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
[redacted]

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 ONRFOIA@navy.mil. 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
Request Type : *FOIA*

Status : *Assignment Determination* **Due Date :** *N/A*
0 (Never Started)

Submitted — Evaluation — Assignment — Processing — Closed

Request Details

Tracking Number : DON-NAVY-2017-008371
Requester : Mr. John Greenewald
Organization : The Black Vault
Requester Has Account : Yes
Email Address : john@greenewald.com
Phone Number : 800-456-2228
Fax Number : 818-659-7688
Address : [redacted]
None
City : [redacted]
State/Province : [redacted]
Zip Code/Postal Code : [redacted]

Submitted Date : 07/11/2017
Last Assigned Date : 07/13/2017
Fee Limit : $15.00
Request Track : Simple
Due Date : N/A
Assigned To : Michael Ferrari (Office of Naval Research)
Last Assigned By : Michael Ferrari (Office of Naval Research)

Submission Details

Request Handling

Requester Info Available to the Public : No
Request Track : Simple
Fee Category :
Fee Waiver Requested: No
Fee Waiver Status: N/A
Expedited Processing Requested : No
Expedited Processing Status : N/A

Request Perfected : No
Appellate Authority : N/A
Acknowledgement Sent Date:
Unusual Circumstances ? : No
5 Day Notifications: No
Litigation : No
* Litigation Court Docket Number :

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. [redacted] FAX 1-818-659-7688

Description Available to the Public : No
Has Description Been Modified? No
0/2000

Additional Information

Case # : N/A
Name of Local Command : N/A
Contract/Sol.# : N/A
Limit Request To Clearly Releasable Info : N/A

~~SECRET~~
UNCLASSIFIED REDACTED

REPORT OF THE

NAVAL RESEARCH ADVISORY COMMITTEE PANEL

ON

LASER EYE PROTECTION

~~Classified by multiple sources.~~
~~Declassify on OADR.~~

APRIL 1988

~~SECRET~~
UNCLASSIFIED REDACTED

SECTION I

EXECUTIVE SUMMARY (U)

TABLE OF CONTENTS

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 agile threat. The panel also recommended the initiation of system level laser protection approaches which involve the use of sensors on the aircraft as part of the laser protection program. This can provide illumination sensing and analysis capability on the aircraft prior to the illumination of the crew itself. The time so gained can be used to initiate 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.

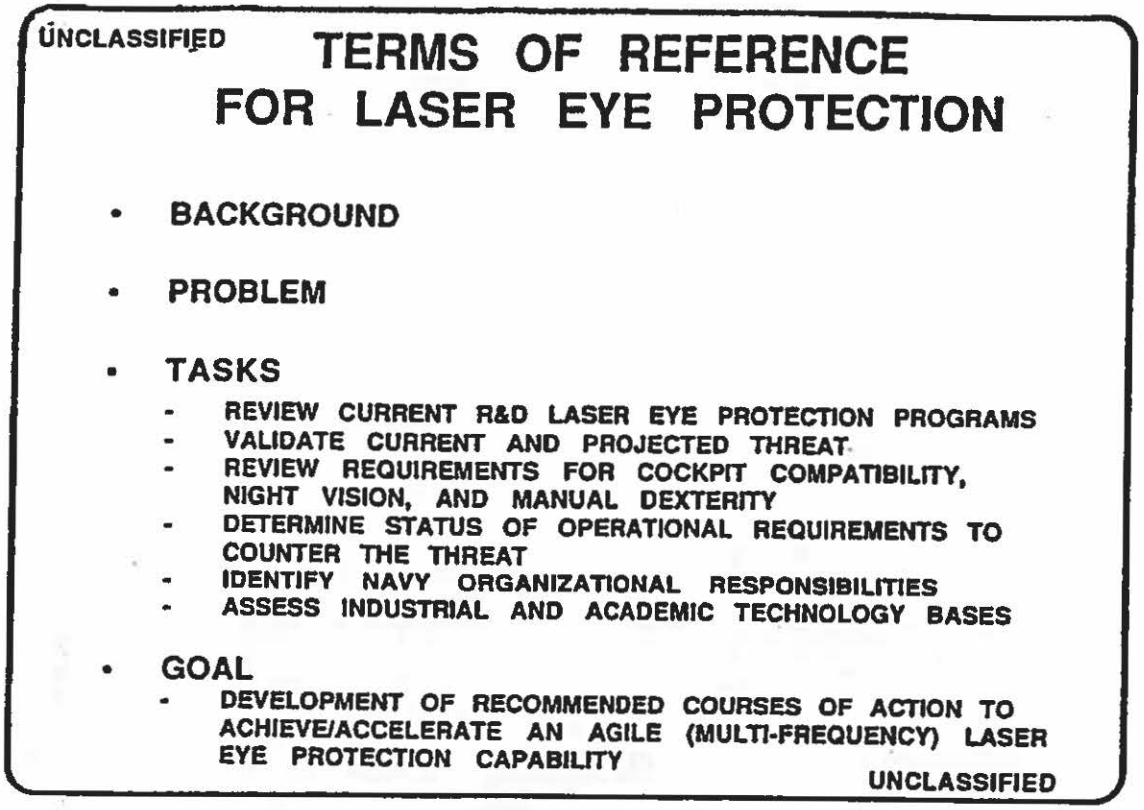

FIGURE 1.

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)

o (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.

- (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.

1. (U) Review current Navy and DOD R&D laser eye protection programs.

2. (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)

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FIGURE 2.

PANEL MEMBERSHIP (U)

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POTENTIAL LASER THREAT TO THE NAVAL AVIATOR/MARINE PILOT

AVIATORS MISSION	AIRCRAFT	PROBABILITY OF ENCOUNTERING THREAT	PROBABILITY OF IMPACT ON MISSION DAY	NIGHT	PRIORITY FOR LASER EYE PROT.
ATTACK (AIR-TO-GROUND)	A-6 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	LOW	LOW	4
JAMMING	EA-6B	LOW	LOW	LOW	4
ASW	S-3 P-3 H-2 SV-22 H-3 SH-60	MED	MED	HIGH	2
INTELLIGENCE	EA-3B EP-3E ES-3	LOW	LOW	LOW	4
HELICOPTER (GROUND SUPPORT FOR MARINES)	CH-46 MV-22A CH-53 OV-10 UH-1 HH-60 AH-1H	HIGH	HIGH	HIGH	1*
COD/VOD	C-2 CH-53 C-130 etc.	LOW	LOW	LOW	4

* WHILE THESE TWO MISSIONS DEMAND THE HIGHEST PRIORITY, THE INHERENT MISSION DIFFERENCES SHOULD BE RECOGNIZED.

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FIGURE 3.

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

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REPRESENTATIVE POTENTIAL THREAT - FRIENDLY AND HOSTILE LASERS§

TYPE OF LASER	WAVELENGTH (μm)	CW AVG POWER (W)	PULSED					NO. OF NEWLY DEPLOYED MOBILE PLATFORMS				
			ENERGY (J)	PULSE WIDTH (μs)	PEAK POWER (W)	REP RATE (PPS)	AVG POWER	1987	1989	1991	1993	1995
CO_2	10.6*											
CS	5.3*											
DF	3.8*											
HF	2.7*											
IODINE	1.3*											
ND:YAG	1.1	1.36X10^{4}	1.0X10^{4}	10	1.0X10^{9}	5	5-10X10^{4}	5	5	10	20	30
ALEXANDRITE	0.81-0.75 (TUNABLE)	—	30-100	400	1-2X10^{8}	100	5-20X10^{4}	10	20	50	100	200
RUBY	.69		1-10X10^{3}	100	1-10X10^{7}	1	5-10X10^{2}	5	10	40	100	150
DYE	0.9-0.40	20-100	500-1000	30	5-10X10^{7}	50	2.5-5X10^{4}	5	20	40	100	150
ND:YAG(SHG)	0.53	1-10X10^{2}	0.5-2.0X10^{2}	5	1-4.0X10^{6}	5	5-10X10^{2}					
ION ION	0.64	1-10X10^{2}						5	10	50	200	500
CU VAPOR	0.50-0.51		1-10	0.05	2-20X10^{7}	5-10X10^{3}	5-50X10^{2}					
AR ION	0.49	5-5X10^{2}	—	—	—	—	—	10	50	100	150	150
ND:YAG (THG)	0.35*											
EXCIMER	0.35-0.19*											
H_2	0.34*											

* ADEQUATE PROTECTION PROVIDED BY COCKPIT CANOPY AND/OR PILOT VISOR/GOGGLES.
§ COMMERCIAL AVAILABILITY SIGNIFICANTLY MORE VARIED
NOTE: PERFORMANCE PROJECTED TO 1992 TIME FRAME ON PRESENT STATE-OF-THE-ART.

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FIGURE 4.

REPRESENTATIVE POTENTIAL THREAT - FRIENDLY AND HOSTILE LASERS (U)

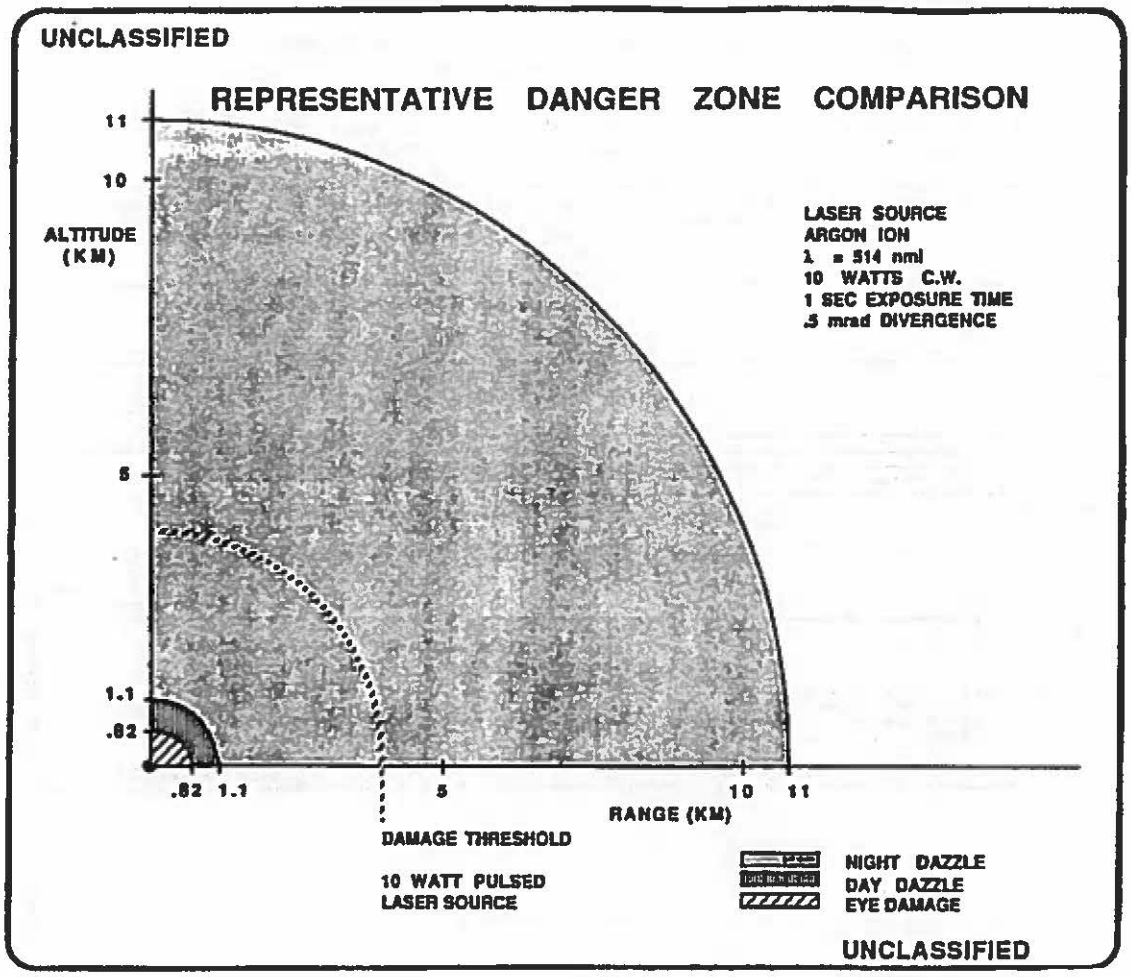

FIGURE 5.

REPRESENTATIVE DANGER ZONE COMPARISON (U)

- (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.
- (U) The most significant near term threat to the successful completion of a naval aviator's mission is laser-induced night dazzle.
- (U) Day dazzle and eye damage can become a more significant threat at higher power levels and for pulsed laser sources.

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OCULAR DAMAGE AND/OR FUNCTIONAL VISUAL IMPAIRMENT

CONDITION	CORNEA AND OCULAR MEDIA	RETINAL HEMORRHAGE	RETINAL BURN: PERIPHERAL RETINA	RETINAL BURN: CENTRAL RETINA	BAZZLE & EFFECT ON LIGHT ADAPTATION
ACCIDENTAL EXPOSURE (RANGING, etc.)	YES, IF SHORT OR LONG WAVE-LENGTH		MOST PROBABLE FOR PILOT	LESS LIKELY FOR PILOT	PERHAPS
PURPOSEFUL EXPOSURE (ANTI-PERSONNEL)	LESS LIKELY THAN RETINAL	Q-SWITCHED LASER HAZARD	HERE, FIRST PULSE IS TO GAIN ATTENTION - MAY NOT BURN. SECOND PULSE IS DIRECTED AT CENTER	DESIGNED OFTEN FOR THIS LESION	YES, A CHEAP SIMPLE OPTION
DAY			LESS DISTRACTING. MAY STILL BE ABLE TO FUNCTION	MUST NOT REDIRECT EYE TO LOOK AT SOURCE	SOMEWHAT DISTURBING
NIGHT			MORE DISTRACTING. MAY STILL BE ABLE TO FUNCTION	MUST NOT REDIRECT EYE TO LOOK AT SOURCE	PARTICULARLY DISORIENTING. CAN CAUSE INABILITY TO FUNCTION
WAVELENGTH BAND	UV YES VISIBLE	YES	YES	YES	SOME FLUORESCENCE YES
	NEAR IR		YES	YES	
	FAR IR YES				
Q-SWITCHED		PARTICULAR HAZARD	MOST PROBABLE SITE		
PULSED			MOST PROBABLE SITE	LOW PROBABILITY FIRST EXPOSURE. POSSIBLE AFTER GAINING ATTENTION	SIMPLE PULSE HAS LITTLE ADAPTIVE EFFECT. MAY DISTURB BY DISTRACTING
CW			LARGER BURN AREA THAN RETINAL IMAGE SIZE. PROBABLE FIRST INTERCEPT	POSSIBLE AFTER GAINING ATTENTION	PARTICULARLY DISTRACTING
TIME FOR RESPONSES	OFTEN NOT AWARE OF EXPOSURE. PAINFUL	VIRTUALLY NONE (PICOSECONDS)	VIRTUALLY NONE (PICOSECONDS)	IF NOT INITIAL SITE, ABOUT 200 MILLISECONDS FOR RESPONSE	TIME IS AVAILABLE FOR AVERSION OR RESPONSE

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FIGURE 6.

