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INTERIM-NIGHT INTEGRATED GOGGLE HEAD TRACKING SYSTEM (I-NIGHTS) FINAL REPORT, VOLUME II: FLIGHT TEST PILOT SURVEY REPORT

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This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

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This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

KENNETH R. BOFF, Chief
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13. ABSTRACT *(Maximum 200 words)*

Helmet-Mounted displays (HMDs) and Night Vision Goggles (NVGs) are being developed for military aircrews. NVGs use image intensifier tubes to amplify ambient starlight thereby enhancing nighttime operations. HMDs present sensor video (infrared, low light TV, etc.) and critical mission data (flight information, weapon status, threat situation) directly to the crew member's eyes. The information remains within his field-of-view no matter where he turns his head. This permits traditional head-down tasks to be performed in a head-up mode. However, placing HMD/NVG technology on the helmet is not a simple task. Many safety related and human factors issues must be considered.

The United States Air Force's Interim-Night Integrated goggle and Head Tracking System (I-NIGHTS) Program addressed many of the safety and human factors issues while testing three I-NIGHTS Helmet designs. Testing had two primary objectives: a) to quantify system performance; b) to identify and quantify the risks of using HMD/NVGs on military aircraft; and c) investigate human factors related issues. This report summarizes the I-NIGHTS program, testing, and results.

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FOREWORD

This report summarizes the testing and results performed for the Interim-Night Integrated Goggle and Head Tracking System (I-NIGHTS) Program by the Helmet-Mounted Systems Technology (HMST) Office of the United States Air Force.

I-NIGHTS results are documented in two volumes. Volume I discusses the ground testing performed to quantify system characteristics, identify risks and assess safety for flight test. Volume II discusses the results from the flight test phase and subjective crew member comments.

This report, Volume II, is a summary of the I-NIGHTS flight evaluation. The report is divided into three sections. The EXECUTIVE SUMMARY contains the essence of the results from the flight evaluation. The EVALUATION SUMMARY contains a verbal description of the results of the data reduction. The QUESTIONNAIRE DATA (see appendix) contains a summation of the crew evaluation responses generalized by aircraft type and I-NIGHTS helmet vendor.

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LIST OF ABBREVIATIONS

ANVIS-6	Aviator's Night Vision System 6
CG	Center-of-Gravity
FOV	Field-of-View
FT	Feet
GEC	General Electric Company - Avionics
HMD	Helmet-Mounted Display
I-NIGHTS	Interim-Night Integrated Goggle and Head Tracking System
IPD	Interpupillary Distance
NVG	Night Vision Goggle
SMOTEC	Special Missions Operational Test and Evaluation Center
WT	Weight

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1. I-NIGHTS FLIGHT EVALUATION

EXECUTIVE SUMMARY

The Interim-Night Integrated Goggle and Head Tracking System (I-NIGHTS) program selected three helmet designs to investigate and evaluate ejection-safe criteria. Each helmet design combines night vision goggle (NVG) and helmet-mounted display (HMD) capabilities. Four operational helmets (two NVG and two HMD) were built by each of three contractors: GEC Avionics, Honeywell Inc., and Kaiser Electronics (Figures 1, 2 and 3). This summary presents the results of the first phase flight evaluation of the NVG portion of the helmets. The magnetic head tracker and HMD capabilities were not implemented due to aircraft avionics integration issues. This phase was conducted using two pilot, non-ejection seat aircraft (HC-130, MH-53 and MH-60). A final report was written by the Special Missions Operational Test and Evaluation Center (SMOTEC) and is included as Appendix C. The second phase consisted of higher risk, ejection seat aircraft (B-52) and will be reported separately (see Appendix D).

After completion of ground and laboratory testing, (see Volume I) the I-NIGHTS helmets were provided to aircrews for an operational evaluation. The purpose of this evaluation was to collect subjective data from potential users on the utility and capabilities of the various designs. The helmets were first provided to HC-130, MH-53, and MH-60 pilots. These aircraft were selected on the basis that they were lower risk, (two pilots and non-ejection seat) and that they would provide good human factors data since these pilots had extensive experience with NVGs. Each pilot was scheduled to fly two flights with each helmet. One flight was scheduled for a high illumination night (moonlight greater than 40% of a full moon) and one for a low illumination night (moonlight less than 40% of a full moon). In all cases the crews were experienced with the ANVIS-6 night vision system. During each flight one pilot and the safety observer used ANVIS-6

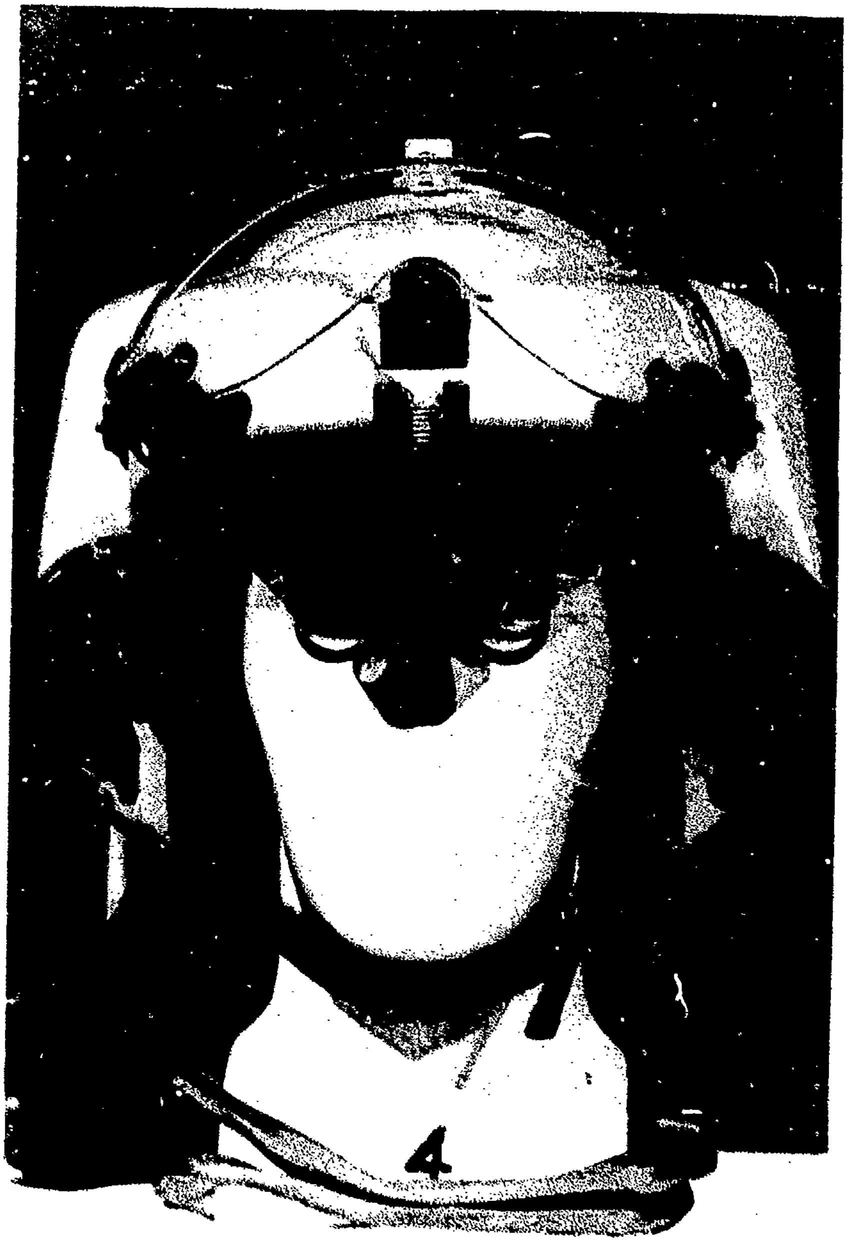


Figure 1. GEC I-NIGHTS Helmet

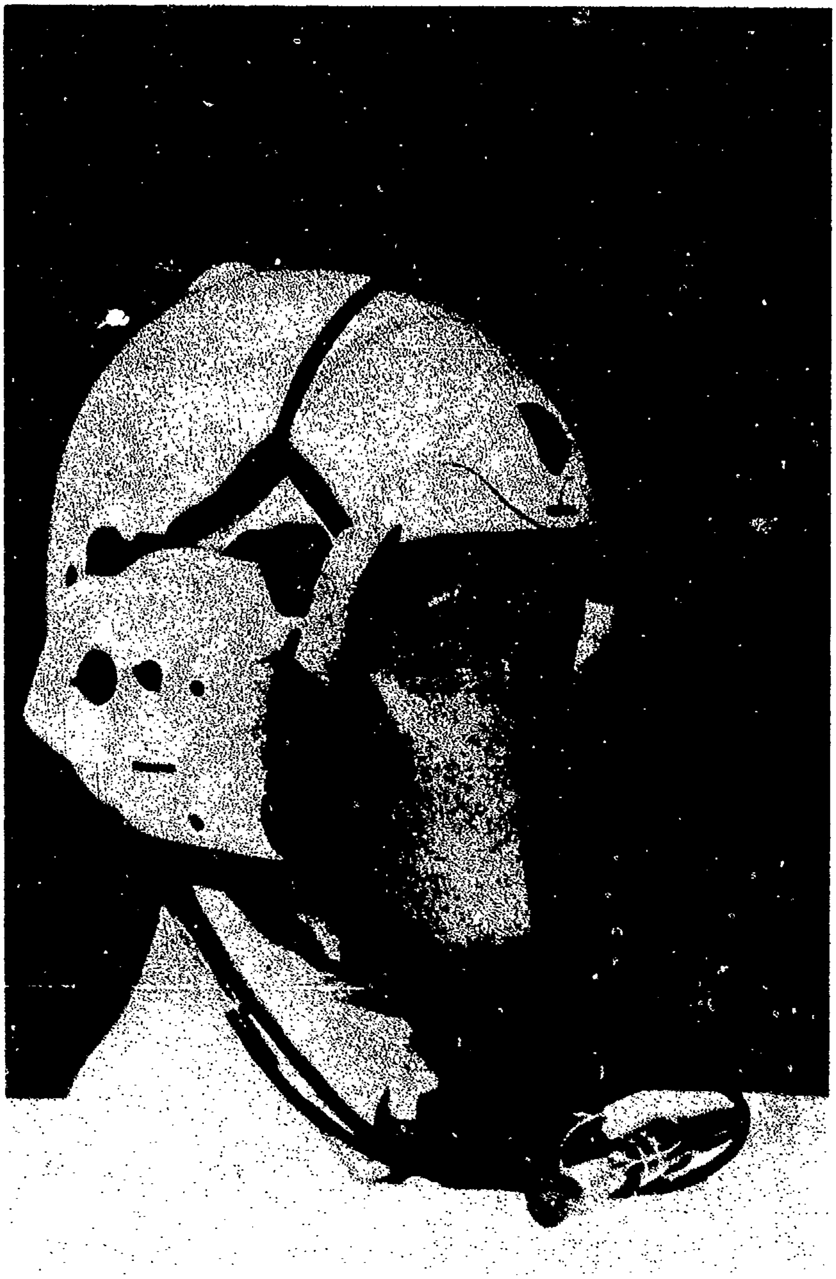


Figure 2. Honeywell I-NIGHTS Helmet

Figure 3. Kaiser I-NIGHTS Helmet

while the other pilot used an I-NIGHTS helmet. The evaluations were conducted via questionnaire (APPENDIX A). Questionnaires were completed before, during, and after each flight.

It should be noted that these evaluations were conducted using operational crews and not "test" pilots. The aircrews were given an overview of the program and briefed on the questionnaire. However, the evaluations may have been affected by the crew's overall perception of the helmet and their view of its acceptability as a replacement for ANVIS-6 rather than its acceptability as a HMD system concept. The flight evaluations provided valuable subjective data on the human factors aspect of the I-NIGHTS program.

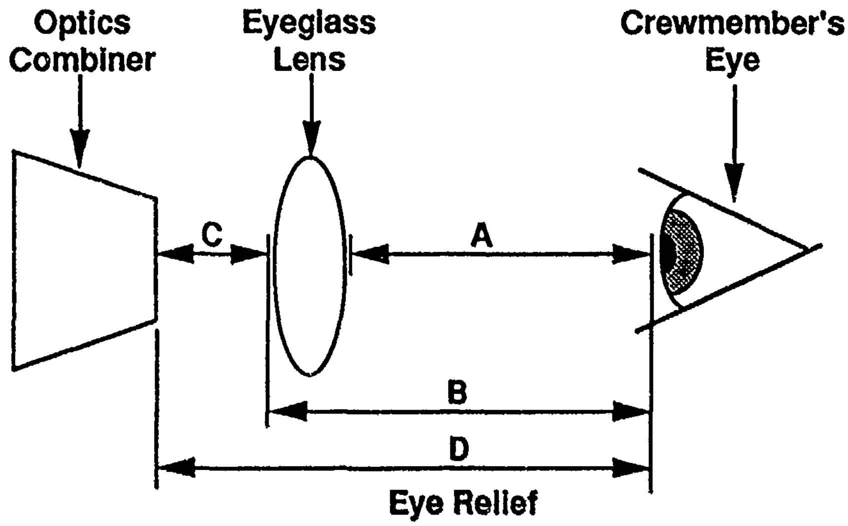
The major result from the flight evaluation is that helmet fit is a paramount factor in overall system performance. The term "helmet fit" includes comfort, stability, and optics alignment. It is essential that the optics remain in a precise position for the duration of helmet wear. This precise positioning is necessary to insure that the exit pupil of the optics is aligned with the pupil of the eye. For this evaluation only one size helmet was available - a size "large." This "one size fits all" approach did not provide helmets that were comfortable or stable for every test subject. Crews reported various degrees of slippage and hot spots with each helmet. The major design challenge is to provide a helmet that fits tight enough to maintain the optics (combiners) in a precise position while not being so tight as to be uncomfortable. The following paragraphs discuss several human factors items that should be addressed in future designs.

The GEC design had a large, padded nape pad in lieu of the customary strap. This pad received positive ratings from every pilot and significantly aided helmet rotational stability for those pilots receiving a "good" fit[1]. The Kaiser had crossed nylon straps (similar to an old football helmet) and received several negative comments.

The GEC design had fixed combiners (the optics could not be moved away from the eyes). This caused problems in both donning and doffing the helmet--especially for those pilots who wore glasses. There were many observations on compatibility with glasses. Almost all of the helmets received negative comments from one or more pilots about eye relief (Figure 4) (the distance from the combiners to the eyes) being too small; especially for pilots requiring glasses. In the case of the Kaiser helmet one pilot reported that the combiners caused his glasses to press painfully on the bridge of his nose. Additionally, all pilots stated the combiners need to be stowable. The Honeywell and Kaiser helmets had stowable combiners whereas the GEC helmet did not. The Honeywell combiners stowed in an up and out position extending beyond the contour of the helmet shell. Pilots noted that the Honeywell combiners would catch on things (communication cords, etc) and might hinder the crew member during emergency egress. The Kaiser helmet combiners required rotation through a compound angle to stow. This was noted as being awkward at first but acceptable. The conclusions for future design are that the combiners must accommodate glasses and must be stowable. The stowing must be a simple process and must not hinder or prevent egress.

The center-of-gravity (CG) is a significant factor in stability. The CG needs to be lower and more centered; as near as possible to the head's natural CG. The Kaiser and GEC helmets both have

[1]NOTE: The GEC helmet was later discovered to be the least "stable" due to the compressible nature of its comfort liner. As the G loading increased, the liner compressed permitting the optics to settle downward toward the pilot's cheeks, thus moving the exit pupil.



A = Vertex Distance

B = Vertex Distance Plus Lens Thickness

C = Distance Between Outer Surface Of The Eyeglass Lens And The Rear Surface Of The Optics Combiner.

D = Eye Relief: For The Purpose Of This Report, "Eye Relief" Is Considered As The Space From The Rear Surface Of The Optics Combiner To The Surface Of The Eye And Surrounding Facial Features. This May Differ From A Strict Clinical Definition Of Eye Relief.

Figure 4. Eye Relief

high, forward CGs. The GEC helmet received several negative comments about forward CG and resulting slippage (this necessitated the nape pad which greatly minimized rotational slippage). The Honeywell helmet was the best example of a low, centered CG design.

Another significant comment made by the pilots is the requirement for adjustability of the optics. The existing adjustments were for focus and interpupillary distance (IPD). Some of the adjustments required hand tools (screwdriver or allen wrench). The requirement for hand tools received strong negative comments in that it was difficult or impossible to make adjustments in flight. There were three other major comments: a) the focus adjustment should be more responsive -- make a change without requiring excessive inputs; and, b) additional adjustments are required -- there needs to be three axis optics adjustments: horizontal (IPD) (left/right), vertical (up/down), and eye relief (in/out) -- especially important for fitting glasses; c) The adjustments should be independent for each eye. Lastly, several pilots noted that in-flight adjustments were required for distant objects, even though the helmets were focused and adjusted in an eye lane prior to leaving life support.

This concept of optics adjustments being accessible in flight is not shared by the laboratory community. Their opinion is that once the optics are set, on the ground in an eye lane, that no further adjustments should be necessary.

Visual obstructions and audio qualities were also rated. The pilots noted that the helmets caused minor but acceptable obstructions to peripheral vision. The audio qualities: hearing, speaking, and noise attenuation were all rated as good or acceptable.

Although it was not the intent of the I-NIGHTS program to meet or exceed current NVG performance standards, the questionnaire also evaluated the crew member's perception of optical performance. Optical performance was judged in areas such as: intensified field-of-view, light transmission, scene resolution image distortion, etc. In general the optical performance was perceived as less than ANVIS-6. The Honeywell and Kaiser helmets both received good ratings on optical performance measures. There was no clear preference for one over the other. The GEC helmet generally received lower ratings on measures of optical performance. One other significant result is the requirement to view cockpit instruments (either NVG compatible or chem light illuminated) without the instrument lighting causing 'blooming' or double/triple images in the optics. A Summary of desirable and undesirable attributes of the three I-NIGHTS designs is included in Figure 5.

Two things should be noted in conclusion: First, the next phase of NVG helmet development should use a custom fit helmet to ensure maximum comfort and stability. Second, a review of the pilot responses should provide valuable data for writing a specification for future NVG helmet development. For example: the GEC nape pad design significantly enhanced helmet stability; the Honeywell optics offered a modular concept for easy maintenance; and the Kaiser helmet had a good design for stowing the optics.

	GEC	HONEYWELL	KAISER
DESIRABLE ATTRIBUTES	• Batteries On Helmet • Excellent Nape Pad • Good Under The Optics Peripheral Vision • Most Comfortable	• Stowable Combiners (Although Not To Best Position) • Modular Components • IPD Adjustment For Each Eye	• Stowable Combiner • Used Commercially Available Batteries • IPD Adjustment Independent For Each Eye • Most Stable (Up/Down Movement)
UNDESIRABLE ATTRIBUTES	• "Smoked" Colored Combiners • Nonstowable Combiners • IPD Adjustment Required Screw Driver • Least Stable (Up/ Down)	• Earcup Seal • Glare & Prism Effect Through Combiners • Poor Peripheral Vision In Lower Quadrants	• Cross Strap Nape Useless • Battery Pack - Large + Heavy • IPD Adjustment Required Allen Wrench • Least Comfortable • Least Stable (Rotational)

Figure 5. Summary of Attributes

2. I-NIGHTS PILOT SURVEY SUMMARY INTRODUCTION

2.1 Scope

The Interim-Night Integrated Goggle and Head Tracking System (I-NIGHTS) program selected three helmet designs to investigate and evaluate ejection-safe criteria. Each helmet design combined NVG and HMD capabilities. Four operational helmets (two NVG and two HMD) were built by each of three contractors: GEC Avionics, Honeywell, and Kaiser. This summary presents the results of the first phase flight evaluation of the I-NIGHTS NVG helmets. This phase was conducted using two pilot, non-ejection seat aircraft (HC-130, MH-53 and MH-60). A final report was written by the Special Missions Operational Test and Evaluation Center (SMOTEC) located at Hurlburt Field, FL and is included as Appendix C. The second phase consisted of higher risk, ejection seat aircraft (B-52) and will be reported separately (see Appendix D).

2.2 Overall Evaluation Focus

After completion of ground and laboratory testing, the I-NIGHTS helmets were provided to aircrews for an operational evaluation. The purpose of this evaluation was to collect subjective data from potential users on the utility and capabilities of the various designs. This phase of the evaluation was limited to the NVG portion of the helmet. The magnetic helmet tracking and HMD capabilities were not implemented due to aircraft avionic integration issues.

The helmets were first provided to HC-130, MH-53, and MH-60 pilots. These aircraft were selected on the basis that they were lower risk (two pilots and non-ejection seat) and that they would provide good human factors data since these pilots had extensive experience with NVGs. Each pilot was scheduled to fly two flights with each helmet. One flight was scheduled for a high illumination night (moonlight greater than 40% of a full moon) and one for a low illumination night (moonlight less than 40% of a full moon). In all cases the crews were experienced with the ANVIS-6 night vision system. During each flight one pilot and the safety observer used ANVIS-6 while the other pilot used an I-NIGHTS helmet. The evaluations of each system were conducted via questionnaire (Appendix A). Questionnaires were completed before, during, and after each flight.

2.3 Evaluation Factors

It should be noted that these evaluations were conducted using operational crews and not "test" crews. The crews were given an overview of the program and briefed on the questionnaire. However, evaluations may have been affected by the crew's overall perception of the helmet and their view of its acceptability as a replacement for ANVIS-6 rather than its acceptability as an HMD system concept. The flight evaluations provided valuable subjective assessments in the area of human factors. However, the small sample size prevents implying any statistical significance to the data.

2.4 Questionnaire Overview

The following paragraphs summarize the results of the questionnaires collected during the I-NIGHTS Flight Evaluation. The results are divided into two sections: HUMAN FACTORS and TECHNICAL FACTORS. The HUMAN FACTORS section deals with the form, fit, useability and acceptability of various aspects of the I-NIGHTS helmets. The TECHNICAL FACTORS section deals primarily with the optical performance of the various designs.

2.5 Questionnaire Scaling Description

The questionnaire the pilots filled out used four primary scales:

1) UNACCEPTABLE, BARELY UNACCEPTABLE, BORDERLINE, BARELY ACCEPTABLE, ACCEPTABLE

2) TERRIBLE, POOR, ONLY FAIR, GOOD, EXCELLENT.

3) YES, NO, Not Applicable and;

4) a few had unique scales such as LARGER THAN, SAME AS, SMALLER THAN.

For this report most of the responses have been translated to the second scale, TERRIBLE through EXCELLENT, for consistency and ease of comparison. However, in a few cases the UNACCEPTABLE to ACCEPTABLE scale was retained for descriptive purposes.

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3. HUMAN FACTORS

Human factors evaluations involve subjective assessments of the helmet systems under operational mission conditions. The crews were asked to assess the helmet designs in the performance of their missions. Although various design aspects from each helmet were noted as being particularly good or particularly bad, one of the most significant findings is that future helmets must maintain a "good" custom fit. The custom fit is necessary to ensure comfort, stability, and optics alignment. It became obvious as the questionnaires were compiled, that many of the negative ratings had their root cause in comfort or stability rather than the particular aspect being evaluated. For example, all of the helmets received lukewarm to negative ratings for extended wear (comfort), but the comments reveal such things as hot spots, slippage, and combiners pressing on glasses as the driving factor.

3.1 Overall Helmet Fit

Crew member ratings of helmet fit ranged from POOR to GOOD with GEC receiving the best ratings and Kaiser receiving the worst. Several pilots reported inserting additional padding in the Honeywell helmet to achieve a "good" fit. It should be noted that FIT may have been interpreted by the aircrews to mean only "comfort" rather than comfort, stability, and optics alignment. The helmet must be comfortable for prolonged wear; but must also be very stable to ensure precise alignment of the optics.

NOTE: During dynamic centrifuge testing up to +8Gs, the GEC system was shown to be the least stable helmet and Kaiser the most stable. The GEC I-NIGHTS helmet suffered from a compressible comfort liner. As the G loading increased the liner compressed permitting the optics to settle downward toward the pilots cheeks. This settling moved the helmet's exit pupil away from the pilot's eyes. The conclusion was that the GEC helmet is the most comfortable but the least stable while the Kaiser helmet is the least comfortable and the most stable. The Honeywell helmet seemed to fare the best across both categories.

3.2 Straps--Chin Strap and Nape Strap

None of the chin straps received high ratings (EXCELLENT or ACCEPTABLE). The Kaiser I-NIGHTS design received several negative comments regarding adjustability and ease of use. This was largely due to the implementation of the snap receiver strap. The receiver strap was extremely short, making it difficult to snap the chin strap.

The nape straps for Honeywell and GEC I-NIGHTS helmets were both rated good with the GEC design receiving several positive comments. The GEC design has more of a large pad rather than a nape strap and provided for good rotational stability. The Kaiser design was generally rated OK but received several very negative comments from the HC-130 crews. The Kaiser 'crossed strap' design was totally ineffective for one of the HC-130 pilots.

3.3 Ear Cups--Comfort, Seal, Noise Attenuation, Speech Intelligibility (Hearing/Speaking)

The ratings for earcup comfort ranged from POOR to GOOD. GEC generally received higher marks while both Honeywell and Kaiser received negative comments for hot spots around the earcup. All helmets received good ratings for earcup seal. In the areas of speech intelligibility and noise attenuation Honeywell and GEC consistently received good to excellent ratings. Kaiser received some lower ratings in the areas of hearing and noise attenuation. Despite the good ratings for earcup seal, the comments revealed that some pilots did not have a good seal with the Kaiser. It should be noted that all pilots stated that they wore ear plugs.

3.4 Helmet Donning and Doffing

The ratings for helmet donning and doffing spanned the spectrum, but there were some trends. The GEC received generally lower ratings. The comments indicated that this was due to the fixed combiners which scraped glasses. The Kaiser generally received ratings of EASY. The Honeywell helmet received ratings across the spectrum from DIFFICULT to BORDERLINE to EASY.

The pilots stated that the combiners for all systems scraped or had the potential to gouge their foreheads. This may be a "trainable skill" in that the more they don the helmet, the more accustomed they will become to it thereby minimizing the risk of injury. A second factor is that the minimal eye relief[2] made it difficult to don the helmet while wearing eye glasses.

3.5 Helmet Weight (WT) and Center-of-Gravity (CG), Weight & Center-of-Gravity Induced Fatigue, Slippage and Abnormal Head Movements

The Honeywell and Kaiser helmets both received good ratings for weight (WT) and center-of-gravity (CG) with the Honeywell enjoying a slight edge. Kaiser and Honeywell both received comments that the WT and CG were better than ANVIS-6. The GEC helmet received ratings from UNACCEPTABLE to ACCEPTABLE. The comments indicated that the CG for the GEC helmet was too far forward. The response to the extended wear, slippage and abnormal head movement questions for the GEC helmet were

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[2]Eye Relief: For the purpose of this report, "Eye Relief" is considered as the space from the rear surface of the NVG optics combiner to the surface of the eye and surrounding facial features. This may differ from a strict clinical definition of eye relief.

consistent with a slippage problem caused by a high, forward CG. The written comments for the slippage and head movement questions for the Honeywell helmet indicate that poor stability required frequent, minor adjustments to keep the image positioned correctly. The written responses to the same questions for the Kaiser helmet indicate that less slippage occurred but adjustments for comfort could not be differentiated from adjustments due to slippage.

3.6 Weight and Center-of-Gravity Induced Fatigue

The general response to this question was that the weight (WT) & center-of-gravity (CG) did not contribute significantly to fatigue. However, several crew members did respond giving times ranging from one to two hours for weight induced fatigue for the GEC and Kaiser helmets. The HC-130 crews commented that the Honeywell helmet was better than ANVIS-6 in this area.

3.7 Hot Spots and Temperature Build Up

None of the crews reported any temperature build up. Conversely most responded "yes" to the questions on hot spots. Some of the written responses were very negative, e.g., "...most uncomfortable helmet I've ever worn" (also see Kaiser helmet write up under helmet fit).

3.8 Batteries--Location, Operation, Indicator Light, and Access

The GEC batteries are located in the helmet. This received high ratings from all the pilots. Some crews noted that the GEC power switch was too small to operate with a gloved hand. One individual indicated that the door to the battery compartment on the GEC helmet should be attached to ensure that it does not separate from the helmet during battery replacement. There was one recorded battery failure (Honeywell helmet) and the indicator light did not function. The exact cause and circumstances cannot be determined but is considered to be an isolated incident. With the exception of this one case, the Honeywell helmet consistently received very good ratings[3]. On the other hand, the Kaiser system had some negative aspects. The Kaiser battery case is large and bulky and requires a screwdriver to change batteries. The case was attached to the survival vest and caused the cord to interfere with some movements. Crews liked the convenience of commercially available "AA" batteries for the Kaiser helmet.

3.9 Emergency Egress

The only problem noted for emergency egress was with the Honeywell helmet. The Honeywell system combiners in the stowed position protrude from the helmet. Several crews noted that the combiners could catch on objects in the aircraft and hinder egress. However, this was not considered serious enough to terminate further flight testing.

3.10 Ingress with Helmet or Donning after Ingress

Honeywell and Kaiser helmets received good ratings in this area. GEC received less than "Good" ratings. This probably relates to the previous comments regarding difficulties with donning the GEC helmet (see paragraph 3.4).

3.11 Head Movement Restriction, Canopy Clearance, Visual Obstructions

There were only two comments on this topic, they were: 1) An MH-53 crew reported that the Honeywell combiners (stowed position) caught the communication cord; and 2) An HC-130 crew

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[3]The Honeywell helmet used the same battery pack as used with ANVIS-6 which the crews were familiar and comfortable with.

reported that the Kaiser helmet hit the side window during scanning. Crews reported minor visual restrictions from stowed combiners, the helmet edge and various attachments (visors, masks, microphones etc.). Several crews reported restrictions from the GEC system combiners when the intensifiers were OFF due to the fact that the combiners could not be stowed.

3.12 Stowing and Unstowing Combiners

All crews stated that the combiners should be stowable. The GEC helmet was criticized because the fixed combiners made donning/doffing difficult and that it was less compatible with eye glasses. In all cases, the minimal eye relief (see Figure 4) contributed to the difficulty of stowing/unstowing combiners while wearing eye glasses. For the Honeywell helmet, the stowed position was rated marginal due to the combiners catching on other objects (communication cord) and possibly impairing emergency egress. The Kaiser helmet was rated better by comparison, but crews noted that the rotation through a compound angle required for stowing and unstowing was acceptable, but awkward at first.

3.13 Combiner Position

The general response to evaluations of combiner position was that the combiners were too close to the eyes. Several crews noted problems donning and doffing the GEC helmet with glasses (see previous comments 3.4 and 3.12). One crew reported the Honeywell system combiners pressed on his face. Two crew members reported the Kaiser system combiners pressed painfully on glasses while crews who didn't wear eye glasses noted that they would not be able to wear glasses. The conclusion is that combiners must accommodate glasses through basic position or through adjustments.

3.14 Adjustments

The only adjustments available inflight were IPD and objective lens focus. Almost all crews reported adjusting the focus in flight while a few reported making IPD adjustments. The comments indicate that even though pre-flight adjustments are made in an eye lane it is necessary to adjust focus inflight after the pilot acquired a distant object. Two of the helmets (Kaiser and GEC) required hand tools (allen wrench, screwdriver) for IPD adjustment. Aircrews commented that requiring hand tools for adjustments is unacceptable "...dumb..". Another comment was that the focus adjustment should be more responsive (requiring only a small movement to induce change). Some crews had reported trouble achieving a satisfactory focus. A few crews indicated the desire to have all adjustments available inflight (horizontal, (IPD) (left/right), vertical (up/down), eye relief (in/out)).

COMMENT: Several conclusions are evident from the responses to the controls questions:

1. Focus control is required.

2. The ratio of change in focus to degrees of turn needs further investigation.

3. Combiners must be adjustable to provide better eye relief.

4. Other in-flight adjustments may be required but it appears that this needs further investigation. In theory, if a comfortable, stable fit is achieved at Life Support then no further adjustments are needed. However, in practice, helmet instabilities, non-ideal

head shape, lack of proper eye lane facilities...lead to the need for in-flight adjustment capability.

5. Adjustments should NOT require hand tools.

3.15 Location and Operation of Power and Lighting Switches

The location of the GEC helmet power switch received good responses. The operation of the GEC helmet power switch received mixed reviews ranging from poor to good. The location of the GEC power switch was generally acceptable. The Honeywell and Kaiser helmet's power switches received mixed reviews for both location and operation. The power switches for both are located on the battery pack which was attached to the survival vest. With all the other items in and on the vest the crews may have had difficulty locating the switches. Optimal placement of the battery pack needs further investigation. This however is a "trainable skill" which should get easier with more experience.

3.16 Abnormal Eye Fatigue

The questions on abnormal eye fatigue received mixed responses. The negative responses may be due to stability problems -- inability to keep combiners in position. Eye fatigue is induced by the eyes having to cope with not having the optics in the "natural" viewing position. The crews reported fatigue onset times ranging from 30 minutes to two hours. Some crews commented however, that the eye fatigue was similar to that experienced with past NVG wear.

4. TECHNICAL FACTORS

4.1 Technology Relevance

The crews were requested to rate the relevance of the technology represented in each of the helmets. The GEC helmet received universal negative reviews. The comments listed several reasons: poor CG, marginal optical performance in low illumination and difficulty of adjustments. One crew provided an objective measure stating that the ANVIS-6 observer could detect objects at twice the range of the GEC I-NIGHTS system equipped pilot.

The Honeywell and Kaiser helmets received mixed reviews with a trend towards acceptance. Some of the HC-130 crews commented that the Honeywell weight and CG were better than GEC, Kaiser, and ANVIS-6. The Kaiser received negative comments on chin, nape strap, and CG (see paragraphs 3.2 and 3.5). The MH-53 crews commented that the field-of-view (FOV) of both Kaiser and Honeywell was too narrow for terminal operations.

4.2 Target Range

Range to target data was collected from all the aircrews based on their mission profiles, and it may be difficult to compare pilot responses between aircraft type. The HC-130 crews flew at altitudes from 1500 ft to 25,000 ft whereas the helicopter crews (MH-53, MH-60) flew at 0 ft to 500 ft. "Range to Target," whether in the air or on the ground, depends upon the amount of ambient light, whether the target was illuminated, and what type of light the target emitted. If the target has its own light source, it can generally be seen at greater ranges than unlighted targets. If the illuminated target was a city or small town, it can be seen at much greater ranges than a single point light source. Also, a small illuminated target in the infrared portion of the spectrum is easily detected at greater ranges than a "white" lighted target. The pilots did not always specify what the "target" was upon which they based their evaluation.

The HC-130 pilots estimated ranges of 50-60 miles for illuminated air targets (all helmets) and 40 miles for unlighted air targets. The HC-130 pilots estimated illuminated ground targets at about 50 miles (all helmets) and about 30 miles for the GEC helmet for unilluminated targets, but 40-50 miles for the Honeywell and Kaiser helmets. The helicopter pilots reported ranges between 0.5-7 miles for most targets. The helicopter pilots also reported that the ANVIS-6 equipped observer picked up targets at twice the range than the pilot wearing the GEC or Kaiser helmet. However, these reports are very subjective in nature. Future developments will need more objective measures: known targets, with known illuminations; and a measure of distance when the target is first detected and first identified.

4.3 Field-of-View Image with Intensifiers ON and OFF

The ratings for FOV varied widely. The GEC helmet was best with the intensifiers OFF ranging from a low "Fair" to a high "Excellent." The GEC helmet ratings decreased to "Poor" to "Fair" with the intensifiers ON. Honeywell helmet ratings ranged from "Terrible" to "Good" with intensifiers OFF and "Poor" to "Good" with intensifiers ON. Kaiser ranged from "Poor" to "Good" with intensifiers OFF or ON. For all cases, the MH-53 ratings were generally lower than the other two aircraft. Due to the variability of results in this area, it appears that a more objective measure is required to adequately evaluate FOV.

4.4 Light Transmission with Intensifiers ON and OFF

The GEC helmet generally rated lower for both conditions. This may be attributed to the fact that the GEC helmet see-through combiners were comparable to looking through a pair of sunglasses. The other two systems had clear combiners. (However, this should not have had any impact during times when the intensifiers were on since all the light is coming from the intensifiers and not "through" the combiners). The Honeywell helmet was generally rated slightly higher than the Kaiser helmet for the OFF condition, ranging from "Fair" to "Good" (Kaiser had a low of "Poor"). For the intensifiers ON condition, the Kaiser system ratings were grouped in the "Good" range while the Honeywell system ranged from "Poor" to "Good". MH-53 crews commented that none of the helmets provide enough light transmissivity with the intensifiers OFF. Again, due to the variability of results in this area, a more objective measure is required.

4.5 Brightness of the Intensified Image

The GEC helmet received relatively low ratings ("Terrible" to "Poor") with a comment that it was "Very Poor" under low illumination conditions. The Honeywell helmet received medium ratings ("Poor" to "Good") with a comment that the brightness of the image was slightly less than the ANVIS-6. The Kaiser helmet received the best overall ratings in this area, ("Fair" to "Good") and a comment that it was "about 85% of ANVIS-6." The ratings for the GEC helmet were tightly grouped. The others showed some variability.

4.6 Uniformity of the Intensified Scene

All helmets received generally good ratings in this area. The ratings were grouped from the low "Good" to low "Excellent" area.

4.7 Judgement of Relative Distance with Intensifiers ON and OFF

With the intensifiers OFF the ratings for all systems varied widely from a low of "Terrible" to a high of "Good" (no

"Excellent" ratings). There was no apparent trend and no apparent significant difference between the helmets. The overall average appears to be in the "Fair" range. With the intensifiers ON, the range of ratings was much tighter from "Poor" to "Good". Again, there appeared to be only small differences between the helmets; however, the Kaiser and Honeywell helmets appeared to have a slight edge over the GEC helmet.

4.8 Scene Distortions: Intensifiers ON and OFF; Intensifiers ON and OFF with Visor

Strictly from the ratings, the crews reported no distortions under all conditions; however, there was a notable comment. The helicopter pilots reported that the Kaiser helmet slightly magnified images creating the illusion of being lower than actual altitude. This became very apparent during landing where the pilot anticipated touchdown "at any moment" while he was actually still 3 to 4 feet in the air.

4.9 Scene Resolution (with and without Night Visor)

All crews reported "Good" scene resolution for the Kaiser with or without the night visor. The GEC helmet received "Poor" to "Fair" ratings without the visor and "Good" ratings with the visor. The Honeywell helmet received "Poor" to "Good" ratings with or without the visor. When compared with other ratings, it appears that the visors did not impact system performance.

4.10 Correlation Between Outside and Intensified Scene

The responses to this question were consistent across aircraft and across helmets. The rating was "Fair". None of the crews appeared to be impressed by this aspect of the helmets. The HC-130 crews commented that the Kaiser made objects appear closer than their actual distance. This coincides with other helicopter pilot comments that the Kaiser helmet magnified the scene slightly, giving false visual cues for landing (see paragraph 4.8). The slight magnification may not be a problem for normal flight operations, but it obviously affects landing. This effect is more detrimental for helicopter mission profiles.

4.11 Scene Size Compared to Real Scene

The predominant rating for the Honeywell helmet was that there was no change in scene size. The intensified scene had the same size and relationships as the real scene. There was no agreement on the GEC helmet. The Kaiser helmet was rated "same as" or "larger than." This is consistent with responses to other questions that indicated that the Kaiser system scene was slightly magnified.

4.12 Image Problems

The crews were asked to note image problems. These problems included: dark areas at the edge of the FOV; bright or sparkling areas at the edge of the FOV; constant flickering or bright spots; dark spots in FOV; honeycomb noise pattern; glare in combiners; reduced contrast in some areas of FOV; flashing; flickering; intermittent operation; scintillation; salt & pepper; snow. In general, the answer to all of these questions was "NO." There were some minor exceptions. All of the helmets received some comments regarding dark areas at the edge of the FOV--all were rated at least "Borderline Acceptable." Several crews noted glare in the combiners. The comments indicated that the source of the glare was instrument lighting. The GEC helmet had reduced contrast in some areas of the FOV. Comments indicated that this was due to wash out caused by ground lights. There was one comment from an HC-130 crew on the image fluctuating from dark to bright that was cured by pressing in on the combiners from the sides. A possible cause for this comment is an improperly adjusted IPD where the pilot had a very small tolerance to helmet movement. Pressing on the combiners, thus slightly changing the optics settings (IPD, eye relief), could afford better exit pupil alignment. Another possible cause is an intermittent electrical connection causing an I^2 tube to cycle on/off. The effect was not experienced by other crew members and could not be duplicated.

4.13 Blooming of the Intensified Scene

The crew members were asked if blooming occurred. The general answer to this question was "YES." This question also elicited a large number of comments. The comments indicated that any bright, external light caused blooming of the intensified scene. This apparently crossed over to the previous questions on dark areas. The blooming caused the scene to wash out, dimming all other aspects of the scene. The only solid "NO" (complete agreement) came from the HC-130 crews for the GEC and Honeywell helmets. This may be attributed to the higher altitudes flown by the HC-130 crews. Ground lights viewed from higher altitudes would be of lower intensity and therefore produce less blooming.

4.14 Ghosting or Double Imaging

The responses to this question were mixed. Some crews apparently had problems with ghost images while others did not. There was no apparent trend by helmet or aircraft type. The comments indicated glare rather than double image problems. However, the comments were consistent with those collected on the distortion question and the landing question (see paragraphs 4.8, 4.19).

4.15 Scene Focus

The general trend of responses was positive, but there were some exceptions. One of the HC-130 crews reported that both the GEC and Kaiser helmets focus degraded in 10-15 minutes. An MH-60 crew member reported that he never had a good focus with either the GEC or the Honeywell helmets. This again points out the need for good adjustments prior to flight.

4.16 Instrument Lighting

Some crews had NVG compatible instrument lighting (MH-60 & MH-53) while others (HC-130) use cyalume (also known as chem lights) to illuminate instruments. In general the crews found viewing instruments acceptable, but it appears from comments that some crew members may normally look under or around the NVG optics. The HC-130 crews commented that viewing instruments through the combiners on either the GEC or Kaiser helmets was impossible. However, the HC-130 crews reported that viewing instruments through the Honeywell combiners was excellent, and in fact a strong point for the design. The ability to see cockpit instruments through or around the combiners requires further investigation. It is necessary to view the instruments and the exterior environment with frequent shifts from one to the other. The design for future helmets should include the capability to switch rapidly and frequently from external to internal viewing without any degradation.

4.17 Viewing Instrument Panels Through Combiners (Dusk, Dawn, Night)

Few responses were received for the dusk & dawn sections of the questionnaire in regards to viewing instrument panels through combiners. For those responses received, (primarily helicopters) the GEC helmet rated "Low" for dusk conditions. The Honeywell and Kaiser helmets rated "Fair" to "Good." For dawn conditions, all helmets were rated "Good." For night conditions, the ratings varied widely. The GEC helmet received ratings from "Terrible" to "Good" and comments indicated that pilots had difficulty focusing on instruments. The Honeywell helmet received ratings from "Poor" to "Good." The HC-130 pilots reported the ability to view instruments through combiners as the best aspect of the Honeywell system design. The Kaiser helmet received ratings ranging from "Poor" to a low "Good." Comments indicated that crews looked under or around the combiners to view the instruments.

4.18 Reflections--Visor, Combiners, Canopy

There were a few reports of reflections in the combiners and on the windscreen/canopy. The source of the reflections was from non-NVG compatible cockpit lighting.

4.19 Use of Helmet for Takeoffs and Landings

The MH-60 and MH-53 pilots used the helmets for takeoffs and landings. They used the intensifiers for dusk and night conditions. For takeoff scenarios the GEC helmet was rated the lowest, the Honeywell helmet received moderate ratings, and the Kaiser helmet received good ratings. The crews noted that the GEC helmet was of marginal utility in low illumination conditions. The crews reported landing with the intensifiers both ON and OFF. The GEC helmet again received the lowest ratings with comments to the effect that it was marginal in low illumination conditions. The Honeywell helmet received mid-level ratings ("Borderline") with one comment that the pilot passed control to the other pilot due to inability to acquire visual cues. The Kaiser helmet received higher ratings ("Borderline" to "Barely Acceptable"). The slight magnification of the Kaiser helmet was again noted. The magnification makes it appear that you are closer to the ground than true altitude (see paragraph 4.8). The HC-130 crews did not use the intensified image for takeoffs or landings.

4.20 Spatial Disorientation

One HC-130 pilot reported an instance of spatial disorientation. The crew flew through cloud tops and the resulting glare flooded the combiners with light and caused vertigo. The pilot reverted to flying on instruments to eliminate the vertigo. However, this effect is inherent to all night vision systems under these conditions.

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5. CONCLUSIONS

5.1 General Comments

The major result from the flight evaluation is that helmet fit is a paramount factor in overall system performance. The term "helmet fit" includes comfort, stability, and optics alignment. It is essential that the optics remain in a precise position for the duration of helmet wear. This precise positioning is necessary to insure that the exit pupil of the optics is aligned with the pupil of the eye. For this evaluation, only one size helmet was available - a size "large." This "one size fits all" approach apparently did not provide helmets that were comfortable or stable for every test subject. Crews reported various degrees of slippage (requiring adjustment) and hot spots with each helmet. It appears that the major design challenge is to provide a helmet that fits tight enough to maintain the optics (combiners) in a precise position, while not being so tight as to be uncomfortable.

5.2 Design Specific Comments

There are several individual human factors items that should be noted for future designs.

5.2.1 Nape Strap

The NVG helmets, with their forward center-of-gravity, require a substantial stabilizing force in the nape area. The customary nape "strap" will not provide enough support to be effective. The GEC helmet had a large nape pad. This design received positive ratings from every pilot and significantly improved the rotational stability of the helmet. The Kaiser helmet would have greatly benefitted from this design.

5.2.2 Combiners

The GEC system design had fixed combiners (the optics could not be moved away from the eyes). This caused problems in both donning and doffing the helmet--especially for those pilots who wore glasses. There were many observations on compatibility with glasses. Almost all of the helmets received negative comments from one or more pilots about eye relief (the space between the combiners and the eyes) being too small; especially for pilots requiring glasses. In the case of the Kaiser helmet one pilot reported that the combiners caused his glasses to press painfully on the bridge of his nose. All pilots stated that combiners should be stowable. The Honeywell and Kaiser helmets had stowable combiners. The Honeywell helmet combiners stowed in an up and out position. Pilots noted that the Honeywell combiners would catch on things (communication cords, etc) and might cause a problem during emergency egress. The Kaiser helmet combiners required rotation through a compound angle to stow. This was noted as being awkward but acceptable. The conclusions for future design are that the combiners must accommodate glasses and must be stowable. The stowing should be simple and must not create additional hazards.

5.2.3 Center-of-Gravity

The CG appeared to be a significant factor in stability. The CG should be centered and low, as near as possible to the head's natural CG. The Kaiser and GEC helmets both appear to have high, forward CGs. The GEC helmet received several negative comments about forward CG and resulting slippage. To the contrary, the GEC helmet was normally rated to have a good fit due to its comfort.

5.2.4 Optics Adjustments

Another significant comment made by the pilots is the requirement for adjustability of the optics. The existing adjustments were for focus and IPD. Some of the adjustments required hand tools (screwdriver or allen wrench). The requirement for hand tools received strong negative comments in that it was difficult or impossible to make adjustments in flight. There were three other major comments: a) the focus adjustment should be more responsive -- make a change without requiring excessive inputs; b) there needs to be three axis optics adjustments: horizontal (IPD) (left/right), vertical (up/down), and eye relief (in/out) -- especially important for fitting glasses; c) The adjustments should be independent for each eye. Lastly, several pilots noted that in-flight adjustments were required for distant objects, even though the helmets were focused and adjusted in an eye lane prior to leaving life support.

This concept of optics adjustments being accessible in flight is not shared by the laboratory community. Those who had never flown feel that, once the optics are set, on the ground in an eye lane, that no further adjustments are needed.

5.2.5 Visual Obstructions

Visual obstructions and audio qualities were also rated by the aircrews. The pilots noted that the helmets caused minor but acceptable obstructions to peripheral vision. The audio qualities of hearing, speaking, and noise attenuation were all rated as "Good" or "Acceptable."

5.2.6 Comparisons to ANVIS-6

Although it was not the intent of the I-NIGHTS program to meet or exceed current NVG performance, the questionnaires also evaluated optical performance. In general, the optical performance was less than ANVIS-6. It appears as a result of the questionnaires that the aircrews feel that the optical performance is acceptable or near acceptable for all systems. The Honeywell and Kaiser helmets both received "Good" ratings on optical performance measures. There was no clear preference for one over the other. The GEC received lower ratings on measures of optical performance. Based on the responses to human factors type questions, the lower rating of the GEC helmet may be due to helmet liner compression problems rather than the optical design. One other significant result from optical path evaluations is the existence of a requirement to view instruments (either NVG compatible or chem light illuminated) without the instrument lighting causing "blooming" in the optics.

5.3 Final Conclusions

Two things should be noted in conclusion: 1) System optical performance is the ultimate "bottom line." The purpose for NVGs in the cockpit is to enhance mission effectiveness. The aircrews will tolerate short term discomfort for superior performance. Future night vision systems must meet or exceed the optical performance set by ANVIS-6 since this is the currently fielded system, or they will not be accepted by the aircrews. 2) Helmet fit is paramount to helmet-mounted NVGs. An NVG system may have the absolute best optical performance but, if optics alignment cannot be maintained under all operational conditions the aircrew and the mission will suffer.

Appendix A

Questionnaire

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AIR FORCE I-NIGHTS EVALUATION
INSTRUCTIONS SHEET

A. You are being asked to assist in the evaluation of the Air Force I-NIGHTS helmets. As a tester and future user of this type of helmet, your inputs are very valuable to this program. It is important for you to understand that **YOUR INPUTS** to this questionnaire will be **THE ONLY DOCUMENTED USER DATA AVAILABLE**. The Air Force will utilize this data to further assess the present helmets and establish future requirements.

The I-NIGHTS questionnaire is lengthy! The questionnaire covers many important issues for the organizations that are responsible for pilot safety, comfort and the flight integrity of the helmets.

Lengthy questionnaires typically discourage aircrews. We recognize that aircrew "ATTITUDE" (good) is crucial for obtaining quality data. **THE I-NIGHTS PROGRAM SINCERELY THANKS EACH OF YOU FOR YOUR TIME AND COOPERATION!!!!**

B. **DATA SHEET AND QUESTIONNAIRE:**

For each test flight and for each helmet, you will be required to complete a data sheet and a questionnaire. You will be recording important flight, weather, lighting and helmet information on the data sheet. If you fly more than one helmet per flight, you must fill out a data sheet and a questionnaire for each helmet.

If you fly more than one flight per night and fly the same helmet or different helmet(s), you will be required to complete a new data sheet and a questionnaire for each helmet worn during this new flight. This is required because lighting and flight conditions change significantly throughout the night. Changes in lighting, terrain, mission, fatigue level and weather will effect your evaluation of the helmets.

On the DATA SHEET, identify all the helmets you wore during your test flight, GEC, KAISER, HONEYWELL. You will need to record the helmet identification number on the DATA SHEET also. The ID# is usually marked on the helmet. If it is not, ask questionnaire administrator for the helmet ID#.

C. **COMPARISON QUESTIONNAIRE:** When you have completed the BIG questionnaires for all three helmets, you will be given a MUCH SMALLER questionnaire that will allow you to pick the "BEST" and "WORST" helmets regarding the major issues (e.g., weight, intensified image quality, etc.). This questionnaire is available for your review from your questionnaire administrator. You may want to familiarize yourself with the issues on the questionnaire so you can keep them in mind when evaluating the helmet independently.

D. **TIMELINESS:** It is very important that you complete each questionnaire immediately following the test flight in which you wore the helmets. Fresh data results in quality data!!

E. Please return all of your questionnaires to your administrator. **IF ALL ELSE FAILS, SEND THEM TO:** KIM LOKOS, 6510 TEST WING/DORN, EDWARDS AFB, CA 93523-5000. Phone #: (805)258-3522.

ORGANIZATION:

AIR FORCE I-NIGHTS DATA SHEET

NOTE: YOU MUST FILL OUT A DATA SHEET FOR EACH TEST FLIGHT AND HELMET

NAME: ________________. CREW POSITION: 1) PILOT 2) COPILOT 3) JUMPSEAT
TODAY'S DATE: ______ FLIGHT DATE: ______ AIRCRAFT: ________ TAIL# ______

OFFICE ADDRESS ________________________ PHONE #s: COMMERCIAL __________
________________________ AUTOVON __________

LOCATION OF FLIGHT:
STATE AND AIRBASE ________________ PAST NVG FLIGHT HOURS: ________
FLIGHT ROUTE ________________ PAST FLIR FLIGHT HOURS: ________

HELMET: 1) GEC-ID# ____ 2) KAISER-ID# ____ 3) HONEYWELL-ID# ____

****NOTE: YOU MUST FILL OUT A QUESTIONNAIRE FOR EACH HELMET WORN ****

LOCAL TAKEOFF TIME : ______ LANDING TIME: ______ TOTAL FLT TIME: ______
TIME OF DONNING THE HELMET: ______ TIME OF DOFFING THE HELMET: ______

AVERAGE MISSION AIRSPEED: ______ ALTITUDE MAX: ______ MIN: ______

WEATHER (WHEN WEARING THE HELMET): (CIRCLE ALL APPLICABLE CONDITIONS)
1) CLEAR 2) RAIN 3) SNOW 4) FOG 5) HAZY 6) COLD 7) WARM
8) CLOUDY 9) HUMID 10) DRY 11) OTHER: ________________
OTHER WEATHER CRITERIA (BLOWING DUST, SMOKE, ETC) ________________

TERRAIN TYPE (WHEN WEARING THE HELMET): (CIRCLE ALL APPLICABLE TYPES):
1) FLAT 2) ROLLING 3) MOUNTAINOUS 4) WATER 5) OTHER ________

SURFACE TYPE (CIRCLE ALL APPLICABLE TYPES): 1) FOREST 2) DESERT
3) PLAINS 4) ROCKS 5) SWAMP 6) GROUND VEGETATION 7) WATER
8) OTHER: ________________________

DESCRIBE THE MISSION ELEMENTS IN WHICH YOU USED THE HELMET (i.e, navigation, target detection, takeoff, landing, etc): ________________
____

DID YOUR COCKPIT HAVE NVG COMPATIBILE LIGHTING? YES/NO

MOON PHASE (PERCENT ILLUMINATED) WHEN WEARING THE HELMET (CIRCLE ONE):
1) NO MOON 2) < 19% 3) 20% - 40% 4) 41% - 70% 5) 71% - 100%

MOON ELEVATION WHEN WEARING THE HELMET (CIRCLE ONE): ELEVATION WAS .....
1) LESS THAN 29 DEGREES 3) BETWEEN 46 AND 70 DEGREES
2) BETWEEN 30 AND 45 DEGREES 4) BETWEEN 71 AND 90 DEGREES

IDENTIFY THE REPORTED VISIBILITY AT TAKEOFF (naked eye): __________
LOCAL TEMPERATURE: ________ LOCAL HUMIDITY: ________
IDENTIFY THE OFFICIAL TIME OF:
MOON RISE ______ MOON SET ______ SUNRISE ______ SUNSET ______

NAME OF OTHER AIRCREW MEMBERS:
1) ______________, 2) ______________, 3)
IF ANY OTHER CREW MEMBERS WORE NVGs, CIRCLE WHICH CREW MEMBER(S).

AIR FORCE I-NIGHTS QUESTIONNAIRE

NAME: ____________________ AIRCRAFT: ____________________
TODAY'S DATE: __________ FLIGHT TEST DATE: ____________________

IDENTIFY THE HELMET FOR WHICH THIS QUESTIONNAIRE IS BEING COMPLETED:
*** NOTE: YOU MUST FILL OUT A QUESTIONNAIRE FOR EACH HELMET ***

1) GEC-ID# ______ 2) KAISER-ID# _____ 3) HONEYWELL-ID# ____

How long did you wear this helmet (hrs/min) __________

INSTRUCTIONS: For questions that are to be evaluated on a scale, circle the scale value that best describes your assessment of the issue. Also, if you select a scale value less than "4", please provide a brief explanation for your evaluation in the space at the bottom of each page. For questions that require a "YES" or "NO", again, please provide a brief explanation for your evaluation. For issues that are not applicable to you, please circle "NA" (not applicable).

A. MISSION SPECIFICS

FOR QUESTIONS 1-3 YOU WILL BE EVALUATING ISSUES REGARDING THE INTEGRATION OF THE HELMET INTO YOUR SPECIFIC MISSION.

1. Is the technology presented in this helmet and the way in which it is packaged suitable for the missions you would most likely perform? YES/NO If NO, why? ____________________
____

2. Identify the approximate range in which you could identify targets at night while using the night vision device:
   a. Air targets (i.e., wingman, other aircraft): __________
   b. Ground targets (i.e., buildings, vehicle, etc): __________

3. Did you continuously move your head in a scan pattern to increase your field-of-regard? YES/NO.

COMMENTS (use back of paper for further comments): ______________
____
____
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____

B. HELMET COMFORT

FOR QUESTIONS 4-21 YOU WILL BE EVALUATING VARIOUS ISSUES REGARDING THE COMFORT OF THE HELMET.

PLEASE USE THE FOLLOWING SCALE TO EVALUATE QUESTIONS 4-10:

1. TERRIBLE 2. POOR 3. ONLY FAIR 4. GOOD 5. EXCELLENT

4. Evaluate the overall fit of the helmet liner.	1	2	3	4	5	
5. Evaluate the chin strap for: a. Fit.	1	2	3	4	5	
b. Adjustability	1	2	3	4	5	
6. Evaluate the nape strap for: a. Fit.	1	2	3	4	5	NA
b. Adjustability.	1	2	3	4	5	NA
7. Evaluate the comfort of the earcup.	1	2	3	4	5	
8. Evaluate the seal of the earcup.	1	2	3	4	5	
9. Evaluate the fit of the mask without visor.	1	2	3	4	5	NA
10. Evaluate the fit of the mask with the visor.	1	2	3	4	5	NA

11. Evaluate the ease of donning the helmet (circle one).
    1) Difficult 2) Borderline 3) Easy

12. Evaluate the ease of doffing the helmet (circle one).
    1) Difficult 2) Borderline 3) Easy

13. Circle the helmet configuration(s) you flew.
    a. Image intensifier tubes only.
    b. CRTs only.
    c. Image intensifier tubes and CRTs.

COMMENTS (use back of paper for further comments):

PLEASE USE THE FOLLOWING SCALE TO EVALUATE QUESTIONS 14-15.

1. UNACCEPTABLE
2. BARELY UNACCEPTABLE
3. BORDERLINE
4. BARELY ACCEPTABLE
5. ACCEPTABLE

14. For the helmet configuration you flew (in Question 13) evaluate the following:

a. Weight. 1 2 3 4 5

b. Center of Gravity (CG). 1 2 3 4 5

c. If the CG was not acceptable identify its location, (circle all applicable items).
1) fore 2) aft 3) left 4) right
5) too high 6) too low

15. Evaluate the helmet for extended wear 1 2 3 4 5

16. Did you experience slippage of the helmet that affected your ability to see through the combiners? YES/NO.

a. If yes, indicate the extent of the slippage.

1. slight 2. moderate 3. severe

b. What would have prevented the slippage?______________________
____

c. Did slippage require abnormal head movement or in flight adjustments to see through the combiners? YES/NO/NA. If yes, describe. ______________________________________
____

d. If you experienced slippage of the helmet, check all movements of the slippage.
_____ fore _____ fore with Gs _____ side-to-side rotation
_____ aft _____ aft with Gs

COMMENTS (use back of paper for further comments):______________
____
____
____
____
____
____
____
____
____
____

17. Did you experience any weight induced fatigue? YES/NO. If yes, after how long and where (e.g., neck fatigue, etc.)__________

18. Did you experience any CG induced fatigue? YES/NO. If yes, after how long and under what flight conditions. __________

19. Did you experience any G induced fatigue? YES/NO. If yes, after how long and under what flight conditions. __________

20. Did you experience any hot spots? YES/NO If yes, where and after how long. __________

21. Did you experience any helmet temperature build-up? YES/NO If yes, after how long. __________

C. HELMET OPERATION

FOR QUESTIONS 22 through 26 YOU WILL BE EVALUATING VARIOUS ISSUES REGARDING THE OPERATION OF THE HELMET.

22. Did the mask bayonet operate properly? YES/NO/NA. If NO, describe.__________

23. Did the mask bayonet receiver operate properly? YES/NO/NA. If NO, describe. __________

24. Did you experience any slippage of the mask? YES/NO/NA. If yes, describe what caused the slippage (e.g., G load, sweat, etc.)

25. Did you experience any difficulty with the visor controls/or in raising and lowering the visor? YES/NO/NA. If YES, describe

COMMENTS (use back of paper for further comments):__________

PLEASE USE THE FOLLOWING SCALE TO EVALUATE QUESTION 26.

1. UNACCEPTABLE
2. BARELY UNACCEPTABLE
3. BORDERLINE
4. BARELY ACCEPTABLE
5. ACCEPTABLE

26. Battery Pack:

a. Evaluate the location of the battery pack. 1 2 3 4 5

b. Evaluate the operation of the battery pack controls. 1 2 3 4 5

c. Evaluate the location of the low battery indicator light. 1 2 3 4 5 NA

d. Evaluate the access of the batteries. 1 2 3 4 5

e. Did the batteries fail in flight? YES/NO/NA. If YES, how many? 1 or 2 (circle one).

f. Was there adequate warning for pending battery failure? YES/NO/NA

D. AIRCRAFT/HELMET INTEGRATION

FOR QUESTIONS 27-37 YOU WILL BE EVALUATING VARIOUS ISSUES REGARDING THE INTEGRATION OF THE HELMET INTO YOUR AIRCRAFT.

27. Do you feel the helmet will interfere with emergency egress? YES/NO. If YES, explain.______________________________

____

28. Did the helmet interfere with any cockpit controls? YES/NO. If YES, identify which controls and panels.______________________________

____

____

29. Did you experience any head movement restriction? YES/NO. If YES, describe.______________________________

COMMENTS (use back of paper for futher comments):______________________________

____

____

____

____

____

____

____

____

PLEASE USE THE FOLLOWING SCALE TO EVALUATE QUESTIONS 30-32.

1. UNACCEPTABLE
2. BARELY UNACCEPTABLE
3. BORDERLINE
4. BARELY ACCEPTABLE
5. ACCEPTABLE

30. If you ingress the cockpit with the helmet on, evaluate the ease in which this can be accomplished.	1	2	3	4	5	NA
31. If you don the helmet after you ingress the cockpit, evaluate the ease in which this can be accomplished.	1	2	3	4	5	NA
32. Evaluate the placement of the helmet cable.	1	2	3	4	5	NA

PLEASE USE THE FOLLOWING SCALE TO EVALUATE QUESTIONS 33 and 34.

1. TERRIBLE 2. POOR 3. ONLY FAIR 4. GOOD 5. EXCELLENT

33. Evaluate the speech intelligibility of the helmet for:

a. Your ability to clearly hear others.	1	2	3	4	5
b. The ability of others to hear you.	1	2	3	4	5
34. Evaluate the helmet for cockpit noise attenuation.	1	2	3	4	5

35. Did you wear earplugs? YES/NO.

36. Did the helmet interfere with the seat? YES/NO. If YES, describe.

____

37. Was there sufficient canopy/cockpit clearance? YES/NO/NA. If NO, describe. ______________________

COMMENTS (use the back of paper for further comments): ____________

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E. COMBINERS

FOR QUESTIONS 38 through 60 YOU WILL BE EVALUATING VARIOUS ISSUES REGARDING THE HELMET OPTIC COMBINERS.

PLEASE USE THE FOLLOWING SCALE TO EVALUATE QUESTIONS 38-42.

1. TERRIBLE 2. POOR 3. ONLY FAIR 4. GOOD 5. EXCELLENT

38. Evaluate the FIELD OF VIEW (FOV) through the combiners for:						
a. DAY: Image intensifiers OFF	1	2	3	4	5	NA
b. NIGHT: Image Intensifiers OFF	1	2	3	4	5	NA
c. NIGHT: Image intensifiers ON	1	2	3	4	5	NA
39. Evaluate the ability to distinguish relative distances for:						
a. DAY: Image intensifiers OFF	1	2	3	4	5	NA
b. NIGHT: Image intensifiers OFF	1	2	3	4	5	NA
c. NIGHT: Image intensifiers ON	1	2	3	4	5	NA
40. Evaluate the LIGHT TRANSMISSION through the combiners for:						
a. DAY: Image intensifiers OFF	1	2	3	4	5	NA
b. NIGHT: Image intensifiers OFF	1	2	3	4	5	NA
c. NIGHT: Image intensifiers ON	1	2	3	4	5	NA
41. Evaluate the scene RESOLUTION through the following:						
a. DAY						
1. Combiners (no visor).	1	2	3	4	5	NA
2. Combiners with day visor.	1	2	3	4	5	NA
b. NIGHT						
1. Combiners (no visor)	1	2	3	4	5	NA
2. Combiners with night visor.	1	2	3	4	5	NA

COMENTS (use back of paper for further comments): ____________________

____

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____

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1. TERRIBLE 2. POOR 3. ONLY FAIR 4. GOOD 5. EXCELLENT

42. Evaluate viewing the instrument panels through the combiners during the following:

a. Day operations.	1	2	3	4	5	NA
b. Dusk operations.	1	2	3	4	5	NA
c. Dawn operations.	1	2	3	4	5	NA
d. Night operations.	1	2	3	4	5	NA

43. With the image intensifier tubes ON: Did you experience any DISTORTIONS through the following:

a. Combiners (visor up)? YES/NO/NA If YES, describe how much.

____

b. Visor and combiners? YES/NO/NA. If yes, describe how much.

____

44. With the image intensifier tubes OFF: Did you experience any DISTORTIONS through the following:

a. Combiners (visor up)? YES/NO/NA If YES, describe how much.

____

b. Visor and combiners? YES/NO/NA. If yes, describe how much.

____

COMENTS (use back of paper for further comments): ______________________________

PLEASE USE THE FOLLOWING SCALE TO EVALUATE QUESTIONS 45-53.

1. UNACCEPTABLE
2. BARELY UNACCEPTABLE
3. BORDERLINE
4. BARELY ACCEPTABLE
5. ACCEPTABLE

45. Did you utilize the helmet during takeoff? YES/NO.
    If yes, identify the conditions at takeoff:
    a. Intensifiers **ON**:
       _____ during dawn
       _____ during dusk
       _____ during night
    b. Intensifiers **OFF**:
       _____ during daytime
       _____ during dawn
       _____ during dusk
       _____ during night

    c. For the condition identified above, evaluate the ability to accomplish takeoffs with this helmet. 1 2 3 4 5

46. Did you utilize the helmet during landing? YES/NO.
    If yes, identify the conditions at landing:
    a. Intensifiers **ON**:
       _____ during dawn
       _____ during dusk
       _____ during night
    b. Intensifiers **OFF**:
       _____ during daytime
       _____ during dawn
       _____ during dusk
       _____ during night

    c. For the condition identified above, evaluate the ability to accomplish landings with this helmet. 1 2 3 4 5

47. Evaluate the overall position of the combiners in front of your eyes. 1 2 3 4 5

48. Evaluate the distance **BETWEEN** the **EYES** and the **COMBINERS** for your application.
    a. Without glasses. 1 2 3 4 5 NA

    b. With glasses. 1 2 3 4 5 NA

COMMENTS (use back of paper for further comments):______________________________

____
____
____
____
____
____
____
____
____
____

1. UNACCEPTABLE
2. BARELY UNACCEPTABLE
3. BORDERLINE
4. BARELY ACCEPTABLE
5. ACCEPTABLE

49. Evaluate the distance BETWEEN the EYES and the VISOR (combiners stowed) for your application.						
a. Without glasses.	1	2	3	4	5	NA
b. With glasses.	1	2	3	4	5	NA
50. Evaluate the ease of stowing the combiners.						
a. Pre-flight	1	2	3	4	5	NA
b. In-flight.	1	2	3	4	5	NA
51. Evaluate the ease of unstowing the combiners.						
a. Pre-flight.	1	2	3	4	5	NA
b. In-flight.	1	2	3	4	5	NA
52. Evaluate the operation of the following combiner adjustments:						
a. Inter-pupillary diameter. (Distance between the eyes).	1	2	3	4	5	
b. Vertical adjustment.	1	2	3	4	5	NA
c. Horizontal adjustment.	1	2	3	4	5	
d. Tilt.	1	2	3	4	5	NA
e. Focus.	1	2	3	4	5	
53. Evaluate the accessibility of the combiner adjustment controls:						
a. Inter-pupillary diameter. (Distance between eyes).	1	2	3	4	5	
b. Vertical adjustment.	1	2	3	4	5	NA
c. Horizontal adjustment.	1	2	3	4	5	
d. Tilt.	1	2	3	4	5	NA
e. Focus.	1	2	3	4	5	

COMMENTS (use the back of paper for further comments):____________

54. Did you adjust the combiners inflight? YES/NO.
   a. If YES, CIRCLE the adjustments you made:
      1. Inter-pupillary diameter.
      2. Vertical adjustment.
      3. Horizontal adjustment.
      4. Tilt.
      5. Focus
   b. Identify the reason for the adjustment: ____________________

   ____

   c. Indicate the ease in which this was accomplished:
      1) DIFFICULT, 2) BORDERLINE, 3) EASY

55. With the combiners UNSTOWED (combiners in front your eyes): Did you experience any visual restrictions (blind spots) due to the following:

   a. Combiners? YES/NO
      If YES, were the visual restrictions tolerable? YES/NO.
      Describe the percent of visual restriction.

      ____

   b. Mask? YES/NO/NA
      If YES, were the visual restrictions tolerable? YES/NO.
      Describe the percent of visual restriction.

      ____

   c. Visor? YES/NO/NA
      If YES, were the visual restrictions tolerable? YES/NO.
      Describe the percent of visual restriction.

      ____

   d. Helmet? YES/NO
      If YES, were the visual restrictions tolerable? YES/NO.
      Describe the percent of visual restriction.

      ____

   e. Boom Mic? YES/NO/NA
      If YES, were the visual restrictions tolerable? YES/NO
      Describe the percent of visual restriction.____ ____________

      ____

56. With the combiners STOWED **IF APPLICABLE**: Did you experience any visual restrictions (blind spots) due to the following:

   a. Combiners? YES/NO
      If YES, were the visual restrictions tolerable? YES/NO.
      Describe the percent of visual restriction.________________

      ____

   b. Mask? YES/NO/NA
      If YES, were the visual restrictions tolerable? YES/NO.
      Describe the visual restriction.____________________

      ____

c. Visor? YES/NO/NA
If YES, were the visual restrictions tolerable? YES/NO.
Describe the percent of visual restriction.________________
____

d. Helmet? YES/NO
If YES, were the visual restrictions tolerable? YES/NO.
Describe the percent of visual restriction.________________
____

e. Boom Mic? YES/NO/NA
If YES, were the visual restrictions tolerable? YES/NO
Describe the percent of visual restriction.________________
____

57. If the combiners were not stowable, should they? YES/NO/NA

58. Did the combiners interfere with the mask and its operation? YES/NO/NA

59. Did the combiners interfere with the visor and its operation? YES/NO/NA

60. With the image intensifier tubes OFF: Did you experience any scene distortion through the following:
a. Combiners (visor up)? YES/NO/NA If YES, describe how much.
____

b. Visor (combiners stowed)? YES/NO/NA. If YES, describe how much. ________________________________

c. Visor and combiners? YES/NO/NA. If yes, describe how much.
____

COMMENTS: (use the back of paper for further comments):______________

F. IMAGE INTENSIFIER TUBES/INTENSIFIED SCENE

FOR QUESTIONS 61 through 76 YOU WILL BE EVALUATING VARIOUS ISSUES REGARDING THE HELMET IMAGE INTENSIFIER TUBES AND THE INTENSIFIED SCENE.

PLEASE USE THE FOLLOWING SCALE TO EVALUATE QUESTION 61.

1. UNACCEPTABLE
2. BARELY UNACCEPTABLE
3. BORDERLINE
4. BARELY ACCEPTABLE
5. ACCEPTABLE

61. With the intensifiers ON, did you experience any of the following. If you answer "YES" please evaluate the degree of acceptability:

a. Dark areas at the edge of the FOV? YES/NO. If yes,	1	2	3	4	5
b. A bright or sparkling area at the outer portion of the FOV? YES/NO. If yes,	1	2	3	4	5
c. Flickering or constant bright spots across the FOV? YES/NO. If yes,	1	2	3	4	5
d. Dark spots in the FOV? YES/NO. If yes,	1	2	3	4	5
e. Honeycomb like noise pattern during high light levels? YES/NO. If yes,	1	2	3	4	5
f. Glare in the combiners? YES/NO. If yes,	1	2	3	4	5
g. Reduced contrast over some areas in the FOV? YES/NO. If yes,	1	2	3	4	5
h. Flashing, flickering, or intermittent operation? YES/NO. If yes,	1	2	3	4	5
i. Scintillation: salt & pepper/snow in the intensified scene. YES/NO, If yes,	1	2	3	4	5

62. Did you experience any blooming of the intensified scene? YES/NO If YES, identify the light source: INTERNAL OR EXTERNAL (circle one or both) and provide an explanation of the situation. ________________

COMMENTS: (use the back of paper for further comments):________________

PLEASE USE THE FOLLOWING SCALE TO EVALUATE QUESTIONS 63-65.

1. TERRIBLE 2. POOR 3. ONLY FAIR 4. GOOD 5. EXCELLENT

63. Evaluate the brightness of the intensified scene (image intensifier tubes ON). 1 2 3 4 5

64. Evaluate the brightness uniformity of the intensified scene. 1 2 3 4 5

65. Evaluate the correlation between the outside scene and the intensified scene. 1 2 3 4 5

PLEASE USE THE FOLLOWING SCALE TO EVALUATE QUESTIONS 66-67.

1. UNACCEPTABLE
2. BARELY UNACCEPTABLE
3. BORDERLINE
4. BARELY ACCEPTABLE
5. ACCEPTABLE

66. Evaluate the LOCATION OF the image intensifier tube POWER SWITCH. 1 2 3 4 5 NO

67. Evaluate the EASE OF OPERATING the image intensifier tube POWER SWITCH. 1 2 3 4 5 N

68. Did the intensified scene remain focused throughout the flight? YES/NO If NO, how long before the focus degraded? ____________

69. Did you experience any ghost or double imaging? YES/NO If YES, describe (e.g. location, which eye, etc ____________

____

70. Did the helmet retain proper fit to consistently maintain the scene? YES/NO. If NO, how long before degradation occurred?

____

71. Did G forces cause loss of the intensified scene? YES/NO If YE describe______________________________________

72. The scene registration appeared to be ____________ the real world scene. Complete the sentence by circling one of the following: A) LARGER THAN B) SMALLER THAN C) SAME AS

COMMENTS (use the back of the paper for further comments):__________

____

____

____

____

____

____

____

73. Did the intensified scene appear to be rotated properly? YES/NO
If NO, describe. ______________________________

74. Did you experience any abnormal eye fatigue? YES/NO. If YES, after how long? ______________________________

75. Did you experience any spatial disorientation? YES/NO.
If YES, under what flight conditions? ______________________________
____

What did you do to recover from the disorientation? ______________________________
____

If possible, identify the cause of the disorientation (e.g., limited FOV, scanning, G onset, etc.) ______________________________
____

76. Did the auto scene rejection (ASR) function properly? YES/NO/NA.
If NO, describe. ______________________________

G. LIGHTING

FOR QUESTIONS 77 THROUGH 82 YOU WILL BE EVALUATING VARIOUS ISSUES REGARDING THE LIGHTING COMPATIBILITY OF YOUR COCKPIT WHILE USING THE IMAGE INTENSIFIERS.

PLEASE USE THE FOLLOWING SCALE TO EVALUATE QUESTION 77.

