIGURE 6.

OCULAR DAMAGE AND/OR FUNCTIONAL VISUAL IMPAIRMENT (U)



BEHAVIORAL AND PSYCHOLOGICAL IMPLICATIONS



SCHEMATIC BLUSTRATION OF THE RELATIONSHIP BETWEEN VISUAL EFFICIENCY AND LUMINANCE FOR RECOGNITION AND FOR GUIDANCE VISION, NOTE THAT WHILE THE EFFICIENCY OF RECOGNITION TASKS (SUCH AS READING OR TARGET IDENTIFICATION) ARE SYSTEMATICALLY RELATED TO LUMINANCE, VISUALLY GUIDED BEHAVIORS ARE ESSENTIALLY INDEPENDENT OF LUMINANCE (AS WELL AS SMAGE BLUR; OVER THE FUNCTIONAL RANGE OF THE VISUAL SYSTEM. THEREFORE, LOW TRANSMITTANCE LASER EYE PROTECTION AT DUSKINIGHT WILL:

- DEGRADE/ELIMINATE ALL VISUAL RECOGNITION AND DETECTION OUTSIDE OF COCKPIT (39% RELATIVE EFFICIENCY)
- -REDUCE DISPLAY LUMINANCE AND CONTRAST/COLOR CONTRAST BELOW DESIGN SPECIFICATIONS TO THE POINT WHERE RESOLUTION OF IMAGERY IS PREVENTED.

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FIGURE 7.

BEHAVIORAL AND PSYCHOLOGICAL IMPLICATIONS (U)

PERFORMANCE OF HUMAN-MACHINE SYSTEMS IS OFTEN LIMITED BY BEHAVIORAL

FACTORS (U)

- (U) Glare can substantially degrade, possibly prevent, visual performance.
 - (U) Short term glare can have the same impact on mission success as permanent eye damage.
- o (U) Glare will differentially affect visual performance as a function of:

- (U) Type of task (recognition/detection versus orientation/visual guidance)
- (U) Ambient illumination (day vs. dusk vs. night)
- (U) Intensity and wavelength (short vs. long wavelength).
- o (U) Psychophysiological effects can only be reduced/ eliminated through adequate eye protection which maintains necessary image quality.
 - (U) High transmittance (photopic, mesopic, and scotopic)
 - (U) Sufficient optical density to eliminate glare
 - (U) No further restrictions to field of view
 - (U) Continuing normal cockpit functions.
- o (U) Psychological effects of glare can be reduced through:
 - (U) Training (e.g., safe exposures)
 - (U) Development of coping strategies/countermeasures (will also be effective in preventing retinal burns).
- (U) Behavioral research on the effects of coherent light is necessary to provide guidelines for engineering decisions for the development and implementation of laser eye protection.

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THREAT SUMMARY

- . THERE IS AN EXISTING AND INCREASING LASER THREAT TO THE NAVAL AVIATOR
- . SOME OF IT IS FROM FRIENDLY SYSTEMS (DESIGNATORS, RANGEFINDERS, ETC.)
- . THE GREATEST NEAR TERM THREAT IS DAZZLE/FLASH BLINDNESS
- . THE THREAT NOW IS AT A FEW DISCRETE WAVELENGTHS
- IT WILL INCLUDE FREQUENCY AGILE LASERS IN THE FUTURE
- · WHETHER INTENDED OR NOT, SOVIET LASER SYSTEMS CAN BE USED AS ANTI-PERSONNEL WEAPONS

PRESENT

- LOW POWER SYSTEMS MOSTLY FOR RANGEFINDING/TARGET DESIGNATION
- SOVIET SYSTEMS TYPICALLY MORE POWERFUL THAN WESTERN EQUIVALENTS
- THREAT FROM OWN SYSTEMS SHOULD BE FACTORED

FUTURE

- WIDE SPREAD LASER WEAPON SYSTEMS DEPLOYMENT LIKELY WITHIN NEXT DECADE WITHIN SOVIET/WARSAW PACT FORCES/THIRD WORLD
- INCREASED POWER LEVELS PROBABLE
- TUNEABLE LASER SYSTEMS LIKELY, LENDING SOVIET WARTIME RESERVE MODE
- (WARM) POTENTIAL

 MAY BE CONSIDERED ESSENTIAL AS COUNTER TO LASER-GUIDED WEAPONS SYSTEM

 ANTI-PERSONNEL USE OFFERS NEAR "UNLIMITED" FIREPOWER
- UNCLASSIFIED

FIGURE 8.

THREAT SUMMARY (U)

UNCLASSIFIE Al	R CREW LASER EYE PE	ROTECTION REQUIREM	MENTS
CAPABILITIES/ CHARACTERISTICS	NAYY OR #099-0587, LASER EYE PROTECTION FOR NAVY/MARINE CORPS AVIATORS	AIR FORCE DRAFT STATEMENT OF OPERATIONAL NEED (SOM) AF-3XX-86 FOR AIR CREW OCULAR LASER PROTECTION	ARMY ASARC REQUIREMENTS FOR LASER EYE PROTECTION
1. WAVELENGTH COVERAGE	(EXPLORE LEP OPTIONS OF COMBINATIONS FOR RISK REDUCTIONS, COST SAYINGS, TECHNOLOGICAL ACHIEVEMENT OR RAPID DEPLOYMENT.)	SAME AS NAVY'S.	
	ALTHOUGH LEP PROGRAMS INDICATE NAYY INTEREST IN 4 1 AND EVENTUALLY IN ACHIEVING A FREQUENCY AGRIC CAPABILITY AGAINST MULTIPLE FREQUENCIES, THE OR DOES NOT MENTION THESE CAPABILITIES REQUIREMENTS.		TRIPLE HOTCH FILTERS APPROACH TO MEET FUTURE THREAT.
2 NATURE OF PROTECTION	EYE PROTECTION AGAINST LASEN THREATS FOR COMPLETION OF MISSION AND AVOIDANCE OF TEMPORARY OR PERMANENT EYE INJURY TO NAVAL AIR CREWS.	PROVIDE AIR CREW PROTECTION TO PRECLUDE TEMPORARY OR PERMANENT LOSS OF VISION WHEN EXPOSED TO LASER ENERGY TO ENABLE TAPS TO PERFORM CLOSE AIR SUPPORT AND BATTLEFIELD INTERDICTION.	PROVIDE EYE PROTECTION TO PILOTS AND GROUND TROOPS IN MISSION PERFORMANCE.
3. WEIGHT	LIGHTWEIGHT (NO SPECIFICS AS TO UPPER LIMITS.)	SAME AS NAVYS.	
4. CONFIGUR- ATION	SPECTACLES, GOGGLES OR VISORS COMPATIBLE WITH EXISTING REQUIRED PERSONNEL EQUIPMENT IF HEAD OR HELMET-MOUNTED.	HELMET-MOUNTED VISOR LENS THAT INTEGRATES WITH CURRENT/ PROPOSED AIR CREW HELMETS, OXYGEN MASKS AND CW DEFENSE EQUIPMENT.	VISOR COMPATIBLE WITH CW DEFENSE

FIGURE 9.

AIR CREW LASER EYE PROTECTION REQUIREMENTS (U)

ICLASSIFIED AIR	CREW LASER EYE PROTECT		
CAPABILITIES/ CHARACTERISTICS	NAVY OR 9009-0587, LASER EYE PROTECTION FOR NAVY/MARINE CORPS AVIATORS	AR FORCE DRAFT STATEMENT OF OPERATIONAL NEED (SOM) AF-1XX-44 FOR AR CREW OCULAR LASER PROTECTION	ARMY ASARC REGISTEMENT FOR LASER EYE PROTECTION
a. Operational Emplications	ENABLE/ALLOW HORMAL OPERATION BOTH DAY AND MIGHT. IF HEAD OR HELMET-MOUNTER, MUST NOT RESTRICT WEARRY'S MOVEMENTIABILITY TO FUNCTION IN MIS OPERATIONAL ENVIRONMENT.	ALLOW UNRESTRICTED VEHOR FOR NORMAL EPERATIONS. NO DISTORTION, IMPARING OF VISUAL ACTIVITY OR SEGRADING THE FIDELITY OF COCKPIT DISPLAYS. MUST NOT EMPOSE EXTENSIVE AC MOORS. NO UNGQUE TRAINING OR MAINTENANCE REGURREMENTS RESILITING FROM SYSTEM. COMPATIBLE WITH SIGTH DAY AND MOHT OPERATIONS.	ENABLE NORMAL OPERATION WITH- OUT UNDUE RESTRICTION OF MOVEMENT OR ABILITY TO FUNCTION IN MISSION ROLE
L OFTICAL DENSITY (00)	E() AT DESIGNATED WAVE- LENGTH FOR ALL INCIDENCE ANGLES THAT COULD CAUSE EYE DAMAGE.	SAME AS HAVY,	-3 (7)
TANGET.	BE'S FOR BOTH DAY AND MIGHT.	NOT MENTIONED.	'
L DURABLITY	MPACT, PENETRATION AND ABRASION RESISTANCES AS SPECIFIED IN MIL-V-222720(AS).	BANE AS NAVY.	7
DUALITY	AS SPECIFIED IN MIL-Y-22272D(AS).	BAME AS NAVY.	
IS CONCEVITY	FIVE (6) YEARS SERVICE LIFE WITH SOME MEANS TO IDENTIFY DEGRADA- TION OR FAILURE.		7
11. COSTS	A) ROTAE B) UNIT PRODUCTION COSTS 1.0K C) LIFE CYCLE COSTS (BASED ON 6800 UNITS) D) PROCUREMENT NUMBER	NO COSTS ON PRODUCTION QUANTITIES WERE IDENTIFIED IN THE AF SON, BUT A VICE CHEF OF STAFF MESSAGE OF MOY, 1980 DIRECTED THE PROCUREMENT OF APPROXIMATELY 18,000 UNITS WITH "37 AND 38 FUNDS OF 3 \ VISOR.	
		113	CLASSIFIED

FIGURE 10.

