



**RDECOM**

## Eye Tracker: Implementing a Physiological Measure of Visual and Mental Workload

*Presented to:*  
**MANPRINT Practitioners Workshop 2010**



**TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.**

*Presented by:*

**Sage Jessee**

Engineering Psychologist

U.S. Army Research Laboratory

Human Research and Engineering Directorate

**March 2010**

# Overview

- Measures of performance that illustrate the workload spectrum
- Subjective measures that provide a broad snapshot of workload and objective measures that provide more sensitivity and diagnosticity
- How eye tracking data is used to measure Visual Workload (VWL) and Mental Workload (MWL)



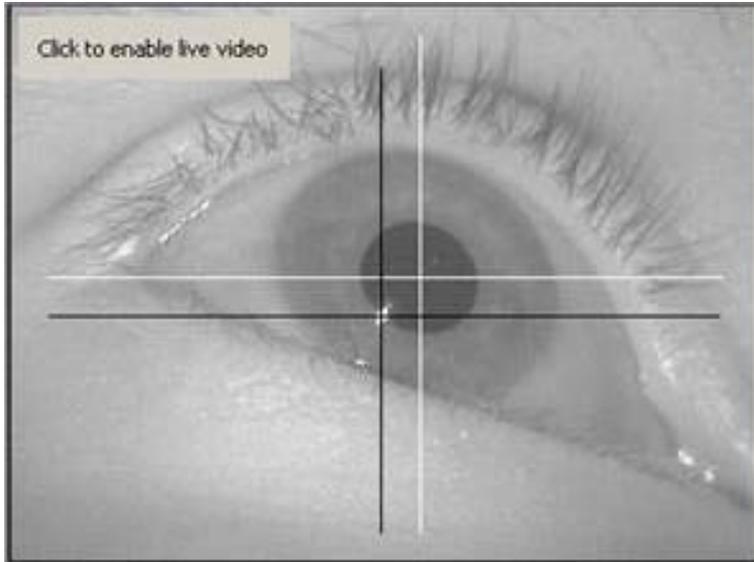
**TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.**

- **Human Factors evaluation data package**
  - **Subjective Measures**
    - Bedford scale
    - **SART - Situational Awareness Rating Technique**
    - Open ended questions
  - **Primary Task Measures**
    - SME observations
    - AAR interviews
  - **Objective measures**
    - Eye tracker data



**TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.**

- **Video based Infra-red eye tracking**
  - Illuminates the cornea reflection (CR) and measures the distance between the center of the pupil and CR
  - Fitted as head gear similar to night vision goggles
  - Recent developments have reduced price significantly





# Eye Tracking Data as a Measure of Mental Workload



- **Ocular activity variables positively correlated with Mental Workload**
  - Fixation Duration (Tole et al., 1983)
  - Pupil Diameter (Ahlstrom & Friedman-Berg, 2006)
  - Blink Interval (Ryu & Myung, 2005)
  - Fixation Frequency (Van Orden, Limbert, Makeig, & Jung, 2001)
- **Ocular activity variables negatively correlated with Mental Workload**
  - Saccadic Extent (Van Orden, Limbert, Makeig, & Jung, 2001)
  - Blink Rate (Wilson, 2002)
  - Blink Frequency (Van Orden, Limbert, Makeig, & Jung, 2001)
  - Blink Duration (Veltman & Gaillard, 1998)
  - Fixation Duration (Willems, Allen, & Stein, 1999)