OCULAR DAMAGE AND/OR FUNCTIONAL VISUAL IMPAIRMENT (U)

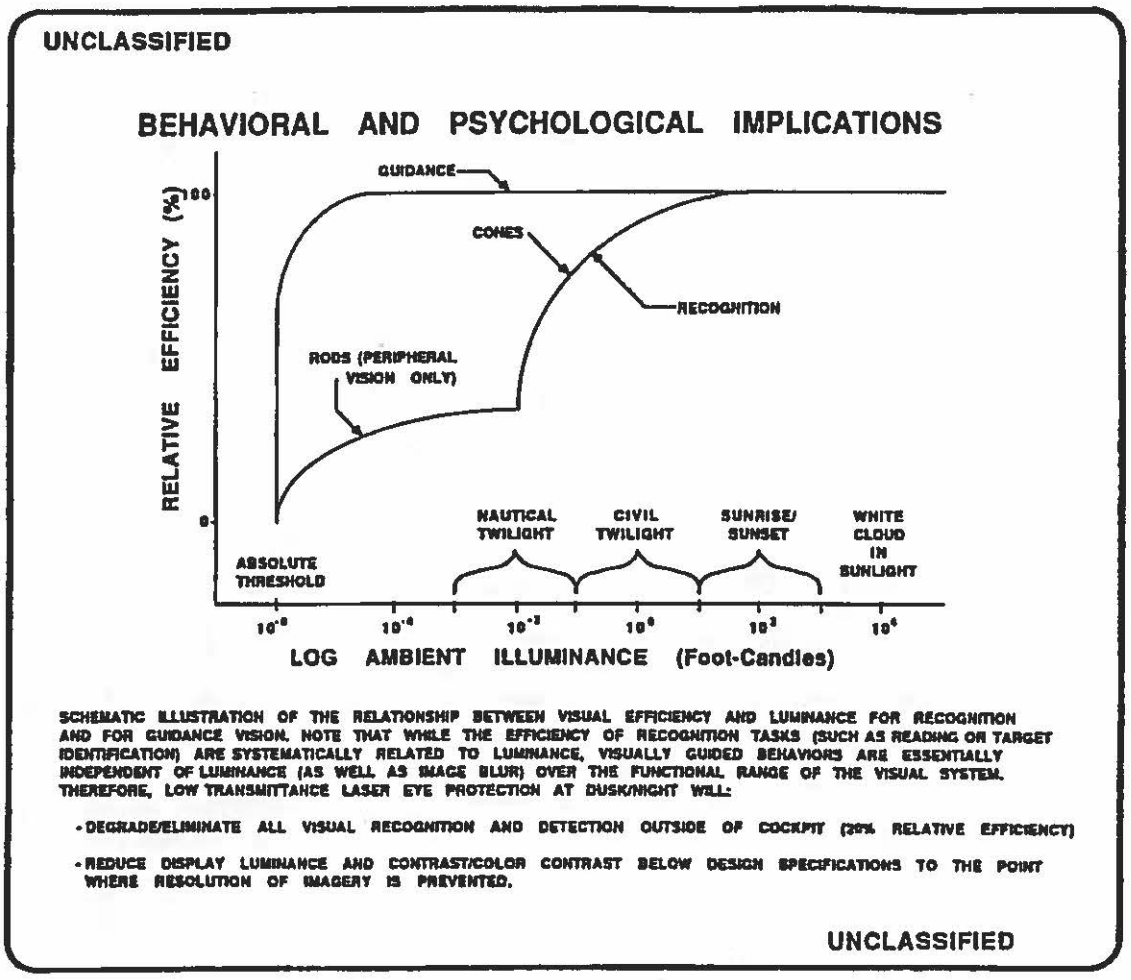

FIGURE 7.

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 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.

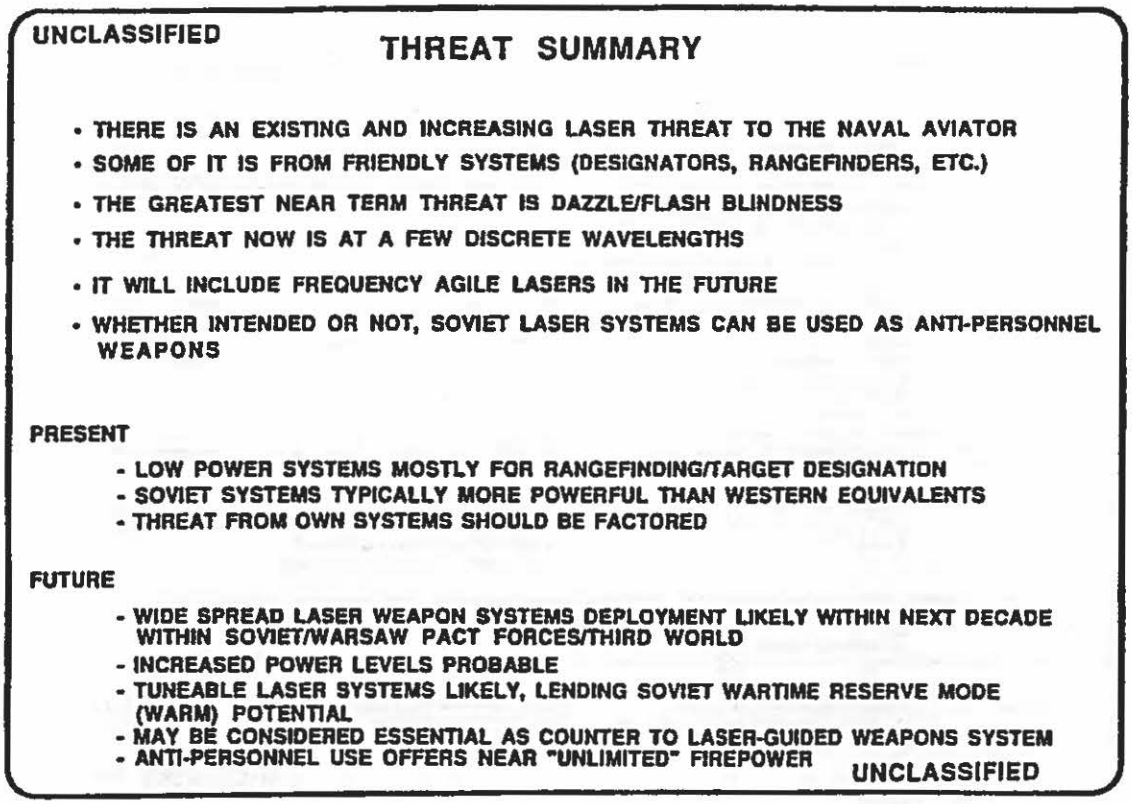

FIGURE 8.

THREAT SUMMARY (U)

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AIR CREW LASER EYE PROTECTION REQUIREMENTS

CAPABILITIES/ CHARACTERISTICS	NAVY OR #099-0587, LASER EYE PROTECTION FOR NAVY/MARINE CORPS AVIATORS	AIR FORCE DRAFT STATEMENT OF OPERATIONAL NEED (SON) 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 SAVINGS, TECHNOLOGICAL ACHIEVEMENT OR RAPID DEPLOYMENT.)	SAME AS NAVY'S.	
	ALTHOUGH LEP PROGRAMS INDICATE NAVY INTEREST IN 4 λ AND EVENTUALLY IN ACHIEVING A FREQUENCY AGILE CAPABILITY AGAINST MULTIPLE FREQUENCIES, THE OR DOES NOT MENTION THESE CAPABILITIES REQUIREMENTS.	P³I PROGRAM TO MEET FUTURE THREAT STIPULATED. (A SEPERATE AF PROGRAM MANAGEMENT PLAN INDICATES A JOINT FUTURE CAPABILITY PROGRAM WITH THE NAVY.)	TRIPLE NOTCH FILTERS APPROACH TO MEET FUTURE THREAT.
2. NATURE OF PROTECTION	EYE PROTECTION AGAINST LASER 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 TAFS 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 NAVY'S.	
4. CONFIGURATION	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.	EYE GLASSES/ VISOR COMPATIBLE WITH CW DEFENSE EQUIPMENT.

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FIGURE 9.

AIR CREW LASER EYE PROTECTION REQUIREMENTS (U)

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AIR CREW LASER EYE PROTECTION REQUIREMENTS (CONT.)

CAPABILITIES/ CHARACTERISTICS	NAVY OR 0099-0597, LASER EYE PROTECTION FOR NAVY/MARINE CORPS AVIATORS	AIR FORCE DRAFT STATEMENT OF OPERATIONAL NEED (SON) AF-XXX-84 FOR AIR CREW OCULAR LASER PROTECTION	ARMY ASARC REQUIREMENT FOR LASER EYE PROTECTION
6. OPERATIONAL IMPLICATIONS	ENABLE/ALLOW NORMAL OPERATION BOTH DAY AND NIGHT. IF HEAD OR HELMET-MOUNTED, MUST NOT RESTRICT WEARER'S MOVEMENT/ABILITY TO FUNCTION IN HIS OPERATIONAL ENVIRONMENT.	ALLOW UNRESTRICTED VISION FOR NORMAL OPERATIONS. NO DISTORTION, IMPAIRING OF VISUAL ACTIVITY OR DEGRADING THE FIDELITY OF COCKPIT DISPLAYS. MUST NOT IMPOSE EXTENSIVE A/C MODS. NO UNIQUE TRAINING OR MAINTENANCE REQUIREMENTS RESULTING FROM SYSTEM. COMPATIBLE WITH BOTH DAY AND NIGHT OPERATIONS.	ENABLE NORMAL OPERATION WITHOUT UNDUE RESTRICTION OF MOVEMENT OR ABILITY TO FUNCTION IN MISSION ROLE.
6. OPTICAL DENSITY (OD)	≥( ) AT DESIGNATED WAVELENGTH FOR ALL INCIDENCE ANGLES THAT COULD CAUSE EYE DAMAGE.	SAME AS NAVY.	-3 (?)
7. TRANSMITTANCE	86% FOR BOTH DAY AND NIGHT.	NOT MENTIONED.	?
8. DURABILITY	IMPACT, PENETRATION AND ABRASION RESISTANCES AS SPECIFIED IN MIL-V-22272D(AS).	SAME AS NAVY.	?
9. OPTICAL QUALITY	AS SPECIFIED IN MIL-V-22272D(AS).	SAME AS NAVY.	?
10 LONGEVITY	FIVE (5) YEARS SERVICE LIFE WITH SOME MEANS TO IDENTIFY DEGRADATION OR FAILURE.	INDEFINITE SHELF LIFE WITH A SERVICE LIFE EQUAL TO EXISTING PROTECTIVE LENSES.	?
11. COSTS	A) RDT&E 4.8M B) UNIT PRODUCTION COSTS 1.0K C) LIFE CYCLE COSTS (BASED ON 6500 UNITS) 19.5M D) PROCUREMENT NUMBER	NO COSTS OR PRODUCTION QUANTITIES WERE IDENTIFIED IN THE AF SON, BUT A VICE CHIEF OF STAFF MESSAGE OF NOV. 1984 DIRECTED THE PROCUREMENT OF APPROXIMATELY 18,000 UNITS WITH '87 AND '88 FUNDS OF 3 ½ VISOR.	

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FIGURE 10.

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

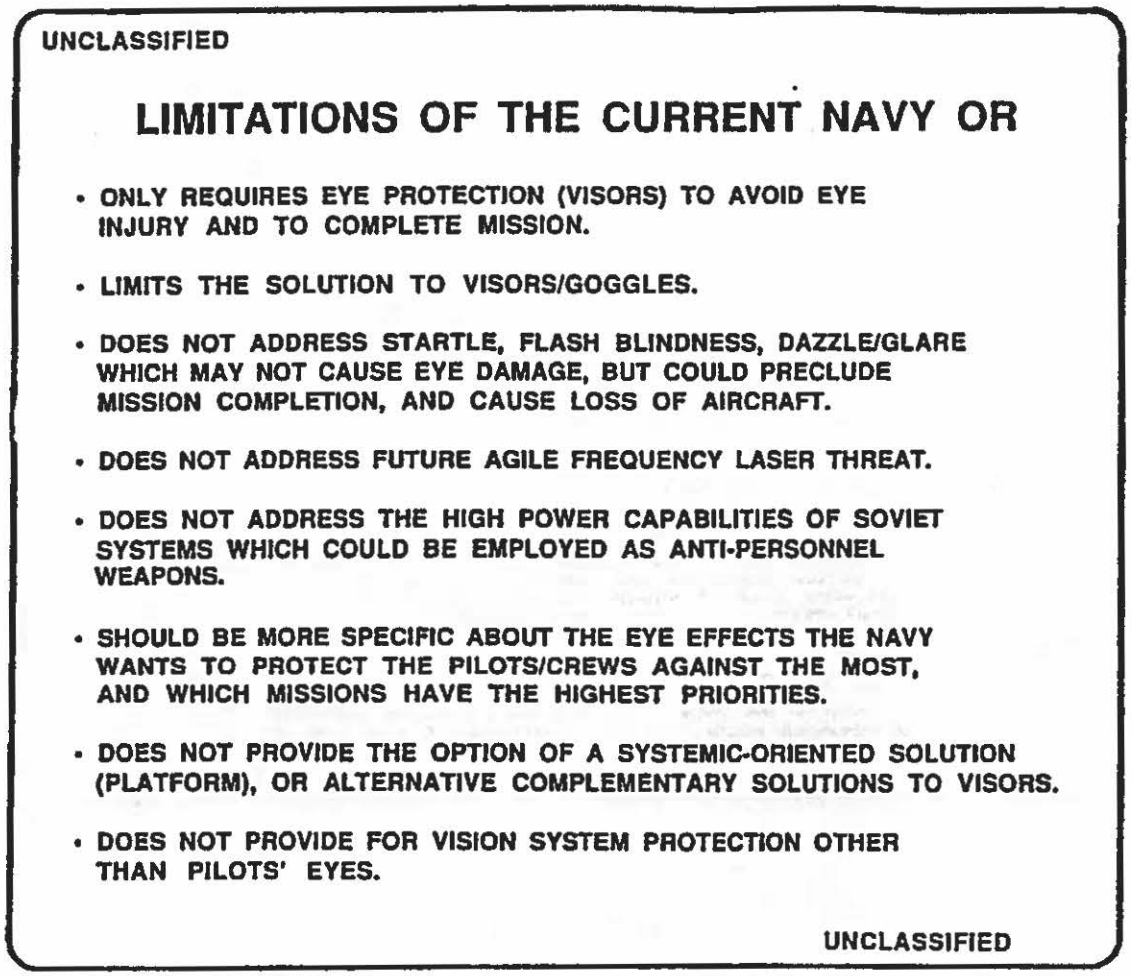

FIGURE 11.