1. UNACCEPTABLE
2. BARELY UNACCEPTABLE
3. BORDERLINE
4. BARELY ACCEPTABLE
5. ACCEPTABLE

77. Evaluate the location of the lighting power switch. 1 2 3 4 5 NA

78. Was the lighting of the instrument panels sufficient for viewing the intensified scene? YES/NO.
If NO, provide an explanation and any recommendations to correct the problem.
____
____
____

COMMENTS (use the back of the paper for futher comments): ______________________________
____
____
____
____
____
____
____
____

79. Was the HUD compatible with the night vision device? YES/NO/NA.
If NO, describe.____
____

80. Were there reflections in the VISOR? YES/NO/NA.
If YES, indicate the location and source.______________________

81. Were there reflection in the COMBINERS? YES/NO.
If YES, which one(s), location, and source.____________________
____

82. Were there reflections in the WINDSCREEN/CANOPY? YES/NO.
If YES, indicate the location and source.______________________
____

COMMENTS (use the back of the paper for further comments):____________

Appendix B
Questionnaire Results

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APPENDIX B

QUESTIONNAIRE RESULTS

INTRODUCTION

The following pages contain a summation of questionnaire data collected during the I-NIGHTS HC-130, MH-60 and MH-53 flight evaluations. The responses to the questions are presented in two major groups: **HUMAN FACTORS** and **TECHNICAL FACTORS.** These groups were reorganized from the original questionnaire (APPENDIX A) to provide a more appropriate order for study. The approach taken to display the data was selected as the best means to quantify the survey results. However, the sample size in this evaluation is NOT statistically significant (n = 12)[1] therefore, great care should be taken when drawing conclusions from these data.

The basic format of each page is: a) a statement of the question; b) an Initial Table of results; c) Pilot Comments; followed by, d) a Summary Table. Refer to Figure 1 as an example. The question at the top of each page is a restatement of the question from the questionnaire. The original question number is presented within parentheses to allow referencing to the questionnaire if so desired. Certain questions or sub-questions were not included since they did not add any information or simply due to non-response by the pilots. In the case of a few questions, there was no difference in responses from all the pilots so only the question and response are listed; without an Initial or Summary table. For example:

> I.C.5 Did the combiners interfere with the visor? (59)
>
> On all the flights, all the pilots either answered "NO" or "NOT APPLICABLE" therefore no table is presented.

The Initial Table on each page is constructed with the helmet vendor and aircraft type on the abscissa to provide a summary of the results of all flights for a given aircraft type. The ordinate axis provides the available responses to the question. In some cases, there are two ordinate responses; one on the left and one on the right. In this instance, the left ordinate indicated the percentage of pilots that answered a question as "YES" or "NO." The right ordinate indicates the evaluation of the situation in question for those pilots who, for example, answered the question "YES." Figure 1 provides a demonstration of this. Studying the Honeywell system ("HON"), 75% of the MH-60 pilots responded "YES" (read using the left

---

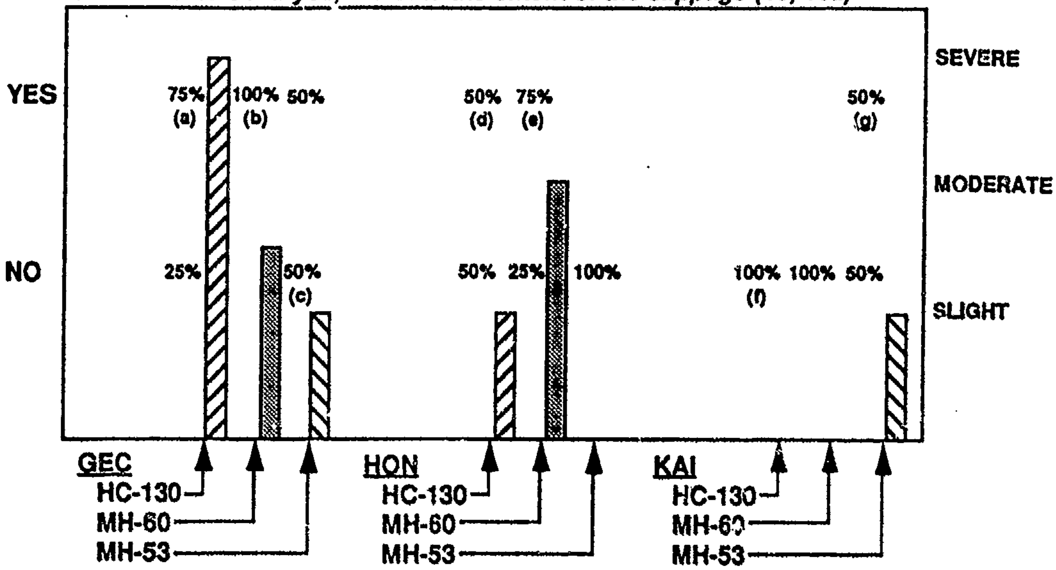
[1] "n" number of flights for each helmet system is approximately 12 = (2 test subjects * 2 flights * 3 aircraft types)

ordinate) that slippage of the helmet effected their ability to see through the combiners. Of those MH-60 pilots responding "YES" the composite response indicates the slippage was "MODERATE" (read using the right ordinate).

The Comments section provides significant comments recorded by the pilots regarding their response or extenuating circumstances.

The Summary Table on the bottom half of the page provides an aggregate result of the data by helmet vendor. This table attempts to examine the merit of each helmet system design and performance across the different aircraft types. Where applicable, the Summary Table data are normalized to the total number of test flights per helmet rather than to the sub-population that answered the survey question in a like manner. This will keep the percentages consistent with the percentages in the Initial Table.

I.A.14.a Did you experience slippage of the helmet that affected your ability to see through the combiners? If yes, indicate the extent of the slippage (16, 16a)



(NOTE: Read percentages from left scale, read bars/ovals from right scale.)

PILOT COMMENTS:

(a) Need to move CG aft for balance.

(b) Slippage due to head/mouth movement and aircraft vibration.

(c) Could not evaluate due to frequent adjustments for comfort.

(d) Could use better fit - repositioned every 3-5 minutes to maintain precise alignment.

(e) Used additional padding to get intensifiers in field of view.

(f) Good fit.

(g) Could not differentiate between comfort and slippage adjustments.

SUMMARY

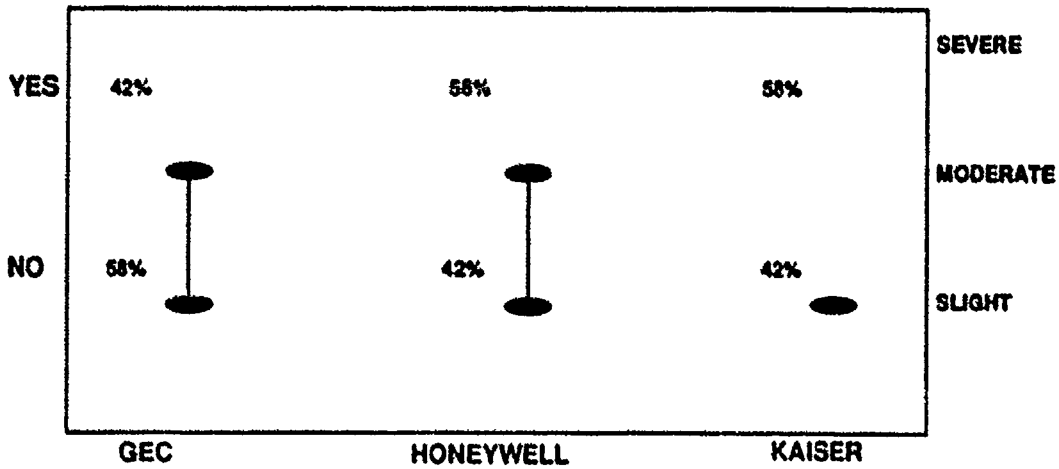


Figure 1. Question Response Example

I. HUMAN FACTORS

I.A HELMET COMFORT

I.A.1 Evaluate the overall fit of the helmet liner. (4)

I.A.2 CHIN STRAP (5)
I.A.2.a Evaluate the chin strap for fit. (5a)
I.A.2.b Evaluate the chin strap for adjustability. (5b)

I.A.3 NAPE STRAP (6)
I.A.3.a Evaluate the nape strap for fit. (6a)
I.A.3.b Evaluate the nape strap for adjustability. (6b)

I.A.4 Evaluate the comfort of the earcup. (7)

I.A.5 Evaluate the seal of the earcup. (8)

I.A.6 SPEECH INTELLIGIBILITY (33)
I.A.6.a Evaluate the speech intelligibility of the helmet for your ability to clearly hear others. (33a)
I.A.6.b Evaluate the speech intelligibility of the helmet for the ability of others to hear you. (33b)

I.A.7 Evaluate the helmet for cockpit noise attenuation. (34)

I.A.8 Did you wear ear plugs? (35)

I.A.9 Evaluate the ease of donning the helmet. (11)

I.A.10 Evaluate the ease of doffing the helmet. (12)

I.A.11 HELMET WEIGHT AND CENTER OF GRAVITY (14)
I.A.11.a For the helmet configuration you flew, evaluate the weight. (14a)
I.A.11.b For the helmet configuration you flew, evaluate the center of gravity. (14b)

I.A.12 Did you experience any center of gravity induced fatigue? If yes, after how long and under what flight conditions? (18)

I.A.13 Did you experience any weight induced fatigue? If yes, after how long and where (e.g. neck fatigue, etc.)? (17)

I.A.14 SLIPPAGE (16)
I.A.14.a Did you experience slippage of the helmet that affected your ability to see through the combiners? (16) If yes, indicate the extent of the slippage. (16a)
I.A.14.b Did slippage require abnormal head movement or inflight adjustments to see through the combiners? (Yes/No/NA) If you experienced slippage of the helmet, check all movements of the slippage. (16c, d)

I.A.15 Did the helmet retain proper fit to consistently maintain the scene? If NO, how long before degradation occurred? (70)

I.A.16 Evaluate the helmet for extended wear. (15)

I.A.17 Did you experience any hot spots? If YES, where and after how long? (20)

I.A.18 Did you experience any helmet temperature build-up? If YES, after how long? (21)

I.A.19 BATTERY PACK (26)
I.A.19.a Evaluate the location of the battery pack controls. (26a)
I.A.19.b Evaluate the operation of the battery pack controls. (26b)
I.A.19.c Evaluate the location of the low battery indicator light. (26c)
I.A.19.d Evaluate the access of the batteries. (26d)
I.A.19.e Did the batteries fail in flight? If YES, how many? (26e)
I.A.19.f Was there adequate warning for pending battery failure? (26f)

I.A.20 Evaluate the placement of the helmet cable. (32)

I.B AIRCRAFT/HELMET INTEGRATION

I.B.1 Do you feel the helmet will interfere with emergency egress? If YES, explain. (27)

I.B.2 Did the helmet interfere with any cockpit controls? If YES, identify which controls and panels. (28) NONE

I.B.3 If you ingress the cockpit with the helmet on, evaluate the ease in which this can be accomplished. (30)

I.B.4 If you don the helmet after you ingress the cockpit, evaluate the ease in which this can be accomplished. (31)

I.B.5 Did you experience any head movement restriction? If YES, describe. (29)

I.B.6 Did the helmet interfere with the seat? If YES, describe. (36)

I.B.7 Was there sufficient canopy/cockpit clearance? If NO, describe. (37)

I.B.8 UNSTOWED COMBINERS/BLIND SPOTS (55)

I.B.8.a With the combiners UNSTOWED (combiners in front of your eyes), did you experience any visual restrictions (blind spots) due to the combiners? If YES, were the visual restrictions tolerable? Describe the percent of visual restriction. (55a)

I.B.8.b With the combiners UNSTOWED (combiners in front of your eyes), did you experience any visual restrictions (blind spots) due to the mask? If YES, were the visual restrictions tolerable? Describe the percent of visual restriction. (55b)

I.B.8.c With the combiners UNSTOWED (combiners in front of your eyes), did you experience any visual restrictions (blind spots) due to the visor? If YES, were the visual restrictions tolerable? Describe the percent of visual restriction. (55c)

I.B.8.d With the combiners UNSTOWED (combiners in front of your eyes), did you experience any visual restrictions (blind spots) due to the helmet? If YES, were the visual restrictions tolerable? Describe the percent of visual restriction. (55d)

I.B.8.e With the combiners UNSTOWED (combiners in front of your eyes), did you experience any visual restrictions (blind spots) due to the boom mic? If YES, were the visual restrictions tolerable? Describe the percent of visual restriction. (55e)

I.B.9 With the combiners STOWED, if applicable, did you experience any visual restrictions (blind spots) due to the combiners? If YES, were the visual restrictions tolerable? Describe the percent of visual restriction. (56a)

I.C HELMET OPERATION

I.C.1	Did you experience any difficulty with the visor controls/or in raising and lowering the visor? If YES, Describe. (25)
I.C.2	If the combiners were not stowable, should they be? (57)
I.C.3	STOWING COMBINERS (50)
I.C.3.a	Evaluate the ease of stowing the combiners during pre-flight. (50a)
I.C.3.b	Evaluate the ease of stowing the combiners while inflight. (50b)
I.C.4	UNSTOWING COMBINERS (51)
I.C.4.a	Evaluate the ease of unstowing the combiners during pre-flight. (51a)
I.C.4.b	Evaluate the ease of unstowing the combiners while inflight. (51b)
I.C.5	Did the combiners interfere with the visor and its operation? (59)
I.C.6	Evaluate the overall position of the combiners in front of your eyes. (47)
I.C.7	DISTANCE BETWEEN EYES AND COMBINERS (48)
I.C.7.a	Evaluate the distance between the eyes and the combiners without glasses. (48a)
I.C.7.b	Evaluate the distance between the eyes and the combiners with glasses. (48b)
I.C.8	DISTANCE BETWEEN EYES AND VISOR (49)
I.C.8.a	Evaluate the distance between the eyes and the visors (combiners stowed) without glasses. (49a)
I.C.8.b	Evaluate the distance between the eyes and the visors (combiners stowed) with glasses. (49b)
I.C.9	OPERATION OF COMBINER ADJUSTMENTS (52)
I.C.9.a	Evaluate the operation of the inter-pupillary diameter (distance between the eyes) combiner adjustment. (52a)
I.C.9.b	Evaluate the operation of the combiner focus adjustments. (52e)
I.C.10	ACCESSABILITY OF COMBINER ADJUSTMENTS (53)
I.C.10.a	Evaluate the accessibility of the inter-pupillary diameter (distance between eyes) combiner adjustment control. (53a)
I.C.10b	Evaluate the accessibility of the combiner focus adjustment control. (52e)
I.C.11	Did you adjust the combiners in flight? If YES, indicate which adjustments you made and the ease in which this was accomplished. (54a,b,c)
I.C.12	Evaluate the location of the image intensifier tube power switch. (66)
I.C.13	Evaluate the ease of operating the image intensifier tube power switch. (67)

II. TECHNICAL FACTORS

II.A MISSION SPECIFICS

II.A.1 Is the technology presented in this helmet and the way in which it is packaged suitable for the missions you would most likely perform? (1)

II.A.2 IDENTIFY APPROXIMATE RANGE (2)

II.A.2.a Identify the approximate range in which you could identify air targets at night while using the night vision device (i.e., wingman, other aircraft, etc.). (2a)

II.A.2.b Identify the approximate range in which you could identify ground targets at night while using the night vision device (i.e., buildings, vehicles, etc.). (2b)

II.A.3 HELMET USE DURING TAKEOFF (45)

II.A.3.a Did you utilize the helmet (intensifiers ON) during takeoff? If YES, identify the conditions at takeoff. (45a)

II.A.3.b Did you utilize the helmet (intensifiers OFF) during takeoff? If YES, identify the conditions at takeoff. (45b)

II.A.3.c For the condition identified above, evaluate the ability to accomplish takeoffs with this helmet. (45c)

II.A.4 HELMET USE DURING LANDING (46)

II.A.4.a Did you utilize the helmet (intensifiers ON) during landing? If YES, identify the conditions at landing. (46a)

II.A.4.b Did you utilize the helmet (intensifiers OFF) during landing? If YES, identify the conditions at landing. (46b)

II.A.4.c For the condition identified above, evaluate the ability to accomplish landings with this helmet. (46c)

II.A.5 Did you experience any spatial disorientation? If YES, under what flight conditions? What did you do to recover from the disorientation? If possible, identify the cause of the disorientation (e.g., limited FOV, scanning, G onset, etc.). (75)

II.B COMBINERS

II.B.1 COMBINER FIELD OF VIEW (FOV) (38)
II.B.1.a Evaluate the FOV through the combiners with image intensifiers OFF. (38b)
II.B.1.b Evaluate the FOV through the combiners with image intensifiers ON. (38c)

II.B.2 COMBINER LIGHT TRANSMISSION (40)
II.B.2.a Evaluate the light transmission through combiners with image intensifiers OFF. (40b)
II.B.2.b Evaluate the light transmission through combiners with image intensifiers ON. (40c)

II.B.3 COMBINER DISTORTIONS (44)
II.B.3.a With the image intensifier tubes OFF, did you experience any distortions through the combiners (visor up)? If YES, describe how much. (44a)
II.B.3.b With the image intensifier tube OFF, did you experience any distortions through the visor and combiners? If YES, describe how much. (44b)

II.B.4 COMBINER DISTORTIONS (60)
II.B.4.a With the image intensifier tubes OFF, did you experience any scene distortion through the combiners (visor up)? If YES, describe how much. (60a)
II.B.4.b With the image intensifier tubes OFF, did you experience any scene distortion through the visor (combiners stowed)? If YES, describe how much. (60b)
II.B.4.c With the image intensifier tubes OFF, did you experience any scene distortion through the visor and combiners? If yes, describe how much. (60c)

II.B.5 Did you experience any abnormal eye fatigue? If YES, after how long? (74)

II.B.6 COMBINERS/INSTRUMENT PANELS (42)
II.B.6.a Evaluate viewing the instrument panels through the combiners during dusk operations. (62b)
II.B.6.b Evaluate viewing the instrument panels through the combiners during dawn operations. (62c)
II.B.6.c Evaluate viewing the instrument panels through the combiners during night operations. (62d)

II.B.7 Were there reflections in the visor? If YES, indicate the location and source. (80)

II.B.8 Were there reflections in the combiners? If YES, which ones(s), location, and source. (81)

II.B.9 Were there reflections in the windscreen/canopy? If YES, indicate the location and source. (82)

II.C IMAGE INTENSIFIER TUBES/INTENSIFIED SCENE

II.C.1 INTENSIFIER TUBE PHENOMENA (61)

II.C.1.a With the intensifiers ON, did you experience dark areas at the edge of the FOV? If you answer "YES" please evaluate the degree of acceptability. (61a)

II.C.1.b With the intensifiers ON, did you experience a bright or sparkling area at the outer portion of the FOV? If you answer "YES" please evaluate the degree of acceptability. (61b)

II.C.1.c With the intensifiers ON, did you experience flickering or constant bright spots across the FOV? If you answer "YES" please evaluate the degree of acceptability. (61c)

II.C.1.d With the intensifiers ON, did you experience dark spots in the FOV? If you answer "YES" please evaluate the degree of acceptability. (61d)

II.C.1.e With the intensifiers ON, did you experience honeycomb like noise pattern during high light levels? If you answer "YES" please evaluate the degree of acceptability. (61e)

II.C.1.f With the intensifiers ON, did you experience glare in the combiners? If you answer "YES" please evaluate the degree of acceptability. (61f)

II.C.1.g With the intensifiers ON, did you experience reduced contrast over some areas in the FOV? If you answer "YES" please evaluate the degree of acceptability. (61g)

II.C.1.h With the intensifiers ON, did you experience flashing, flickering, or intermittent operation? If you answer "YES" please evaluate the degree of acceptability. (61h)

II.C.1.i With the intensifiers ON, did you experience scintillation: salt & pepper/snow in the intensified scene? If you answer "YES" please evaluate the degree of acceptability. (61i)

II.C.2 Did G forces cause loss of the intensified scene? If YES, describe. (71)

II.C.3 Did you experience any blooming of the intensified scene? If YES, identify the light source (internal or external) and provide an explanation of the situation. (62)

II.C.4 Did you experience any ghost or double imaging? If YES, describe (e.g. location, which eye, etc). (69)

II.C.5 Did the intensified scene remain focused throughout the flight? If NO, how long before the focus degraded? (68)

II.C.6 Evaluate the brightness of the intensified scene (image intensifier tubes ON). (63)

II.C.7 Evaluate the uniformity of intensified scene (image intensifier tubes ON). (64)

II.C.8 DISTINGUISH RELATIVE DISTANCES (39)

II.C.8.a Evaluate the ability to distinguish relative distances with image intensifiers OFF. (39b)

II.C.8.b Evaluate the ability to distinguish relative distances with image intensifiers ON. (39c)

II.C.9 SCENE DISTORTION (43)

II.C.9.a With the image intensifier tubes ON, did you experience any distortions through the combiners (visor up)? If YES, describe how much. (43a)

II.C.9.b With the image intensifier tubes ON, did you experience any distortions through the visor and combiners? If YES, describe how much. (43b)

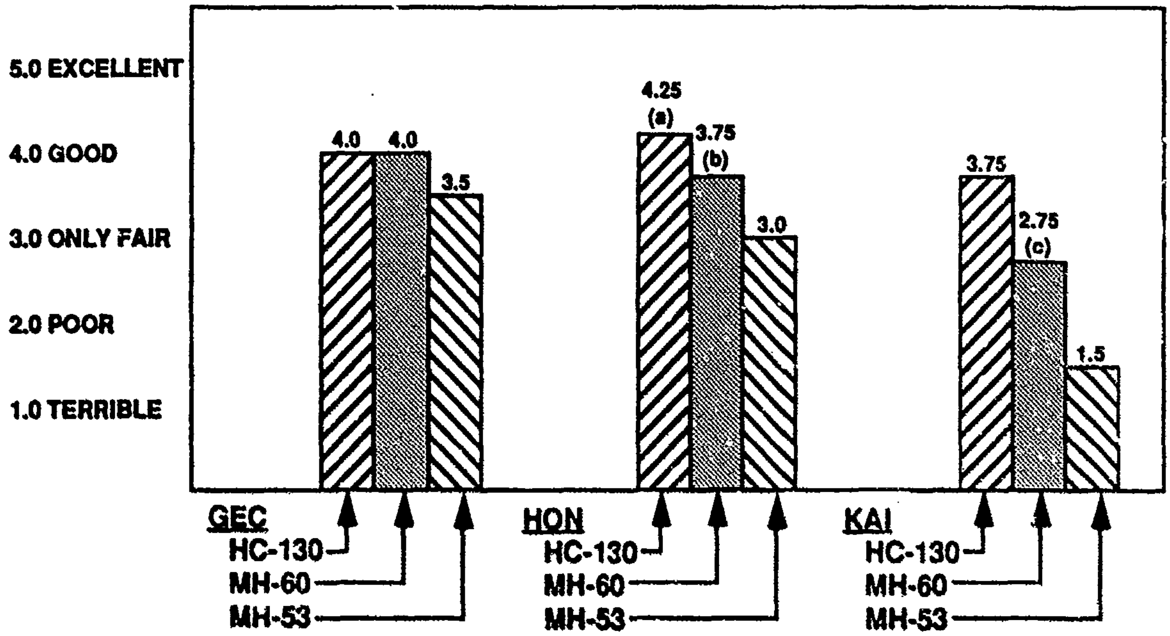
II.C.10 Did the intensified scene appear to be rotated properly? If NO, describe. (73)

II.C.11 Evaluate the scene resolution at night through the combiners, without the visor. (41b 1)

II.C.12 Evaluate the corre' 'ion between the outside scene and the intensified scene. (65)

II.C.13 The scene registration appeared to be (larger than/same as/smaller than) the real world scene. (Select one). (72)

I.A.1 Evaluate the overall fit of the helmet liner. (4)



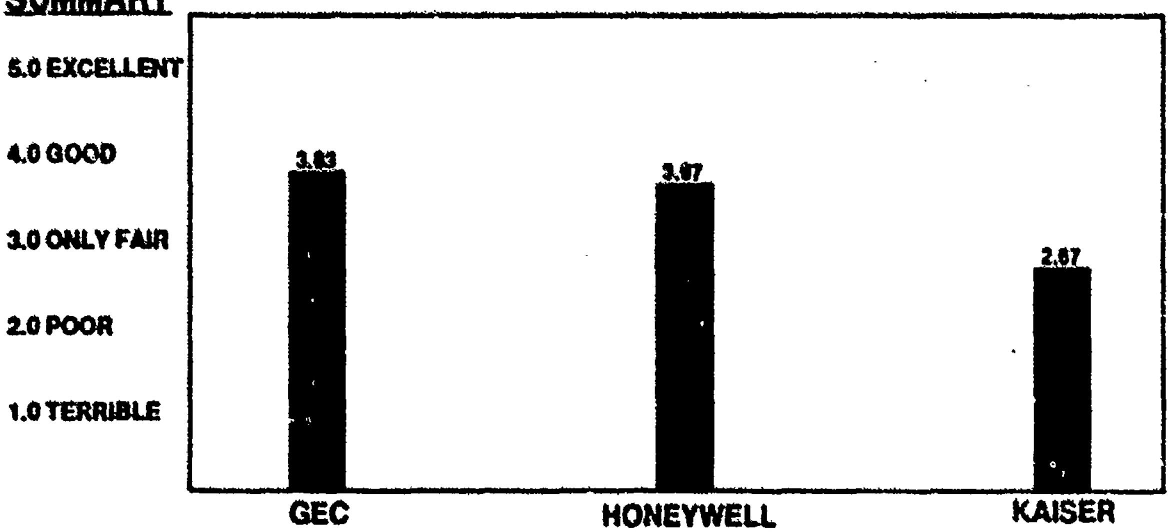
PILOT COMMENTS:

(a) Added pad in front to snug up and provide room for glasses.

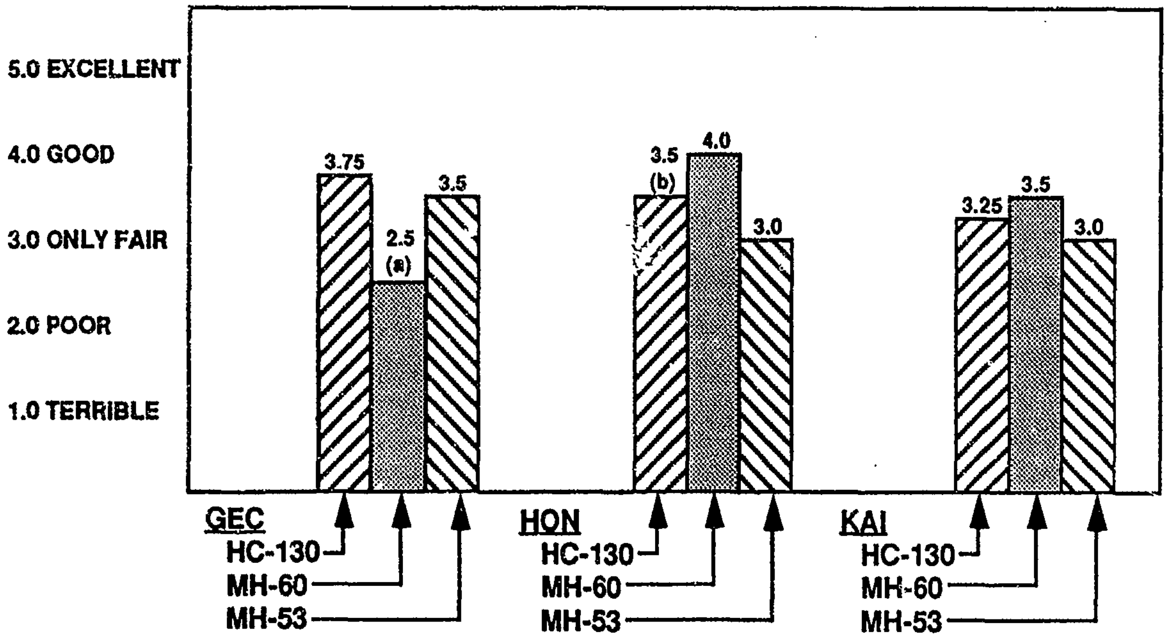
(b) Needed additional padding to get intensifiers into FOV.

(c) Hot spot on temple after 45 minutes.

SUMMARY



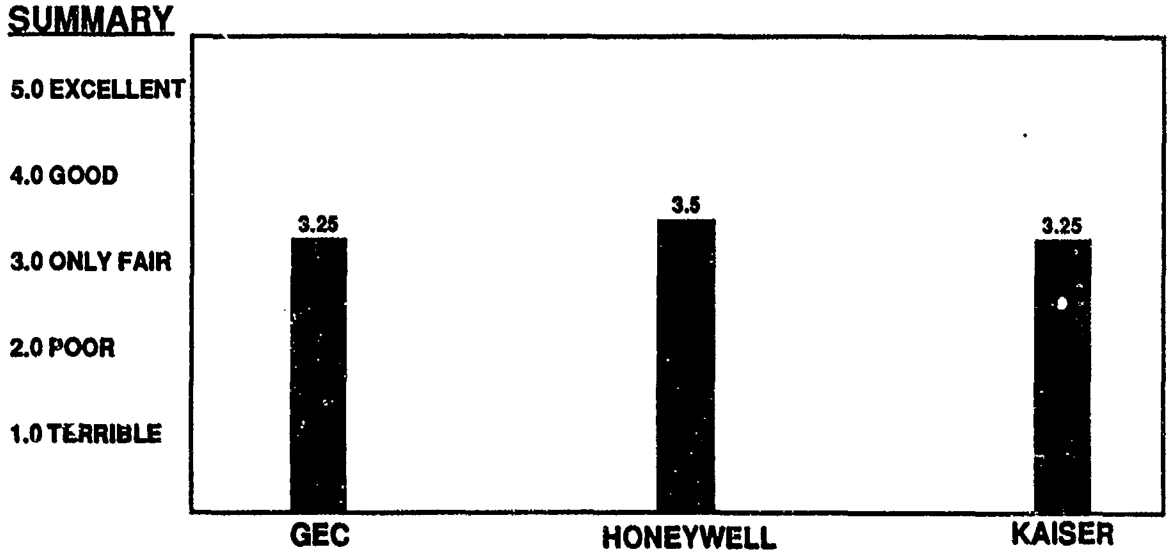
I.A.2.a Evaluate the chin strap for fit. (5a)



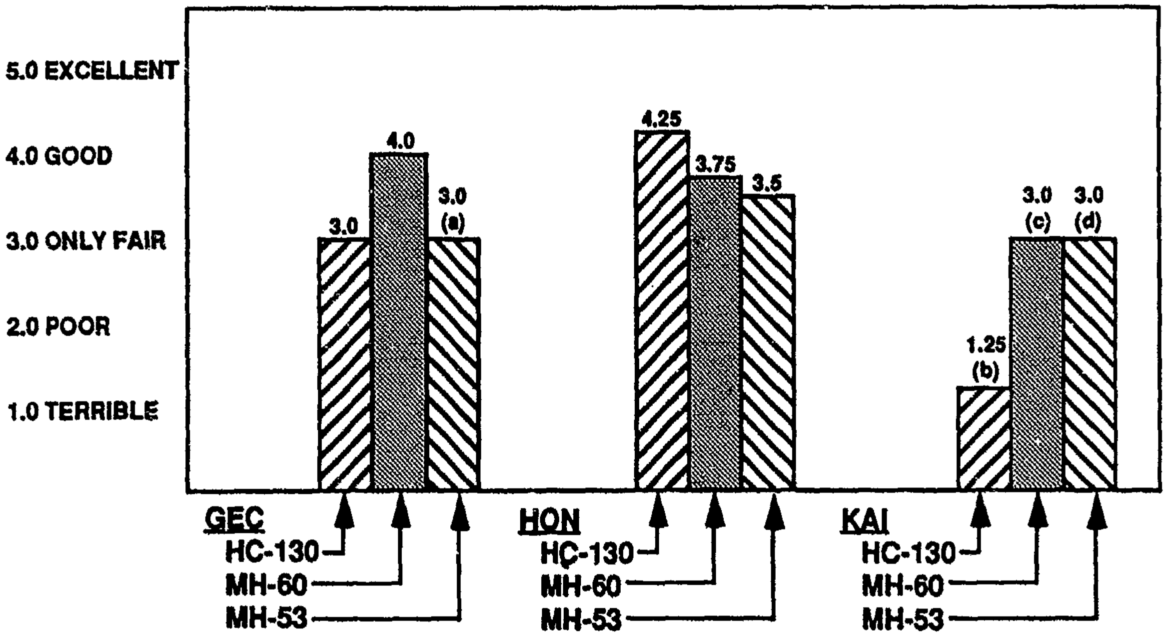
PILOT COMMENTS:

(a) Replace with standard jaw strap.
(b) Too far forward, needs like nape.

SUMMARY



I.A.2.b Evaluate the chin strap for adjustability. (5b)



PILOT COMMENTS:

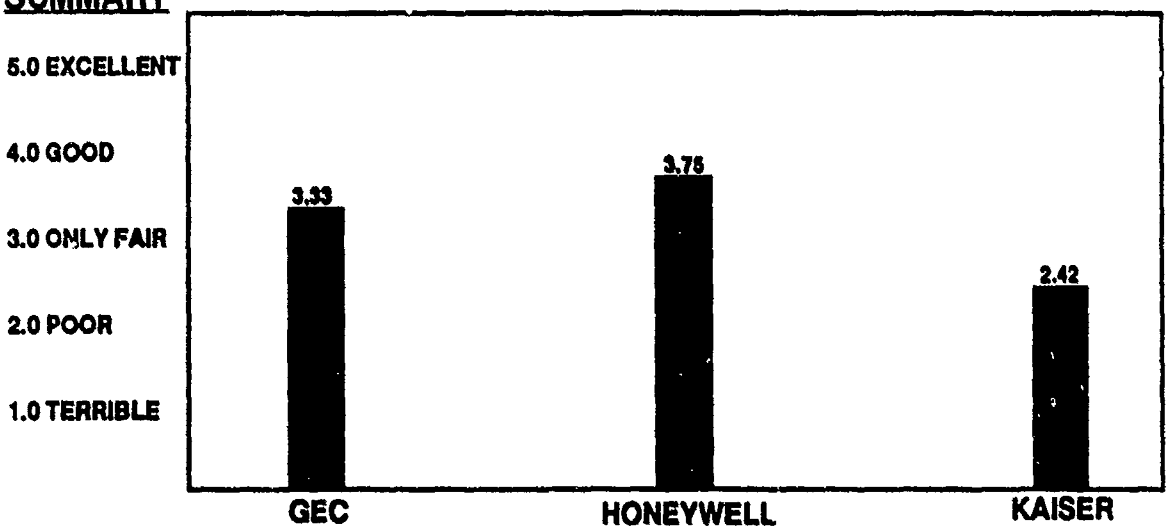
(a) Unsatisfactory, took over one minute to remove.

(b) Attachment too short, too far in shell.

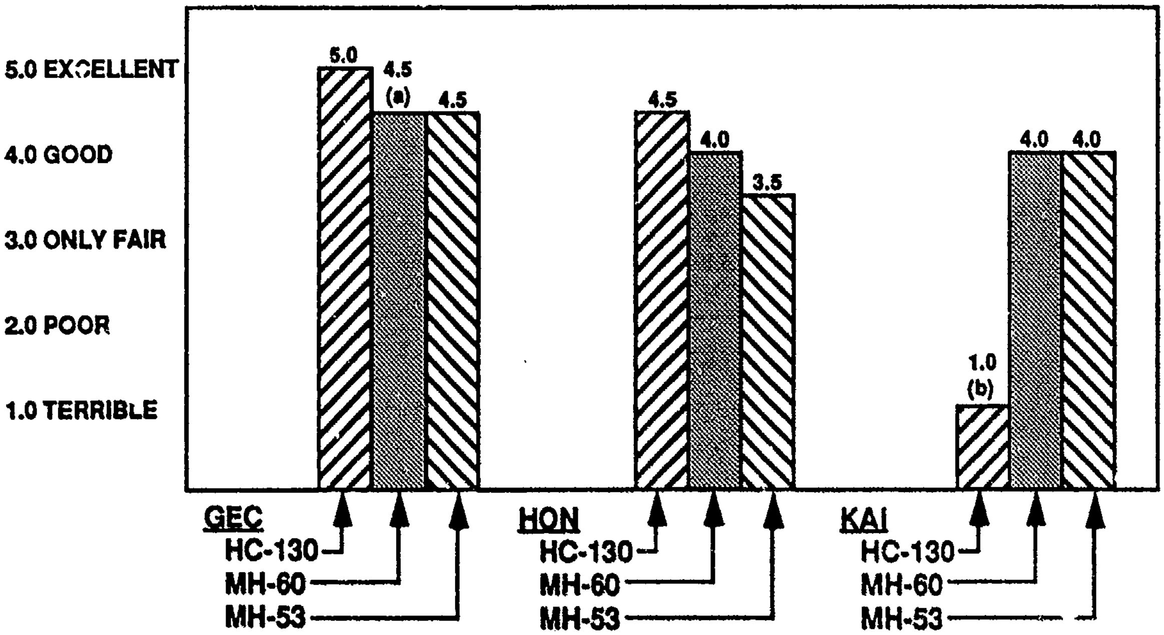
(c) Too short, both ends.

(d) Leads too short.

SUMMARY



I.A.3.a Evaluate the nape strap for fit. (6a)

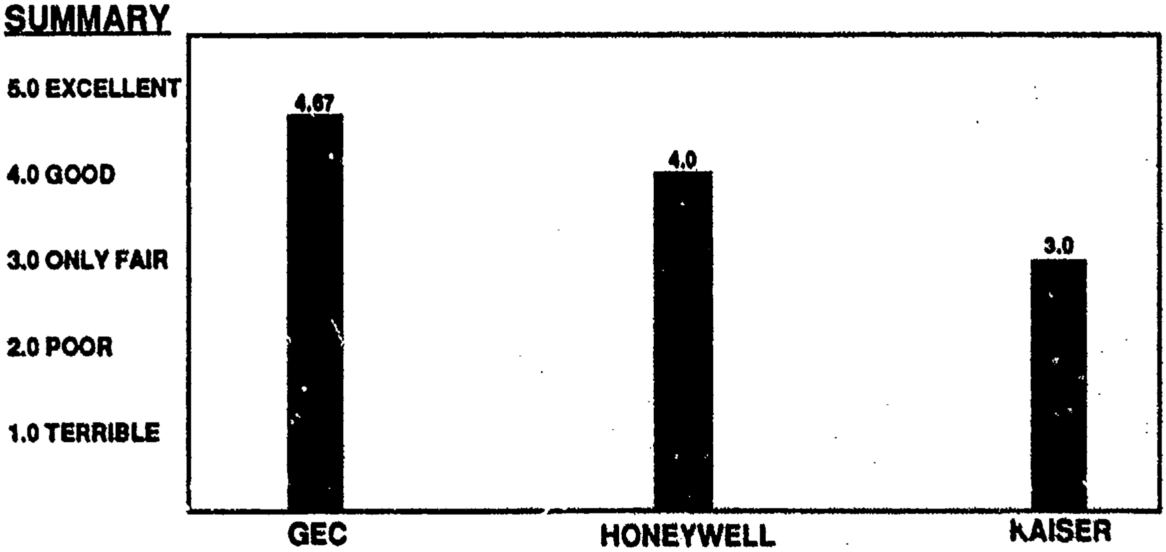


PILOT COMMENTS:

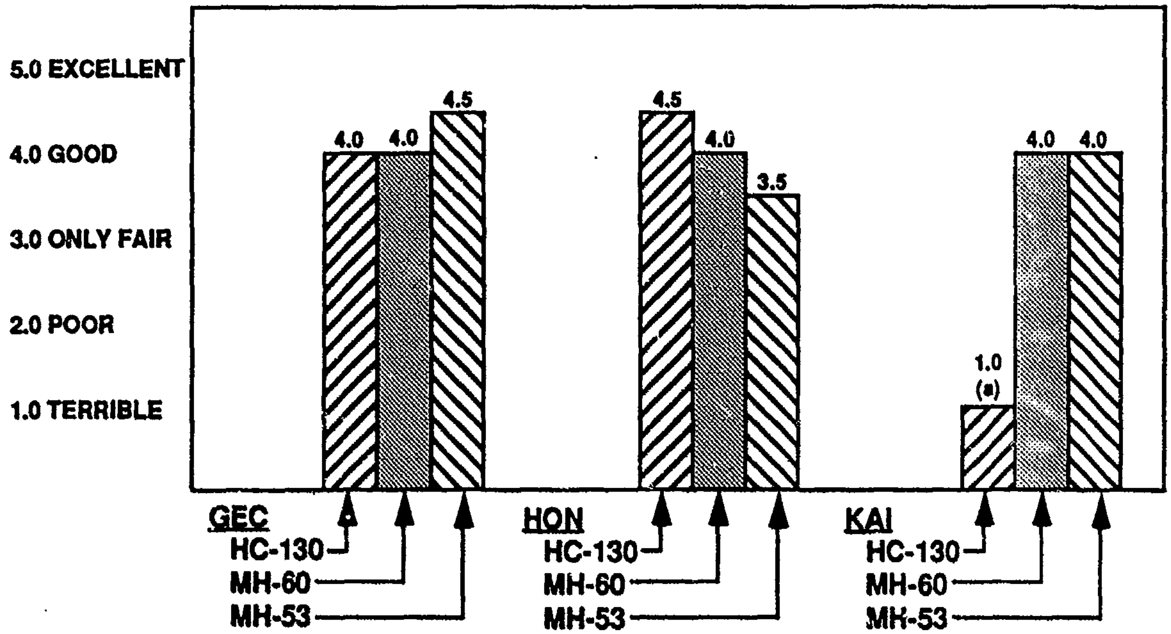
(a) Really liked this system.

(b) Crossing straps don't contact nape.

SUMMARY



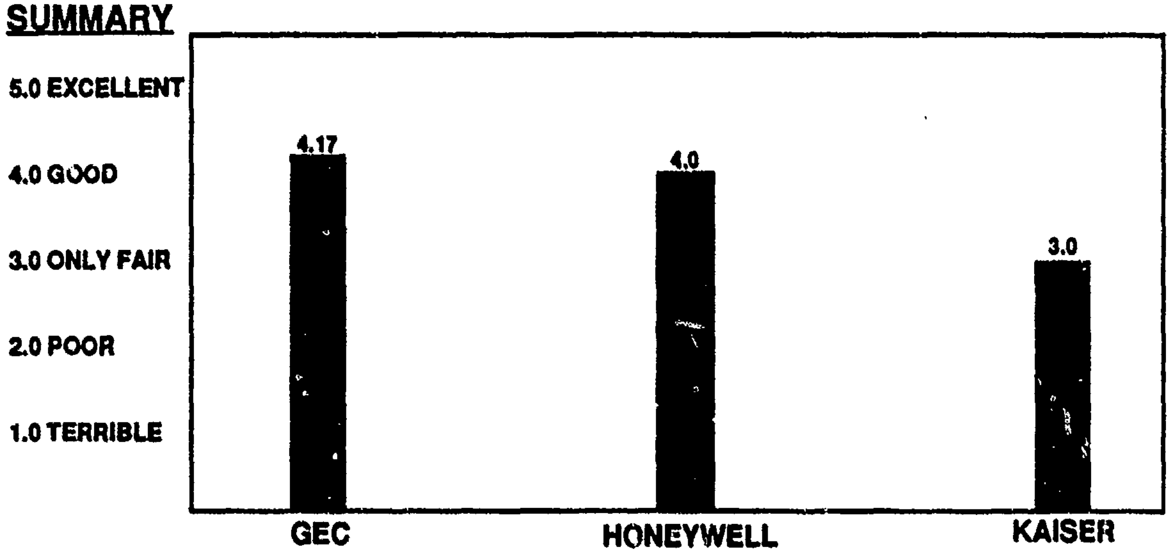
I.A.3.b Evaluate the nape strap for adjustability. (6a)



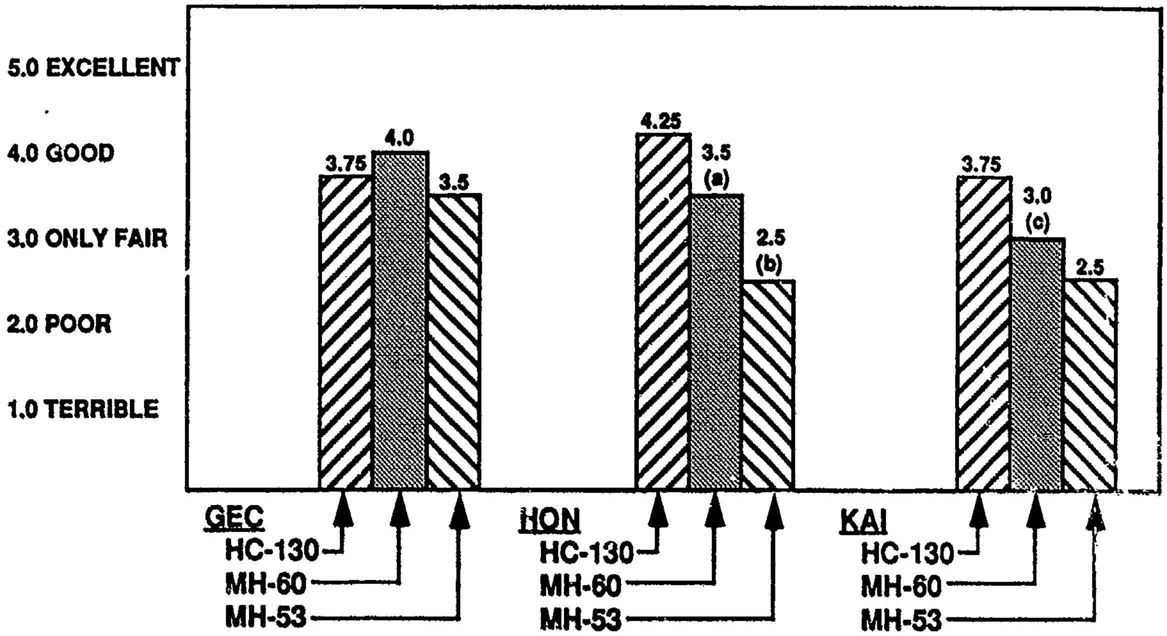
PILOT COMMENTS:

(a) Poor location negates adjustment.

SUMMARY



I.A.4 Evaluate the comfort of the earcup. (7)



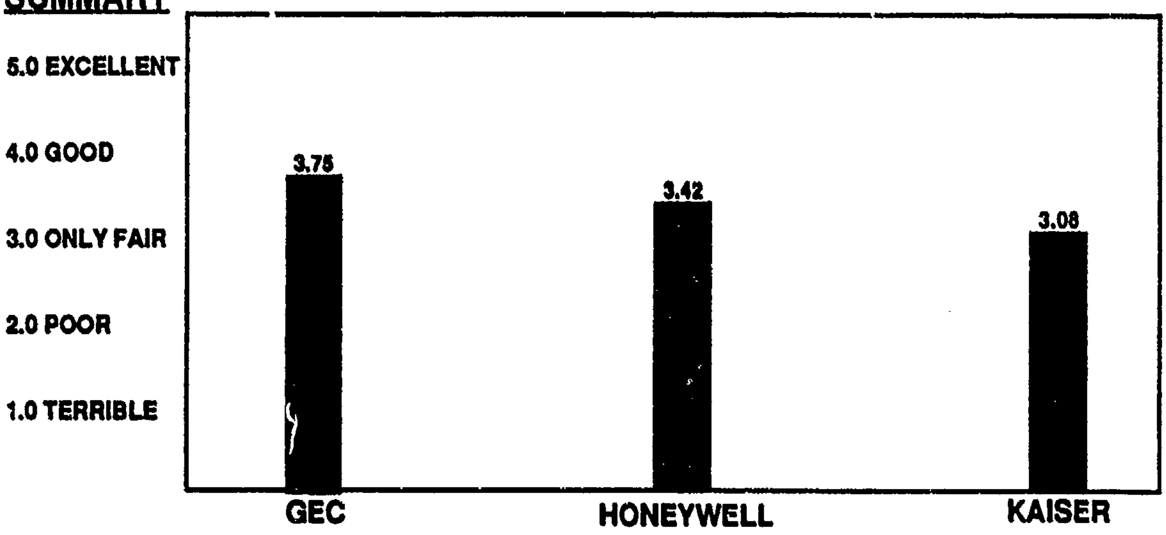
PILOT COMMENTS:

(a) Hot spots after one hour.

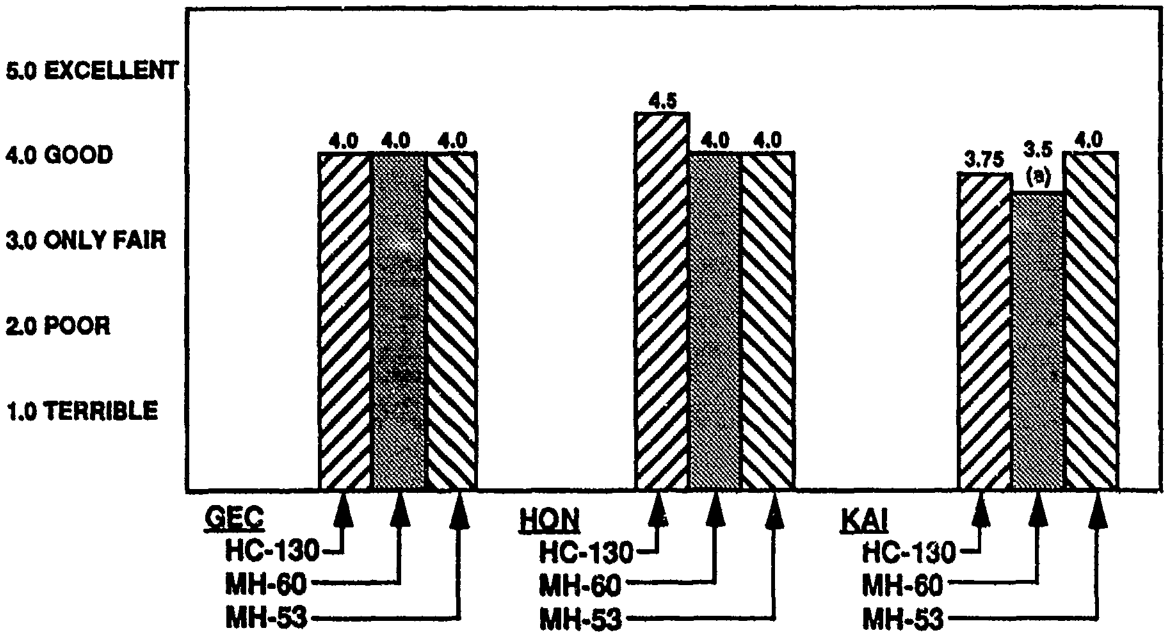
(b) Earcup caused pressure/pain.

(c) Hot spots both earcups.

SUMMARY



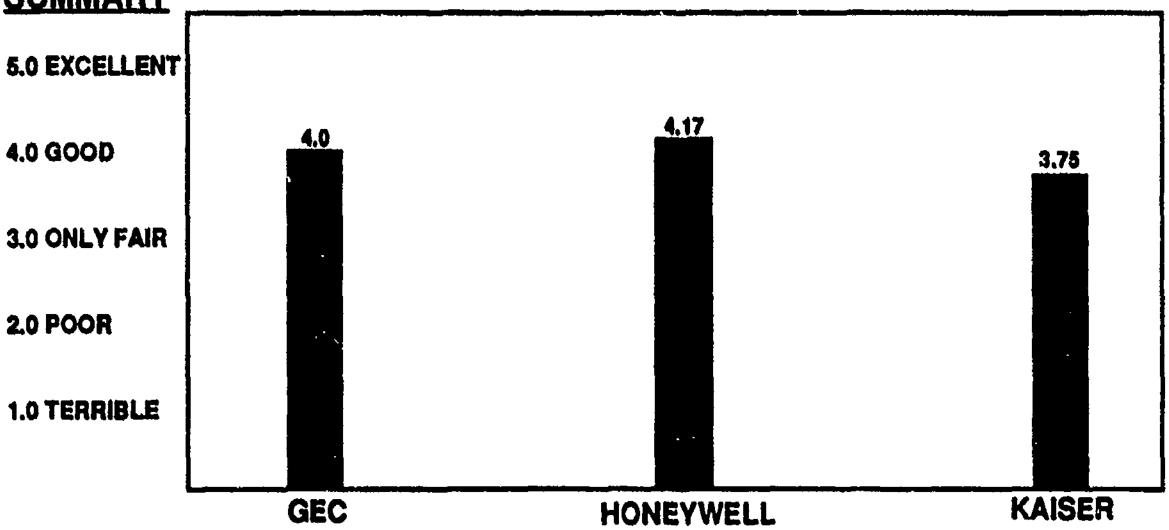
I.A.5 Evaluate the seal of the earcup. (8)



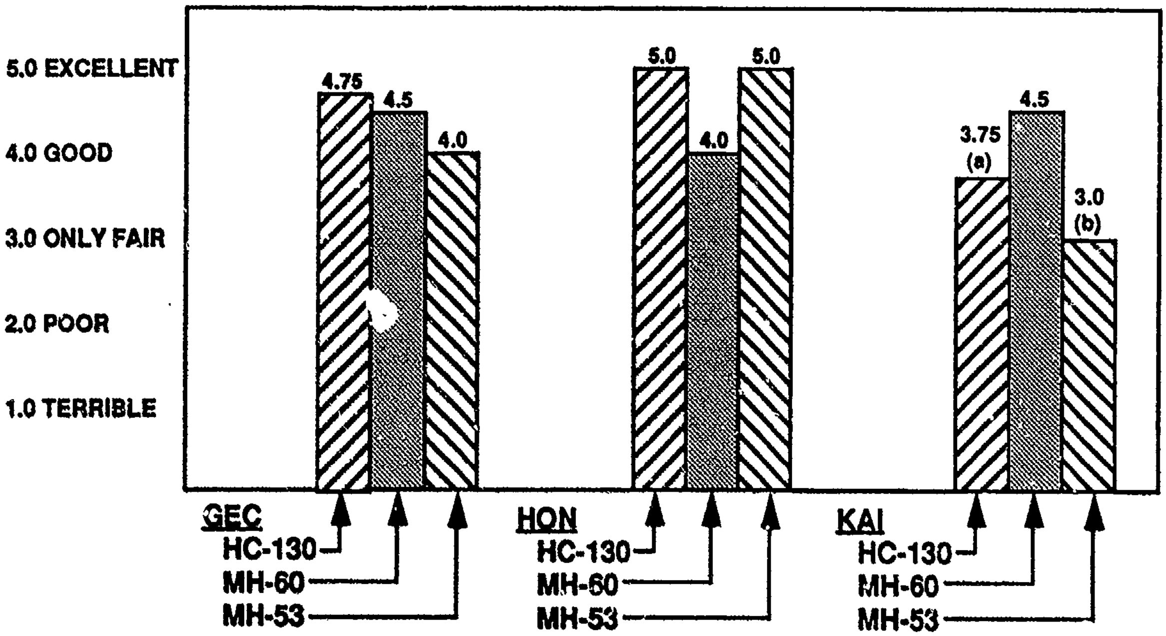
PILOT COMMENTS:

(a) Fell out.

SUMMARY



I.A.6.a Evaluate the speech intelligibility of the helmet for your ability to clearly hear others. (33a)

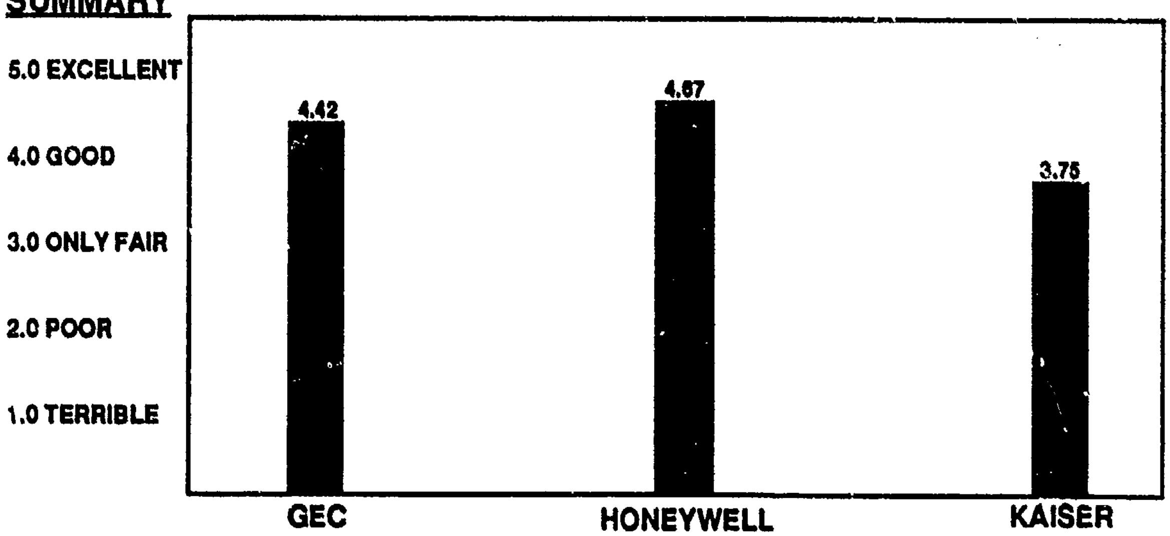


PILOT COMMENTS:

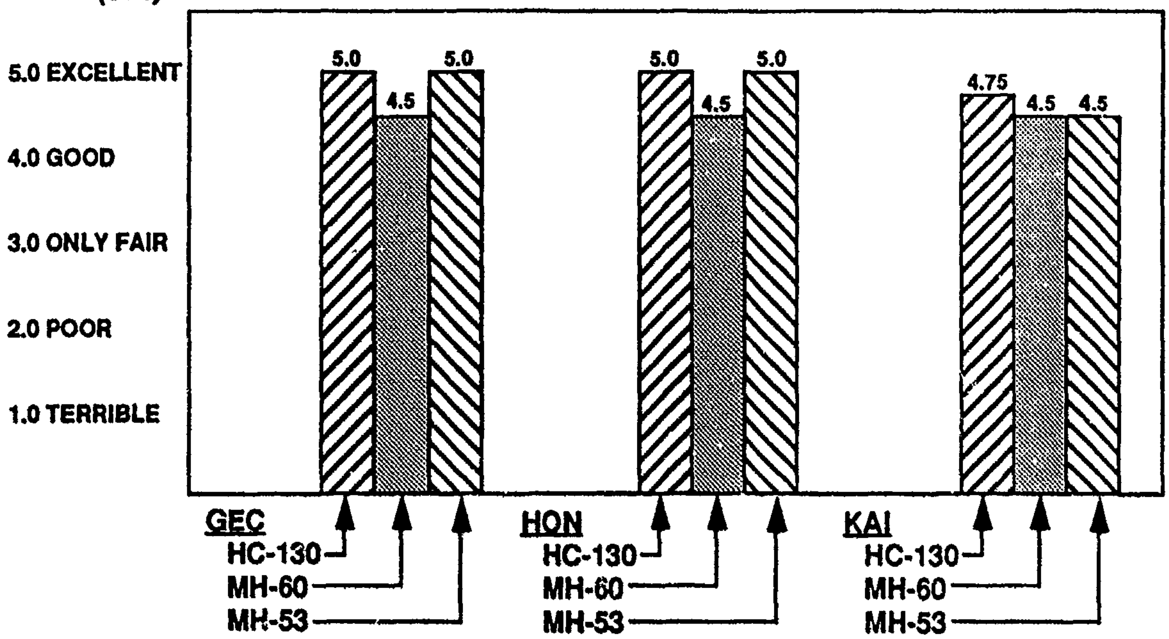
(a) Lots of vibration in earcups.

(b) Operation caused tingling/shock in ears - not painful but distracting.

SUMMARY



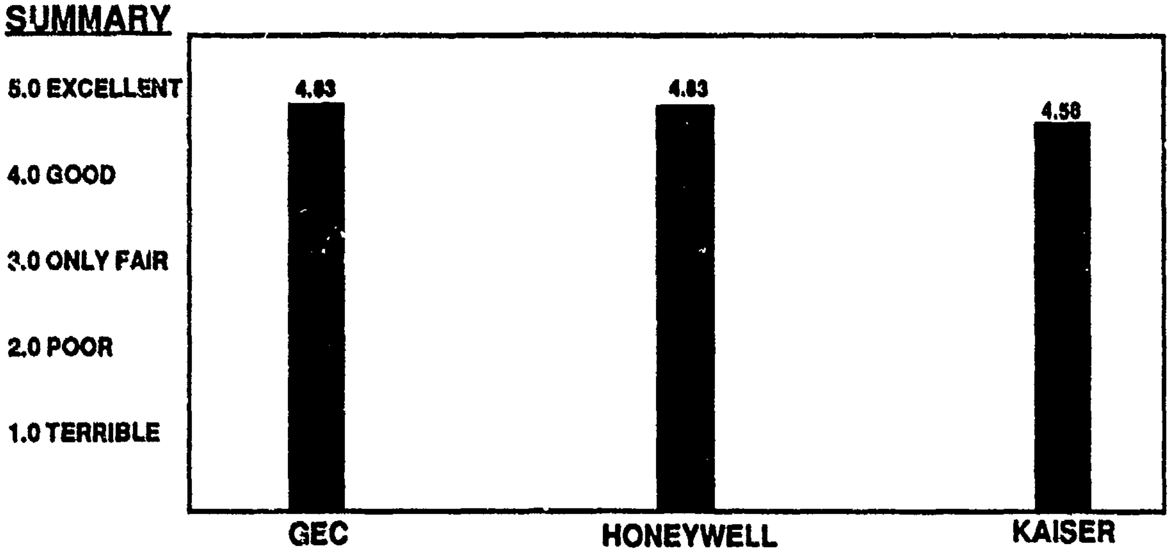
I.A.6.b Evaluate the speech intelligibility of the helmet for the ability of others to hear you. (33b)



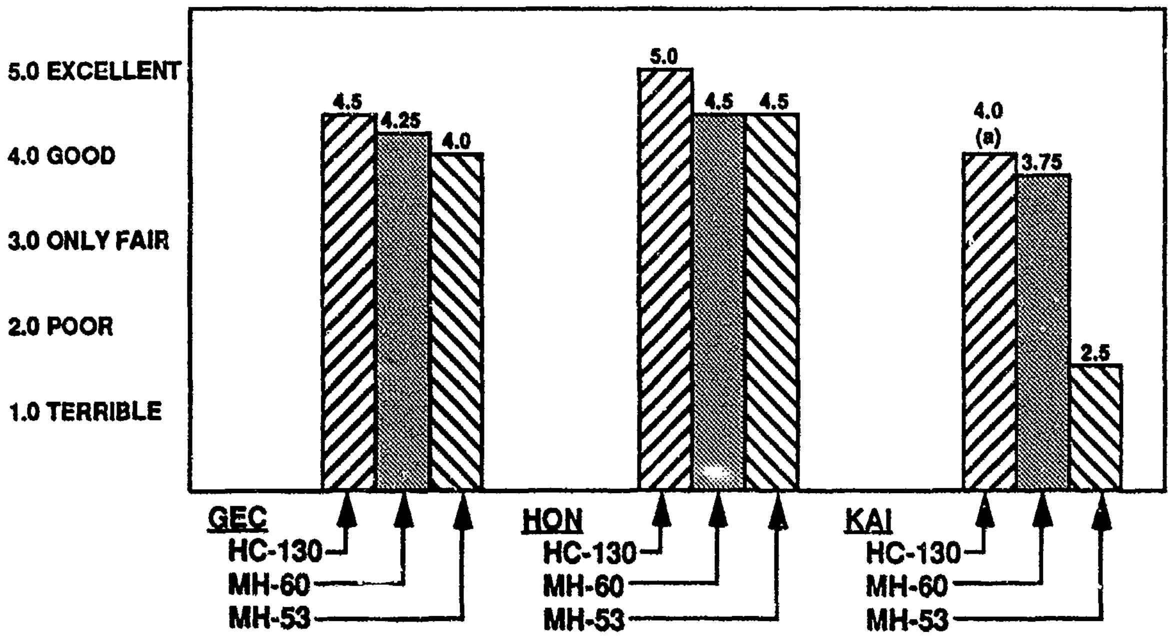
PILOT COMMENTS:

NONE

SUMMARY



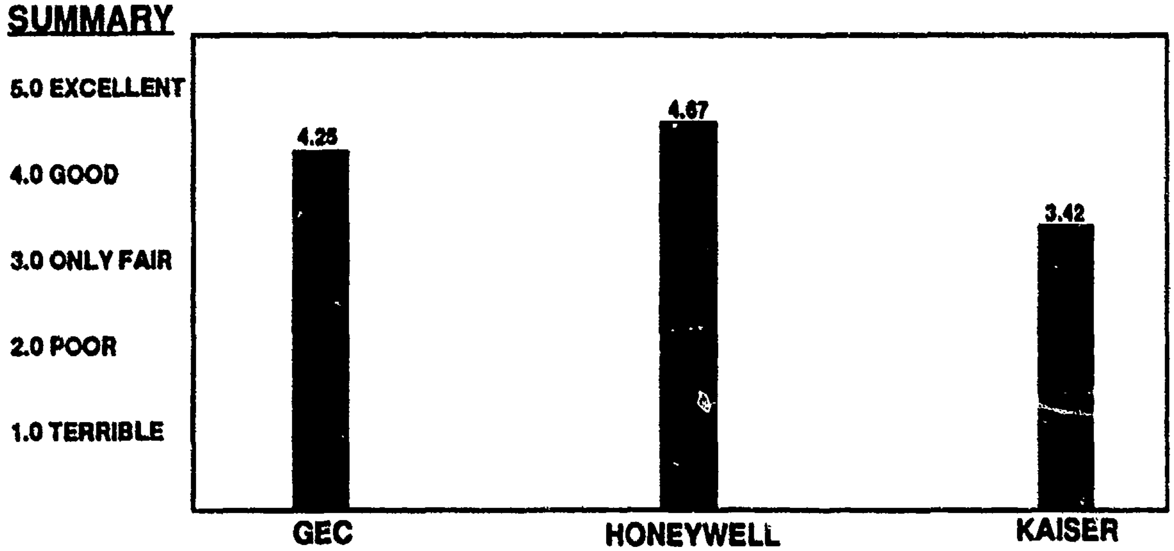
I.A.7 Evaluate the helmet for cockpit noise attenuation. (34)



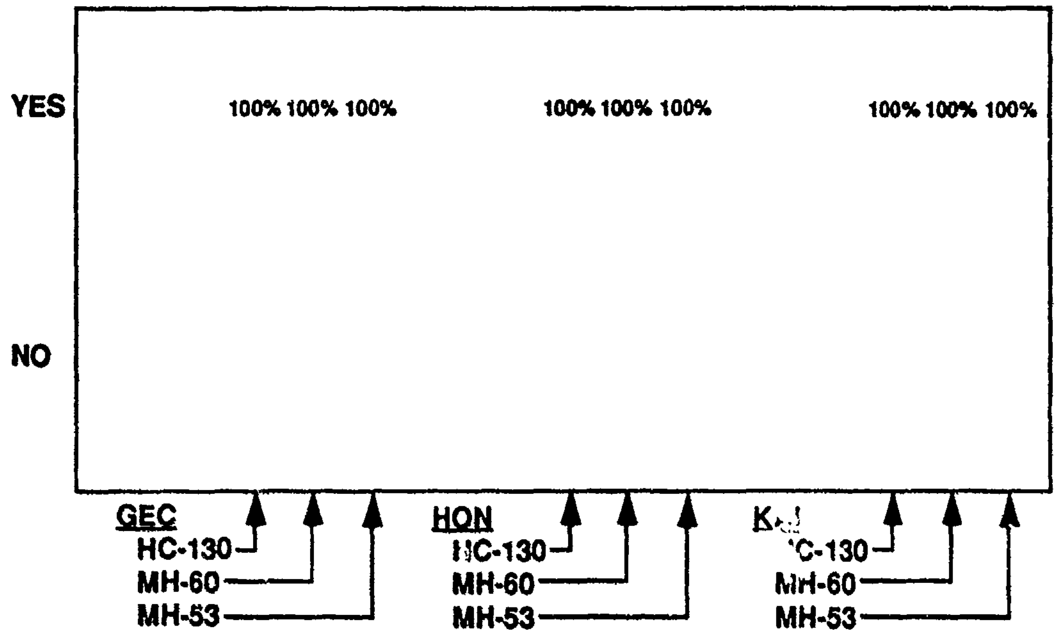
PILOT COMMENTS:

(a) Poor seal due to fit.

SUMMARY

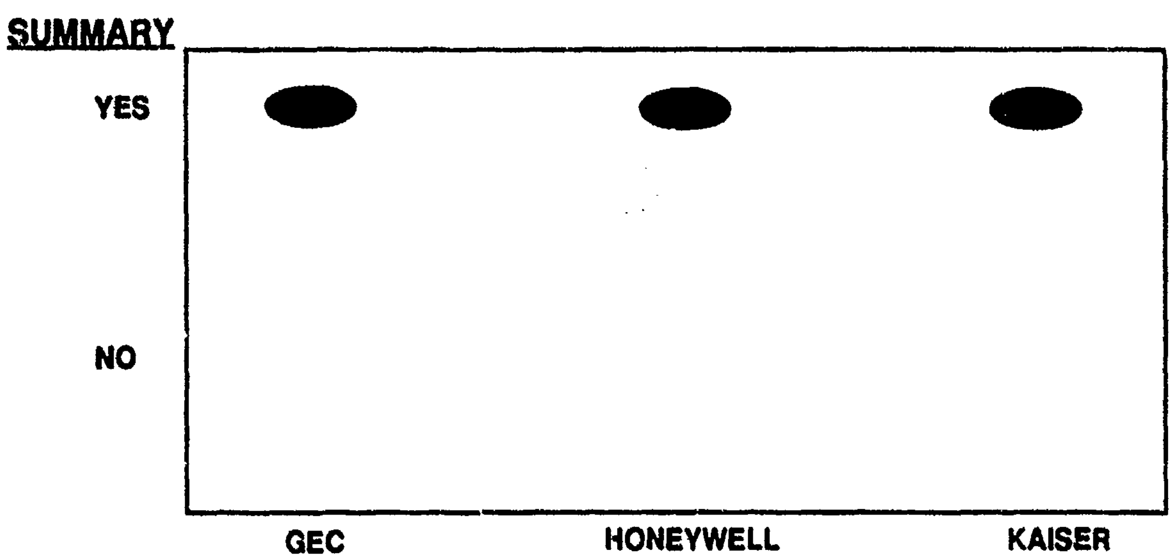


I.A.8 Did you wear ear plugs? (35)

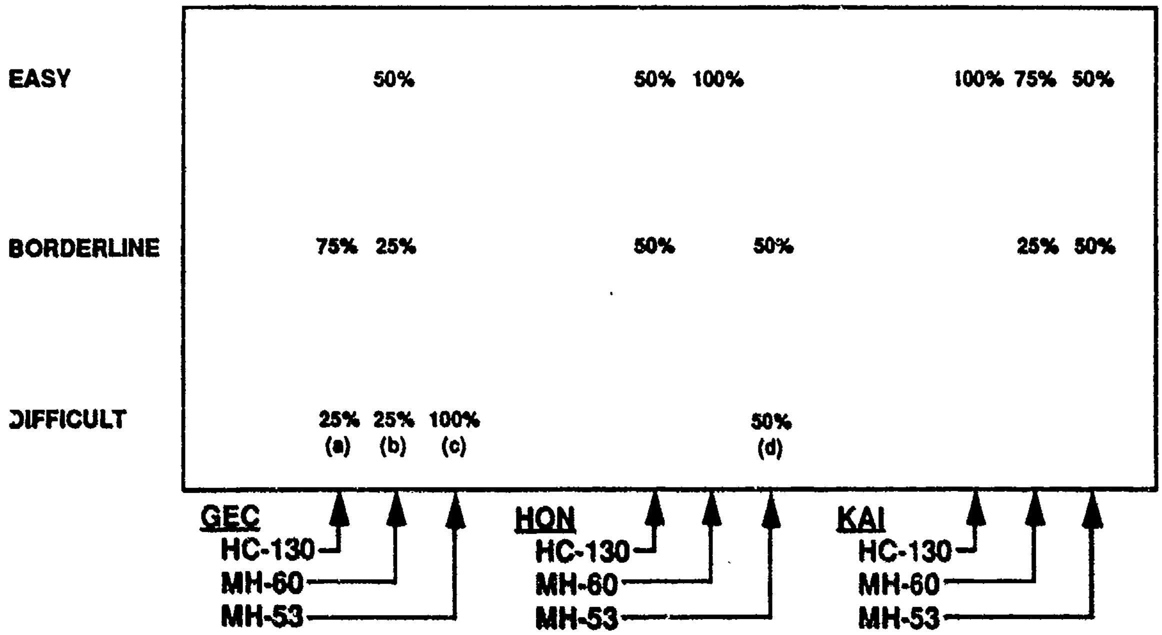


PILOT COMMENTS:

NONE



I.A.9 Evaluate the ease of donning the helmet. (11)



PILOT COMMENTS:

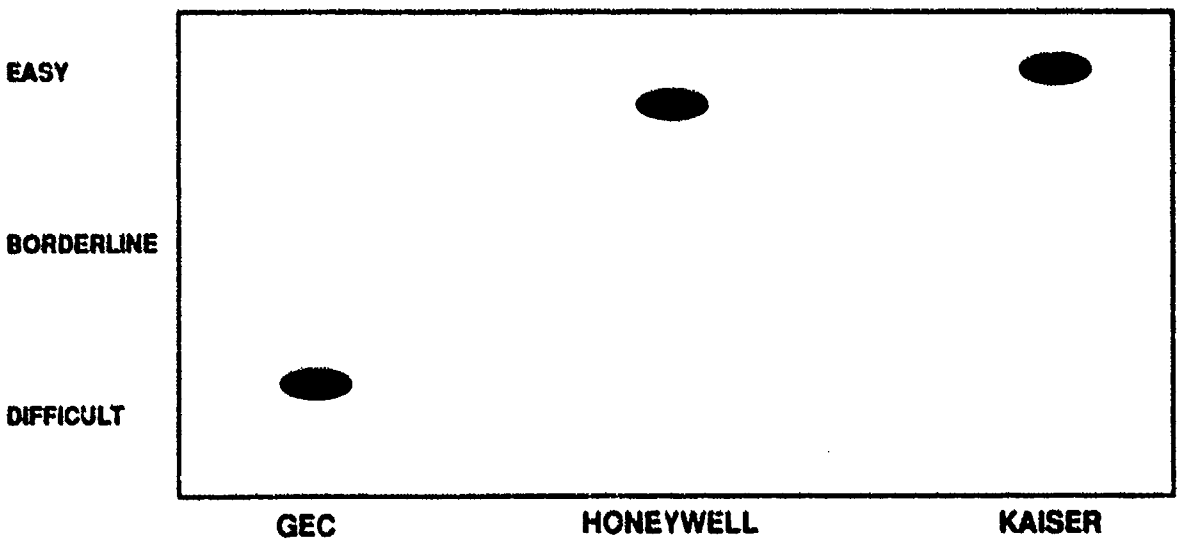
(a) Combiners hit glasses while donning.

(b) Earcups are hard to get in place.

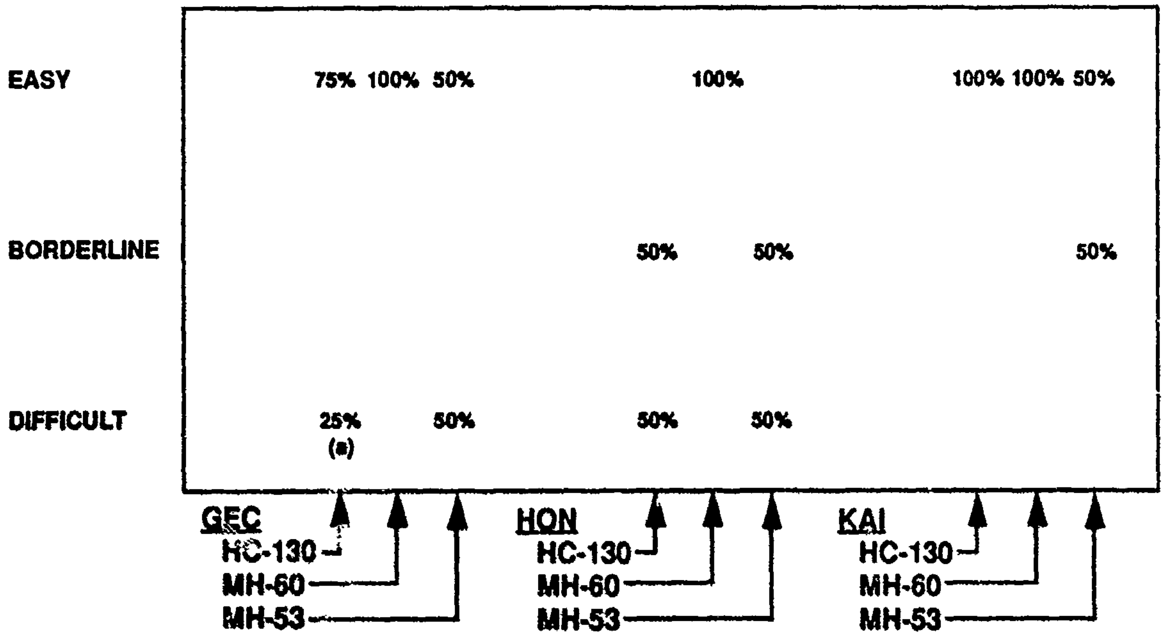
(c) Chin strap is difficult.