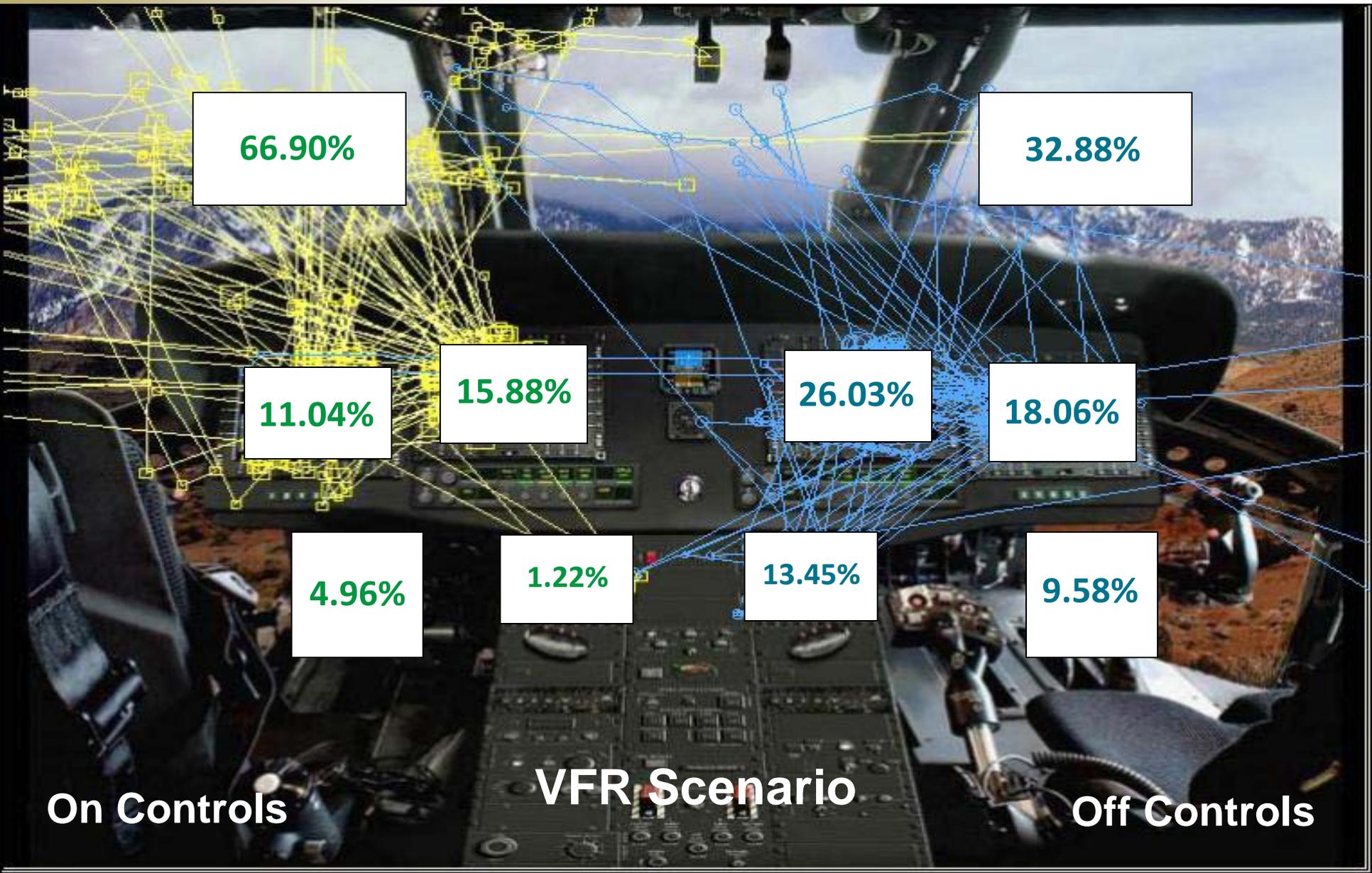
# Eye Tracking Data as a Measure of Visual Workload

- Dwell Analysis
  - Overall “heads-up” versus “heads-down” analysis
  - Task specific instrument gaze analysis
- Ocular activity correlates of VWL
  - Saccadic Extent
  - Blink Interval