AIR CREW LASER EYE PROTECTION REQUIREMENTS (CONT'D) (U)

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LIMITATIONS OF THE CURRENT NAVY OR

- ONLY REQUIRES EYE PROTECTION (VISORS) TO AVOID EYE INJURY AND TO COMPLETE MISSION.
- · LIMITS THE SOLUTION TO VISORS/GOGGLES.
- DOES NOT ADDRESS STARTLE, FLASH BLINDNESS, DAZZLE/GLARE WHICH MAY NOT CAUSE EYE DAMAGE, BUT COULD PRECLUDE MISSION COMPLETION, AND CAUSE LOSS OF AIRCRAFT.
- DOES NOT ADDRESS FUTURE AGILE FREQUENCY LASER THREAT.
- DOES NOT ADDRESS THE HIGH POWER CAPABILITIES OF SOVIET SYSTEMS WHICH COULD BE EMPLOYED AS ANTI-PERSONNEL WEAPONS.
- SHOULD BE MORE SPECIFIC ABOUT THE EYE EFFECTS THE NAVY WANTS TO PROTECT THE PILOTS/CREWS AGAINST THE MOST, AND WHICH MISSIONS HAVE THE HIGHEST PRIORITIES.
- DOES NOT PROVIDE THE OPTION OF A SYSTEMIC-ORIENTED SOLUTION (PLATFORM), OR ALTERNATIVE COMPLEMENTARY SOLUTIONS TO VISORS.
- DOES NOT PROVIDE FOR VISION SYSTEM PROTECTION OTHER THAN PILOTS' EYES.

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FIGURE 11.

LIMITATIONS OF THE CURRENT NAVY OR (U)

HIMOL	-		-	-
	-	12 12	i den i	

EXISTING LASER EYE PROTECTION PROGRAMS

SERVICE	IOC TIME_FRAME	TYPE OF FUNDING	WAYE- LENGTH	DESCRIPTION OF DEVICE	PURPOSE
NAVY	AVAILABLE	PRODUCTION STOCK FUNDS	λ,	EEK-J VISOR EDU-1P GLASSES	PROTECTION AGAINST OUR OWN & ENEMY RANGE FINDERS/DESIGNATORS
NAVY	LATE 60°s	6.4	3 % '6+	7	RESOLVE THREAT PROTECTION HOLE BETWEEN WHAT'S AVAILABLE & WHAT'S BEING DEVELOPED
KAYY	EARLY DO's	8.3	4 % '6	7	MEET MID-TERM THREAT PROJECTION
NAVY	LATE 90's	6.2	AGILE	7	MEET THE TOTAL LONG TERM THREAT
AIR FORCE	LATE BO's	PRODUCTION STOCK FUNDS	32'e+	ROZIV	PROVIDE EARLIEST PROTECTION AGAINST EXISTING THREAT PLUB OUR OWN SYSTEMS (POTENTIAL P-43 PHOSP. PROB.)
ARMY	LATE BO's	PRODUCTION STOCK FUNDS	21's	EYEGLASSES	PROTECTION FOR GROUND TROOPS & HELO PILOTS
ARMY	EARLY 90's	6.2	7	TRIPLE NOTCH FILTER	LONG TERM THREAT
					UNCLASSIFIED

FIGURE 12.

EXISTING LASER EYE PROTECTION PROGRAMS (U)

UNCLASS		EYE PROTECTION PROGRAMS
SERVICE	λ·n	LATE 80's EARLY 90's LATE 90's
NAVY	λ _a	▼
3	з у,≈ +	
	$\lambda_1 / \lambda_2 / \lambda_3 / \lambda_4$	Fire A Control of the
	AGILE	
YMRA	λ ₂ / λ ₃	**************************************
4	TRIPLE NOTCH	
AIR FORCE	$\lambda_1 / \lambda_2 / \lambda_3$	***************************************
		FY 87 FUNDING \$
1		PROJECTED IOC 6.3 UNCLASSIFIED

FIGURE 13.

LASER EYE PROTECTION PROGRAMS (U)

UNCLASSIFI		PROTECTION PROGRAMS (CONT.)
SERVICE	IOC TIME FRAME	λ_1 λ_2 λ_3 λ_4 AGILE
NAVY	LATE BOS	+
AFMY	EARLY 90s	
MAVY }	EAHLT SUS	10世紀 (1996年 1996年 19
AF }	LATE 90s	FY 87 FUNDING
ARMY J		0000000000 PRODUCTION 0.4 0.3 0.111111111 6.2 UNCLASSIFIED

FIGURE 14.

LASER EYE PROTECTION PROGRAMS (CONT'D) (U)

NAV	Y R&D BUDGET	PROFILE	FOR PERSONNEL	LASER	EYE PROTECT	TION
FUNDING SOURCE	FISCAL YEAR	'87	*88	'89	*90	'91
6.2		\$400K	\$400K	\$400K	\$400K	\$400K
6.3		\$500K	\$397K	\$934K	\$2.39M	\$2.306M
6.4		\$151K	\$900K	\$800K	\$1M	\$1 M

FIGURE 15.

NAVY R&D BUDGET PROFILE FOR PERSONNEL LASER EYE PROTECTION

COOPERA		D AT THE AGILE THE DING)	EAT
FUNDING SOURCE	FY87	FY88	FY89
ARMY	\$500K	\$675K	\$700K
NAVY	\$400K	\$400K	\$400K
AIR FORCE	\$200K	\$100K	\$200K
MARINES	\$200K	\$200K	\$200K
DARPA	\$0	\$400K	\$500K

FIGURE 16.
COOPERATIVE EFFORTS AIMED AT THE AGILE THREAT (U)

UNCLASSIFIED

TECHNOLOGY OVERVIEW

- •THREAT DICTATES NEED FOR MULTIPLE APPROACHES
- •DIFFERENT TECHNOLOGIES SHOULD BE COMBINED TO PROTECT AGAINST DIVERSE WAVELENGTHS AND TRUE AGILE THREATS
- PASSIVE (SELF-ACTUATING) AND ACTIVE (DETECT AND REACT) SCHEMES MAY BOTH BE USEFUL
- REMOTE VIEWING (TV OR HMD) PROVIDES ULTIMATE PROTECTION IN HEAVY LASER EXPOSURE ENVIRONMENT
- · LASER WARNING SYSTEMS WILL BE IMPORTANT, IF NOT ESSENTIAL
- DEVELOPMENT OF PROCEDURES/AUTOMATIC SYSTEMS FOR DAZZLE ARE NECESSARY

UNCLASSIFIED

FIGURE 17.

TECHNOLOGY OVERVIEW (U)

UNCLASSIFIED

PRESENT TECHNICAL APPROACHES

VISORS/EYEGLASSES

- ABSORBING DYES
 - + LARGE ANGULAR EFFECTIVENESS
 - WIDE BANDS REDUCE OVERALL TRANSMISSION
 - NIGHT VISION INTERFERENCE
- HOLOGRAMS
 - + NARROWBAND REJECTION
 - ANGULAR ACCEPTANCE PROBLEM IN VISORS (CAN MAKE CONTACT LENSES, ESPECIALLY FOR HELO PILOTS)
- . ALL
 - + SIMPLE RETROFIT, PILOT ACCEPTANCE
 - OD NOT HIGH ENOUGH IF PURPOSEFUL USE OF EVEN EXISTING RANGEFINDERS

UNCLASSIFIED

FIGURE 18.

PRESENT TECHNICAL APPROACHES (U)

UNCLASSIFIED

POSSIBLE FUTURE APPROACHES

BETTER EYE GLASSES

AGILE FILTER
HIGHER OD
OPTICAL LIMITERS
MATERIALS (MOSTLY ORGANICS AT THE MOMENT):
POLYMERS - NONLINEAR
LIQUID XTAL
PHOTOCHROMICS
OPTICAL SWITCHES?