LIMITATIONS OF THE CURRENT NAVY OR (U)

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EXISTING LASER EYE PROTECTION PROGRAMS

SERVICE	IOC TIME FRAME	TYPE OF FUNDING	WAVE-LENGTH	DESCRIPTION OF DEVICE	PURPOSE
NAVY	AVAILABLE	PRODUCTION STOCK FUNDS	λ_3	EEK-3 VISOR EDU-1P GLASSES	PROTECTION AGAINST OUR OWN & ENEMY RANGE FINDERS/DESIGNATORS
NAVY	LATE 90's	6.4	3 λ's+	?	RESOLVE THREAT PROTECTION HOLE BETWEEN WHAT'S AVAILABLE & WHAT'S BEING DEVELOPED
NAVY	EARLY 90's	6.3	4 λ's	?	MEET MID-TERM THREAT PROJECTION
NAVY	LATE 90's	6.2	AGILE	?	MEET THE TOTAL LONG TERM THREAT
AIR FORCE	LATE 80's	PRODUCTION STOCK FUNDS	3 λ's+	VISOR	PROVIDE EARLIEST PROTECTION AGAINST EXISTING THREAT PLUS OUR OWN SYSTEMS (POTENTIAL P-43 PHOSP. PROB.)
ARMY	LATE 80's	PRODUCTION STOCK FUNDS	2 λ's	EYEGLASSES	PROTECTION FOR GROUND TROOPS & HELO PILOTS
ARMY	EARLY 90's	6.2	?	TRIPLE NOTCH FILTER	LONG TERM THREAT

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FIGURE 12.

EXISTING LASER EYE PROTECTION PROGRAMS (U)

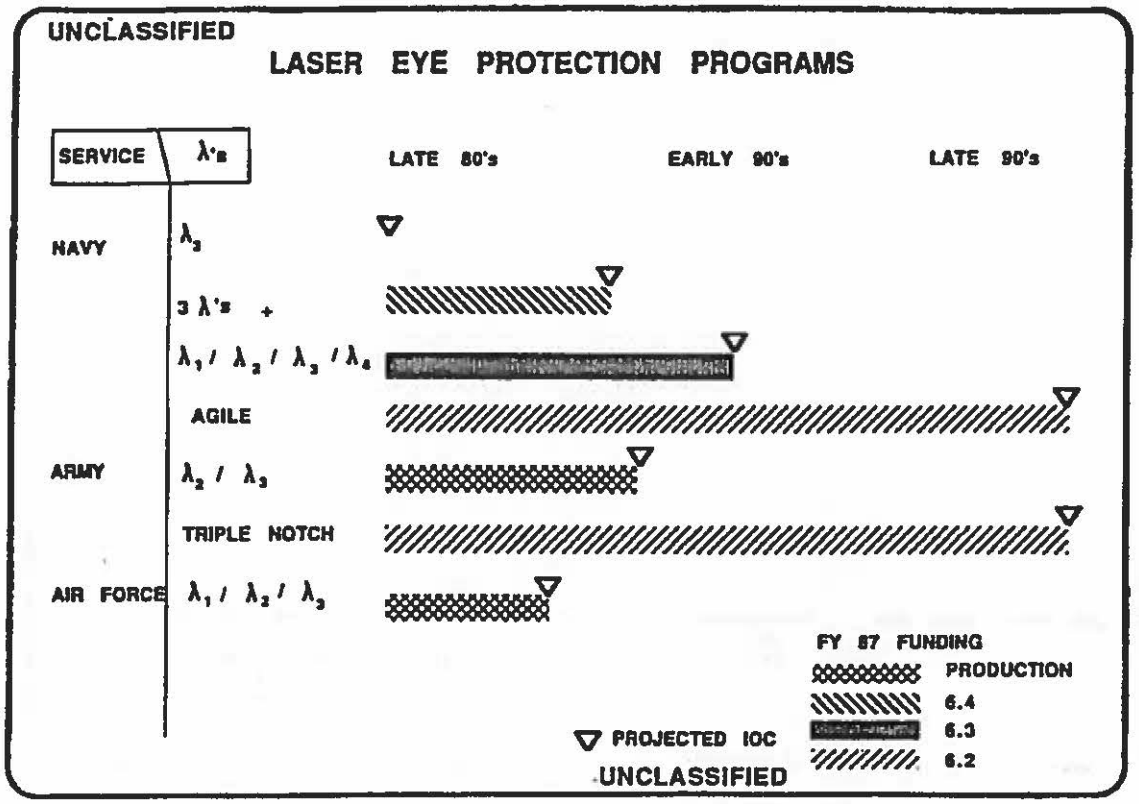

FIGURE 13.

LASER EYE PROTECTION PROGRAMS (U)

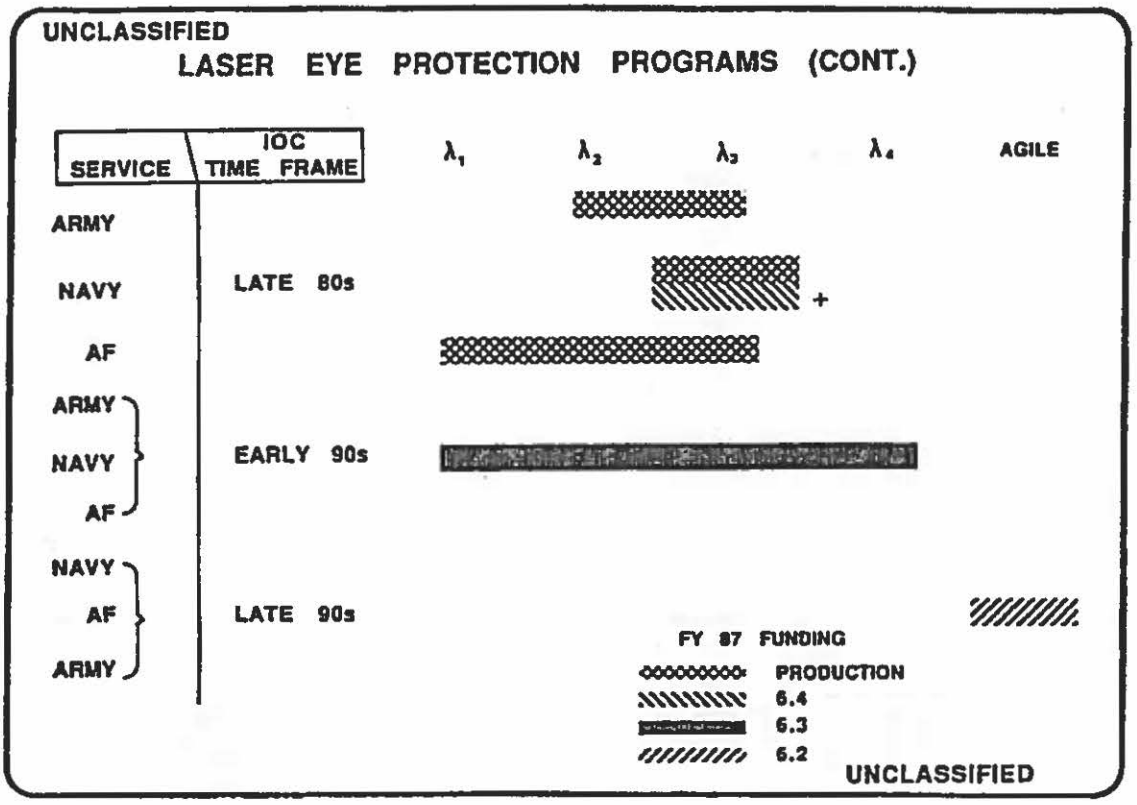

FIGURE 14.

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

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NAVY R&D BUDGET PROFILE FOR PERSONNEL LASER EYE PROTECTION

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	$1M

NOTE: 6.2 BUDGET INCLUDES EFFORTS AGAINST THE AGILE THREAT AND IS A SEGMENT OF THE TOTAL BUDGET AVAILABLE FOR RESEARCH TO DEAL WITH THE AGILE THREAT. ALL FIGURES ARE SUBJECT TO PERIODIC REVIEW AND MINOR ADJUSTMENT.

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FIGURE 15.

NAVY R&D BUDGET PROFILE FOR PERSONNEL LASER EYE PROTECTION

UNCLASSIFIED

COOPERATIVE EFFORTS AIMED AT THE AGILE THREAT
(6.2 FUNDING)

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

UNCLASSIFIED

FIGURE 16.

COOPERATIVE EFFORTS AIMED AT THE AGILE THREAT (U)

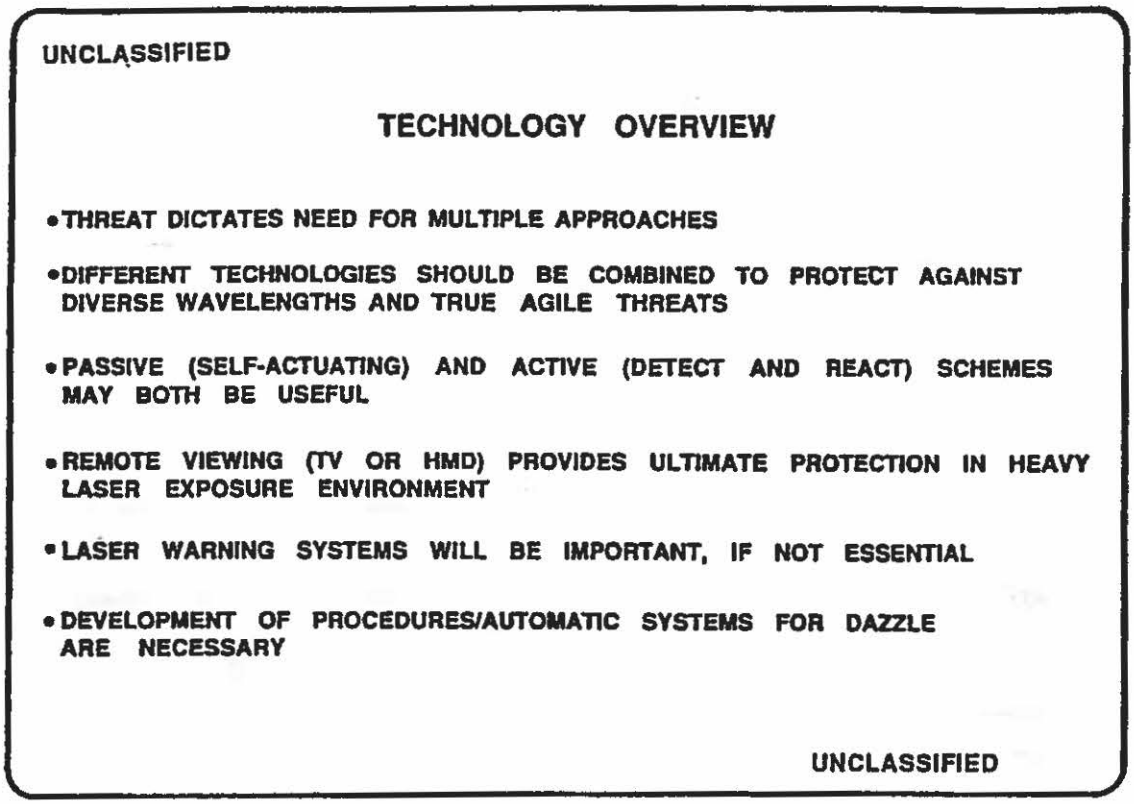

FIGURE 17.

TECHNOLOGY OVERVIEW (U)

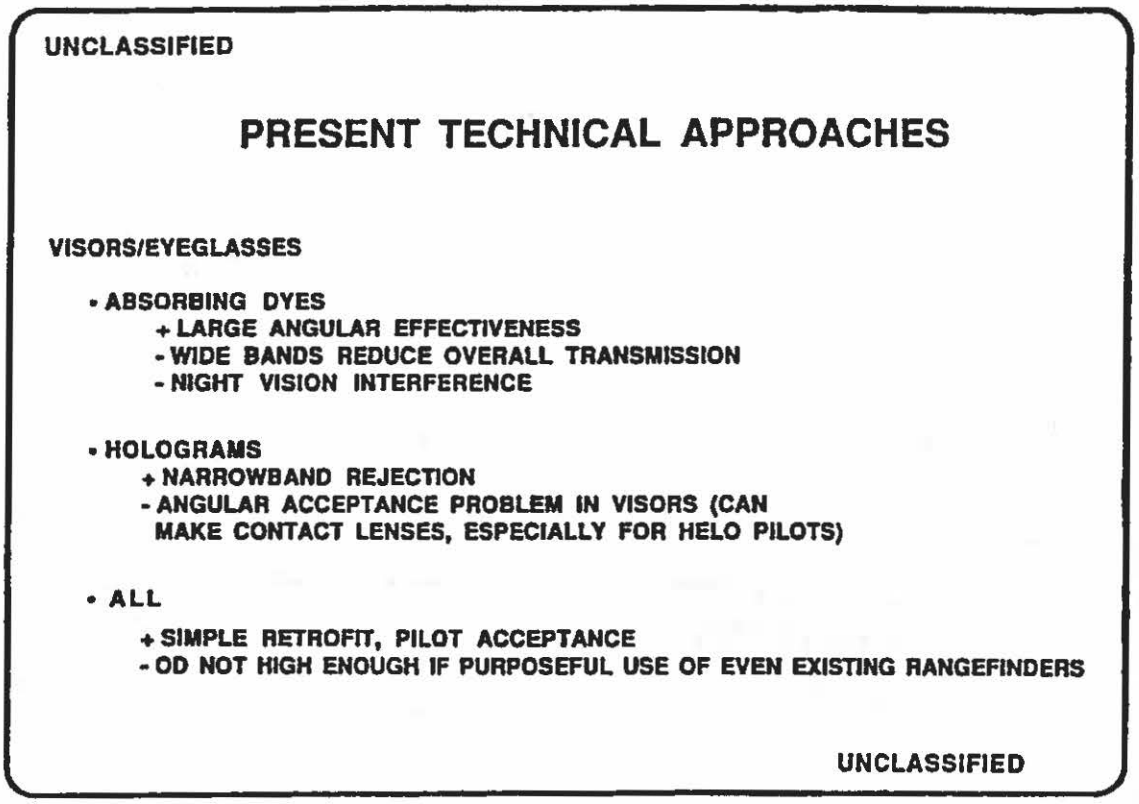

FIGURE 18.