# Overall Head-Up Vs. Heads Down Analysis (VWL)

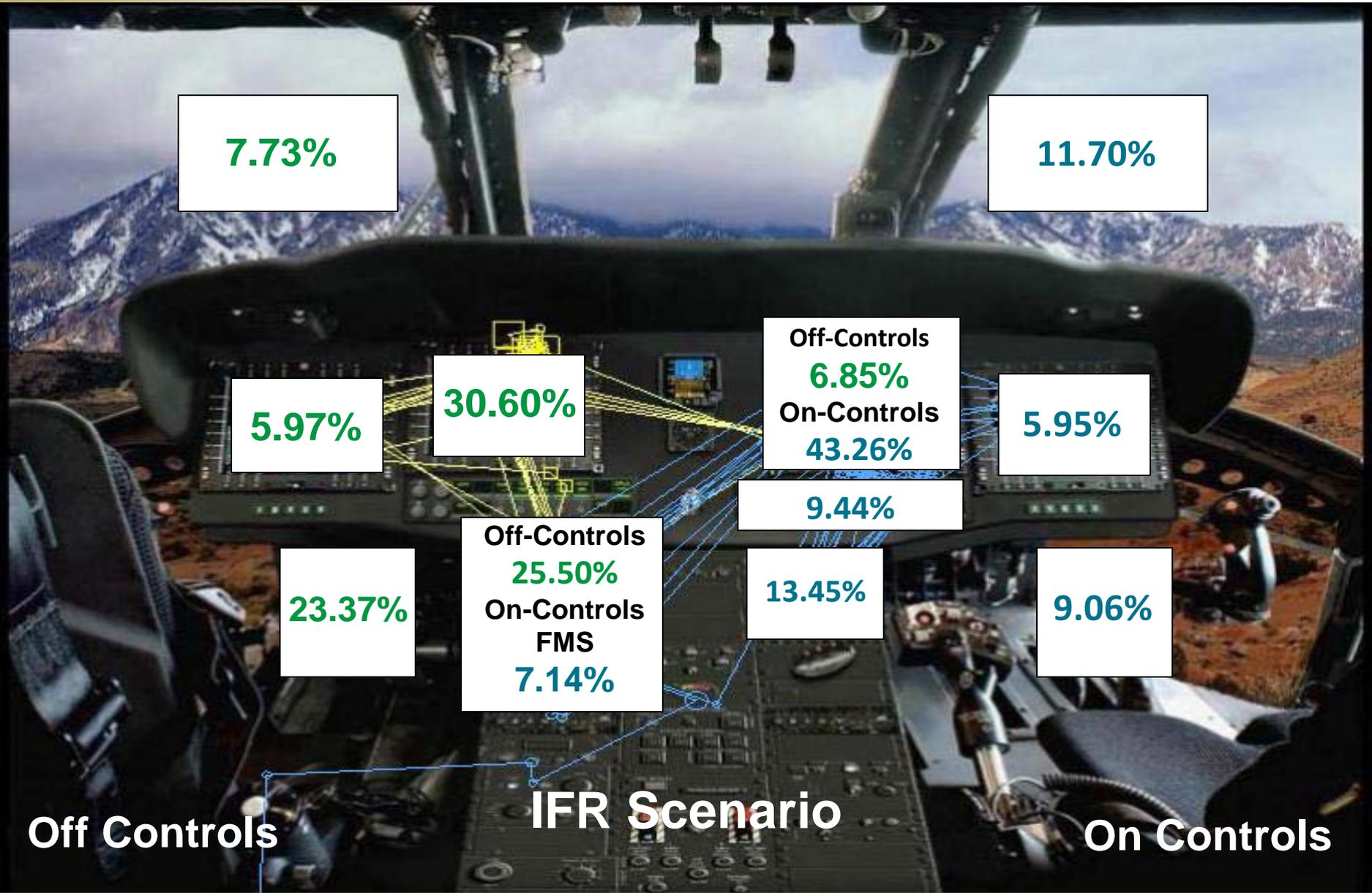


On Controls

VFR Scenario

Off Controls

# Gaze Analysis During an Emergency Tactical Approach



Off-Controls  
**6.85%**  
 On-Controls  
**43.26%**

Off-Controls  
**25.50%**  
 On-Controls  
 FMS  
**7.14%**

Off Controls

IFR Scenario

On Controls

# Gaze Analysis During a Holding Pattern



Off Controls

IFR Scenario

On Controls



# Specific Ocular Activity Variables Analysis



- **VWL is the effort required to *detect* information**
- **Visual Workload**
  - **Conduct relevant baseline data collection for each pilot**
    - **Saccadic Extent – Highly influenced by task and information location**
      - **Saccadic suppression occludes vision during long saccades**
    - **Blink Interval**
      - **Visual system is occluded during blinks**
- **MWL is the effort required to *service* information**
- **Mental Workload**
  - **Pupil Size**
    - **A good measure of arousal, as it is affected by task demands**



# Eye Tracker Data Used in Symphony with Other Measures



- **Unfavorable dwell times can be the result of...**
  - **High Workload**
  - **Pilot familiarity with the cockpit**
  - **Unfavorable page structures/layouts**
- **Subjective measures often have to be short and to the point, as such...**
  - **Eye tracker data can provide more information regarding the difficulty of specific tasks**
  - **It can validate subjective data**
  - **Subjective data can lead to specific task for eye tracker analysis**
- **Converging data sources offer more robust conclusions for requirements documentation, validation, and customer support that feeds further design efforts.**