SYSTEMPLATFORM LEVEL SOLUTIONS (MULTIPLE SYSTEM SOLUTION)
UV AND IR FILTERING AT CANOPY
LOW CONCENTRATIONS OF VIS. DYES MAY REDUCE CANOPY GLARE
DAZZLE PROTECTION: DETECT AND REACT TO SPECIFIC WAVELENGTHS
HIGH ENERGY PULSES

FOCAL PLANE PASSIVE (LIMITERS OR SWITCHES) FOR GUNNERS REP RATE DETECTORS AND "HIDE AND PEEK" MODE REMOVE DIRECT VIEWING - HIMD AND TY CAMERAS MATERIALS RESEARCH:

NON-LINEAR ($\chi^{(3)}$) MATERIALS (PHASE CONJUGATE MIRRORS, LIMITERS) FAST PHOTO CHROMICS SEMICONDUCTOR AND PLASMA SWITCHES

ABLATIVE, FRUSTRATED TOTAL INTERNAL REFLECTION OR PHASE CHANGE SACRIFICIAL MIRRORS

LASER WARNING DEVICES

LASER SIGNATURES
COHERENCE/DIRECTIONALITY - REDUCED AFTER ATMOSPHERIC TRAVEL
HIGH INTENSITY
BRIGHT REL TO BACKGROUND - ALLOWS FALSE SIGNALS
MONOCHROME SPIKE - NEED SPECTRUM ANALYZERS
PULSE SOURCE

USUALLY FIXED REP RATE SMALL ON : OFF RATIO

UNCLASSIFIED

FIGURE 19.

POSSIBLE FUTURE APPROACHES (U)

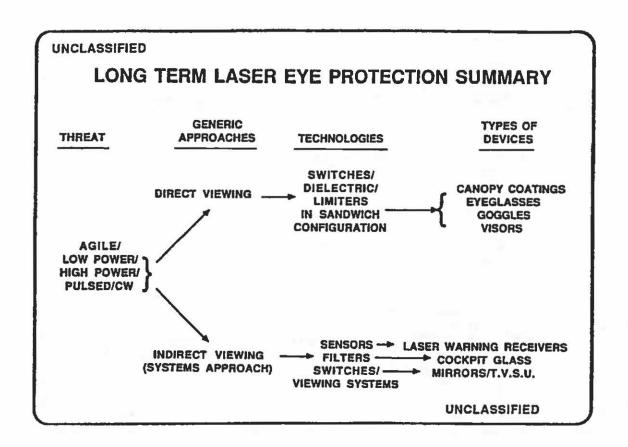


FIGURE 20.

LONG TERM LASER EYE PROTECTION SUMMARY (U)

UNCLASSIFIED

NAVY ORGANIZATIONAL RESPONSIBILITIES

- TRI-SERVICE LASER EYE PROTECTION R&D ACTIVITIES ARE FULLY INTEGRATED & PROPERLY ORGANIZED.
- THE CURRENT NAVY ORGANIZATION IS TUNED TO THE PRESENT TECHNICAL APPROACHES FOR THE EYE PROTECTION PROBLEM (E.G., GLASSES, VISORS).
- FUTURE TECHNICAL APPROACHES TO COUNTERING THE AGILE THREATS (E.G., THE SYSTEMS APPROACH) WILL REQUIRE A NEW MULTI-DISCIPLINE ORGANIZATIONAL APPROACH TO SUCCESSFULLY MANAGE THE PLATFORM SOLUTIONS THAT WILL BE REQUIRED.

UNCLASSIFIED

FIGURE 21.

NAVY ORGANIZATIONAL RESPONSIBILITIES (U)

UNCLASSIFIED

RECOMMENDATIONS

REQUIREMENTS

- . MODIFY THE OR TO INCLUDE:
 - PROTECTION AGAINST AGILE THREAT
 - SYSTEM & PLATFORM SOLUTIONS (INCLUDING LASER WARNING RECEIVERS AS PART OF PLATFORM DEFENSIVE SUITS)
 - HIGHER OD FILTERS AND OTHER APPROACHES SOONER (HIGHER POWER LASERS MIGHT BE USED AS ANTI-PERSONNEL DEVICES)
 - RESEARCH ON THE "DAZZLE" THREAT
 - OTHER TECHNIQUES

EDUCATION & TRAINING

- · EFFECTIVE EDUCATION PROGRAMS ARE NEEDED TO:
 - MAKE AVIATORS AWARE OF THE LASER THREAT
 - ENABLE THEM TO MAKE VALID ASSESSMENTS OF OBSERVED ENEMY LASER SYSTEMS
 - TRAIN THEM TO TAKE APPROPRIATE EVASIVE/AVOIDANCE MEASURES IN THE EVENT OF LASER THREAT EXPOSURE
- INCORPORATE "DAZZLE" AND LASER THREAT SIMULATIONS INTO AIR CREW TRAINERS

UNCLASSIFIED

FIGURE 22.

RECOMMENDATIONS (U)

UNCLASSIFIED

RECOMMENDATIONS

INTELLIGENCE

- DEVELOP AND FIELD DEVICES FOR COLLECTING TECHNICAL INTELLIGENCE ON THE LASER THREAT TO:
 - DETECT LASER ILLUMINATION
 - DETERMINE WAVELENGTHS
 - DETERMINE INTENSITIES
 - RECONSTRUCT THE GEOMETRY
 - DETERMINE THE WAVEFORM/PULSE LENGTH/PRF/ETC.
- TASK HUMINT AND OTHER SYSTEMS FOR INFORMATION TO DETERMINE WHAT PROTECTIVE DEVICES AND MEASURES THE SOVIETS ARE USING NOW (OR PLAN TO USE IN THE FUTURE) AGAINST THE LASER THREAT (AND AGAINST THEIR OWN DEVICES).
- HUMINT IS NEEDED RELATIVE TO SOVIETS INTENTIONS REGARDING USING LASERS AS ANTI-PERSONNEL WEAPONS.

UNCLASSIFIED

FIGURE 23.

RECOMMENDATIONS (CONT'D) (U)

UNCLASSIFIED

RECOMMENDATIONS

R&D PROGRAM

- DEVELOP INTERMEDIATE VISOR PROTECTION DEVICES FOR 4 IDENTIFIED LASER THREAT WAVELENGTHS
- DEVELOP LONG TERM PROTECTION AGAINST THE AGILE THREAT
- DEVELOP COUNTERS TO "DAZZLE" PHENOMENA
- · INITIATE STUDIES TOWARD SYSTEM/PLATFORM SOLUTIONS, INCLUDING:
 - LASER WARNING DEVICES & SENSORS FOR INTELLIGENT RESPONSE TRIGGER
 - EXTERNAL (TV) VIEWERS AND HELMUT-MOUNTED DISPLAYS
 - HARDENED CANOPIES
 - OPTICAL SWITCHES
 - MECHANISMS THAT WOULD BE USED ONLY UPON THREAT WARNING

CONDUCT RESEARCH ON

- NONLINEAR OPTICAL MATERIALS (NLO)
- · OPTICAL SWITCHES
- · LIMITERS

FUNDING

- CONSIDERATION SHOULD BE GIVEN TO FUND THE R&D PROGRAM AT AN ANNUAL LEVEL OF ABOUT \$5M

UNCLASSIFIED

FIGURE 24.

RECOMMENDATIONS (CONT'D) (U)

APPENDIX A

TERMS OF REFERENCE FOR LASER EYE PROTECTION (U)

UNCLASSIFIED



TERMS OF REFERENCE FOR LASER EYE PROTECTION (U)

BACKGROUND (U)

(U) Thousands of lasers are currently deployed for various purposes (e.g., rangefinding and target designation) and could be used against personnel to cause either temporary or permanent eye damage. Of particular concern is the fact that future laser devices could operate anywhere in the visible, near infrared and far infrared bands. The present Navy/Marine Corps program to provide laser eye protection consists of three elements: two directed at discrete wavelength protection and the third, longer term effort under development, against the entire agile laser band.

PROBLEM (U)

- o (U) Laser eye protection devices are wavelength dependent and multiple devices cannot normally be used concurrently. Additionally, cockpit display and visual requirements greatly inhibit protection device versatility. A need exists for a generic laser eye protection device that places no limitation on personnel performance.
- o (U) Navy participation in the development of protection against the entire agile laser band is minimal and only leads to a full capability in 1998.

TASKS (U)

- (U) The following subjects and tasks will be reviewed and/or accomplished.
- (U) Review current Navy and DOD R&D laser eye protection programs.
- (U) Validate current and projected threat. Specifically, review potential present and future laser devices capable of use against personnel.
- (U) Review requirements for cockpit compatibility, night vision, and manual dexterity.
- 4. (U) Determine status of OR to counter the threat.
- (U) Identify Navy organizational responsibilities for laser eye protection.
- 6. Assess industrial and academic technology bases.

