Aircraft Display/Helmet Mounted Display (HMD) Compatibility with Laser Eye Protection (LEP)

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Presented to: RAMS / NATO STO Technical Course 2023

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NAVAIR

Agenda

- Provide an overview of the Naval Air Warfare Center Aircraft Division Vision Lab Capabilities

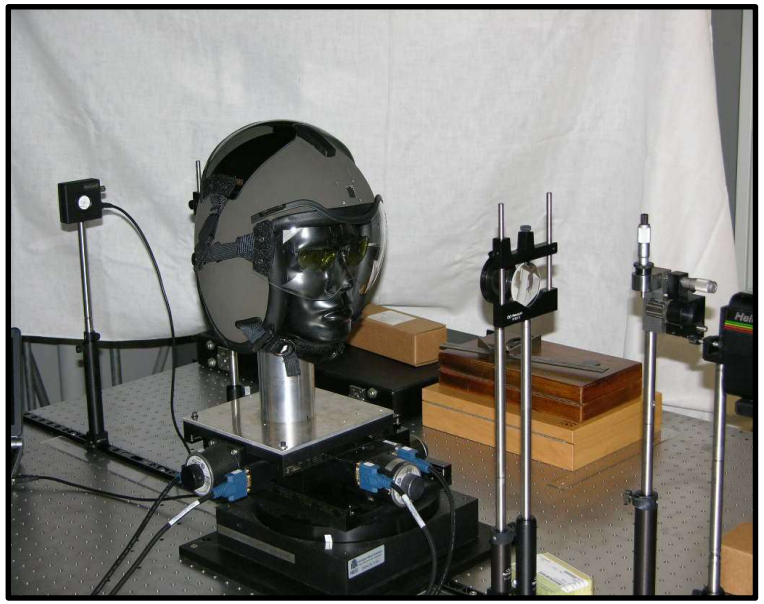
- Discuss aeromedical concerns with the use of LEP and visual performance

- Discuss a project that was recently conducted in the Vision Lab to address display compatibility issues

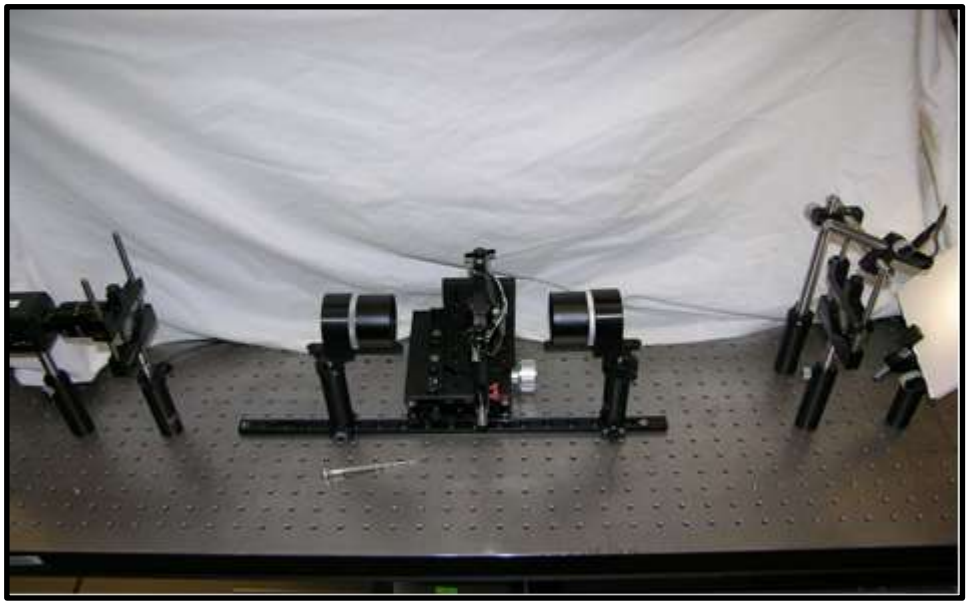
Naval Air Warfare Center Aircraft Division Vision Lab Overview