(d) Had trouble with glasses.

SUMMARY



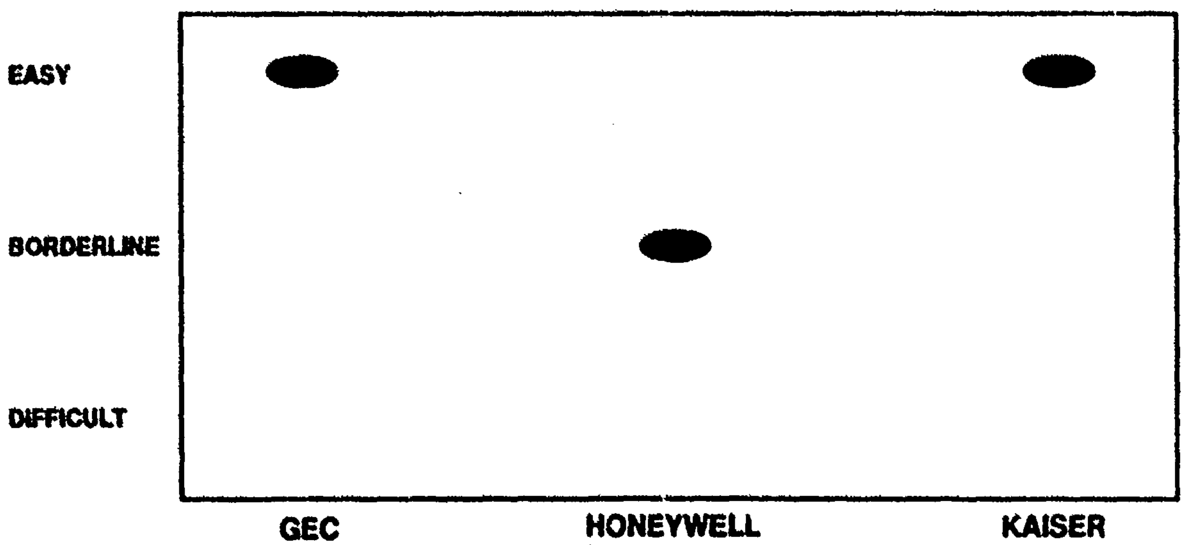
I.A.10 Evaluate the ease of doffing the helmet. (12)



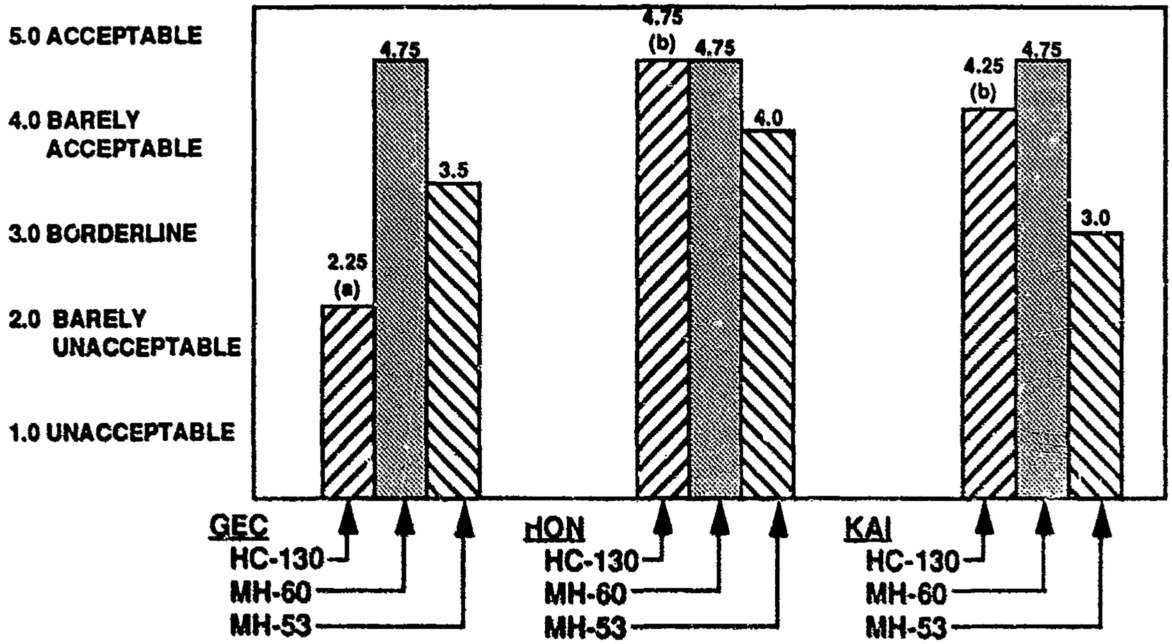
PILOT COMMENTS:

(a) Combiners hit glasses while doffing.

SUMMARY



I.A.11.a For the helmet configuration you flew, evaluate the weight (14a).

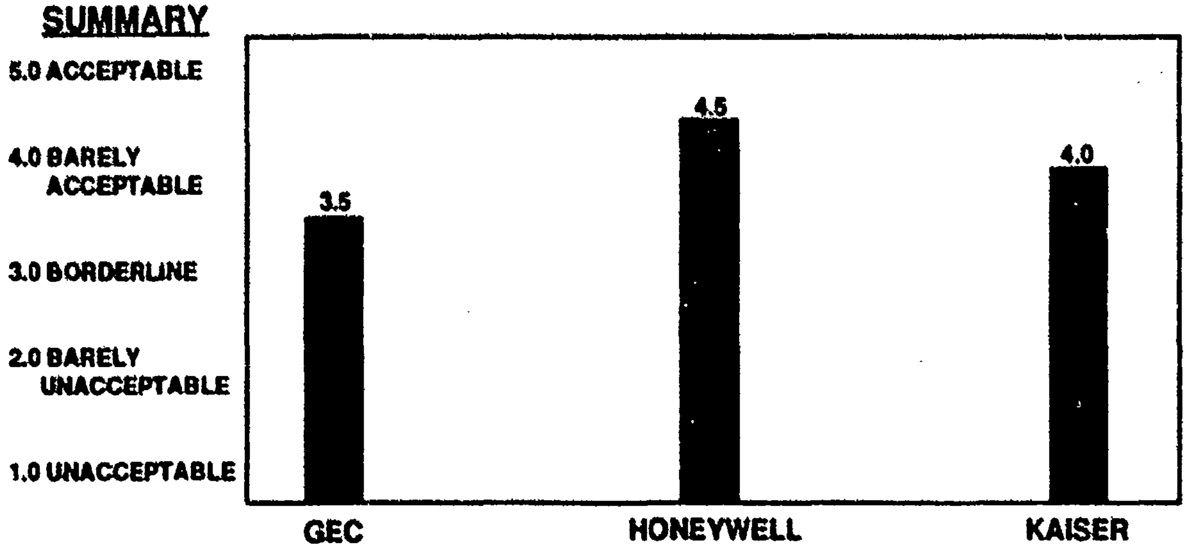


PILOT COMMENTS:

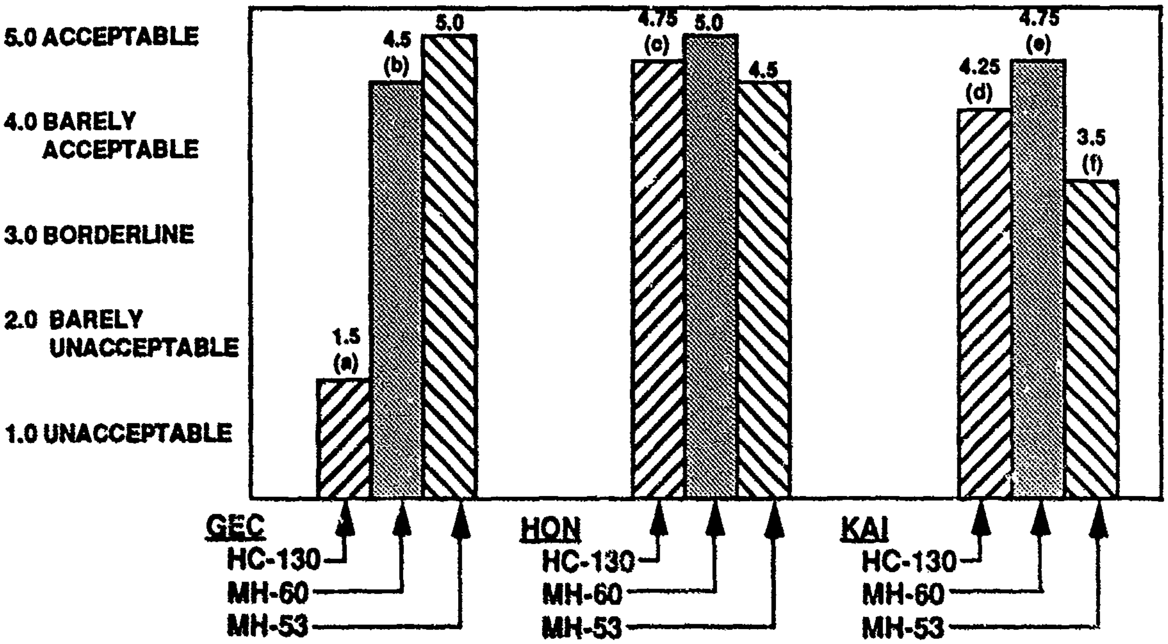
(a) Too heavy.

(b) Weight and center of gravity better than ANVIS-6.

SUMMARY



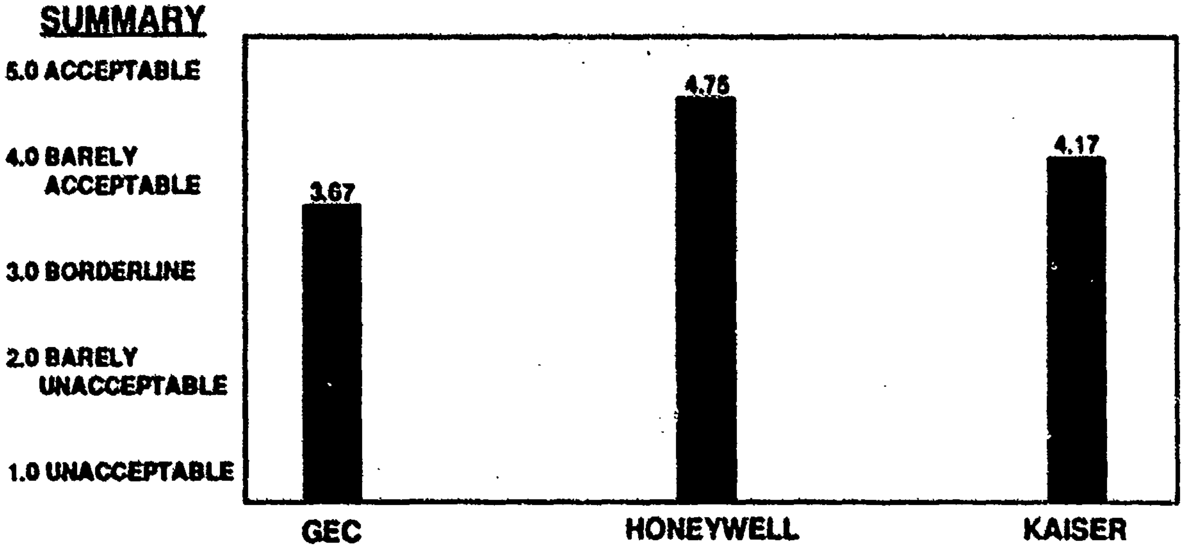
I.A.11.b For the helmet configuration you flew, evaluate the center of gravity. (14b)



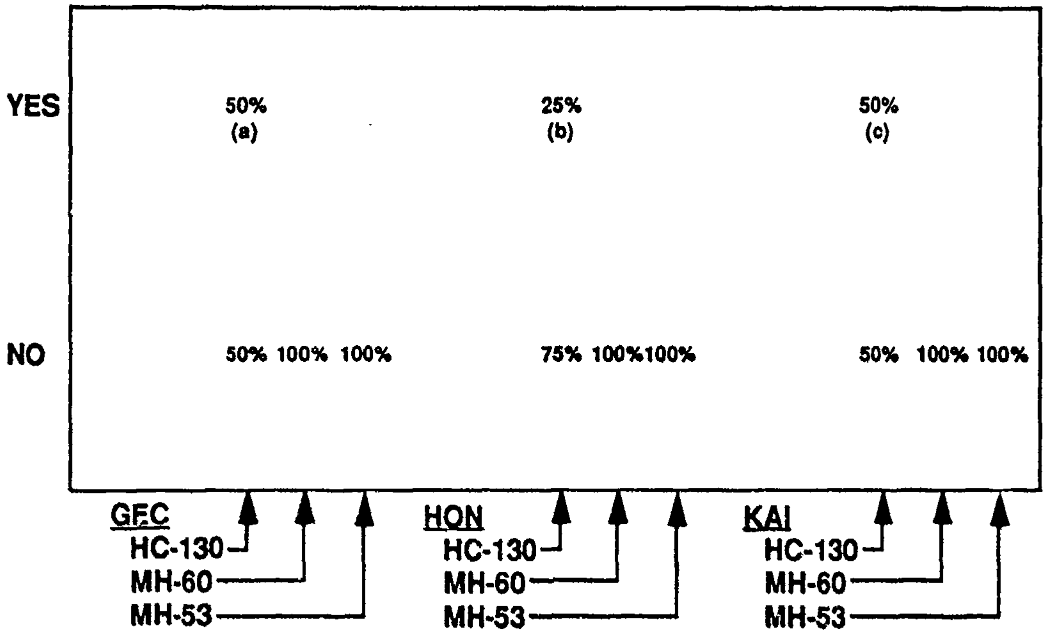
PILOT COMMENTS:

(a) Forward, left and right; too far forward, must periodically push up to retain view.
(b) Forward.
(c) Weight and center of gravity (CG) better than ANVIS-6, CG slightly forward.
(d) Better than ANVIS-6 but still too much forward; forward, left and right.
(e) Forward.
(f) High.

SUMMARY



I.A.12 Did you experience any center of gravity induced fatigue? If yes, after how long and under what flight conditions? (18)



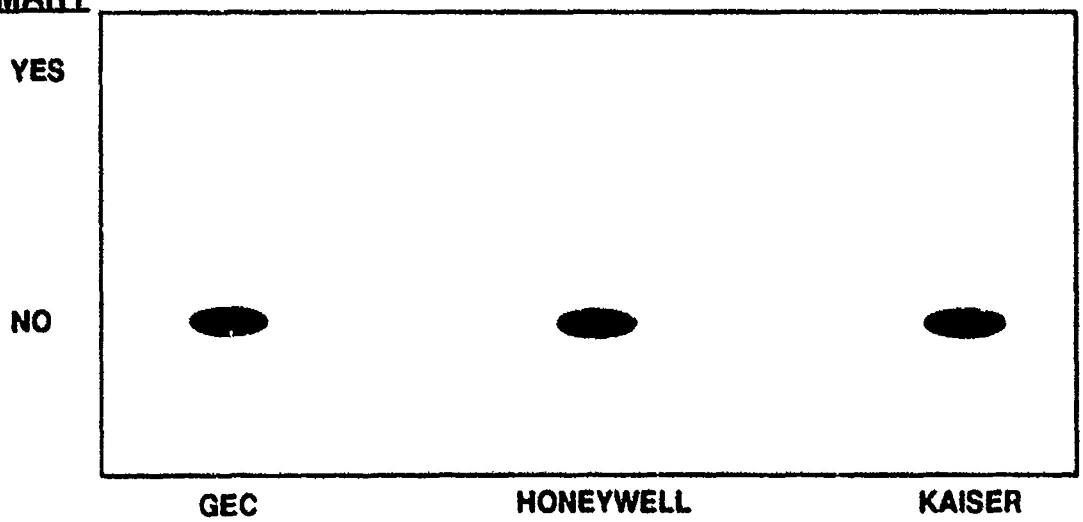
PILOT COMMENTS:

(a) Too far forward after 30 - 45 minutes.

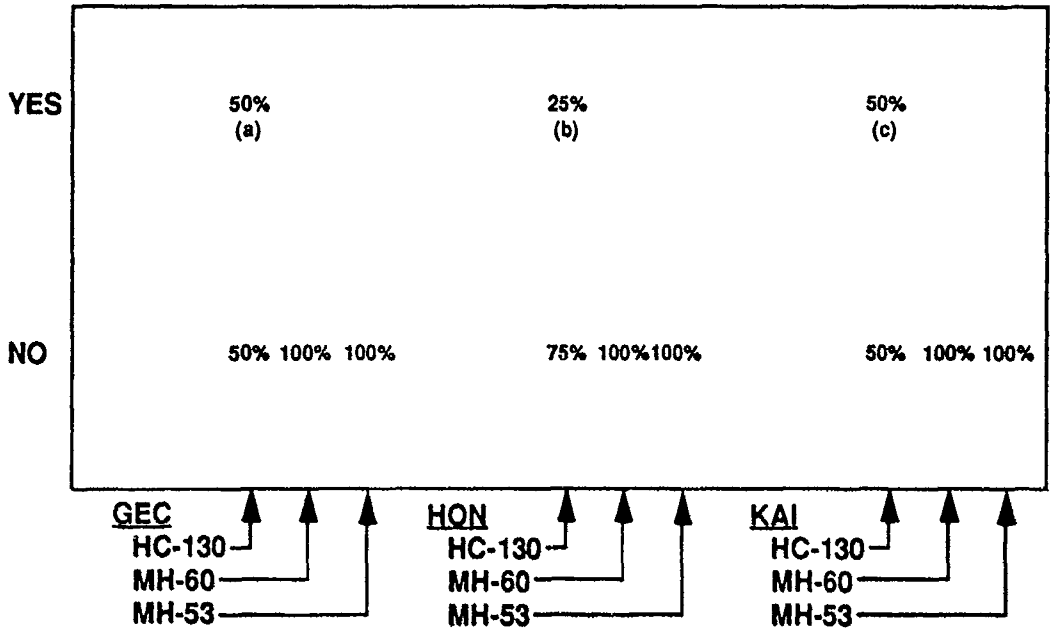
(b) Better than ANVIS-6.

(c) 1-2 hours, upper neck.

SUMMARY



I.A.13 Did you experience any weight induced fatigue? If yes, after how long and where (e.g. neck fatigue, etc.)? (17)



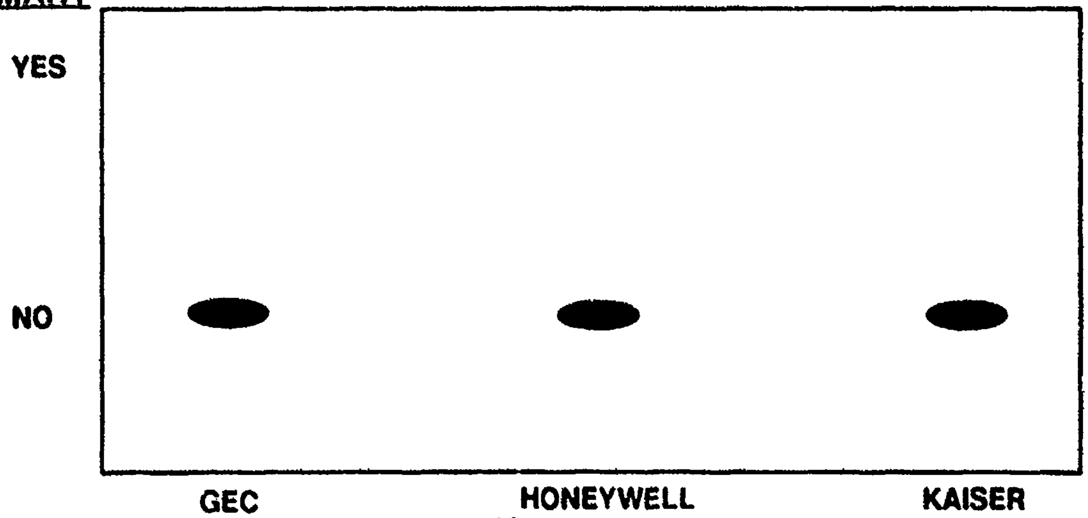
PILOT COMMENTS:

(a) Too heavy, 30 - 45 minutes.

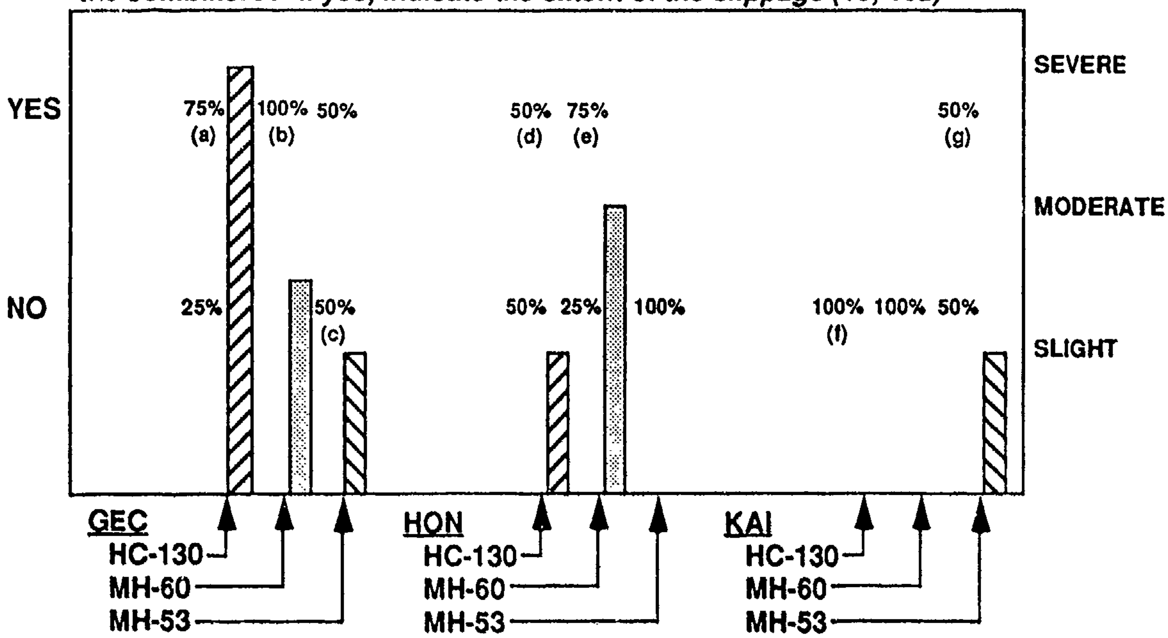
(b) Better than ANVIS-6.

(c) 1-2 hours, upper neck.

SUMMARY



I.A.14.a Did you experience slippage of the helmet that affected your ability to see through the combiners? If yes, indicate the extent of the slippage (16, 16a)



(NOTE: Read percentages from left scale, read bars/ovals from right scale.)

PILOT COMMENTS:

(a) Need to move CG aft for balance.

(b) Slippage due to head/mouth movement and aircraft vibration.

(c) Could not evaluate due to frequent adjustments for comfort.

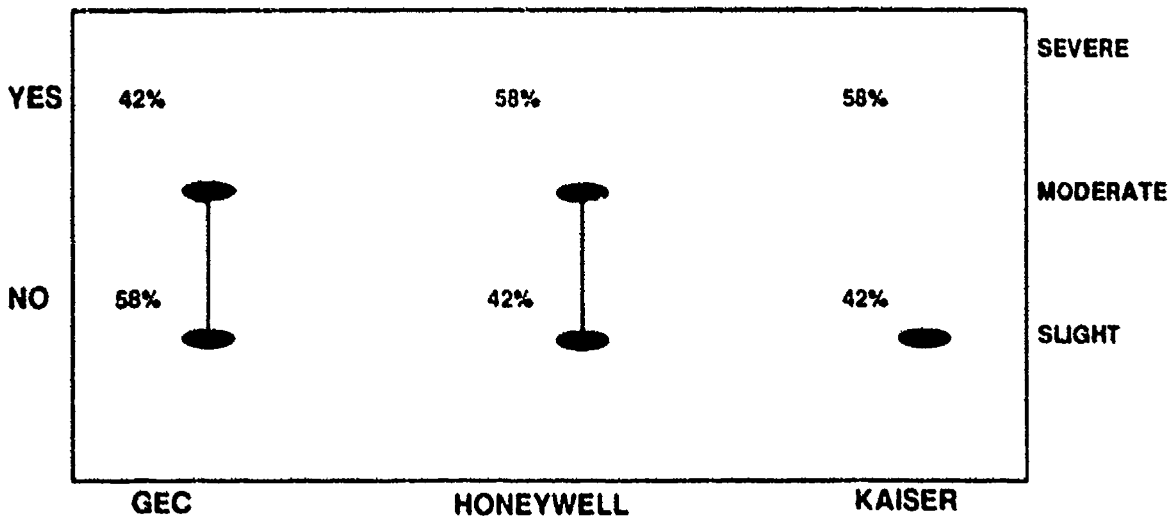
(d) Could use better fit - repositioned every 3-5 minutes to maintain precise alignment.

(e) Used additional padding to get intensifiers in field of view.

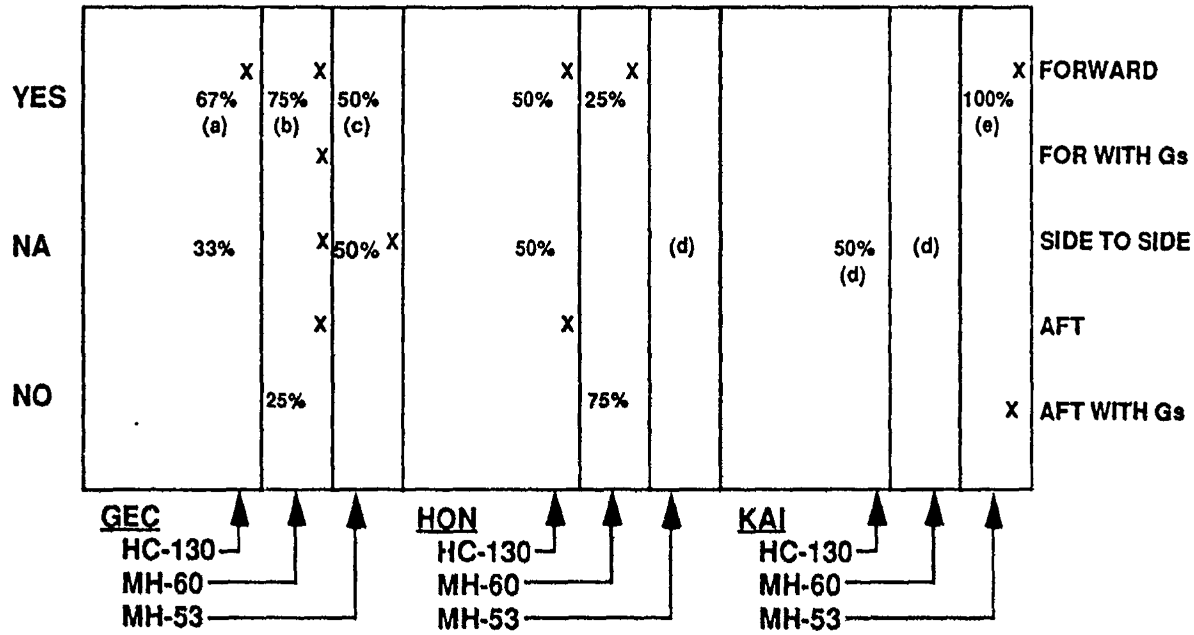
(f) Good fit.

(g) Could not differentiate between comfort and slippage adjustments.

SUMMARY



I.A.14.b Did slippage require abnormal head movement or inflight adjustments to see through the combiners? If you experienced slippage indicate the directions that apply. (16c, 16d)



(NOTE: Read percentages from left scale, read "Xs" from right scale.)

PILOT COMMENTS:

(a) Frequently pushed helmet back to see through combiners.

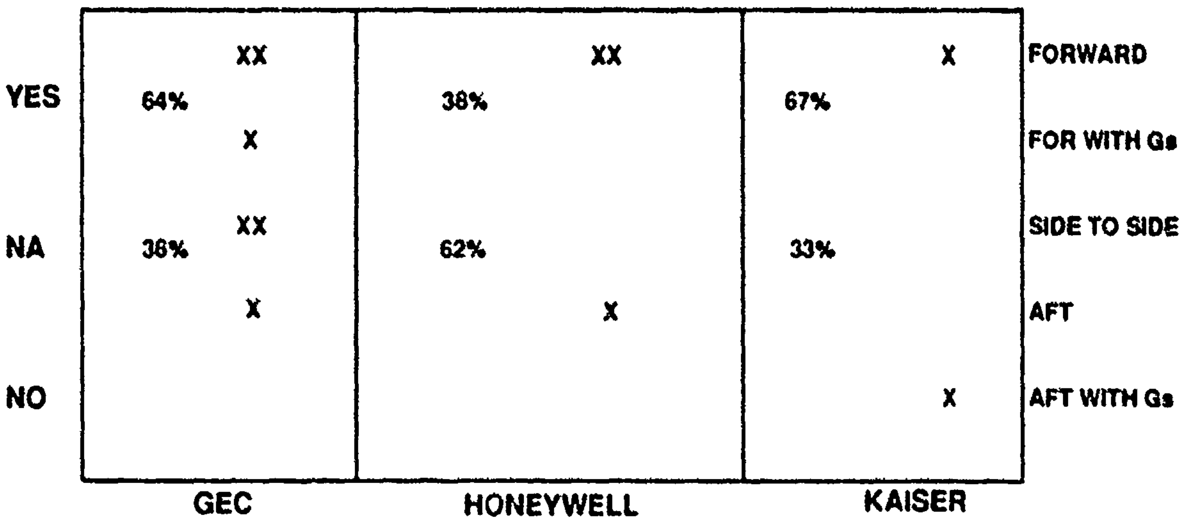
(b) Re-adjust helmet and minimize jaw movement.

(c) Constant head movement required to keep image in view, slightest slip caused loss of image.

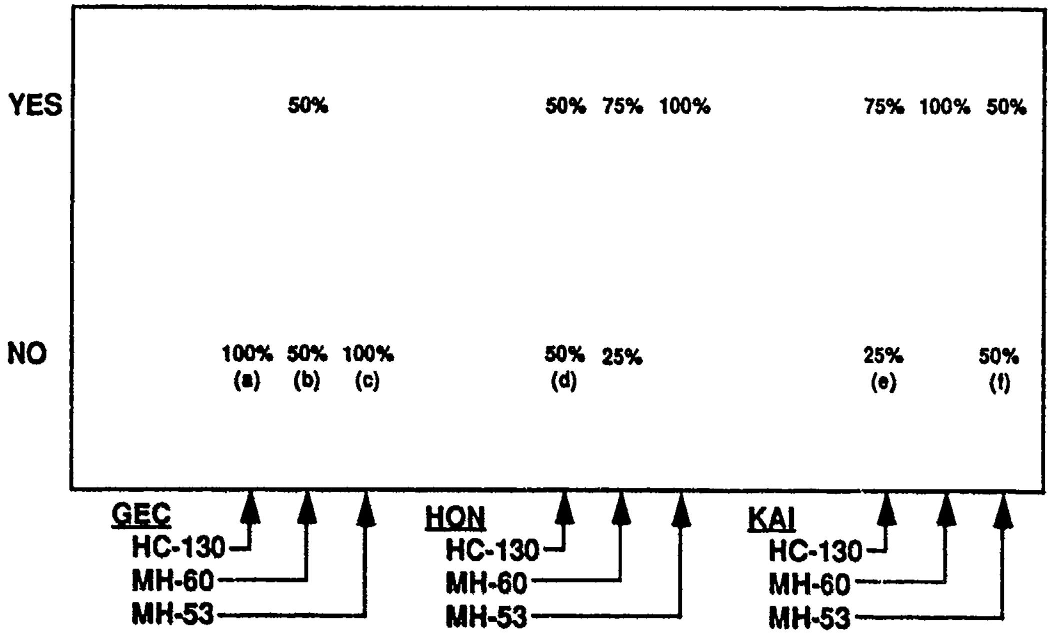
(d) Category not rated by some or all the pilots.

(e) Constant adjustment needed for comfort and combiner position.

SUMMARY



I.A.15 Did the helmet retain proper fit to consistently maintain the scene? If NO, how long before degradation occurred? (70)



PILOT COMMENTS:

(a) Forward slip starts 5-10 minutes after donning.

(b) Degregation constant.

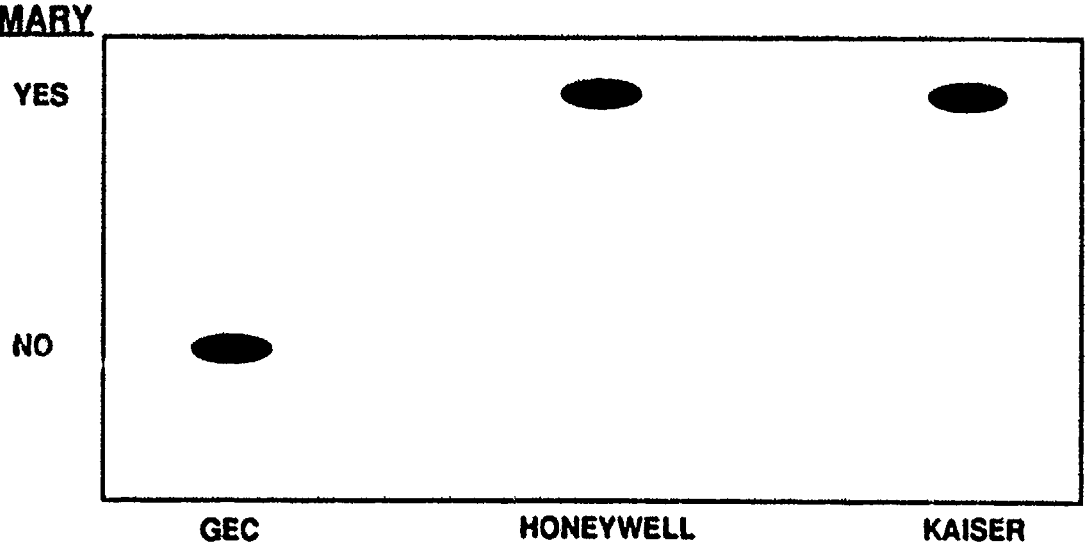
(c) Constant adjustment, immediate degregation.

(d) 30-45 minutes, 15 minutes adjustment every 3-4 minutes.

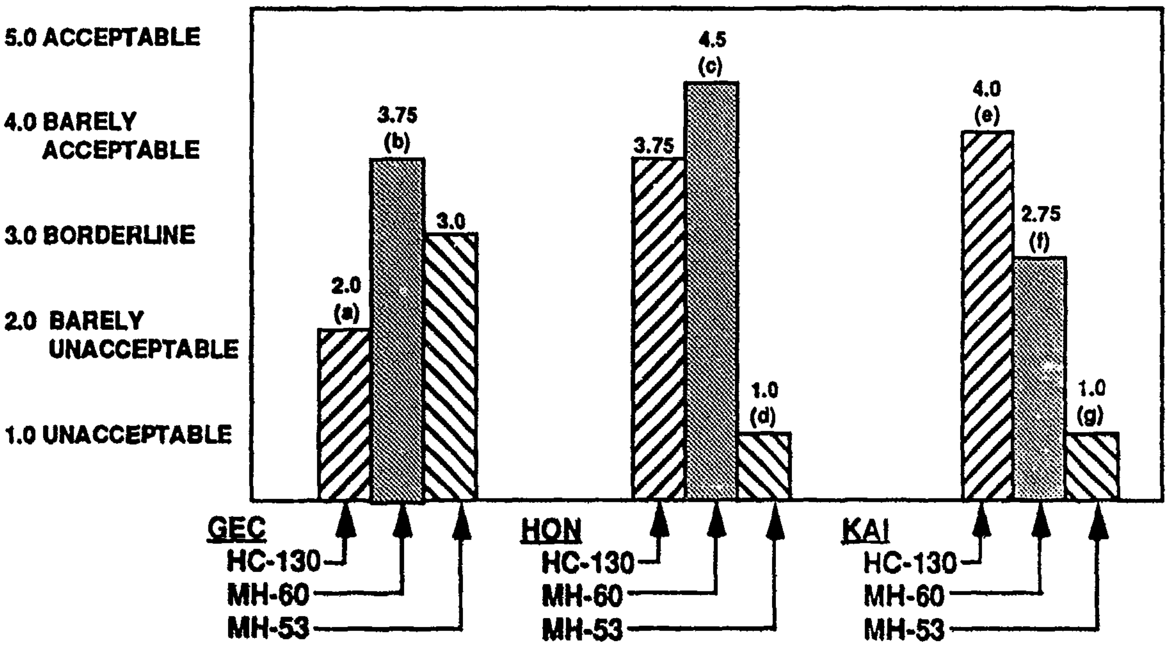
(e) Moved to ease pressure on glasses.

(f) Required constant adjustment.

SUMMARY



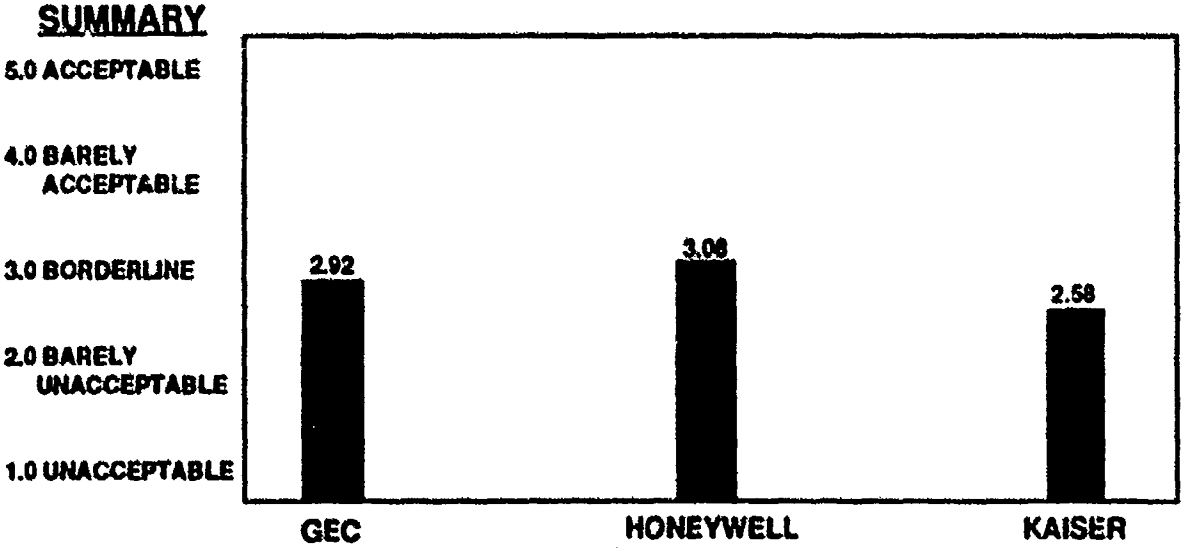
I.A.16 Evaluate the helmet for extended wear. (15)



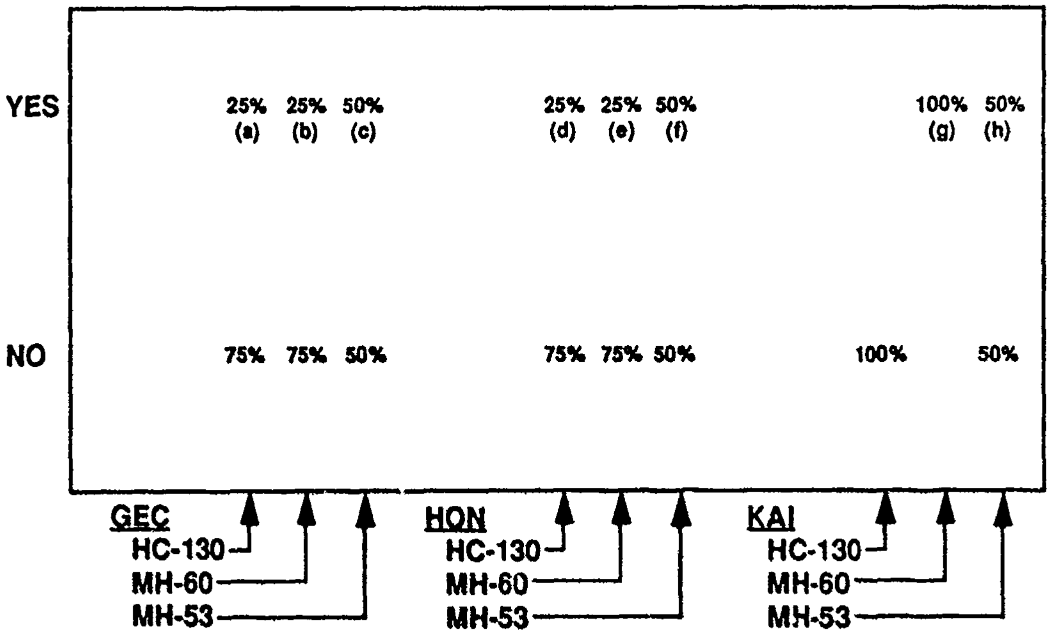
PILOT COMMENTS:

(a) Too heavy, CG too far forward, nape strap excellent.
(b) Combiners too close to face.
(c) Hot spots from earcups.
(d) Knob in forehead area and earcup hot spot.
(e) Shell OK, combiners press on glasses.
(f) Hot spots.
(g) Bad fit.

SUMMARY



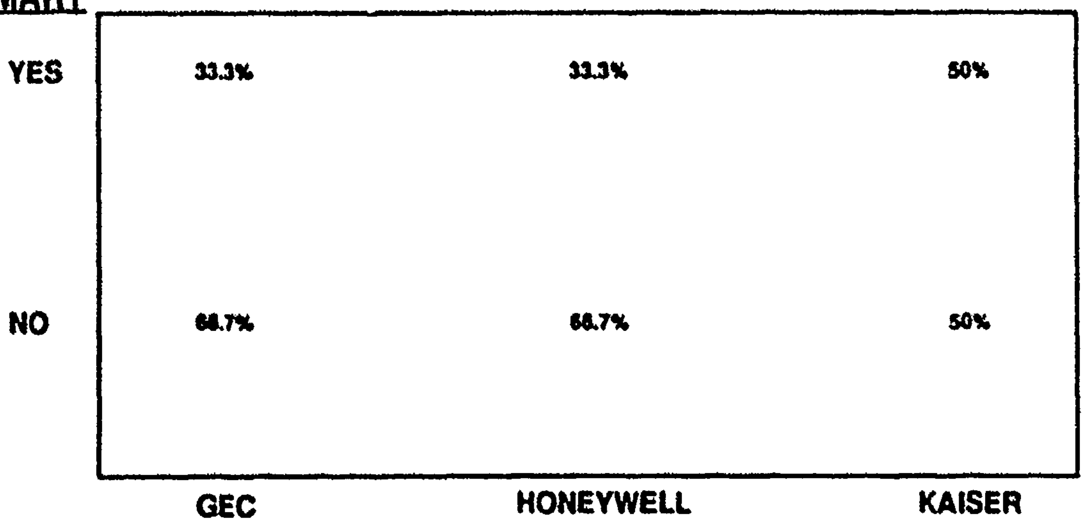
I.A.17 Did you experience any hot spots? If YES, where and after how long? (20)



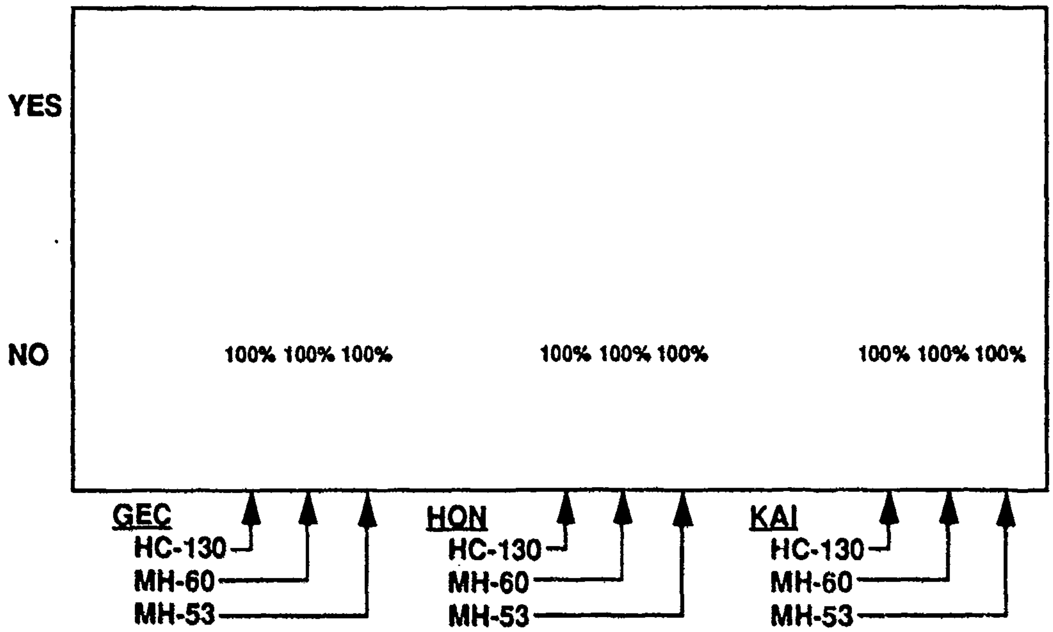
PILOT COMMENTS:

(a) Top of forehead - 60 minutes.
(b) From combiner assembly on forehead.
(c) Forehead, 10 minutes.
(d) Forehead, 30-45 minutes.
(e) Top of earcups.
(f) Combiners pushed glasses into nose - so painful that earcup hot spots ignored.
(g) Temple 45 minutes, earcups 45 minutes, crown 1.5 hours.
(h) Nose, ears, top of head - most uncomfortable helmet ever worn.

SUMMARY



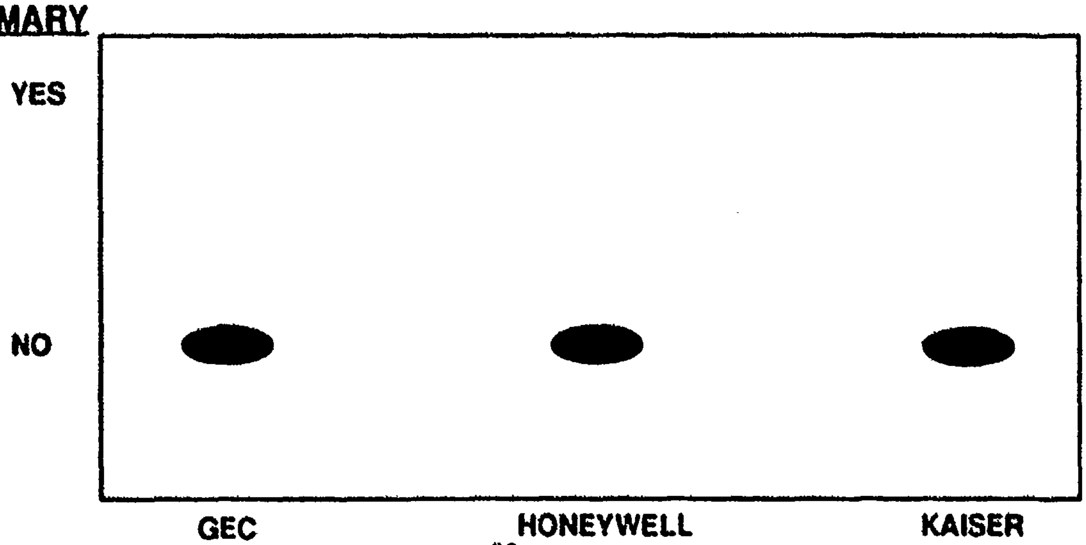
I.A.18 Did you experience any helmet temperature build-up? If YES, after how long? (21)



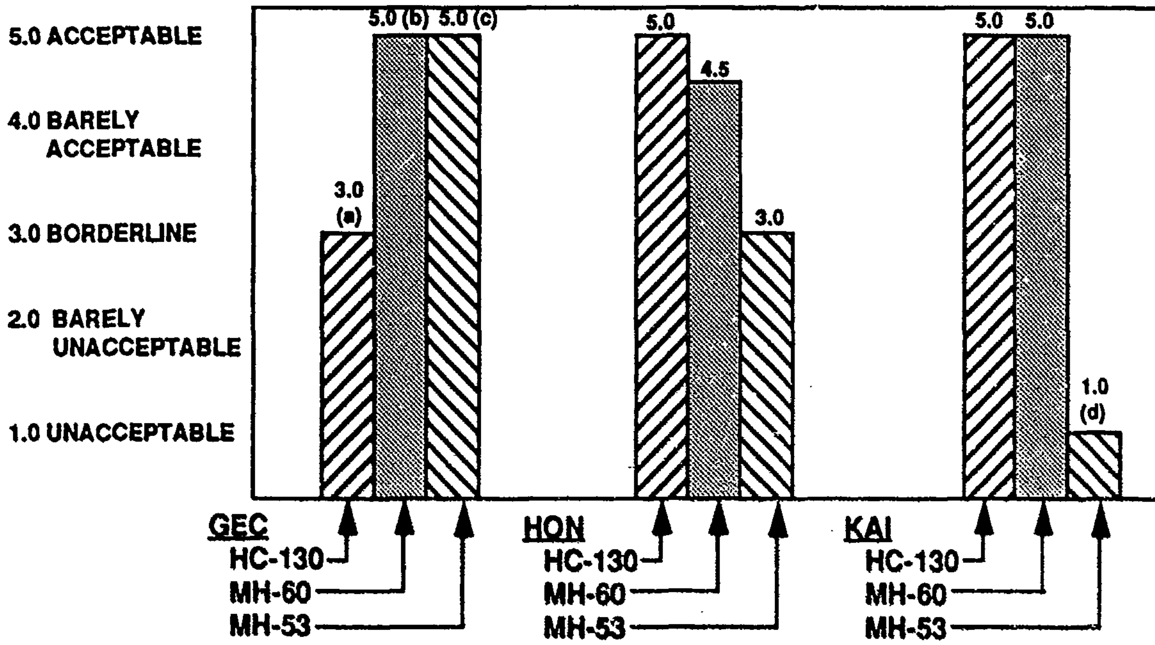
PILOT COMMENTS:

NONE

SUMMARY



I.A.19.a Evaluate the location of the battery pack controls. (26a)



PILOT COMMENTS:

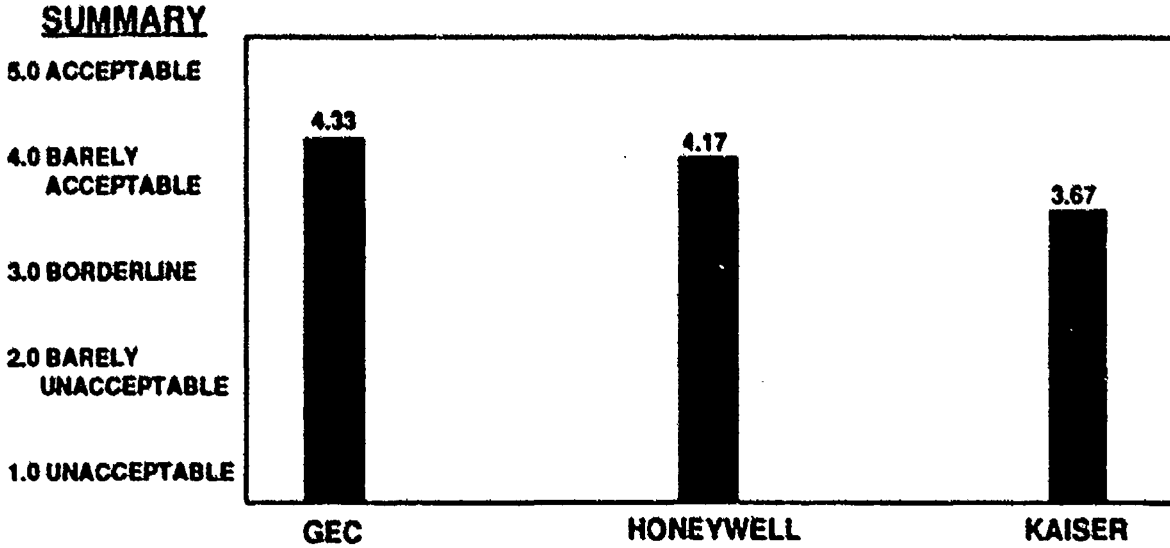
(a) Helmet must be removed to replace batteries.

(b) Good idea.

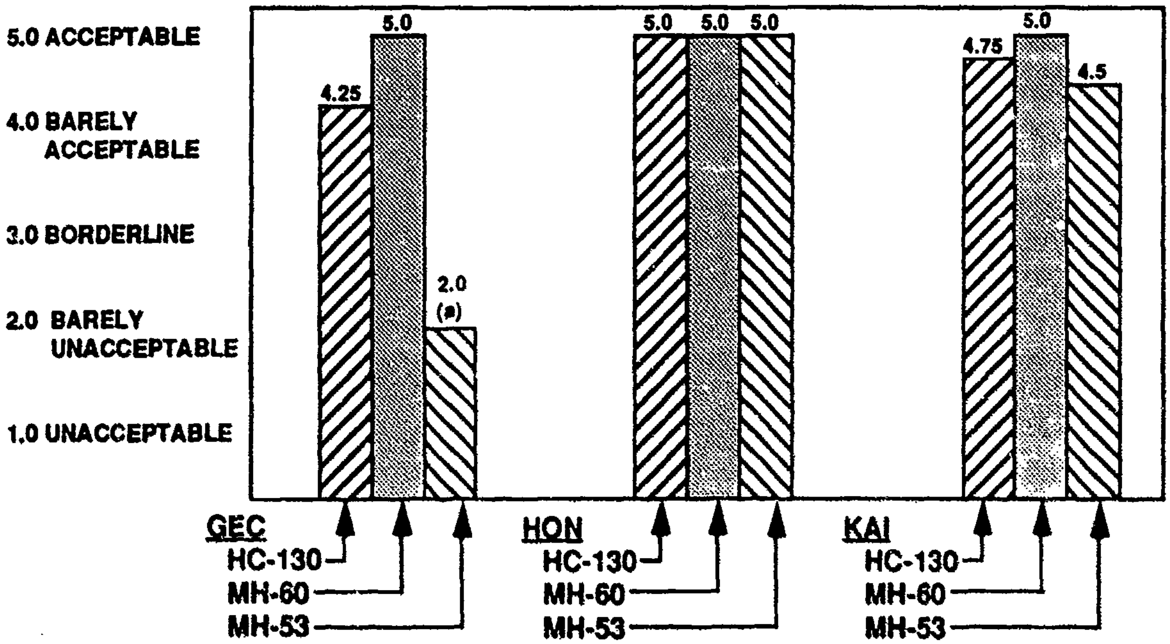
(c) Great.

(d) Attaching to flight suit or survival vest is bad idea - cord gets in the way.

SUMMARY



I.A.19.b Evaluate the operation of the battery pack controls. (26b)

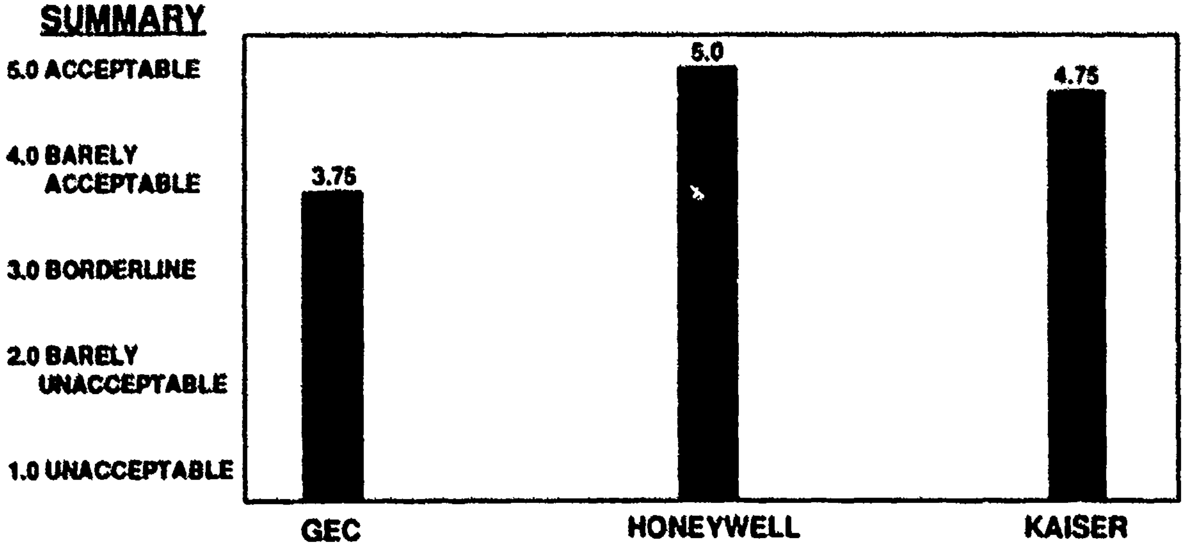


PILOT COMMENTS:

(a) Too small for gloved hand.

NOTE: The Honeywell battery pack was the same type as used with the ANVIS-6. The pilots "subjective" rating may have been influence by their familiarity with the ANVIS-6 battery pack that they normally use.

SUMMARY

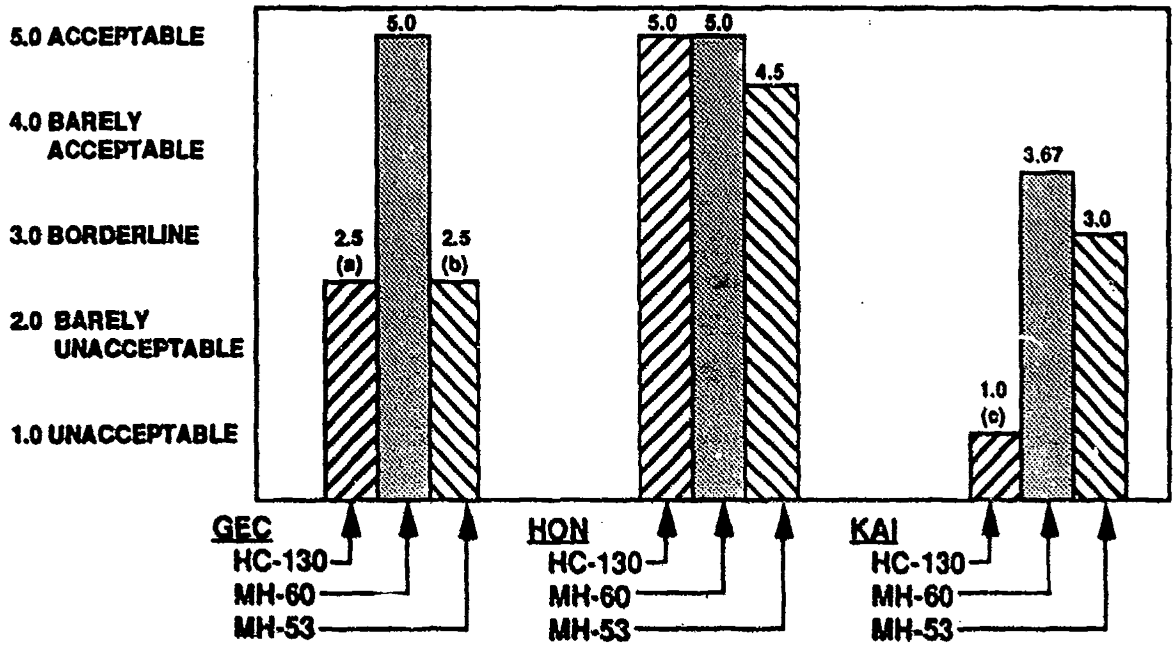


I.A.19.c Evaluate the location of the low battery indicator light. (26c)

This question was generally not rated with three exceptions. The exceptions were:

1) Honeywell - HC-130 pilots rated the indicator light as "Acceptable" (5.0).
2) Honeywell - MH-60 pilots rated the indicator light as "Unacceptable" (1.0).
3) Kaiser - MH-60 pilots rated the indicator light as "Acceptable" (5.0).
   Please note: There is no low battery indicator light on the Kaiser system

I.A.19.d Evaluate the access of the batteries. (26d)



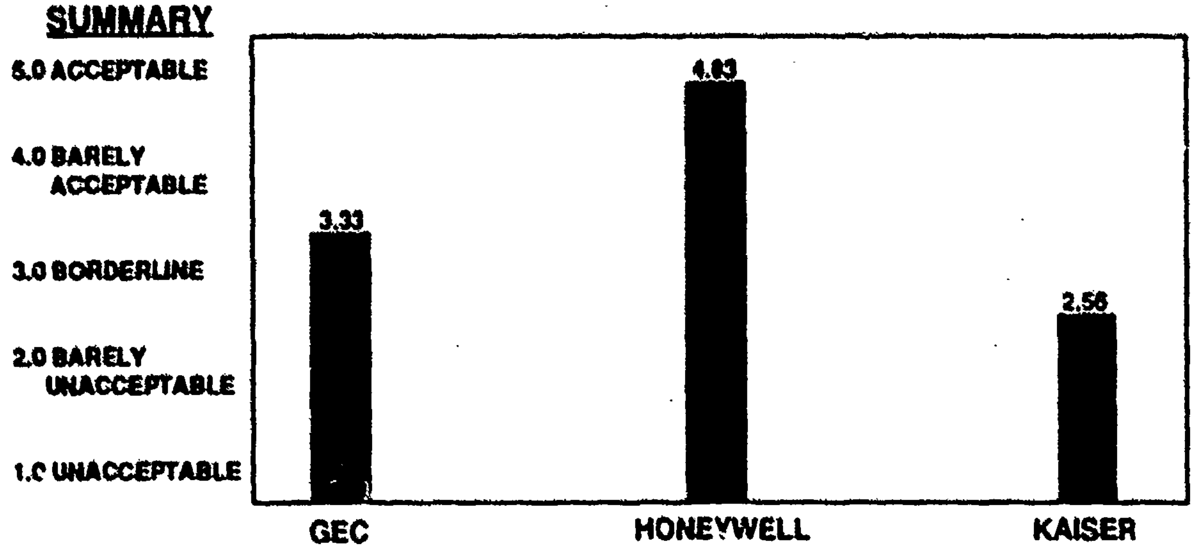
PILOT COMMENTS:

(a) Helmet must be removed.

(b) Access door needs to be attached to helmet.

(c) Should not require a screw driver.

SUMMARY



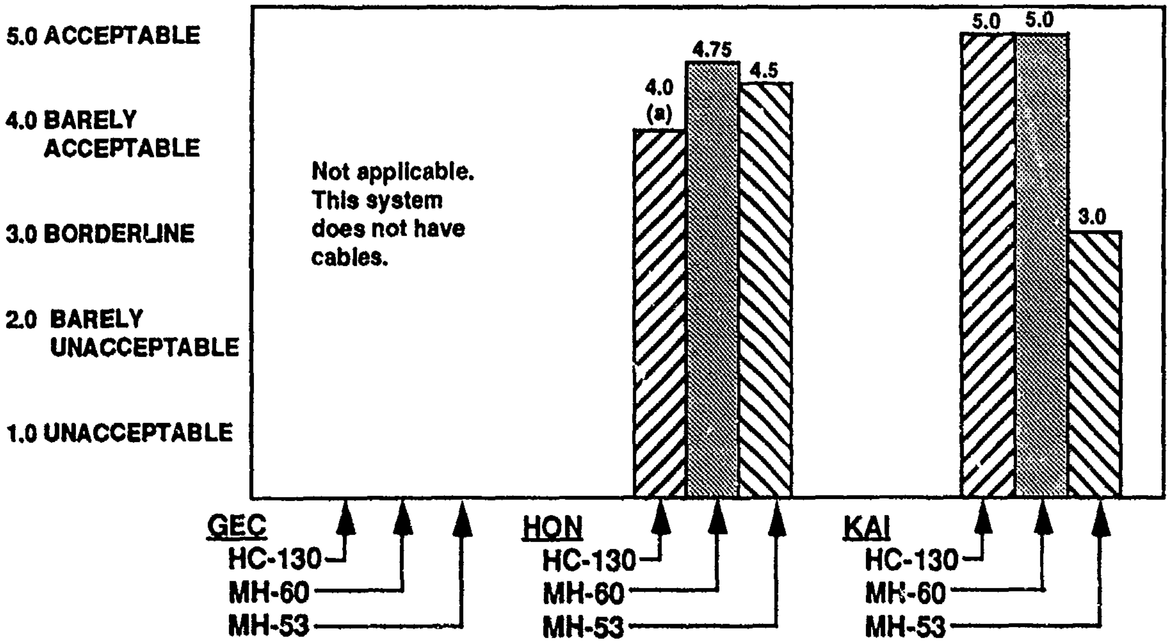
I.A.19.e Did the batteries fail in flight? If YES, how many? (26e)

A single incident of one battery failure occurred on one MH-60 flight.

I.A.19.f Was there adequate warning for pending battery failure? (26f)

There was no warning of the pending battery failure. The low battery light indicates a low battery state after the intensified image has disappeared. The indicator light aids the pilot in isolating the problem to the low battery state rather than to a malfunction of some other system component.

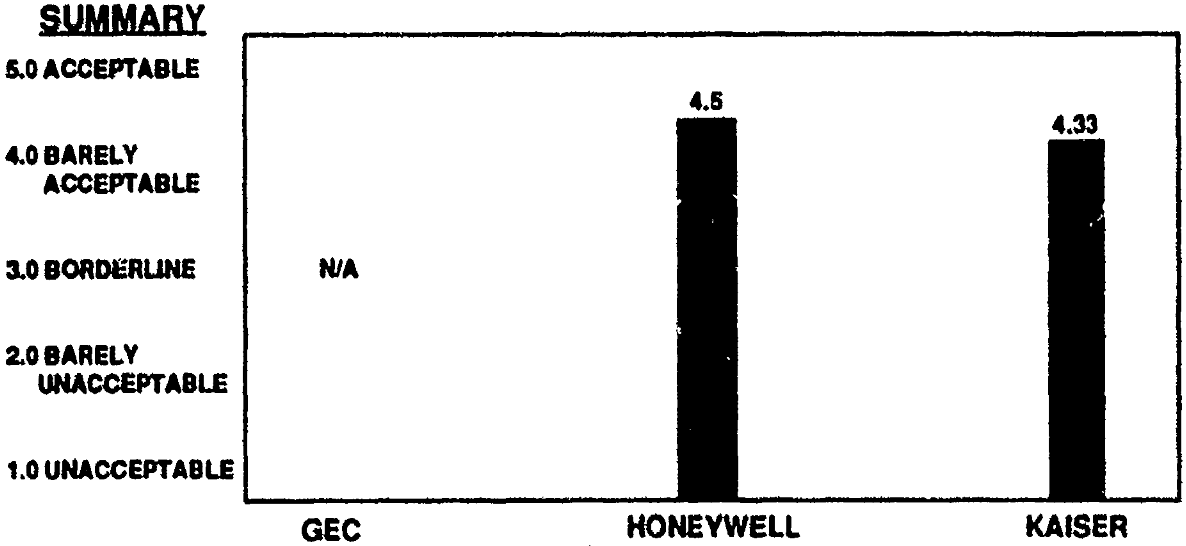
I.A.20 Evaluate the placement of the helmet cable. (32)



PILOT COMMENTS:

(a) Helmet must be off to connect.

SUMMARY



I.B AIRCRAFT/HELMET INTEGRATION

I.B.1 Do you feel the helmet will interfere with emergency egress? If YES, explain. (27)

All pilots said "NO" except for one HC-130 pilot who said "YES". The exception pertains to the Honeywell system. An HC-130 pilot and an MH-60 pilot both were concerned that the Honeywell combiners, while in the stowed position, could possibly hinder rapid egress.

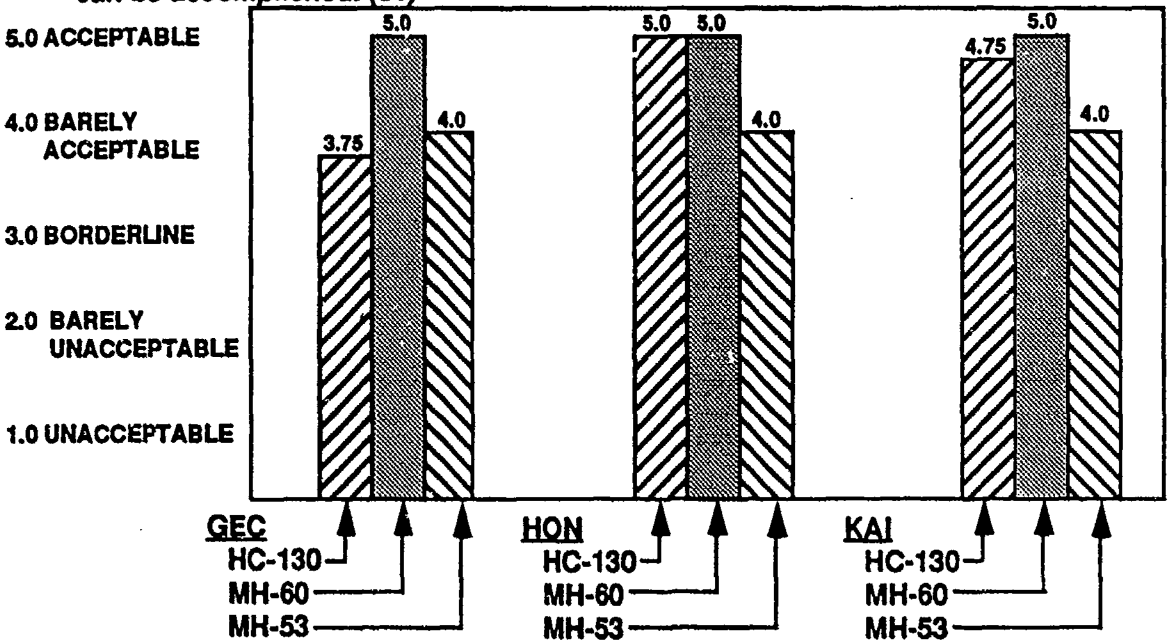
I.B.2 Did the helmet interfere with any cockpit controls? If YES, identify which controls and panels. (28)

All pilots said "NO."

I.B.3 If you ingress the cockpit with the helmet on, evaluate the ease in which this can be accomplished. (30)

All pilots rated all the helmets as "ACCEPTABLE" (5.0) with two exceptions. The two exceptions were that the HC-130 pilots did not ingress with the GEC or Kaiser helmets.

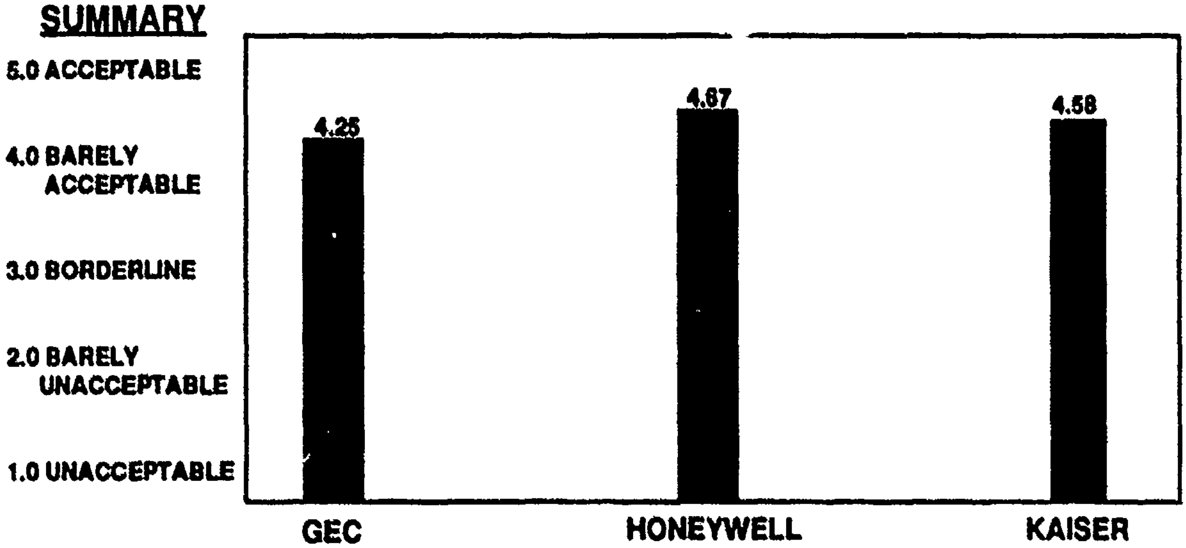
I.B.4 If you don the helmet after you ingress the cockpit, evaluate the ease in which this can be accomplished. (31)



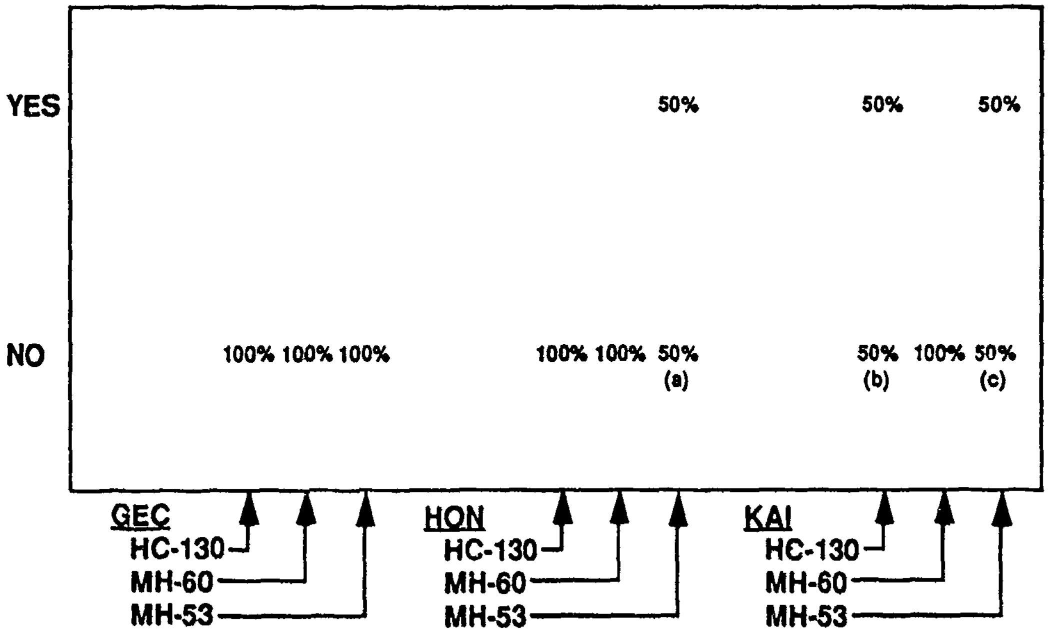
PILOT COMMENTS:

NONE

SUMMARY



I.B.5 Did you experience any head movement restriction? If YES, describe. (29)



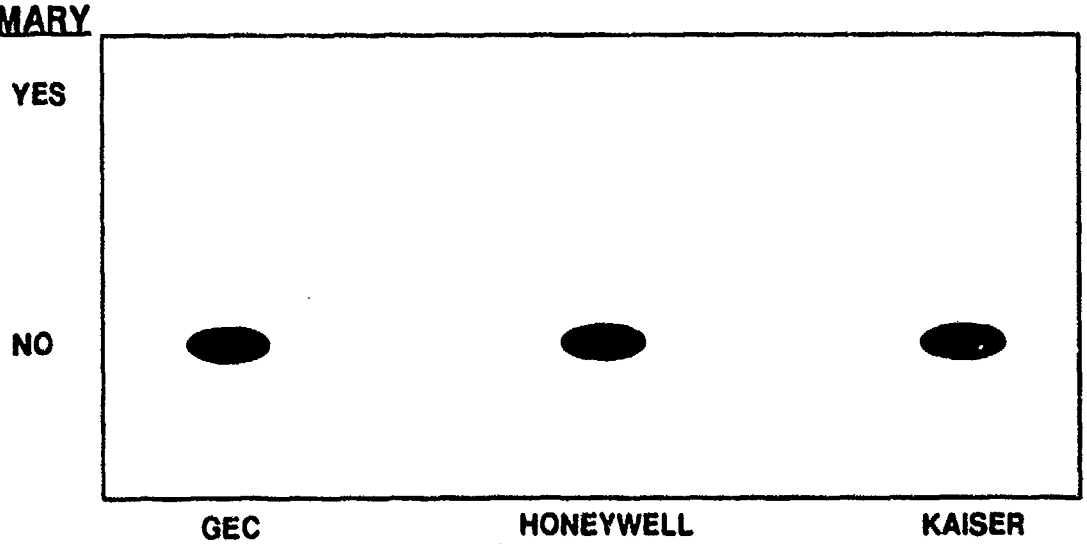
PILOT COMMENTS:

(a) Stowed combiners caught on comm cord.