GOAL (U)

(U) To develop recommended courses of action to achieve/accelerate an agile (multi-frequency) laser eye protection capability.

APPENDIX B
PANEL MEMBERSHIP (U)



PANEL MEMBERSHIP

Dr. George S. Sebestyen, Chairman President, Defense Systems, Inc.

Mr. Larry Blair Los Alamos National Laboratories Dr. Ursula J. Gibson University of Arizona

VADM E. A. Burkhalter, USN (RET) President, Burkhalter Associates

Mr. William R. Graver Analytic Decisions, Inc.

Dr. Jay Enoch University of California, Berkeley Dr. Hershel W. Leibowitz Pennsylvania State University

Dr. Michael Feld Massachusetts Institute of Technology Dr. Alexander L. Slafkosky Private Consultant (Former Chief Scientist, USMC)

Mr. Harvey S. Fromer Grumman Aircraft Systems Division

CDR E.D. Pope, Executive Secretary Office of Assistant Secretary of the Navy (R,E&S)



APPENDIX C

LASER EYE PROTECTION RESEARCH PROGRAMS MEMORANDUM (U)





THE ASSISTANT SECRETARY OF THE NAVY
(RESEARCH, ENGINEERING AND SYSTEMS)
WASHINGTON, D.C. 20050

JUL 2 8 1987

MEMORANDUM FOR THE CHIEF OF NAVAL RESEARCH

Subj: LASER EYE PROTECTION RESEARCH PROGRAMS

A recent Naval Research Advisory Committee Study on Laser Eye Protection concluded that current Navy Laser Eye Protection programs were too narrowly focused toward resolving the eye protection problem by utilizing specific (i.e., at the eye) protection devices such as visors, goggles or eye glasses. The study group concluded that research should be expanded into technologies that could lead toward eventual system/platform solutions, including explorations into:

(a) Laser Warning Devices

(b) Indirect Viewing Systems

(c) Hardened Canopies
(d) Optical Switches an

(d) Optical Switches and(e) Trigger Mechanisms on Threat Illumination

Accordingly, the Chief of Naval Research is directed to ensure that a research program is initiated and funded to cover the areas listed above and as further outlined in the report which will soon be published from the NRAC panel's review.

RICHARD L. RUMPI

AC

Copy to: OPNAV (OP-09, 05 HQMC DC/S(R,D&S)

APPENDIX D

TRAINING AND EDUCATION FOR THE LASER BATTLEFIELD THREAT (U)

UNCLASSIFIED





THE ASSISTANT SECRETARY OF THE NAVY IRESEARCH, ENGINEERING AND SYSTEMS)
WASHINGTON, D.C. 20060

JUL 2 4 1987

MEMORANDUM FOR THE DIRECTOR, RESEARCH, DEVELOPMENT AND ACQUISITION (OP-098)

Subj: TRAINING AND EDUCATION FOR THE LASER BATTLEFIELD THREAT

A recent Naval Research Advisory Committee Study on Laser Eye Protection recommended that the Navy's education and training programs be modified to prepare aviators for the potential laser threat that could be encountered on today's battlefield and the expected proliferation of such systems in the future. The study found that effective education and tactics development programs are needed to:

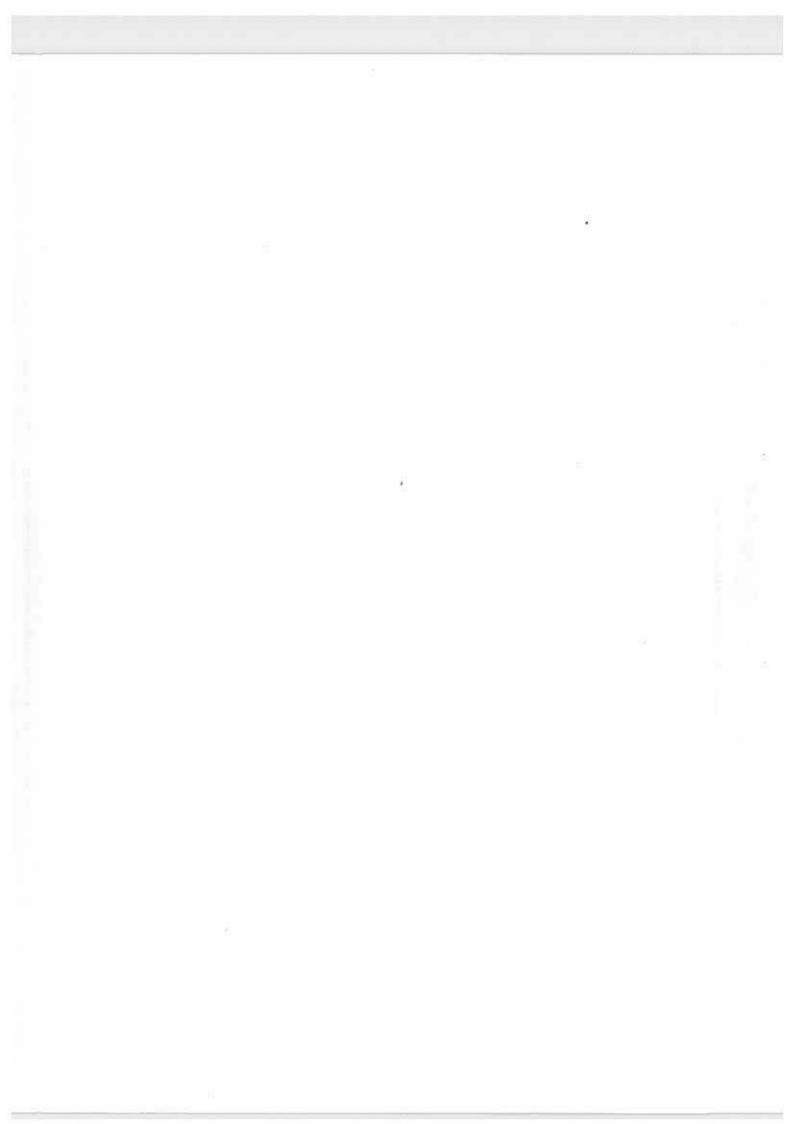
- a. Insure that existing aircrews have a full "AWARENESS" of the laser threat.
- b. Enable aviators to make rapid, valid assessments of observed enemy lasers.
- c. Train flight crews to take appropriate evasive/avoidance measures in the event of laser threat exposure.

Request you initiate action to ensure a thorough review of the curricula at all aviation training facilities to ensure that classroom material and aircrew trainer simulators are equipped with adequate materials and programs to accomplish the above objectives.

It should be noted that the review identified the attack/strike mission as the highest immediate priority to receive attention in this area. At a later date, other mission disciplines and warfare areas will also require emphasis in this area. Prior to publication of the panel's final report, the findings of this NRAC review can be made available in the form of a briefing. Both Navy and Marine Corps programs should be closely coordinated.

Kichand I Kumpf RICHARD L. RUMPF

Copy to: OPNAV (OP-09, 05, 03, 009, 01) HQMC DC/S(R,D&S) CNR



APPENDIX E PRIORITY INTELLIGENCE COLLECTION REQUIREMENTS AGAINST LASER THREAT (U)

SECTION II
BRIEFING CHARTS

UNCLASSIFIED TERMS OF REFERENCE FOR LASER EYE PROTECTION

- BACKGROUND
- PROBLEM
- TASKS
 - REVIEW CURRENT R&D LASER EYE PROTECTION PROGRAMS
 - VALIDATE CURRENT AND PROJECTED THREAT.
 - REVIEW REQUIREMENTS FOR COCKPIT COMPATIBILITY, NIGHT VISION, AND MANUAL DEXTERITY
 - DETERMINE STATUS OF OPERATIONAL REQUIREMENTS TO COUNTER THE THREAT
 - IDENTIFY NAVY ORGANIZATIONAL RESPONSIBILITIES
 - ASSESS INDUSTRIAL AND ACADEMIC TECHNOLOGY BASES
- GOAL
 - DEVELOPMENT OF RECOMMENDED COURSES OF ACTION TO ACHIEVE/ACCELERATE AN AGILE (MULTI-FREQUENCY) LASER EYE PROTECTION CAPABILITY UNCLASSIFIED

FIGURE 1.

TERMS OF REFERENCE FOR LASER EYE PROTECTION (U)

BACKGROUND (U)

(U) Thousands of lasers are currently deployed for various purposes (e.g., rangefinding and target designation) and could be used against personnel to cause either temporary or permanent eye damage. Of particular concern is the fact that future laser devices could operate anywhere in the visible, near infrared and far infrared bands. The present Navy/Marine Corps program to provide laser eye protection consists of three elements: two directed at discrete wavelength protection and the third, longer term effort under development, against the entire agile laser band.