PRESENT TECHNICAL APPROACHES (U)

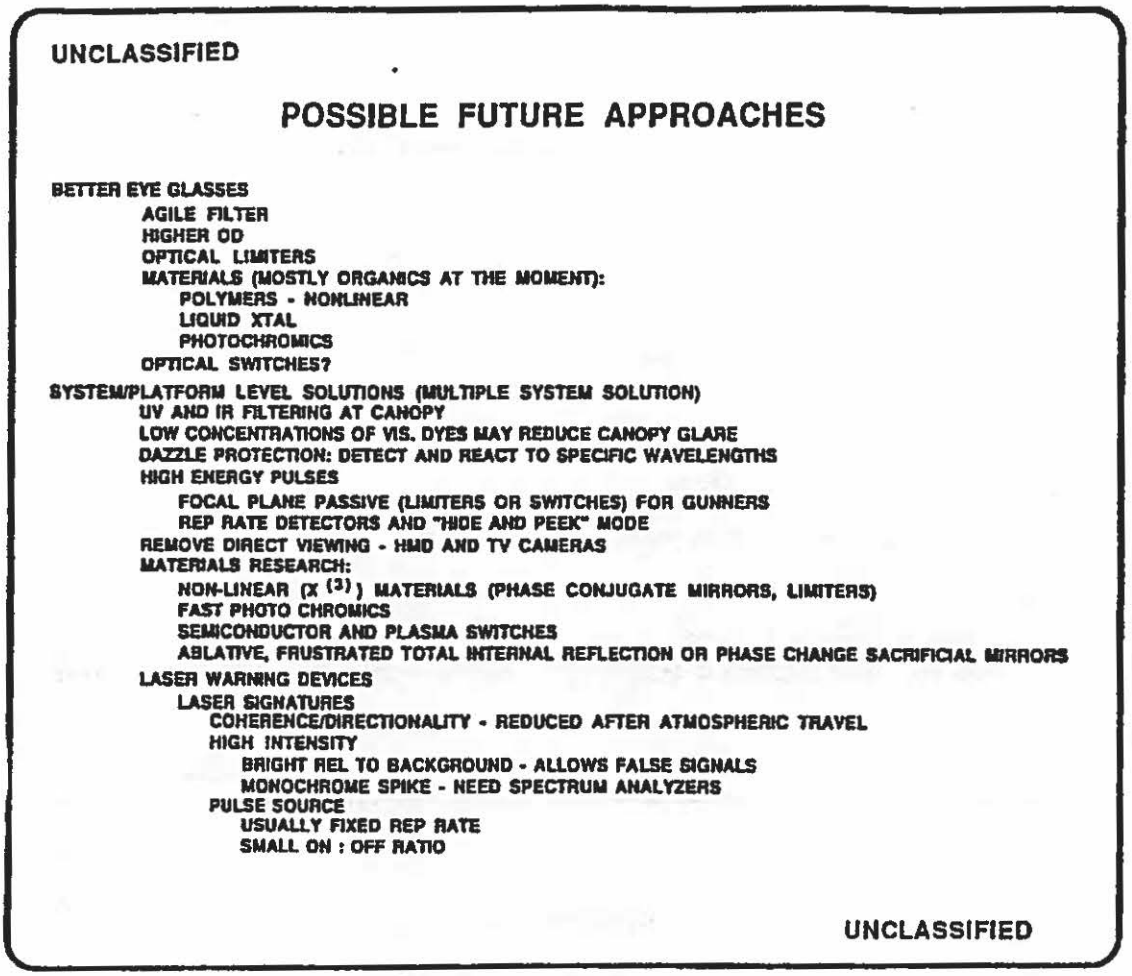

FIGURE 19.

POSSIBLE FUTURE APPROACHES (U)

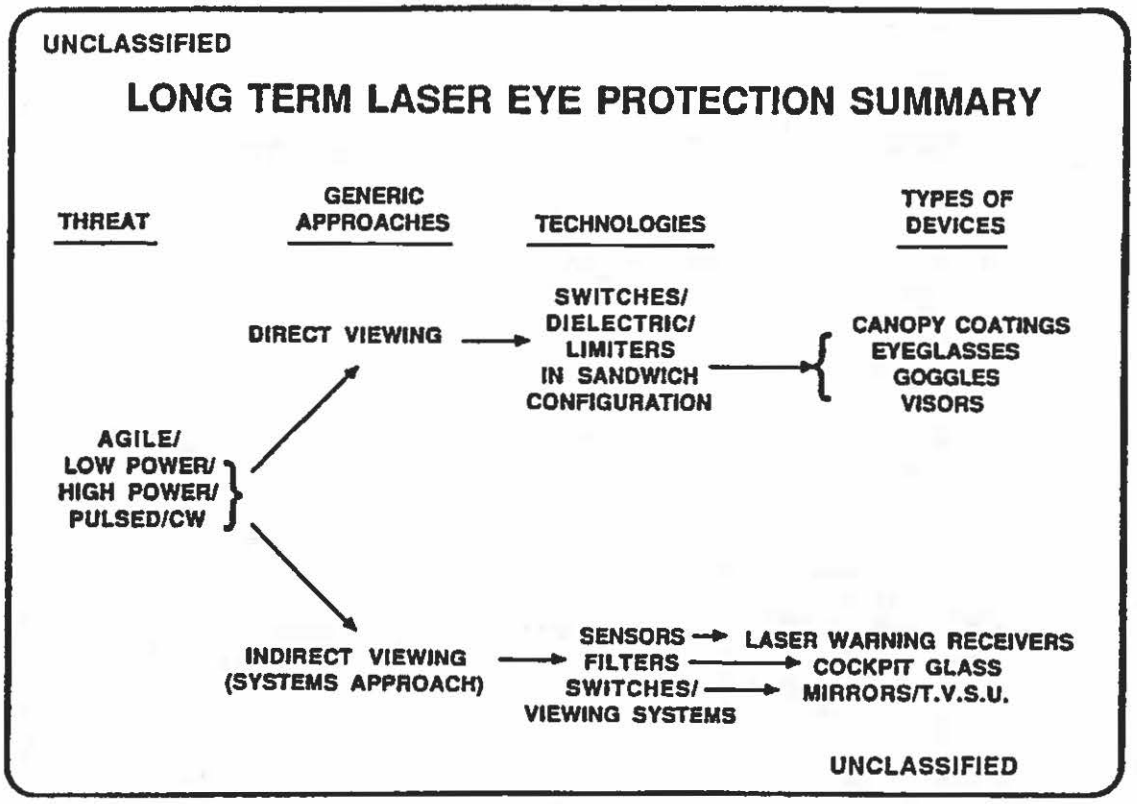

FIGURE 20.

LONG TERM LASER EYE PROTECTION SUMMARY (U)

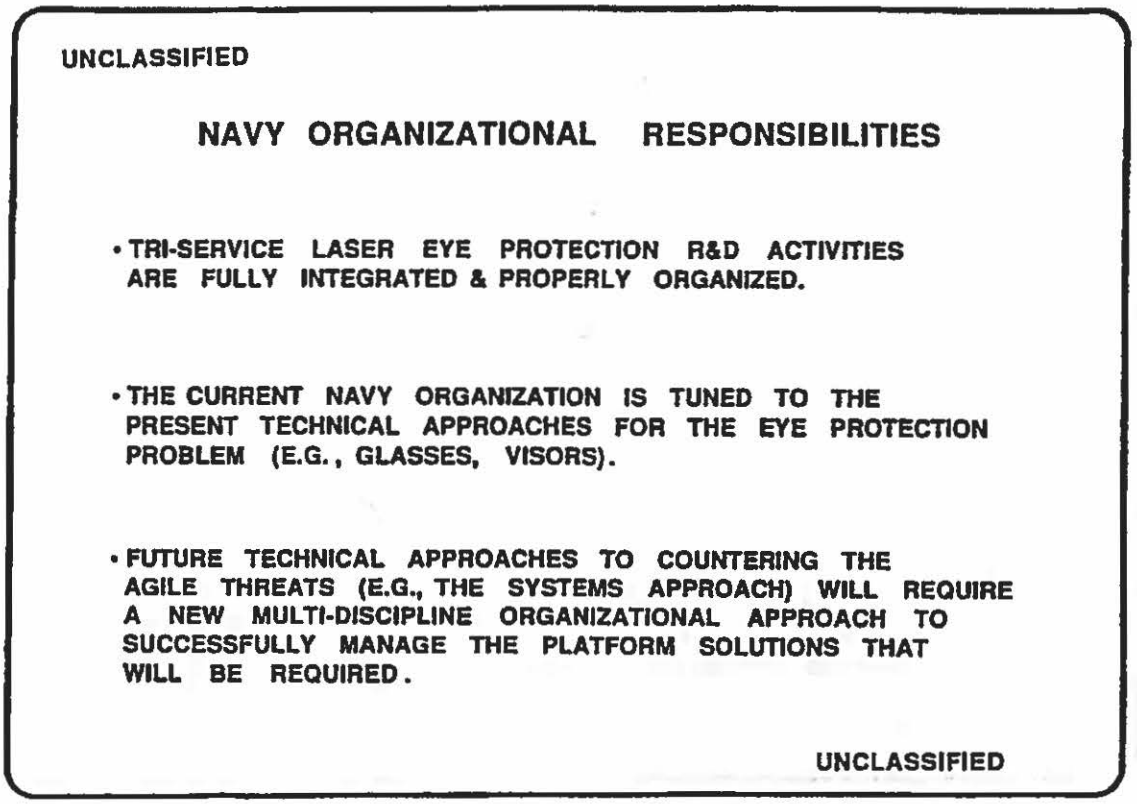

FIGURE 21.

NAVY ORGANIZATIONAL RESPONSIBILITIES (U)

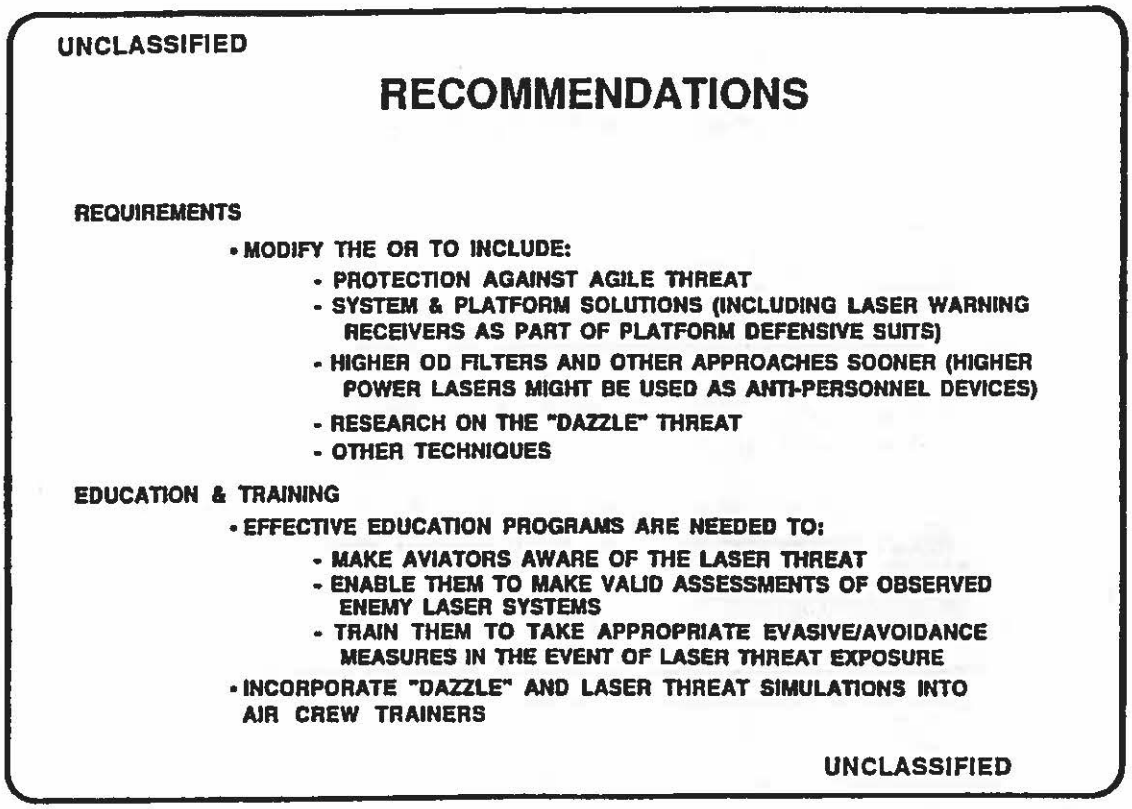

FIGURE 22.

RECOMMENDATIONS (U)

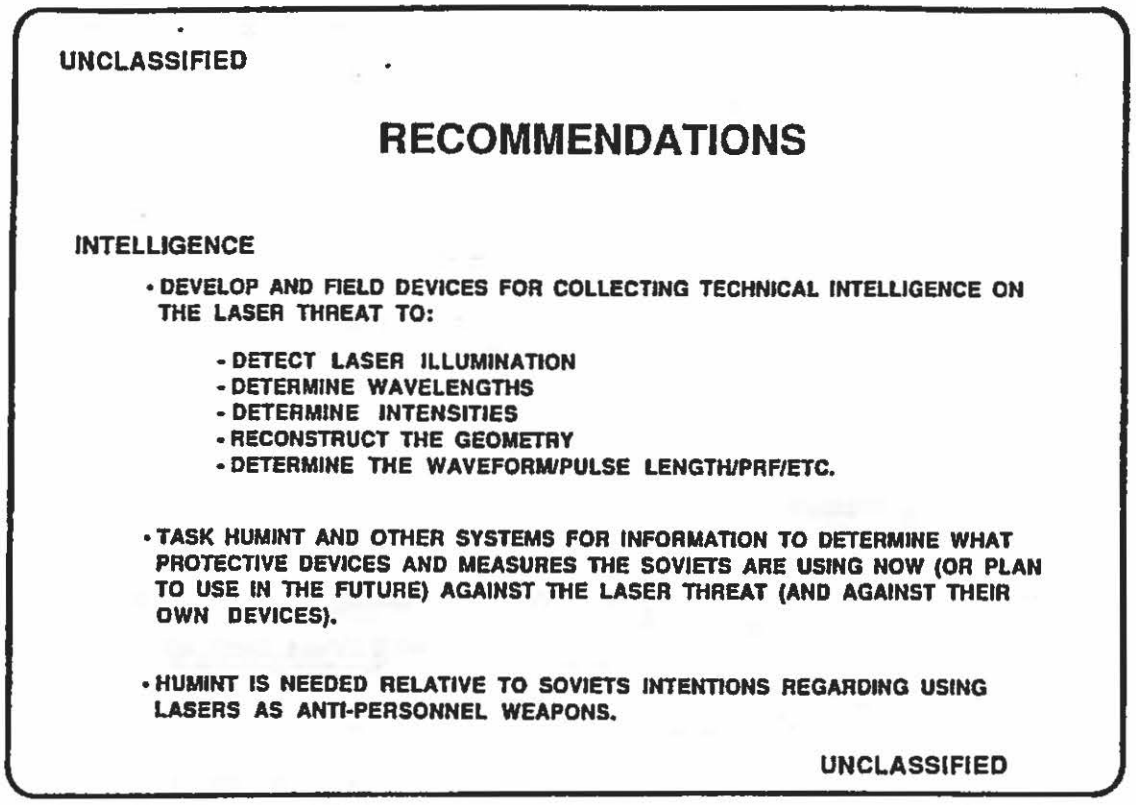

FIGURE 23.