(b) Bumps side windows when clearing.

(c) Power cable tangled with HEEDS bottle.

SUMMARY



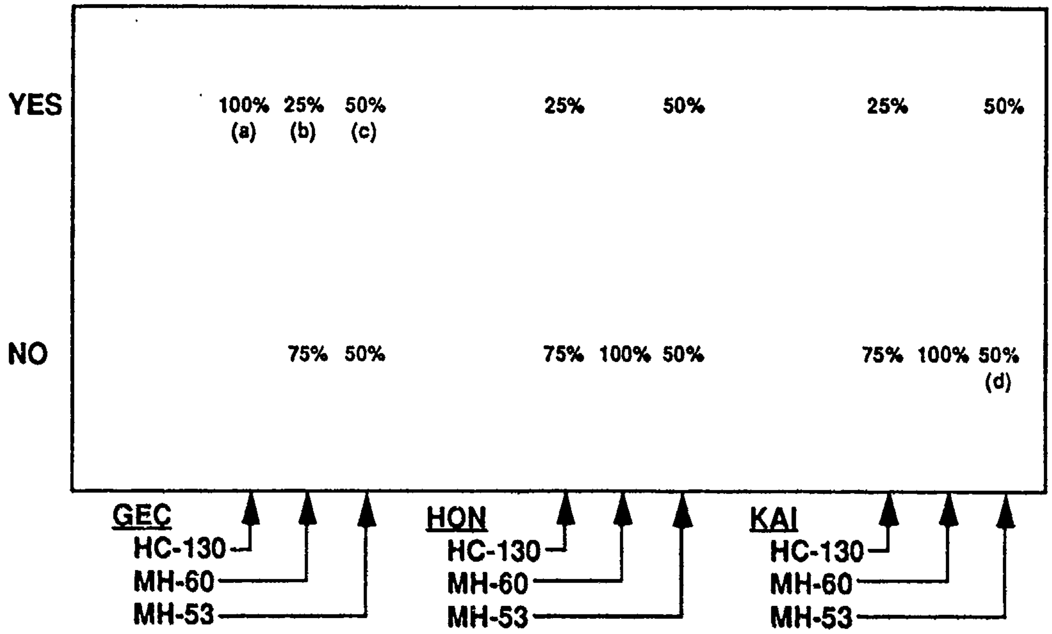
I.B.6 Did the helmet interfere with the seat? If YES, describe. (29)

All the pilots said "NO."

I.B.7 Was there sufficient cannopy/cockpit clearance? If NO, describe. (37)

All the pilots said "YES" with one exception. The one exception was an HC-130 pilot wearing the Kaiser helmet.

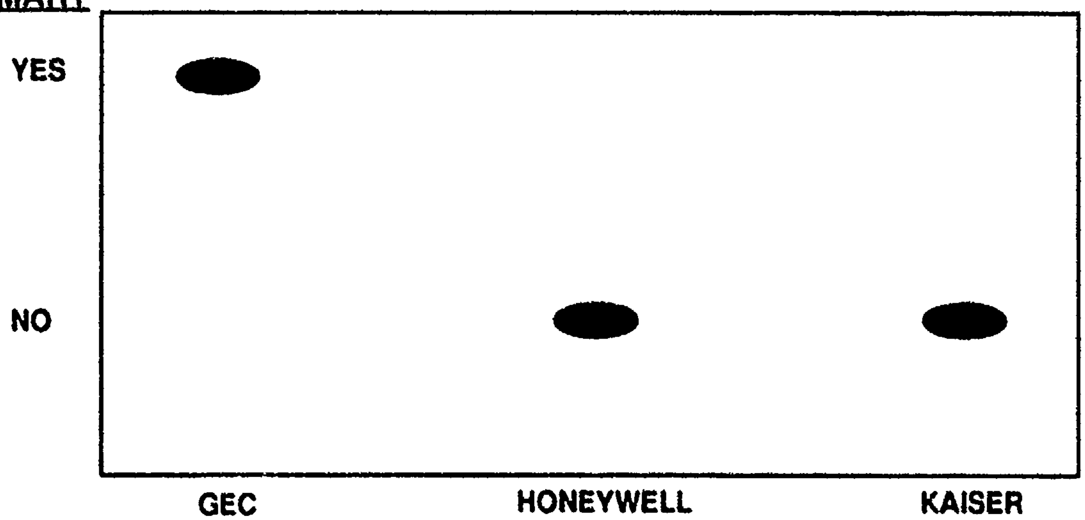
I.B.8.a With the combiners UNSTOWED (combiners in front of your eyes), did you experience any visual restrictions (blind spots) due to the combiners? If YES, were the visual restrictions tolerable? (55a)



PILOT COMMENTS:

(a) When helmet slipped, also combiner structure.
(b) 25% upper periphery visual restriction.
(c) Looked around rather than through combiners when intensifiers were off.
(d) Combiners were a restriction when tubes were off.

SUMMARY



I.B.8.b With the combiners UNSTOWED (combiners in front of your eyes), did you experience any visual restrictions (blind spots) due to the mask? If YES, were the visual restrictions tolerable? Describe the percent of visual restriction. (55b)

This question is not applicable to the MH-60 and MH-53 pilots. They do not use an oxygen mask and their helmets were conigured with boom mics.

This question does apply to the HC-130 pilots. The HC-130 pilots said "NO."

I.B.8.c With the combiners UNSTOWED (combiners in front of your eyes), did you experience any visual restrictions (blind spots) due to the visor? If YES, were the visual restrictions tolerable? Describe the percent of visual restriction.

All pilots said "NO" with one exception. The one exception was an HC-130 pilot who reported glare from the instrument panel while wearing the Honeywell helmet with the visor down.

I.B.8.d With the combiners UNSTOWED (combiners in front of your eyes), did you experience any visual restrictions (blind spots) due to the helmet? If YES, were the visual restrictions tolerable? Describe the percent of visual restriction. (55e)

All pilots said "NO" except that the HC-130 pilots reported minor peripheral restrictions.

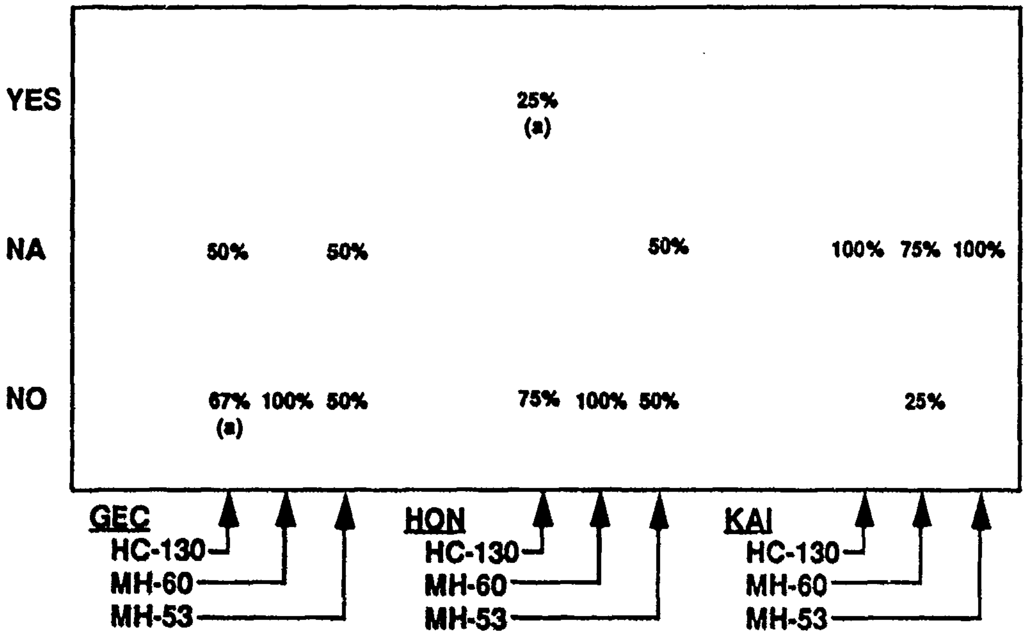
I.B.8.e With the combiners UNSTOWED (combiners in front of your eyes), did you experience any visual restrictions (blind spots) due to the boom mic? If YES, were the visual restrictions tolerable? Describe the percent of visual restriction. (55e)

This question is not applicable to the HC-130 pilots. The MH-60 and MH-53 pilots said "NO."

I.B.9 With the combiners STOWED, if applicable, did you experience any visual restrictions (blind spots) due to the combiners? If YES, were the visual restrictions tolerable? Describe the percent of visual restriction (56a)

This question is not applicable to the GEC helmet. The GEC helmet has fixed combiners. The general answer to this is "NO" with one exception. The exception pertains to the Honeywell helmet on which the HC-130 pilots reported minor blind spots with the combiners in the stowed position.

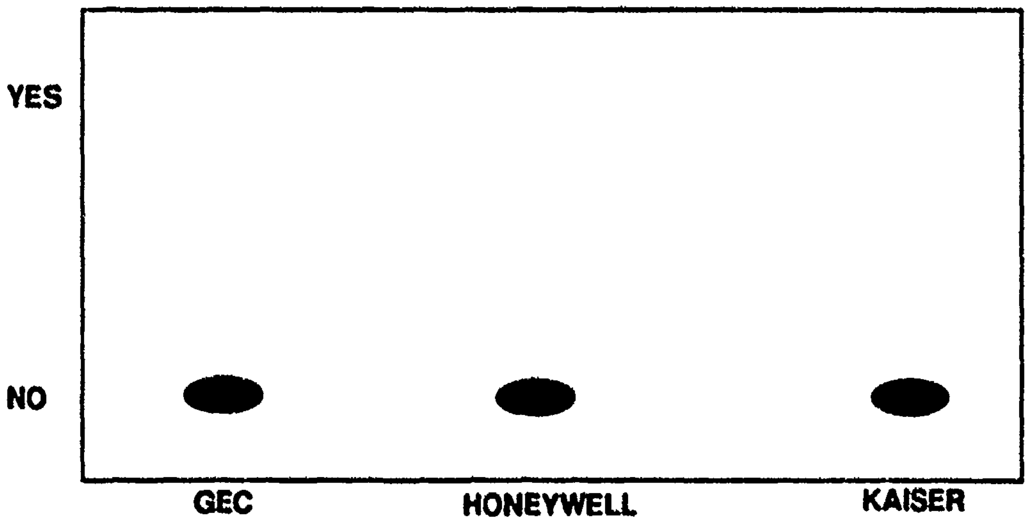
I.C.1 Did you experience any difficulty with the visor controls/or in raising and lowering the visor? If YES, describe. (25)



PILOT COMMENTS:

(a) Detent difficult.

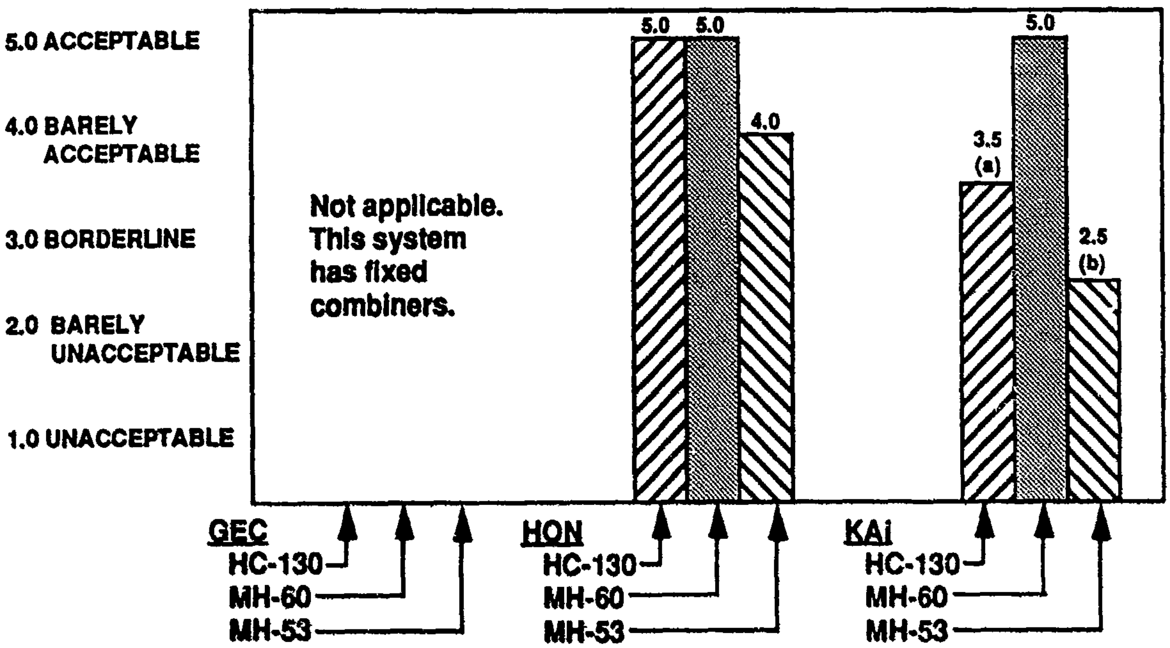
SUMMARY



I.C.2 If the combiners were not stowable, should they be? (57)

All the pilots said "YES."

I.C.3.a Evaluate the ease of stowing the combiners during pre-flight. (50a)

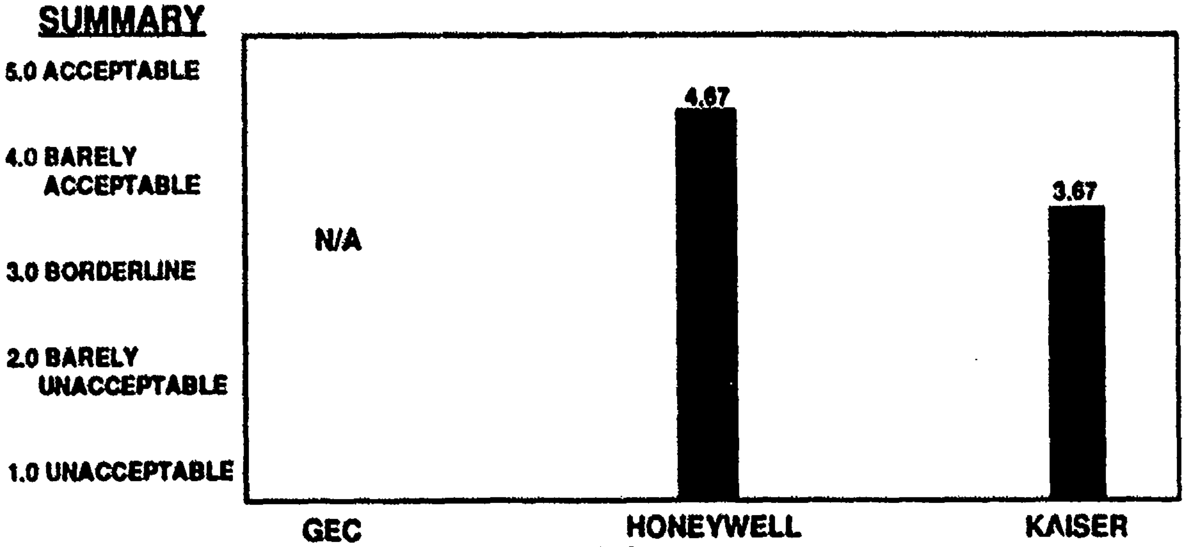


PILOT COMMENTS:

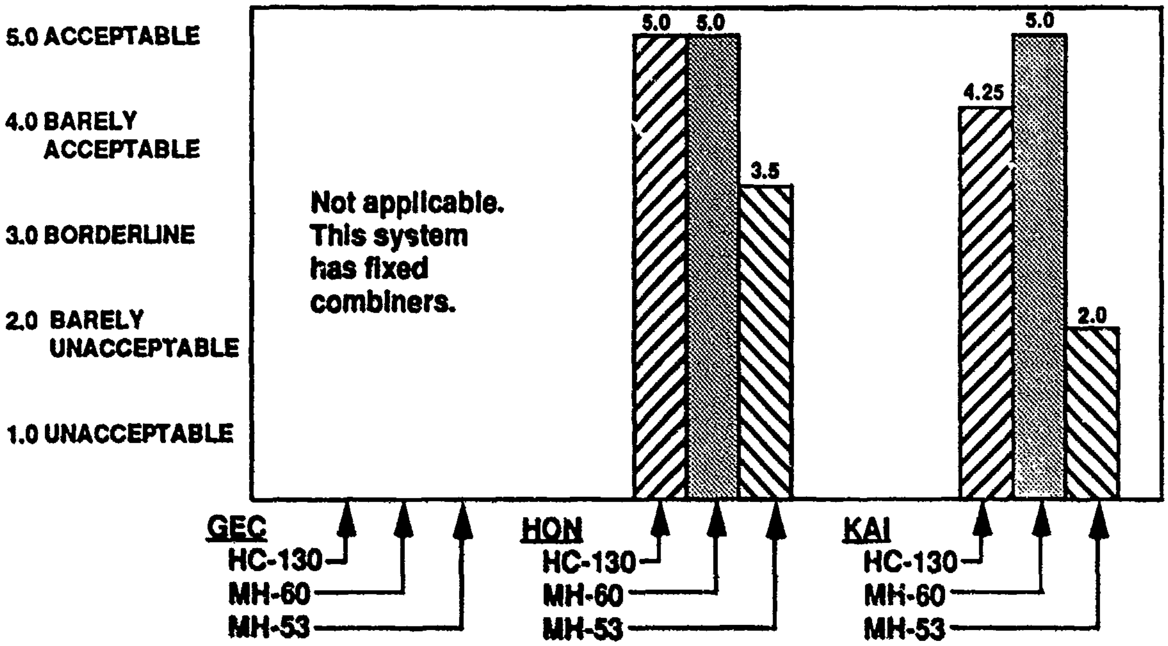
(a) Strange rotation angle.

(b) Required multiple attempts.

SUMMARY



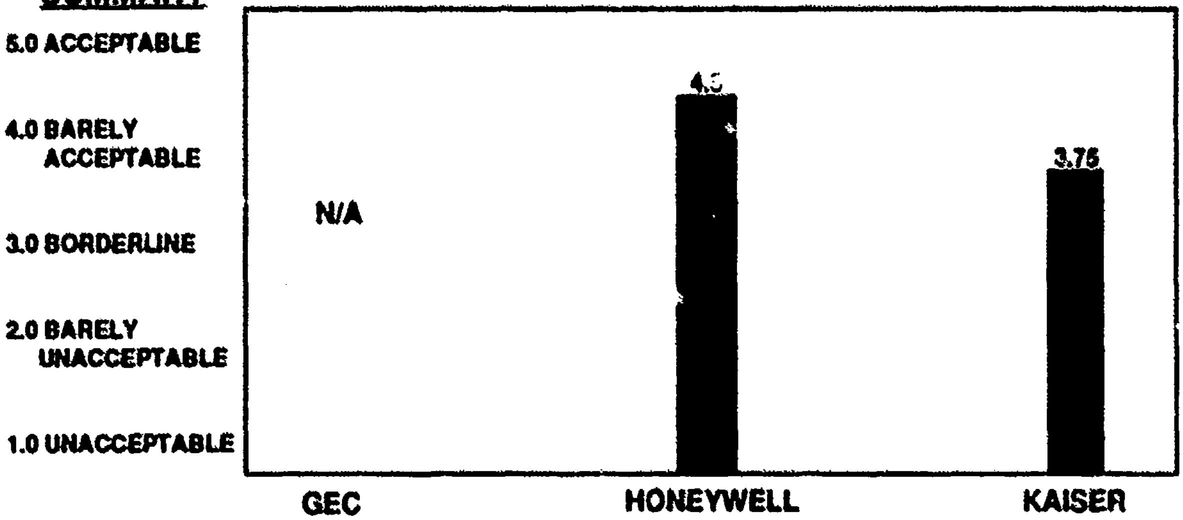
I.C.3.b Evaluate the ease of stowing the combiners while inflight. (50b)



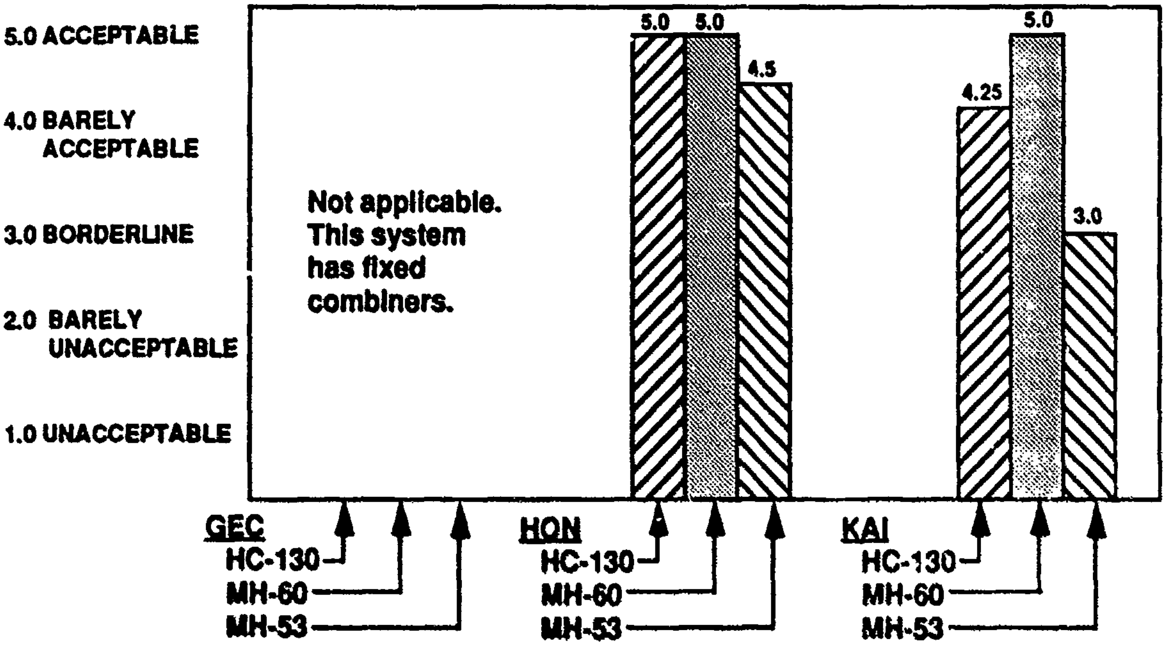
PILOT COMMENTS:

NONE

SUMMARY

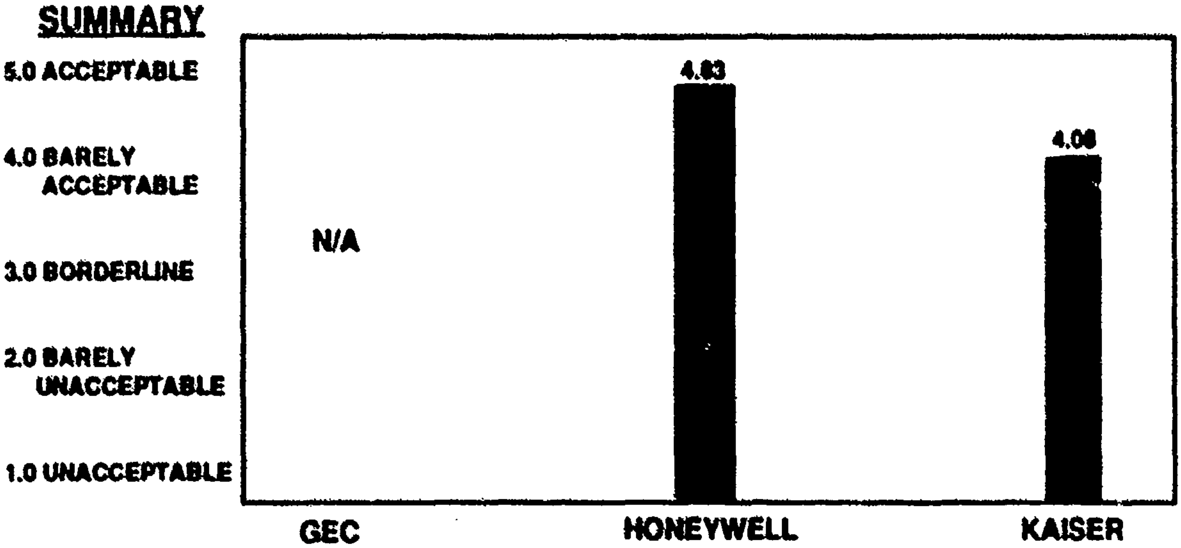


I.C.4.a Evaluate the ease of unstowing the combiners during pre-flight (51a).

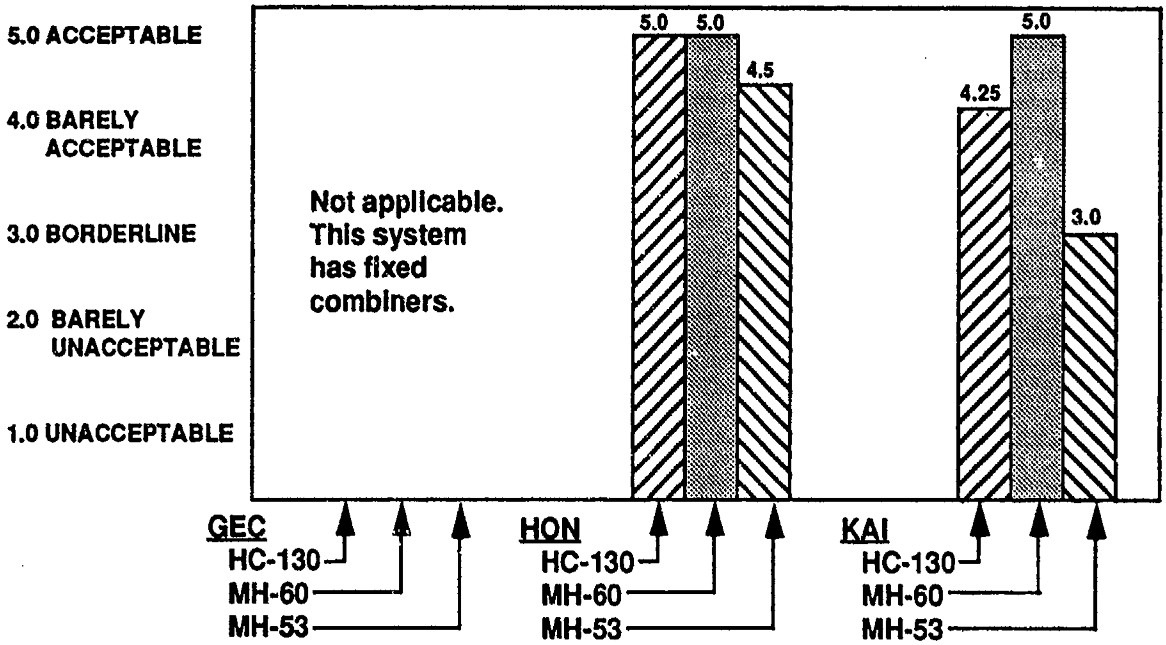


PILOT COMMENTS:
NONE

SUMMARY

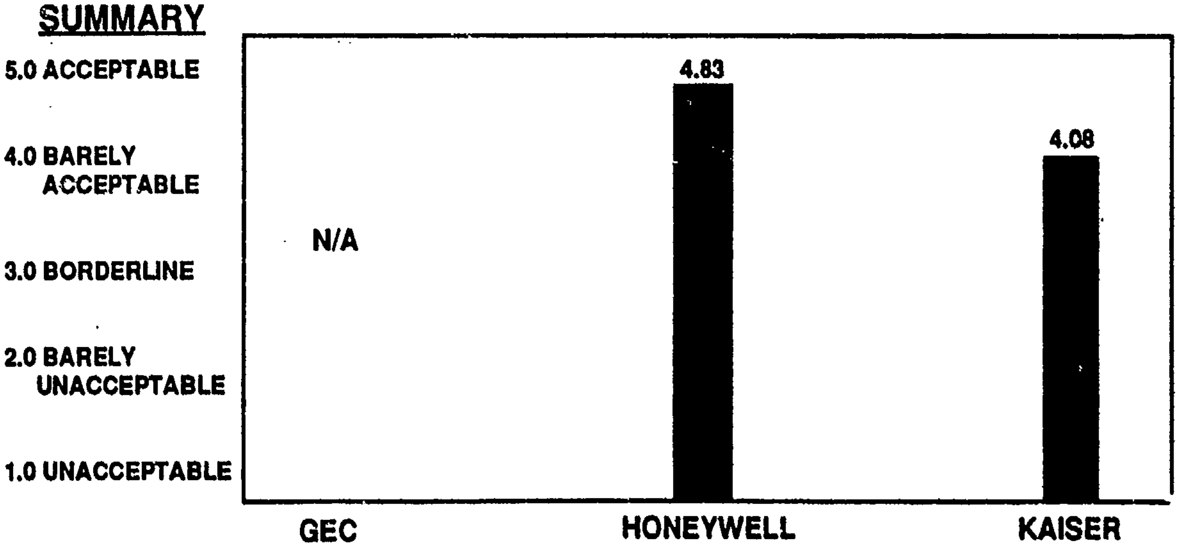


I.C.4.b Evaluate the ease of unstowing the combiners during inflight. (51b).



PILOT COMMENTS:
NONE

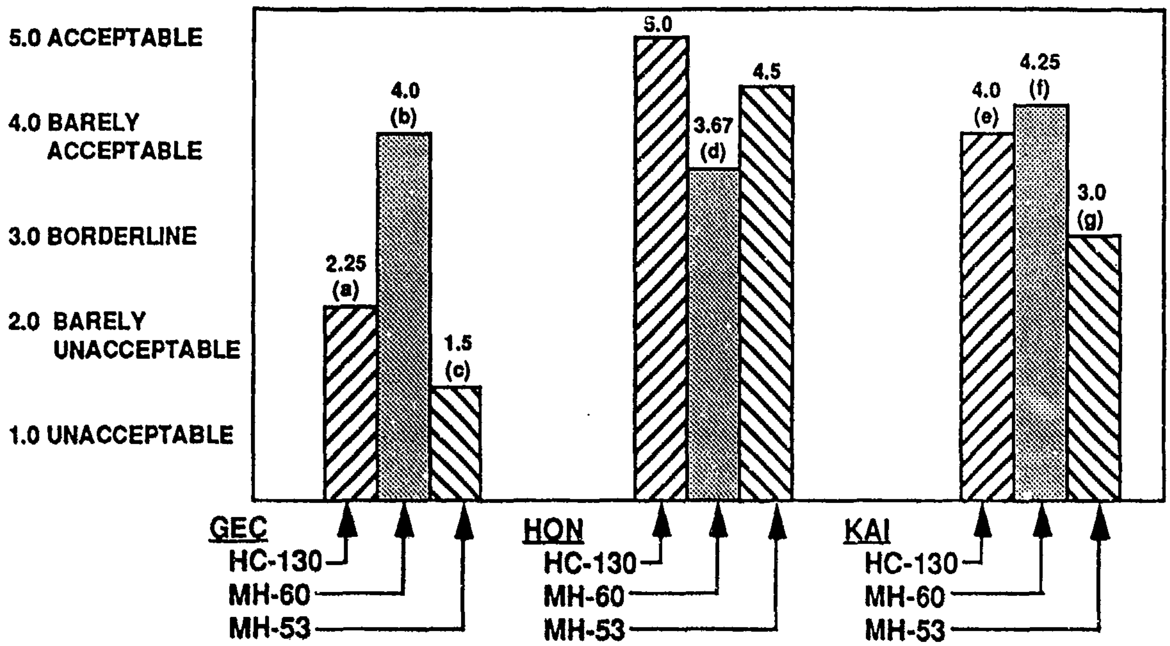
SUMMARY



I.C.5 Did the combiners interfere with the visor and its operation? (59)

All the pilots said "NO" or "NOT APPLICABLE."

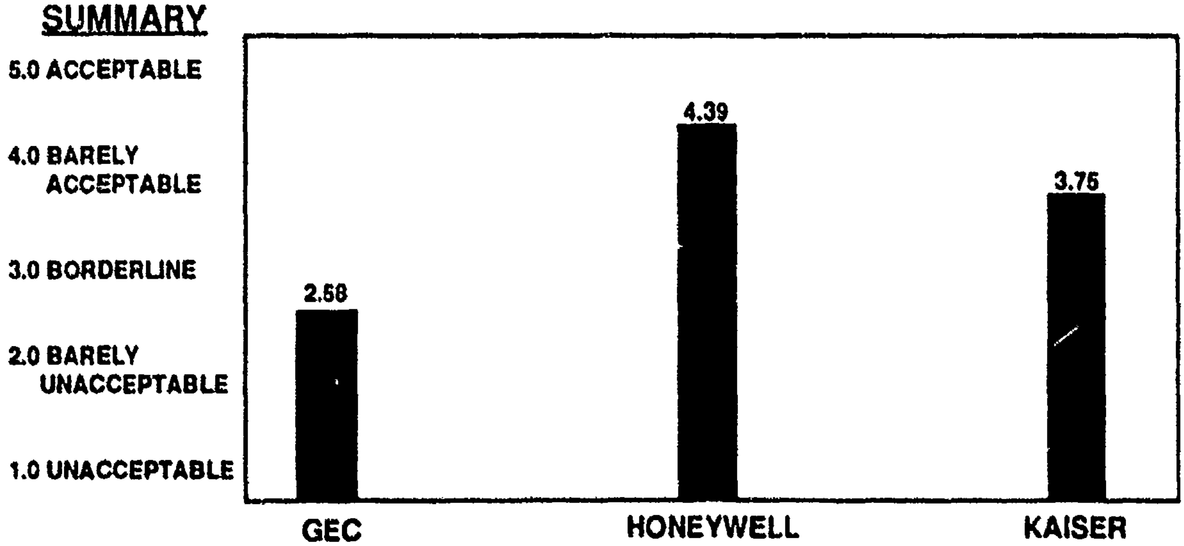
I.C.6 Evaluate the overall position of the combiners in front of your eyes. (47)



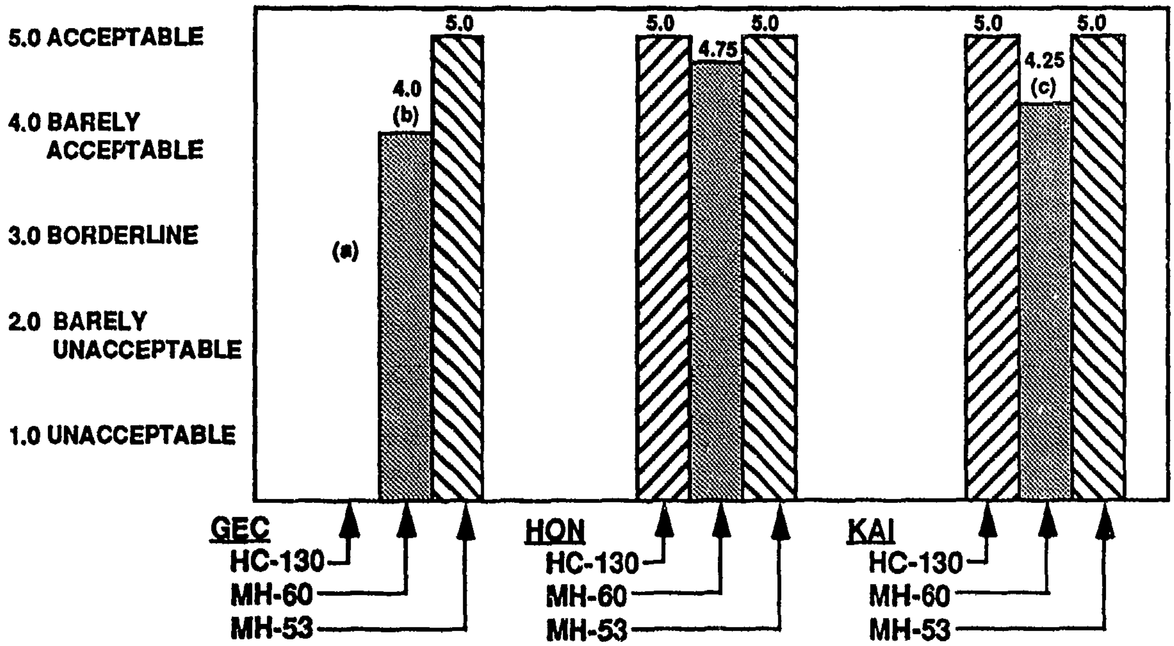
PILOT COMMENTS:

(a) Forward CG and poor fit caused helmet to rotate forward and view slips out of alignment.
(b) Too close.
(c) Almost impossible to keep combiners centered.
(d) Combiners pressed on face.
(e) Combiners pressed on glasses.
(f) Too close to eyes.
(g) Tilted head to compensate for lack of tilt adjustment.

SUMMARY



I.C.7.a Evaluate the distance between the eyes and the combiners without glasses. (48a)



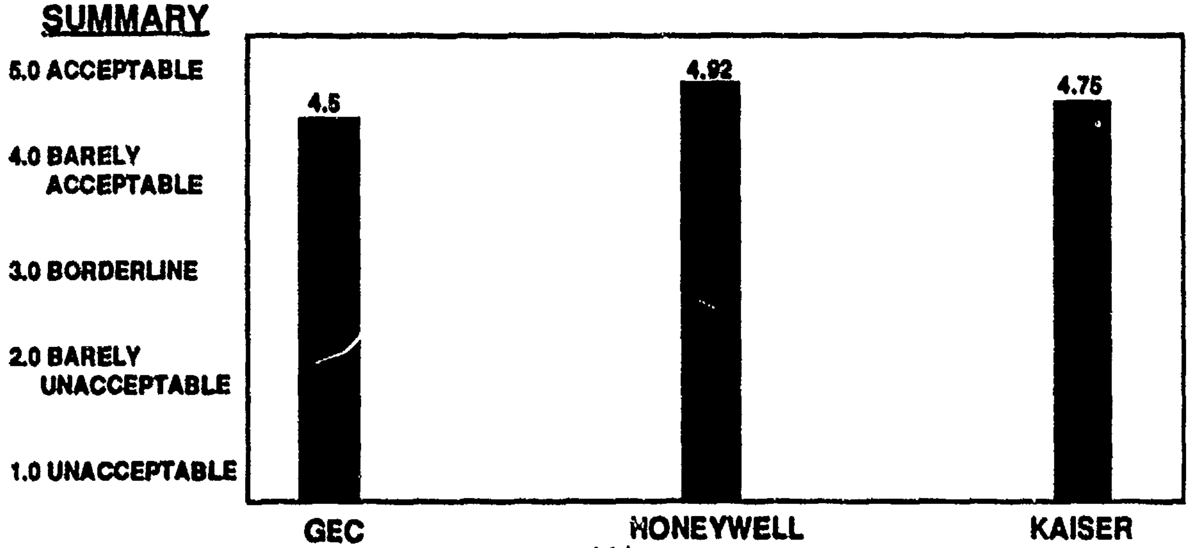
PILOT COMMENTS:

(a) Not rated.

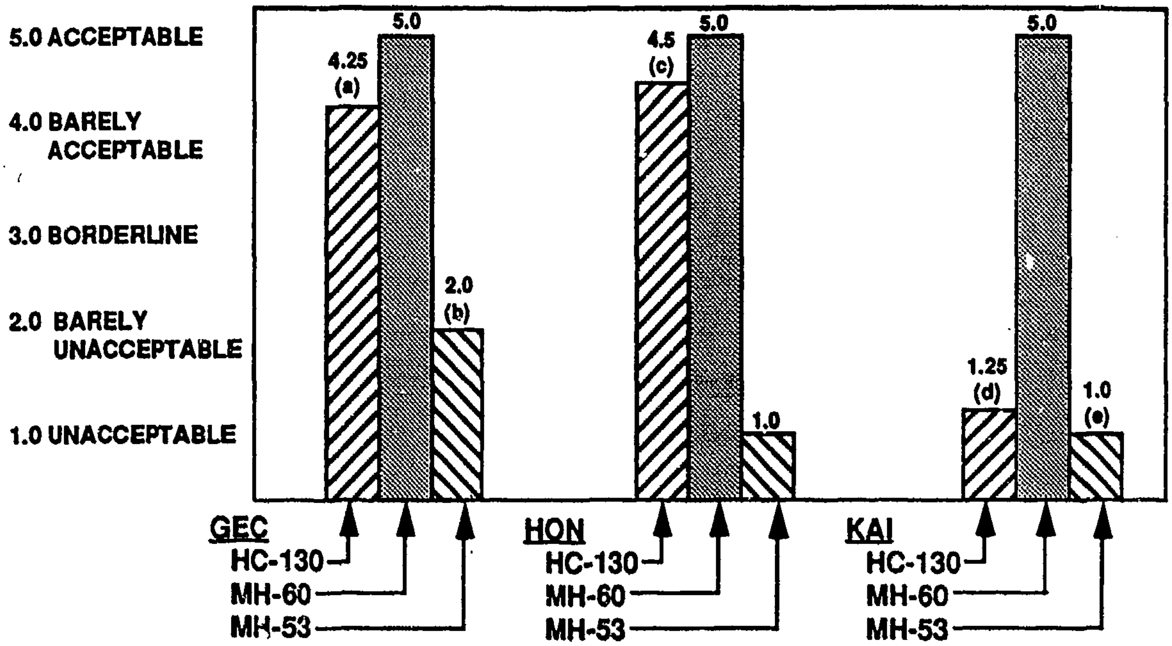
(b) Too close, could not have worn glasses.

(c) Too close, but useable.

SUMMARY



I.C.7.b Evaluate the distance between the eyes and the combiners with glasses. (48b)



PILOT COMMENTS:

(a) OK for wear, but hard to get on and off.

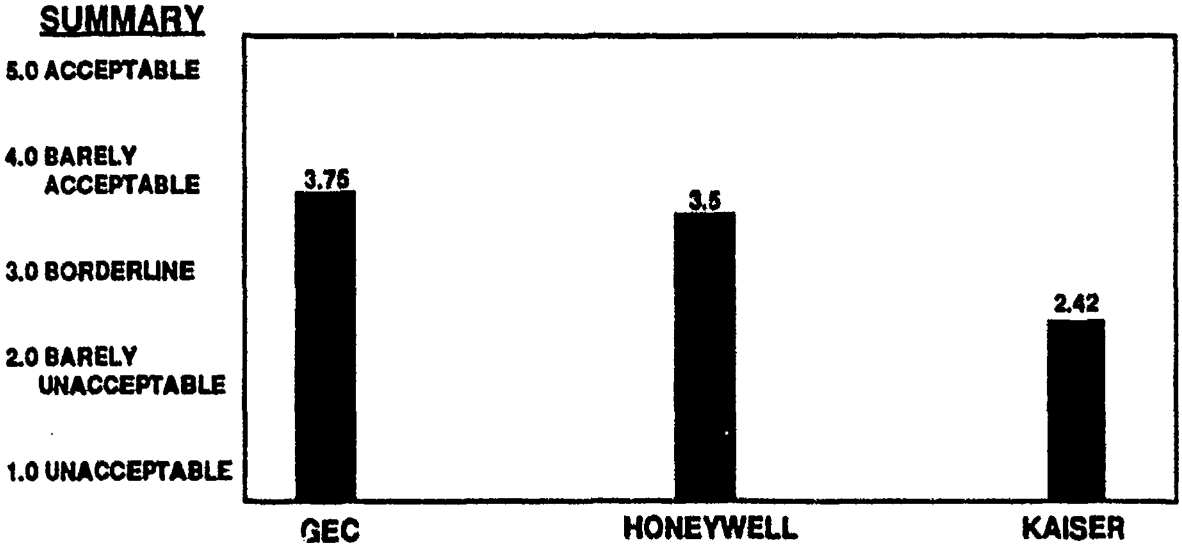
(b) Barely cleared glasses.

(c) Slight contact with glasses.

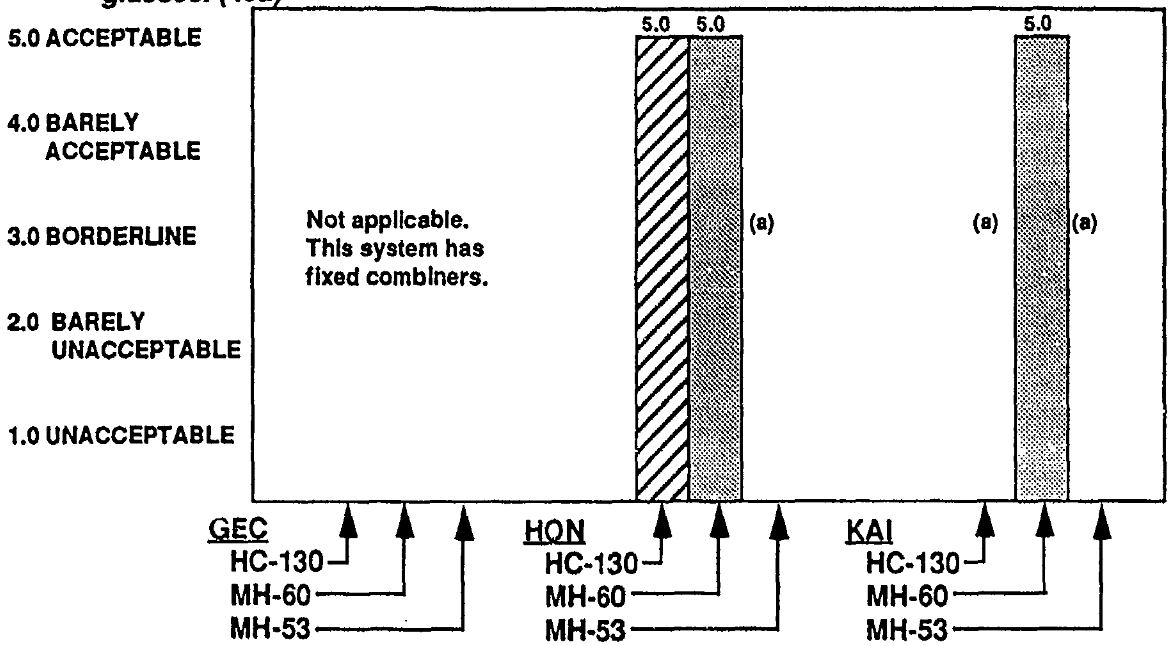
(d) Combiners pressed on glasses.

(e) Combiners pressed glasses against nose.

SUMMARY



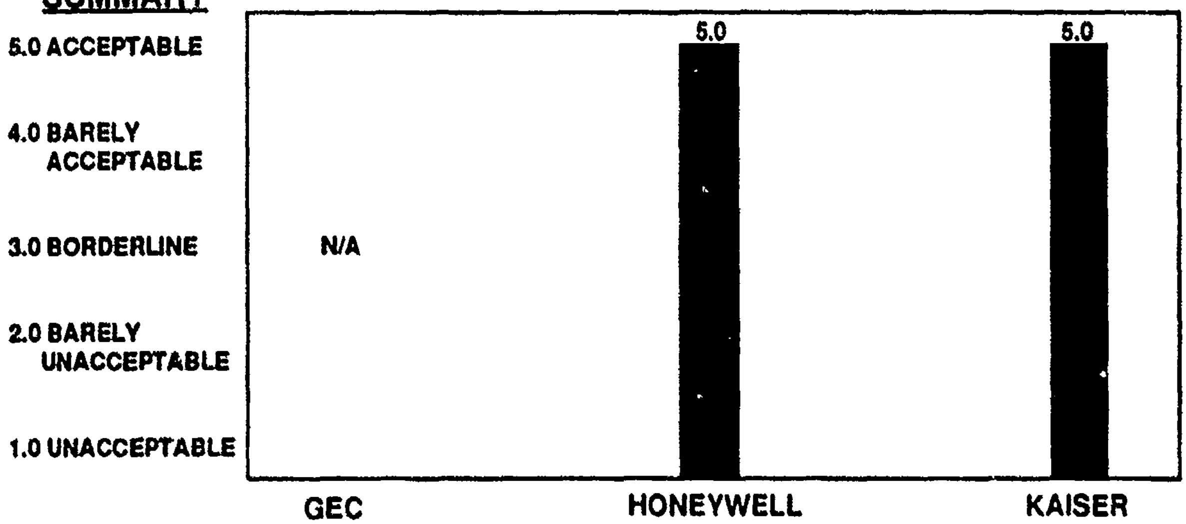
I.C.8.a Evaluate the distance between the eyes and the visors (combiners stowed) without glasses. (49a)



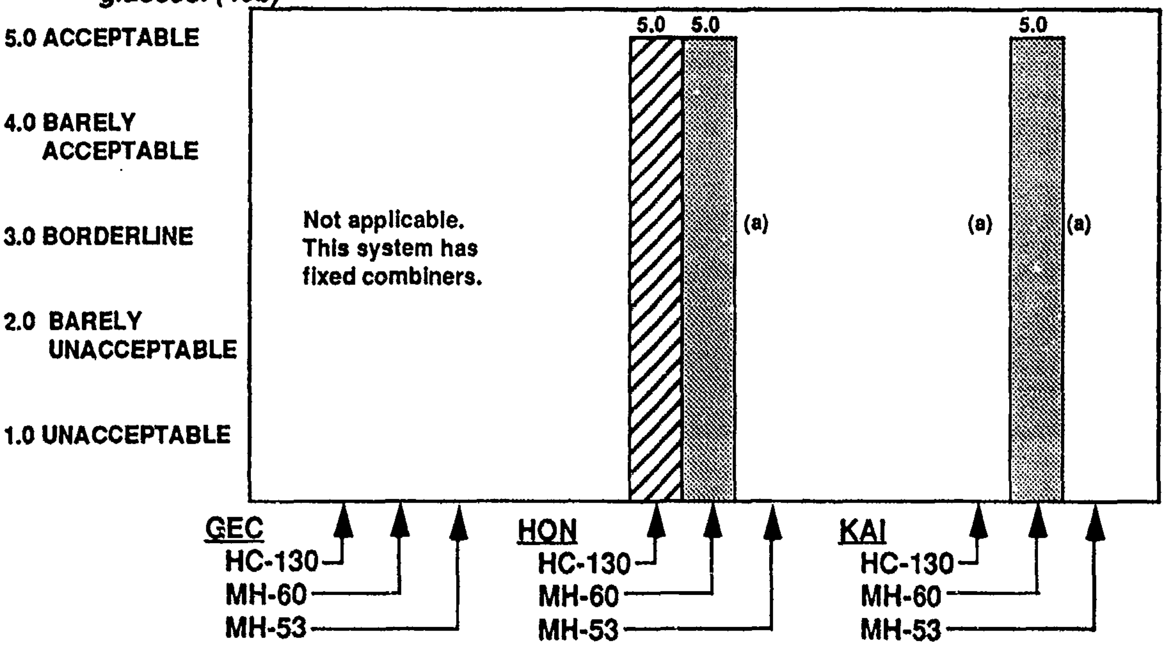
PILOT COMMENTS:

(a) This category was not rated.

SUMMARY



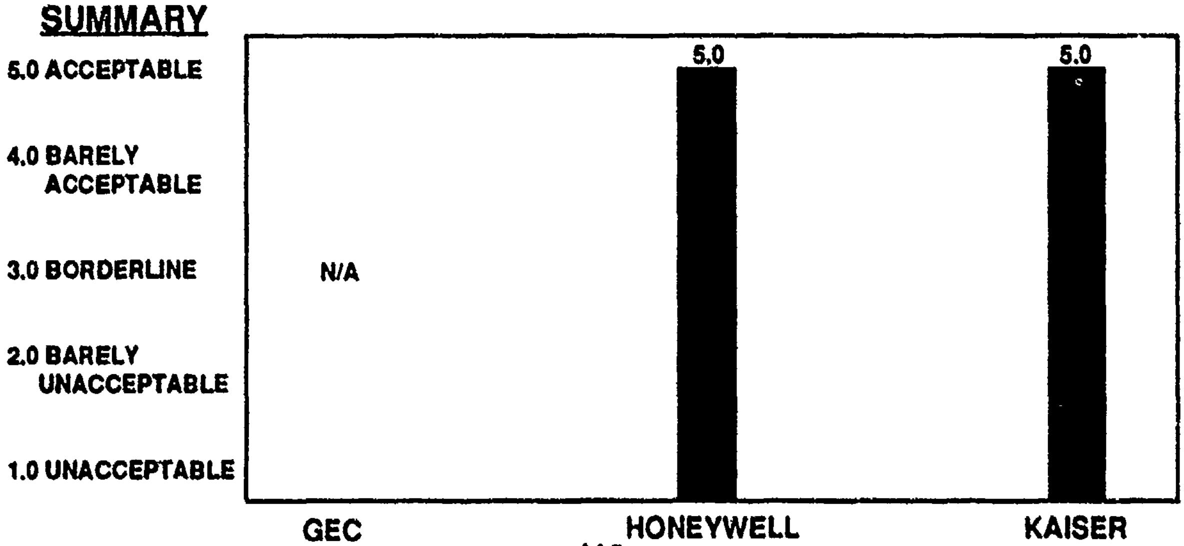
I.C.8.b Evaluate the distance between the eyes and the visors (combiners stowed) with glasses. (49b)



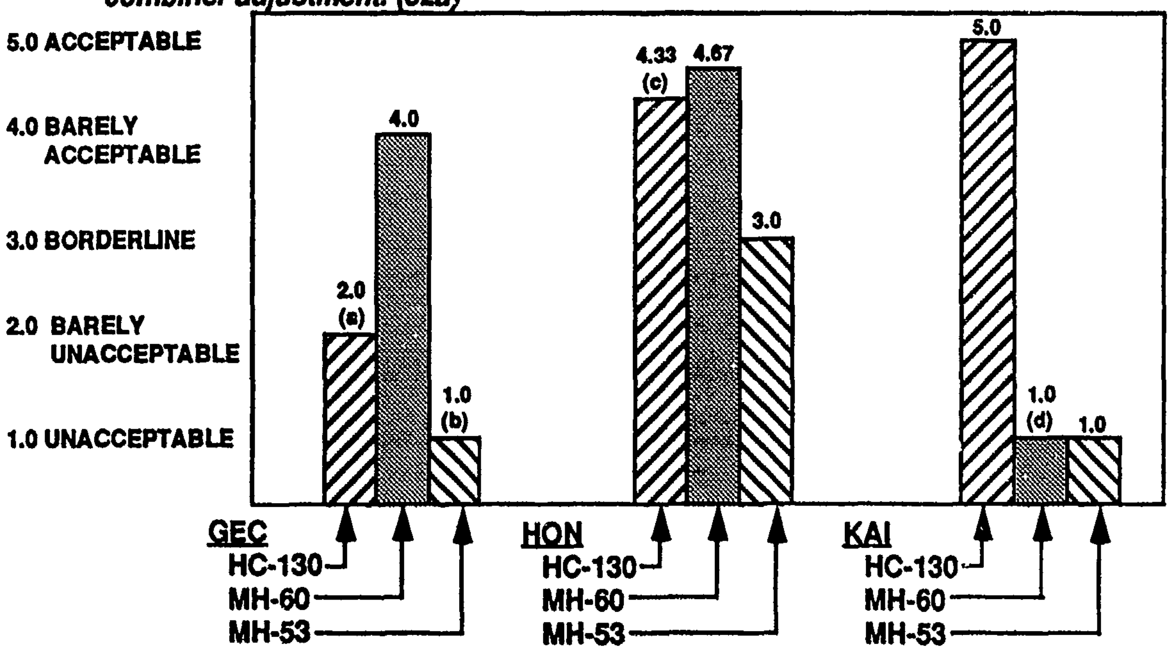
PILOT COMMENTS:

(a) This category was not rated.

SUMMARY



I.C.9.a Evaluate the operation of the inter-pupillary diameter (distance between the eyes) combiner adjustment. (52a)



PILOT COMMENTS:

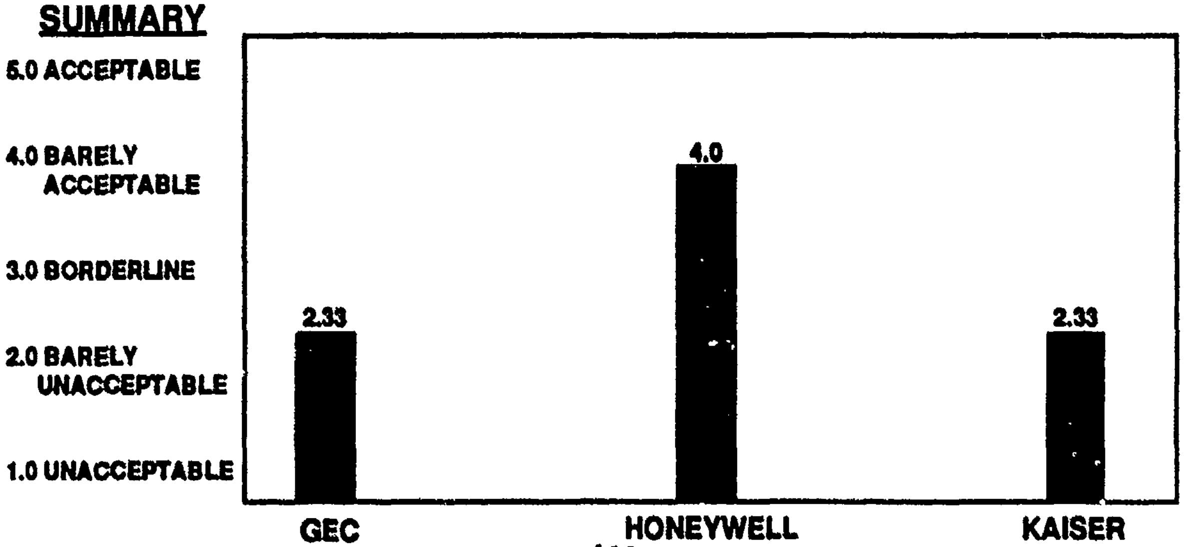
(a) Requires a screw driver, not adjustable.

(b) Requires a screw driver - ridiculous.

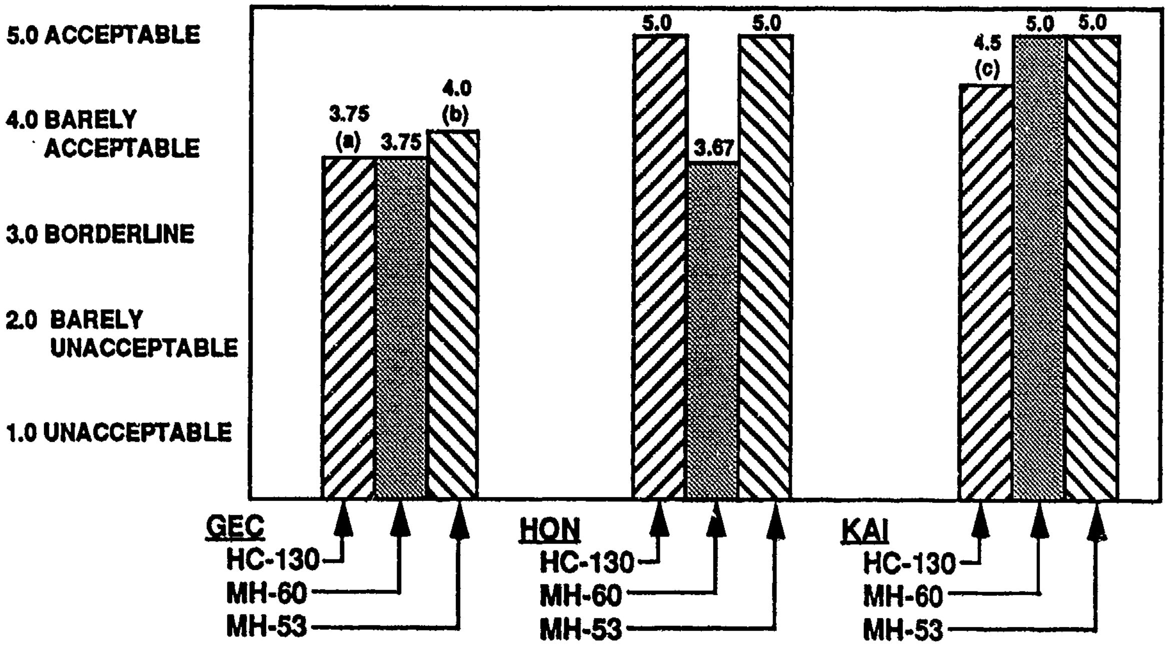
(c) Needs more movement per twist of adjusting knob.

(d) Requires all wrench - dumb.

SUMMARY



I.C.9.b Evaluate the operation of the combiner focus adjustments. (52e)



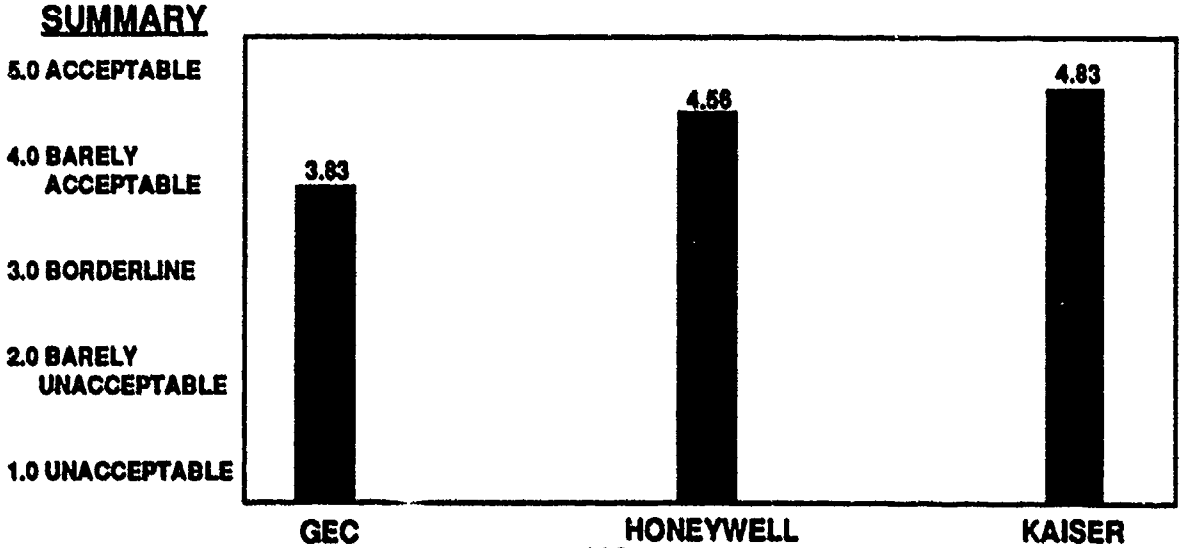
PILOT COMMENTS:

(a) Adjustment range too short.

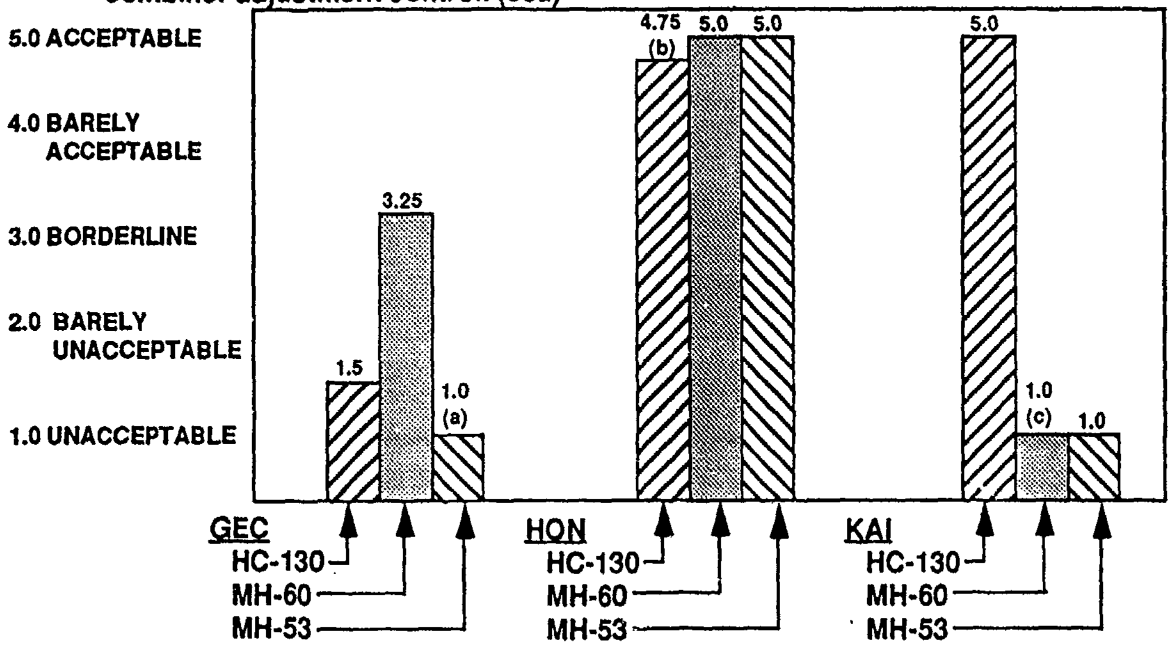
(b) Did not appear to have any effect.

(c) Adjustment does not do much; focal area too narrow.

SUMMARY



I.C.10.a Evaluate the accessibility of the inter-pupillary diameter (distance between eyes) combiner adjustment control. (53a)



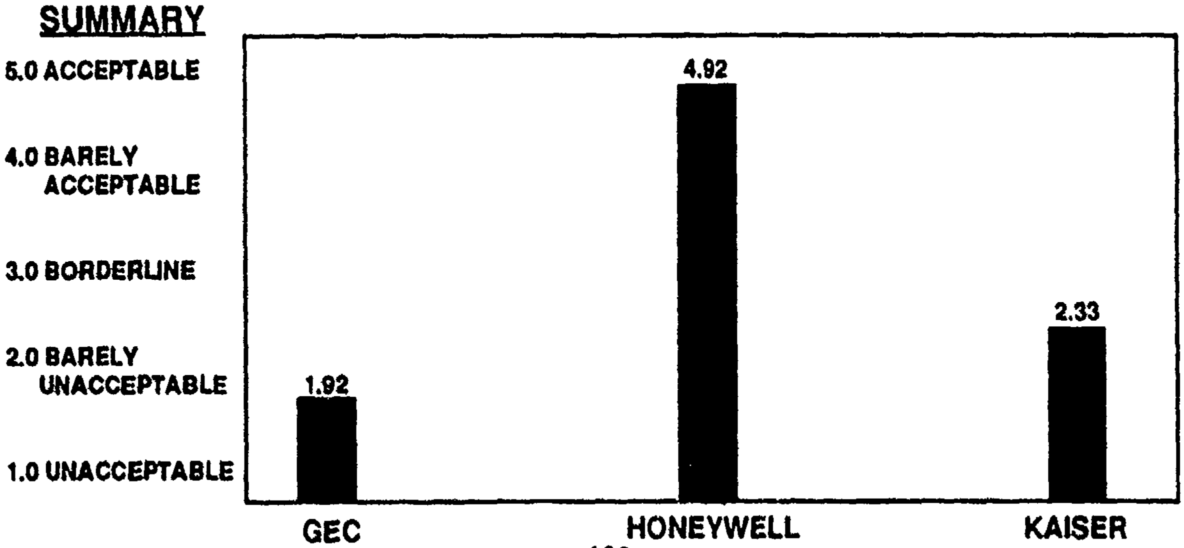
PILOT COMMENTS:

(a) All adjustments need to be accesible inflight - tilt, diopter and vertical should be added.

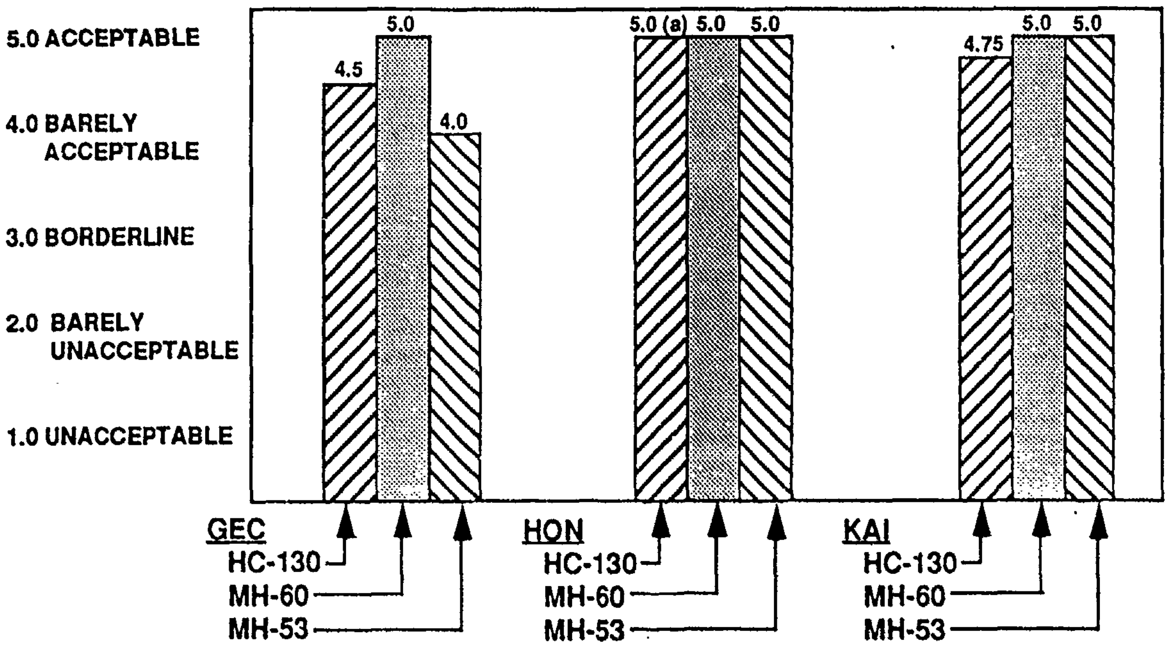
(b) A little too small.

(c) Requires an allen wrench - dumb.

SUMMARY



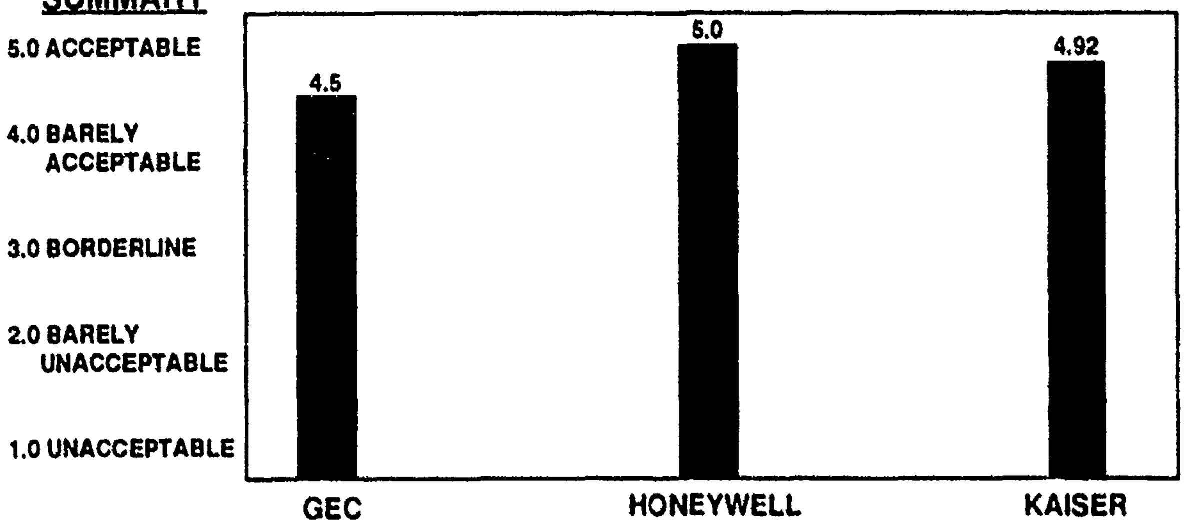
I.C.10.b Evaluate the accessibility of the combiner focus adjustment control. (53e)



PILOT COMMENTS:

(a) A little too small.

SUMMARY



I.C.11 Did you adjust the combiners in flight? YES/NO. If yes, indicate the adjustments you made and the reason for the adjustment. (54a,b,c)

	GEC HC-130	GEC MH-60	GEC MH-53	HON HC-130	HON MH-60	HON MH-53	KAI HC-130	KAI MH-60	KAI MH-53
YES	75%	75%	0%	75%	100%	50%	100%	100%	50%
NO	25%	25%	100%	25%	0%	50%	0%	0%	50%
IPD[1]	0%	50%	0%	50% (c)	25%	0%	0%	0%	0%
FOCUS[1]	75% (a)	75% (b)	0%	50% (c)	100% (d)	50% (e)	100% (f)	100% (g)	50% (h)
DIFFICULT[1]	0%	38% (i)	0%		25%	0%		0%	
BORDERLINE[1]	0%		0%	19%	50%	0%	(i)	0%	(i)
EASY[1]	75%	19%	0%	56%	25%	50%	50%	100%	25%

(NOTE 1: Percentage of all flights for each aircraft type.)

PILOT COMMENTS:

(a) Fine tune distant objects.

(b) To see, poor resolution - never had good adjustment.

(c) Refine pre-flight setting.

(d) Adjusted focus to see - poor infinity on left combiner.

(e) Fine tune focus.

(f) To get clearer picture - could not get clear picture.

(g) Adjusted to be able to see, fine tuning, best focus not at infinity.

(h) Tried to get better image, but never suceeded.

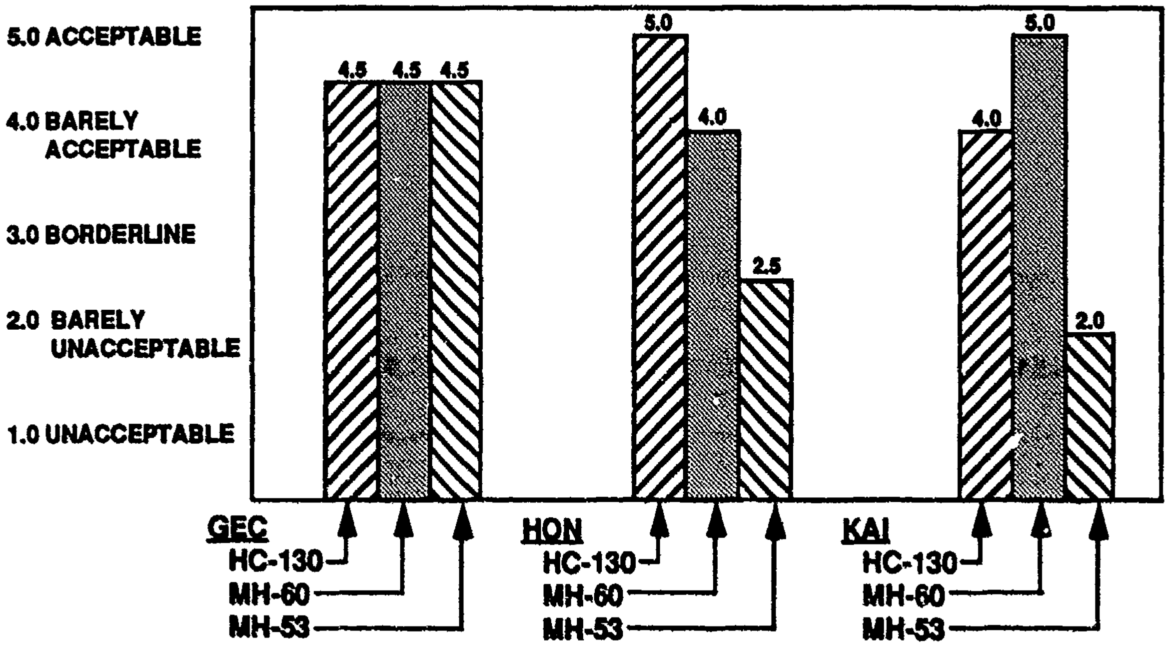
(i) This category was not rated by some or all pilots.