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- 4. (U) Determine status of OR to counter the threat.
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- 6. Assess industrial and academic technology bases.

GOAL (U)

(U) To develop recommended courses of action to achieve/accelerate an agile (multi-frequency) laser eye protection capability.

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PANEL MEMBERSHIP

* DR. GEORGE S. SEBESTYEN - PANEL CHAIRMAN PRESIDENT DEFENSE SYSTEMS, INC. MR. LARRY BLAIR LOS ALAMOS NATIONAL LABORATORIES VADM E. A. BURKHALTER, USN (RET) PRESIDENT, BURKHALTER ASSOCIATES DR. JAY ENOCH UNIVERSITY OF CALIFORNIA, BERKELEY DR. MICHAEL FELD MASSACHUSETTS INSTITUTE OF TECHNOLOGY MR. HARVEY S. FROMER GRUMMAN AIRCRAFT SYSTEMS DIVISION DR. URSULA J. GIBSON UNIVERSITY OF ARIZONA MR. WILLIAM R. GRAVER ANALYTIC DECISIONS INC. DR. HERSHEL W. LEIBOWITZ PENNSYLVANIA STATE UNIVERSITY DR. ALEXANDER L. SLAFKOSKY PRIVATE CONSULTANT (FORMER CHIEF SCIENTIST USMC) CDR E. D. POPE - PANEL EXECUTIVE SECRETARY OFFICE OF ASSISTANT SECRETARY OF THE NAVY (R,E&S)

FIGURE 2.

UNCLASSIFIED

PANEL MEMBERSHIP (U)

POTENTI	AL LASER	THREAT TO THE PROBABILITY OF	NAVAL AVIATOR/MA	RINE PILOT
AVIATORS MISSION	AIRCRAFT	ENCOUNTERING THREAT	IMPACT ON MISSION DAY HIGHT	PRIORITY FOR LASER EYE PRO
ATTACK (AIR- TO-GROUND)	A-6 A-7 AV-8 A-18	нен	MED HIGH	1.
FIGHTER (AIR- TO-AIR)	F-14 F-18	LOW	FOM FOM	3
AEW	E-3	LOW	LOW LOW	4
JAMMING	CA-88	LOW	TOM TOM	4
ASW	S-3 P-3 H-2 SV-2: H-3 SH-6		HED HIGH	2
INTELLIGENCE	EA-38 EP-31 ES-3	LOW	FOM FOM	4
HELICOPTER (CAOUND SUPPORT FOR MARINES)	CH-46 MY-2 CH-53 GY-1 UH-1 HH-6 AH-1H	•	нісн нісн	1*
COOMOO	C-2 CH- C-130 etc.	7 Y	FOM FOM	4
WHILE THESE TY DIFFERENCES SHO			EST PRIORITY, THE INHE	RENT MISSION .

FIGURE 3.

POTENTIAL LASER THREAT TO THE NAVAL AVIATOR/MARINE PILOT (U)

UNCLASSIFIED
REPRESENTATIVE POTENTIAL THREAT - FRIENDLY AND HOSTILE LASERS

					PULSED			NO, OF	HEWLY DE	PLOYED I	HOBILE P	LATFORM
TIPE OF LUSER	WAVELEVAN (mm)	POWER (W)	Defect (J)	PUL3 원 배경해 (보호)	REWON (W)	#67 #ATE (008)	AVQ	1917	1949	1991	1983	1493
ದ್ಯಾ	14.4*				1						L	
Ce	4.2*								1	1	1	
·	1.4*				1		ł					1
100	2.7*				1						Į.	1
E)QMEE	1.3*		l i					g				
11017AB	1.1		1.4210 ⁴	10	1.4214		2-1021d			18	76	40
AUDZAMONITE	8.81-8.71 [TUMABLE]	_	10-100	400	1-2X10	100	5-20X10	10	20	86	100	300
RUST	.40		1-14210	140	1-10210	•	1-10X10		10	40	100	184
ant I	0,8-0,48	4-100	100-1000	24	0-10Z10	64	2.4-0210		20	40	100	184
10:7AQ(2MQ)	0.88	1-10E10	4-2.0213		1-4.0Z10		2-10216				l	
-	0,44	-10210							14		110	100
CO ATLON	0.39-8,81		1-10	3.06	2-102107	0-10 E 10 ¹	5-40Z10		ĺ			1
A 104	0,40	1-4210		_	L		L 1	10	40	380	150	
	0.30*						Γ					
DOWER	8,28-0,19*											1
".]	9.34*		1 1								1	1

⁻ ADEQUATE PROTECTION PROVIDED BY COCKPIT CAMOPY AND/OR PROT VEXOMODISALES. § COMMERCIAL AVAILABILITY SIGNAFICANTLY MORE VARIED

ROTE PERFORMANCE PROJECTED TO 1912 TIME FRAME ON PRESENT STATE-OR-THE-ARE.

UNCLASSIFIED

FIGURE 4.

REPRESENTATIVE POTENTIAL THREAT - FRIENDLY AND HOSTILE LASERS (U)

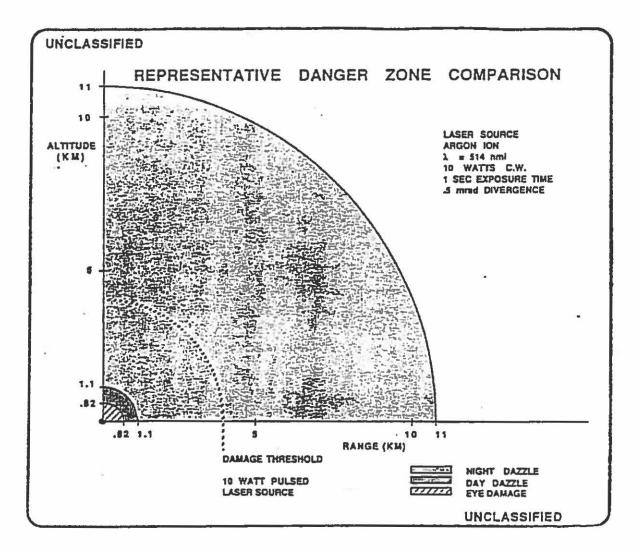


FIGURE 5.

REPRESENTATIVE DANGER ZONE COMPARISON (U)

- O (U) Dazzle is the loss of visual function caused by excessive light in the eye. The light profile is characterized by both temporal and spatial nonuniformity of illumination.
- O (U) The most significant near term threat to the successful completion of a naval aviator's mission is laser-induced night dazzle.
- o (U) Day dazzle and eye damage can become a more significant threat at higher power levels and for pulsed laser sources.

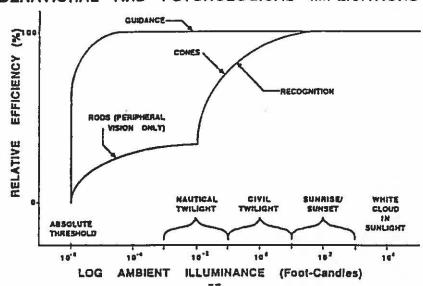
3. 244	OCULAR DAM	AGE AND/OR	FUNCTIONAL VISU		
COMBITTION	CORNEA AND	RETINAL	PEMPHERAL BUI	CENTRAL PETINA	DATTLE & EFFECT ON
ACCIDENTAL E2PO3URE (RANGING,+14.)	YEL IF SHORT OR LONG WAVE.		MOST PROBABLE	LESS LIKELY FOR PILOT	PERHAPS
PURPOSEFUL EXPOSURE (ANTI- PERSONNEL)	LESS LIKELY THAN RETINAL	GRAÇAH RELAJ	HERE, FIRST PULSE IS TO GAIN ATTEN- TION - MAY NOT BURN, SECONO PULSE IS DIRECTED AY CENTER	BESIGNED OFTEN FOR THIS LESSON	YES, A CHEAR SUMPLE OFTION
DAT			LESS DISTRACTING. MAY STILL BE ABLE TO PUNCTION	MUST NOT REDIRECT EYE TO LOOK AT SOURCE	SOMEWHAT DISTURBING
Induct			MORE DISTRACTING. MAY STILL BE ABLE TO PUNCTION	MUST NOT REDWICT EYE TO LOOK AT SOURCE	PARTICULARLY DIS- GRIENTING, EAST CAUSE MARRITY TO PUNCTION
BAKO	UV YES VISIBLE HEAR IN PAR IR YES	VES	YES	Y63 16	SOME FLUORESCENCE
Q-EWITCHED		PARTICULAR HAZARD	MOST PROBABLE SITE		
PVLSED			MOST PROBABLE	LOW PAGGABILITY FREST EXPOSURE, POSSIBLE AFTER GABANG ATTENTION	SMPLE PULSE HAS LITTLE ADAPTIVE SPECT, DAY DISTUR BY DISTRACTING
CM			LARGER BURN AREA THAN REWHAL IMAGE SCE. PROGABLE PRIST INTERCEPT	POSSULE AFTER GLENNIG ATTENTION	PARTICULARLY BISTRACTING
TIME POR RESPONSES	OFTEN HOT AWARE OF EXPOSURE, PAINFUL	(MCDS4CD=00)	(PICOSECONDS)	IF NOT MOTELL SITE, ABOUT 300 MILLISCOMOS FOR ASSPONSE	THE IS AVAILABLE FOR AVERSION OR RESPONSE

FIGURE 6.