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

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FIGURE 24.

RECOMMENDATIONS (CONT'D) (U)

APPENDIX A

TERMS OF REFERENCE FOR LASER EYE PROTECTION (U)

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

- (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.

1. (U) Review current Navy and DOD R&D laser eye protection programs.

2. (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.

APPENDIX B

PANEL MEMBERSHIP (U)

PANEL MEMBERSHIP

Dr. George S. Sebestyen, 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, 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. 20350

JUL 2 2 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 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. Rumpf

RICHARD L. RUMPF
ACTING

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

APPENDIX D

TRAINING AND EDUCATION FOR THE LASER BATTLEFIELD THREAT (U)

THE ASSISTANT SECRETARY OF THE NAVY
(RESEARCH, ENGINEERING AND SYSTEMS)
WASHINGTON, D.C. 20350

JUL 24 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.

Richard L Rumpf

RICHARD L. RUMPF
ACTING

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)

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SECTION II

BRIEFING CHARTS

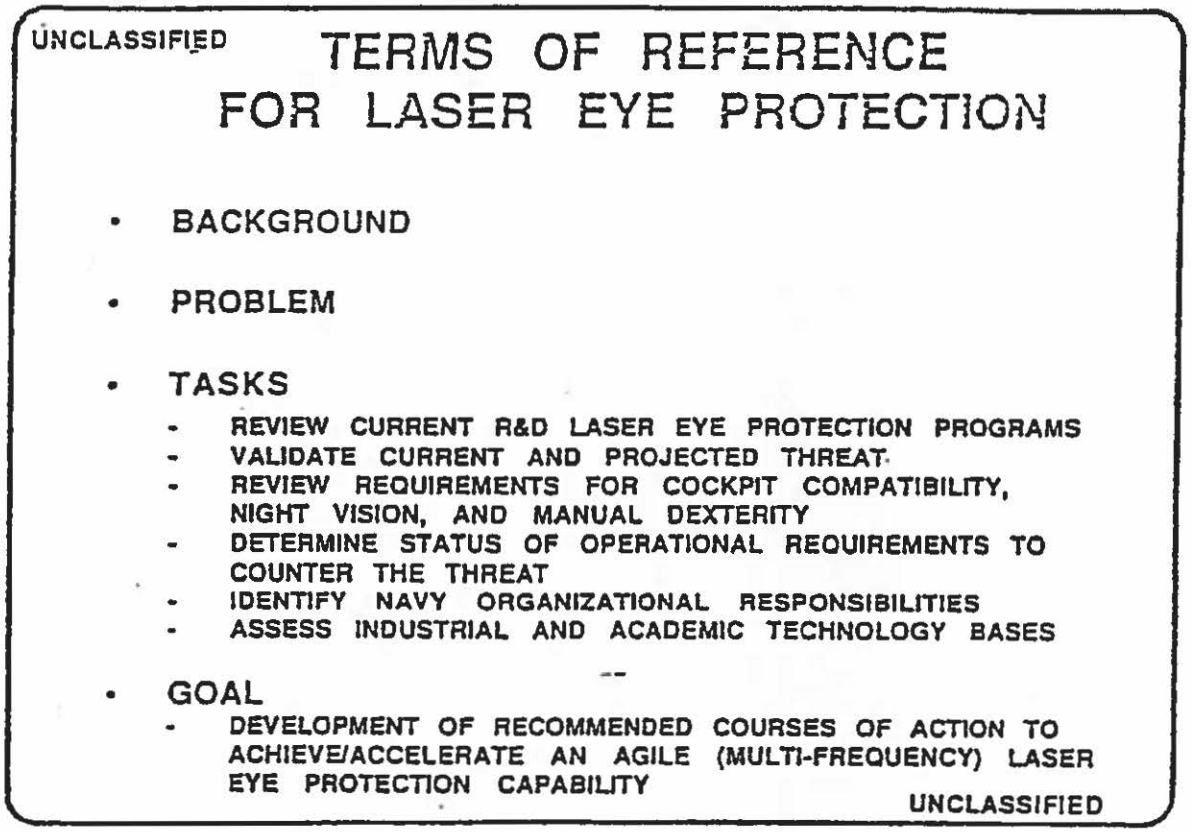

FIGURE 1.

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)

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.

- (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.

1. (U) Review current Navy and DOD R&D laser eye protection programs.

2. (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.

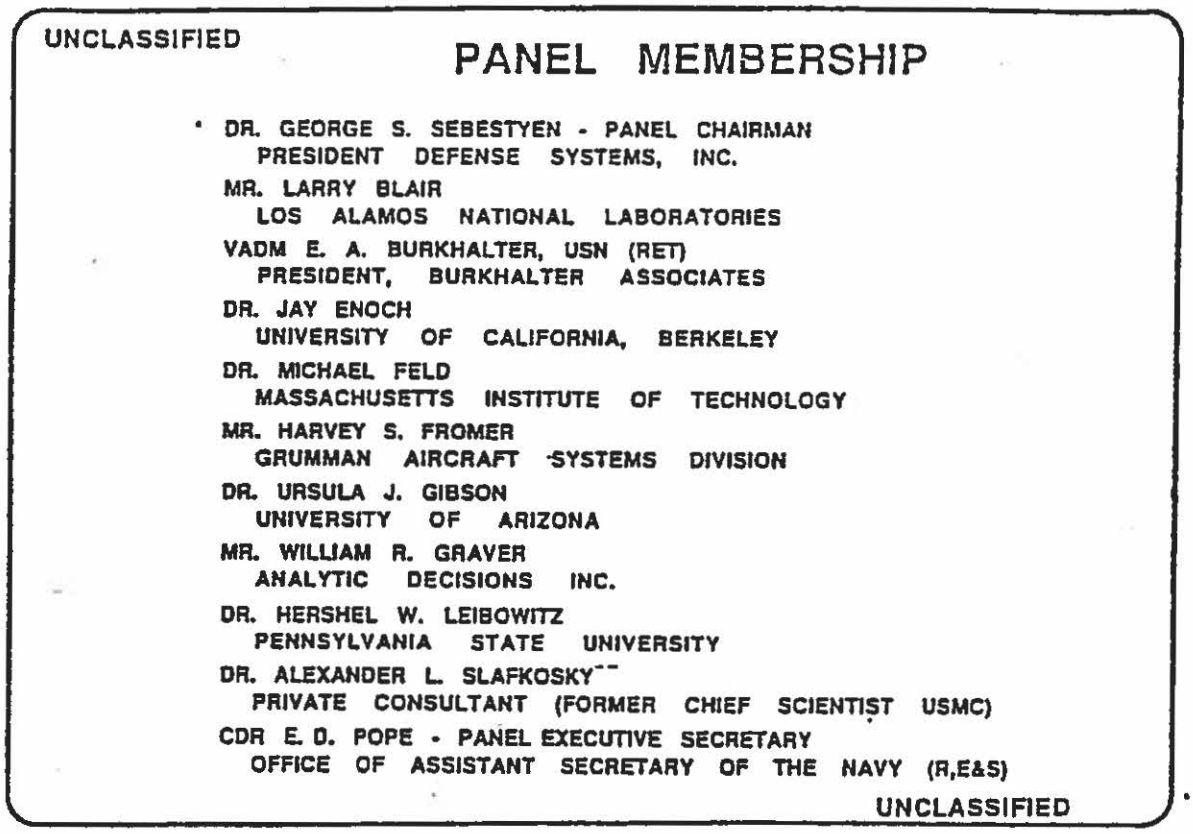

FIGURE 2.

PANEL MEMBERSHIP (U)

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POTENTIAL LASER THREAT TO THE NAVAL AVIATOR/MARINE PILOT

AVIATORS MISSION	AIRCRAFT	PROBABILITY OF ENCOUNTERING THREAT	PROBABILITY OF IMPACT ON MISSION DAY	NIGHT	PRIORITY FOR LASER EYE PROT.
ATTACK (AIR-TO-GROUND)	A-6 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	LOW	LOW	4
JAMMING	EA-6B	LOW	LOW	LOW	4
ASW	S-3 P-3 H-2 SV-22 H-3 SH-60	MED	MED	HIGH	2
INTELLIGENCE	EA-3B EP-3E ES-3	LOW	LOW	LOW	4
HELICOPTER (GROUND SUPPORT FOR MARINES)	CH-46 MV-22A CH-53 OV-10 UH-1 HH-60 AH-1H	HIGH	HIGH	HIGH	1*
COD/VOD	C-2 CH-53 C-130 etc.	LOW	LOW	LOW	4

* WHILE THESE TWO MISSIONS DEMAND THE HIGHEST PRIORITY, THE INHERENT MISSION DIFFERENCES SHOULD BE RECOGNIZED.

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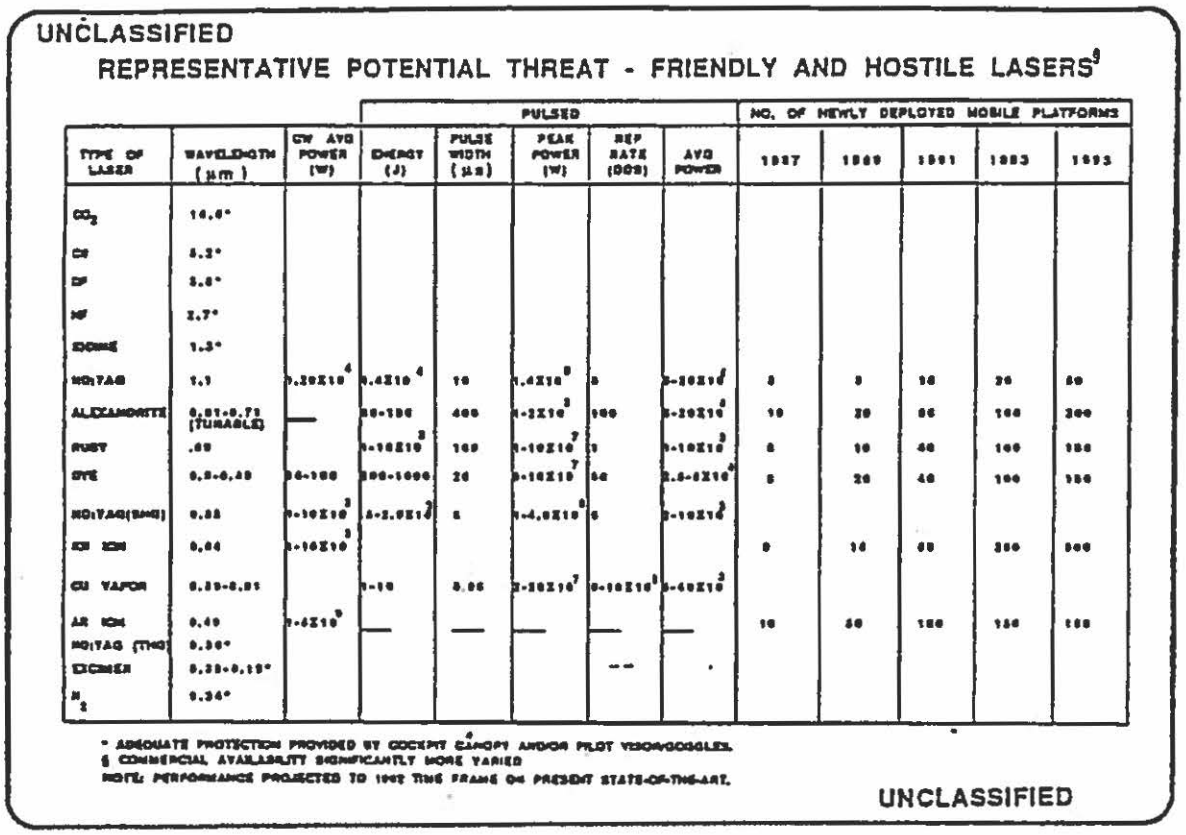
FIGURE 3.

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



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REPRESENTATIVE POTENTIAL THREAT - FRIENDLY AND HOSTILE LASERS[9]

TYPE OF LASER	WAVELENGTH (μm)	CW AVG POWER (W)	PULSED					NO. OF NEWLY DEPLOYED MOBILE PLATFORMS				
			ENERGY (J)	PULSE WIDTH (μs)	PEAK POWER (W)	REP RATE (PPS)	AVG POWER	1987	1989	1991	1993	1995
CO_2	10.6*											
CW	5.3*											
DF	3.8*											
HF	2.7*											
EXCIMER	1.3*											
ND:YAG	1.1	0.20×10^4	0.4×10^4	10	1.4×10^8	5	$2-20 \times 10^4$	5	5	10	20	50
ALEXANDRITE	0.81-0.71 (TUNABLE)	—	50-100	400	$1-2 \times 10^3$	100	$5-20 \times 10^4$	10	20	50	100	200
RUBY	.69		$5-10 \times 10^2$	100	$5-10 \times 10^7$	1	$5-10 \times 10^3$	5	10	40	100	150
DYE	0.5-0.49	50-100	500-1000	20	$5-10 \times 10^7$	50	$2.5-5 \times 10^4$	5	20	40	100	150
ND:YAG(SHG)	0.53	$5-10 \times 10^3$	$5-2.5 \times 10^2$	5	$1-4.0 \times 10^8$	5	$2-10 \times 10^2$					
XE ION	0.44	$5-10 \times 10^3$						0	10	50	250	500
CU VAPOR	0.51-0.51		5-10	0.05	$2-20 \times 10^7$	$0-10 \times 10^3$	$5-40 \times 10^2$					
AR ION	0.49	$2-5 \times 10^3$	—	—	—	—	—	10	50	100	150	150
ND:YAG (THG)	0.35*											
EXCIMER	0.35-0.19*					--	.					
N_2	0.34*											

* ADEQUATE PROTECTION PROVIDED BY COCKPIT CANOPY AND/OR PILOT VISOR/GOGGLES.
§ COMMERCIAL AVAILABILITY SIGNIFICANTLY MORE VARIED
NOTE: PERFORMANCE PROJECTED TO 1992 TIME FRAME ON PRESENT STATE-OF-THE-ART.

