MAVERIC: Design and Multi-Stage Validation of a Wearable fNIRS Platform for Operational Neurophysiological Monitoring

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INTRODUCTION

Closing the Operational Neurophysiological Monitoring Gap

Military training and operations demand technologies capable of continuously monitoring Warfighter physiological and cognitive state without disrupting mission performance. Functional near-infrared spectroscopy (fNIRS) offers a non-invasive method for measuring cortical hemodynamics associated with cognitive workload, fatigue, and stress, but conventional systems remain largely confined to laboratory environments due to their size, weight and operational constraints (Geeseman et al., 2020).

MAVERIC was developed to address this capability gap through a compact, wearable neurophysiological sensing platform designed specifically for operational environments while maintaining scientific measurement quality.

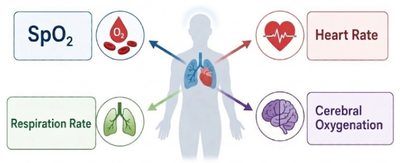
CAPABILITY DESCRIPTION

MAVERIC Wearable Neurophysiological Platform

The flexible MAVERIC fNIRS integrates multimodal physiological sensing into a lightweight forehead-mounted device designed for military training and operational environments. MAVERIC weighs about 16 grams, has up to 8 hours of battery life, and is easily applied to the skin with dual-sided medical adhesive.

MAVERIC core capabilities include functional near-infrared spectroscopy (fNIRS), heart rate, respiration, Oxygen saturation (SpO^2), and companion software for visualization, analytics and synchronized data collection.

The MAVERIC platform was engineered to minimize size, weight and operational burden while supporting compatibility with military equipment including flight helmets and mixed-reality systems.



APPLICABILITY TO MEDICAL ROLES OF CARE

From Reactive Care to Preventative Health Monitoring

MAVERIC supports proactive health monitoring by providing continuous, objective measures of physiological response during exposure to operational stressors. Integrated assessment of oxygen saturation, cardiovascular activity, respiration, and neurophysiological signals may enable earlier identification of physiological strain, support medical risk stratification, and inform individualized care decisions. By extending physiological monitoring beyond episodic clinical assessments, MAVERIC has potential to enhance medical surveillance, recovery tracking, and prevention strategies across training and operational environments.

TECHNICAL APPROACH

Human-Centered Development and Validation

System development followed an iterative human-centered design process incorporating feedback from subject matter experts, operational stakeholders, and end users throughout the engineering and testing lifecycle.

IMPACT TO THE WARFIGHTER

From Laboratory Measurement to Operational Insight

MAVERIC enables scalable assessment of warfighter state during realistic training and operational activities by overcoming limitations of traditional laboratory-based measurement approaches. Wearable neurophysiological monitoring provides objective insight into workload, fatigue, adaptation, and readiness, supporting improved training evaluation, performance optimization, and mission preparation. By enabling physiological assessment in representative environments, MAVERIC advances data-driven approaches for understanding and sustaining human performance in complex operational settings.

DEVELOPMENTAL STATUS

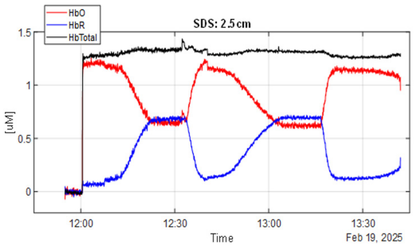
Advancing Toward Deployment

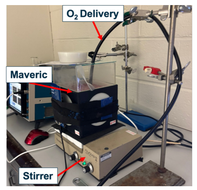
MAVERIC has reached Technology Readiness Level (TRL) 6 following engineering validation, laboratory testing, and human systems evaluations. Ongoing efforts focus on validating neurophysiological responses during hypoxia exposure and cognitive task performance while preparing the platform for environmental qualification, flight simulator evaluations, and live-flight demonstrations.

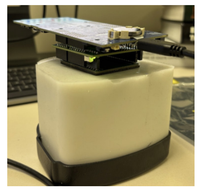
RESULTS

Multi-Stage Validation Demonstrates System Capability

Engineering, human systems, and operational testing demonstrated MAVERIC's capability across progressively realistic environments.



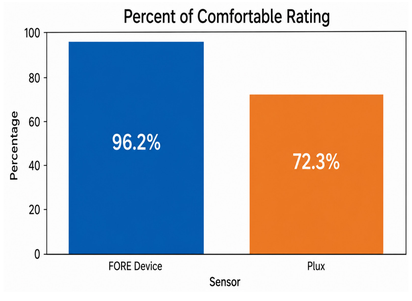




Engineering Validation

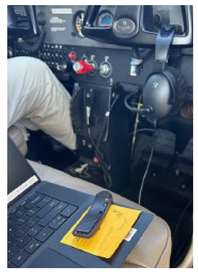
MAVERIC successfully detected controlled changes in oxygenation using blood-based liquid phantoms. Solid phantoms were used for linearity and noise tests.

	Comfort Mean	SD	*t*	*p*
VR Headset	4.00	0.77	-0.90	0.39
Helmet	3.70	1.06		
MAVERIC	4.43	0.51	-2.35	0.04*
Plux	3.76	0.83		



Wearability Validation

Multiple wearability studies have concluded participants report superior comfort for MAVERIC compared to a COTS device. Comfort has also been demonstrated under both flight helmets and virtual reality headsets.



Operational Compatibility

Cockpit evaluations demonstrated HGU-68/P helmet compatibility and no interference with avionics.

Human Performance Validation

While validation is ongoing, early results demonstrate that MAVERIC combines laboratory-grade sensing with operational usability through controlled human performance studies and ambulatory testing.

References & Citations

Geeseman, J., Balters, S., Cotton, O. F., Kiehl, Z., Lucia, L., & Tenison, C. (2020). Functional near-infrared spectroscopy (fNIRS) in an aerospace environment: Challenges and considerations. *Aerospace Medicine and Human Performance*, 91(10), 833-835.

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