SUMMARY

	GEC	HONEYWELL	KAISER
YES	50%	75%	83%
NO	50%	25%	17%
IPD[2]	11%	23%	0%
FOCUS[2]	34%	67%	83%
DIFFICULT[2]	9%	6%	
BORDERLINE[2]	(i)	19%	(i)
EASY[2]	21%	50%	

(NOTE 2: Percentage of all flights for each aircraft type.)

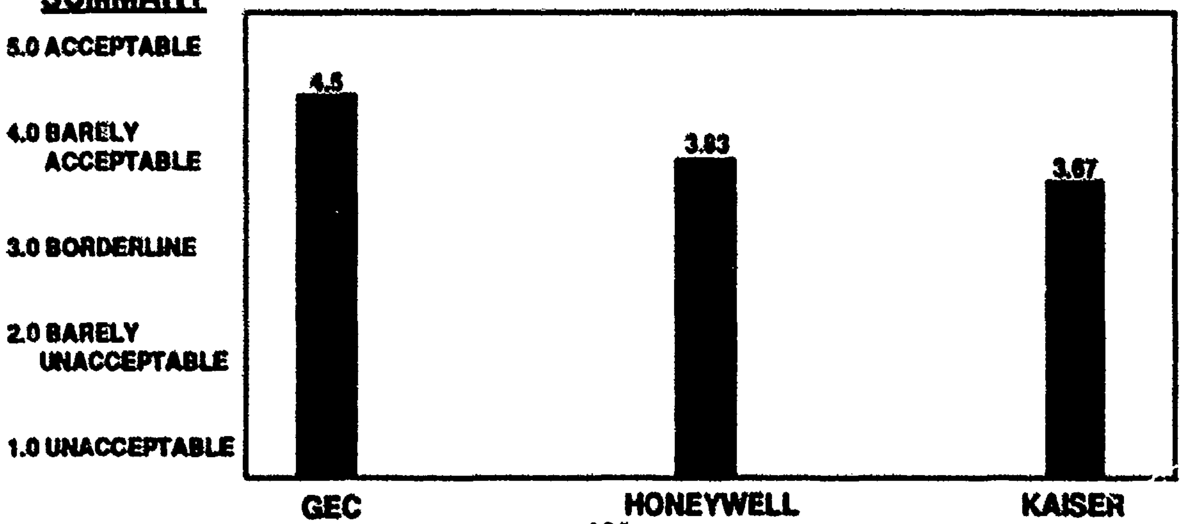
I.C.12 Evaluate the location of the image intensifier tube power switch. (66)



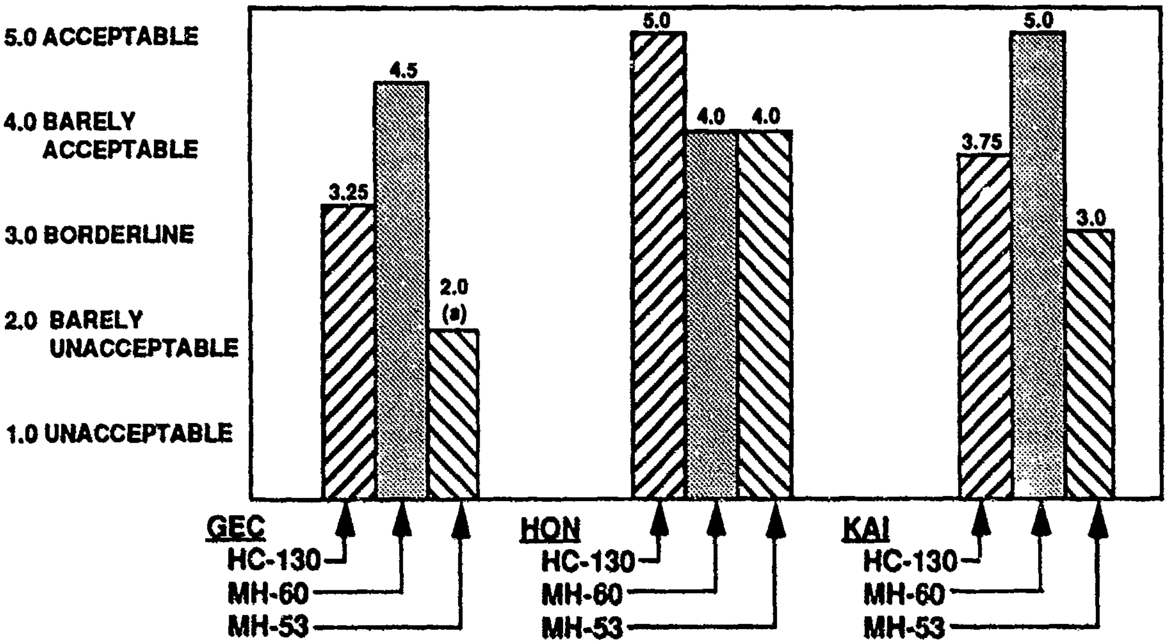
PILOT COMMENTS:

NONE

SUMMARY

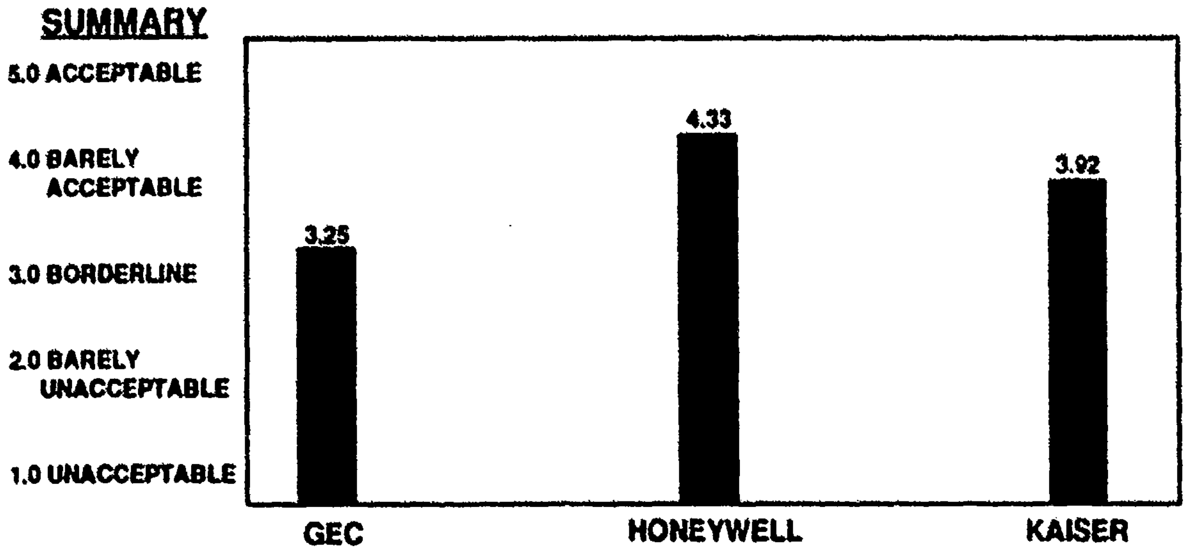


I.C.13 Evaluate the ease of operating the image intensifier tube power switch. (67)

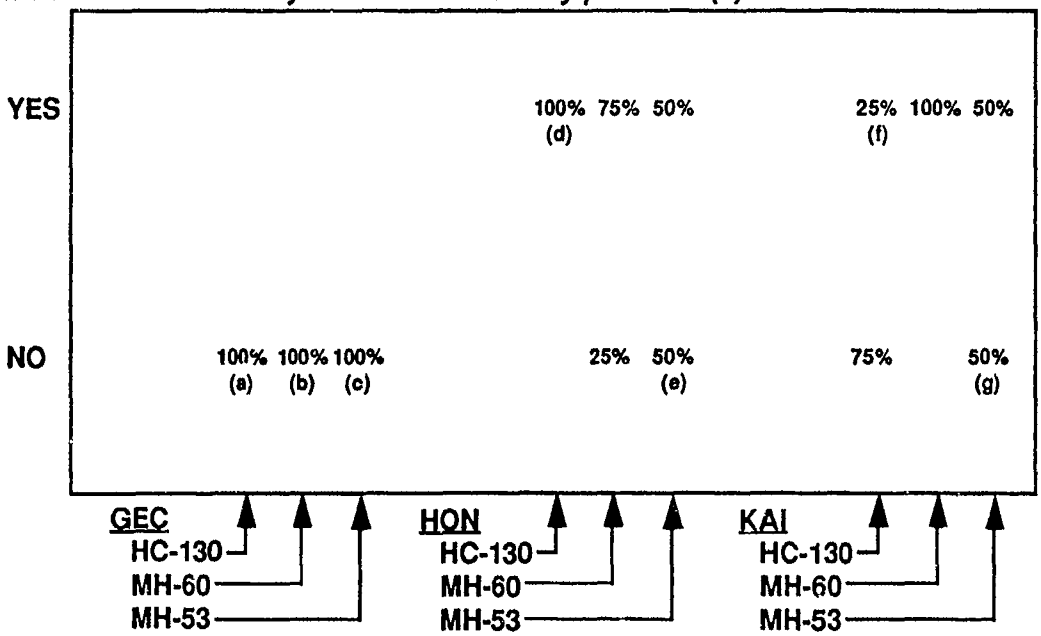


PILOT COMMENTS:

(a) Too small.



II.A.1 Is the technology presented in this helmet and the way in which it is packaged suitable for the missions you would most likely perform? (1)



PILOT COMMENTS:

(a) CG, less than ANVIS-6, 3/4 quality.

(b) Marginal for low illumination - OK with IR searchlight. Chem light detection distance 50% of range for ANVIS-6 equipped observer.

(c) Combiners did not stay centered, needed more adjustments, focus control had no apparent effect.

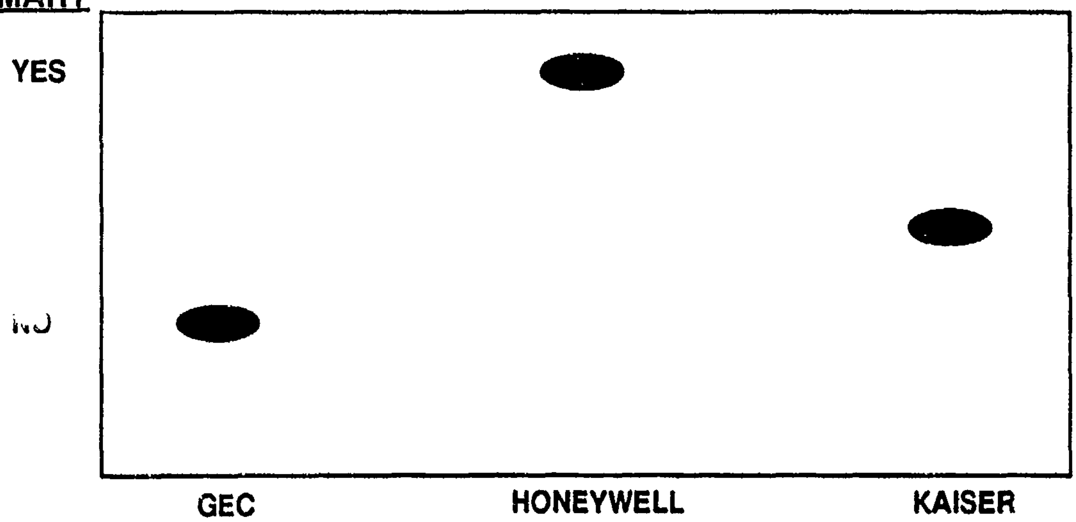
(d) Some features better than ANVIS-6.

(e) FOV too small for terminal ops, not eyeglass compatible, image not clear.

(f) Weight, CG, nape and chinstraps - recommend using HGU-55/P as base helmet.

(g) Uncomfortable, FOV inadequate for terminal ops.

SUMMARY



II.A.2.a Identify the approximate range in which you could identify air targets at night while using the night vision device (i.e., wingman, other aircraft, etc.). (2a)

AIR

	GEC HC-130	GEC MH-60	GEC MH-53	HON HC-130	HON MH-60	HON MH-53	KAI HC-130	KAI MH-60	KAI MH-53
LIGHTED	50	7	(a)	60	3	15	60	7	(a)
UNLIGHTED	(a)	(a)	(a)	20	(a)	(a)	40	(a)	(a)

(NOTE: Ranges, in miles, differ due to low/high altitude mission profiles.)

PILOT COMMENTS:

(a) This category was not completed by some or all the pilots.

(b) Co-pilot picked up landing zone at twice the distance using ANVIS-6.

(c) Co-pilot with ANVIS-6 picked up targets at twice the range.

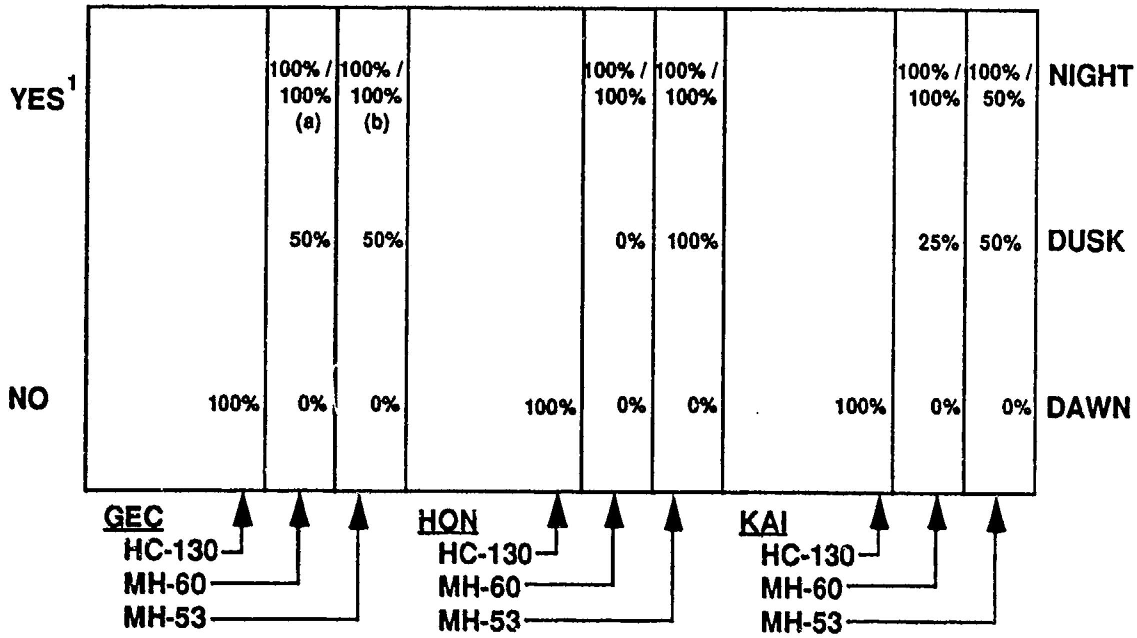
II.A.2.b Identify the approximate range in which you could identify ground targets at night while using the night vision device (i.e., buildings, vehicles, etc). (2b)

GROUND

	GEC HC-130	GEC MH-60	GEC MH-53	HON HC-130	HON MH-60	HON MH-53	KAI HC-130	KAI MH-60	KAI MH-53
LIGHTED	60	7	.5 (b)	50	2	5	50	2	5 (c)
UNLIGHTED	30	(a)	(a)	40	(a)	(a)	50	(a)	(a)

(NOTE: Ranges, in miles, differ due to low/high altitude mission profiles.)

II.A.3.a Did you utilize the helmet (intensifiers ON) during takeoff? If YES, identify the conditions at takeoff. (45a)



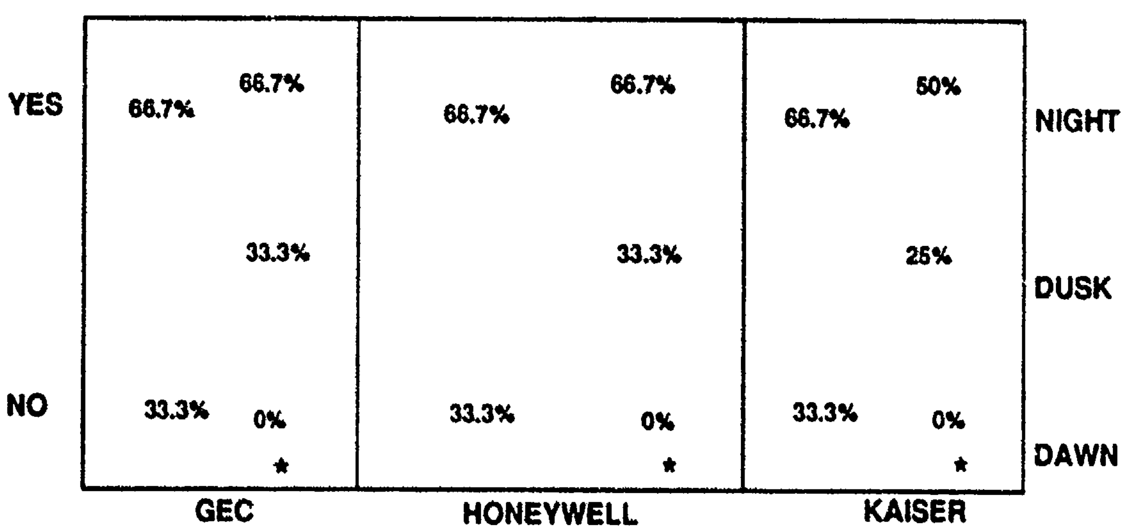
***NOTE 1:** Read upper percentage on left scale, read lower percentage on right scale.*
***NOTE:** Pilots made multiple takeoffs under various conditions.*

PILOT COMMENTS:

(a) Marginal in low illumination conditions

(b) Possible but very difficult with this helmet.

SUMMARY



**For this composite percentage of pilots please consider the "NOTE" above.*

II.A.3.b Did you utilize the helmet (intensifiers OFF) during takeoff? If YES, identify the conditions at takeoff. (45b)

	GEC HC-130	GEC MH-60	GEC MH-53 (a)	HON HC-130	HON MH-60	HON MH-53	KAI HC-130	KAI MH-60 (a)	KAI MH-53
NIGHT		50%			50%			25%	
DUSK		50%			25%	50%			50%
DAY	100%			100%	25%	50%	100%	25%	50%
DAWN									

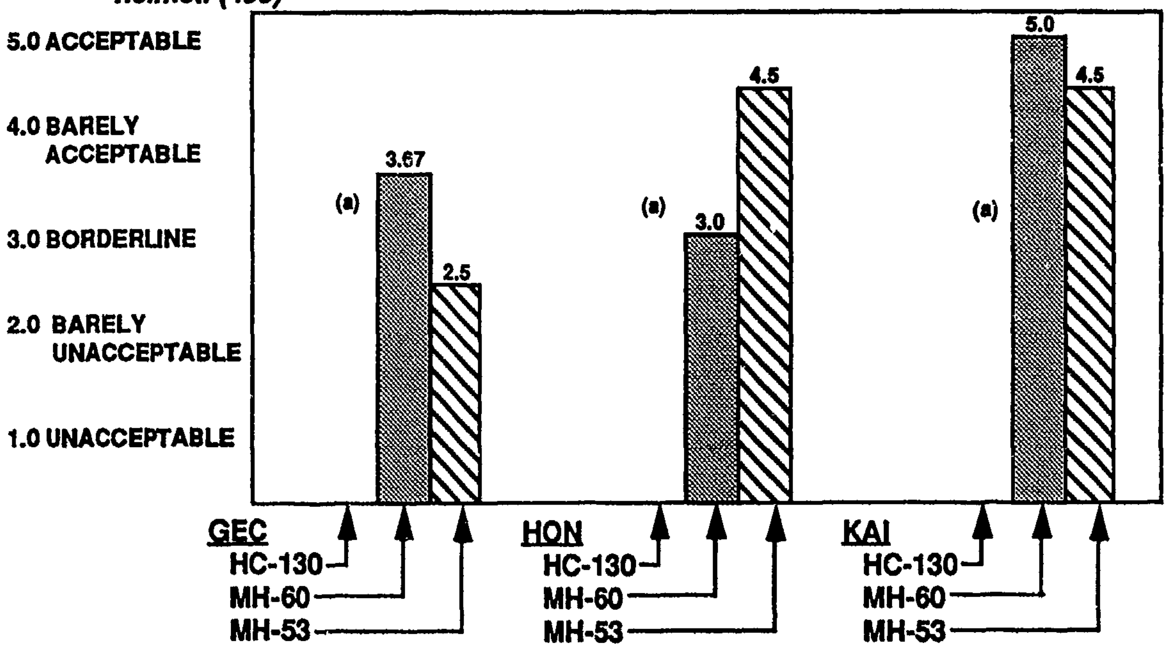
PILOT COMMENTS:

(a) This category was not rated by some or all the pilots.

SUMMARY

	GEC	HONEYWELL	KAISER
NIGHT	16.7%	16.7%	8.3%
DUSK	16.7%	25%	16.7%
DAY	33.3%	58.3%	58.3%
DAWN	0%	0%	0%

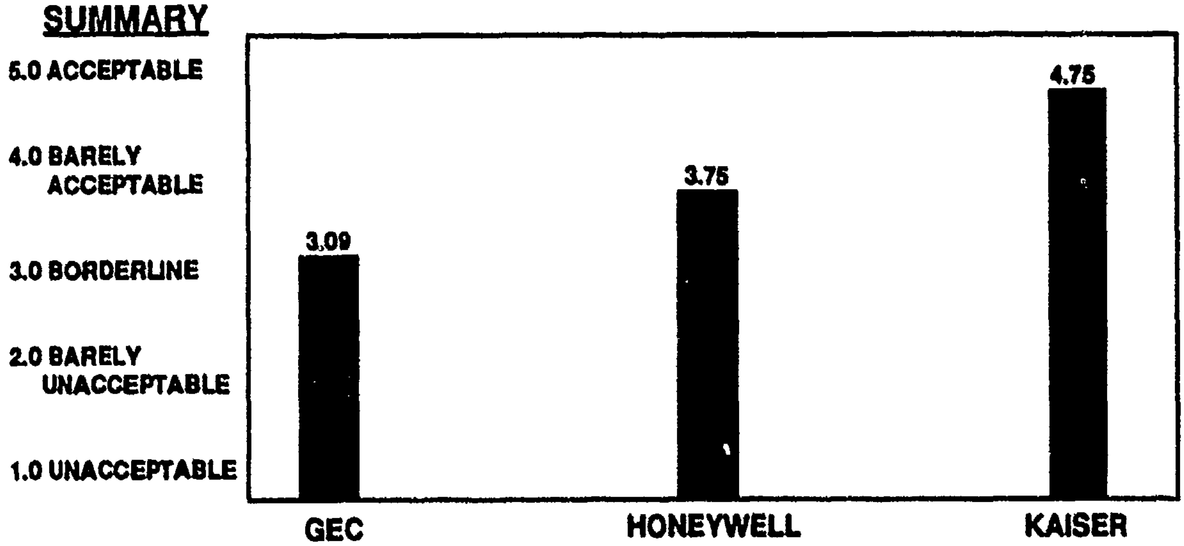
II.A.3.c For the condition of identified above, evaluate the ability to accomplish takeoffs with this helmet. (45c)



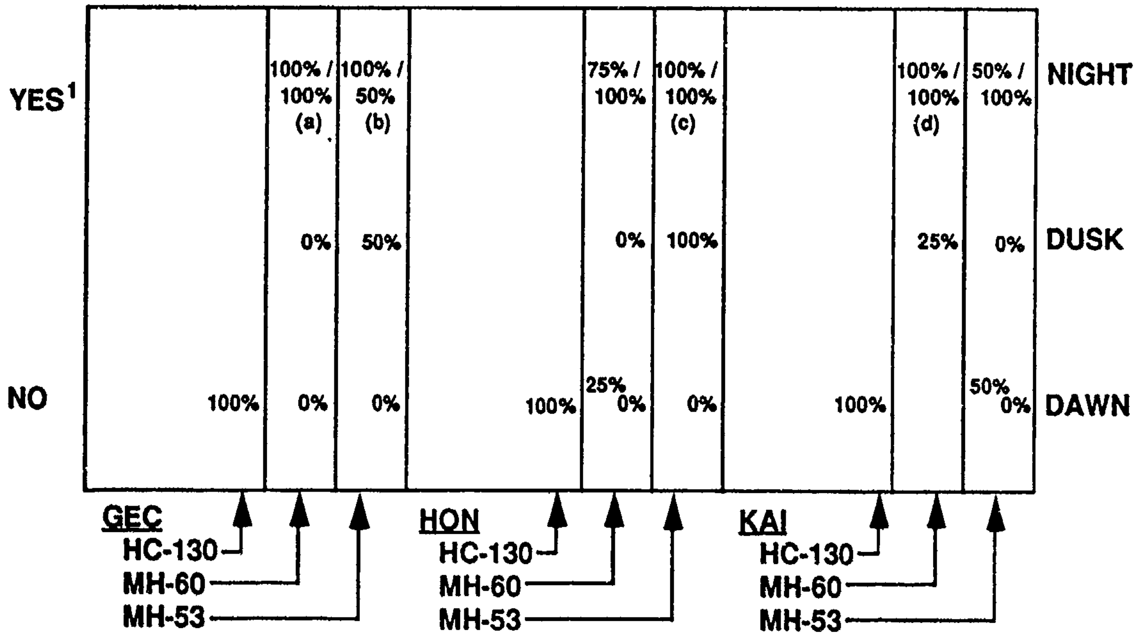
PILOT COMMENTS:

(a) This category was not rated by some or all the pilots.

SUMMARY



II.A.4.a ***Did you utilize the helmet (intensifiers ON) during landing? If YES, identify the conditions at landing. (46a)***

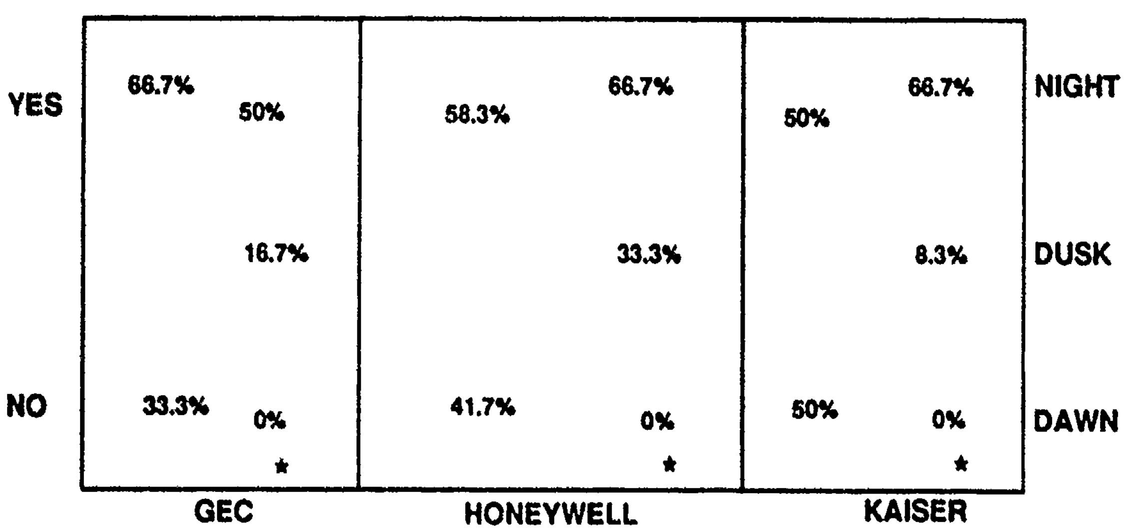


NOTE 1: Read upper percentage on left scale, read lower percentage on right scale.
NOTE: Pilots made multiple takeoffs under various conditions.

PILOT COMMENTS:

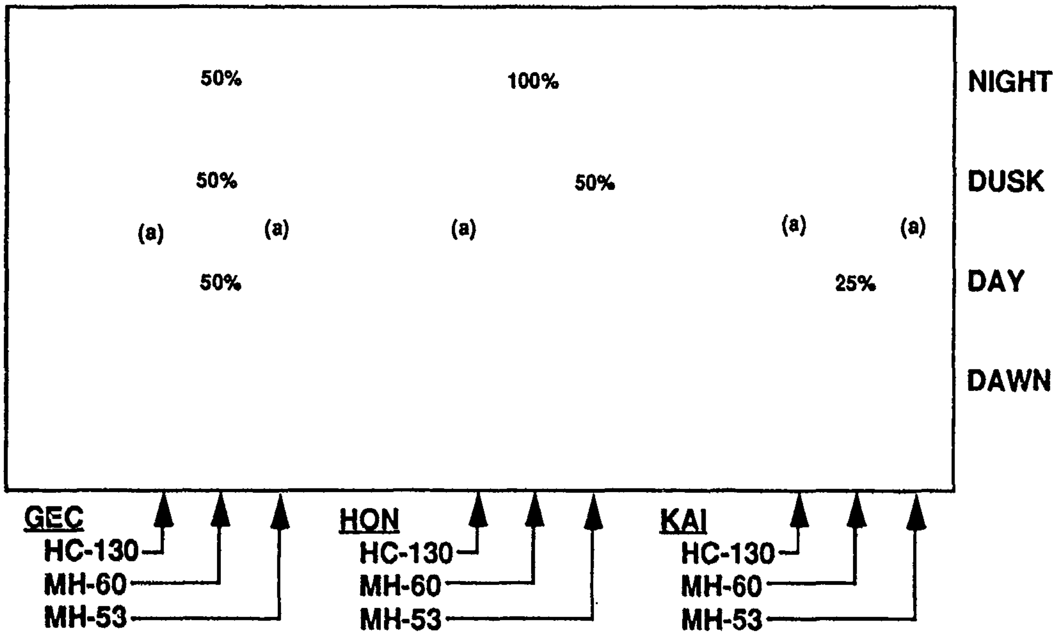
(a) Marginal in low illumination conditions
(b) Possible but very difficult with this helmet.
(c) Passed control to co-pilot due to inability to locate visual cues.
(d) Apparent position is 2-3 feet lower than actual.

SUMMARY



****For this composite percentage of pilots please consider the "NOTE" above.***

II.A.4.b Did you utilize the helmet (intensifiers OFF) during landing? If YES, identify the conditions at landing. (46b)

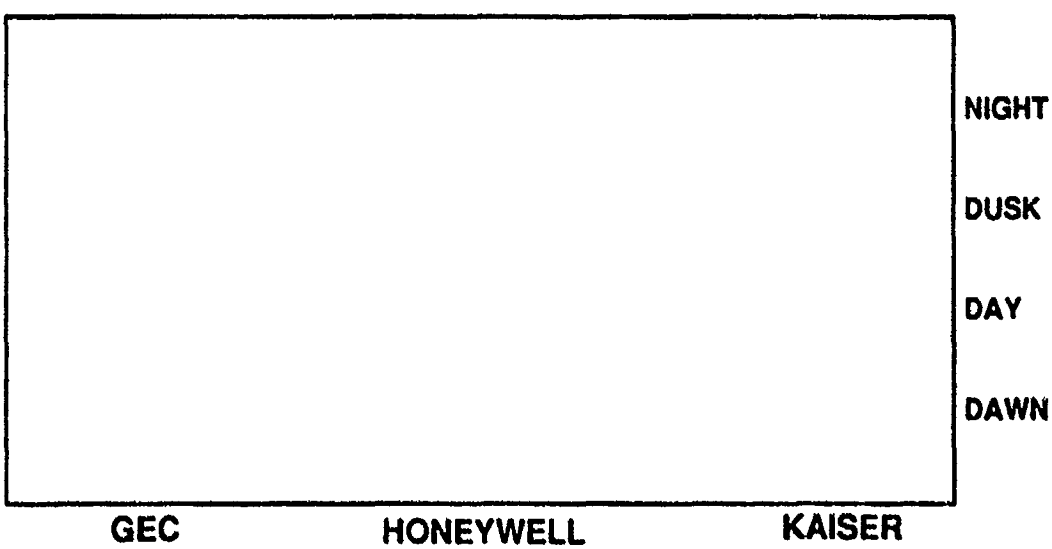


NOTE: Pilots made multiple landings under various conditions.

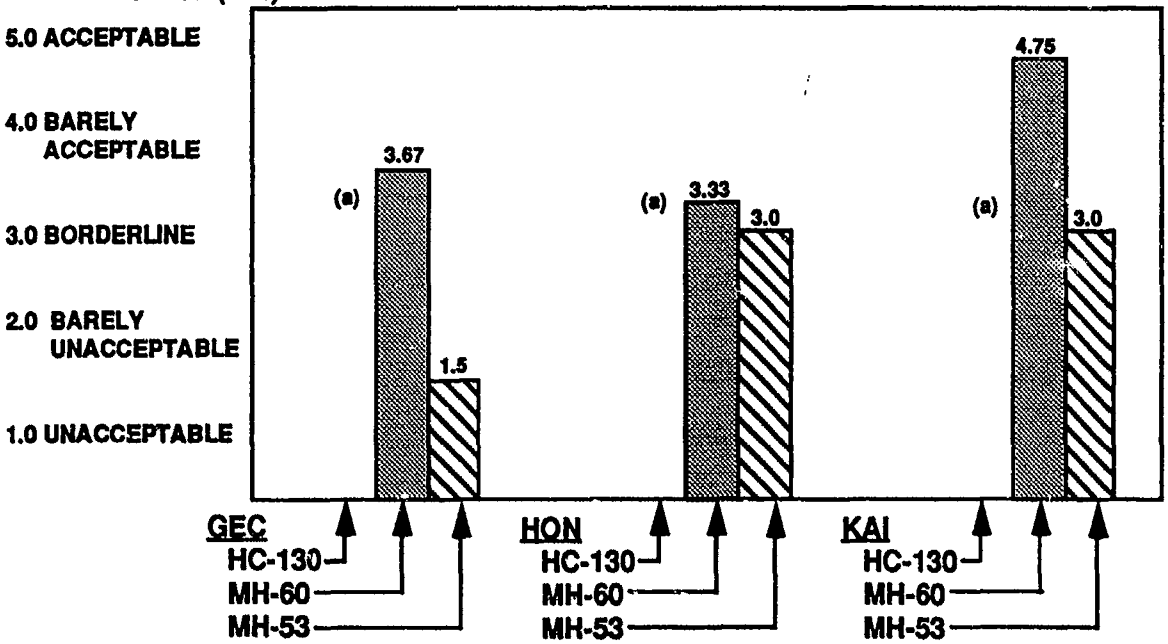
PILOT COMMENTS:

(a) This category was not rated by some or all the pilots.

SUMMARY



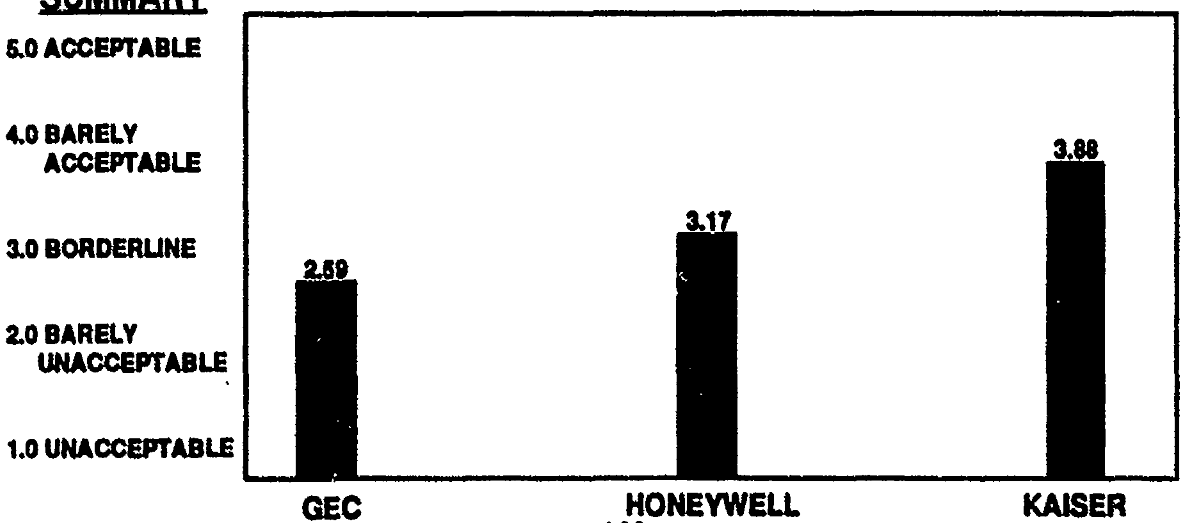
II.A.4.c For the condition of identified above, evaluate the ability to accomplish landings with this helmet. (46c)



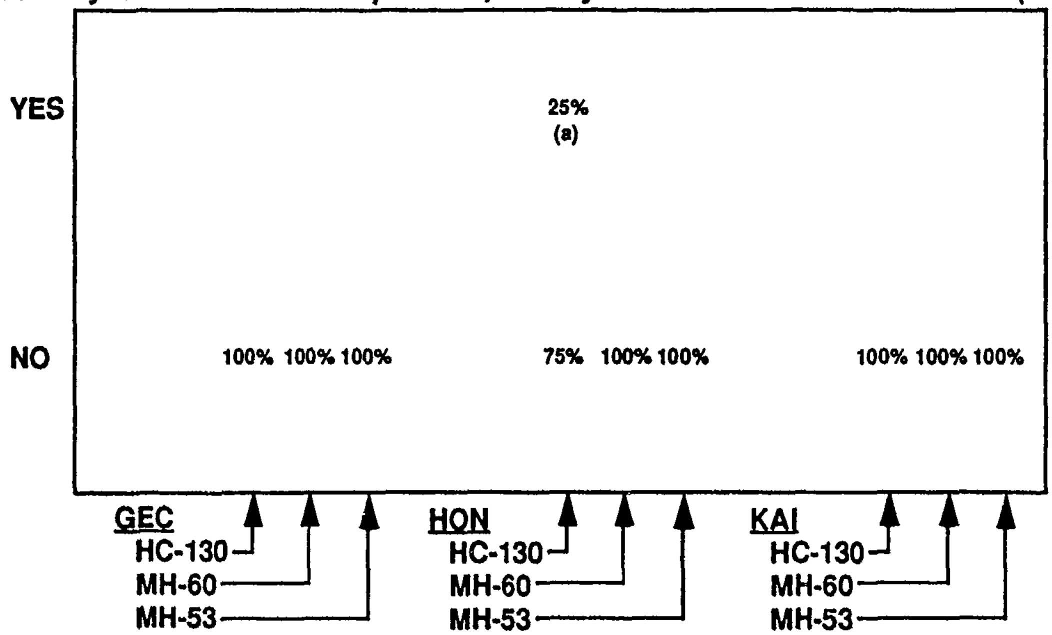
PILOT COMMENTS:

(a) This category was not rated by some or all the pilots.

SUMMARY



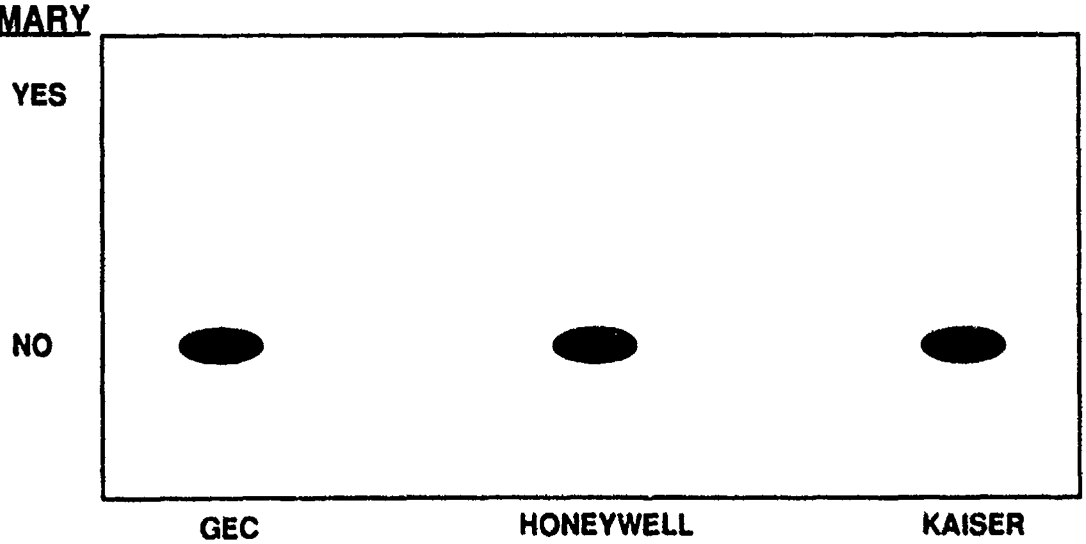
II.A.5 Did you experience any spatial disorientation? If YES, under what flight conditions? What did you do to recover? If possible, identify the cause of the disorientation. (75)



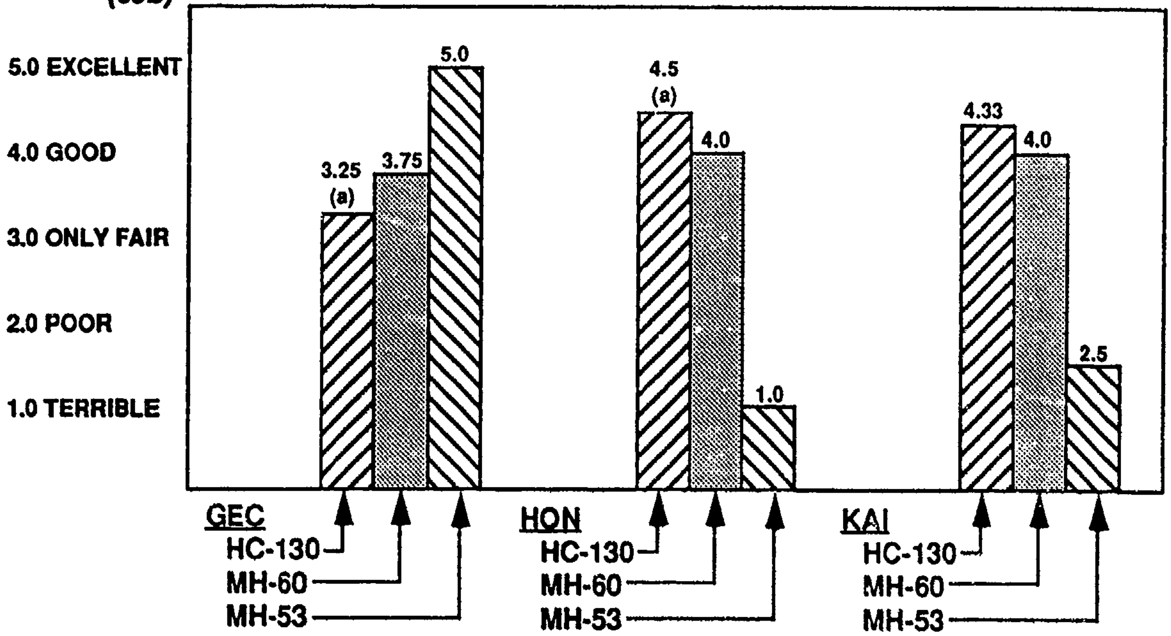
PILOT COMMENTS:

(a) **Inadvertent flight through cloud tops flooded combiners with light and caused vertigo - went on instruments to recover.**

SUMMARY



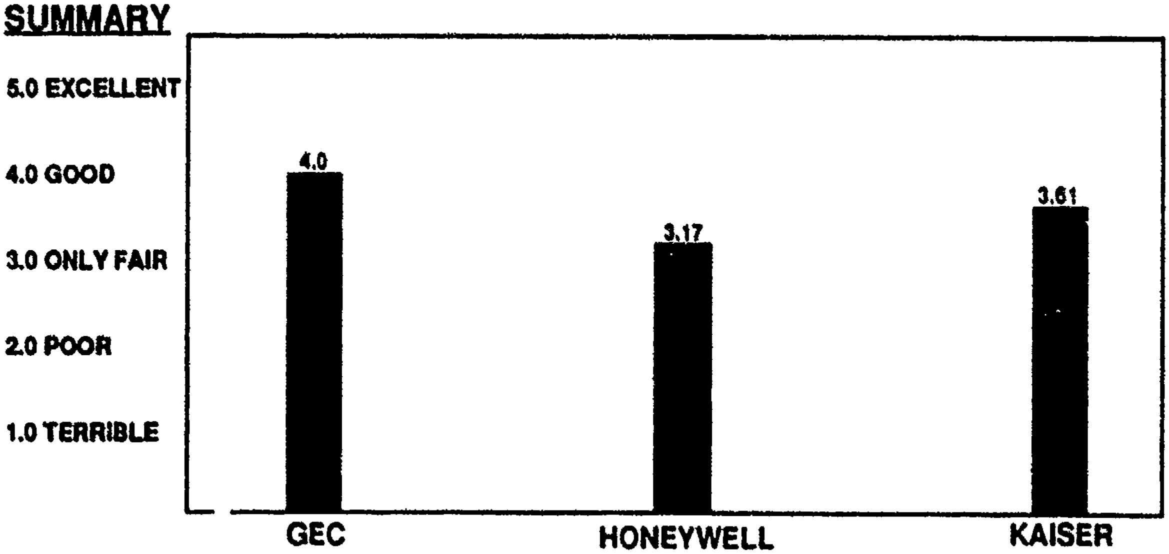
II.B.1.a Evaluate the field of view (FOV) through the combiners with image intensifiers OFF. (38b)



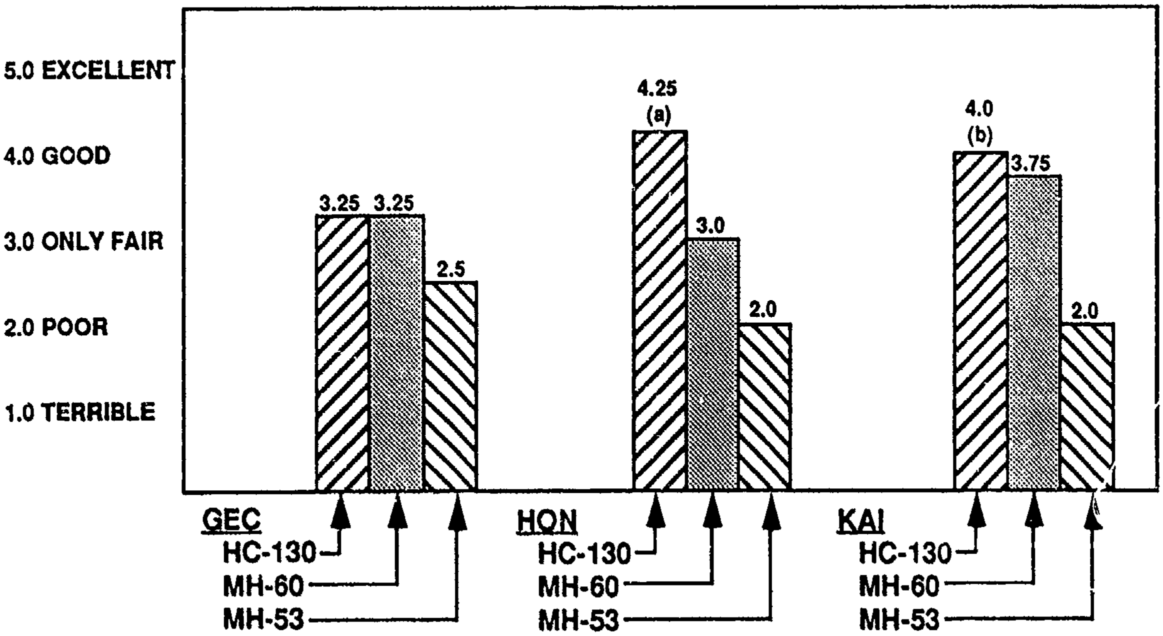
PILOT COMMENTS:

(a) Smaller than ANVIS-6.

SUMMARY



II.B.1.b Evaluate the field of view (FOV) through the combiners with image intensifiers ON. (38c)

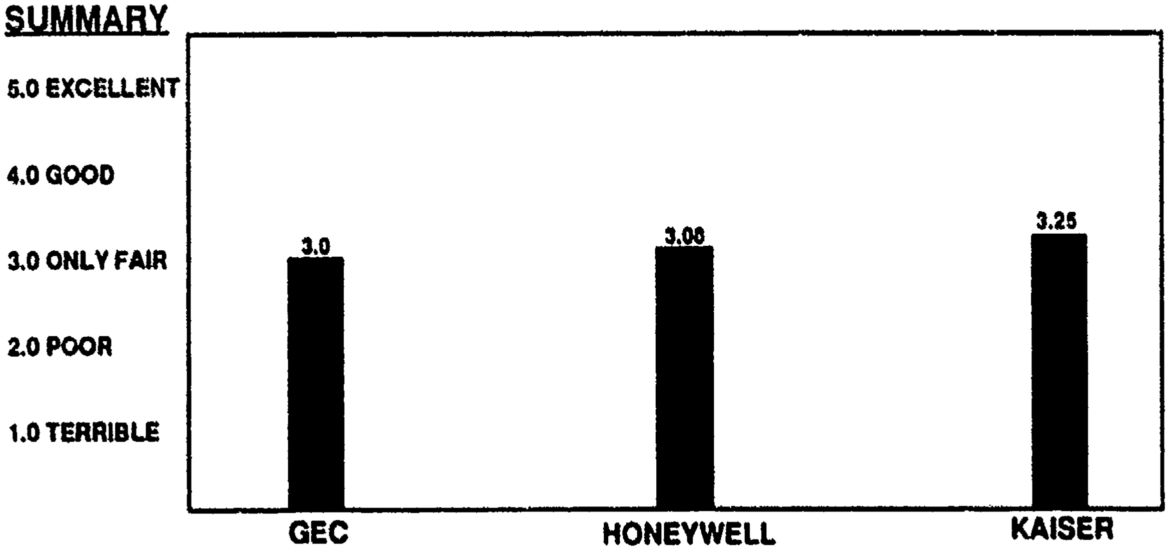


PILOT COMMENTS:

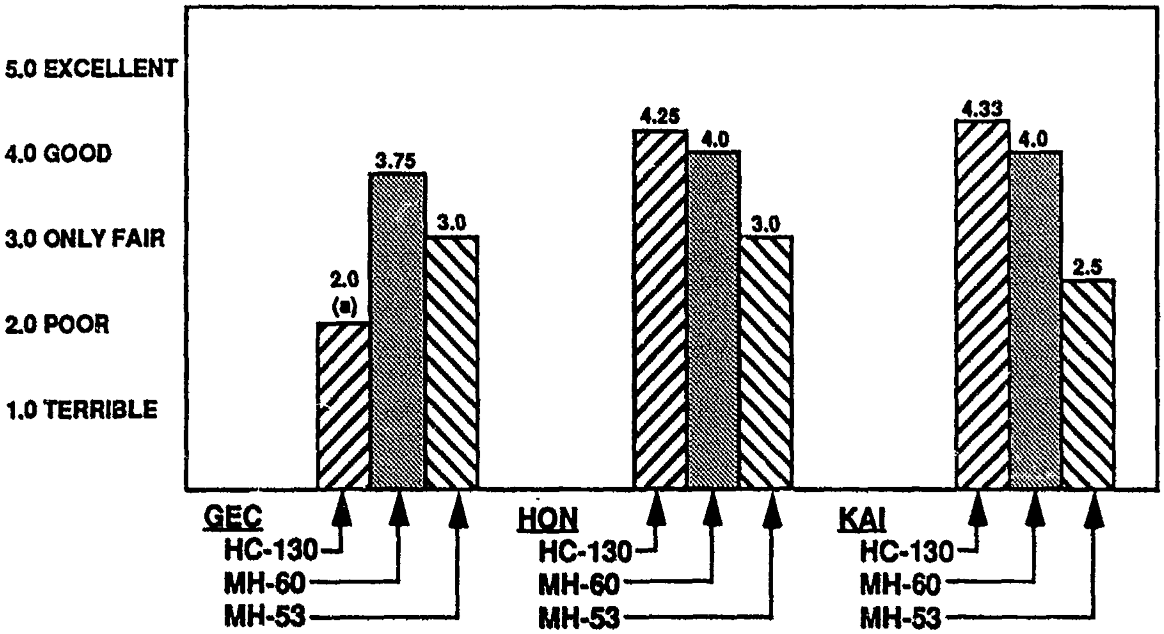
(a) 85% - 90% of ANVIS-6.

(b) Smaller than ANVIS-6.

SUMMARY



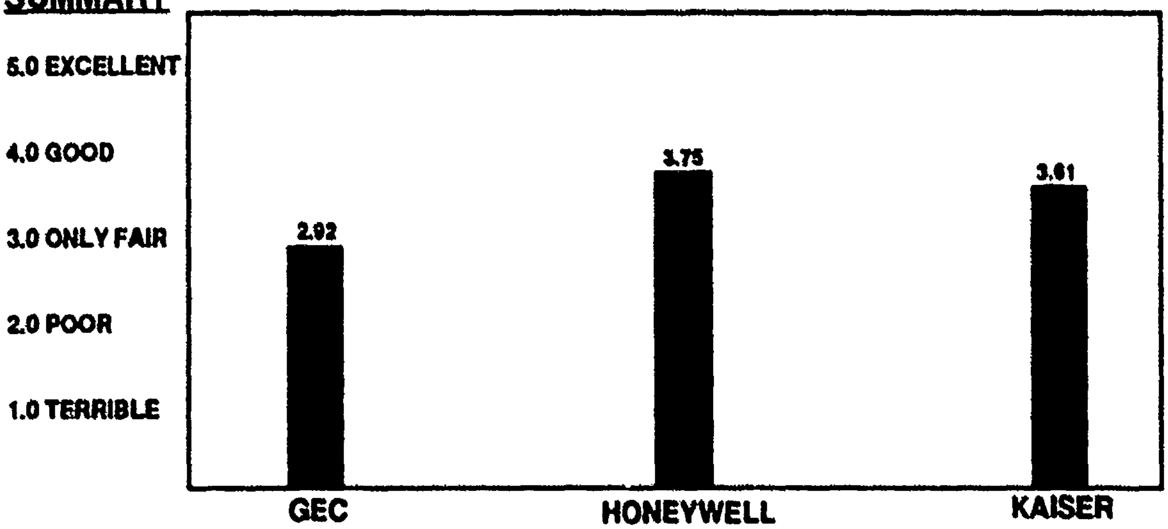
II.B.2.a Evaluate the light transmission through combiners with image intensifiers OFF. (40b)



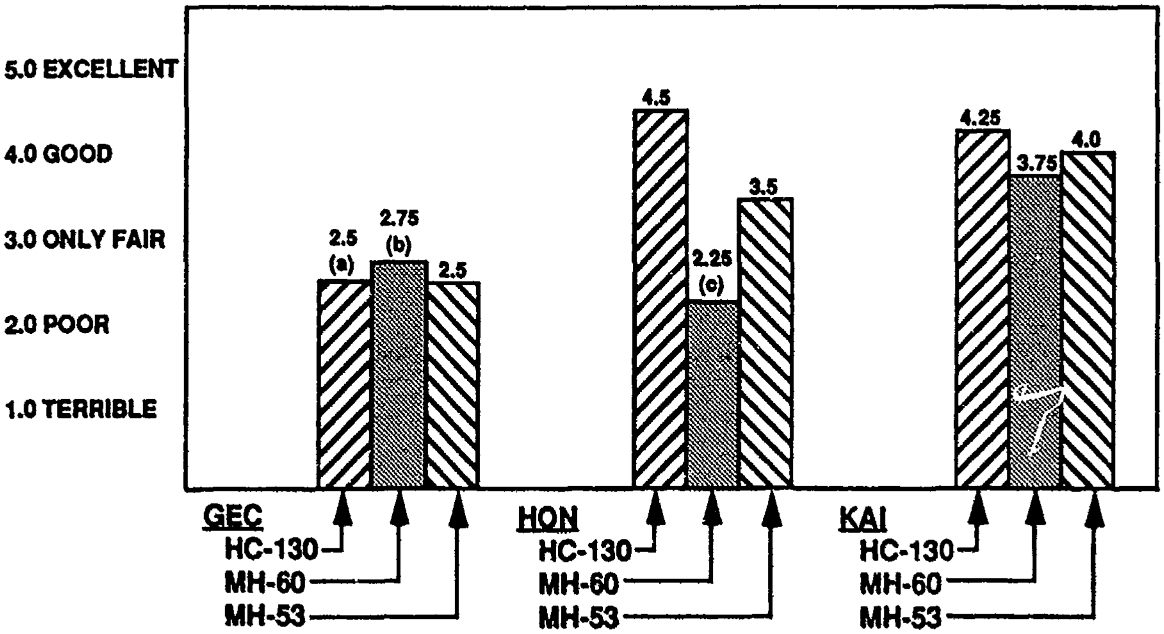
PILOT COMMENTS:

(a) Like wearing a pair of sunglasses.

SUMMARY



II.B.2.b Evaluate the light transmission through combiners with image intensifiers ON. (40c)



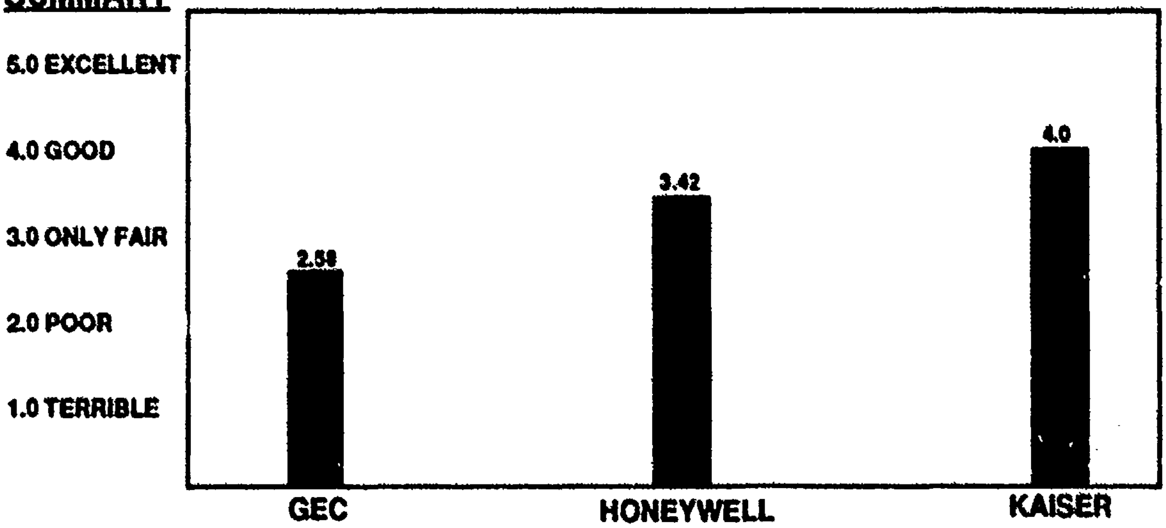
PILOT COMMENTS:

(a) Less than half of ANVIS-6, sunglass effect, poor in low illumination, milky - washed out a bit.

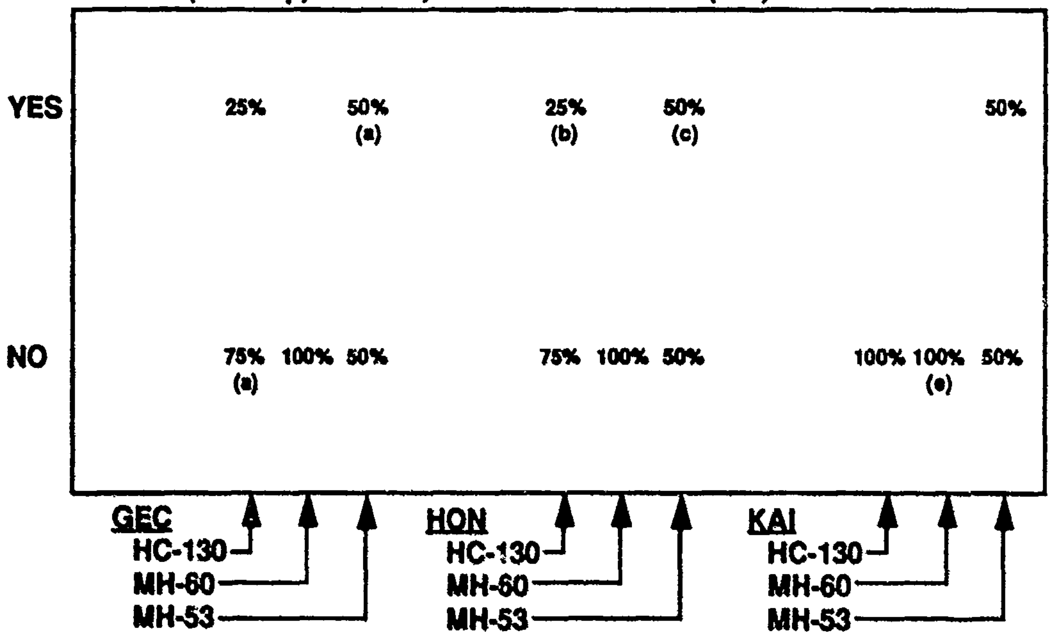
(b) Poor sensitivity.

(c) Good but had 68% moon.

SUMMARY



II.B.3.a With the image intensifier tubes OFF, did you experience any distortions through the combiners (visor up)? If YES, describe how much. (44a)



PILOT COMMENTS:

(a) Really good.

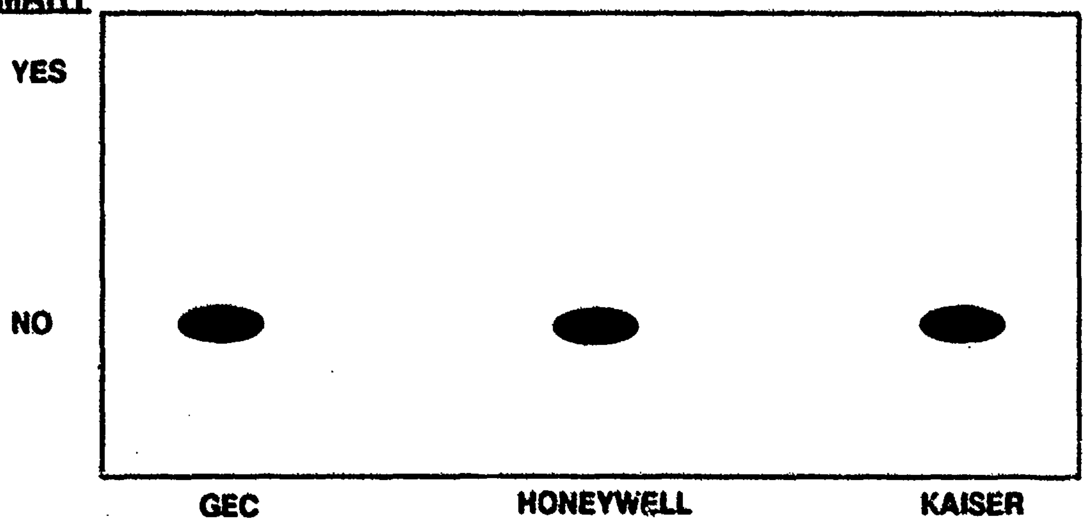
(b) A little, not a problem.

(c) At edges, straight through OK.

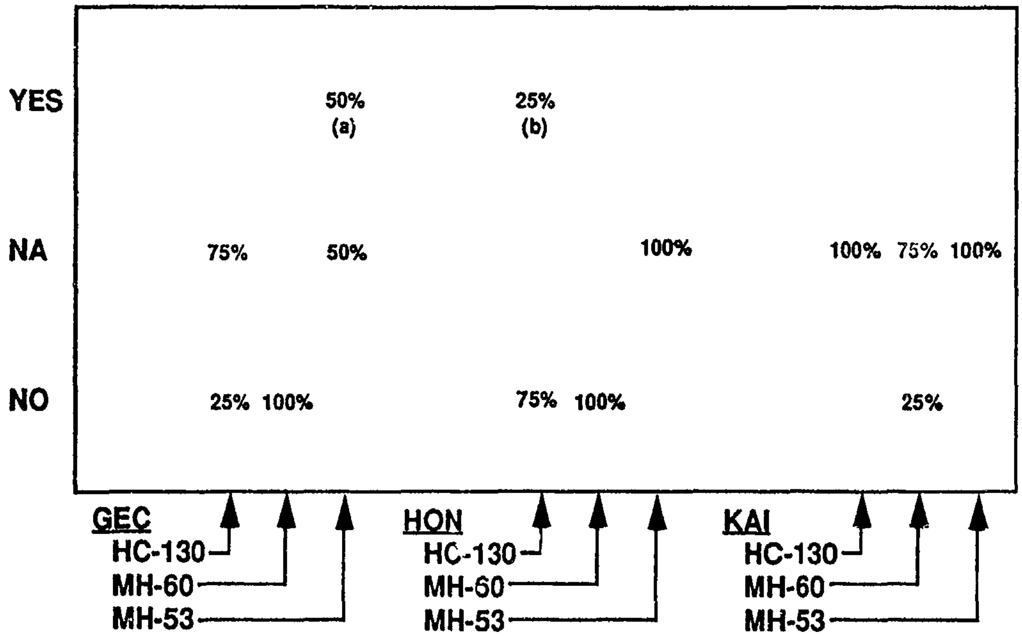
(d) At edge of combiners, minor.

(e) Magnifies image by .3.

SUMMARY



II.B.3.b With the image intensifier tubes OFF did you experience any distortions through the visor and combiners? If YES, describe how much. (44b)

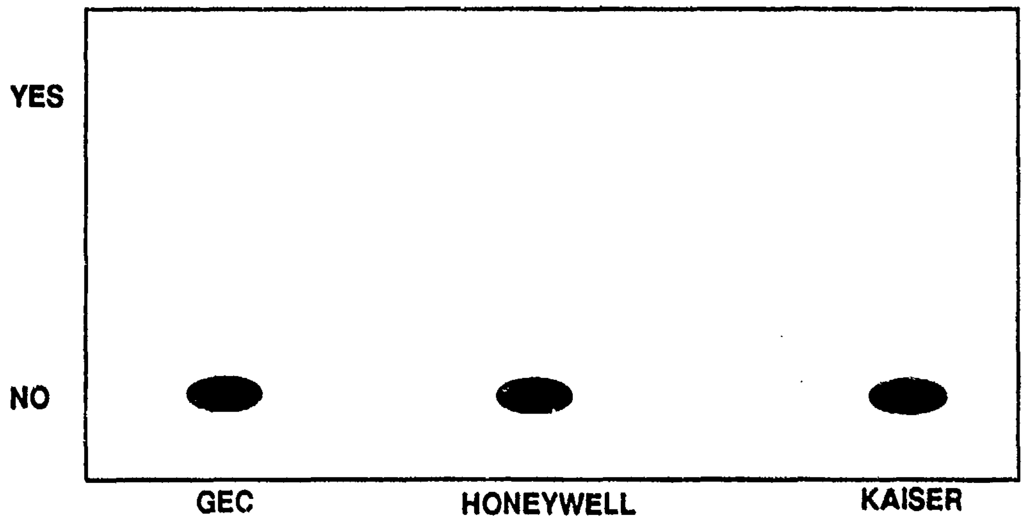


PILOT COMMENTS:

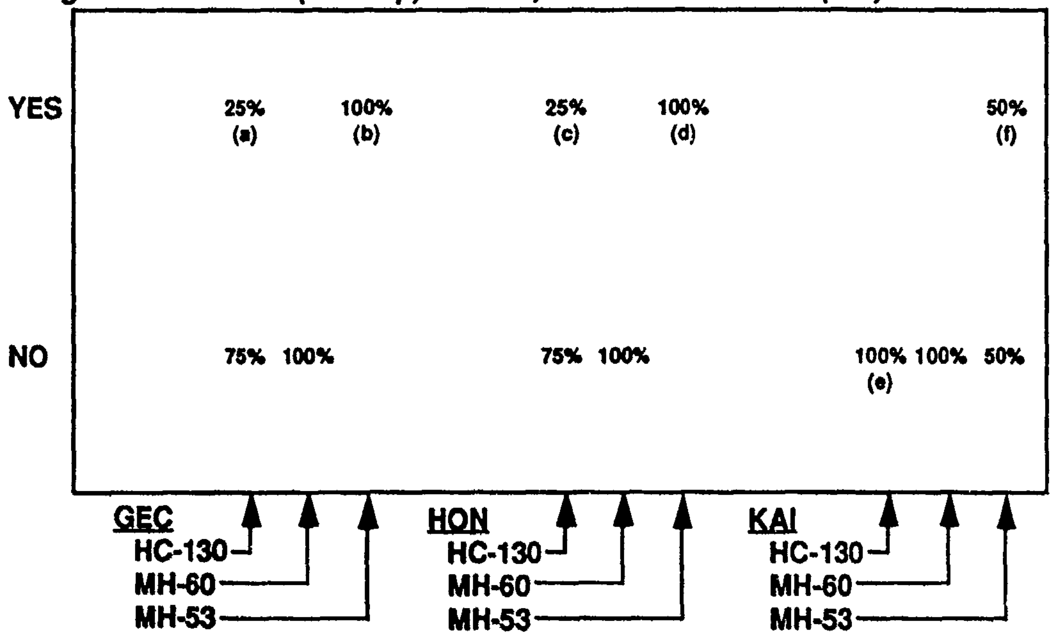
(a) A little, not a problem.

(b) At edges, straight through OK.

SUMMARY



II.B.4.a With the image intensifier tubes OFF, did you experience any scene distortion through the combiners (visor up)? If YES, describe how much. (60a)



PILOT COMMENTS:

(a) At bottom edge.

(b) Not enough transmissivity - looked over and around, considered combiners blind spot when intensifiers off.

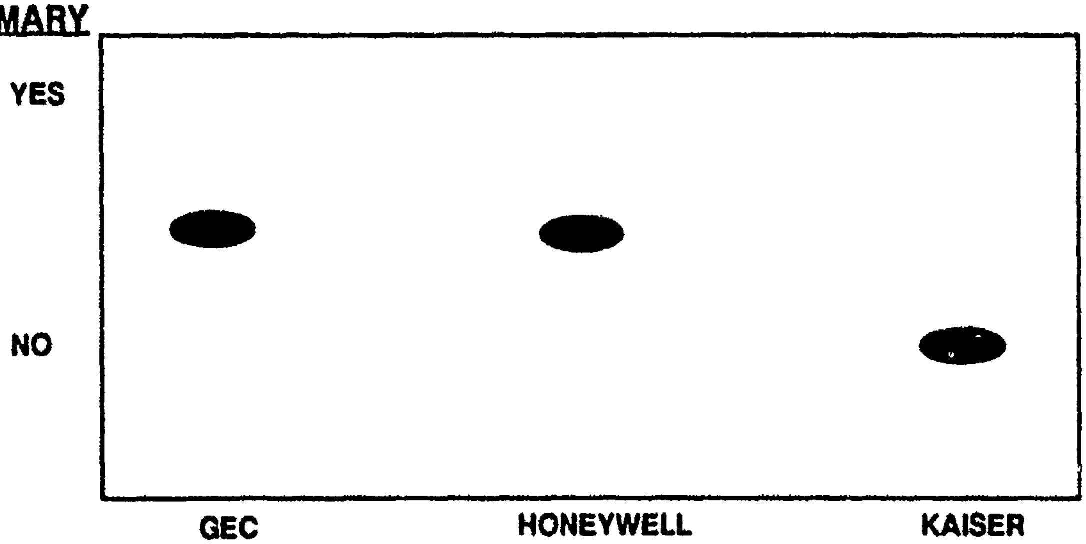
(c) At edges, OK.

(d) Transmissivity problem, used look around.

(e) Very good, clear.

(f) Did not provide enough light for normal flight.

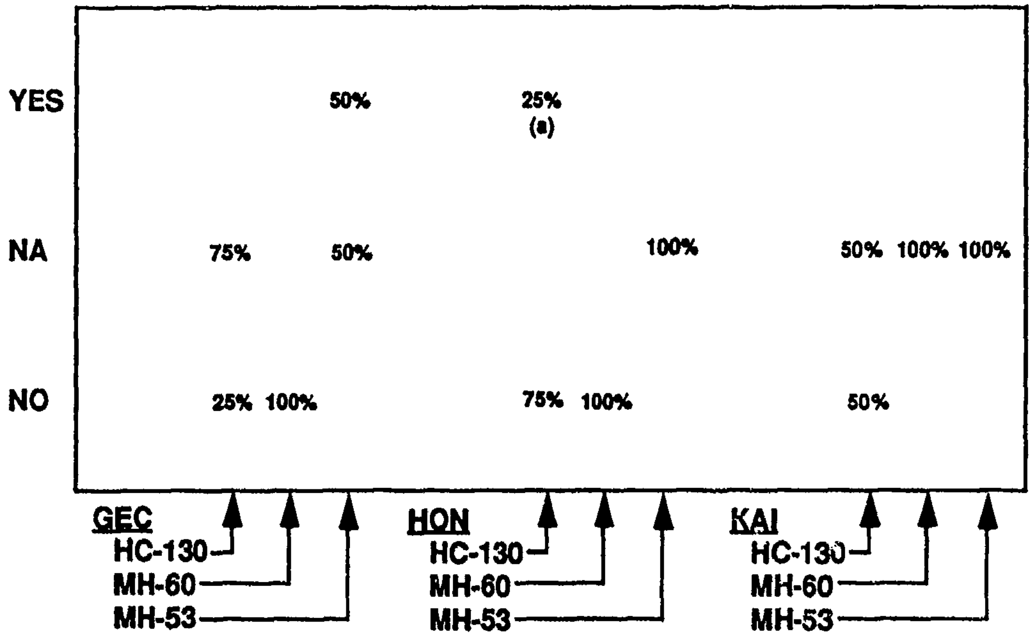
SUMMARY



II.B.4.b With the image intensifie tubes OFF, did you experience any scene distortion through the visor (combiners stowed)? If YES, describe how much. (60b)

All the pilots said "NO" or "NOT APPLICABLE."