UNCLASSIFIED

FIGURE 4.

REPRESENTATIVE POTENTIAL THREAT - FRIENDLY AND HOSTILE LASERS (U)

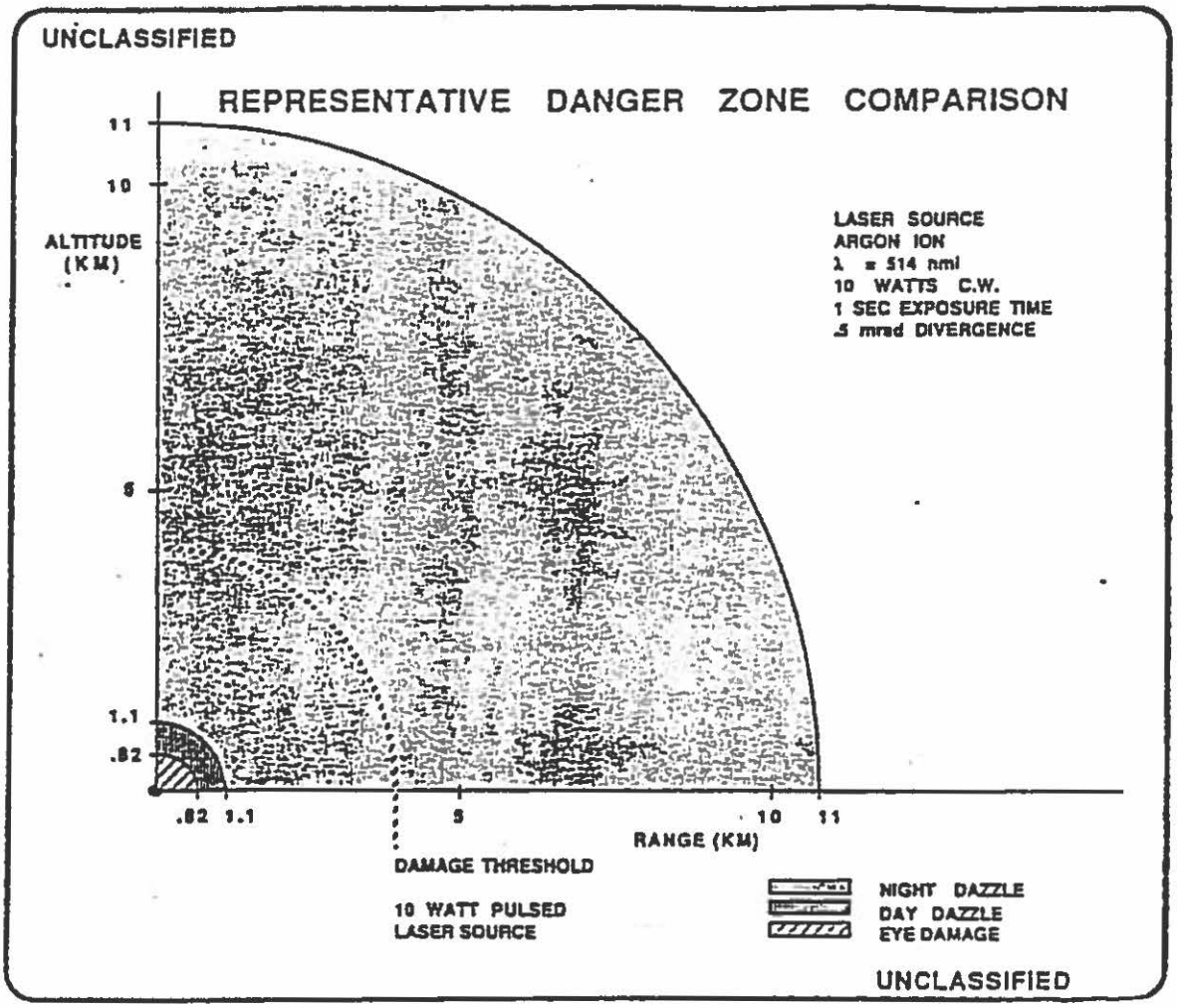

FIGURE 5.

REPRESENTATIVE DANGER ZONE COMPARISON (U)

- (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.
- (U) The most significant near term threat to the successful completion of a naval aviator's mission is laser-induced night dazzle.
- (U) Day dazzle and eye damage can become a more significant threat at higher power levels and for pulsed laser sources.

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OCULAR DAMAGE AND/OR FUNCTIONAL VISUAL IMPAIRMENT

CONDITION	CORNEA AND OCULAR MEDIA	RETINAL HEMORRHAGE	RETINAL BURN: PERIPHERAL RETINA	RETINAL BURN: CENTRAL RETINA	DAZZLE & EFFECT ON LIGHT ADAPTATION
ACCIDENTAL EXPOSURE (RANGING, etc.)	YES, IF SHORT OR LONG WAVE-LENGTH		MOST PROBABLE FOR PILOT	LESS LIKELY FOR PILOT	PERHAPS
PURPOSEFUL EXPOSURE (ANTI-PERSONNEL)	LESS LIKELY THAN RETINAL	Q-SWITCHED LASER HAZARD	HERE, FIRST PULSE IS TO GAIN ATTENTION - MAY NOT BURN. SECOND PULSE IS DIRECTED AT CENTER	DESIGNED OFTEN FOR THIS LESION	YES, A CHEAP SIMPLE OPTION
DAY			LESS DISTRACTING, MAY STILL BE ABLE TO FUNCTION	MUST NOT REDIRECT EYE TO LOOK AT SOURCE	SOMEWHAT DISTURBING
NIGHT			MORE DISTRACTING, MAY STILL BE ABLE TO FUNCTION	MUST NOT REDIRECT EYE TO LOOK AT SOURCE	PARTICULARLY DISORIENTING, CAN CAUSE INABILITY TO FUNCTION
WAVELENGTH BAND	UV YES VISIBLE NEAR IR FAR IR YES	YES	YES YES	YES YES	SOME FLUORESCENCE YES
Q-SWITCHED		PARTICULAR HAZARD	MOST PROBABLE SITE		
PULSED			MOST PROBABLE SITE	LOW PROBABILITY FIRST EXPOSURE, POSSIBLE AFTER GAINING ATTENTION	SIMPLE PULSE HAS LITTLE ADAPTIVE EFFECT, MAY DISTURB BY DISTRACTING
CW			LARGER BURN AREA THAN RETINAL IMAGE SIZE, PROBABLE FIRST INTERCEPT	POSSIBLE AFTER GAINING ATTENTION	PARTICULARLY DISTRACTING
TIME FOR RESPONSE	OFTEN NOT AWARE OF EXPOSURE, PAINFUL	VIRTUALLY NONE (PICOSECOND)	VIRTUALLY NONE (PICOSECONDS)	IF NOT INITIAL SITE, ABOUT 200 MILLISECONDS FOR RESPONSE	THIS IS AVAILABLE FOR AVERSION OR RESPONSE

UNCLASSIFIED

FIGURE 6.

OCULAR DAMAGE AND/OR FUNCTIONAL VISUAL IMPAIRMENT (U)

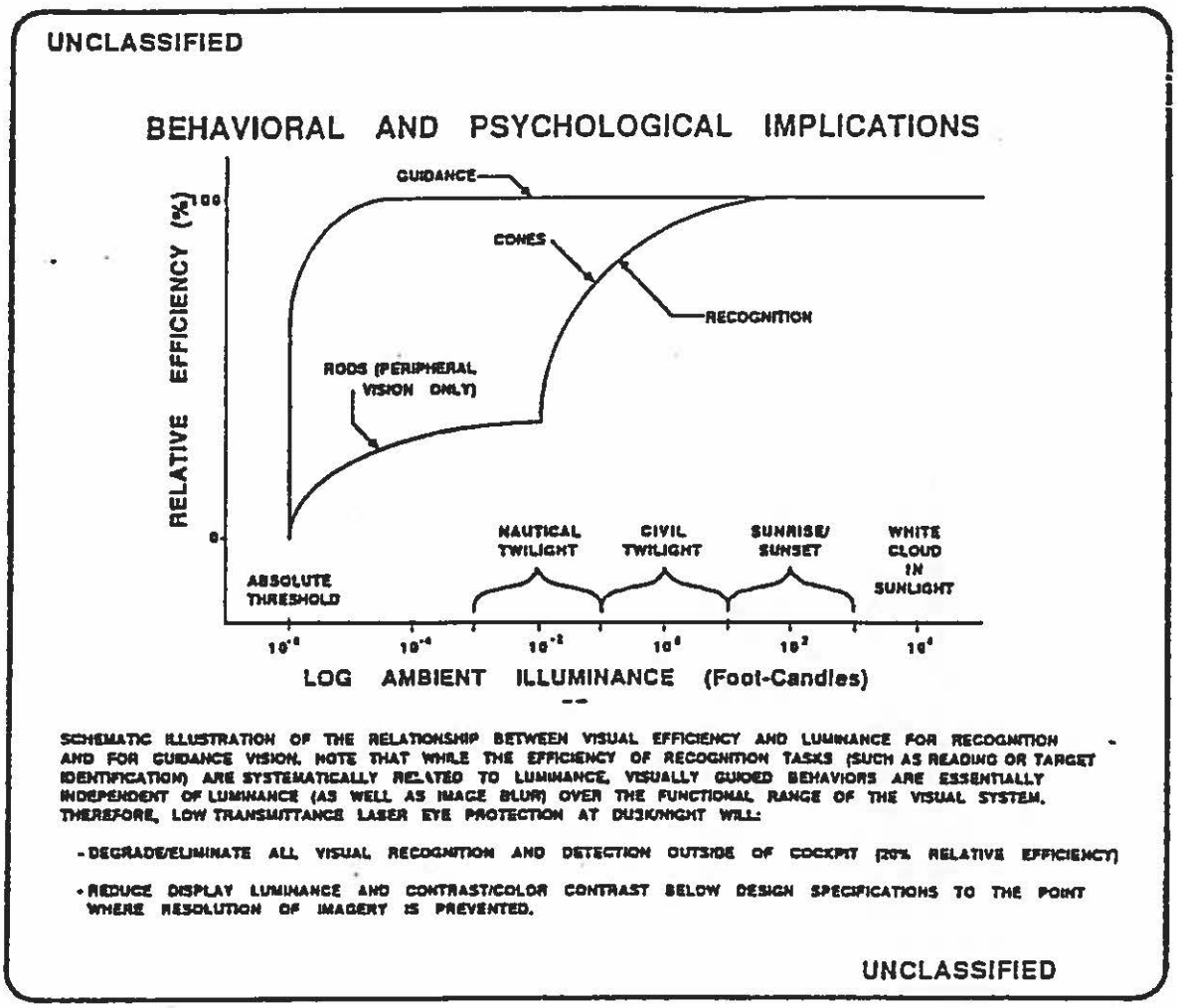

FIGURE 7.

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 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.

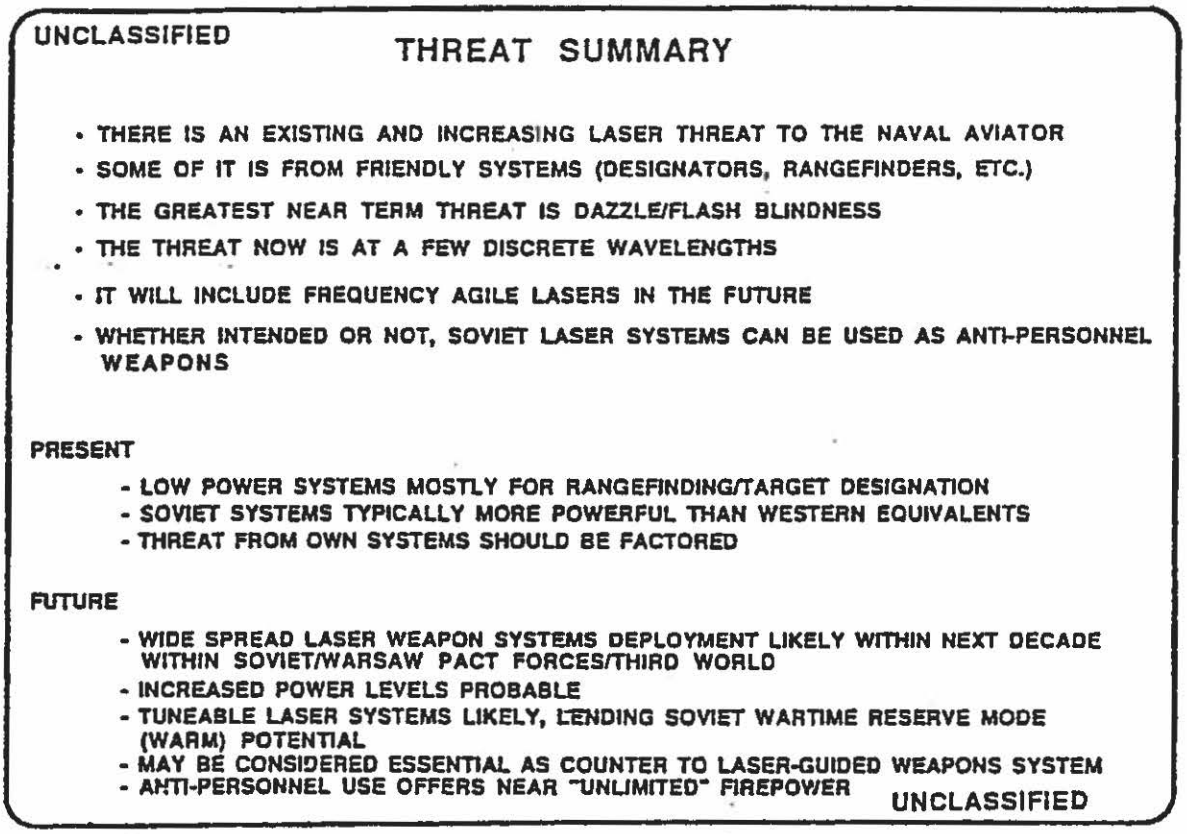

FIGURE 8.

THREAT SUMMARY (U)

UNCLASSIFIED

AIR CREW LASER EYE PROTECTION REQUIREMENTS

CAPABILITIES/ CHARACTERISTICS	NAVY OR #099-0537, LASER EYE PROTECTION FOR NAVY/MARINE CORPS AVIATORS	AIR FORCE DRAFT STATEMENT OF OPERATIONAL NEED (SON) AF-XXX-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 SAVINGS, TECHNOLOGICAL ACHIEVEMENT OR RAPID DEPLOYMENT.)	SAME AS NAVY'S.	
	ALTHOUGH LEP PROGRAMS INDICATE NAVY INTEREST IN 4 λ AND EVENTUALLY IN ACHIEVING A FREQUENCY AGILE CAPABILITY AGAINST MULTIPLE FREQUENCIES, THE OR DOES NOT MENTION THESE CAPABILITIES REQUIREMENTS.	P^{3}I PROGRAM TO MEET FUTURE THREAT STIPULATED. (A SEPERATE AF PROGRAM MANAGEMENT PLAN INDICATES A JOINT FUTURE CAPABILITY PROGRAM WITH THE NAVY.)	TRIPLE NOTCH FILTERS APPROACH TO MEET FUTURE THREAT.
2. NATURE OF PROTECTION	EYE PROTECTION AGAINST LASER 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 TAFS 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 NAVY'S.	
4. CONFIGURATION	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.	EYE GLASSES/ VISOR COMPATIBLE WITH CW DEFENSE EQUIPMENT.