## MANPRINT Mission

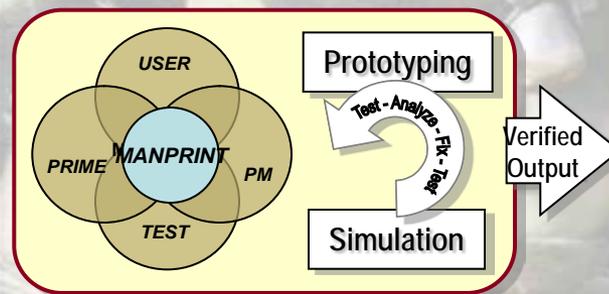


- Get out, talk to Soldiers, find out what they want and need

***"Remember The Soldier"***

Objective measure provided in concert with subjective measures extends capability

Allows for a more in depth analysis in support of the MANPRINT mission



# References

- Ahlstrom, U., & Friedman-Berg, F. J. (2006). Using eye movement activity as a correlate of cognitive workload. *International Journal of Industrial Ergonomics*, 36, 623-636.
- Ryu, K., & Myung, R. (2005). Evaluation of mental workload with a combined measure based on physiological indices during a dual task of tracking and mental arithmetic. *International Journal of Industrial Ergonomics*, 35, 991-1009.
- Tole, J. R., Stephens, A. T., Vivaudou, M., Ephrath, A. R., & Young, L. R. (1983). *Visual scanning behavior and pilot workload* (NASA Contractor Rep. No. 3717). Hampton, VA: Langley Research Center.
- Van Orden, K. F., Limbert, W., Makeig, S., & Jung, T. (2001). Eye activity correlates of workload during a visuospatial memory task. *Human Factors*, 43(1), 111-121.
- Veltman, J. A., & Gaillard A. W. K. (1998). Physiological workload reactions to increasing levels of task difficulty. *Ergonomics*, 41(5), 656-669.
- Willems, B., Allen, R. C., & Stein, E. S. (1999). *Air traffic control specialist visual scanning II: Task load, visual noise, and intrusions into controlled airspace* (DOT/FAA/CT-TN99/23). Federal Aviation Administration, William J. Hughes Technical Center. Atlantic City International Airport, NJ.
- Wilson, G. F. (2002). An analysis of mental workload in pilots during flight using multiple psychophysiological measures. *International Journal of Aviation Psychology*, 12,(1), 3-18.