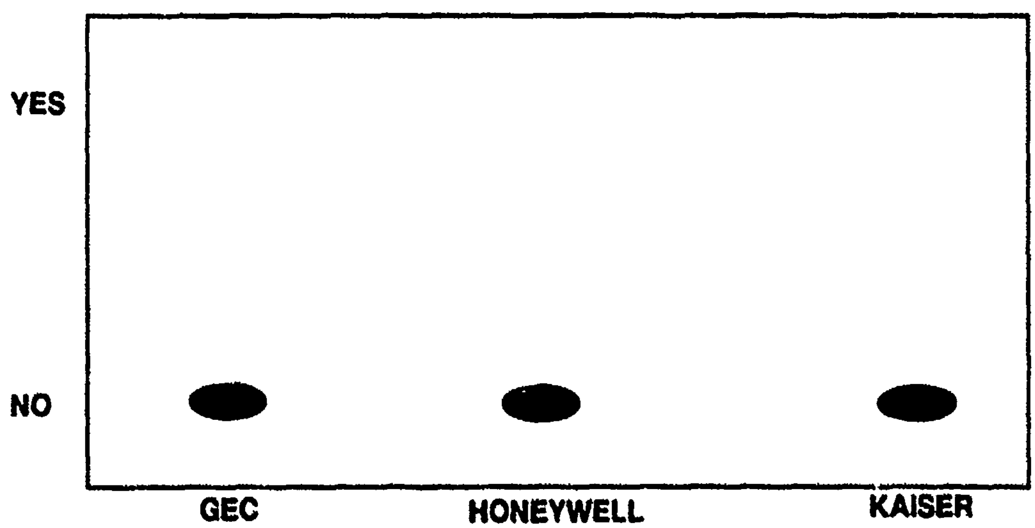
II.B.4.c With the Image Intensifier tubes OFF, did you experience any scene distortion through the visor and combiners? If YES, describe how much. (60c)



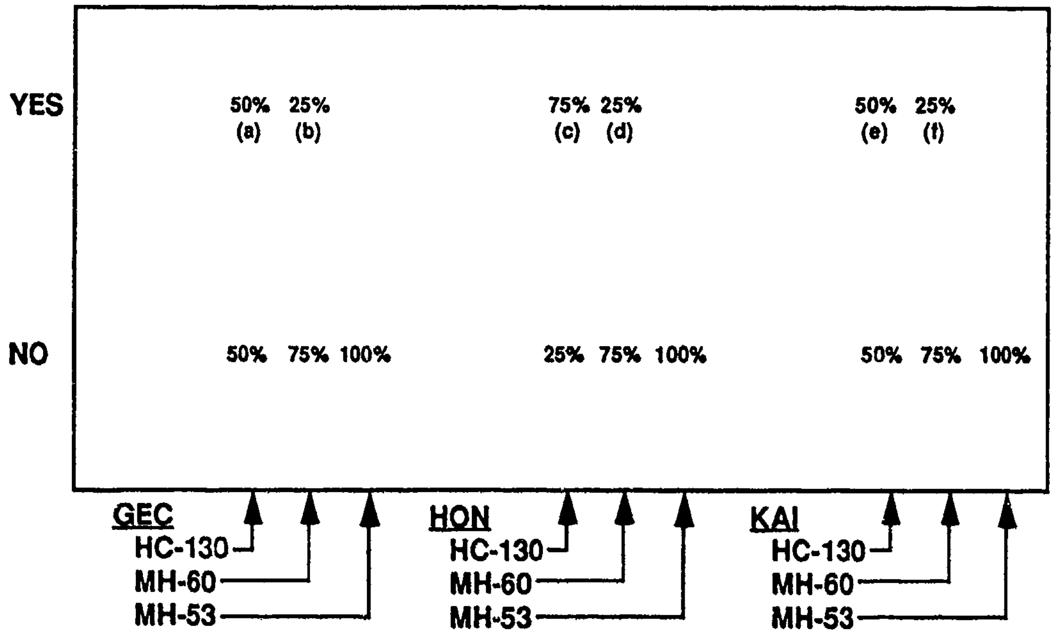
PILOT COMMENTS:

(a) Minor, at edges.

SUMMARY



II.B.5 Did you experience any abnormal eye fatigue? If YES, after how long? (74)



PILOT COMMENTS:

(a) Dark optics caused eye strain, 30 minutes, CG

(b) After one hour - minor.

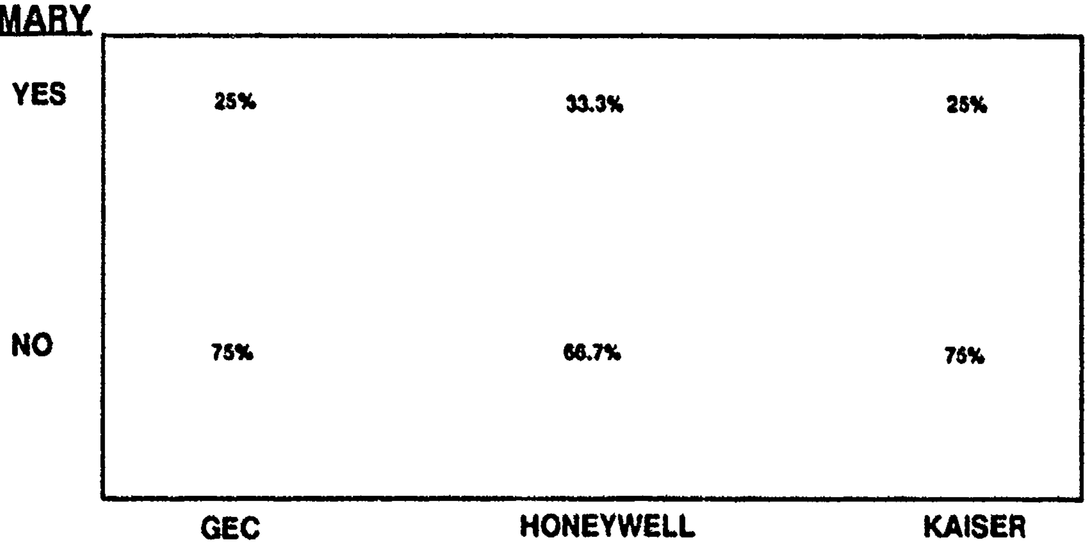
(c) At two hours - also to cycle from bright to dim.

(d) Both pilots after 1 hour - focus problems, 15 minutes - focus.

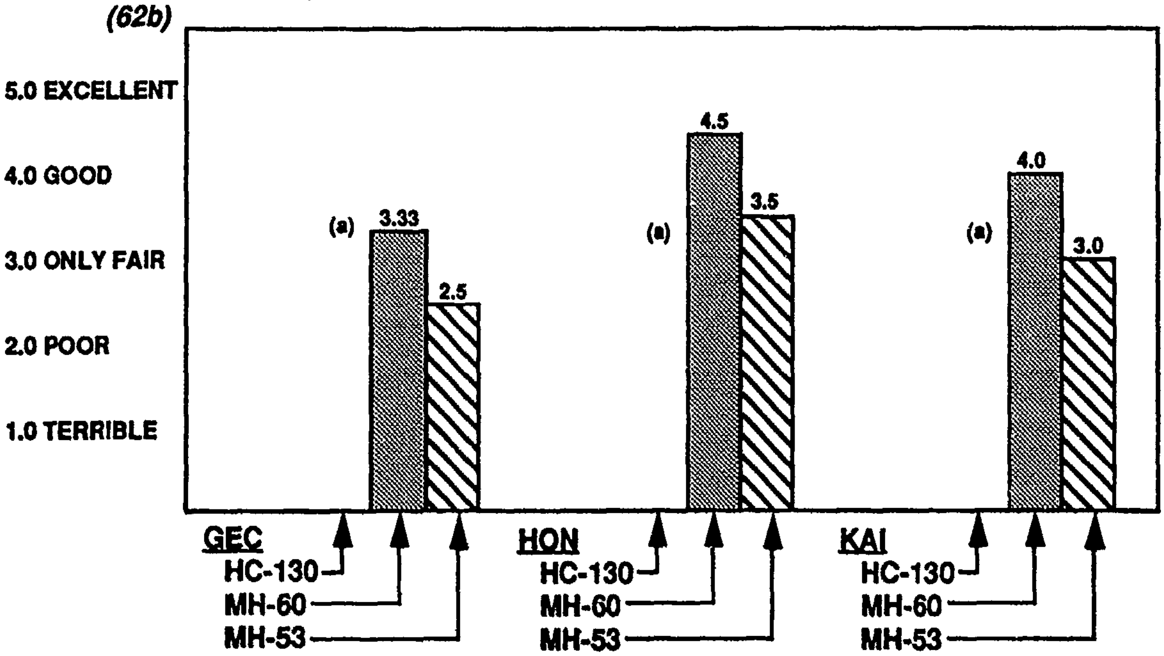
(e) 2.8 hours, similar to ANVIS-6.

(f) Normal NVG fatigue.

SUMMARY



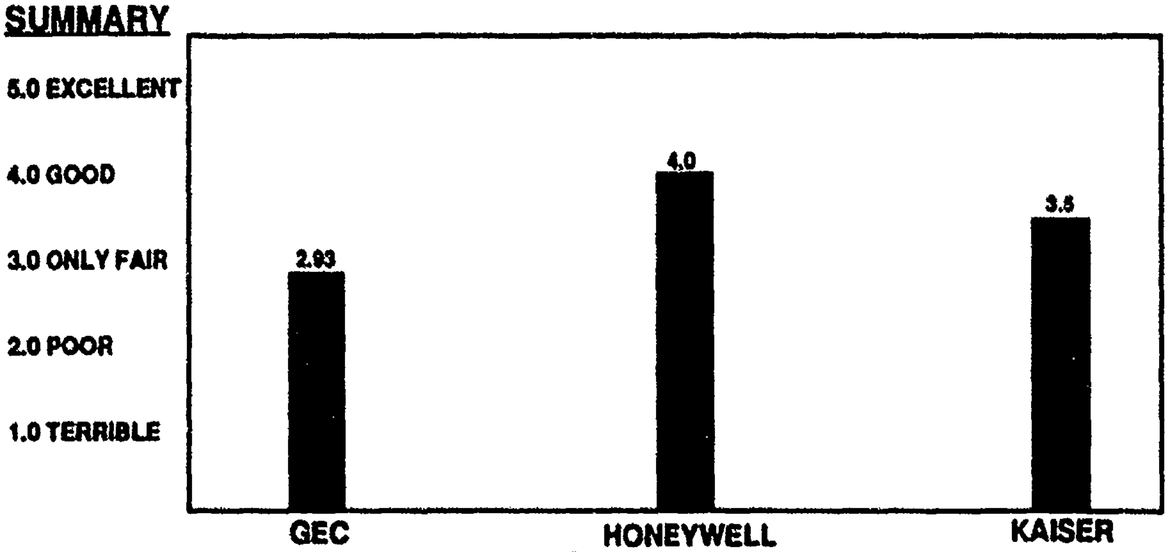
II.B.6.a Evaluate viewing the instrument panels through the combiners during dusk operations. (62b)



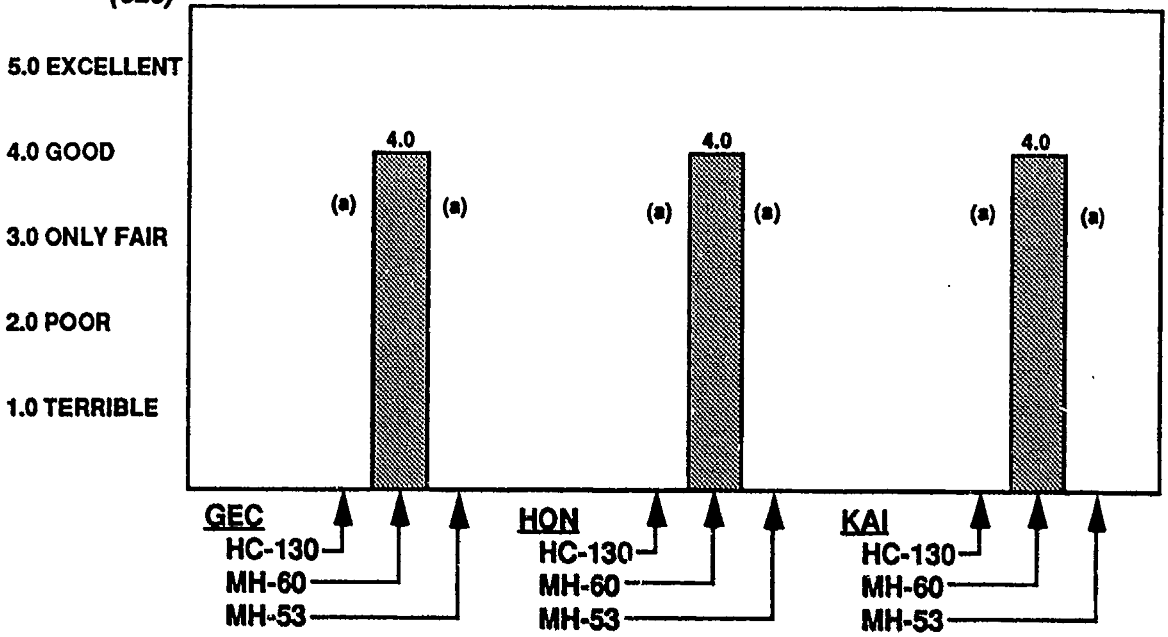
PILOT COMMENTS:

(a) This category was not rated.

SUMMARY



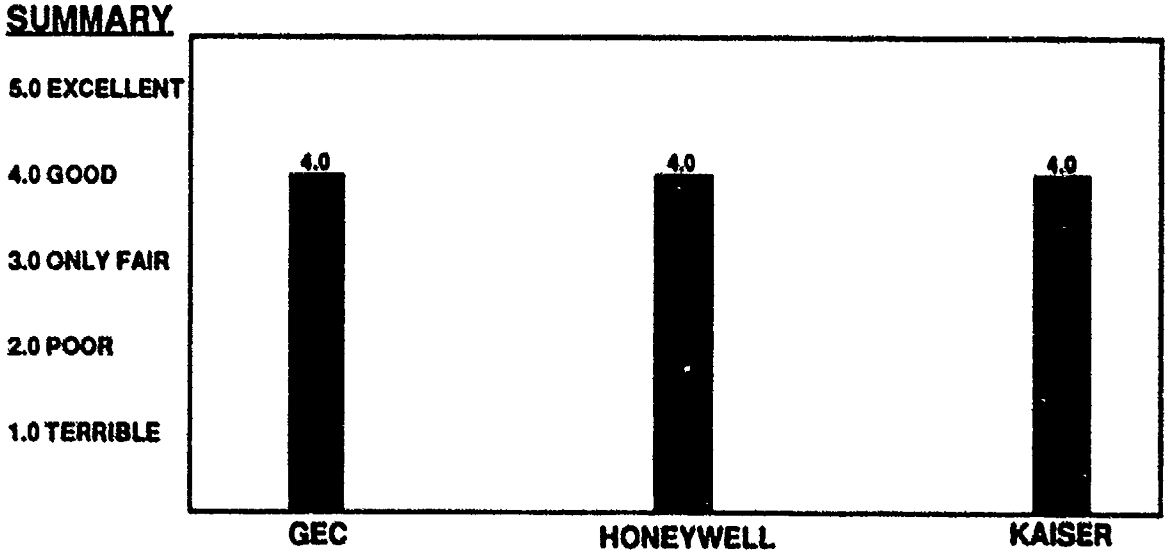
II.B.6.b Evaluate viewing the instrument panels through the combiners during dawn operations. (62c)



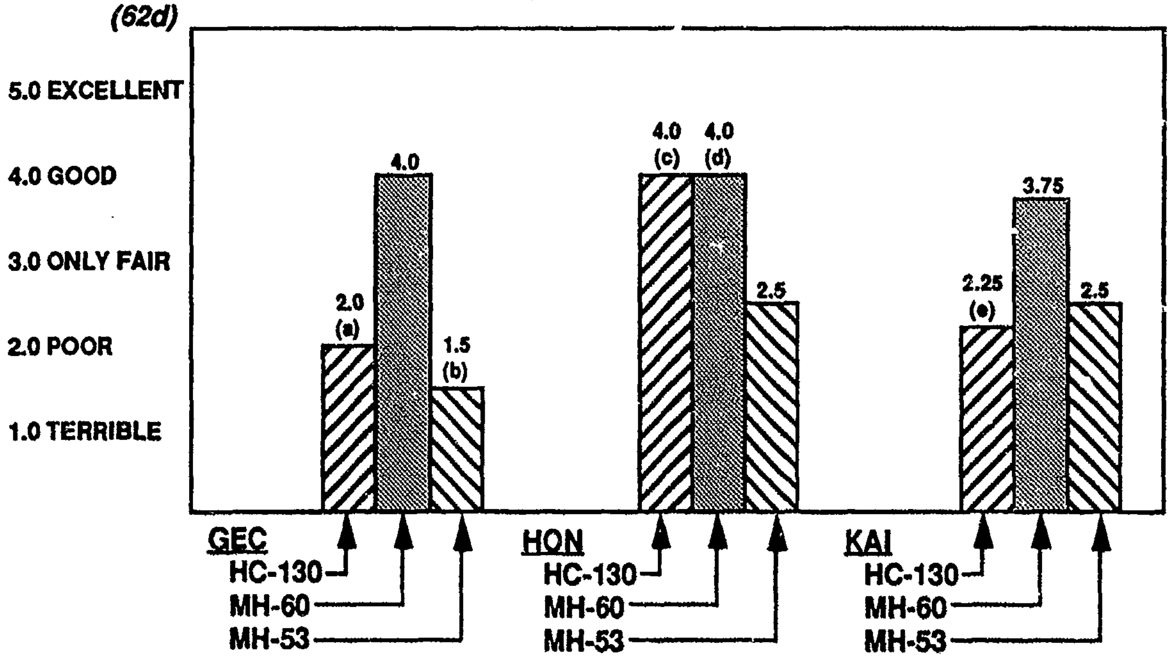
PILOT COMMENTS:

(a) Mission profiles were not flown under "dawn" conditions.

SUMMARY



II.B.6.c Evaluate viewing the instrument panels through the combiners during night operations. (62d)



PILOT COMMENTS:

(a) Cannot view instruments when focused outside.

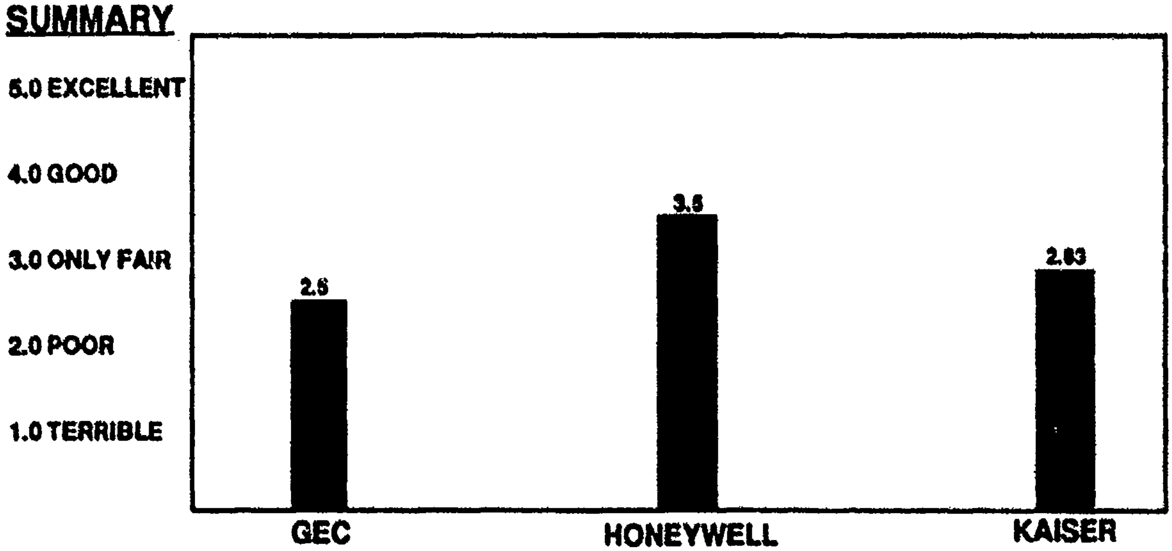
(b) Lights blurred and distorted images.

(c) Really strong point - could see over, under or through combiners with intensifiers on.

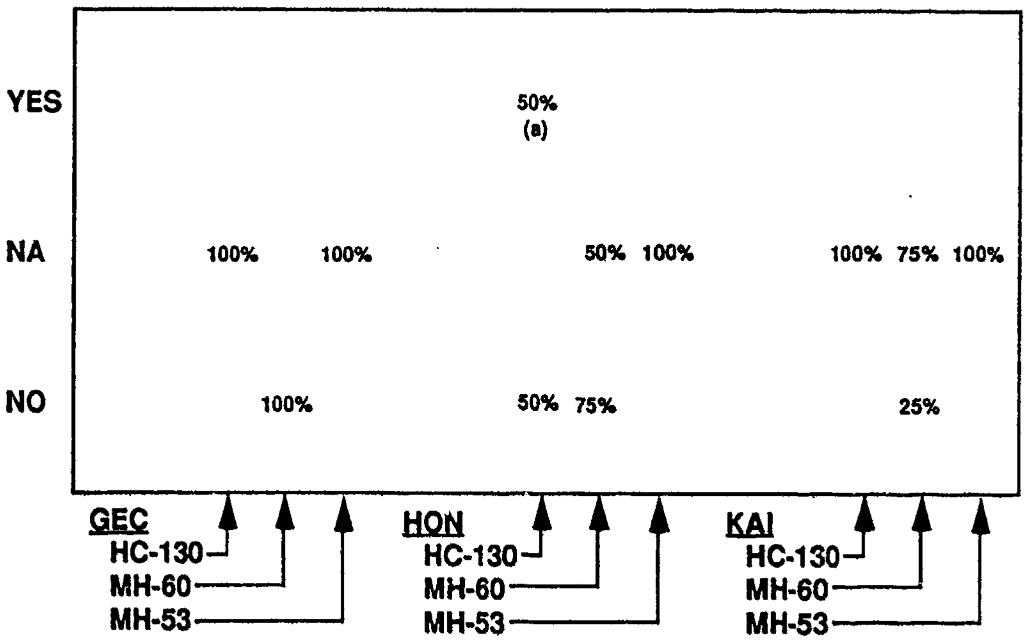
(d) Lots of green tint, hard to focus on instruments.

(e) Cannot be viewed through combiners when they are on - must look over or under, like ANVIS-6.

SUMMARY



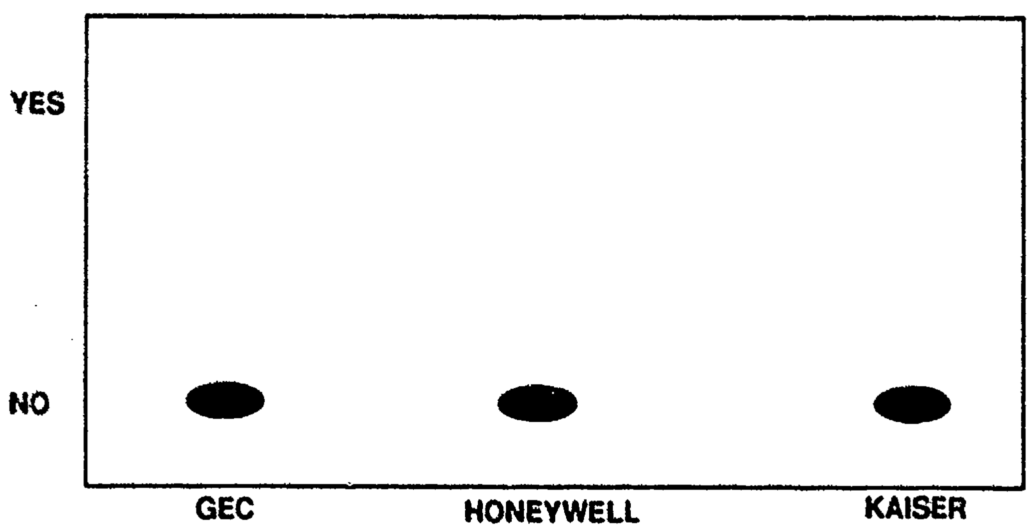
II.B.7 Were there reflections in the visor? If YES, indicate the location and source. (80)



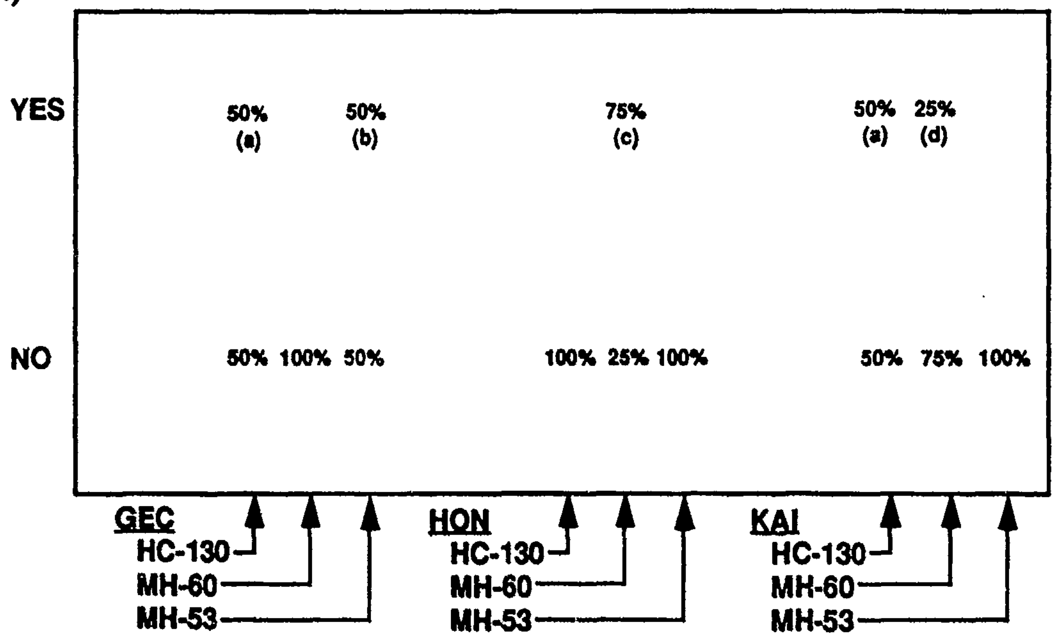
PILOT COMMENTS:

(a) Combiners, cockpit lights.

SUMMARY



II.B.8 Were there reflections in the combiners? If YES, which one(s), location, and source. (81)



PILOT COMMENTS:

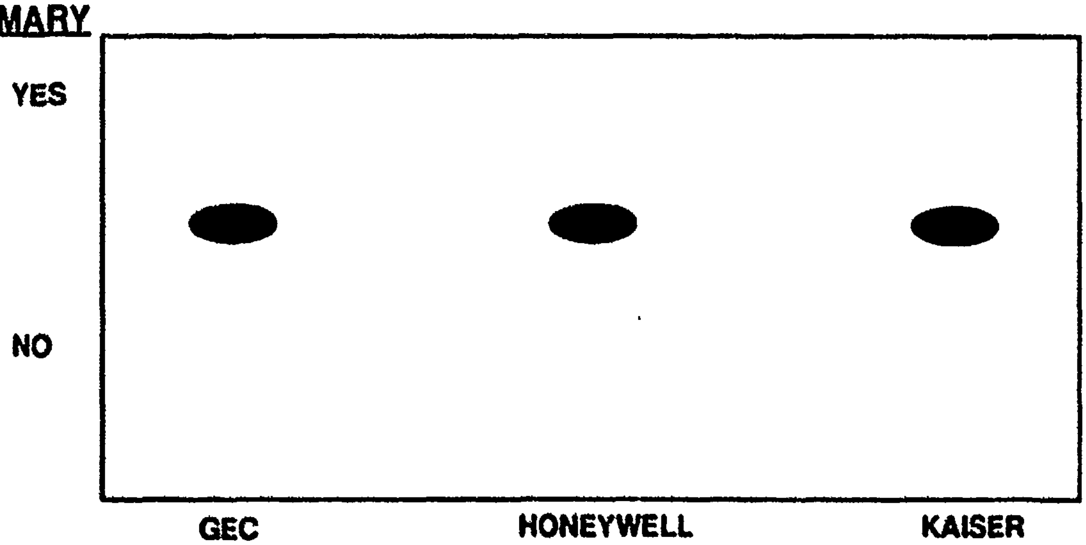
(a) Cockpit lights.

(b) When looking directly at cockpit lights.

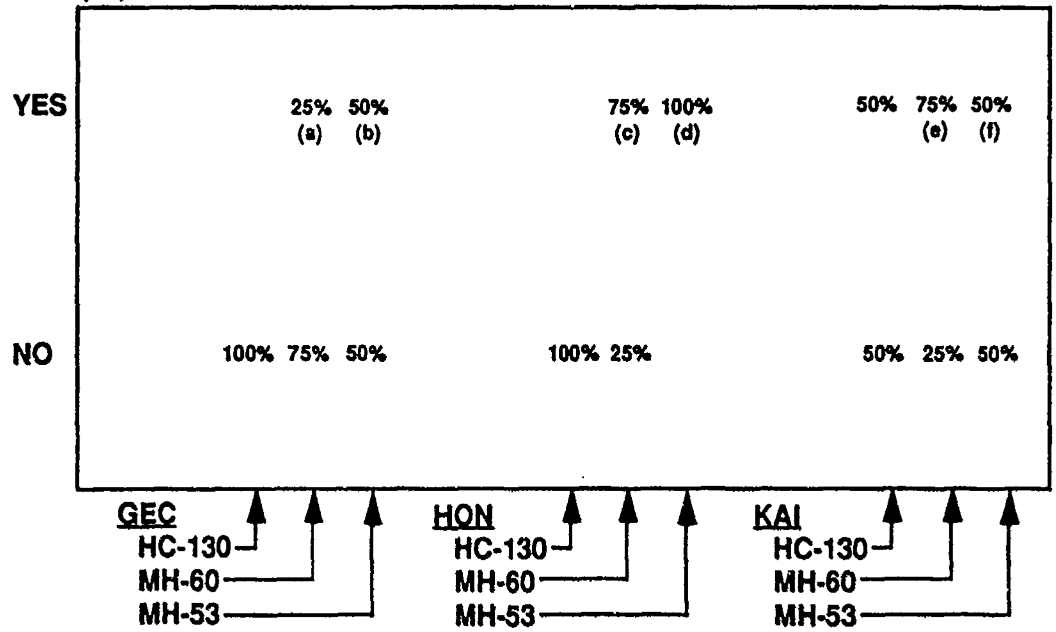
(c) Ground lights.

(d) Pilot's CDU, radar.

SUMMARY



II.B.9 Were there reflections in the windscreen/canopy? If YES, indicate the location and source. (82)



PILOT COMMENTS:

(a) From co-pilot's finger light.

(b) From one or two non-compatible lights.

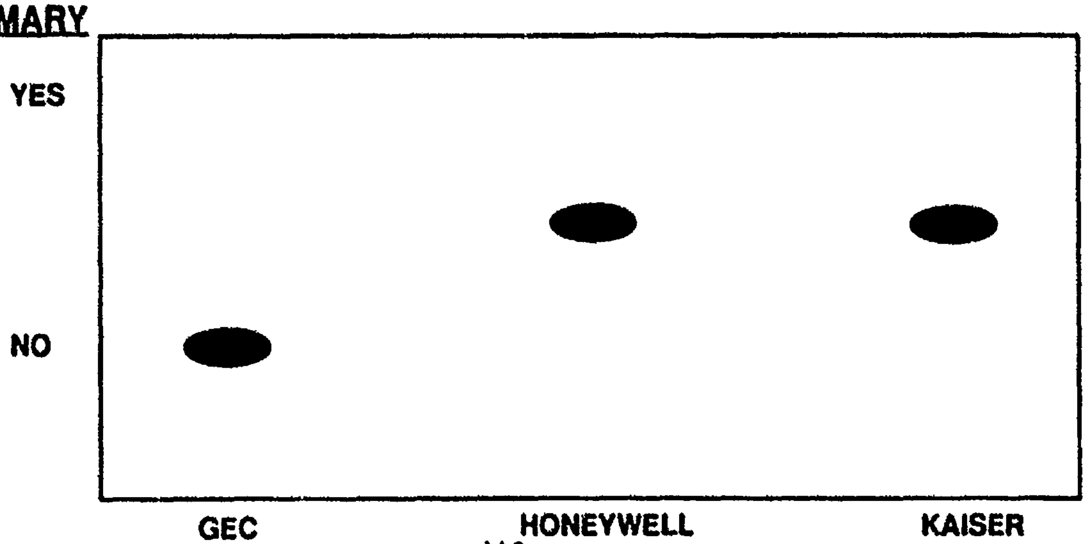
(c) From co-pilot's finger linger light and instruments.

(d) FLIR and cockpit lights.

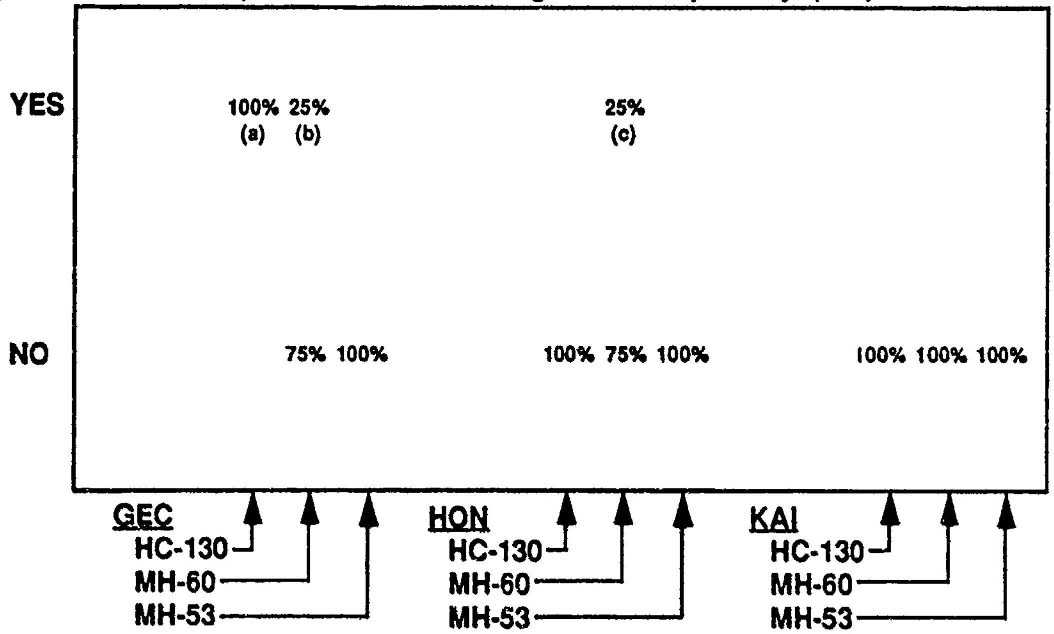
(e) From co-pilots finger light, pilot's CDU, radar.

(f) From windscreen and non-compatible lights - solved with extensive taping.

SUMMARY



II.C.1.a With the intensifiers ON, did you experience dark areas at the edge of the FOV? If you answer "YES" please evaluate the degree of acceptability. (61a)



PILOT COMMENTS:

(a) Rating: 2.75, BORDERLINE. Bottom - dim display - dark area all around field of view.

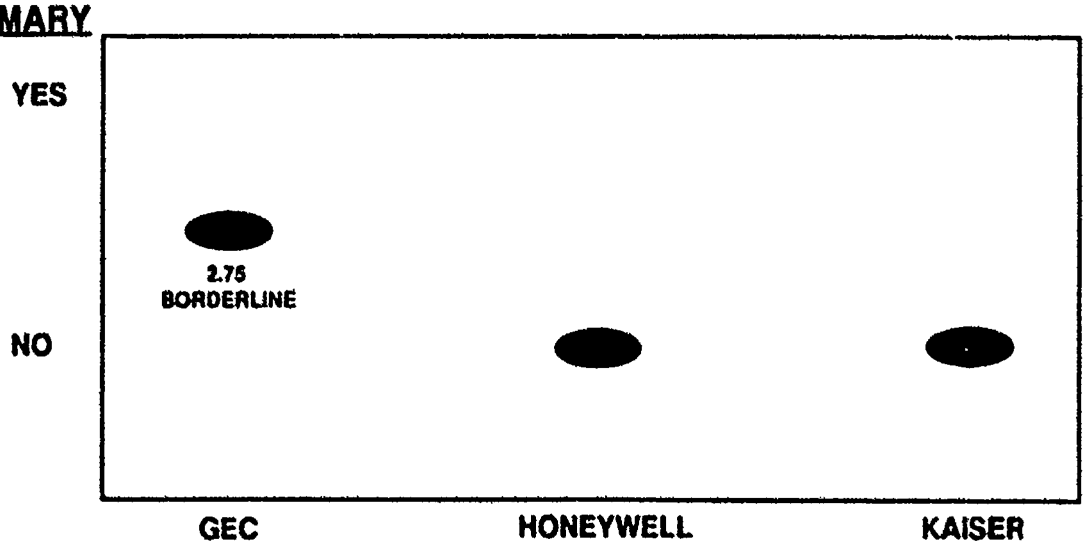
(b) Rating: NONE

(c) Rating: 5.0, ACCEPTABLE. Slight clip at edge of field of view.

DEGREE OF ACCEPTABILITY

5.0 ACCEPTABLE
4.0 BARELY ACCEPTABLE
3.0 BORDERLINE
2.0 BARELY UNACCEPTABLE
1.0 UNACCEPTABLE

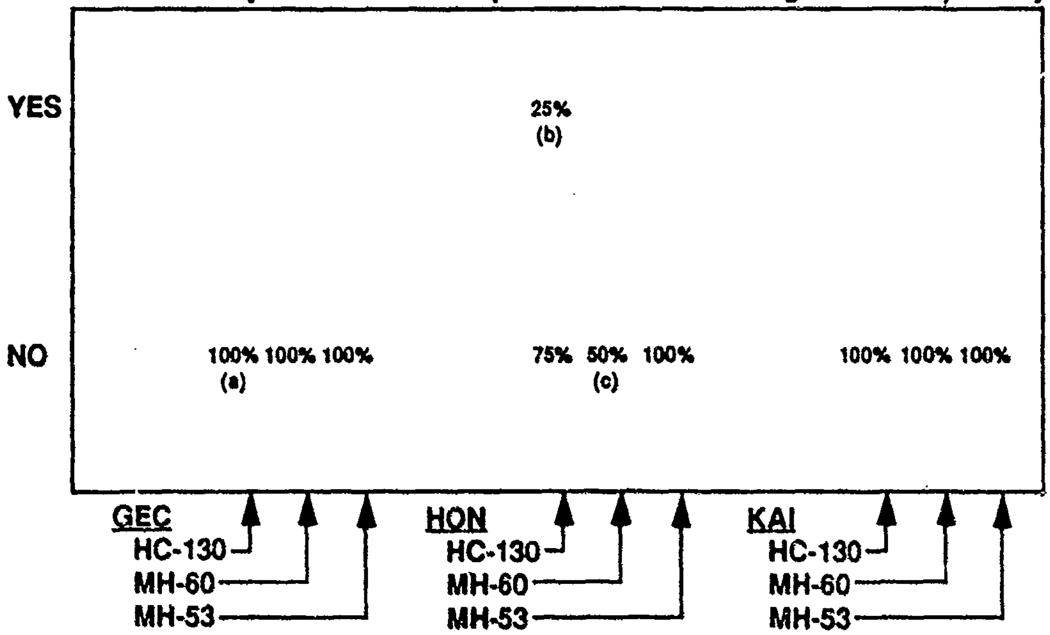
SUMMARY



II.C.1.b With the intensifiers ON, did you experience a bright or sparkling area at the outer portion of the FOV? If you answer "YES" please evaluate the degree of acceptability. (61b)

All the pilots answered "NO."

II.C.1.c With the intensifiers ON, did you experience flickering or constant bright spots across the FOV? If you answer "YES" please evaluate the degree of acceptability.



PILOT COMMENTS:

(a) Grainy throughout field of view.

(b) Rating: 1.0, UNACCEPTABLE.

(c) This category was not completed by some or all the pilots.

DEGREE OF ACCEPTABILITY

5.0 ACCEPTABLE

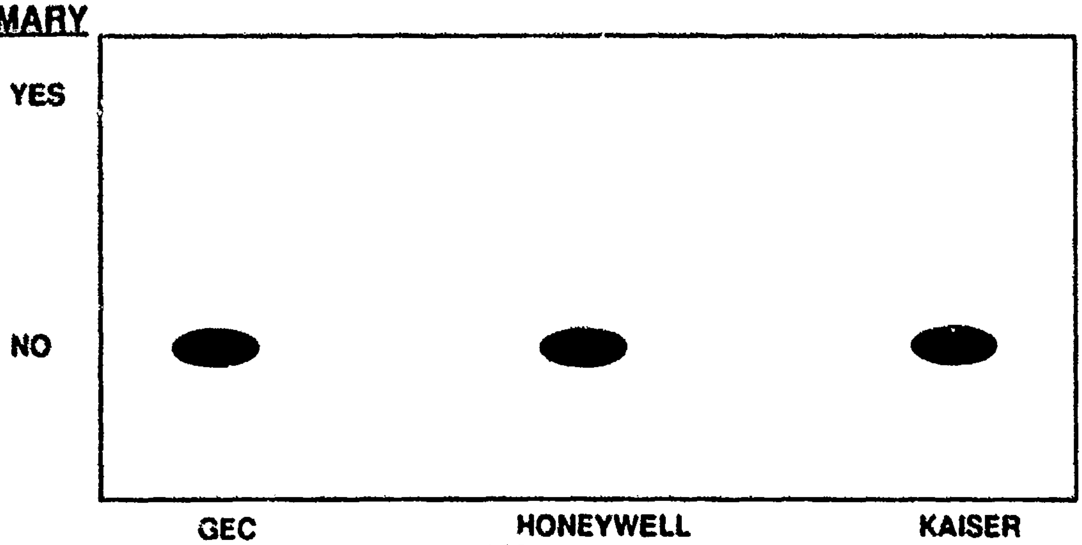
4.0 BARELY ACCEPTABLE

3.0 BORDERLINE

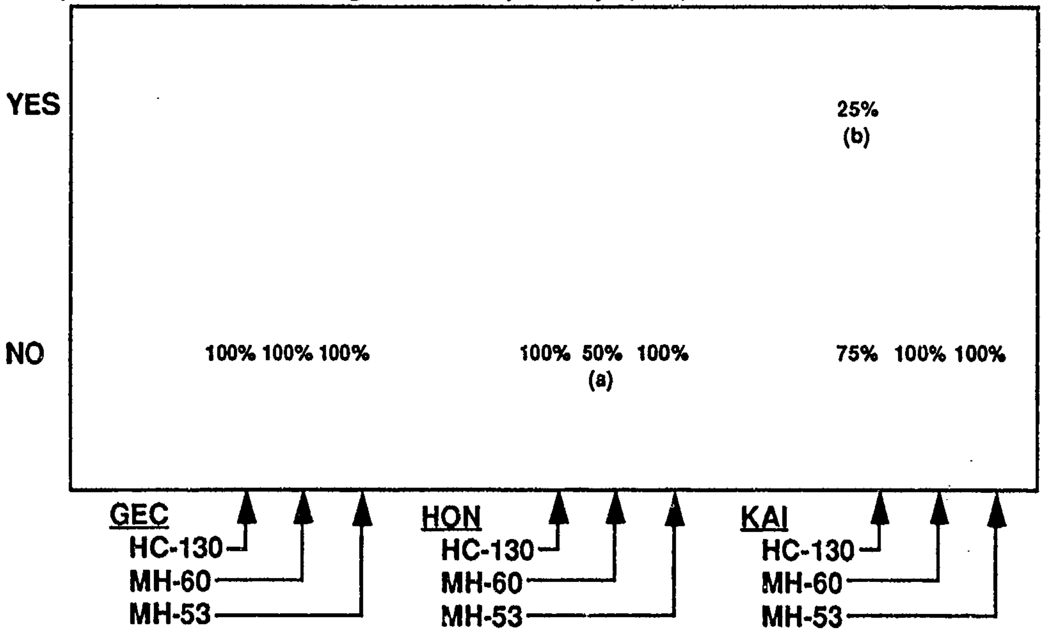
2.0 BARELY UNACCEPTABLE

1.0 UNACCEPTABLE

SUMMARY



II.C.1.d With the Intensifiers ON, did you experience dark spots in the FOV? If you answer "YES" please evaluate the degree of acceptability. (61d)



PILOT COMMENTS:

(a) This category was not completed by some or all the pilots.

(b) Rating: 5.0, ACCEPTABLE. Looked a bit like dirt.

DEGREE OF ACCEPTABILITY

5.0 ACCEPTABLE

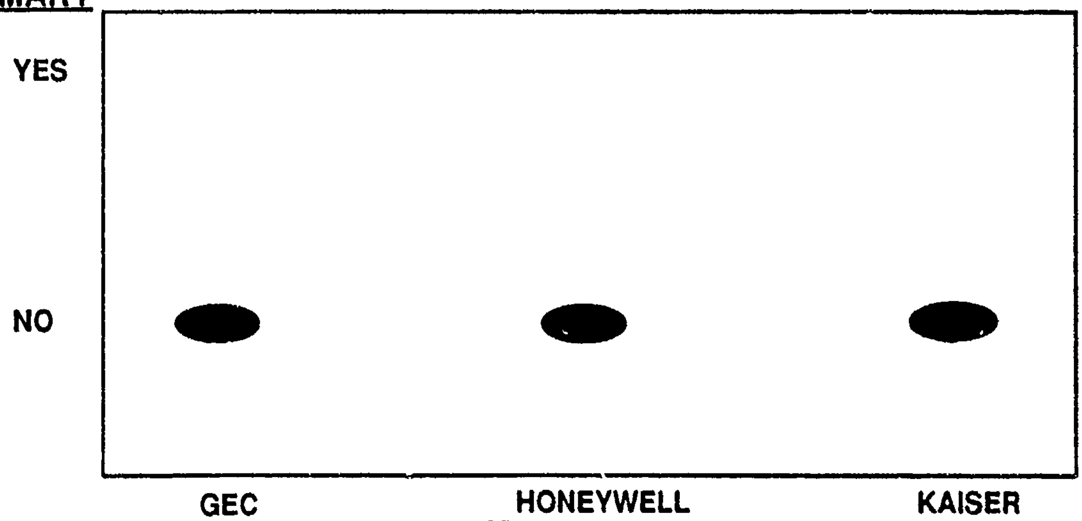
4.0 BARELY ACCEPTABLE

3.0 BORDERLINE

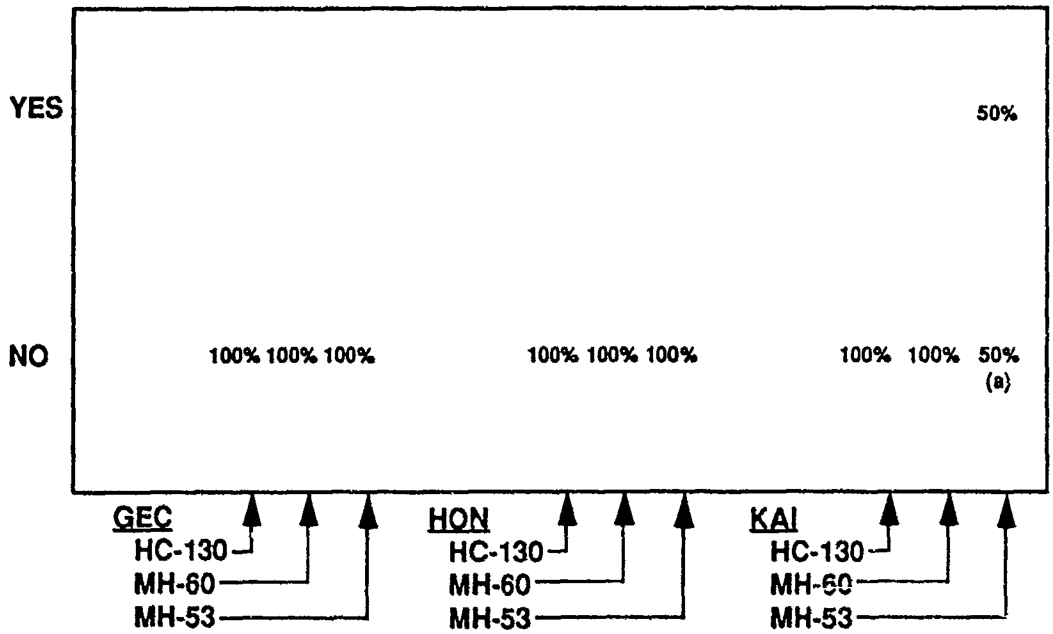
2.0 BARELY UNACCEPTABLE

1.0 UNACCEPTABLE

SUMMARY



II.C.1.e With the intensifiers ON, did you experience honeycomb like noise pattern during high light levels? If you answer "YES" please evaluate the degree of acceptability. (61e)



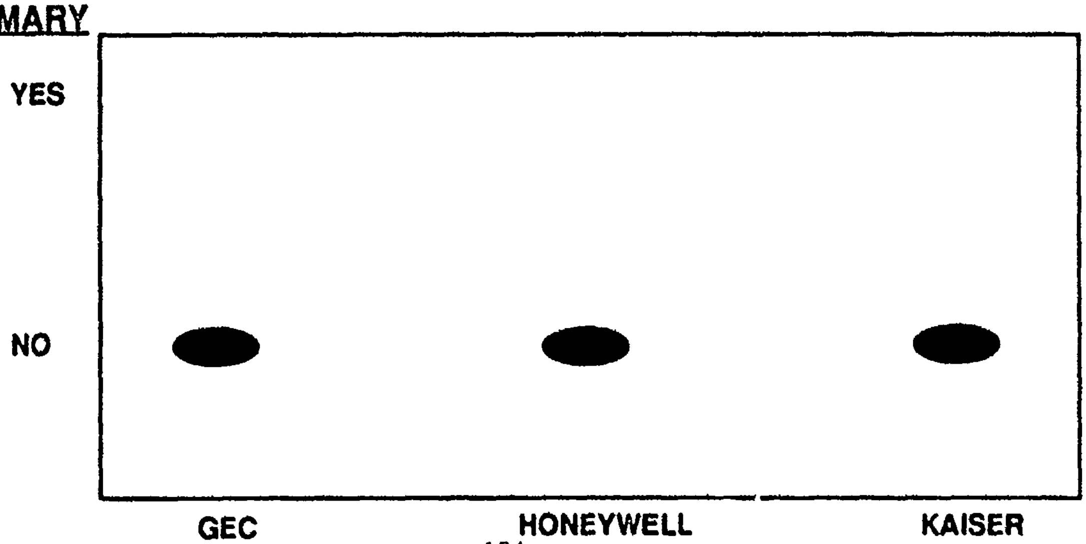
PILOT COMMENTS:

(a) Rating: 5.0, ACCEPTABLE.

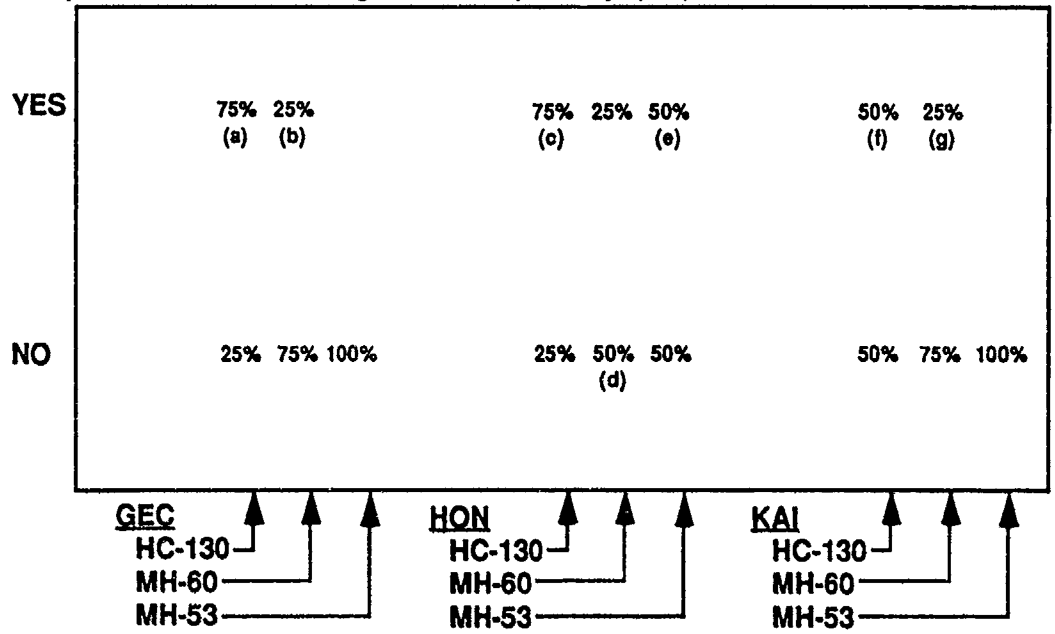
DEGREE OF ACCEPTABILITY

5.0 ACCEPTABLE
4.0 BARELY ACCEPTABLE
3.0 BORDERLINE
2.0 BARELY UNACCEPTABLE
1.0 UNACCEPTABLE

SUMMARY



II.C.1.f With the intensifiers ON, did you experience glare in the combiners? If you answer "YES" please evaluate the degree of acceptability. (61f)



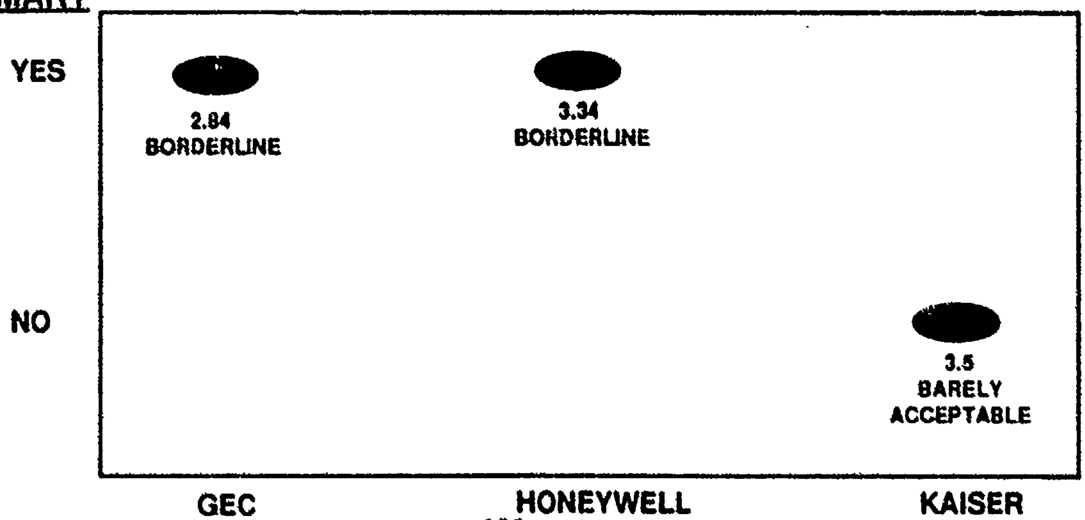
PILOT COMMENTS:

(a) Rating: 2.67, BORDERLINE. From the instrument panel.
(b) Rating: 3.0, BORDERLINE.
(c) Rating: 4.67, ACCEPTABLE. From chem lights.
(d) This category was not rated by some or all the pilots.
(e) Rating: 2.0, BARELY UNACCEPTABLE. Glare from FLIR.
(f) Rating: 4.0, BARELY ACCEPTABLE. Instrument lights.
(g) Rating: 3.0, BORDERLINE.

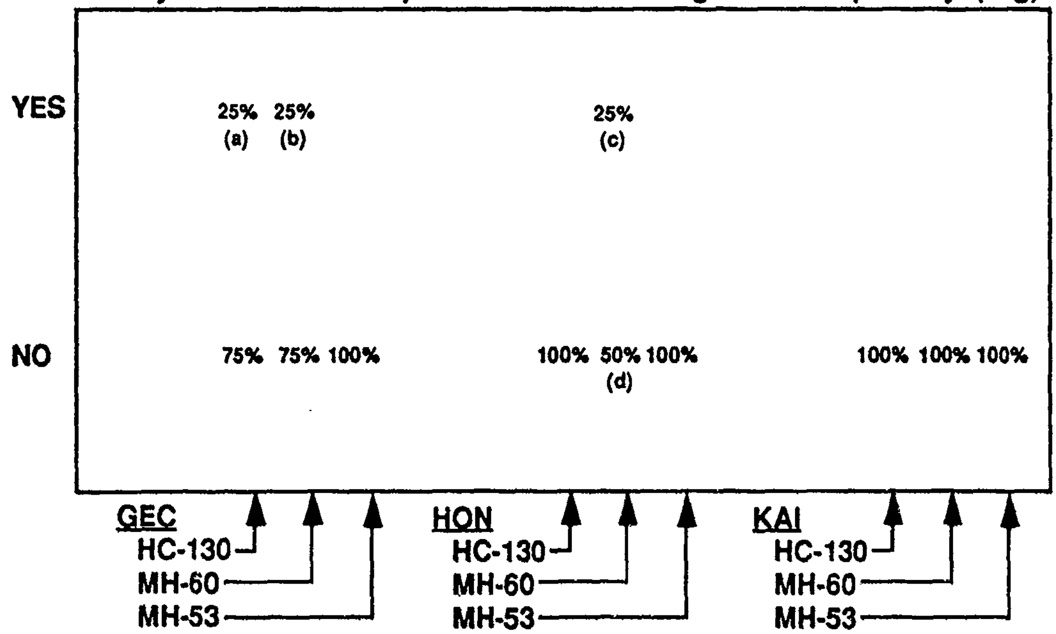
DEGREE OF ACCEPTABILITY

5.0 ACCEPTABLE
4.0 BARELY ACCEPTABLE
3.0 BORDERLINE
2.0 BARELY UNACCEPTABLE
1.0 UNACCEPTABLE

SUMMARY



II.C.1.g With the Intensifiers ON, did you experience reduced contrast over some areas in the FOV? If you answer "YES" please evaluate the degree of acceptability. (61g)



PILOT COMMENTS:

(a) Rating: 1.0, UNACCEPTABLE. Under low illumination ground lights caused scene to wash out.

(b) Rating: 4.0, BARELY ACCEPTABLE.

(c) Rating: 3.0, BORDERLINE.

(d) This category was not rated by some or all the pilots.

DEGREE OF ACCEPTABILITY

5.0 ACCEPTABLE

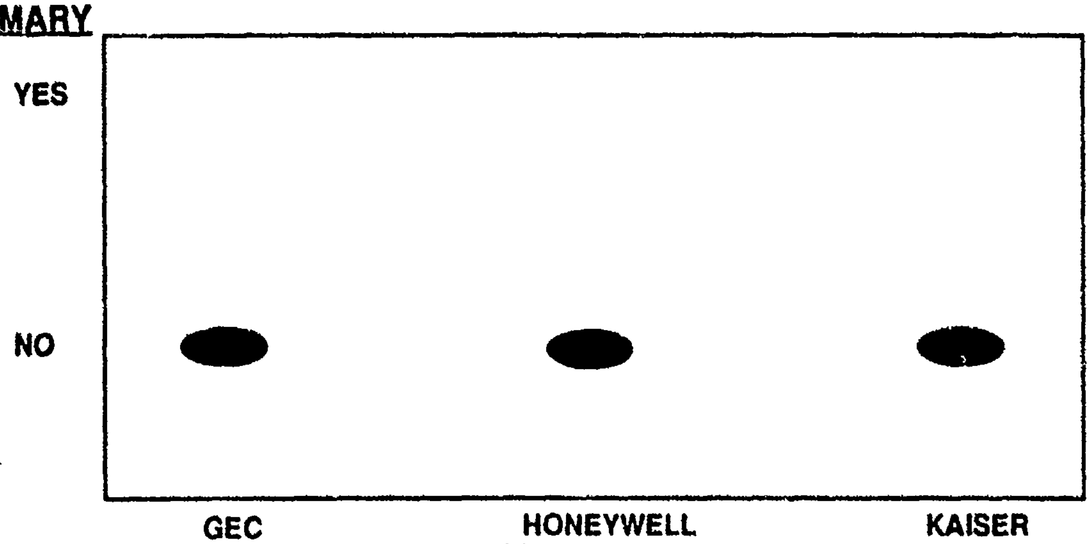
4.0 BARELY ACCEPTABLE

3.0 BORDERLINE

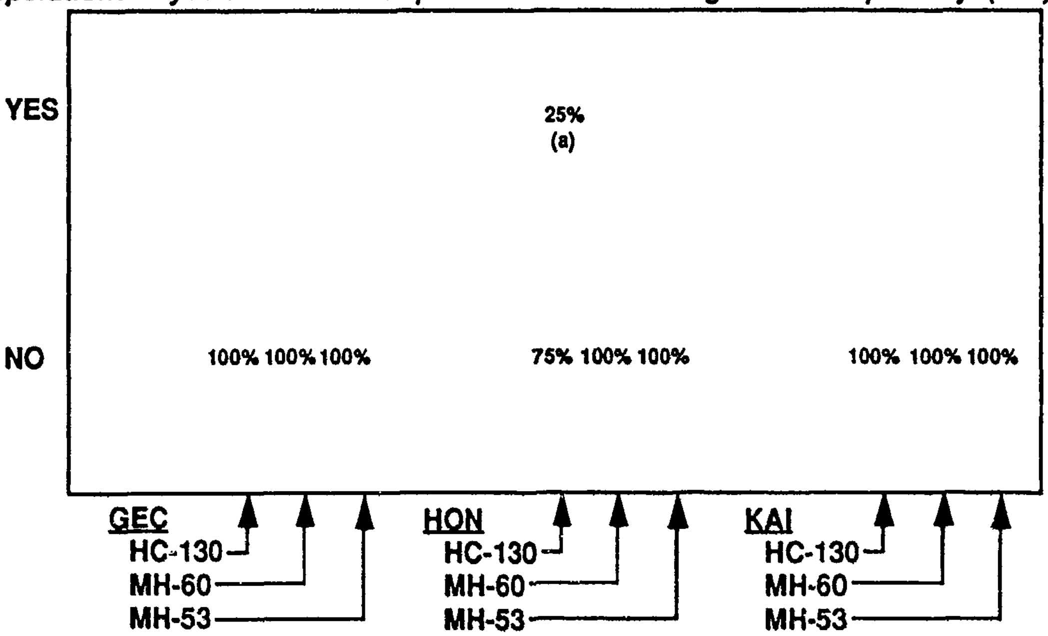
2.0 BARELY UNACCEPTABLE

1.0 UNACCEPTABLE

SUMMARY



II.C.1.h With the Intensifiers ON, did you experience flashing, flickering, or intermittent operation? If you answer "YES" please evaluate the degree of acceptability. (61h)



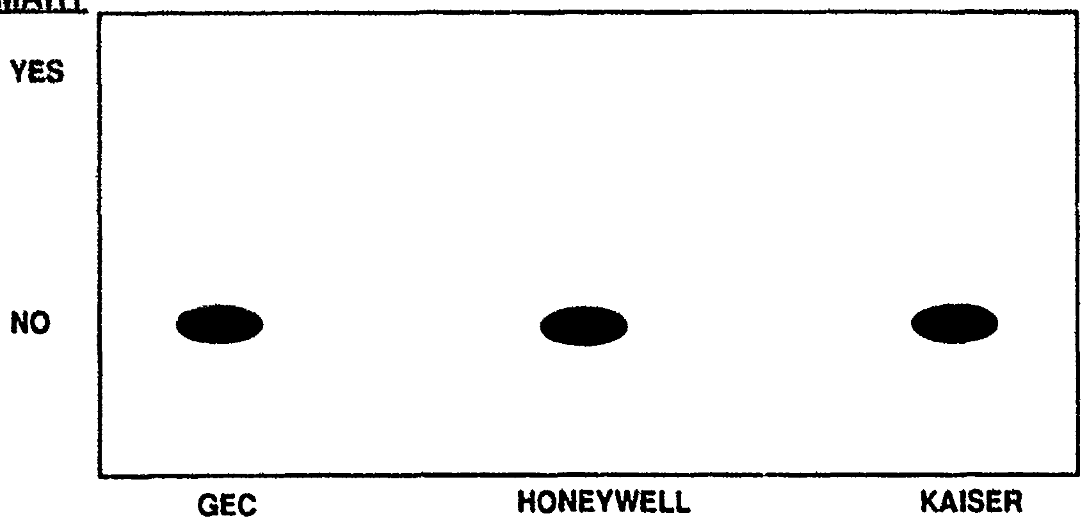
PILOT COMMENTS:

(a) Rating: 1.0, UNACCEPTABLE.

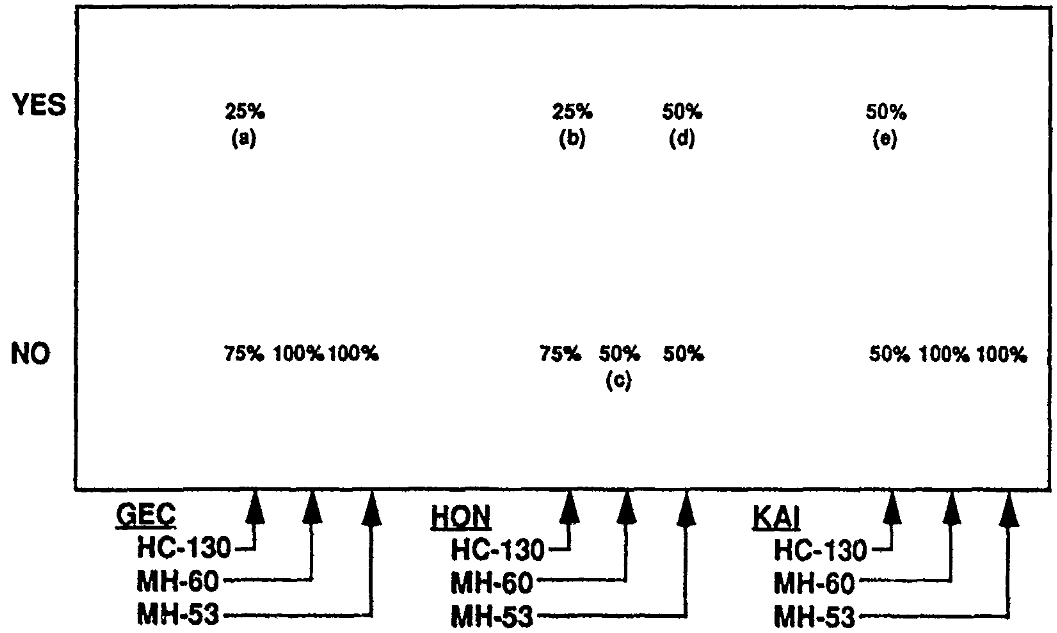
DEGREE OF ACCEPTABILITY

5.0 ACCEPTABLE
4.0 BARELY ACCEPTABLE
3.0 BORDERLINE
2.0 BARELY UNACCEPTABLE
1.0 UNACCEPTABLE

SUMMARY



II.C.1.i With the intensifiers ON, did you experience scintillation: salt & pepper/snow in the intensified scene? If you answer "YES" please evaluate the degree of acceptability. (61i)



PILOT COMMENTS:

(a) Rating: 5.0, ACCEPTABLE.

(b) Rating: 5.0, ACCEPTABLE. Normal compared to ANVIS-6.

(c) This category was not completed by some or all the pilots.

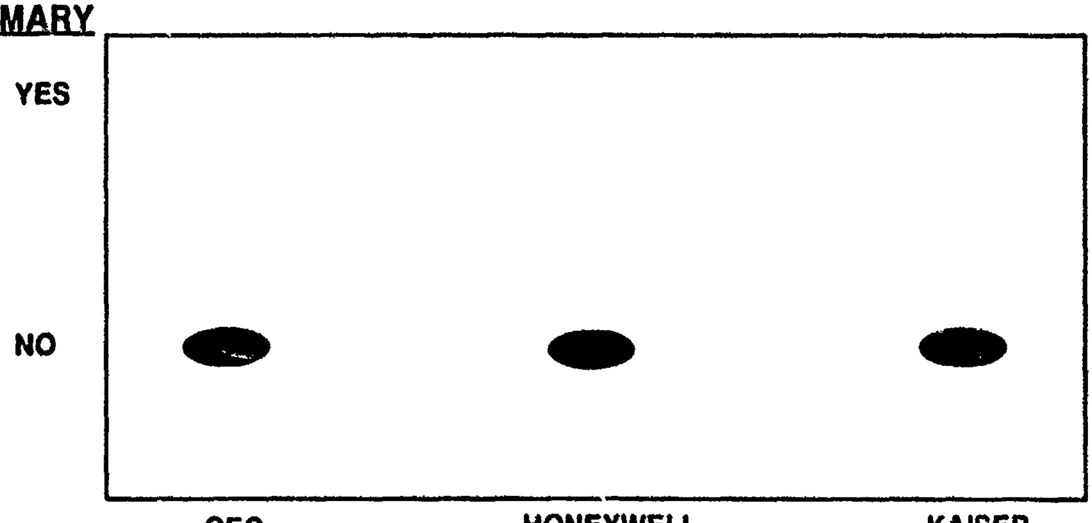
(d) Rating: 3.0, BORDERLINE.

(e) Rating: 5.0, ACCEPTABLE.

DEGREE OF ACCEPTABILITY

5.0 ACCEPTABLE
4.0 BARELY ACCEPTABLE
3.0 BORDERLINE
2.0 BARELY UNACCEPTABLE
1.0 UNACCEPTABLE

SUMMARY

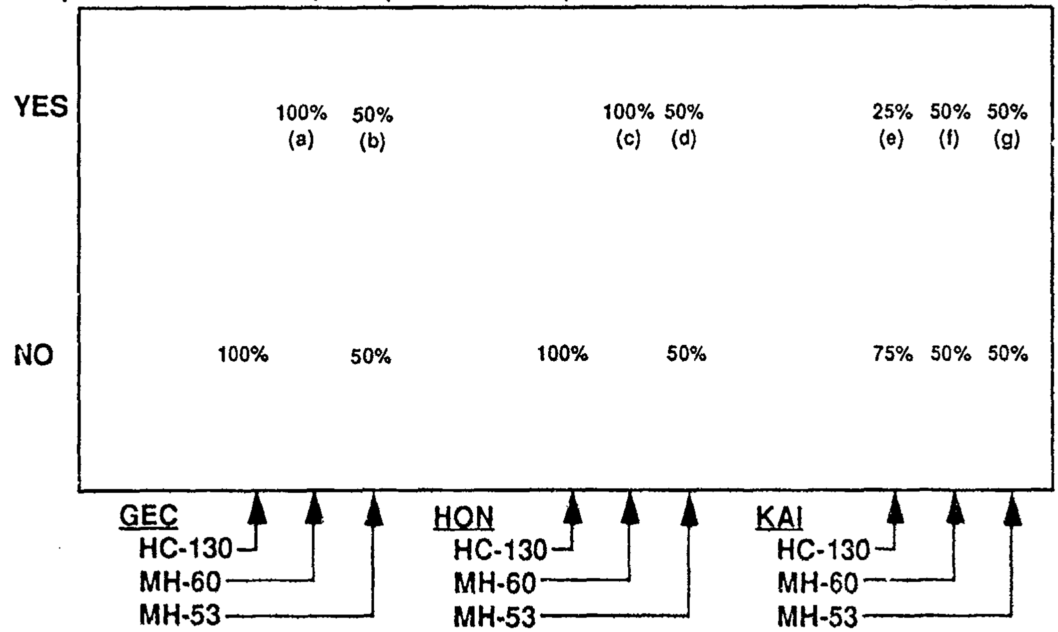


II.C.2 Did G forces cause loss of the intensified scene? If YES, describe. (71)

All the pilots said "NO."

NOTE: Mission profiles may not have included G forces high enough for the pilots to have experienced this effect; "NOT APPLICABLE" was not an option in answering this question.

II.C.3 Did you experience any blooming of the intensified scene? If YES, identify the light source (internal or external) and provide an explanation of the situation. (62)



PILOT COMMENTS:

(a) 75% internal, 100% external from ground lights and some instrument lights.

(b) 100% internal, 100% external - any bright light.

(c) External light source, tower lights, vehicles - low illumination could not see lead well enough to fly formation - could see better unaided when ground lights visible.

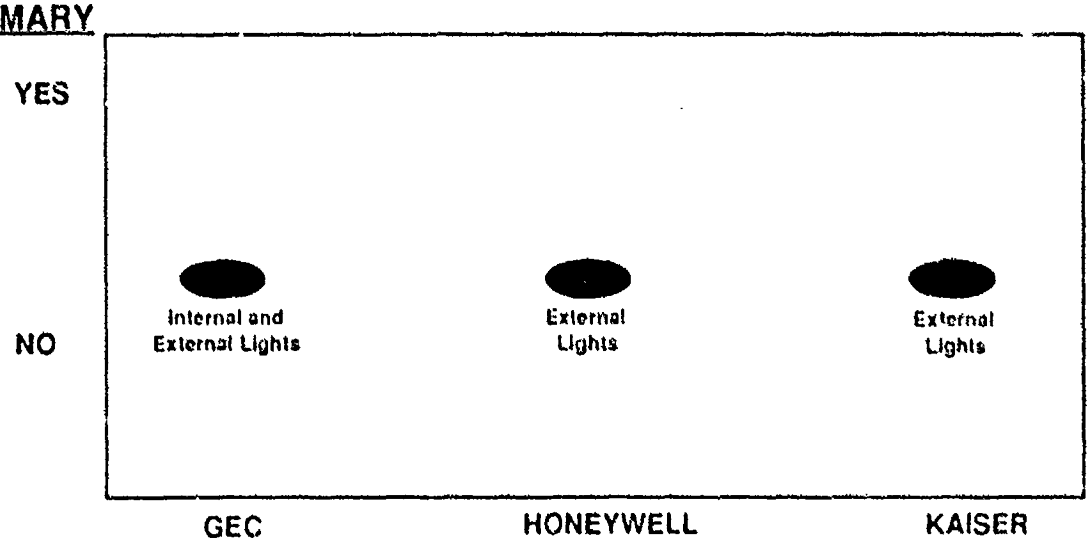
(d) External light source, all exterior lights caused blooming.

(e) External light source, under low illumination ground lights wash out unlighted areas.

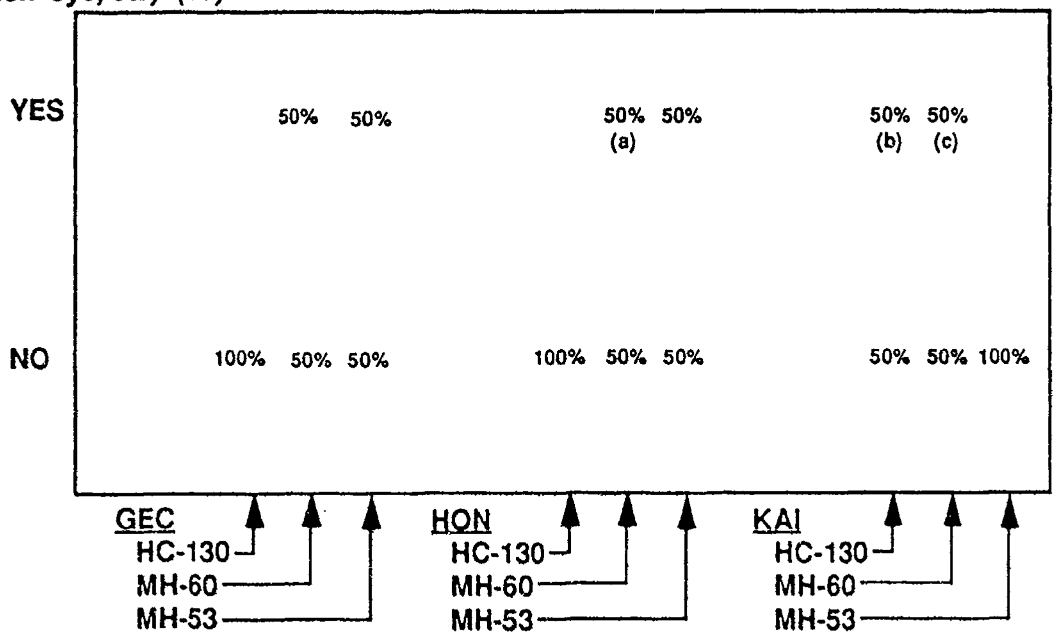
(f) 50% internal, 100% external, caused by ground lights, vehicle lights, co-pilot's finger light, lights streak when head moves - worse than ANVIS-6 performance.

(g) External yes - any bright external light - no, had clear sharp focused image.

SUMMARY



II.C.4 Did you experience any ghost or double imaging? If YES, describe (e.g. location, which eye, etc). (69)



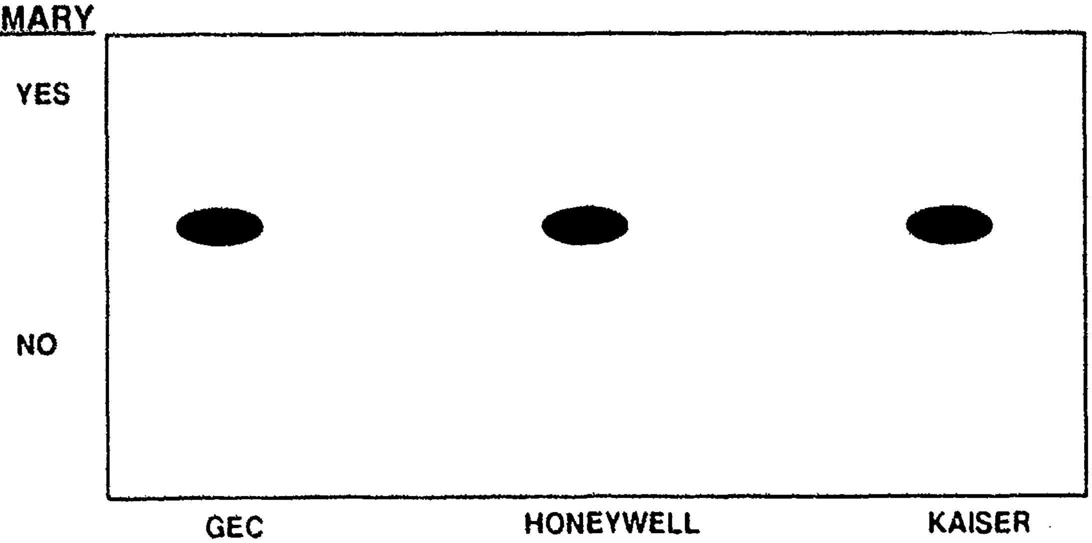
PILOT COMMENTS:

(a) Intensified field of view and ground lights.