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FIGURE 9.

AIR CREW LASER EYE PROTECTION REQUIREMENTS (U)

UNCLASSIFIED

AIR CREW LASER EYE PROTECTION REQUIREMENTS (CONT.)

CAPABILITIES/ CHARACTERISTICS	NAVY OR 6096-0567, LASER EYE PROTECTION FOR NAVY/MARINE CORPS AVIATORS	AIR FORCE DRAFT STATEMENT OF OPERATIONAL NEED (SON) AF-3XX-86 FY'? AIR CREW OCULAR LASER PROTECTION	ARMY ASARC REQUIREMENT FOR LASER EYE PROTECTION
5. OPERATIONAL IMPLICATIONS	ENABLE/ALLOW NORMAL OPERATION BOTH DAY AND NIGHT. IF HEAD OR HELMET-MOUNTED, MUST NOT RESTRICT WEARER'S MOVEMENT/ABILITY TO FUNCTION IN HIS OPERATIONAL ENVIRONMENT.	ALLOW UNRESTRICTED VISION FOR NORMAL OPERATIONS. NO DISTORTION, IMPAIRING OF VISUAL ACTIVITY OR DEGRADING THE FIDELITY OF COCKPIT DISPLAYS. MUST NOT IMPOSE EXTENSIVE A/C MODS. NO UNIQUE TRAINING OR MAINTENANCE REQUIREMENTS RESULTING FROM SYSTEM. COMPATIBLE WITH BOTH DAY AND NIGHT OPERATIONS.	ENABLE NORMAL OPERATION WITHOUT UNDUE RESTRICTION OF MOVEMENT OR ABILITY TO FUNCTION IN MISSION ROLE.
6. OPTICAL DENSITY (OD)	?( ) AT DESIGNATED WAVELENGTH FOR ALL INCIDENCE ANGLES THAT COULD CAUSE EYE DAMAGE.	SAME AS NAVY.	-2 (?)
7. TRANSMITTANCE	85% FOR BOTH DAY AND NIGHT.	NOT MENTIONED.	?
8. DURABILITY	IMPACT, PENETRATION AND ABRASION RESISTANCES AS SPECIFIED IN MIL-V-22272D(AS).	SAME AS NAVY.	?
9. OPTICAL QUALITY	AS SPECIFIED IN MIL-V-22272D(AS).	SAME AS NAVY.	?
10 LONGEVITY	FIVE (5) YEARS SERVICE LIFE WITH SOME MEANS TO IDENTIFY DEGRADATION OR FAILURE.	INDEFINITE SHELF LIFE WITH A SERVICE LIFE EQUAL TO EXISTING PROTECTIVE LENSES.	?
11. COSTS	A) RDT&E 4.8M B) UNIT PRODUCTION COSTS 1.6K C) LIFE CYCLE COSTS 10.5M (BASED ON 6500 UNITS) D) PROCUREMENT NUMBER	NO COSTS OR PRODUCTION QUANTITIES WERE IDENTIFIED IN THE AF SON, BUT A VICE CHIEF OF STAFF MESSAGE OF NOV. 1984 DIRECTED THE PROCUREMENT OF APPROXIMATELY 10,000 UNITS WITH '87 AND '88 FUNDS OF 3 1 VISOR.	

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FIGURE 10.

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

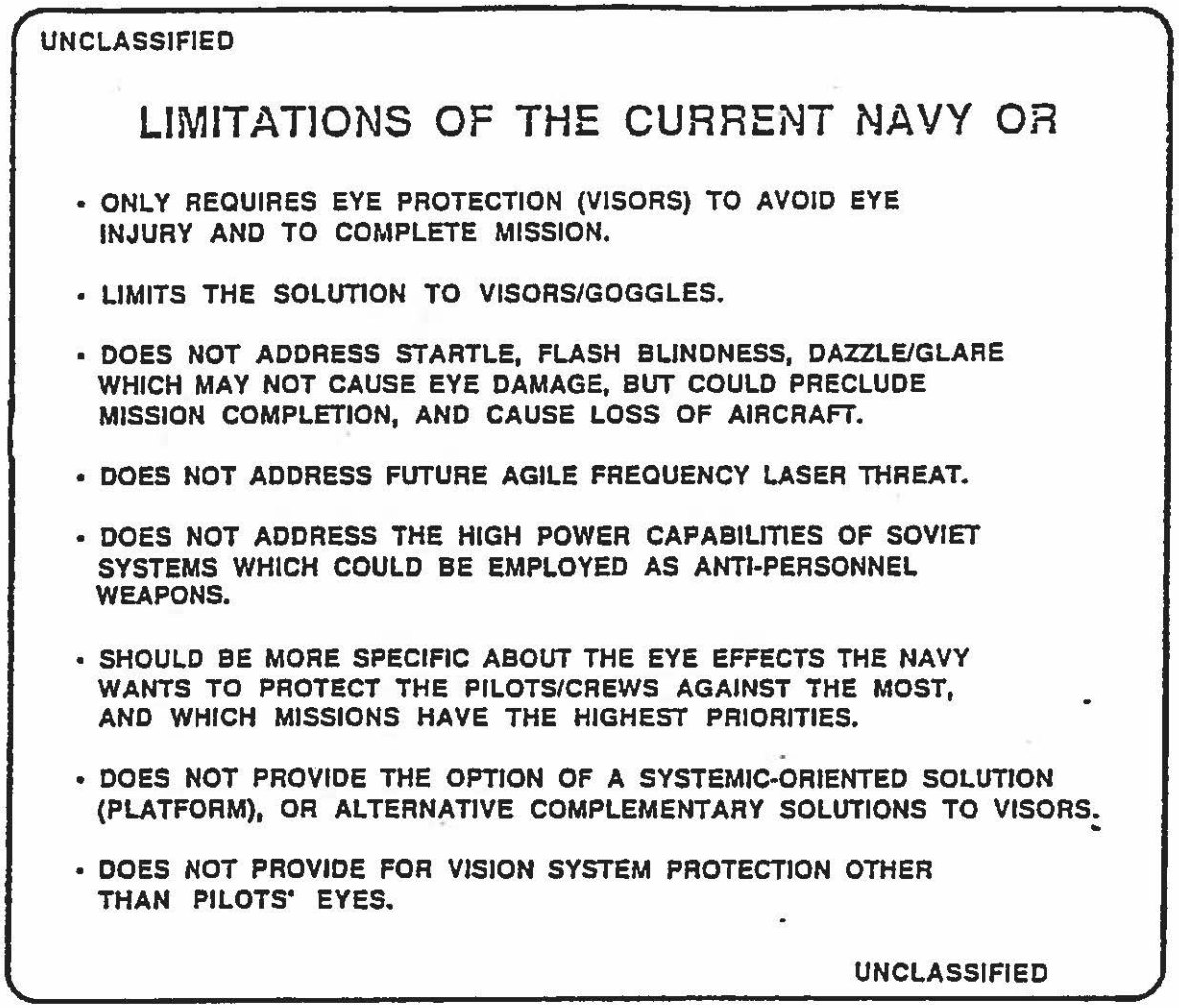

FIGURE 11.

LIMITATIONS OF THE CURRENT NAVY OR (U)

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EXISTING LASER EYE PROTECTION PROGRAMS

SERVICE	IOC TIME FRAME	TYPE OF FUNDING	WAVE-LENGTH	DESCRIPTION OF DEVICE	PURPOSE
NAVY	AVAILABLE	PRODUCTION STOCK FUNDS	λ_3	EEK-3 VISOR EDU-1P GLASSES	PROTECTION AGAINST OUR OWN & ENEMY RANGE FINDERS/DESIGNATORS
NAVY	LATE 80's	6.4	3 λ's+	?	RESOLVE THREAT PROTECTION HOLE BETWEEN WHAT'S AVAILABLE & WHAT'S BEING DEVELOPED
NAVY	EARLY 90's	6.3	4 λ's	?	MEET MID-TERM THREAT PROJECTION
NAVY	LATE 90's	6.2	AGILE	?	MEET THE TOTAL LONG TERM THREAT
AIR FORCE	LATE 80's	PRODUCTION STOCK FUNDS	3 λ's+ --	VISOR	PROVIDE EARLIEST PROTECTION AGAINST EXISTING THREAT PLUS OUR OWN SYSTEMS (POTENTIAL P-43 PHOSP. PROB.)
ARMY	LATE 80's	PRODUCTION STOCK FUNDS	2 λ's	EYEGLASSES	PROTECTION FOR GROUND TROOPS & HELO PILOTS
ARMY	EARLY 90's	6.2	?	TRIPLE NOTCH FILTER	LONG TERM THREAT

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FIGURE 12.

EXISTING LASER EYE PROTECTION PROGRAMS (U)

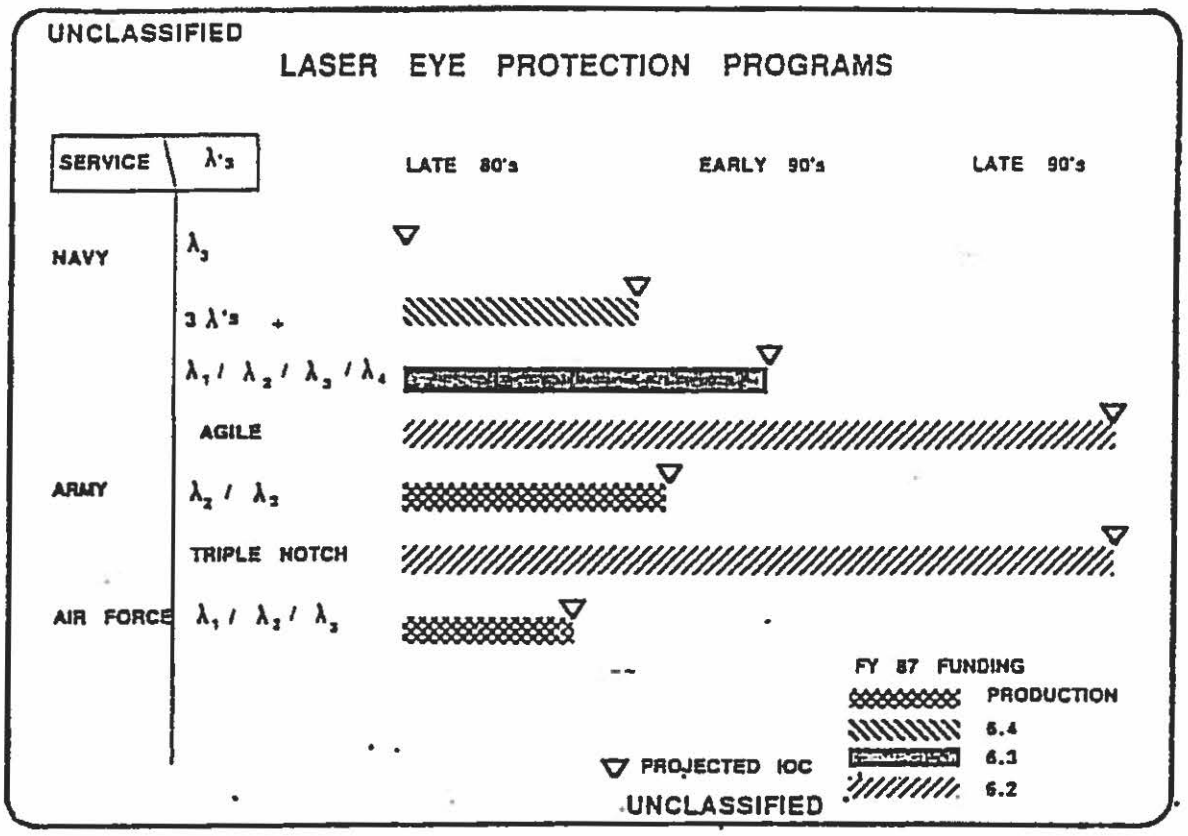

FIGURE 13.

LASER EYE PROTECTION PROGRAMS (U)

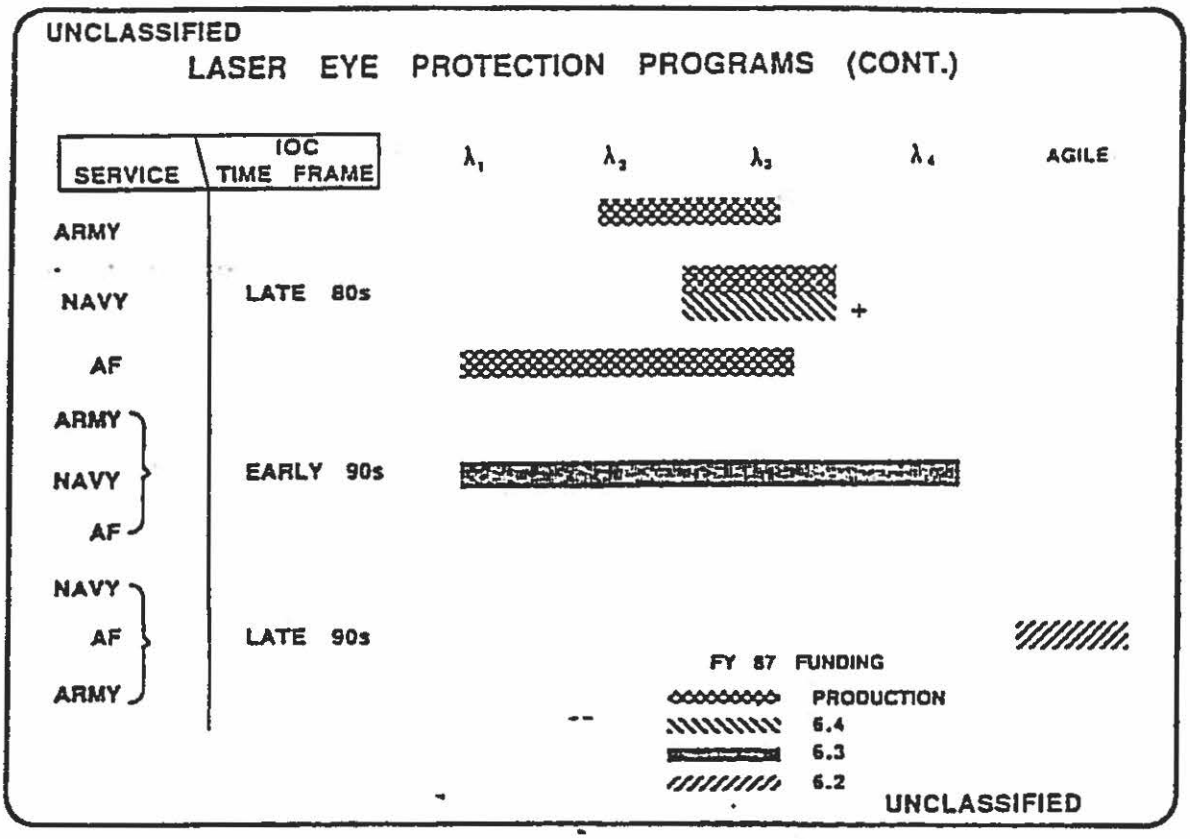

FIGURE 14.