Optical Characterization

- Haze – HazeGard Plus
- Lens Analysis – Lensometer, Custom Laser Based Lens Analysis (LBLA) – patented in 2015
- Cosmetic analysis - Microscope with CCD, Crossed Polarizer
- Ann Arbor Distortion – Custom set up



Laser Based Lens Analysis



Custom Distortion Set Up

Optical Protection

- Spectrophotometry (UV-Near IR and Near IR to Far IR)
  - Large Spectrophotometer – High Resolution
  - USB spectrometer – Fast Capture
- Densitometry (Laser Protection) –
  - CW, Visible and IR wavelengths
  - Pulsed and Tunable Pulsed, Visible and IR wavelengths

Spectrometer

Custom CW Laser System

Visual Performance

- Topcon Perimeter – Field of View
- Contrast Sensitivity
  - Custom set up
- Eye Lane – color assessment
- Vision assessment
  - Wall charts
  - Titmus Vision tester

Environmental / Material Durability

- Solarization Chamber
- Humidity, High, and Low Temp Environmental Chambers
- Abrasion
- High Velocity Impact Chamber (ballistic)
- Ball Drop Test

Field Of View Testing

High Velocity Impact Testing

Solar Chamber

Support provided

- Eye Protection Development and Fleet sustainment
  - Provide engineering support for acquisition efforts
    - Requirements, Testing, Engineering Investigations

- Science and Technology
  - Develop novel test methodologies for the evaluation of vision technology
    - 1 Recent US Patent in 2015
    - Test Methodologies frequently incorporated into ANSI or MIL Standards
  - Assessment of Human Performance in various aviation environments

Related Support

- Participate in National and International Laser Safety Committees
  - US Navy: Laser Safety Review Board
  - DoD: Laser Systems Safety Working Group
  - NATO: Laser Safety Panel
  - Commercial Standard: American National Standards Institute Z136.1 S*afe Use of Lasers* and Z136.7 *Testing and Labeling of Laser Protective Equipment*

Aeromedical concerns with the use of LEP and visual performance

- LEP can have several negative side effects:
  - Poor optics can lead to adverse physiological issues: Nausea, vertigo, headaches, fatigue, etc…
  - Low transmittance can make the lens too dark, causing a safety issue in twilight/night conditions
  - Color shifting can lead to issues with:
    - Displays, Caution/Warning lights, Printed material (maps, tech manuals, etc..), and Navigational/Taxiway lighting

Note: *The color of the LEP does not indicate the wavelength/color that is rejected. LEP that is designed to block ultraviolet or infrared light can also impact the amount (%) of visible light transmitted depending on the technology used.*

What Can Be Done?

- These issues can be addressed to some extent:
  - Optical issues can be corrected via proper lens design
  - Transmittance issues:
    - Transmittance can be increased through choice of technology, e.g. reflective vs absorptive technology
    - Color shifting can be corrected by “color balancing” via the use of dyes or shifting display chromaticity coordinates
  - There are limits to these correction factors that are dependent on the technology of the LEP and the laws of physics
  - Can anything be done on the display side?

Specific Effort:
Aircraft Display/Helmet Mounted Display Compatibility with Laser Eye Protection

Overview

- Identify a method to adjust an electronic display using existing monitor settings

- Human subject testing conducted with various commercial off the shelf equipment. Users were asked to perform the test with:
  - (1) Default display settings to measure a baseline
  - (2) LEP with default display settings
  - (3) LEP with displays modified to address for color shift

- Findings indicate that a low cost, readily applicable solution can improve LEP and display compatibility over baseline settings