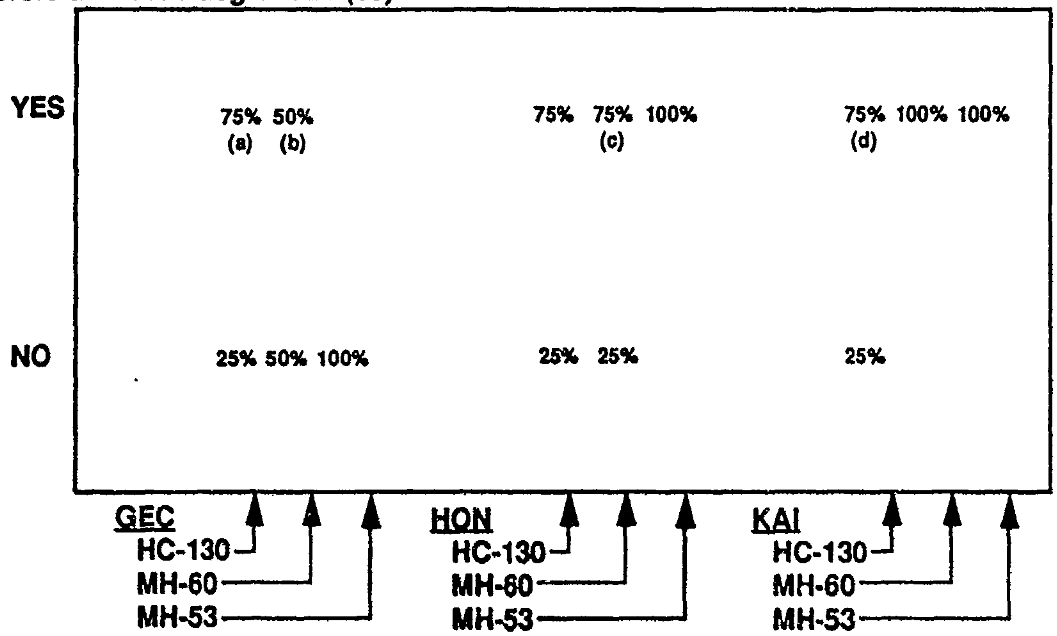
(b) Cockpit lights and objects more than 8 miles.

(c) From cockpit instruments.

SUMMARY



2.5. Did the intensified scene remain focused throughout the flight? If NO, how long before the focus degraded? (68)



PILOT COMMENTS:

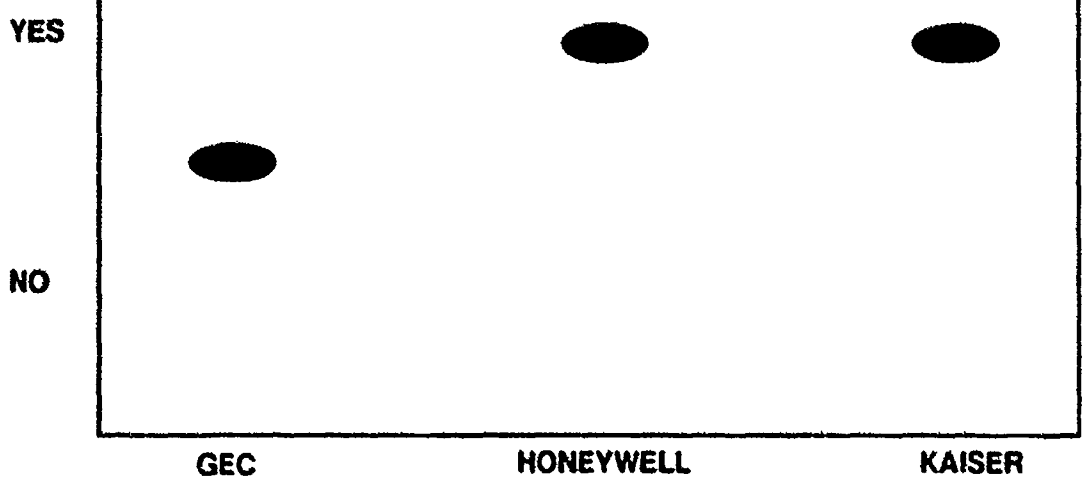
(a) Out after 5-10 minutes.

(b) Never had good focus - degraded immediately.

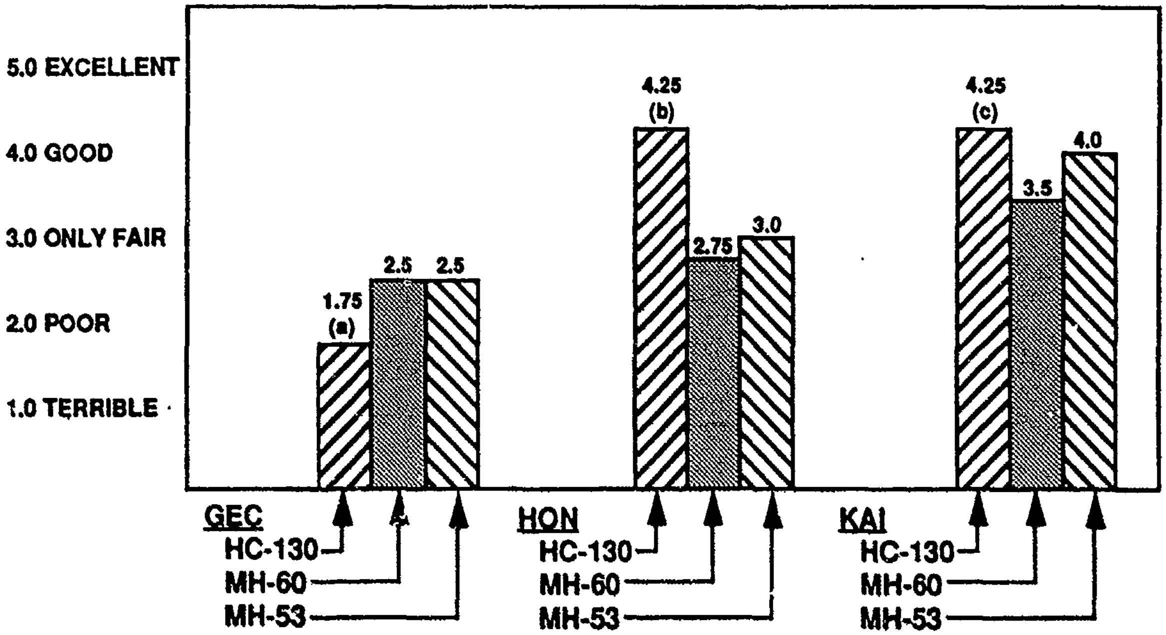
(c) Never had good focus.

(d) Degraded in 10-15 minutes.

SUMMARY



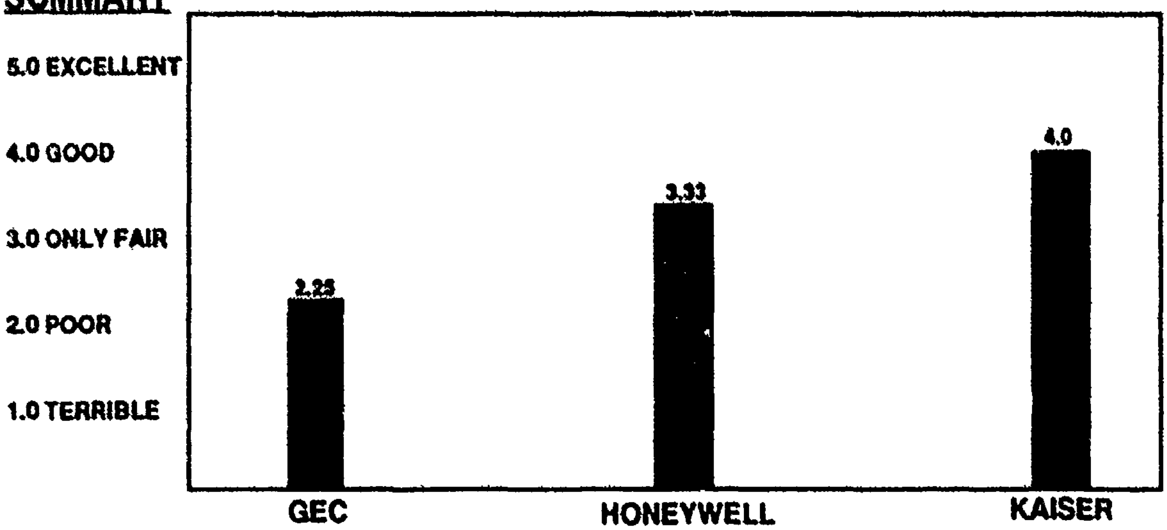
II.C.6 Evaluate the brightness of the intensified scene (image intensifier tubes ON). (63)



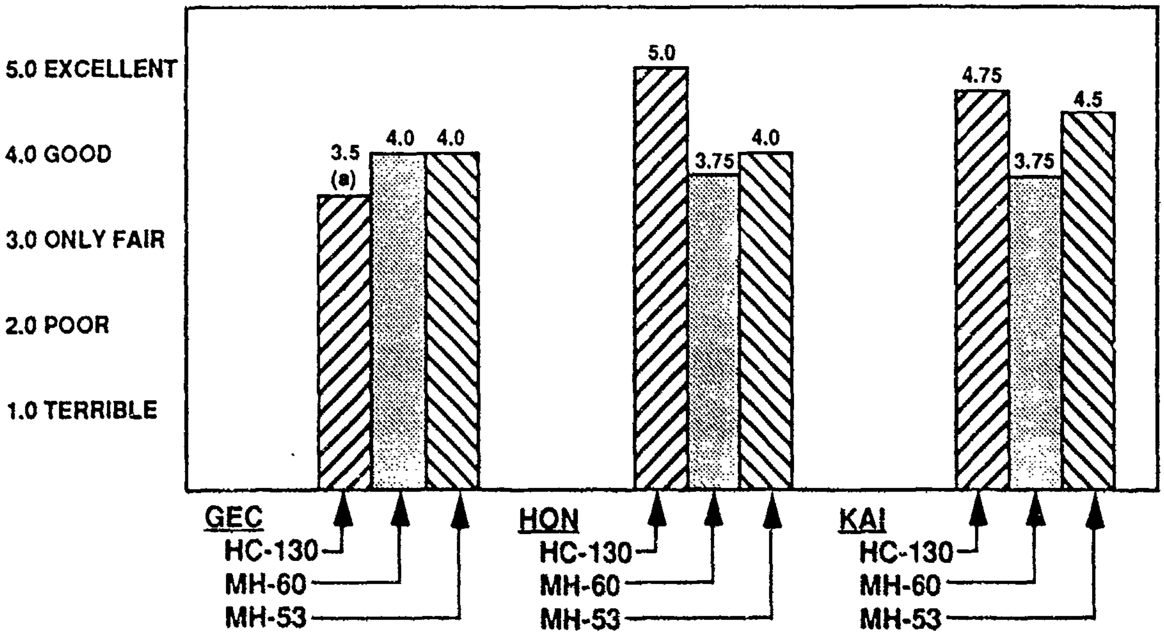
PILOT COMMENTS:

(a) Very poor in low illumination.
(b) Slightly less than ANVIS-6.
(c) About 85% of ANVIS-6.

SUMMARY



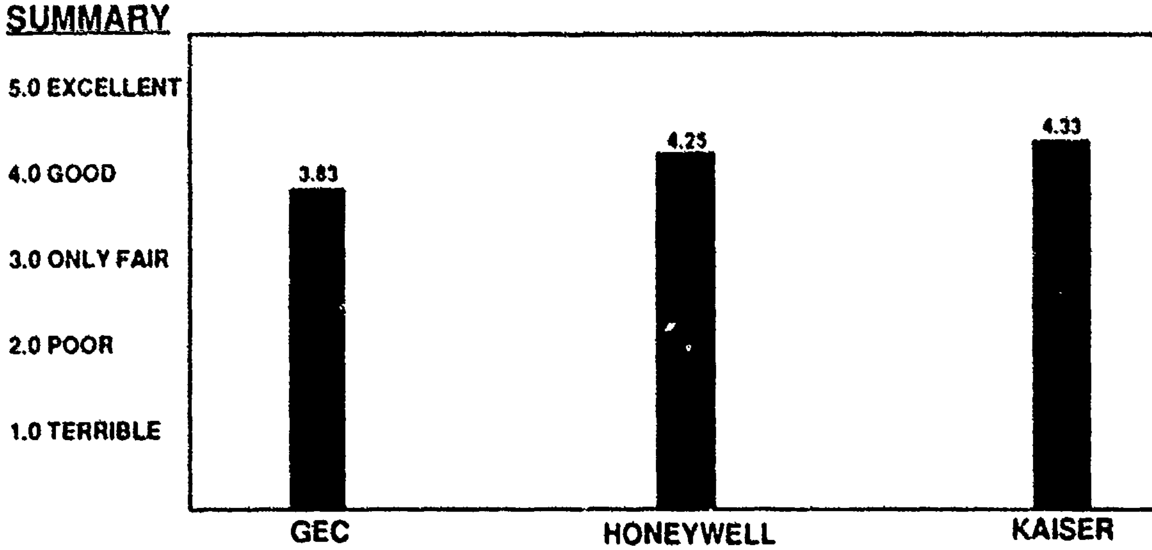
II.C.7 Evaluate the uniformity of intensified scene (image intensifier tubes ON). (64)



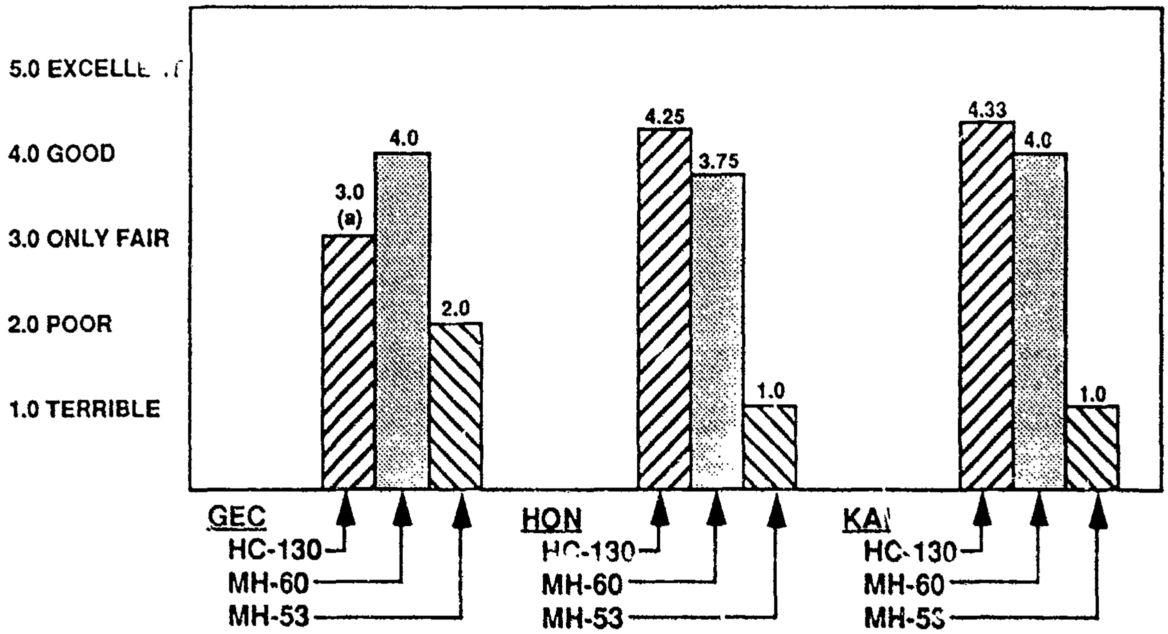
PILOT COMMENTS:

(a) Terrible under low illumination.

SUMMARY



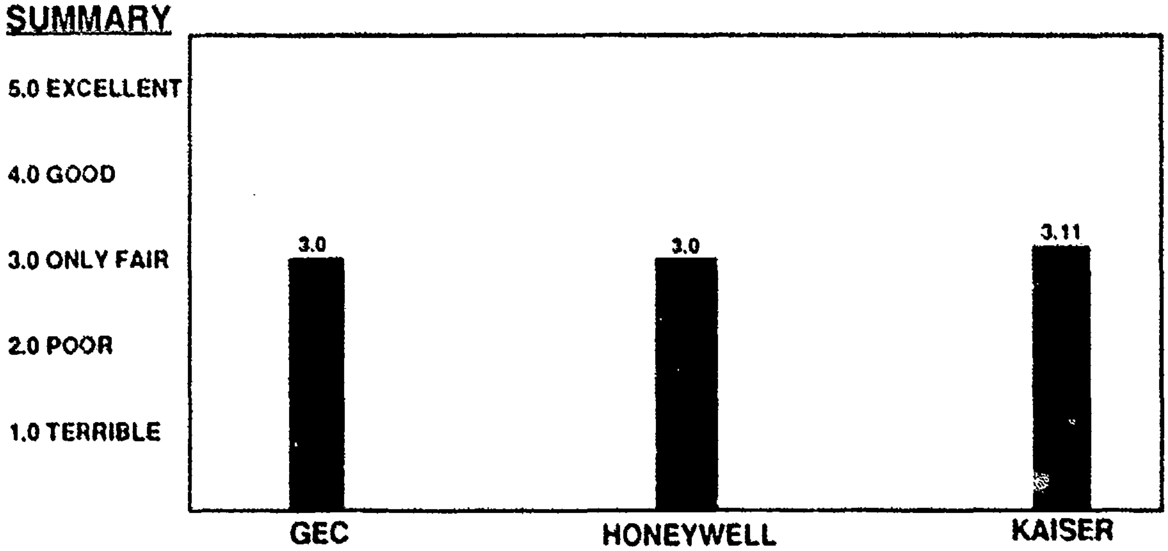
II.C.8.a Evaluate the ability to distinguish relative distances with image intensifiers OFF. (39b)



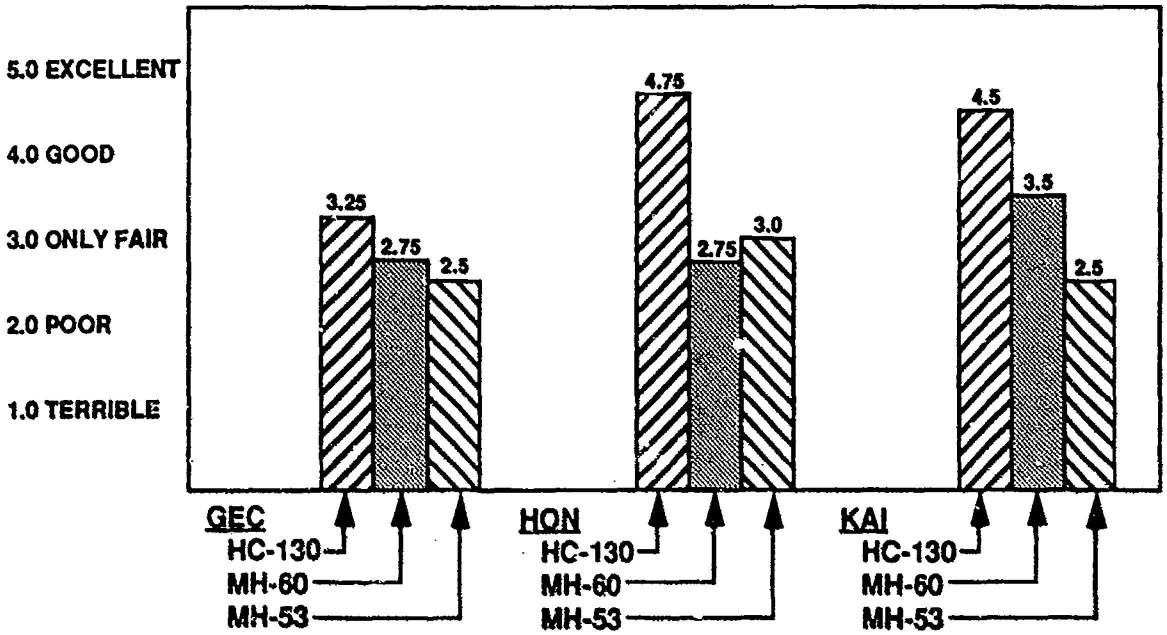
PILOT COMMENTS:

(a) Dark glasses effect degrades.

SUMMARY



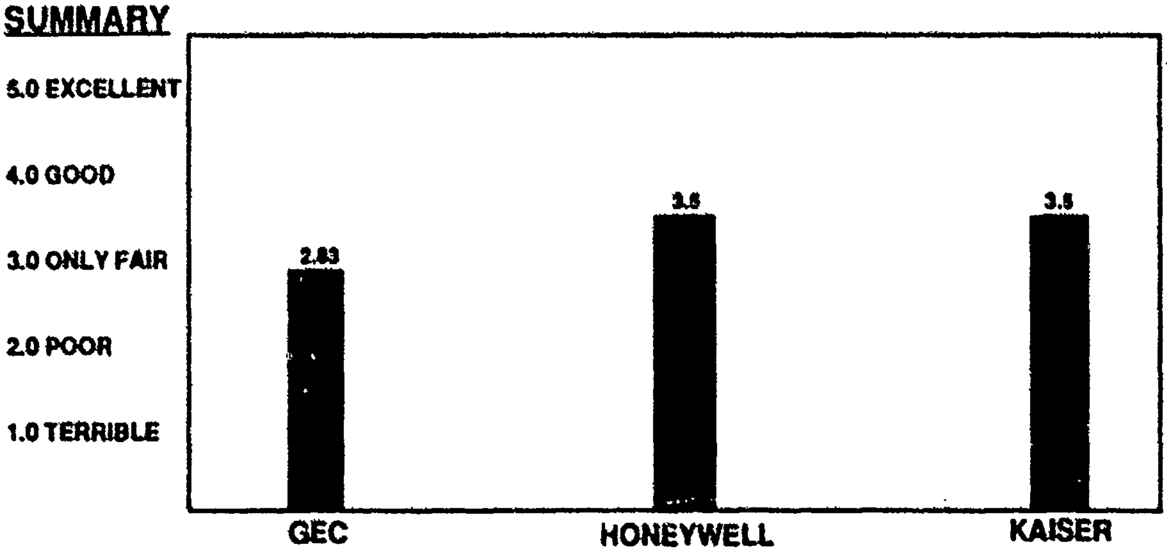
II.C.8.b Evaluate the ability to distinguish relative distances with Image Intensifiers ON. (39c)



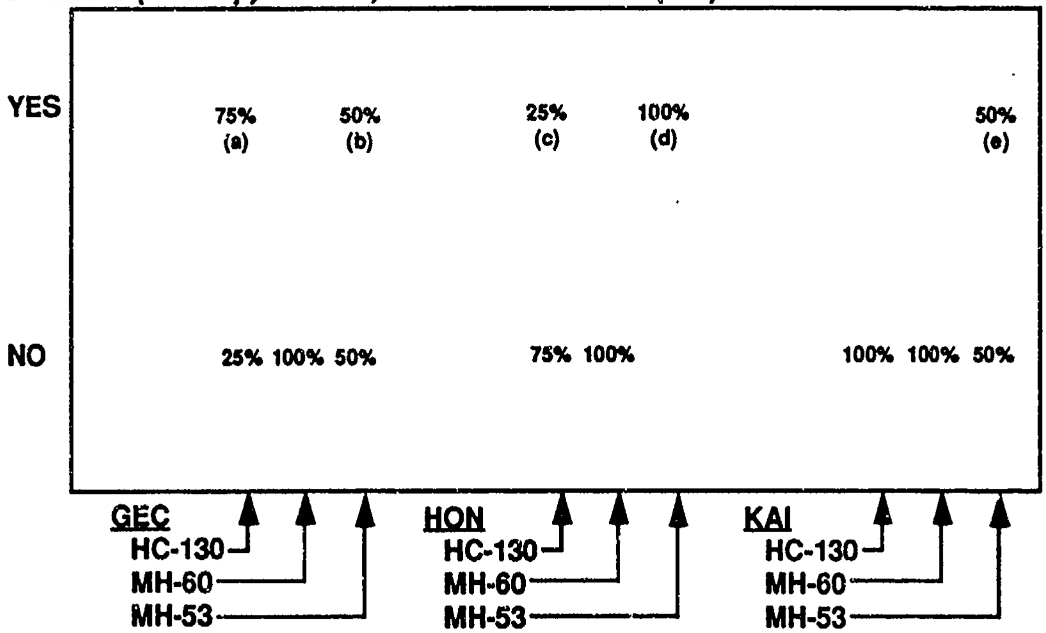
PILOT COMMENTS:

NONE

SUMMARY



II.C.9.a With the image intensifier tubes ON, did you experience any distortions through the combiners (visor up)? If YES, describe how much. (43a)



PILOT COMMENTS:

(a) Moving head side to side caused rolling.

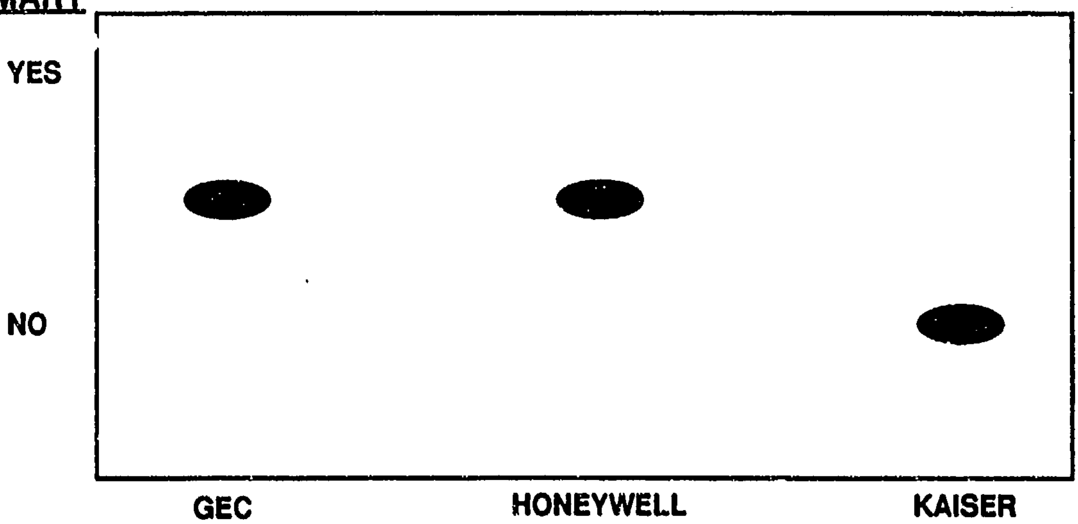
(b) When looking at instruments.

(c) Slightly, near bottom.

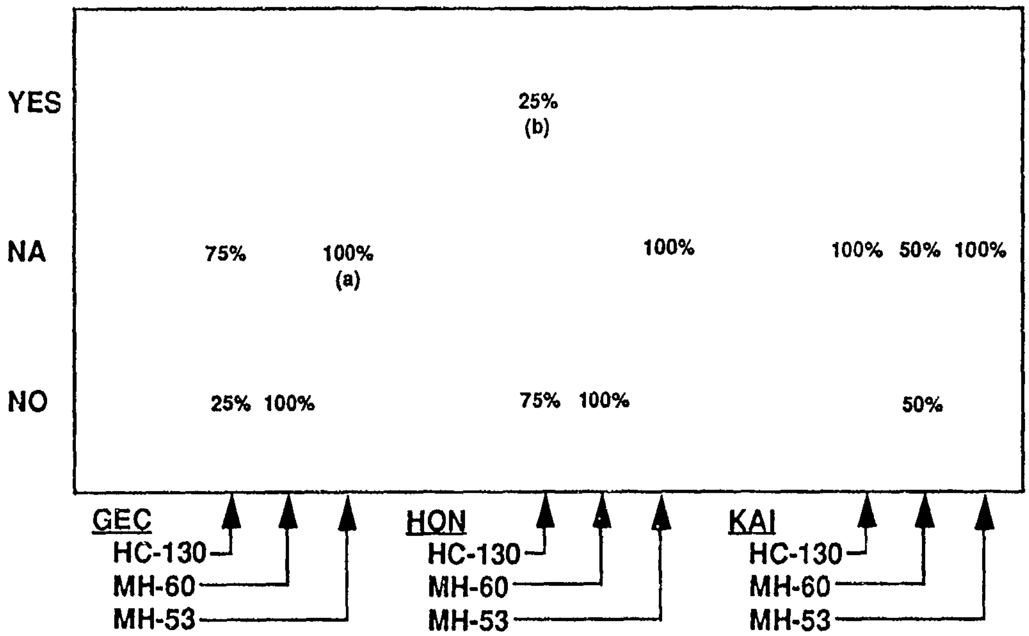
(d) Ground lights did not line up between combiners and intensifiers - blur from windscreen supports during scan, - glare from FLIR imagery.

(e) Appeared to be 5-10 feet below actual altitude.

SUMMARY



II.C.9.b With the image intensifier tubes ON, did you experience any distortions through the visor and combiners? If YES, describe how much. (43b)

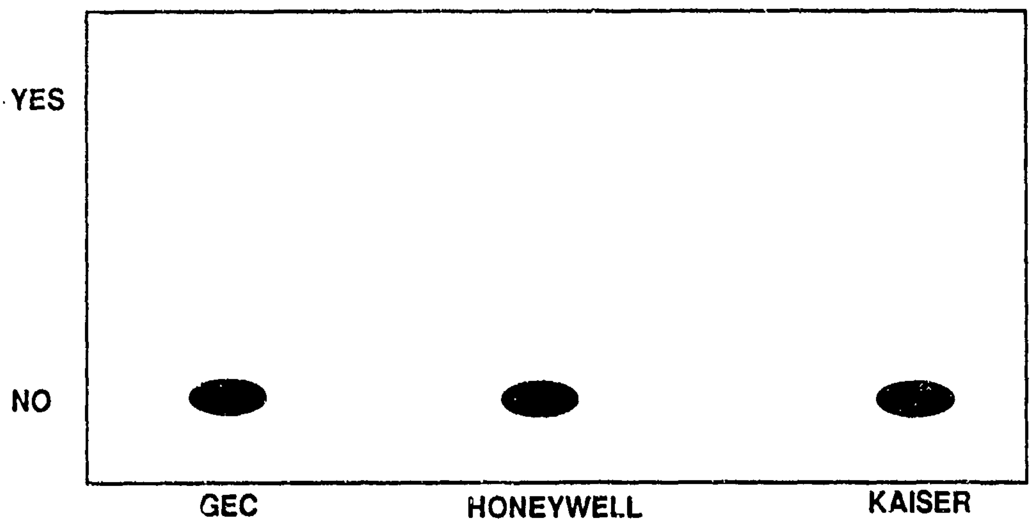


PILOT COMMENTS:

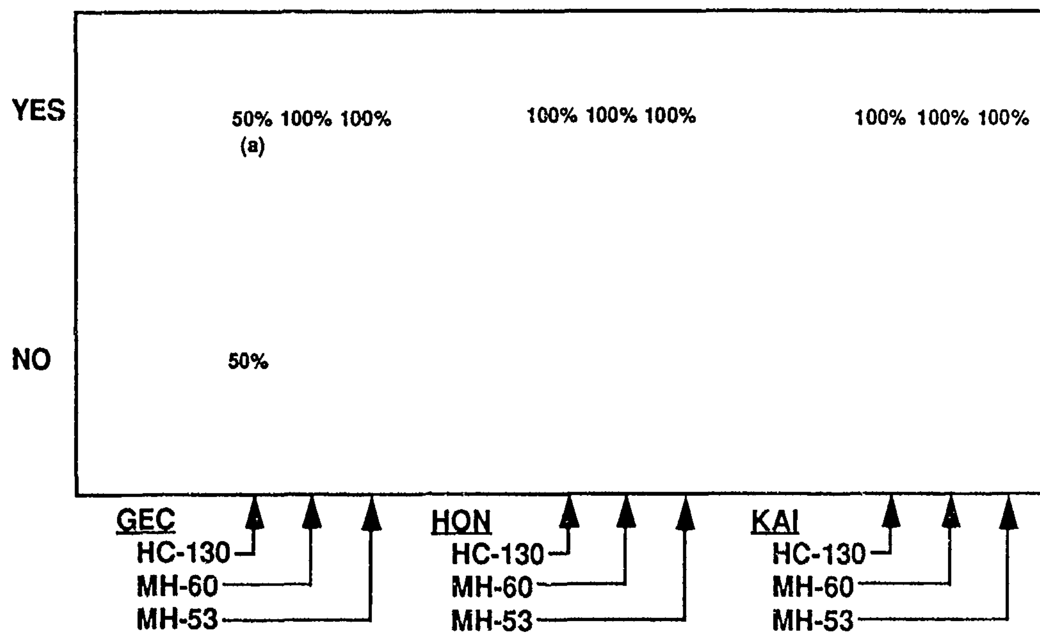
(a) Resolution and low light transmission made approaches into landing zone uncomfortable.

(b) Slight, near edges. NOTE: cycled from bright to dim and return - cured by pressing on combiners.

SUMMARY



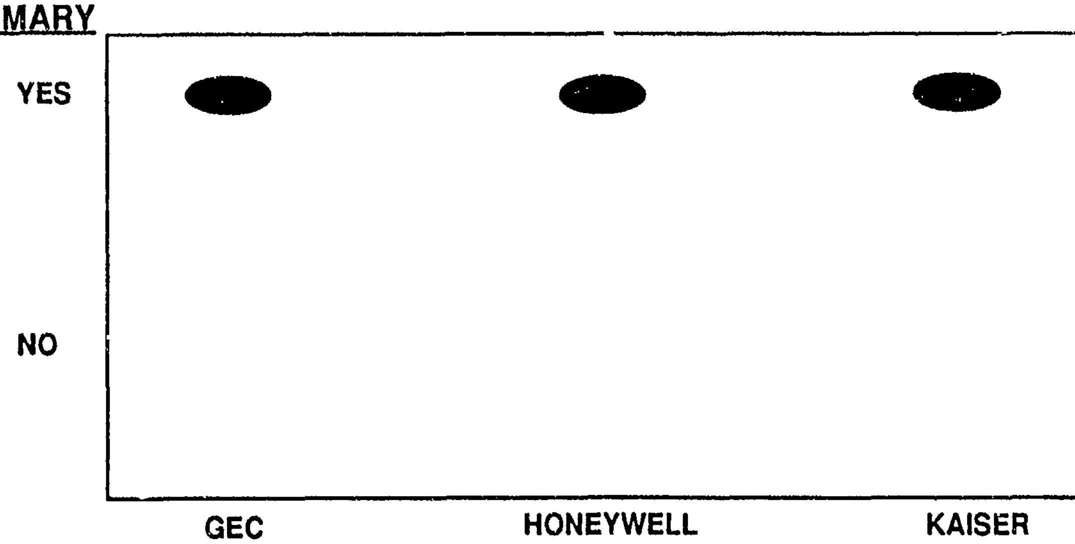
II.C.10 Did the intensified scene appear to be rotated properly? If NO, describe. (73)



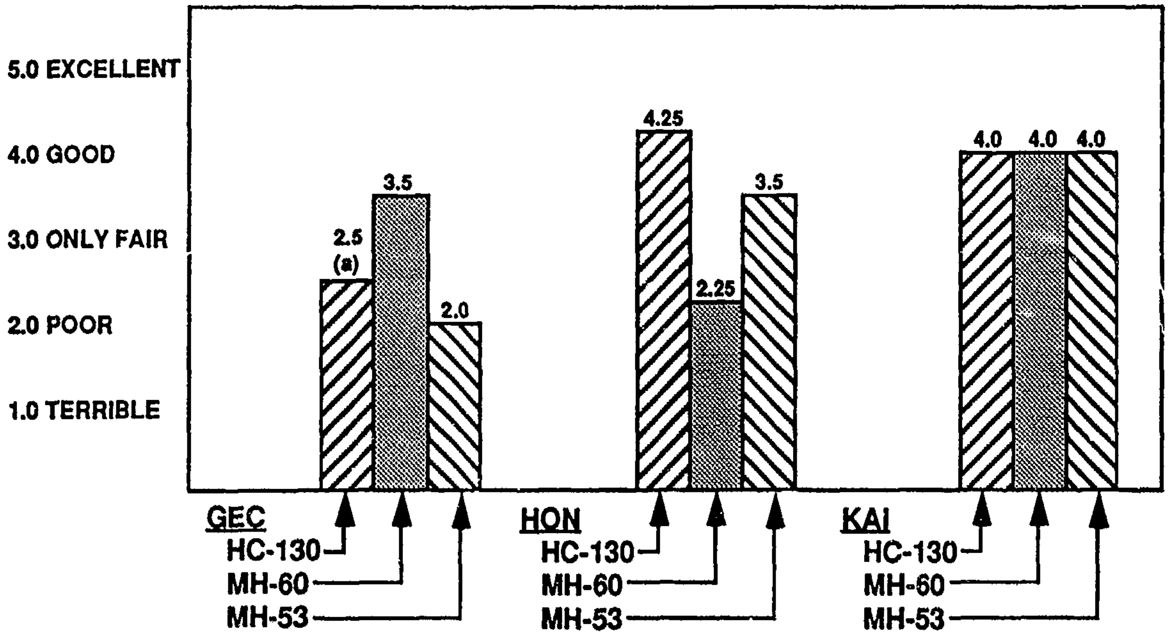
PILOT COMMENTS:

(a) Image rolls slightly with side to side movement of head - rotating head upward causes scene to move towards aircraft.

SUMMARY



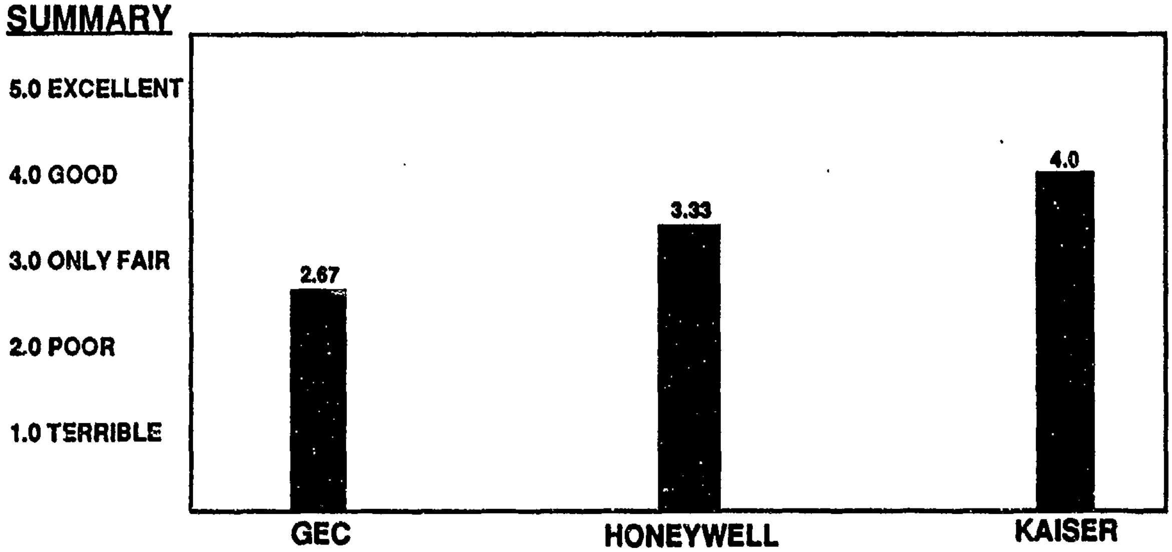
II.C.11 Evaluate the scene resolution through the combiners, without the visor (41b 1)



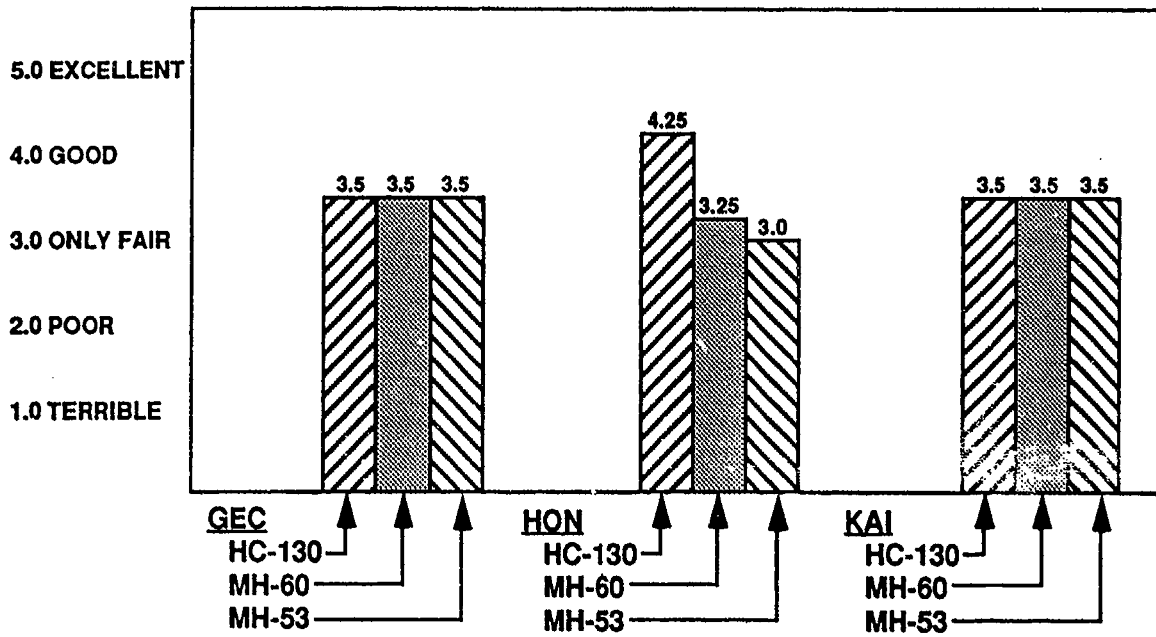
PILOT COMMENTS:

(a) Two thirds ANVIS-6, can see instruments with intensifiers off, but not on. Can't get sharp focus. Display too dim. Resolution poor past ten miles.

SUMMARY



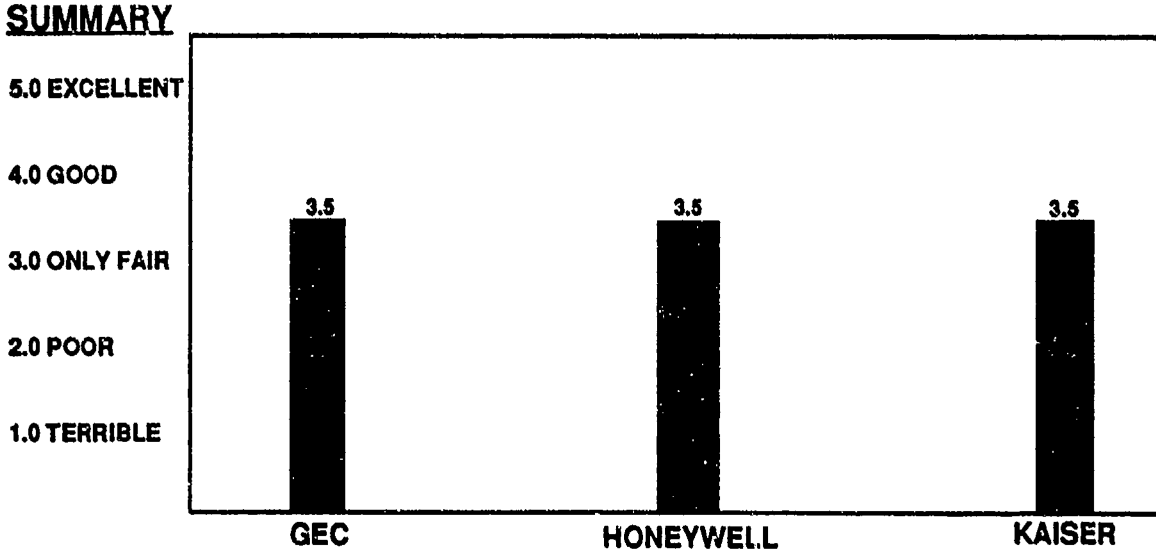
II.C.12 Evaluate the correlation between the outside scene and the intensified scene. (65)



PILOT COMMENTS:

NONE

SUMMARY



II.C.13 The scene registration appeared to be (larger than/same as/smaller than) the real world scene. (Select one). (72)

	GEC HC-130	GEC MH-60	GEC MH-53	HON HC-130	HON MH-60	HON MH-53	KAI HC-130	KAI MH-60	KAI MH-53
LARGER THAN	25% (a)	25%		25% (c)			50% (e)	25%	50%
SAME AS	50%	75%	50%	75%	75% (d)	100%	50%	75%	50%
SMALLER THAN	25%		50% (b)						

PILOT COMMENTS:

(a) Larger, about one half closer than ANVIS-6.
(b) Smaller, appeared to be higher than actual.
(c) Larger, like ANVIS-6.
(d) This category was not rated by some pilots.
(e) Larger, like ANVIS-6 about twice as close.

SUMMARY

	GEC	HONEYWELL	KAISER
LARGER THAN	17%		42%
SAME AS	58%	91% (d)	58%
SMALLER THAN	25%		

Appendix C
SMOTEC Final Report

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AIR FORCE SPECIAL OPERATIONS COMMAND

SPECIAL MISSIONS OPERATIONAL TEST & EVALUATION CENTER

HURLBURT FIELD, FLORIDA 32544-5000

OPERATIONAL FEASIBILITY TEST AND EVALUATION (OFT&E) OF THE INTERIM-NIGHT INTEGRATED GOGGLE AND HEAD TRACKING SYSTEM (I-NIGHTS)

MAC PROJECT 15-136-90

NOVEMBER 1991

FINAL REPORT

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MAC PROJECT 15-136-90

OPERATIONAL FEASIBILITY TEST AND EVALUATION (OFT&E) OF THE INTERIM-NIGHT INTEGRATED GOGGLE AND HEAD TRACKING SYSTEM (I-NIGHTS)

FINAL REPORT

NOV 91

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Approved by: MARVIN A. SCHOTT, Col, USAF
Commander

THIS FINAL REPORT IS APPROVED BY HQ MAC

SPECIAL MISSIONS OPERATIONAL TEST AND EVALUATION CENTER
AIR FORCE SPECIAL OPERATIONS COMMAND
HURLBURT FIELD, FLORIDA 32544-5000

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

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2. REPORT DATE
NOV 91

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FINAL REPORT OCT 90-APR 91

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OFT&E of the Interim-Night Integrated Goggle and Head Tracking System (I-NIGHTS)

5. FUNDING NUMBERS

6. AUTHOR(S)
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Gary J. Kopec, CMSgt, USAF

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
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Scott AFB IL 62225-5001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
MAC TEST 15-136-90

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

1. This OFT&E assessed the operational effectiveness and suitability of three I-NIGHTS helmet models in the special operations environment.

2. Critical Operational Issues for this OFT&E were:

a. Do any of the I-NIGHTS candidates exhibit sufficient operational effectiveness to justify further development?

b. Are the I-NIGHTS candidates operationally suitable?

c. What parameters are significant to defining operational requirements for an aircrew night vision imaging system (ANVIS) device?

14. SUBJECT TERMS

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89)

Block 13 (cont'd)

EXECUTIVE SUMMARY

1. The Special Missions Operational Test and Evaluation Center (SMOTEC) conducted an initial operational feasibility test and evaluation (OFT&E) of the I-NIGHTS at Hurlburt Field FL, Eglin AFB FL and Moffett Field CA from 11 Oct 90 to 22 Apr 91. The purpose of the OFT&E was to provide an assessment of the operational effectiveness and suitability of three I-NIGHTS helmet models on the MH-53J, the MH-60G, MC-130E and the HC-130P and provide information for generating operational requirements for a follow-on procurement program.

2. The I-NIGHTS is a modular ejection-capable custom helmet with third generation image intensification and binocular helmet-mounted display (BHMD) capabilities. I-NIGHTS is designed to provide acceptable optical performance for critical night, low-level mission requirements. The I-NIGHTS designs are based upon the need for a modular system. Other enhanced capabilities include an improved off-boresight cuing and designation capability and reduced crew fatigue. The system is capable of providing four different configurations: Helmet only, Helmet with night vision goggles (NVG), Helmet with BHMD, and Helmet with NVG/BHMD. I-NIGHTS will be used as an aid to pilot vision during night operations to enhance situational awareness, navigational performance, and to increase the probability of night visual target acquisition, thus improving mission effectiveness and survivability. The three I-NIGHTS models evaluated during the test were all of similar design but manufactured by three different contractors. Honeywell, Kaiser and GEC each provided an I-NIGHTS for evaluation.

3. Strategic Air Command (SAC) Statement of Operational Need (SON) 309-87, Aircrew Night Vision Imaging System (ANVIS), which Military Airlift Command (MAC) and the Air National Guard (ANG) co-sponsored, identified the need for a modular, ejection capable, custom helmet system with night vision goggles (NVGs) and binocular helmet-mounted displays (BHMDs). The I-NIGHTS program is a combined Air Force/Navy development program to develop a modular NVG/HMD-helmet with the Navy, the lead service. The Navy planned to select from the three systems involved and procure units for use in operational fighter aircraft, but has subsequently dropped out of the program. The Air Force is treating the effort as a feasibility demonstration/risk reduction program. The systems MAC/Air Force Special Operations Command (AFSOC) received for evaluation contained only NVGs, not HMDs.

4. This OFT&E was structured to address three critical operational issues (COI). The critical issues and associated findings are summarized below:

a. Do any of the I-NIGHTS candidates exhibit sufficient operational effectiveness to justify further development?

The I-NIGHTS did not exhibit sufficient effectiveness in the special operations environment to justify further development. None of the candidates provided capabilities comparable to the ANVIS-6 which is currently used as a night vision aid.

b. Are the I-NIGHTS candidates operationally suitable? None of the three I-NIGHTS helmets evaluated during this test were operationally suitable for the special operations mission.

c. What parameters are significant to defining operational requirements for an ANVIS device? Significant design parameters relevant to defining user requirements for future I-NIGHTS designs should include:

(1) an intensified image field of view greater than 40 degrees

(2) enhanced low light intensification

(3) enhanced noise attenuation

(4) a helmet mounted display

(5) stowable combiners

(6) eye glass compatibility

(7) an integral power supply

(8) an extensive, inflight adjustment capability

5. Major Conclusion. The I-NIGHTS negatively affected the aircrew's ability to perform inflight operations and is not suitable for use on special operations aircraft.

6. Substantiating documents and data for this report are available at SMOTEC, Hurlburt Field Fl 32544-5000, 6510 TW/DORN, Edwards AFB CA, and OL-AC HSD/YAH-HMST, Wright Patterson AFB OH 45433-6573.

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LIST OF TABLES

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LIST OF ABBREVIATIONS

AFOTEC	Air Force Operational Test and Evaluation Center
AFR	Air Force Regulation
ANVIS	air crew night vision imaging system
BHMD	binocular helmet mounted display
COI	critical operational issue
EC	evaluation criteria
FOV	field of view
HMD	helmet mounted display
IAW	in accordance with
I-NIGHTS	Interim-Night Integrated Goggle and Head Tracking System
LRU	line replaceable unit
LZ	landing zone
MOE	measure of effectiveness
MDT	mean down time
MRT	mean repair time
MTBCF	mean time between critical failure
NVG	night vision goggles
O&M	operations and maintenance
OFT&E	operational feasibility test and evaluation
OPR	office of primary responsibility
PA	public affairs
PMD	program management directive
QOT&E	qualification operational test and evaluation

LIST OF ABBREVIATIONS (cont'd)

QT&E	qualification test and evaluation
SE	support equipment
SMOTEC	Special Missions Operational Test and Evaluation Center
SOF	Special Operations Forces
SORD	system operational requirements document

SECTION I - PURPOSE AND BACKGROUND

1.0 OFT&E PURPOSE. This OFT&E assessed the operational effectiveness and suitability of three I-NIGHTS helmet models on the MH-53J, the MH-60G and the HC-130P and MC-130E. This document contains the results of the OFT&E and provides information for generating operational requirements for a follow-on procurement program.

1.1 AUTHORIZING DIRECTIVES. This test was completed under the authority of Air Force Regulation (AFR) 80-14, AFR 55-43, Military Command Regulation (MACR) 55-80, Military Airlift Command (MAC) Test Order 15-136-90, and MAC Test Plan 15-136-90.

1.2 OFT&E BACKGROUND. Strategic Air Command (SAC) Statement of Operational Need (SON) 309-87, Aircrew Night Vision System (ANVS), which Military Airlift Command (MAC) and the Air National Guard (ANG) co-sponsored, identified the need for a modular, ejection capable, custom helmet system with night vision goggles (NVGs) and binocular helmet-mounted displays (HMDs). The I-NIGHTS Program is a combined Air Force/Navy development program to develop a modular NVG/HMD-helmet with the Navy the lead service. The Navy planned to select from the three systems involved and procure units for use in operational fighter aircraft but has subsequently dropped out of the program. The Air Force is treating the effort as a feasibility demonstration/risk reduction program. The systems that MAC/Air Force Special Operations Command (AFSOC) received for evaluation contained only NVGs, not HMDs.

1.3 DESCRIPTION OF SYSTEM TESTED. The I-NIGHTS is a modular ejection-capable custom helmet with third generation image intensification and binocular helmet-mounted display (BHMD) capabilities. I-NIGHTS is designed to provide acceptable optical performance for critical night, low-level mission requirements. The I-NIGHTS designs are based upon the need for a modular system. Other enhanced capabilities include an improved off-boresight cuing and designation capability and reduced crew fatigue. The system is capable of providing four different configurations: Helmet only, Helmet with night vision goggles (NVG), Helmet with HMD, and Helmet with NVG/HMD. I-NIGHTS will be used as an aid to pilot vision during night operations to enhance situational awareness, navigational performance, and to increase the probability of night visual target acquisition, thus improving mission effectiveness and survivability. The three I-NIGHTS models evaluated during the test were all of similar design but manufactured by three different contractors. Honeywell, Kaiser and GEC each provided a I-NIGHTS for evaluation.

1.4 TEST FORCE, LOCATION, DATES. SMOTEC directed and participated in the test. The 20 and 8 SOS from Hurlburt Field FL, the 55 SOS from Eglin AFB FL, and the 129 ARS from Moffett Field CA supplied aircraft and aircrews for the evaluation. Additional support was provided by the AFTI/F-16 JTF of the 6510 TW Edwards AFB CA, and the Human Systems Division of Wright-Patterson AFB OH. Evaluation flights were flown from Hurlburt Field FL, Eglin AFB FL, and Moffett Field CA. The first test sortie was conducted on 11 Dec 90 with the last sortie flown on 22 Apr 91.

1.5 CLASSIFICATION STATEMENT. This test was unclassified and the documentation of this test contains no classified information.

SECTION II - OFT&E DESCRIPTION

2.0 CRITICAL OPERATIONAL ISSUES AND OBJECTIVES.

2.0.1 Critical Operational Issues.

2.0.1.1 COI-1. Do any of the I-NIGHTS candidates exhibit sufficient operational effectiveness to justify further development?

2.0.1.2 COI-2. Are the I-NIGHTS candidates operationally suitable?

2.0.1.3 COI-3. What parameters are significant to defining operational requirements for an ANVIS device?

2.0.2 Objectives.

2.0.2.1 Objective E-1. Assess the acceptability of performing inflight operations while wearing the I-NIGHTS.

2.0.2.2 Objective E-2. Assess the illumination and visibility capabilities of the I-NIGHTS units.

2.0.2.3 Objective E-3. Assess the peripheral vision capability of the I-NIGHTS units.

2.0.2.4 Objective E-4. Assess the impact of the exit pupil distance on the use of the I-NIGHTS units for special operations missions.

2.0.2.5 Objective E-5. Assess other design parameters on the operational effectiveness of the I-NIGHTS.

2.0.2.6 Objective E-6. Assess the I-NIGHTS for reducing fatigue as compared to current NVGs.

2.0.2.7 Objective E-7. Assess the I-NIGHTS human factor impacts on operational effectiveness.

2.0.2.8 Objective E-8. Assess inflight adjustability of each of the I-NIGHTS.

2.0.2.9 Objective S-9. Assess the reliability of each of the I-NIGHTS.

2.0.2.10 Objective S-10. Assess the maintainability of each of the I-NIGHTS in a two level maintenance environment with the organizational level being performed by aircrew life support.

2.0.2.11 Objective S-11. Assess the availability of each of the I-NIGHTS.

Table 2.1 COI/Objective Matrix

COI	OBJECTIVE
COI-1	E-1, E-2, E-3, E-5, E-6, E-7
COI-2	All Objectives
COI-3	E-5

2.1 SCOPE AND METHOD OF ACCOMPLISHMENT.

2.1.1 This OFT&E was conducted in the Eglin AFB FL, Hurlburt Field FL, and Moffett Field CA local flying areas. A total of 10 pilots participated in this test. The MH-53J, MH-60G, MC-130E and HC-130P aircraft were used for the evaluation. Table 2.2 contains flight hour distribution. Flying time was evenly distributed among each of the three I-NIGHTS models on each aircraft. Dedicated OFT&E flights were conducted under conditions that were as operationally realistic as possible and practical. Helicopter missions included low level navigation with altitudes down to 50 feet AGL, gunnery, terminal operations, formation and instrument procedures. Fixed wing missions included low level navigation with altitudes down to 500 feet AGL, airborne rendezvous with helicopters and air drop. Fixed wing landings were not accomplished with I-NIGHTS helmets.

2.1.2 Each pilot was tasked to fly each of the three helmets during one day mission and two night missions. After each flight, the evaluation pilots filled out an extensive questionnaire which collected specific data about the I-NIGHTS worn during that mission. After each pilot completed the entire evaluation, a comparison questionnaire was completed in which the three helmets were rank ordered in several categories. All questionnaires were forwarded to 6510 TW/DORN for data reduction. Reduced data was distributed to SMOTEC and Wright-Patterson.

Table 2.2 Flight Hour Distribution

ACFT	DAY SORTIES	NIGHT SORTIES	DAY HOURS	NIGHT HOURS
H-53	12	10	5.3	18.6
H-60	6	12	3.0	30.3
C-130	8	13	4.8	23.0
Total	26	35	13.1	71.9

2.2 PLANNING CONSIDERATIONS AND LIMITING FACTORS. Two MH-53J and two MC-130E pilots were unable to complete the test due to operation Desert Storm. They were replaced by two additional

MH-53J pilots and two HC-130P pilots. Time constraints allowed the second pair of MH-53J pilots to fly each helmet for only one day and one night sortie. Each of the contractors maintained the I-NIGHTS during the test. This limited the scope of the maintainability and availability assessment of the I-NIGHTS.

2.3 CONTRACTOR INVOLVEMENT. The three manufacturers, Honeywell, Kaiser, and GEC provided the I-NIGHTS for test, participated in helmet fitting, provided limited aircrew training, and maintained the systems during the test.

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SECTION III - OPERATIONAL EFFECTIVENESS AND SUITABILITY

3.0 SUMMARY. This evaluation provided an assessment of the operational effectiveness and suitability of the three I-NIGHTS helmet models in an operational environment on the MH-53J, the MH-60G, MC-130E and the HC-130P. The results will provide information for generating operational requirements for a follow-on procurement program.

3.0.1 None of the three I-NIGHTS helmets evaluated during this test were operationally acceptable for the special operations mission. A combination of a decreased field of view, degraded scene clarity and insufficient light intensification negatively affected pilot performance. To differing degrees, each I-NIGHTS helmet was difficult to adjust and was very uncomfortable. In addition, each system experienced at least one critical failure during the evaluation which degraded system reliability.

3.0.2 Pilot performance was significantly degraded while wearing the I-NIGHTS due to a decreased field of view, insufficient light intensification, and image distortion. Test participants indicated that none of the I-NIGHTS models provided the same night vision capability as the ANVIS-6 NVGs.

3.0.3 The I-NIGHTS was designed to meet the requirements for use in a high performance fighter aircraft. Those I-NIGHTS features which were designed to make the helmets ejection seat safe and prevent helmet slippage during high "G" maneuvers were of no use to the helicopter or C-130 pilot. The helmet design sacrificed comfort to meet these requirements. Test participants indicated that the I-NIGHTS was very uncomfortable and developed distracting hot spots within one hour of wear. In addition, all of the evaluation pilots complained that helmet discomfort led to increased fatigue. The I-NIGHTS design also sacrificed noise attenuation to keep total weight to a minimum. SOF aircraft are extremely noisy, requiring the need for enhanced noise attenuation. To prevent interference with riser deployment during ejection, the helmet had very smooth lines with limited adjustment available to the pilot inflight. The I-NIGHTS did not provide an adequate inflight adjustment capability. Test participants identified the need for a wider range of optic system adjustments which can be easily accessed in flight. These adjustments require relatively large knobs which would negate ejection seat certification. One design will not fulfill both requirements.

3.0.4 The next generation SOF helmet needs a wider, intensified field of view (greater than 40 degrees), stowable combiners, eye glass compatibility, an integral power supply, extensive inflight adjustment capability, and enhanced noise attenuation. Integration of the helmet mounted display with the 1553 data bus is also desirable. The I-NIGHTS Program does not show any promise of fulfilling these needs any time in the near future.

3.1 OBJECTIVE E-1. Assess the acceptability of performing inflight operations while wearing the I-NIGHTS.

3.1.1 Method. The pilot's ability to perform normal inflight operations while wearing I-NIGHTS was assessed during each test sortie. Mission profiles were representative of realistic tactical sorties. Operations included departure, enroute, formation, low-level, gunnery and terminal operations. Aircrews provided comments and identified problem areas.

3.1.2 Results.

3.1.2.1 All test participants indicated that the I-NIGHTS negatively affected their ability to perform inflight operations. A combination of a decreased field of view, degraded scene clarity and insufficient light intensification, prevented pilots from performing tasks using I-NIGHTS as well as they could while using the ANVIS-6. In some cases, pilots on I-NIGHTS could not accomplish tasks that they could accomplish using ANVIS-6. For example, a MH-53J pilot aborted several attempts at landing in a remote landing zone (LZ) while wearing I-NIGHTS but successfully completed the landing, in the same LZ on the first attempt, after switching to ANVIS-6. The impact I-NIGHTS had on pilot performance varied between pilots and between the three different I-NIGHTS models. However, I-NIGHTS consistently degraded pilot performance and negatively affected the ability of aircrews to perform inflight operations when compared to the ANVIS-6.

3.1.2.2 Several crew members complained of image distortion in which the intensified scene was not exactly aligned with reality. This distortion presented a skewed image which made cross checks both inside and outside of the cockpit difficult. The combiners also blocked some of the instrument panel from view. Refraction and reflection of sunlight inside the combiners was also identified as a problem.

3.1.3 Conclusions.

3.1.3.1 The limited I-NIGHTS intensified field of view negatively affected the aircrew's ability to perform inflight operations.

3.1.3.2 The low light level intensification capability of I-NIGHTS is not adequate to perform inflight operations in the special missions operational environment.

3.1.3.3 The image distortion created by the I-NIGHTS combiners negatively impacted the aircrew's ability to perform inflight operations.

3.1.4 Recommendations.

3.1.4.1 Recommend future I-NIGHTS designs provide, as a minimum, the same low light level intensification capability as the ANVIS-6 prior to operational use.

3.1.4.2 Recommend future I-NIGHTS designs provide an intensified field of view greater than 40 degrees to adequately perform special operations missions.

3.1.4.3 Recommend future I-NIGHTS designs reduce the image distortion created by the combiners.

3.2 OBJECTIVE E-2. Assess the illumination and visibility capabilities of the I-NIGHTS units.

3.2.1 Method. The illumination and visibility capabilities of the I-NIGHTS were assessed in a realistic operational environment. Available light levels varied between essentially zero to nearly 100% effective moon illumination.

3.2.2 Results. The three I-NIGHTS assessed during this test displayed varying degrees of illumination and visibility. However, none of the I-NIGHTS provided the same level of illumination and visibility as the ANVIS-6. Under conditions of medium to high light levels, the I-NIGHTS provided sufficient cues to perform most tasks. Under conditions of low light availability, many tasks could not be accomplished using I-NIGHTS when the same task could still be accomplished by an ANVIS-6 equipped pilot. The I-NIGHTS visual detection range for ground and airborne targets was consistently less than that of the ANVIS-6.

3.2.3 Conclusions. The I-NIGHTS did not provide adequate illumination and visibility levels to effectively perform the special operations mission.

3.2.4 Recommendations. Recommend future I-NIGHTS designs incorporate at least the same low light illumination and visibility levels as provided by the ANVIS-6.

3.3 OBJECTIVE E-3. Assess the peripheral vision capability of the I-NIGHTS units.

3.3.1 Method. The peripheral vision capability of the I-NIGHTS was evaluated during all missions. Aircrews provided comments assessing the adequacy of the peripheral vision provided by I-NIGHTS.

3.3.2 Results. All three of the I-NIGHTS models displayed only minor obstructions to peripheral vision. The Kaiser system presented the least amount of obstruction to peripheral vision. Two systems (Honeywell and Kaiser) had provisions to stow the optics when not in use. The GEC combiners did not stow and presented the most obstruction to peripheral vision. All systems did however, display less obstruction to peripheral vision than the ANVIS-6.

3.3.3 Conclusions. The adequacy of the peripheral vision provided by each of the I-NIGHTS is satisfactory for performing special operations missions.

3.3.4 Recommendations. Recommend future I-NIGHTS designs specify stowable combiners to reduce the obstruction to peripheral vision during daylight operations.

3.4 OBJECTIVE E-4. Assess the impact of the exit pupil distance on the use of the I-NIGHTS units for special operations missions.

3.4.1 Method. The operational impact of the I-NIGHTS exit pupil distance was evaluated during all missions. After each sortie, crew members completed a data collection questionnaire assessing the impact of the exit pupil distance on mission accomplishment.

3.4.2 Results. Several crew members indicated that the combiners of all three of the I-NIGHTS systems were located too close to the eyes for comfortable viewing. Pilots could not comfortably use any of the systems while wearing glasses. One crew member indicated that it was impossible to wear glasses with the combiners down.

3.4.3 Conclusions. The I-NIGHTS combiners were too close to the eyes for comfort and precluded wearing spectacles.

3.4.4 Recommendations. Recommend the combiners of future I-NIGHTS designs be located far enough from the eyes to allow wearing glasses.

3.5 OBJECTIVE E-5. Assess other design parameters on the operational effectiveness of the I-NIGHTS.

3.5.1 Method. After each test sortie, crew members were asked to provide additional significant design parameters relevant to defining user requirements for future I-NIGHTS designs.

3.5.2 Results.

3.5.2.1 The Kaiser and Honeywell systems were powered by battery packs which were attached to the pilot's flight suit by velcro. Most crew members found this configuration unacceptable and the possibility of the battery pack wiring getting caught on something existed. The on/off switches were also difficult to find and the packs were cumbersome. The GEC system was powered by batteries which were integral to the helmet but could still be changed in flight. This configuration was most acceptable. The on/off switch was easily accessible.

3.5.2.2 Several crew members indicated that some type of noise reduction capability should be incorporated in the I-NIGHTS helmet design to preclude another generation of hearing impaired helicopter and C-130 pilots.

3.5.2.3 Making the helmet mounted display compatible with SOF aircraft was also identified as a desirable enhancement to the I-NIGHTS design.

3.5.3 Conclusions.

3.5.3.1 Separate I-NIGHTS battery packs are not suitable in an operational environment.

3.5.3.2 The I-NIGHTS did not provide sufficient noise reduction capability.

3.5.3.3 Integrating the helmet mounted display with SOF aircraft would enhance operational effectiveness.

3.5.4 Recommendations.

3.5.5.1 Recommend that future helmet designs include an easily accessed on/off switch.

3.5.5.2 Recommend that future helmet designs be powered by integral batteries that can be changed inflight or by aircraft power.

3.5.5.3 Recommend that future helmet designs include an enhanced noise reduction capability.

3.5.5.4 Recommend the helmet mounted display of future I-NIGHTS designs be integrated into SOF aircraft.

3.6 OBJECTIVE E-6. Assess the I-NIGHTS for reducing fatigue as compared to current NVGs.

3.6.1 Method. The I-NIGHTS was assessed for the ability to reduce aircrew fatigue during long duration missions. Aircrews were asked to compare the capability of I-NIGHTS to reduce fatigue as compared to the ANVIS-6 NVGs.

3.6.2 Results.

3.6.2.1 The intensified field of view (FOV) of the three I-NIGHTS was between 30 and 35 degrees. The FOV of the ANVIS-6 is approximately 40 degrees. The decreased I-NIGHTS FOV caused pilots to increase head movement, especially during labor intensive tasks, which led to higher levels of fatigue and lower levels of performance.

3.6.2.2 SOF aircraft do not perform high "G" maneuvers; therefore, "G" induced fatigue was not a factor on SOF aircraft. Although judged to be heavier than a standard NVG configuration, none of the evaluation pilots reported any weight induced fatigue. No center of gravity induced fatigue was reported. Although the average sortie length for this evaluation was under two hours, all of the evaluation pilots complained that helmet discomfort led to increased fatigue. All of the crew members indicated that the I-NIGHTS did not reduce fatigue as compared to current NVGs.

3.6.3 Conclusions.

3.6.3.1 The limited intensified field of view of the I-NIGHTS is not adequate to perform the special operations missions and increases pilot fatigue.

3.6.3.2 I-NIGHTS helmet induced discomfort increased aircrew fatigue as compared to the current NVGs.

3.6.4 Recommendations.

3.6.4.1 Recommend that future helmet designs provide a field of view in excess of 40 degrees to reduce pilot fatigue.

3.6.4.2 Recommend helmet comfort be emphasized on future helmet designs to reduce aircrew fatigue.

3.7 OBJECTIVE E-7. Assess the I-NIGHTS human factor impacts on operational effectiveness.

3.7.1 Method. This objective assessed the human factors associated with the use of I-NIGHTS in the operational environment. After each sortie, crew members completed a data collection questionnaire and provided comments on human factor impacts while using each of the three I-NIGHTS.

3.7.2 Results. Crew members indicated that all three I-NIGHTS models were uncomfortable. The Kaiser helmet was the most uncomfortable and developed distracting hot spots in as little as ten minutes. The GEC helmet was the most comfortable of the three designs, but was still not as comfortable as a properly fitted SPH-4 or HGU-55 and was not suitable for long missions. In all cases, the severity of the hot spots was sufficient to degrade mission performance.

3.7.3 Conclusions. The I-NIGHTS was very uncomfortable and developed distracting hot spots within one hour of wear.

3.7.4 Recommendations. Recommend increased emphasis on aircrew comfort and eliminating helmet induced hot spots in future helmet designs.

3.8 OBJECTIVE E-8. Assess the inflight adjustability of each of the I-NIGHTS.

3.8.1 Method. Inflight adjustability was evaluated during all missions. This objective assessed the ability of the pilot to adjust/readjust each I-NIGHTS helmet inflight. After each sortie, crew members completed a data collection questionnaire providing comments on the adjustability of the I-NIGHTS.

3.8.2 Results. All crew members indicated that none of the I-NIGHTS provided sufficient inflight adjustability. The capability to make quick and easy inflight adjustment of focus, diopter, vertical position, interpupillary distance, exit pupil, and tilt is required. Several of these adjustments were incorporated in each of the I-NIGHTS models, but none provided the inflight adjustment capability of the ANVIS-6. Of those adjustments that were available, some required the use of a screwdriver or allen wrench, while others could only be performed with the helmet off.

3.8.3 Conclusions. The I-NIGHTS did not provide the inflight adjustment capability required by special operations aircrews.

3.8.4 Recommendations. Recommend that future helmet designs provide the capability to make focus, diopter, vertical position, interpupillary distance, exit pupil, and tilt adjustments quickly and easily inflight.

3.9 OBJECTIVE S-9. Assess the reliability of each of the I-NIGHTS.

3.9.1 Method. A limited assessment of I-NIGHTS reliability was conducted during the entire test period. System failures and operating time were documented throughout the duration of the test and used to calculate a mean time between failure.

3.9.2 Results. All three of the I-NIGHTS models experienced at least one failure during the evaluation which degraded the reliability of the systems. Based on the number of hours flown and the number of failures experienced, the mean time between failure rate of the I-NIGHTS was less than 30 hours. A mean time between failure rate of less than 30 hours is not adequate to effectively perform the special operations mission.

3.9.3 Conclusions. The reliability of the I-NIGHTS will negatively affect system effectiveness in the special operations environment.

3.9.4 Recommendations. Recommend additional emphasis be placed on system reliability of future I-NIGHTS designs.

3.10 OBJECTIVE S-10. Assess the maintainability of each of the I-NIGHTS in a two level maintenance environment with the organizational level being performed by aircrew life support.

3.10.1 Method. A limited assessment of I-NIGHTS maintainability was conducted during the entire test period. The contractor performed all required maintenance on each of the I-NIGHTS during the test which limited the scope of the evaluation of this objective.

3.10.2 Results. During the course of the test, each of the I-NIGHTS experienced at least one failure which required contractor expertise to correct. Based on observations made during the test and the subjective comments made by maintenance personnel, there were no factors identified that would prevent Air Force 3- and 5-skill level maintenance personnel from maintaining the I-NIGHTS after being provided adequate technical data and training.

3.10.3 Conclusions. No factors were identified that would adversely impact the maintainability of the I-NIGHTS.

3.10.4 Recommendations. None.

3.11 OBJECTIVE S-11. Assess the availability of each of the I-NIGHTS.

3.11.1 Method. The availability of each of the three I-NIGHTS was monitored during the test. Factors that affected I-NIGHTS availability were documented.

3.11.2 Results. Three test sorties were canceled during the test due to the non-availability of the I-NIGHTS. However, the availability of the I-NIGHTS was dependent on contractor availability and a limited number of spare parts. The I-NIGHTS were maintained by the contractor throughout the duration of the test. The contractor was not, however, on-scene during the entire test period to provide immediate maintenance support. Therefore, if a malfunction occurred, that particular helmet remained in a non-serviceable status until contractor support could be obtained. This situation negatively impacted system availability and prevented an accurate assessment of I-NIGHTS availability.

3.11.3 Conclusions. The operational availability of the I-NIGHTS could not be accurately determined during this assessment.

3.11.4 Recommendations. None.

SECTION IV - SERVICE REPORTS

4.0 SERVICE REPORTS. No service reports were submitted during this assessment.

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SECTION V - SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

5.0 GENERAL.

5.0.1 None of the three I-NIGHTS helmets evaluated during this test were operationally acceptable for the special operations mission. A combination of a decreased field of view, degraded scene clarity and insufficient light intensification negatively affected pilot performance. To differing degrees, each I-NIGHTS helmet was difficult to adjust and was very uncomfortable. In addition, each system experienced at least one critical failure during the evaluation which degraded system reliability.

5.0.2 The I-NIGHTS negatively affected the aircrew's ability to perform inflight operations and is not suitable for use on special operations aircraft.

5.1 CONCLUSIONS.

5.1.1 The limited I-NIGHTS intensified field of view negatively affected the aircrew's ability to perform inflight operations.

5.1.2 The low light level intensification capability of I-NIGHTS is not adequate to perform inflight operations in the special missions operational environment.

5.1.3 The image distortion created by the I-NIGHTS combiners negatively impacted the aircrew's ability to perform inflight operations.

5.1.4 The I-NIGHTS did not provide adequate illumination and visibility levels to effectively perform the special operations mission.