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

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NAVY R&D BUDGET PROFILE FOR PERSONNEL LASER EYE PROTECTION

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	$1M

NOTE: 6.2 BUDGET INCLUDES EFFORTS AGAINST THE AGILE THREAT AND IS A SEGMENT OF THE TOTAL BUDGET AVAILABLE FOR RESEARCH TO DEAL WITH THE AGILE THREAT. ALL FIGURES ARE SUBJECT TO PERIODIC REVIEW AND MINOR ADJUSTMENT.

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FIGURE 15.

NAVY R&D BUDGET PROFILE FOR PERSONNEL LASER EYE PROTECTION

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COOPERATIVE EFFORTS AIMED AT THE AGILE THREAT
(6.2 FUNDING)

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

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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)

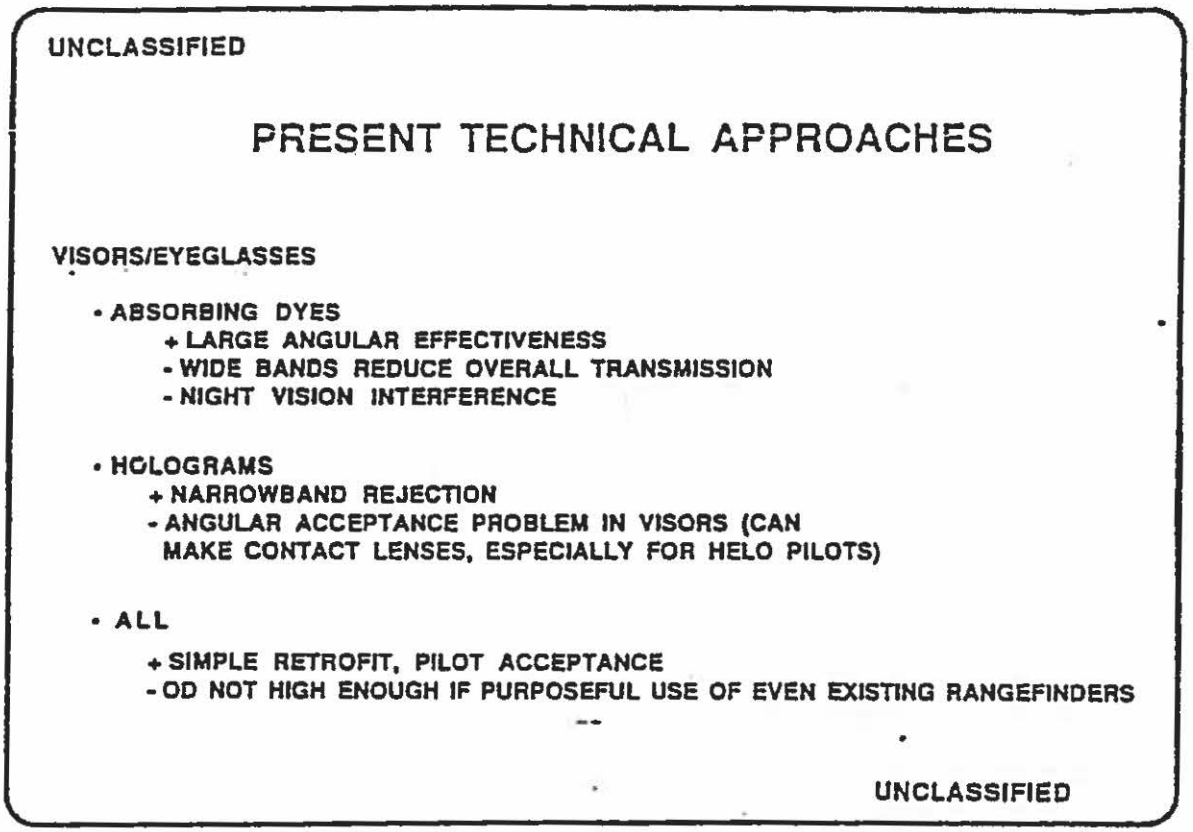

FIGURE 18.

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 "HIDE AND PEEK" MODE
  - REMOVE DIRECT VIEWING - HMD AND TV 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

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FIGURE 19.

POSSIBLE FUTURE APPROACHES (U)

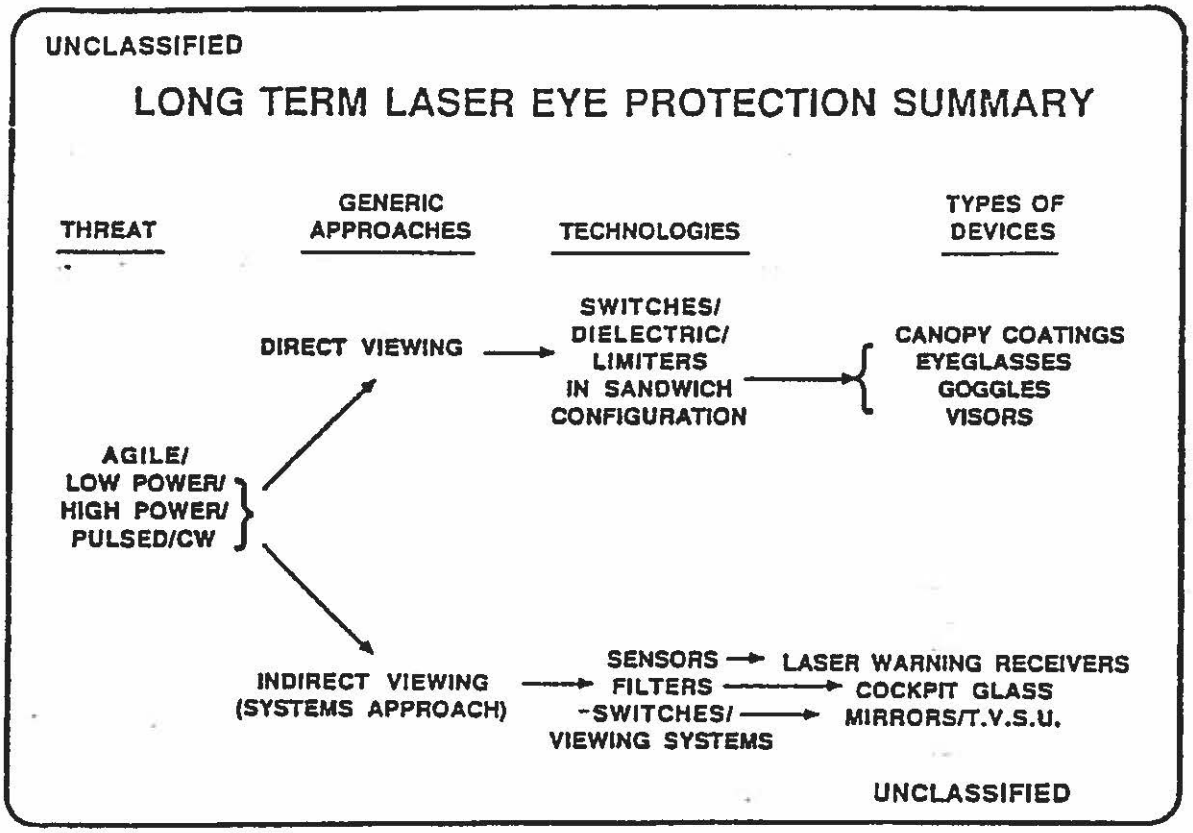

FIGURE 20.

LONG TERM LASER EYE PROTECTION SUMMARY (U)

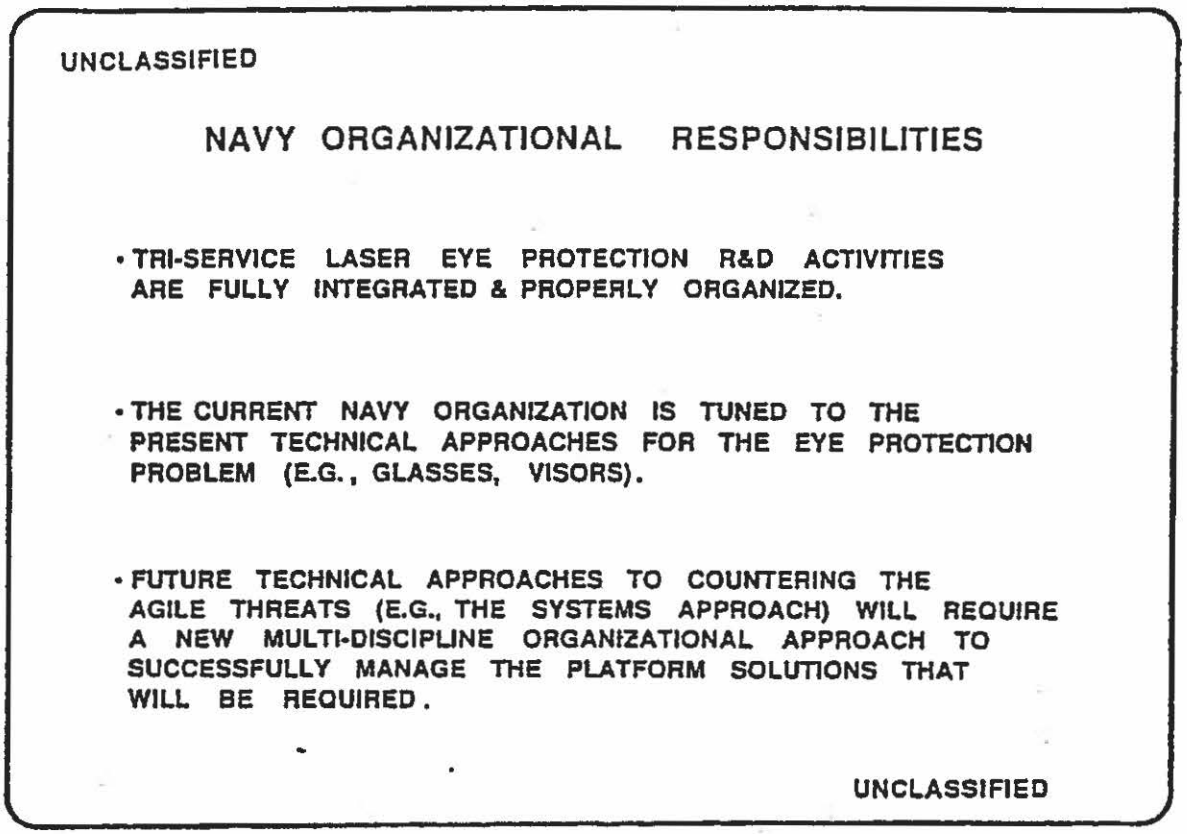

FIGURE 21.

NAVY ORGANIZATIONAL RESPONSIBILITIES (U)

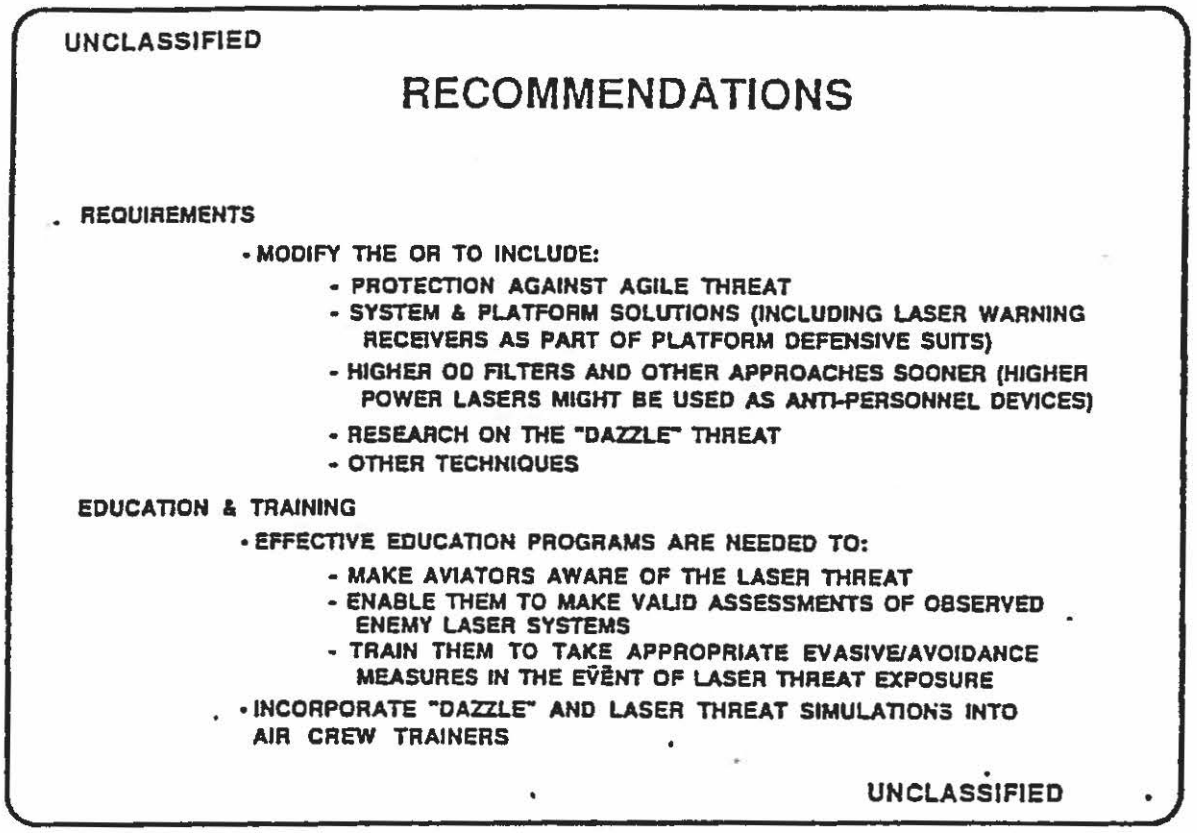

FIGURE 22.

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)