Test Equipment

CRT

LCD

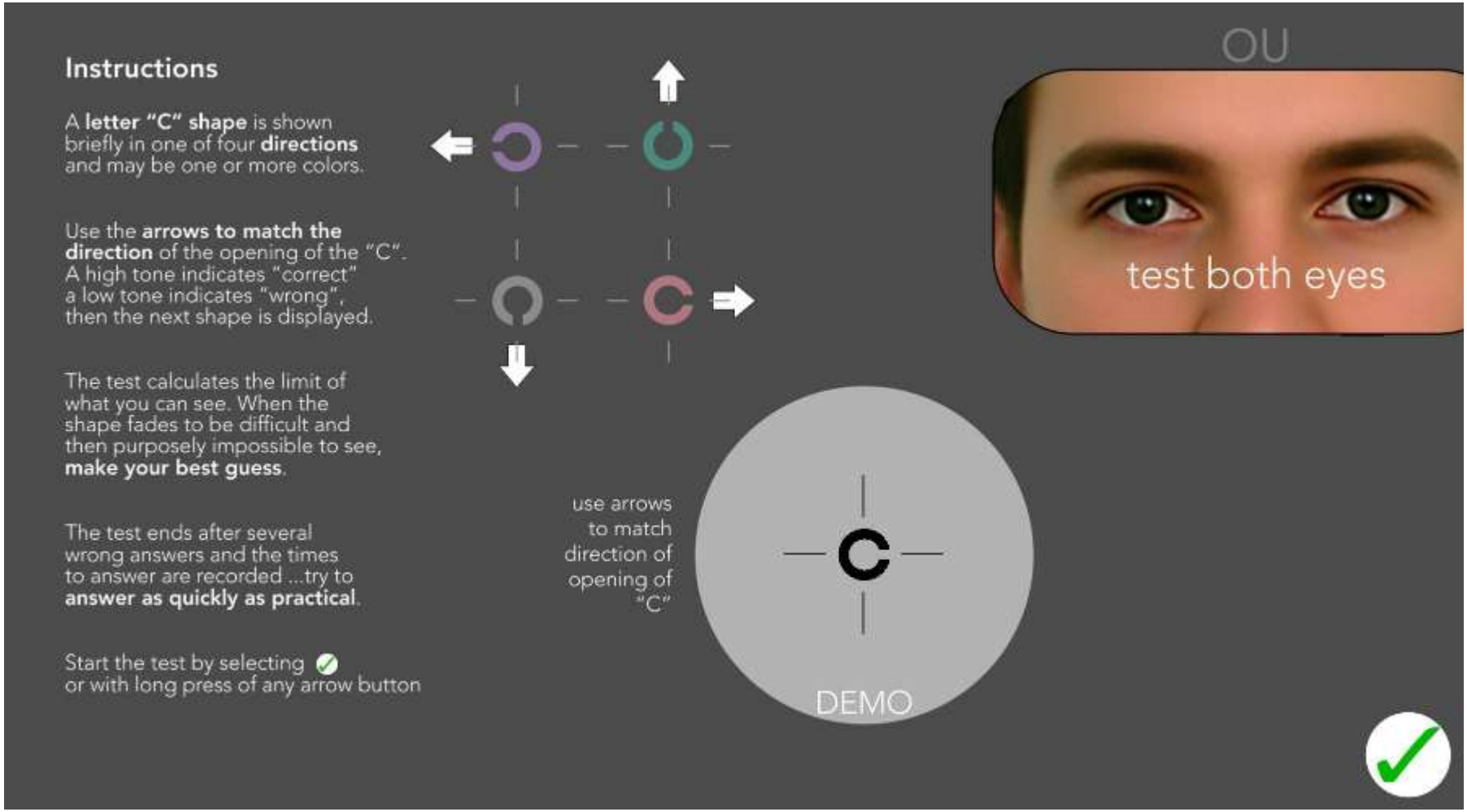
OLED (Wall mounted)

Sample COTS LEP that was tested

Subjects were screened for near and far visual acuity and color blindness using a vision tester