5.1.5 The adequacy of the peripheral vision provided by each of the I-NIGHTS is satisfactory for performing special operations missions.

5.1.6 The I-NIGHTS combiners were too close to the eyes for comfort and precluded wearing spectacles.

5.1.7 Separate I-NIGHTS battery packs are not suitable in an operational environment.

5.1.8 The I-NIGHTS did not provide sufficient noise reduction capability.

5.1.9 Integrating the helmet mounted display with SOF aircraft would enhance operational effectiveness.

5.1.10 The limited intensified field of view of the I-NIGHTS is not adequate to perform the special operations missions and increases pilot fatigue.

5.1.11 I-NIGHTS helmet induced discomfort increased aircrew fatigue as compared to the current NVGs.

5.1.12 The I-NIGHTS was very uncomfortable and developed distracting hot spots within one hour of wear.

5.1.13 The I-NIGHTS did not provide the inflight adjustment capability required by special operations aircrews.

5.1.14 The reliability of the I-NIGHTS will negatively affect system effectiveness in the special operations environment.

5.1.15 No factors were identified that would adversely impact the maintainability of the I-NIGHTS.

5.1.16 The operational availability of the I-NIGHTS could not be accurately determined during this assessment.

5.2 RECOMMENDATIONS.

5.2.1 Recommend future I-NIGHTS designs provide, as a minimum, the same low light level intensification capability as the ANVIS-6 prior to operational use.

5.2.2 Recommend future I-NIGHTS designs provide an intensified field of view greater than 40 degrees to adequately perform special operations missions.

5.2.3 Recommend future I-NIGHTS designs reduce the image distortion created by the combiners.

5.2.4 Recommend future I-NIGHTS designs incorporate at least the same low light illumination and visibility levels as provided by the ANVIS-6.

5.2.5 Recommend future I-NIGHTS designs specify stowable combiners to reduce the obstruction to peripheral vision during daylight operations.

5.2.6 Recommend the combiners of future I-NIGHTS designs be located far enough from the eyes to allow wearing glasses.

5.2.7 Recommend that future helmet designs include an easily accessed on/off switch.

5.2.8 Recommend that future helmet designs be powered by integral batteries that can be changed inflight or by aircraft power.

5.2.9 Recommend that future helmet designs include an enhanced noise reduction capability.

5.2.10 Recommend the helmet mounted display of future I-NIGHTS designs be integrated into SOF aircraft.

5.2.11 Recommend that future helmet designs provide a field of view in excess of 40 degrees to reduce pilot fatigue.

5.2.12 Recommend helmet comfort be emphasized on future helmet designs to reduce aircrew fatigue.

5.2.13 Recommend increased emphasis on aircrew comfort and eliminating helmet induced hot spots in future helmet designs.

5.2.14 Recommend that future helmet designs provide the capability to make focus, diopter, vertical position, interpupillary distance, exit pupil, and tilt adjustments quickly and easily inflight.

5.2.15 Recommend additional emphasis be placed on system reliability of future I-NIGHTS designs.

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Appendix D
SAC Final Report

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STRATEGIC AIR COMMAND

B-52 INTERIM NIGHT INTEGRATED GOGGLE AND HEAD

TRACKING SYSTEM EJECTION COMPATIBLE HELMET

EARLY OPERATIONAL ASSESSMENT FINAL REPORT

FEBURARY 1992

HEADQUARTERS
STRATEGIC AIR COMMAND
Offutt Air Force Base, Nebraska

SAC FORM JUL 85 442

SAC PROJECT

6814

B-52 INTERIM NIGHT INTEGRATED GOGGLE AND HEAD TRACKING SYSTEM EJECTION COMPATIBLE HELMET EARLY OPERATIONAL ASSESSMENT FINAL REPORT

FEBURARY 92

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13. ABSTRACT (*Maximum 200 words*)

The I-NIGHTS program was designed to provide a concept demonstration of an ejectable helmet with acceptable optical performance for night low-level mission requirements. The assessment results will provide HQ SAC early operational information supporting milestone II of SAC's acquisition decision for an aircrew night vision system. The three I-NIGHTS helmets flown in this assessment were independently developed and fabricated, each incorporating night vision enhancement capabilities using third generation image intensifier tubes. The assessment consisted of seven flights, one day mission and six night missions. The early operational assessment results showed the I-NIGHTS concept will not be operationally feasible until the resolution is increased, the focal capabilities are improved, the double imaging is resolved, the weight distribution is corrected, and the windscreen interference problem is corrected.

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EXECUTIVE SUMMARY

1. The 31st Test and Evaluation Squadron conducted the B-52 early operational assessment of three Interim Night Integrated Goggle and Head Tracking System (I-NIGHTS) Ejection Compatible Helmet designs at Ellsworth AFB, South Dakota, from 29 July to 14 August 1991. The I-NIGHTS program was designed to provide a concept demonstration of an ejection compatible helmet with acceptable optical performance for night low-level flight mission requirements. The assessment results will provide Headquarters Strategic Air Command (HQ SAC) early operational information supporting milestone II of SAC's acquisition decision for an aircrew night vision system.

2. The prime contractor for the I-NIGHTS program is McDonnell Aircraft Company who subcontracted to GEC Avionics, Honeywell, and Kaiser Electronics for the independent development and fabrication of three separate helmet designs. The I-NIGHTS helmet designs incorporate night vision enhancement capabilities using third-generation image intensifier tubes (I^2 tubes) and a helmet-mounted display (HMD). The intensified image and HMD is projected onto transparent combining surfaces superimposing these images with the real world scene, which is seen through the combiners. The I-NIGHTS helmet designs were built in two configurations: 1) Night vision goggle (NVG) helmet (I^2 tubes only). 2) HMD helmet (I^2 tubes and HMD). The configuration assessed was the NVG helmet. The HMD helmet was not assessed on the B-52 since the interface between the aircraft flight displays and the I-NIGHTS helmets has not been developed.

3. The I-NIGHTS early operational assessment was designed to address five critical operational issues (COIs). The COIs and a summary of the findings are listed below:

a. Are the vision characteristics adequate for B-52 pilots? In general, the performance of the I-NIGHTS helmets was rated inferior to the ANVIS-6 night vision goggles currently used in the B-52. The helmets need increased resolution and better focus capabilities to give the image greater contrast and to bring out detail in darker areas. The intensified image requires corrections to prevent double images which appear in the combiners when viewing outside light sources.

b. Is the helmet compatible with the aircrew? In general, the helmets weight distribution caused the helmets to slip forward on the head. The helmets need to have the center-of-gravity adjusted aft. Good nape straps appear to prevent some forward slippage of the helmet. The overall weight of the helmets during the short flight periods (30-60 minutes) did not affect pilot performance or cause fatigue.

c. Is the helmet compatible with the cockpit environment? The I-NIGHTS helmets were compatible with all aspects of the cockpit environment except for the windscreen. The location of the I^2 tubes (one on each side of the head) periodically allowed one tube to point out of the window while the other tube pointed into a window spar blanking one combiner.

d. Are there any maintainability concerns with the helmet? A maintenance concept needs to be developed to assure availability. Training will be required for life support technicians to accomplish organizational level maintenance. To prevent damage and enhance cleanliness a modified helmet container and protective covers for the optics will be required. Additional maintenance testing needs to be conducted on the operational system.

e. Are there any reliability concerns with the helmet? The I-NIGHTS intensifier tubes and combiners are fragile. Extra care will need to be executed while transporting and handling the helmets. Additional reliability testing needs to be conducted on the operational system.

4. 24 System Deficiency Reports were written during the assessment. Each system deficiency is summarized by helmet manufacturer in section IV.

5. The I-NIGHTS concept will not be operationally feasible until the resolution is increased, the focal capabilities are improved, the double imaging is resolved, the weight distribution is corrected, and the windscreen interference problem is corrected.

TABLE OF CONTENTS

SECTION IIIC - OPERATIONAL EFFECTIVENESS AND SUITABILITY FOR THE KAISER HELMET

LIST OF TABLES

LIST OF ABBREVIATIONS/ACRONYMS/SYMBOLS

ADPO	advanced development program office
AFB	air force base
ANG	air national guard
BMW	bombardment wing
COI	critical operational issue
D-Level	depot-level
DSN	defense switched network
EOA	early operational assessment
FAX	facsimile
FOUO	for official use only
G-forces	gravitational-forces
G-induced	gravity-induced
HMD	helmet mounted display
HMST	helmet mounted system technology
HQ	headquarters
HSD	human systems division
I-NIGHTS	interim-night integrated goggle and head tracking system
I^2 tubes	image intensifier tubes
MAC	Military Airlift Command
MOE	measure of effectiveness
NVG	night vision goggles
SAC	Strategic Air Command
SON	statement of need
SORD	system operational requirements document
SWW	strategic weapons wing
TAC	Tactical Air Command
TEMP	test and evaluation master plan
TES	test and evaluation squadron

SECTION I - PURPOSE AND BACKGROUND

1.0 ASSESSMENT PURPOSE. The 31st Test and Evaluation Squadron conducted the B-52 early operational assessment (EOA) of three Interim Night Integrated Goggle and Head Tracking System (I-NIGHTS) Ejection Compatible Helmet designs at Ellsworth AFB, South Dakota, from 29 July to 14 August 1991. The I-NIGHTS program was designed to provide a concept demonstration of an ejection compatible helmet with acceptable optical performance for night low-level flight mission requirements. The assessment results will provide Headquarters Strategic Air Command (HQ SAC) early operational information supporting milestone II of SAC's acquisition decision for an aircrew night vision system.

1.1 AUTHORIZING DIRECTIVES. HQ SAC/XRT tasked the 31 TES as the responsible test organization to perform this early operational assessment for the B-52 per message dated 021400Z APR 90.

1.2 ASSESSMENT BACKGROUND. A contract was awarded to McDonnell Aircraft Company in August 1989, who in turn subcontracted to Honeywell, Kaiser Electronics, and GEC Avionics for the development and fabrication of three independent helmet designs to meet both Air Force and Navy night vision requirements. The I-NIGHTS program was started to reduce ejection risk and to demonstrate a modular, ejection-capable custom helmet with image intensifier tubes (I^2 tubes) and a binocular Helmet-Mounted Display (HMD). The I-NIGHTS program is an advanced development/risk reduction approach to the SAC Statement of Need (SON) 309-087, co-sponsored by Military Airlift Command (MAC) and the Air National Guard (ANG). Other relevant program documentation includes the draft SAC System Operational Requirements Document (SORD) 309-87-I (Aircrew Night Vision System), Tactical Air Command (TAC) A-16 SORD 312-88-1-A (HMD requirements), and the I-NIGHTS Test and Evaluation Master Plan (TEMP).

1.3 DESCRIPTION OF SYSTEM TESTED.

a. The I-NIGHTS helmet designs incorporate night vision enhancement capabilities using third generation I^2 tubes and an HMD. The intensified image and HMD are projected onto transparent combining surfaces superimposing these images with the real world scene, also seen through the combiners. The aviator may view both the intensified image of the scene outside the cockpit and the aircraft controls and displays. The I-NIGHTS helmet designs were built in two configurations designated as follows: 1) Night vision goggles (NVG) helmet (I^2 tubes only). 2) HMD helmet (I^2 tubes and HMD). The configuration assessed was the NVG helmet. The HMD helmet was not assessed on the B-52 since interface between the B-52 flight displays and the I-NIGHTS helmet designs has not been developed. The impact/penetration protection of the I-NIGHTS helmet designs is designed to be equivalent or superior to the standard aircrew HGU-55/P helmet.

b. The I-NIGHTS helmet designs were created to achieve a proper fit on each pilot. The designs contain controls for adjusting the combiners so they may be placed directly in front of the pilot's eyes for optimum field of view. Focus adjustments, power switches, low battery indicators, and choice of day or night visors are incorporated into each design. The I-NIGHTS helmet designs assessed on the B-52 were battery operated. The battery pack contained two batteries, one main and one spare.

c. The I-NIGHTS helmet designs were designed to be compatible with current issue life support equipment, communications equipment, and oxygen systems. The system should allow physical and functional compatibility with corrective eyeglasses. I-NIGHTS is compatible with the existing night vision lighting. I-NIGHTS was designed to be electromagnetically compatible with the aircraft.

1.4 ASSESSMENT FORCE, LOCATION, DATES.

1.4.1 ASSESSMENT FORCE. Human Systems Division's Helmet Mounted System Technology Program Office (OL-AC HSD/YAH-HMST) at Wright-Patterson AFB, was designated as the Air Force Advanced Development Program Office (ADPO) for the I-NIGHTS program. Overall SAC program monitoring is the responsibility of HQ SAC/XRHV. SAC test management is the responsibility of HQ SAC/XRTR. The following is a list of the key assessment personnel:

1Lt Kent Trenkle	SAC Test Director	31 TES/ENY	DSN 527-2792
Maj Michael Oliverson	SAC Program Monitor	HQ SAC/XRHV	DSN 271-2266
Maj Jim Moudry	SAC Test Manager	HQ SAC/XRTR	DSN 271-6855
Capt Paul Moscarelli	Test Project Officer	99 SWW/SACTS	DSN 675-2860
MSgt Soderberg	Life Support Monitor	28 BMW/DOTL	DSN 675-1165
Scott Prescott	ADPO Program Manager	OL-AC HSD/YAH	DSN 785-2951
Jim Stiffler	On-Site Technical Expert	Ball Systems Inc	DSN 785-2951

1.4.2 ASSESSMENT LOCATION AND DATES. Flight test was conducted at Ellsworth AFB, SD from 29 July through 14 August 1991. The 99 Strategic Weapons Wing (SWW) provided the flight crews and scheduled the missions. The 28 Bombardment Wing (BMW) provided the life support technicians, aircraft, and aircraft maintenance. Ellsworth AFB was selected for flight test since the 99 SWW is currently conducting NVG tests for SAC.

1.5 CLASSIFICATION STATEMENT. The I-NIGHTS program is unclassified. HQ SAC/XRTR has determined there are no special security requirements for this test program. However, precautions normally taken to protect equipment and information were exercised (Ref. FAX letter HQ SAC/XRTR 24 Oct 90).

1.5.1 SOURCE SELECTION. Source selection was not involved in this assessment; however, all information gathered on each design is proprietary.

SECTION II - ASSESSMENT DESCRIPTION

2.0 CRITICAL OPERATIONAL ISSUES AND OBJECTIVES.

2.0.1 Critical Operational Issues. The following are the critical operational issues (COIs) this assessment addressed. The COIs were provided by HQ SAC/XRTR.

a. Are the vision characteristics adequate for B-52 pilots?

b. Is the helmet compatible with the aircrew?

c. Is the helmet compatible with the cockpit environment?

d. Are there any maintainability concerns with the helmet?

e. Are there any reliability concerns with the helmet?

2.0.2 Operational Effectiveness and Suitability Objectives.

a. Objective E-1. Assess the pilot's visibility and field-of-view during each phase of flight while wearing each helmet.

b. Objective E-2. Assess the comfort and fit of each helmet.

c. Objective E-3. Assess donning and doffing each helmet.

d. Objective E-4. Assess each helmet's compatibility and interoperability with the cockpit during each phase of flight.

e. Objective E-5. Assess the human factors aspects of each helmet's controls.

f. Objective E-6. Assess the operability of each helmet's controls.

g. Objective S-7. Assess the maintainability of each helmet.

h. Objective S-8. Assess the reliability of each helmet.

2.0.3 COI/Objective Matrix. Table 2.1 shows the relationship between the COIs and the objectives used to address them.

TABLE 2.1 CRITICAL OPERATIONAL ISSUES vs OBJECTIVES

		OBJECTIVES							
		1	2	3	4	5	6	7	8
	A.	X					X		
CRITICAL	B.		X	X		X	X		
OPERATIONAL	C.			X	X	X	X		
ISSUES	D.							X	
	E.								X

2.1 SCOPE AND METHOD OF ACCOMPLISHMENT.

2.1.1 Seven sorties were flown during the assessment. The first sortie was a day mission and the following six were night missions. The goal of the first sortie was to familiarize the pilots with the I-NIGHTS helmet designs. The goal for the following six sorties was to assess the three versions of the NVG helmet configuration. Missions for the I-NIGHTS assessment were normal B-52 training missions flown by the 99 SWW. Missions included taxi, takeoff, air refueling, low-level flight, and landing. There was no simulation during the assessment.

2.1.2 Two pilots were custom fitted for each of the three I-NIGHTS helmet designs. An alternate pilot was also fitted but was not needed. They received an introductory briefing from the test director and ground training from an ADPO representative on the I-NIGHTS helmets prior to their first sortie. Part of this ground training included wearing each of the helmets in the B-52 cockpit to check for visual and physical obstructions and a night familiarization session on the ground.

2.1.3 The two primary pilots each flew part of the day mission with each of the three helmet designs to familiarize themselves with the helmets prior to the night sorties. Each pilot flew with an I-NIGHTS helmet for half of the low-level portion of each night sortie (see table 2.1 below). One pilot wore an I-NIGHTS helmet while the other pilot wore his standard HGU-55/P. At no time during the assessment did both pilots wear I-NIGHTS helmets at the same time.

TABLE 2.2 I-NIGHTS Flight Schedule

Flight Number	Pilot	Helmet	Hours Worn
1 (Day)	Hannon	GEC	1.3
	Moscarelli	GEC	0.4
	Hannon	Honeywell	0.4
	Moscarelli	Honeywell	0.2
	Hannon	Kaiser	0.3
	Moscarelli	Kaiser	0.2
2 (Night)	Hannon	Kaiser	0.7
	Moscarelli	GEC	0.8
3 (Night)	Hannon	GEC	0.7
	Moscarelli	Kaiser	0.5
4 (Night)	Hannon	Honeywell	1.3
	Moscarelli	GEC	1.2
5 (Night)	Hannon	Kaiser	0.9
	Moscarelli	Honeywell	1.3
6 (Night)	Hannon	Honeywell	1.1
	Moscarelli	Kaiser	0.4
7 (Night)	Hannon	GEC	0.7
	Moscarelli	Honeywell	0.7

2.1.4 After each flight the pilots completed an Air Force I-NIGHTS Evaluation and noted any deficiencies or recommended any enhancements on the I-NIGHTS helmet designs. After the final flight, the participating aircrew members completed an Air Force I-NIGHTS Comparison Questionnaire. The test director collected and reviewed all questionnaires for clarity and completeness. The test director maintained the data from the questionnaires for the final report and forwarded a copy of the completed questionnaires to the 6510 Test Wing/DORN, Edwards AFB, CA 93523-5000. The 6510 Test Wing developed the questionnaires for all test agencies and with the support of the test director analyze the data. A copy of the analyzed data was forwarded to the ADPO.

2.2 PLANNING CONSIDERATIONS AND LIMITING FACTORS. No planning considerations or limiting factors adversely affected the early operational assessment.

2.3 CONTRACTOR INVOLVEMENT. There was no contractor involvement in the assessment.

SECTION IIIA

OPERATIONAL EFFECTIVENESS AND OPERATIONAL SUITABILITY FOR THE GEC HELMET

3A.0 **SUMMARY.** Both pilots rated the GEC helmet unsuitable for B-52 missions. The pilots had low confidence in their ability to fly the aircraft safely with the GEC helmet. They commented the night vision performance of the current ANVIS-6 night vision goggles was much better than the GEC helmet. The pilots said they would almost rather fly without the GEC helmet at night and just use the terrain trace inside the cockpit. The helmet had a slight forward center-of-gravity which led to some discomfort while wearing the helmet for more than an hour. The location of the I^2 tubes (one on each side of the head) periodically allowed one tube to point out of the window while the other tube pointed into a window spar blanking one combiner.

3A.1 **OBJECTIVE E-1.** Assess the pilot's visibility and field-of-view during each phase of flight while wearing each helmet.

3A.1.1 **Method.**

3A.1.1.1 Five sorties were flown to support the GEC helmet. One day sortie was flown to familiarize the pilots with the helmet in the cockpit. Touch and go landings and low-level flight were completed by both pilots while only one pilot completed air refueling. Four night sorties were flown and each pilot wore the GEC helmet for half of the low-level flight on two sorties. The helmet was worn for 1.7 hours during the day and 3.4 hours during the night for a total of 5.1 hours.

3A.1.1.2 After each flight the pilots completed an Air Force I-NIGHTS Evaluation noting deficiencies and recommending enhancements for the GEC helmet. After the final flight, the pilots completed an Air Force I-NIGHTS Comparison Questionnaire which will be used by the ADPO when they combine the data from all aircraft assessed. Personal observations and aircrew comments were collected by the test director who flew as an observer on all assessment sorties.

3A.1.1.3 Air Force I-NIGHTS Evaluation questions were rated using two five point scales or yes/no responses. The five point scale was broken down two ways. The first scale consisted of: 1)terrible 2)poor 3) fair 4)good 5)excellent, and the second scale consisted of 1)unacceptable 2)barely unacceptable 3)borderline 4)barely acceptable 5)acceptable.

3A.1.1.4 The test director collected and maintained the questionnaires. The data was analyzed by the test director with the support of the 6510 Test Wing. Data was analyzed by entering it into a database from which a distribution of responses to each question was calculated. These distributions were used to support individual measures of effectiveness (MOEs) which were used as guidelines to form the analysis in assessing the objective. Written comments were summarized and used to support the conclusions and recommendations.

3A.1.2 **Results and Conclusions.**

3A.1.2.1 MOE 1-1, adequacy of the pilot's field-of-view while wearing the NVG helmet (I^2 tubes off). The pilots commented the field-of-view looking through the combiners at night with the I^2 tubes off was very good and their responses were one good rating and two excellent ratings.

3A.1.2.2 MOE 1-2, adequacy of the pilot's field-of-view while wearing the NVG helmet (I^2 tubes on). The pilot's field-of-view looking through the combiners with the I^2 tubes on was rated slightly less than with the I^2 tubes off. Pilot responses showed three good ratings and one excellent rating. The pilots commented the location of the I^2 tubes (one on each side of the head) periodically allowed one tube to point out of the window while the other tube pointed into a window spar blanking one combiner.

3A.1.2.3 MOE 1-3, capability of the NVG helmet (I^2 tubes on) to increase the pilot's visibility at night. The GEC helmet did not greatly increase the pilot's visibility at night. Pilot comment's showed the intensified image was very poor, and always seemed out of focus. They commented the optics were borderline to unacceptable, and that the quality was inferior to the ANVIS-6 night vision goggles currently being used by B-52 pilots. Buildings were not visible with the GEC helmet, the pilots could make out farm fields which showed up as different shaded areas. The pilots had low confidence in their ability to fly the aircraft safely with the GEC helmet. A bridge, 1.6 miles away, was visible with the ANVIS-6 but not with the GEC helmet. Other aircraft lights were also visible with the ANVIS-6 but not with the GEC helmet. The information below shows the responses to questions about the pilot's visibility at night using the GEC helmet.

a. Ability to distinguish relative distances was rated terrible three times and poor once.

b. The light transmission through the combiners was rated poor once, good once, and excellent twice.

c. Scene resolution through the combiners with no visor was rated terrible all four times. The scene resolution though the combiners and the visor was rated terrible three times and poor once.

d. No distortions were experienced when looking though the combiners with the visor up or down.

e. Distortions appearing from the GEC helmet included: 1) Dark areas at the edge of the field-of-view were noted 50% of the time and were rated barely acceptable once and borderline once. 2) Flashing, flickering, or intermittent operation was noted once and was rated unacceptable. 3) Scintillation or salt and pepper/snow was noted in the intensified scene 50% of the time and was rated barely acceptable once and acceptable once.

f. Blooming of the intensified scene was noted 50% of the time and was caused by external light sources. No internal light sources bloomed the I^2 tubes.

g. The brightness of the intensified scene was rated terrible once, fair once, good once, and excellent once.

h. The brightness uniformity of the intensified scene was rated good three times and excellent once.

i. The correlation between the outside scene and the intensified scene was rated terrible once and poor three times.

j. Double imaging was reported 50% of the time from lights on the ground. The ground lights seen though the I^2 tubes and projected onto the combiners did not overlay the lights seen by the eye looking only through the combiners.

k. The scene registration appeared to be the same (not larger or smaller) as the real world 100% of the time.

l. The intensified scene appeared to be rotated properly 100% of the time.

3A.1.2.4 MOE 1-4, adequacy of the pilot's visibility inside the cockpit while wearing the NVG helmet (I^2 tubes on). Viewing of the instrument panels while looking through the combiners received four excellent ratings. No blind spots were experienced due to the combiners, mask, visor, or the helmet.

3A.1.3 Recommendations.

3A.1.3.1 The intensified image needs to be improved to provide more ground detail. The present configuration does not provide enough contrast and resolution to allow the pilots to fly at low-level altitudes with a high degree of confidence.

3A.1.3.2 The focus need to be improved to produce a clear sharp presentation in the combiners.

3A.1.3.3 The compatibility problem between the I^2 tubes and the windscreen spars needs to be addressed.

3A.2 OBJECTIVE E-2. Assess the comfort and fit of each helmet.

3A.2.1 Method. See section 3A.1.1.

3A.2.2 Results and Conclusions. Extended wear of the GEC helmet was rated barely acceptable three times and acceptable once. On one flight a pilot experienced pressure points (hot spots) on the front left area of the head after extended wear of the helmet, but neither pilot had any helmet temperature build-up. Eye strain, weight-induced fatigue, and fit of the GEC helmet are broken out in the data below.

3A.2.2.1 MOE 2-1, amount of eye strain caused by the NVG helmet (I^2 tubes on). The pilots experienced abnormal eye fatigue 50% of the time from the GEC helmet after about 10-15 minutes of wear. Pilots commented it was very difficult to use the goggles. No spatial disorientation was experienced by either pilot.

3A.2.2.2 MOE 2-2, amount of weight-induced fatigue caused by the helmet. The weight of the GEC helmet was rated barely acceptable once and acceptable three times. The center of gravity was rated barely acceptable twice and acceptable twice. Barely acceptable ratings were due to the forward center-of-gravity. One case of weight-induced fatigue, and one case of center-of-gravity-induced fatigue were reported after wearing the helmet for approximately one hour during low-level flight. The weight of the helmet would probably not be a problem if the center-of-gravity was adjusted over the center of the head. No G-induced fatigue was experienced by the pilots.

3A.2.2.3 MOE 2-3, ability of the helmet to achieve proper fit. The overall fit of the helmet liner was rated fair once and good three times. The results of the individual fit of the chin strap, earcups, mask, and combiners are explained below.

a. The fit of the chin strap received three good ratings and one excellent rating. The chin strap was rated good twice and excellent twice for adjustability. The fit of the nape strap was rated good three times and excellent once. The nape strap was rated good once and excellent three times for adjustability. One pilot commented the nape strap was excellent and mandatory for helping control the helmet from sliding forward on the head.

b. The seal of the earcups were rated good three times and excellent once. The comfort of the earcups received four good ratings, but one pilot commented the earcups got uncomfortable towards the end of the flight.

c. The fit of the mask without the visor was rated poor once, good twice, and excellent once. When the fit of the mask was assessed with the visor the rating were identical to those without the visor.

d. The overall position of the combiners in front of the eyes was rated unacceptable once, barely acceptable once and acceptable twice. The distance between the eyes and the combiners was rated barely acceptable twice and acceptable twice. One pilot commented the combiners could have been closer to his eyes. The distance between the eyes and the visor was rated acceptable all four times.

3A.2.2.4 MOE 2-4, ability of the helmet to maintain proper fit. One pilot had slippage occur while wearing the GEC helmet. The extent of the slippage was moderate and did not require abnormal head movement or in-flight adjustment to see through the combiners. The slippage was forward along the fore and aft axis. The pilot thought a better fit of the helmet liner would have prevented the slippage. The liner seemed to move inside the helmet. One pilot's mask slipped down his nose. The pilots responded the helmet did retain adequate fit to consistently maintain the scene through the combiners. Slippage caused by G-forces did not cause loss of the intensified scene.

3A.2.3 Recommendations.

3A.2.3.1 Investigate ways of reducing eye fatigue. Pilots reported possibly moving the combiners closer to the eyes like glasses would prevent eye fatigue.

3A.2.3.2 The center-of-gravity should be moved aft on the helmet to prevent center-of-gravity-induced fatigue.

3A.2.3.3 The helmet liner should be redesigned to provide a better fit and prevent it from moving inside the helmet shell.

3A.3 OBJECTIVE E-3. Assess donning and doffing each helmet.

3A.3.1 Method. See section 3A.1.1.

3A.3.2 Results and Conclusions.

3A.3.2.1 MOE 3-1, ease of donning the helmet. Both pilots reported no problems donning the GEC helmet inside or outside the cockpit. The ease of donning the GEC helmet inside the cockpit had one barely acceptable and three acceptable ratings.

3A.3.2.2 MOE 3-2, ease of doffing the helmet. Both pilots reported doffing the GEC helmet was easy and no problems were reported with doffing the helmet inside or outside the cockpit.

3A.3.3 Recommendations. None.

3A.4 OBJECTIVE E-4. Assess each helmet's compatibility and interoperability with the cockpit during each phase of flight.

3A.4.1 Method. See section 3A.1.1.

3A.4.2 Results and Conclusions.

3A.4.2.1 MOE 4-1, compatibility/interoperability of the helmet with the aircraft interphone. The pilots did not wear earplugs during the assessment. The ability of the pilots to clearly hear others was rated fair once and excellent three times. One pilot commented the interphone sounded far away. The ability of others to hear the pilots was rated excellent all four times. Cockpit noise attenuation was rated good twice and excellent twice.

3A.4.2.2 MOE 4-2, compatibility/interoperability of the helmet with the aircraft life support systems. The mask bayonet and bayonet receiver operated properly throughout the assessment. One pilot experienced slippage of the mask down on his nose due to the forward center-of-gravity of the helmet. No interference problems were reported between the combiners and the mask or the combiners and the visor.

3A.4.2.3 MOE 4-3, compatibility of the helmet's night vision equipment with cockpit lighting. Normal B-52 cockpit lighting was not compatible with the helmet. Only one flight was flown with modified cockpit lighting and the rest were flown using chemical light sticks. The GEC helmet was compatible with the modified cockpit and with the chemical light sticks. No reflections were reported in the visor, the combiners, or in the windscreen from the night vision lighting.

3A.4.2.4 MOE 4-4, compatibility/interoperability of the helmet with the cockpit environment. The pilots reported the GEC helmet would not interfere with emergency egress. The helmet did not interfere with any cockpit controls. The pilots did not experience any head movement restrictions. One pilot reported insufficient cockpit clearance after the first flight, but after the second flight both pilots reported there was sufficient cockpit clearance while wearing the GEC helmet.

3A.4.3 **Recommendations.** Helmet fit needs to be addressed to prevent the oxygen mask from slipping.

3A.5 **OBJECTIVE E-5.** Assess the human factors aspects of each helmet's controls.

3A.5.1 **Method.** See section 3A.1.1.

3A.5.2 **Results and Conclusions.** MOE 5-1, ease of operating the helmet's controls.

3A.5.2.1 No problems were encountered with the visor controls or in raising or lowering the visor.

3A.5.2.2 The location of the battery pack for the GEC helmet was rated acceptable all four times. Access of the batteries had one borderline rating, one barely acceptable rating, and two acceptable ratings.

3A.5.2.3 The GEC helmet only had inter-pupillary diameter (distance between eyes) and focus combiner adjustment controls. The accessibility of the inter-pupillary diameter controls was rated unacceptable twice, barely unacceptable once and borderline once. The inter-pupillary diameter controls have to be adjusted by another person while wearing the helmet. The accessibility of the focus controls was rated unacceptable once, barely acceptable once, and acceptable three times. The pilots commented they could see better out of the top of the combiners than through the middle and said vertical adjustments would allow them to adjust the combiners for optimum vision.

3A.5.2.4 One pilot commented having nonstowable combiners was not a factor with this helmet. The other pilot commented ideally the combiners should be stowable.

3A.5.2.5 The location of the I^2 tube power switch and the ease of operating the switch was rated barely acceptable once and acceptable twice.

3A.5.3 **Recommendations.**

3A.5.3.1 Access of the batteries while wearing the GEC helmet should be examined for possible improvements.

3A.5.3.2 The inter-pupillary diameter controls should be reengineered to be easily adjusted in-flight.

3A.5.3.3 A vertical adjustment capability should be added to the combiners.

3A.5.3.4 The combiners should be made stowable or even removable if it can be done without degrading the performance of the optics. If not, pilots commented they would rather have high performance and better night vision than stowable combiners

3A.6 OBJECTIVE E-6. Assess the operability of each helmet's controls.

3A.6.1 Method. See section 3A.1.1.

3A.6.2 Results and Conclusions. MOE 6-1, operability of the helmet's controls.

3A.6.2.1 The chin strap was rated good twice and excellent twice for adjustability. The nape strap was rated good once and excellent three times for adjustability.

3A.6.2.2 Operating the battery pack controls received all acceptable ratings. The batteries failed in flight once and no adequate warning was visible before battery failure. The pilot commented the intensified image gradually faded.

3A.6.2.3 The operation of the inter-pupillary diameter control was rated unacceptable once, borderline twice, and barely acceptable once. The pilots commented they needed the inter-pupillary diameter to be wider. Maintenance personnel also commented the range of movement for the optics was a problem and said an increase in the movement would assist in adjusting the optics. During one preflight adjustment the pilot was not even able to attain 20/100 in the left eye. The focus needs to have more capability and work in smaller increments. The pilots reported the intensified scene did not remain focused throughout the flight: it started out poor and degraded.

3A.6.3 Recommendations.

3A.6.3.1 The helmet needs to have a low battery indicator in view while he is looking through the combiners.

3A.6.3.2 The inter-pupillary diameter adjustment range needs to be increased to accommodate all possible flyers.

3A.6.3.3 The focus needs to be improved to sharpen the image. Also the focus should hold constant throughout the flight and not degrade over time.

3A.7 OBJECTIVE E-7. Assess the maintainability of each helmet.

3A.7.1 Method. Specific questions in the questionnaires and information from the logs provided data for each MOE. The test director kept a maintenance history log during the assessment. An I-NIGHTS Test Log Book, provided by the ADPO, accompanied each helmet and all maintenance actions, deficiencies, enhancements, and flight information was recorded in the logs. The test director maintained and analyzed the logs for the final report. The I-NIGHTS Test Log Books were returned to the ADPO with the helmets after the assessment. See section 3A.1.1.

3A.7.2 Results and Conclusions.

3A.7.2.1 MOE 7-1, maintainability of each helmet. The only maintenance performed during the assessment was cleaning. Maintenance personnel were concerned the GEC helmet does not use standard HGU-55/P helmet parts. A maintainability concept has not been developed. The life support technicians encouraged a maintainability concept where most of the maintenance is done in the life support shop with a minimal number of parts requiring D-level maintenance.

3A.7.2.2 MOE 7-2, adequacy of storage and handling methods for each helmet.

a. Storage. If a helmet of this type become operational: additional space would be required in life support shops, additional storage lockers would be required with secure locks due to the high cost of the helmet, additional funds for new parts to support the helmet, and personnel requirements would increase to maintain additional helmets.

b. Handling. During the assessment the helmets were transported to and from the aircraft in a modified helmet bag which was larger than the standard helmet bag and had a larger opening. A helmet of this type will not fit into the standard helmet bags. The GEC helmet is more fragile than the HGU-55/P helmet and requires careful handling when transporting to and from the aircraft. A padded helmet container would help prevent damage to the helmet. Protective covers for the optics would also prevent them from damage and help keep them free of dirt and finger prints during handling.

3A.7.3 Recommendations.

3A.7.3.1 Develop the maintainability concept for the operational system.

3A.7.3.2 Develop a helmet container to transport and protect the helmets.

3A.8 OBJECTIVE 8-8. Assess the reliability of each helmet.

3A.8.1 Method. See section 3A.7.1.

3A.8.2 Results and Conclusions. MOE 8-1, reliability of each helmet. The GEC helmet was worn in flight for 3.4 night hours and 1.7 day hours for a total of 5.1 hours. No failures occurred on the GEC helmet during the assessment. The helmet was rugged except for the intensifier tubes and combiners. Transporting and handling the helmet will require extra care.

3A.8.3 Recommendations. Additional reliability testing needs to be conducted on the operational system.

SECTION IIIB

OPERATIONAL EFFECTIVENESS AND OPERATIONAL SUITABILITY FOR THE HONEYWELL HELMET

3B.0 **SUMMARY.** Although inferior to ANVIS-6, the pilots felt the Honeywell helmet may be suitable for B-52 missions if the resolution was slightly improved. The field-of-view through the combiners with the intensifier tubes on needs to be slightly increased. Small amounts of slippage drastically reduces the field-of-view seen through the combiners. The glass combiners need to be optically corrected to prevent distortion when looking through the edge of the combiners. The location of the I^2 tubes (one on each side of the head) periodically allowed one tube to point out of the window while the other tube pointed into a window spar blanking one combiner. The bayonets and bayonet receivers need to be reengineered for ease of operation. The visor should be reshaped so it does not interfere with stowing or unstowing the combiners. The combiners need to have a greater range of adjustability to better fit individual pilots.

3B.1 **OBJECTIVE E-1.** Assess the pilot's visibility and field-of-view during each phase of flight while wearing each helmet.

3B.1.1 **Method.**

3B.1.1.1 Five sorties were flown to support the Honeywell helmet. One day sortie was flown to familiarize the pilots with the helmet in the cockpit. Touch and go landings and low-level flight were completed by both pilots while only one pilot completed air refueling. Four night sorties were flown and each pilot wore the Honeywell helmet for half of the low-level flight on two sorties. The helmet was worn for 0.6 hours during the day and 4.4 hours during the night for a total of 5.0 hours.

3B.1.1.2 After each flight the pilots completed an Air Force I-NIGHTS Evaluation noting deficiencies and recommending enhancements for the Honeywell helmet. After the final flight, the pilots completed an Air Force I-NIGHTS Comparison Questionnaire which will be used by the ADPO when they combine the data from all aircraft assessed. Personal observations and aircrew comments were collected by the test director who flew as an observer on all assessment sorties.

3B.1.1.3 Air Force I-NIGHTS Evaluation questions were rated using two five point scales or yes/no responses. The five point scale was broken down two ways. The first scale consisted of: 1)terrible 2)poor 3) fair 4)good 5)excellent, and the second scale consisted of 1)unacceptable 2)barely unacceptable 3)borderline 4)barely acceptable 5)acceptable.

3B.1.1.4 The test director collected and maintained the questionnaires. The data was analyzed by the test director with the support of the 6510 Test Wing. Data was analyzed by entering it into a database from which a distribution of responses to each question was calculated. These distributions were used to support individual measures of effectiveness (MOEs) which were used as guidelines to form the analysis in assessing the objective. Written comments were summarized and used to support the conclusions and recommendations.

3B.1.2 **Results and Conclusions.**

3B.1.2.1 MOE 1-1, adequacy of the pilot's field-of-view while wearing the NVG helmet (I^2 tubes off). The pilot's field-of-view looking through the combiners at night with the I^2 tubes off was very good. Pilot responses showed two good ratings and two excellent ratings.

3B.1.2.2 MOE 1-2, adequacy of the pilot's field-of-view while wearing the NVG helmet (I^2 tubes on). The pilots rated the field-of-view with the I^2 tubes on fair once, good once, and excellent twice. The pilots commented the field-of-view was somewhat limited and small amounts of slippage drastically reduces the field-of-view. The pilots commented the location of the I^2 tubes (one on each side of the head) periodically allowed one tube to point out of the window while the other tube pointed into a window spar blanking one combiner.

3B.1.2.3 MOE 1-3, capability of the NVG helmet (I^2 tubes on) to increase the pilot's visibility at night. Overall pilot comments showed the intensified image was inferior to ANVIS-6. The pilots could make out terrain and were able to see unlit objects on the ground two miles away but felt it was not quite good enough to do an actual low-level mission. Responses to questions about the pilot's visibility at night using the Honeywell helmet follow:

a. Ability to distinguish relative distances was rated good three times and excellent once.

b. The light transmission through the combiners was rated good twice and excellent twice.

c. Scene resolution through the combiners with and without the visor down was rated fair once and good three times.

d. Distortions were experienced when looking through the combiners on all four night missions with the visor both up and down. Pilot comments showed they experienced distortion at the edges of the combiners when viewing the flight instruments. They said it was not significant enough to prohibit flight but caused eye fatigue. They also commented the problem was worse with the visor down.

e. Scintillation (salt and pepper/snow) was visible in the intensified scene when flying during low-light conditions, but the pilots rated the distortion acceptable.

f. Some blooming of the intensified scene was reported due to lights on the ground.

g. The brightness of the intensified scene was rated good twice and excellent twice.

h. The brightness uniformity of the intensified scene was rated good twice and excellent twice.

i. The correlation between the outside scene and the intensified scene was rated fair once and good three times. This was due to outside lights not being co-located in the combiners with the intensified image.

j. Double imaging was reported from lights on the ground. Again the outside lights seen with the eye did not overlay the same lights projected onto the combiners from the image intensifier tubes.

k. The scene registration appeared to be the same (not larger or smaller) as the real world 100% of the time.

l. The intensified scene appeared to be rotated properly 100% of the time.

3B.1.2.4 MOE 1-4, adequacy of the pilot's visibility inside the cockpit while wearing the NVG helmet (I^2 tubes on). Viewing the instrument panels while looking through the combiners received three good ratings and one excellent rating. The pilots commented there was some distortion when looking through the edges of the combiners. No blind spots were experienced due to the combiners, mask, visor, or the helmet.

3B.1.3 Recommendations.

3B.1.3.1 The field-of-view through the combiners with the I^2 on needs to be slightly increased.

3B.1.3.2 The field-of-view through the combiners should be adjusted so slippage does not drastically reduce the field-of-view.

3B.1.3.3 The compatibility problem between the I^2 tubes and the windscreen spars needs to be addressed.

3B.1.3.4 The intensified image needs to be improved to produce an image with better resolution.

3B.1.3.5 The glass combiners need to be optically corrected to prevent distortion when looking through the edge of the combiners.

3B.2 OBJECTIVE E-2. Assess the comfort and fit of each helmet.

3B.2.1 Method. See section 3B.1.1.

3B.2.2 Results and Conclusions. Extended wear of the Honeywell helmet was rated borderline once, barely acceptable once, and acceptable twice. One pilot mentioned the top of the earcups pressed in on the head and there was a pressure point in the back of the helmet. Pressure points (hot spots) were experienced 50% of the time, one on the bridge of the nose from the mask and another on the lower back portion of the liner. No temperature build-up was experienced.

3B.2.2.1 MOE 2-1, amount of eye strain caused by the NVG helmet (I^2 tubes on). Abnormal eye fatigue was experienced 50% of the time and the pilots commented it occurred after wearing the helmet for about an hour. No spatial disorientation was experienced.

3B.2.2.2 MOE 2-2, amount of weight-induced fatigue caused by the helmet. The weight and the center-of-gravity of the Honeywell helmet was rated acceptable all four times. No weight-induced fatigue, center-of-gravity-induced fatigue, or gravity-induced fatigue was experienced.

3B.2.2.3 MOE 2-3, ability of the helmet to achieve proper fit. The overall fit of the helmet liner was rated fair once, good twice, and excellent once. The results of the individual fit of the chin strap, nape strap, earcups, mask, and combiner are explained in a thou d.

a. The fit of the chin strap received three good ratings and one excellent rating. The nape strap was rated fair once, good twice, and excellent once. The chin strap was rated good twice and excellent twice for adjustability. The nape strap was rated good all four times for adjustability.

b. The seal of the earcup was rated good three times and excellent once. The comfort of the earcup was rated poor once and good three times. One pilot commented the earcup had "very little room for ears".

c. The fit of the mask with and without the visor down was rated poor once, fair once, good once, and excellent once. The mask was pushing down on the top of one pilot's nose.

d. The overall position of the combiners in front of the eyes was rated borderline once and acceptable three times. The pilots commented a small amount of movement caused a large loss in the field-of-view. The distance between the eyes and the combiners was rated acceptable all four times. The distance between the eyes and the visor was also rated acceptable all four times.

3B.2.2.4 MOE 2-4, ability of the helmet to maintain proper fit. No excess slippage of the helmet or the mask was reported by either pilot. G-forces did not cause loss of the intensified scene.

3B.2.3 Recommendations.

3B.2.3.1 The earcups need to be available in different sizes to fit all pilots ears.

3B.2.3.2 The fit of the mask should be adjusted to prevent it from pushing down on the top of the nose.

3B.3 OBJECTIVE E-3. Assess donning and doffing each helmet.

3B.3.1 Method. See section 3B.1.1.

3B.3.2 Results and Conclusions.

3B.3.2.1 MOE 3-1, ease of donning the helmet. One pilot on one flight rated donning the helmet borderline. The pilot commented it was a very tight fit.

The pilots rated donning the helmet in the cockpit acceptable all four times.

3B.3.2.2 MOE 3-2, ease of doffing the helmet. One pilot on one flight rated doffing the helmet borderline. On the other flights doffing the helmet was rated acceptable.

3B.3.3 **Recommendations.** Provide helmets in different sizes so each pilot is fitted with a helmet of the proper size.

3B.4 **OBJECTIVE E-4.** Assess each helmet's compatibility and interoperability with the cockpit during each phase of flight.

3B.4.1 **Method.** See section 3B.1.1.

3B.4.2 **Results and Conclusions.**

3B.4.2.1 MOE 4-1, compatibility/interoperability of the helmet with the aircraft interphone. The pilots did not wear earplugs during the assessment. The ability of the pilots to clearly hear others was rated good twice and excellent twice. The ability of others to hear the pilots was rated good twice and excellent twice. Cockpit noise attenuation was rated good twice and excellent twice.

3B.4.2.2 MOE 4-2, compatibility/interoperability of the helmet with the aircraft life support systems. Both pilots commented the bayonet was very difficult to connect and very difficult to line up with the bayonet receiver. The pilots both felt it was too hard to operate and took too long to connect the mask (one to two minutes). No slippage of the mask was reported. No interference problems were reported between the combiners and the mask, but there was an interference problem between the combiners and the visor. During stowing and unstowing of the combiners, the combiners caught on the visor.

3B.4.2.3 MOE 4-3, compatibility of the helmet's night vision equipment with cockpit lighting. The lights were compatible with the Honeywell helmet optics and intensifier tubes. No reflections were reported in the visor, combiners, or windscreen from the cockpit lighting.

3B.4.2.4 MOE 4-4, compatibility/interoperability of the helmet with the cockpit environment. The pilots felt the Honeywell helmet would not interfere with emergency egress. The helmet did not interfere with any cockpit controls. The pilots did not experience any head movement restrictions. The placement of the battery pack cable was rated barely acceptable once and acceptable three times. The pilots reported there was no interference between the helmet and the seat and there was sufficient cockpit clearance.

3B.4.3 **Recommendations.**

3B.4.3.1 The bayonet and bayonet receiver need to be reengineered to be easily operated when wearing the helmet. If possible use the current bayonet and bayonet receiver being used on the HGU-55/P.

3B.4.3.2 The visor should be reshaped so it does not interfere with stowing or unstowing the combiners.

3B.5 OBJECTIVE E-5. Assess the human factors aspects of each helmet's controls.

3B.5.1 Method. See section 3B.1.1.

3B.5.2 Results and Conclusions. MOE 5-1, ease of operating the helmet's controls.

3B.5.2.1 No problems were encountered with the visor controls or in raising or lowering the visor.

3B.5.2.2 The location of the battery pack and access of the batteries was rated borderline once, barely acceptable once, and acceptable twice. The pilots commented the battery pack located in the survival vest was very difficult to access in-flight.

3B.5.2.3 The ease of stowing the combiners during preflight and in-flight was rated barely acceptable once and acceptable three times. The ease of unstowing the combiners during preflight and in-flight was rated barely acceptable once and acceptable three times. Pilots commented the end of the combiners rubbed the visor during stowing and unstowing.

3B.5.2.4 The accessibility of the inter-pupillary diameter controls was rated barely acceptable twice and acceptable twice. The focus was rated barely acceptable once, and acceptable twice.

3B.5.2.5 The location of the image intensifier tube power switch was rated barely acceptable twice and acceptable twice. The pilots commented the power switch would be better if it was located on the helmet rather than on the battery pack in the survival vest. The ease of operating the image intensifier power switch was rated barely acceptable twice and acceptable twice.

3B.5.3 Recommendations.

3B.5.3.1 The batteries should be located in a more accessible place.

3B.5.3.2 The image intensifier tube power switch should be located in an easily accessible place.

3B.5.3.3 The visor should be reshaped so it does not interfere with the stowing or unstowing of the combiners.

3B.6 OBJECTIVE E-6. Assess the operability of each helmet's controls.

3B.6.1 Method. See section 3B.1.1.

3B.6.2 Results and Conclusions. MOE 6-1, operability of the helmet's controls.

3B.6.2.1 Operation of the battery pack controls was rated borderline once, barely acceptable once, and acceptable twice.

3B.6.2.3 The operation of the inter-pupillary diameter control was rated borderline once, barely acceptable once, and acceptable twice. Maintenance personnel commented the range of movement for the optics was a problem and said an increase in the movement would assist in adjusting the optics. The operation of the focus was rated borderline twice, barely acceptable once, and acceptable once. The pilots commented the focus adjustments are inadequate because they couldn't achieve a sharp focus. The intensified scene focus did not change throughout the flight.

3B.6.3 Recommendations.

3B.6.3.1 The operation of the inter-pupillary diameter control needs to have a greater range of adjustability.

3B.6.3.2 The focus needs to be improved to provide a sharper picture.

3B.7 OBJECTIVE S-7. Assess the maintainability of each helmet.

3B.7.1 Method. Specific questions in the questionnaires and information from the logs will provide data for each MOE. The test director kept a maintenance history log during the assessment. An I-NIGHTS Test Log Book, provided by the ADPO, accompanied each helmet and all maintenance actions, deficiencies, enhancements, and flight information was recorded in the logs. The test director maintained and analyzed the logs for the final report. The I-NIGHTS Test Log Books were returned to the ADPO with the helmets after the assessment. See section 3B.1.1.

3B.7.2 Results and Conclusions.

3B.7.2.1 MOE 7-1, maintainability of each helmet. The only maintenance performed during the assessment was cleaning. Maintenance personnel were concerned the Honeywell helmet does not use standard HGU-55/P helmet parts. A maintainability concept has not been developed. The life support technicians encouraged a maintainability concept where most of the maintenance is done in the life support shop with a minimal number of parts requiring D-level maintenance.

3B.7.2.2 MOE 7-2, adequacy of storage and handling methods for each helmet.

a. Storage. If a helmet of this type become operational: additional space would be required in life support shops, additional storage lockers would be required with secure locks due to the high cost of the helmet, additional funds for new parts to support the helmet, and personnel requirements would increase to maintain additional helmets.

b. Handling. During the assessment the helmets were transported to and from the aircraft in a modified helmet bag which was larger than the standard helmet bag and had a larger opening. A helmet of this type will not fit into the standard helmet bags. The Honeywell helmet is more fragile than the HGU-55/P helmet and requires careful handling when transporting to and from the aircraft. A padded helmet container would help prevent damage to the helmet. Protective covers for the optics would also prevent them from damage and help keep them free of dirt and finger prints during handling.

3B.7.3 Recommendations.

3B.7.3.1 Develop the maintainability concept for the operational system.

3B.7.3.2 Develop a helmet container to transport and protect the helmets.

3B.8 OBJECTIVE S-8. Assess the reliability of each helmet.

3B.8.1 Method. See section 3B.7.1.

3B.8.2 Results and Conclusions. MOE 8-1, reliability of each helmet. The Honeywell helmet was worn in flight for 4.4 night hours and 0.6 day hours for a total of 5.0 hours. No failures occurred on the Honeywell helmet during the assessment. The helmet was fairly rugged except for the intensifier tubes and combiners. Extra care will need to be executed while transporting and handling the helmet.

3B.8.3 Recommendations. Additional reliability testing needs to be conducted on the operational system.

SECTION IIIC

OPERATIONAL EFFECTIVENESS AND OPERATIONAL SUITABILITY FOR THE KAISER HELMET

3C.0 **SUMMARY.** Both pilots agreed the Kaiser helmet would not be suitable for B-52 missions. They commented the night vision performance of the current ANVIS-6 night vision goggles was much better than the Kaiser helmet. The Kaiser helmet needs to fit better and the center-of-gravity must be shifted aft. The helmet was constantly sliding forward on the pilot's heads causing them to lose the intensified image in the combiners. Hot spots from the hard helmet liner caused discomfort, and pilots removed the helmet within the first hour after donning. The intensified image needs to be improved to produce an image with better resolution and focus. The location of the I^2 tubes (one on each side of the head) periodically allowed one tube to point out of the window while the other tube pointed into a window spar blanking one combiner. The visor should be redesigned so it does not require small slots and snaps to keep it in the up or down positions.

3C.1 **OBJECTIVE E-1.** Assess the pilot's visibility and field-of-view during each phase of flight while wearing each helmet.

3C.1.1 **Method.**

3C.1.1.1 Five sorties were flown to support the Kaiser helmet. One day sortie was flown to familiarize the pilots with the helmet in the cockpit. Touch and go landings and low-level flight were completed by both pilots while only one pilot completed air refueling. Four night sorties were flown and each pilot wore the Kaiser helmet for half of the low-level flight on two sorties. The helmet was worn for 0.5 hours during the day and 2.5 hours during the night for a total of 3.0 hours.

3C.1.1.2 After each flight the pilots completed an Air Force I-NIGHTS Evaluation noting deficiencies and recommending enhancements for the Kaiser helmet. After the final flight, the pilots completed an Air Force I-NIGHTS Comparison Questionnaire which will be used by the ADPO when they combine the data from all aircraft assessed. Personal observations and aircrew comments were collected by the test director who flew as an observer on all assessment sorties.

3C.1.1.3 Air Force I-NIGHTS Evaluation questions were rated using two five point scales or yes/no responses. The five point scale was broken down two ways. The first scale consisted of: 1)terrible 2)poor 3) fair 4)good 5)excellent, and the second scale consisted of 1)unacceptable 2)barely unacceptable 3)borderline 4)barely acceptable 5)acceptable.

3C.1.1.4 The test director collected and maintained the questionnaires. The data was analyzed by the test director with the support of the 6510 Test Wing. Data was analyzed by entering it into a database from which a distribution of responses to each question was calculated. These distributions were used to support individual measures of effectiveness (MOEs) which were used as guidelines to form the analysis in assessing the objective. Written comments were summarized and used to support the conclusions and recommendations.

3C.1.2 **Results and Conclusions.**

3C.1.2.1 MOE 1-1, adequacy of the pilot's field-of-view while wearing the NVG helmet (I^2 tubes off). The pilot's unaided field-of-view looking through the combiners at night with the I^2 tubes off was very good. Pilot responses showed two good ratings and two excellent ratings.

3C.1.2.2 MOE 1-2, adequacy of the pilot's field-of-view while wearing the NVG helmet (I^2 tubes on). The pilots rated the field-of-view with the I^2 tubes on fair twice and good twice. The pilots commented the location of the I^2 tubes (one on each side of the head) periodically allowed one tube to point out of the window while the other tube pointed into a window spar blanking one combiner.

3C.1.2.3 MOE 1-3, capability of the NVG helmet (I^2 tubes on) to increase the pilot's visibility at night. Overall pilot comments showed the Kaiser helmet was "barely better than not using a night vision device". Lighted objects on the horizon were visible but were not well defined and appeared blurred or caused blooming. Refocusing the optics did not improve the presentation. Unlighted objects on the ground were not visible; the ground appeared black. With the ANVIS-6, the same objects were visible and the pilots said the ANVIS-6 was much better. The information below shows the responses to questions about the pilot's visibility at night using the Kaiser helmet.

a. Ability to distinguish relative distances was rated fair twice and good twice.

b. The light transmission through the combiners was rated good all four times.

c. Scene resolution through the combiners with the visor up was rated poor twice and fair twice. With the visor down it was rated poor once, fair twice, and good once. One pilot commented when the visor is up it interferes with the picture.

d. Distortions were reported by one pilot when looking through the combiners with the I^2 tubes on. The pilot said the image appeared blurred and double images were present. These distortions occurred whether the visor was up or down.

e. Glare was present in the combiners 50% of the time and was rated unacceptable during each occurrence. Scintillation (salt and pepper/snow) in the intensified scene was reported 50% of the time due to low light conditions and was rated acceptable.

f. Blooming of the intensified scene was reported 50% of the time and all the blooming was caused by ground lights.

g. The brightness of the intensified scene was rated good three times and excellent once.

h. The brightness uniformity of the intensified scene was rated good three times and excellent once.

i. The correlation between the outside scene and the intensified scene was rated poor twice, fair once, and good once. The pilots commented the intensified scene was not in focus.

j. No ghost or double imaging was reported other than ground lights which when viewed through the I^2 tubes and projected onto the combiners did not overlay the lights seen by the eye looking only through the combiners.

k. The scene registration appeared to be the same (not larger or smaller) as the real world 100% of the time.

l. The intensified scene appeared to be rotated properly 100% of the time.

3C.1.2.4 MOE 1-4, adequacy of the pilot's visibility inside the cockpit while wearing the NVG helmet (I^2 tubes on). Viewing of the instrument panels while looking through the combiners at night was rated good once and excellent once, but during dusk operations it was rated poor twice due to glare. No blind spots were experienced due to the combiners, mask, visor, or the helmet.

3C.1.3 Recommendations.

3C.1.3.1 The I^2 tubes need to be relocated on the helmet to allow both tubes to point out the windscreen at the same time while the pilot is looking in the forward directions.

3C.1.3.2 The intensified image needs to be improved to produce an image with better resolution. Unlighted objects on the ground are currently not visible to the pilots with the Kaiser helmet.

3C.1.3.3 The optics need to be changed to avoid the glare and reflections caused from outside light sources. Operating at dusk produced the worst glare in the combiners.

3C.1.3.4 The focus needs to be improved to provide a sharper picture.

3C.2 OBJECTIVE E-2. Assess the comfort and fit of each helmet.

3C.2.1 Method. 3C.1.1.

3C.2.2 Results and Conclusions. Extended wear of the Kaiser helmet was rated unacceptable twice, borderline once, and barely acceptable once. Pressure points (hot spots) were experienced three out of four times the helmet was worn and occurred in numerous places after 15-20 minutes. Temperature build-up was reported 50% of the time after 20 minutes.

3C.2.2.1 MOE 2-1, amount of eye strain caused by the NVG helmet (I^2 tubes on). One pilot experienced abnormal eye fatigue after wearing the Kaiser helmet for 30 minutes. No spatial disorientation was experienced by either pilot.

3C.2.2.2 MOE 2-2, amount of weight-induced fatigue caused by the helmet. The weight of the Kaiser helmet was rated borderline once, barely acceptable once, and acceptable twice. The center-of-gravity was rated unacceptable twice, and borderline twice. The center-of-gravity location was reported in the fore position. No weight-induced fatigue was reported. One pilot on one flight reported center-of-gravity-induced fatigue after 15 minutes of continuously trying to keep the combiners aligned. No G-induced fatigue was experienced by the pilots.

3C.2.2.3 MOE 2-3, ability of the helmet to achieve proper fit. The overall fit of the helmet liner was rated terrible once, poor once, and good once.

a. The fit of the chin strap received one poor, one fair, and two good ratings. No nape strap was present in the Kaiser helmet. The chin strap was rated poor once and good three times for adjustability. Pilots commented it was too short and difficult to fasten. The Kaiser helmet does not have a nape strap. The pilots commented the lack of a nape strap contributed to the slippage.

b. The seal and the comfort of the earcups were rated fair once, and good three times.

c. The fit of the mask was rated good all four times.

d. The overall position of the combiners in front of the eyes was rated borderline once and acceptable three times. The distance between the pilot's eyes and the combiners was rated barely acceptable once and acceptable twice. The distance between the pilot's eyes and the visor was rated acceptable all four times.

3C.2.2.4 MOE 2-4, ability of the helmet to maintain proper fit. Slippage of the helmet affecting the pilots ability to see through the combiners occurred on two of the four flights. The slippage was indicated to be moderate on one occurrence and severe on the other. Both cases reported the slippage in the forward direction and required in-flight adjustments to see through the combiners. One pilot said the helmet slid forward every two to four minutes and the other pilot said the degradation of the fit occurred in less than ten minutes after donning the helmet. Both pilots reported a nape strap and weight in the back of the helmet would have prevented the slippage. No slippage of the mask was reported. G-forces did not cause loss of the intensified scene.

3C.2.3 Recommendations.

3C.2.3.1 The helmet liner needs to be reengineered to provide a better fit to reduce hot spots and temperature build-up. The liner should be made from a softer material as opposed to the hard foam used in this Kaiser helmet.

3C.2.3.2 Move the center-of-gravity aft to make the helmet acceptable for extended wear.

3C.2.3.3 Prevent the helmet from slipping forward and causing loss of the intensified scene.

3C.2.3.4 Add a nape strap.

3C.2.3.5 Make the chin strap easy to fasten.

3C.3 **OBJECTIVE E-3.** Assess donning and doffing each helmet.

3C.3.1 **Method.** 3C.1.1.

3C.3.2 **Results and Conclusions.**

3C.3.2.1 MOE 3-1, ease of donning the helmet. On one out of four flights donning of the Kaiser helmet was reported acceptable while the others were reported borderline. The ease of donning the Kaiser helmet inside the cockpit was reported acceptable all four times.

3C.3.2.2 MOE 3-2, ease of doffing the helmet. Doffing the helmet was reported as acceptable 100% of the time.

3C.3.3 **Recommendations.** None.

3C.4 **OBJECTIVE E-4.** Assess each helmet's compatibility and interoperability with the cockpit during each phase of flight.

3C.4.1 **Method.** See section 3C.1.1.

3C.4.2 **Results and Conclusions.**

3C.4.2.1 MOE 4-1, compatibility/interoperability of the helmet with the aircraft interphone. The pilots did not wear ear plugs during the assessment. The ability of the pilots to clearly hear others was rated good once, and excellent three times. The ability of others to hear the pilots was rated poor twice, fair once, and excellent once. The pilots commented the microphone in the mask is too far away from the face and caused the pilot wearing the helmet to sound muffled.

3C.4.2.2 MOE 4-2, compatibility/interoperability of the helmet with the aircraft life support systems. The mask bayonet and the mask bayonet receiver operated properly throughout the flight test. No slippage of the mask was reported. There was one reported case of interference between the mask and the combiners. When raising the mask the pilot reported he occasionally struck the left combiner with his mask. No interference was reported between the combiners and the visor.

3C.4.2.3 MOE 4-3, compatibility of the helmet's night vision equipment with the cockpit lighting. The lighting of the instrument panels was not sufficient for viewing the intensified scene during dusk operation. The pilots commented that when flying into a sunset, after the sun was well below the horizon, the overall illumination in the combiners was too bright to see the instruments. No reflections were reported in the visor, but reflections were reported in the combiners. The pilots commented the reflections were present in both combiners but the source of the light was unknown. Reflections were also reported in the windscreen when looking at the intensified scene through the combiners. These reflections were caused from various cockpit lights.

3C.4.2.4 MOE 4-4, compatibility/interoperability of the helmet with the cockpit environment. Neither pilot felt the Kaiser helmet would interfere with emergency egress or any cockpit controls. No head movement restrictions were experienced by the pilots. The placement of the battery pack cable was rated barely acceptable once and acceptable three times. The helmet did not interfere with the seat and both pilots felt there was sufficient cockpit clearance while wearing the Kaiser helmet.

3C.4.3 Recommendations.

3C.4.3.1 Enough room should be allowed between the mask and the combiners so when pilots raise the mask they are not smudging the combiners and are able to hook the mask without interference.

3C.4.3.2 The combiners should be adjusted to prevent glare and reflections from appearing in the intensified scene.

3C.4.3.3 Reduce blooming caused by high light levels so instruments can be seen.

3C.5 OBJECTIVE H-5. Assess the human factors aspects of each helmet's controls.

3C.5.1 Method. See section 3C.1.1.

3C.5.2 Results and Conclusions. MOE 5-1, ease of operating the helmet's controls.

3C.5.2.1 The pilots had difficulty operating the visor controls. The pilots commented the visor controls are awkward and it was very difficult to find the side slots and snap the visor down.

3C.5.2.2 The location of the battery pack and access of the batteries was rated barely acceptable twice and acceptable twice. The pilots commented the battery pack located in the survival vest was very difficult to access in-flight.

3C.5.2.3 The ease of stowing the combiners in-flight and during preflight was rated barely acceptable once and acceptable three times. The ease of unstowing the combiners in-flight and during preflight was also rated barely acceptable once and acceptable three times.

3C.5.2.4 The accessibility of the inter-pupillary diameter controls was rated unacceptable twice and barely unacceptable twice. The pilots commented the combiners were unadjustable in flight because it has to be done by another person with an Allen wrench. Accessibility to the focus adjustment was rated acceptable all four times.

3C.5.2.5 The location of the I^2 tube power switch was rated borderline once, barely acceptable once, and acceptable twice. The ease of operating the I^2 tube power switch was rated barely acceptable once and acceptable three times.

3C.5.3 Recommendations.

3C.5.3.1 The inter-pupillary diameter controls should be reengineered to be easily adjusted in-flight without tools.

3C.5.3.2 The visor should be redesigned to operate easily.

3C.5.3.3 The batteries should be located in a more accessible place.

3C.5.3.4 The image intensifier tube power switch should be located in an easily accessible place.

3C.6 OBJECTIVE E-6. Assess the operability of each helmet's controls.

3C.6.1 Method. See section 3C.1.1.

3C.6.2 Results and Conclusions. MOE 6-1, operability of the helmet's controls.

3C.6.2.1 The operation of the battery pack controls was rated barely acceptable twice and acceptable twice. The batteries failed in flight once with no indication pending battery failure.

3C.6.2.2 The operation of the inter-pupillary diameter was rated barely unacceptable twice and acceptable twice. The pilots did not like the requirement of an Allen wrench to make the adjustment. Maintenance personnel commented the range of movement for the optics was a problem and said an increase in the movement would assist in adjusting the optics. The operation of the focus was rated barely unacceptable once and acceptable three times. The pilots commented the focus adjustments are inadequate because they couldn't achieve a sharp focus. The intensified scene focus degraded 75% of the time.

3C.6.3 Recommendations.

3C.6.3.1 The optics need to have a greater range of adjustability.

3C.6.3.2 The focus needs to be improved to sharpen the image. Also the focus should hold constant throughout the flight and not degrade over time.

3C.6.3.3 The helmet needs to have a low battery indicator in view of the pilot's eyes while he is looking through the combiners.

3C.7 OBJECTIVE E-7. Assess the maintainability of each helmet.

3C.7.1 Method. Specific questions in the questionnaires and information from the logs will provide data for each MOE. The test director kept a maintenance history log during the assessment. An I-NIGHTS Test Log Book, provided by the ADPO, accompanied each helmet and all maintenance actions, deficiencies, enhancements, and flight information was recorded in the logs. The test director maintained and analyzed the logs for the final report. The I-NIGHTS Test Log Books were returned to the ADPO with the helmets after the assessment. See section 3C.1.1.

3C.7.2 Results and Conclusions.

3C.7.2.1 MOE 7-1, maintainability of each helmet. The only maintenance performed during the assessment was cleaning. Maintenance personnel were concerned the Kaiser helmet does not use standard HGU-55/P helmet parts. A maintainability concept has not been developed. The life support technicians encouraged a maintainability concept where most of the maintenance is done in the life support shop with a minimal number of parts requiring D-level maintenance.

3C.7.2.2 MOE 7-2, adequacy of storage and handling methods for each helmet.

a. Storage. If a helmet of this type become operational: additional space would be required in life support shops, additional storage lockers would be required with secure locks due to the high cost of the helmet, additional funds for new parts to support the helmet, and personnel requirements would increase to maintain additional helmets.

b. Handling. During the assessment the helmets were transported to and from the aircraft in a modified helmet bag which was larger than the standard helmet bag and had a larger opening. A helmet of this type will not fit into the standard helmet bags. The Kaiser helmet is more fragile than the HGU-55/P helmet and requires careful handling when transporting to and from the aircraft. A padded helmet container would help prevent damage to the helmet. Protective covers for the optics would also prevent them from damage and help keep them free of dirt and finger prints during handling.

3C.7.3 Recommendations.

3A.7.3.1 Develop the maintainability concept for the operational system.

3A.7.3.2 Develop a helmet container to transport and protect the helmets.

3C.8 OBJECTIVE S-8. Assess the reliability of each helmet.

3C.8.1 Method. See section 3C.7.1.

3C.8.2 Results and Conclusions. MOE 8-1, reliability of each helmet. The Kaiser helmet was worn in flight for 2.5 night hours and 0.5 day hours for a total of 3.0 hours. No failures occurred on the Kaiser helmet during the assessment. The helmet was fairly rugged except for the intensifier tubes and combiners. Extra care will need to be executed while transporting and handling the helmet.

3C.8.3 Recommendations. Additional reliability testing needs to be conducted on the operational system.

SECTION IV - SYSTEM DEFICIENCY REPORTS

4.0 SUMMARY OF SYSTEM DEFICIENCY REPORTS. 24 system deficiency reports were submitted during the assessment. Each system deficiency report is summarized below by the helmet manufacturer.

4.1 GEC HELMET.
910001 Poor Intensified Image:
The present configuration does not provide enough contrast and resolution to allow the pilots to fly at low-level altitudes with a high degree of confidence. The intensified image needs to be improved to provide more ground detail. The GEC helmet did not greatly increase the pilot's visibility at night. Buildings were not visible with the GEC helmet, the pilots could make out farm fields which showed up as different shaded areas. A bridge, 1.6 miles away, was visible with the ANVIS-6 but not with the GEC helmet.

910002 Poor Focus:
The focus does not produce a clear sharp presentation in the combiners. During preflight the focus in the left combiner was: 20/70, 20/70, 20,80, and over 20/100. The focus in the right combiner was: 20/60, 20/70, and over 20/100 twice.

910003 Compatibility Between the Helmet and Windscreen:
The location of the intensifier tubes (one on each side of the head) periodically allowed one intensifier tube to point out of the windscreen while the other intensifier tube pointed into a window spar blanking one combiner.

910004 Forward Center-of-Gravity:
The center-of-gravity was located too far forward in the helmet causing fatigue. The center-of-gravity should be moved aft on the helmet.

910005 Helmet Slippage:
The helmet liner moved inside the helmet shell and the liner also moved on the pilot's head allowing the helmet to slip forward. The slippage was moderate and did not cause loss of the intensified scene.

910006 Limited Inter-Pupillary Diameter Adjustment Range:
The inter-pupillary diameter adjustment did not have a wide enough range.

910007 Inter-Pupillary Diameter Adjustment Ease:
The inter-pupillary diameter adjustment had to be adjusted by another person while wearing the helmet. The inter-pupillary diameter adjustment should be easily adjustable in-flight.

4.2 HONEYWELL HELMET.
910008 Limited Field-of-View:
The field-of-view through the combiners with the intensifier tubes on is somewhat limited and small amounts of slippage drastically reduces the field-of-view.

910009 Compatibility Between the Helmet and Windscreen:
The location of the intensifier tubes (one on each side of the head) periodically allowed one intensifier tube to point out of the windscreen while the other intensifier tube pointed into a window spar blanking one combiner.

910010 Poor Resolution:
The intensified image does not have adequate resolution for the pilots to use it for low-level B-52 missions. The pilots could make out terrain and were able to see unlit objects on the ground two miles away but felt it was not quite good enough to do an actual low-level mission.

910011 Combiner Distortion:
The pilots experienced distortion at the edges of the combiners when viewing the flight instruments. The pilots said it was not significant enough to prohibit flight but caused eye fatigue. They also commented the problem was worse with the visor down.

910012 Poor Bayonet and Bayonet Receiver Design:
The bayonet was very difficult to connect and very difficult to line up with the bayonet receiver. It took the pilots one to two minutes to hook the mask even after three flights with the helmet.

910013 Visor Interference:
The combiners caught on the visor during stowing and unstowing. The visor needs to be reshaped to prevent the interference problem.

910014 Poor Focus:
The focus does not produce a clear sharp presentation in the combiners. During preflight the focus in the left combiner was: 20/45, 20/45, 20/45, and 20/50. The focus in the right combiner was: 20/45, 20/45, 20/50, and 20/50.

910015 Limited Inter-Pupillary Diameter Adjustment Range:
The inter-pupillary diameter adjustment did not have a wide enough range.

4.3 KAISER HELMET.

910016 Compatibility Between the Helmet and Windscreen:
The location of the intensifier tubes (one on each side of the head) periodically allowed one intensifier tube to point out of the windscreen while the other intensifier tube pointed into a window spar blanking one combiner.

910017 Poor Resolution:
The intensified image does not have adequate resolution for the pilots to use it for low-level B-52 mission. The terrain and unlighted objects on the ground were not visible. The pilots commented the ground appeared black.

910018 Poor Focus:
The focus does not produce a clear sharp presentation in the combiners. During preflight the focus in the left combiner was: 20/45, 20/45, 20/50, and 20/60. The focus in the right combiner was: 20/50, 20/50, 20/50, and 20/70.

910019 Poor Fitting Helmet Liner:
The helmet liner did not fit the pilots well. They experienced hot spots in numerous places after 15-20 minutes. Temperature build-up was also experienced after wearing the helmet for 20 minutes.

910020 Forward Center-of-Gravity:
The center-of-gravity was located too far forward in the helmet causing fatigue and slippage. The center-of-gravity should be moved aft on the helmet.

910021 Slippage of the Helmet:
The helmet slid forward on the head during flight causing loss of the intensified scene. The slippage was moderate to severe and required in-flight adjustments to see through the combiners. One pilot reported the helmet slid forward every two to four minutes and the other pilot said degradation of the fit occurred in less than 10 minutes after donning the helmet.

910022 Extreme Blooming:
High light levels caused such extreme blooming in the combiners that the instruments could not be seen. The pilots commented that when flying into a sunset, after the sun was well below the horizon, the overall illumination in the combiners was too bright to see the instruments.

910023 Inter-Pupillary Diameter Adjustment Ease:
The inter-pupillary diameter adjustment had to be adjusted by another person with an Allen wrench. The inter-pupillary diameter adjustment should be easily adjustable in-flight without the use of tools.

910024 Limited Optics Adjustment Range:
The optics adjustments did not have enough flexibility or wide enough range to achieve the best fit. The maintenance personnel commented the range of movement for the optics was a problem and said an increase in the movement would assist in adjusting the optics.

SECTION V - SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

5.1 **GEC HELMET.** Both pilots rated the GEC helmet unsuitable for B-52 missions. The pilots had low confidence in their ability to fly the aircraft safely with the GEC helmet. They commented the night vision performance of the current ANVIS-6 night vision goggles was much better than the GEC helmet. The pilots said they would almost rather fly without the GEC helmet at night and just use the terrain trace inside the cockpit. The helmet had a slight forward center-of-gravity which led to some discomfort while wearing the helmet for more than an hour. The location of the I^2 tubes (one on each side of the head) periodically allowed one tube to point out of the window while the other tube pointed into a window spar blanking one combiner.

5.2 **HONEYWELL HELMET.** Although inferior to ANVIS-6, the pilots felt the Honeywell helmet may be suitable for B-52 missions if the resolution was slightly improved. The field-of-view through the combiners with the intensifier tubes on needs to be slightly increased. Small amounts of slippage drastically reduces the field-of-view seen through the combiners. The glass combiners need to be optically corrected to prevent distortion when looking through the edge of the combiners. The location of the I^2 tubes (one on each side of the head) periodically allowed one tube to point out of the window while the other tube pointed into a window spar blanking one combiner. The bayonets and bayonet receivers need to be reengineered for ease of operation. The visor should be reshaped so it does not interfere with stowing or unstowing the combiners. The combiners need to have a greater range of adjustability to better fit individual pilots.

5.3 **KAISER HELMET.** Both pilots agreed the Kaiser helmet would not be suitable for B-52 missions. They commented the night vision performance of the current ANVIS-6 night vision goggles was much better than the Kaiser helmet. The Kaiser helmet needs to fit better and the center-of-gravity must be shifted aft. The helmet was constantly sliding forward on the pilot's heads causing them to lose the intensified image in the combiners. Hot spots from the hard helmet liner caused discomfort, and pilots removed the helmet within the first hour after donning. The intensified image needs to be improved to produce an image with better resolution and focus. The location of the I^2 tubes (one on each side of the head) periodically allowed one tube to point out of the window while the other tube pointed into a window spar blanking one combiner. The visor should be redesigned so it does not require small slots and snaps to keep it in the up or down positions.

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