OCULAR DAMAGE AND/OR FUNCTIONAL VISUAL IMPAIRMENT (U)



BEHAVIORAL AND PSYCHOLOGICAL IMPLICATIONS



SCHEMATIC RELUSTRATION OF THE RELATIONSHIP BETWEEN VISUAL EFFICIENCY AND LUMINANCE FOR RECOGNITION AND FOR CUIDANCE VISION, NOTE THAT WHILE THE EFFICIENCY OF RECOGNITION TASKS (SUCH AS READING OR TARGET EDENTIFICATION) ARE SYSTEMATICALLY RELATED TO LUMINANCE, VISUALLY GUIDED BEHAVIORS ARE ESSENTIALLY INDEPENDENT OF LUMINANCE (AS WELL AS IMAGE BLUR) OVER THE FUNCTIONAL RANGE OF THE VISUAL SYSTEM, THEREFORE, LOW TRANSMITTANCE LASER EYE PROTECTION AT DUSKNIGHT WILL:

- DEGRADE/ELIMINATE ALL VISUAL RECOGNITION AND DETECTION OUTSIDE OF COCKPIT (20% RELATIVE EFFICIENCY)
- -REDUCE DISPLAY LUMINANCE AND CONTRAST/COLOR CONTRAST BELOW DESIGN SPECIFICATIONS TO THE POINT WHERE RESOLUTION OF IMAGERY IS PREVENTED.

UNCLASSIFIED

FIGURE 7.

BEHAVIORAL AND PSYCHOLOGICAL IMPLICATIONS (U)

PERFORMANCE OF HUMAN-MACHINE SYSTEMS IS OFTEN LIMITED BY BEHAVIORAL

FACTORS (U)

- o (U) Glare can substantially degrade, possibly prevent, visual performance.
 - (U) Short term glare can have the same impact on mission success as permanent eye damage.
- o (U) Glare will differentially affect visual performance as a function of:

- (U) Type of task (recognition/detection versus orientation/visual guidance)
- (U) Ambient illumination (day vs. dusk vs. night)
- (U) Intensity and wavelength (short vs. long wavelength).
- O (U) Psychophysiological effects can <u>only</u> be reduced/ eliminated through adequate eye protection which maintains necessary image quality.
 - (U) High transmittance (photopic, mesopic, and scotopic)
 - (U) Sufficient optical density to eliminate glare
 - (U) No further restrictions to field of view
 - (U) Continuing normal cockpit functions.
- o (U) Psychological effects of glare can be reduced through:
 - (U) Training (e.g., safe exposures)
 - (U) Development of coping strategies/countermeasures (will also be effective in preventing retinal burns).
- (U) Behavioral research on the effects of coherent light is necessary to provide guidelines for engineering decisions for the development and implementation of laser eye protection.

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THREAT SUMMARY

- . THERE IS AN EXISTING AND INCREASING LASER THREAT TO THE NAVAL AVIATOR
- SOME OF IT IS FROM FRIENDLY SYSTEMS (DESIGNATORS, RANGEFINDERS, ETC.)
- . THE GREATEST NEAR TERM THREAT IS DAZZLE/FLASH BLINDNESS
- . THE THREAT NOW IS AT A FEW DISCRETE WAVELENGTHS
- IT WILL INCLUDE FREQUENCY AGILE LASERS IN THE FUTURE
- WHETHER INTENDED OR NOT, SOVIET LASER SYSTEMS CAN BE USED AS ANTI-PERSONNEL WEAPONS

PRESENT

- LOW POWER SYSTEMS MOSTLY FOR RANGEFINDING/TARGET DESIGNATION
- SOVIET SYSTEMS TYPICALLY MORE POWERFUL THAN WESTERN EQUIVALENTS
- THREAT FROM OWN SYSTEMS SHOULD BE FACTORED

FUTURE

- WIDE SPREAD LASER WEAPON SYSTEMS DEPLOYMENT LIKELY WITHIN NEXT DECADE WITHIN SOVIET/WARSAW PACT FORCES/THIRD WORLD
- INCREASED POWER LEVELS PROBABLE
- TUNEABLE LASER SYSTEMS LIKELY, L'ENDING SOVIET WARTIME RESERVE MODE (WARM) POTENTIAL
 - MAY BE CONSIDERED ESSENTIAL AS COUNTER TO LASER-GUIDED WEAPONS SYSTEM
 - ANTI-PERSONNEL USE OFFERS NEAR "UNLIMITED" FIREPOWER
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- - UNCLASSIFIED

FIGURE 8.

THREAT SUMMARY (U)

	ROTECTION REQUIREM	MENTS		
	AIR FORCE DRAFT STATEMENT OF OPERATIONAL HEED (SON) AF-3XX-86 FOR AIR CREW OCULAR LASER PROTECTION	ARHY ASARC REQUIREMENTS FOR LASER EYE PROTECTION		
(EXPLORE LEP OPTIONS OF COMBINATIONS FOR RISK REDUCTIONS, COST SAVINGS, TECHNOLOGICAL ACHIEVEMENT OR RAPID DEPLOYMENT.)	SAME AS HAVYS.			
EVENTUALLY IN ACHIEVING A FREQUENCY		TRIPLE HOYCH FILTERS APPROACH TO MEET FUTURE THREAT.		
MISSION AND AVOIDANCE OF TEMPORARY OR PERMANENT EYE INJURY TO NAVAL AIR	PROVIDE AIR CREW PROTECTION TO PRECLUDE TEMPORARY OR PERMANENT LOSS OF VISION WHEN EXPOSED TO LASER EMERGY TO EMBLE TAFS TO PERFORM CLOSE AIR SUPPORT AND BATTLEFIELD INTERDICTION.	PROVIDE EYE PROTECTION TO PILOTS AND GROUNE TROOPS IN MISSION PERFORMANCE.		
	SAME AS HAVY'S.	·		
COMPATIBLE WITH EXISTING REQUIRED PERSONNEL-EQUIPMENT	THAT INTEGRATES WITH CURRENT; PROPOSED AIR CREW HELMETS, OXYGEN MASKS AND CW DEFENSE	VISOR COMPATIBLE WITH CW DEFENSE		
	HAVY OR M99-0587, LASER EYE PROTECTION FOR HAVY/MARINE CORPS AVIATORS (EXPLORE LEP OPTIONS OF COMBINATIONS FOR RISK REDUCTIONS, COST SAVINGS, TECHNOLOGICAL ACHIEVEMENT OR RAPID DEPLOYMENT.) ALTHOUGH LEP PROGRAMS INDICATE MAYY RITEREST IN 4 1 AND EVENTUALLY IN ACHIEVING A FREQUENCY AGILE CAPABILITY AGAINST MULTIPLE FREQUENCIES, THE OR DOES NOT MENTION THESE CAPABILITIES REQUIREMENTS. EYE PROTECTION AGAINST LASER THREATS FOR COMPLETION OF MISSION AND AVOIDANCE OF TEMPORARY OR PERMANENT EYE INJURY TO NAVAL AIR CREWS. LIGHTWEIGHT (NO SPECIFICS AS TO UPPER LIMITS.) SPECTACLES, GOGGLES OR VISORS COMPATIBLE WITH EXISTING	R CREW LASER EYE PROTECTION REQUIRENT HAVY OR 1039-0537, LASER EYE PROTECTION FOR HAVY/MARINE CORPS AVIATORS (EXPLORE LEP OPTIONS OF COMBINATIONS FOR RISK REDUCTIONS, COST SAVINGS, TECHNOLOGICAL ACHIEVEMENT OR RAPID DEPLOYMENT.) ALTHOUGH LEP PROGRAMS INDICATE MAVY RITEREST IN 4 \(\) AND EVENTUALLY IN ACHIEVING A FREQUENCY ACHIEVEMENTS. EYE PROTECTION AGAINST MULTIPLE FREQUENCIES, THE OR DOES NOT MENTION THESE CAPABILITIES REQUIREMENTS. EYE PROTECTION AGAINST LASER THREATS FOR COMPLETION OF MISSION AND AVOIDANCE OF PERMANENT LOSS OF VISION TEMPORARY OR PERMANENT EYE INJURY TO HAVAL AIR CREWS. EYE INJURY TO HAVAL AIR CREWS. EYEROR CLOSE AIR CREW PROTECTION TO PRECLUDE TEMPORARY OR PERMANENT LOSS OF VISION WHEN EXPOSED TO LASER EMERGY TO EMBRIL TAPS TO PERFORM CLOSE AIR SUPPORT AND BATTLEFIELD INTERDICTION. LIGHTWEIGHT (NO SPECIFICS AS TO UPPER LIMITS.) EYELONG TO MAYOUR AIR CREWS. FROM AND AVOIDANCE OF PERMANENT LOSS OF VISION WHEN EXPOSED TO LASER EMERGY TO EMBRIL TAPS TO PERFORM CLOSE AIR SUPPORT AND BATTLEFIELD INTERDICTION. HELMET-MOUNTED VISIOR LENS THAT INTEGRATES WITH CURRENT; PROPOSED AIR CREW HELMETS,		

FIGURE 9.