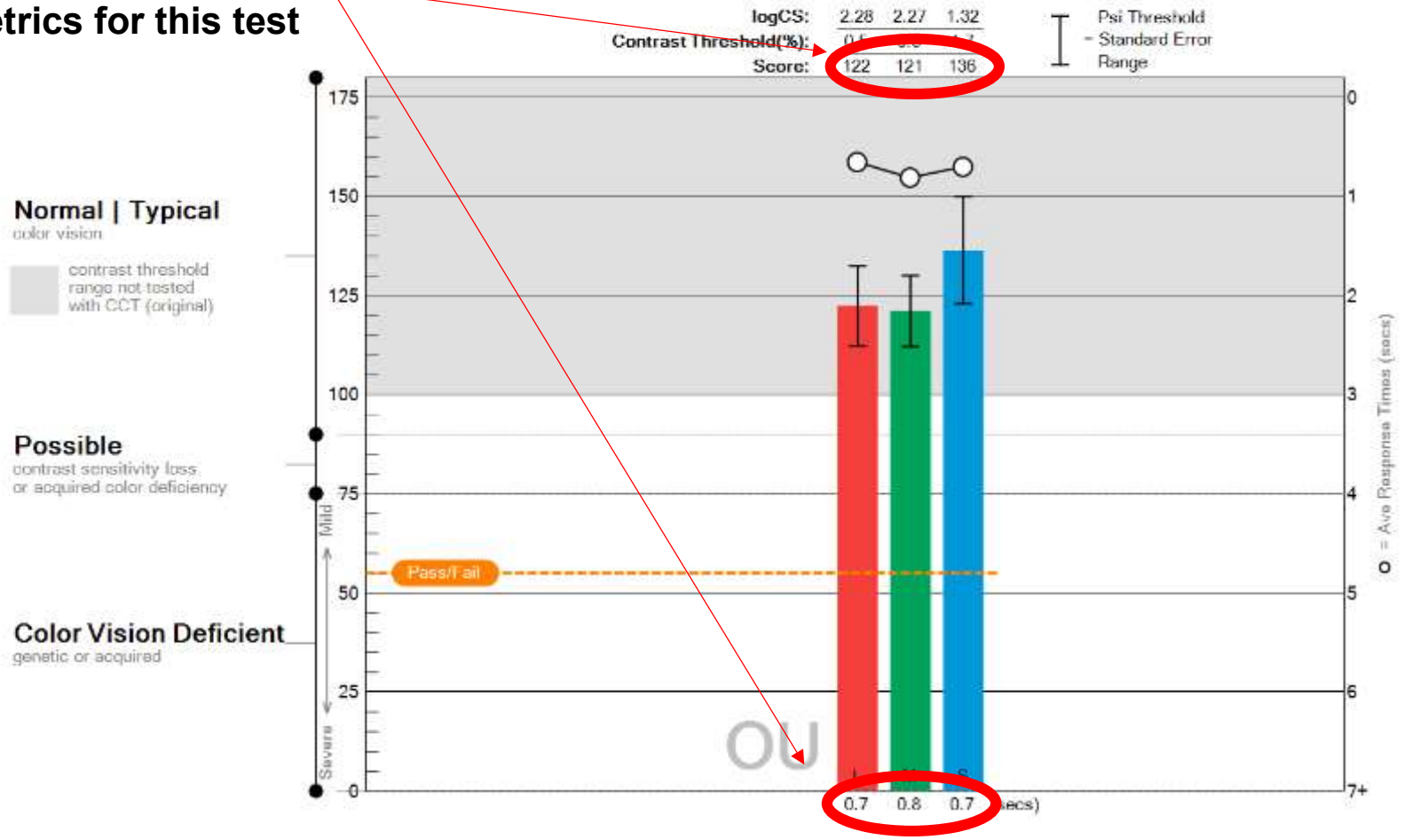
Eye Lane for CRT LCD and OLED Displays

Test initiation



Sample baseline results

Numerical score and response time are metrics for this test



Qualitative results

Display	LCD			CRT			OLED		
LEP	RED	Green	Blue	RED	Green	Blue	RED	Green	Blue
TS1									
TS2									
TS3									
TS4									
TS5									
TS6									
TS7									
TS8									
TS9									
TS10									
TS11									
TS12									

Color code		
Decrease of 5 or more	Neutral	Increase of 5 or more

Results

- Findings indicate that a low cost, readily available solution can improve LEP and display compatibility over baseline settings
- 81% of results were either positive or neutral
- The most improvement over baseline was found with the Blue LEP and LCD display, however the same LEP and the CRT display, yielded a negative performance from baseline indicating the method cannot be universally applied.
- The average improvement over all subjects was 5 units.

Questions?