AIR CREW LASER EYE PROTECTION REQUIREMENTS (U)

NCLASSIFIED A) A CREW LASER EYE PROTEC	TION REQUIREMENTS (CONT.)		
CAPABILITIES/ CHARACTERISTICS	MAYY OR 1000-0507, LASER EYE PROTECTION FOR MAYMARINE CORPS AVIATORS	AIR FORCE DRAFT STATEMENT OF OPERATIONAL NEED (SOM) AF-31X-00 FTR AIR CREW OCULAR LASER PROTECTION	ARMY ASARC REQUREMENT FOR LASER EYE PROTECTION	
e, operational, implications	ERABLE/ALLOW MORMAL OPERATION BOTH DAT AND NIGHT. IF MEAD OR MELMET-LOUNTED, MUST MOT RESTRICT WEAREN'S MOVEMENT/ABILITY TO FUNCTION IN MIS OPERATIONAL ENVIRONMENT.	ALLOW UMBESTRICTED VISION FOR NORMAL OPERATIONS, NO CISTORTION, IMPAIRING OF VISUAL ACTIVITY OR DEGRADING THE FIDELITY OF COCKPIT DISPLAYS, MUST NOT IMPOSE EXTENSIVE AIC MODS, NO UNIQUE TRAINING OR MAINTENANCE REQUIREMENTS RESULTING FROM SYSTEM, COMPATIBLE WITH BOTH DAY AND MIGHT OPERATIONS.	EHABLE HORMAL OPERATION WITH- OUT UNDUE RESTRICTION OF MOVEMENT OR ABILITY TO FUNCTION IN MISSION ROLE	
e offical Deserty (DD)	EMOTH FOR ALL INCIDENCE ANGLES THAT COULD CAUSE FYE DAMAGE	TVAN EA SMAE	-2 (7)	
TANCE	ME'S FOR BOTH BAY AND MIGHT.	NOT MENTIONED.	1	
& DURABILITY	MPACT, PENETRATION AND ABRASION RESISTANCES AS SPECIFIED IN ML-Y-222720(AS).	SAME AS HAVY.	7	
OVALITY	AS EPECIFIED IN MIL-V-20272D(AS).	SAME AS HAVY.	7	
IS FONGEALLA	FIVE (5) TEARS SERVICE LIFE WITH SOME MEANS TO IDENTIFY DEGRADA- TION OR FAILURE.	INDEFINITE SHELF LIFE WITH A SERVICE LIFE EQUAL TO EXISTING PROTECTIVE LENGES.	7	
11. COSTS		MO COSTS OR PRODUCTION QUANTITIES WERE IDENTIFIED IN THE AF SON, BUT A VICE CHIEF OF STAFF MESSAGE OF 1994, 1996 DIRECTED THE PROCUREMENT OF APPROXIMATELY 18,000 UMTS WITH TA AND 'M FUNCS OF 3) YISON.		

FIGURE 10.

AIR CREW LASER EYE PROTECTION REQUIREMENTS (CONT'D) (U)

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LIMITATIONS OF THE CURRENT NAVY OR

- ONLY REQUIRES EYE PROTECTION (VISORS) TO AVOID EYE INJURY AND TO COMPLETE MISSION.
- · LIMITS THE SOLUTION TO VISORS/GOGGLES.
- DOES NOT ADDRESS STARTLE, FLASH BLINDNESS, DAZZLE/GLARE WHICH MAY NOT CAUSE EYE DAMAGE, BUT COULD PRECLUDE MISSION COMPLETION, AND CAUSE LOSS OF AIRCRAFT.
- DOES NOT ADDRESS FUTURE AGILE FREQUENCY LASER THREAT.
- DOES NOT ADDRESS THE HIGH POWER CAPABILITIES OF SOVIET SYSTEMS WHICH COULD BE EMPLOYED AS ANTI-PERSONNEL WEAPONS.
- SHOULD BE MORE SPECIFIC ABOUT THE EYE EFFECTS THE NAVY WANTS TO PROTECT THE PILOTS/CREWS AGAINST THE MOST, AND WHICH MISSIONS HAVE THE HIGHEST PRIORITIES.
- DOES NOT PROVIDE THE OPTION OF A SYSTEMIC-ORIENTED SOLUTION (PLATFORM), OR ALTERNATIVE COMPLEMENTARY SOLUTIONS TO VISORS.
- DOES NOT PROVIDE FOR VISION SYSTEM PROTECTION OTHER THAN PILOTS' EYES.

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FIGURE 11.

LIMITATIONS OF THE CURRENT NAVY OR (U)

UNCLASS	IFIED				
	EXISTIN	IG LASER	EYE	PROTECTION	PROGRAMS
SERVICE	IOC TIME FRAME	TYPE OF FUNDING	WAVE-	DESCRIPTION OF DEVICE	PURPOSE
NÁVY .	AVAILABLE	PRODUCTION STOCK FUNDS	1,	EEK-3 VISOR EDU-1P GLASSES	PROTECTION AGAINST OUR OWN & ENEMY RANGE FINDERS/DESIGNATORS
NAVY	LATE SO's	6.4	3 % ***	7	RESOLVE THREAT PROTECTION HOLE BETWEEN WHAT'S AVAILABLE & WHAT'S BEING DEVELOPED
MAYY	EARLY 90's	6.3	4 \ \ 'o	7	MEET MID-TERM THREAT PROJECTION
NAVY	LATE BO's	6,2 ,	AGILE	7	MEET THE TOTAL LONG TERM THREAT
AIR FORCE	LATE 80's	PRODUCTION STOCK FUNDS	37,00	VISOR	PROVIDE EARLIEST PROTECTION AGAINST EXISTING THREAT PLUS OUR OWN SYSTEMS
		•			PROB.)
ARMY *	LATE BO's	PRODUCTION STOCK FUNDS	2 l 's	EYEGLASSES	PROTECTION FOR GROUND TROOPS & HELO PILOTS
ARMY	EARLY 90's	6.2	7	TRIPLE NOTCH FILTER	LONG TERM THREAT

FIGURE 12. EXISTING LASER EYE PROTECTION PROGRAMS (U)

UNCLASS		EYE PROTE	CTION PROG	RAMS	
SERVICE	λ·3	LATE 80's	EARLY 90	D's (LATE 90°s
HAVY	λ,	∇	_	29	
	3 γ,= +	unununun.	<i>'''''</i>		
	λ, / λ, / λ, / λ,	***			7
	AGILE				
ARATY	λ ₂ / λ ₂	***************************************	***** ^V		-
	TRIPLE HOTCH				
AIR FORCE	$\lambda_1 / \lambda_2 / \lambda_3$	*********	٠		
			-~	FY 87 FUN	DING PRODUCTION
				111111111	5.4
1	● 0 g		A BEO'ECTED 100	Company of the last	6.3
	•	9	UNCLASSIFIE	D 311111111	6.2

FIGURE 13.

LASER EYE PROTECTION PROGRAMS (U)

UNCLASSI		EYE	PROTECT	ION	PROGRA	MS (CONT.)		
SERVICE	TIME F		λ_{i}	λ	λ		λ	AGILE	
ARMY				***	**********	4.			
NAVY	LATE	80s				/////////////////////////////////////	+		
AF			******	******	**********	8			
ARMY]									
HAVY	EARL	Y 90s	K.E.C.	Sec.	SELT S.543	E Street			
AF									
NAVY									,
AF }	LATE	903			FY 87	FUNDI	NG		
ARMY					000000000		DUCTION		
	ı				munn.	6.3			
					minn				
			-			y.4	UNCLA	SSIFIED	

FIGURE 14.

LASER EYE PROTECTION PROGRAMS (CONT'D) (U)

UNCLASSI NA'	FIED VY R&D BUDGET	PROFILE	FOR PERSONNEL	LASER	EYE PROTEC	TION
FUNDING	FISCAL YEAR	'87	'88	*89	*90	'91
5.2		\$400K	\$400K	\$400K	\$400K	\$400K
6.3		\$500K	\$397K	\$ 934K	52.39M	\$2,306M
6.4		\$151K	\$900K	\$800K	\$1M	\$114
	6.2 BUDGET INCLUDE THE TOTAL BUDGET ALL FIGURES ARE S	AVAILABLE	FOR RESEARCH TO	DEAL WITH	THE AGILE THE	

FIGURE 15.

NAVY R&D BUDGET PROFILE FOR PERSONNEL LASER EYE PROTECTION

UNCLASSIFIED COOPE		WED AT THE AGILE THRE	EAT
FUNDING SOURCE	FY87	FY88	FY89
ARMY	\$500K	\$675K	\$700K
NAVY	\$400K	\$400K	\$400K
AIR FORCE	\$200K	\$100K	\$200K
MARINES	\$200K	\$200K	\$200K
DARPA	\$ 0	\$400K	\$500K
•		. UNCL	ASSIFIED

FIGURE 16.

COOPERATIVE EFFORTS AIMED AT THE AGILE THREAT (U)

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TECHNOLOGY OVERVIEW

- .THREAT DICTATES NEED FOR MULTIPLE APPROACHES
- *DIFFERENT TECHNOLOGIES SHOULD BE COMBINED TO PROTECT AGAINST DIVERSE WAVELENGTHS AND TRUE AGILE THREATS
- PASSIVE (SELF-ACTUATING) AND ACTIVE (DETECT AND REACT) SCHEMES MAY BOTH BE USEFUL
- REMOTE VIEWING (TV OR HMD) PROVIDES ULTIMATE PROTECTION IN HEAVY LASER EXPOSURE ENVIRONMENT
- · LASER WARNING SYSTEMS WILL BE IMPORTANT, IF NOT ESSENTIAL
- *DEVELOPMENT OF PROCEDURES/AUTOMATIC SYSTEMS FOR DAZZLE ARE NECESSARY

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FIGURE 17.

TECHNOLOGY OVERVIEW (U)

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PRESENT TECHNICAL APPROACHES

VISORS/EYEGLASSES

- ABSORBING DYES
 - + LARGE ANGULAR EFFECTIVENESS
 - WIDE BANDS REDUCE OVERALL TRANSMISSION
 - NIGHT VISION INTERFERENCE
- · HOLOGRAMS
 - + NARROWBAND REJECTION
 - ANGULAR ACCEPTANCE PROBLEM IN VISORS (CAN MAKE CONTACT LENSES, ESPECIALLY FOR HELO PILOTS)
- . ALL
 - + SIMPLE RETROFIT, PILOT ACCEPTANCE
 - OD NOT HIGH ENOUGH IF PURPOSEFUL USE OF EVEN EXISTING RANGEFINDERS

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FIGURE 18.

PRESENT TECHNICAL APPROACHES (U)

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POSSIBLE FUTURE APPROACHES

BETTER EYE GLASSES

AGILE FILTER HIGHER OD OPTICAL LIMITERS
MATERIALS (MOSTLY ORGANICS AT THE MOMENT): POLYMERS - NONLINEAR

LIQUID XTAL **PHOTOCHROMICS**

OPTICAL SWITCHES?

SYSTEM/PLATFORM LEVEL SOLUTIONS (MULTIPLE SYSTEM SOLUTION) UV AND IR FILTERING AT CANOPY

LOW CONCENTRATIONS OF VIS. DYES MAY REDUCE CANOPY GLARE DAZZLE PROTECTION: DETECT AND REACT TO SPECIFIC WAVELENGTHS HIGH ENERGY PULSES

FOCAL PLANE PASSIVE (LIMITERS OR SWITCHES) FOR GUNNERS REP RATE DETECTORS AND THIDE AND PEEKT MODE REMOVE DIRECT VIEWING - HND AND TV CAMERAS

MATERIALS RESEARCH:

NON-LINEAR (X $^{\{3\}}$) MATERIALS (PHASE CONJUGATE MIRRORS, LIMITERS) FAST PHOTO CHROMICS

SEMICONDUCTOR AND PLASMA SWITCHES

ABLATIVE, FRUSTRATED TOTAL INTERNAL REFLECTION OR PHASE CHANGE SACRIFICIAL MIRRORS LASER WARNING DEVICES

LASER SIGNATURES

COHERENCE/DIRECTIONALITY . REDUCED AFTER ATMOSPHERIC TRAVEL

HIGH INTENSITY

BRIGHT REL TO BACKGROUND - ALLOWS FALSE SIGNALS MONOCHROME SPIKE - NEED SPECTRUM ANALYZERS

PULSE SOURCE USUALLY FIXED REP HATE SMALL ON : OFF RATIO

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FIGURE 19.

POSSIBLE FUTURE APPROACHES (U)

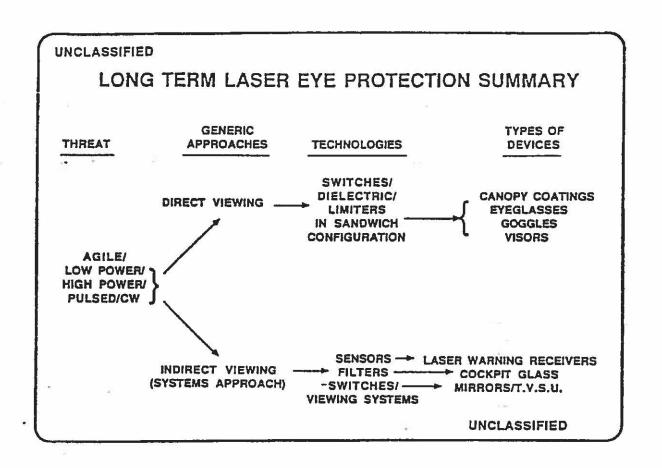


FIGURE 20.

LONG TERM LASER EYE PROTECTION SUMMARY (U)

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NAVY ORGANIZATIONAL RESPONSIBILITIES

- TRI-SERVICE LASER EYE PROTECTION R&D ACTIVITIES ARE FULLY INTEGRATED & PROPERLY ORGANIZED.
- THE CURRENT NAVY ORGANIZATION IS TUNED TO THE PRESENT TECHNICAL APPROACHES FOR THE EYE PROTECTION PROBLEM (E.G., GLASSES, VISORS).
- FUTURE TECHNICAL APPROACHES TO COUNTERING THE AGILE THREATS (E.G., THE SYSTEMS APPROACH) WILL REQUIRE A NEW MULTI-DISCIPLINE ORGANIZATIONAL APPROACH TO SUCCESSFULLY MANAGE THE PLATFORM SOLUTIONS THAT WILL BE REQUIRED.

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FIGURE 21.

NAVY ORGANIZATIONAL RESPONSIBILITIES (U)

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RECOMMENDATIONS

REQUIREMENTS

- MODIFY THE OR TO INCLUDE:
 - PROTECTION AGAINST AGILE THREAT
 - SYSTEM & PLATFORM SOLUTIONS (INCLUDING LASER WARNING RECEIVERS AS PART OF PLATFORM DEFENSIVE SUITS)
 - HIGHER OD FILTERS AND OTHER APPROACHES SOONER (HIGHER POWER LASERS MIGHT BE USED AS ANTI-PERSONNEL DEVICES)
 - RESEARCH ON THE "DAZZLE" THREAT
 - OTHER TECHNIQUES

EDUCATION & TRAINING

- · EFFECTIVE EDUCATION PROGRAMS ARE NEEDED TO:
 - MAKE AVIATORS AWARE OF THE LASER THREAT
 - ENABLE THEM TO MAKE VALID ASSESSMENTS OF OBSERVED ENEMY LASER SYSTEMS
 - TRAIN THEM TO TAKE APPROPRIATE EVASIVE/AVOIDANCE MEASURES IN THE EVENT OF LASER THREAT EXPOSURE
- ·INCORPORATE "DAZZLE" AND LASER THREAT SIMULATIONS INTO AIR CREW TRAINERS

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FIGURE 22.

RECOMMENDATIONS (U)

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RECOMMENDATIONS

INTELLIGENCE

- DEVELOP AND FIELD DEVICES FOR COLLECTING TECHNICAL INTELLIGENCE ON THE LASER THREAT TO:
 - DETECT LASER ILLUMINATION
 - DETERMINE WAVELENGTHS
 - DETERMINE INTENSITIES
 - RECONSTRUCT THE GEOMETRY
 - DETERMINE THE WAVEFORM/PULSE LENGTH/PRF/ETC.
- TASK HUMINT AND OTHER SYSTEMS FOR INFORMATION TO DETERMINE WHAT PROTECTIVE DEVICES AND MEASURES THE SOVIETS ARE USING NOW (OR PLAN TO USE IN THE FUTURE) AGAINST THE LASER THREAT (AND AGAINST THEIR OWN DEVICES).
- · HUMINT IS NEEDED RELATIVE TO SOVIETS INTENTIONS REGARDING USING LASERS AS ANTI-PERSONNEL WEAPONS.

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FIGURE 23.

RECOMMENDATIONS (CONT'D) (U)