Operational Biomechanics & Ergonomics (OBiE) Lab

Naval Medical Research Unit Dayton

Mission:
To maximize warfighter performance and survivability through premier aerospace medical and environmental health effects research by delivering solutions to the Field, the Fleet and for the Future.

Vision:
By working with military, government, academic and industry partners, we will develop innovative solutions for the aeromedical and environmental health threats faced by our Navy and Marine Corps.

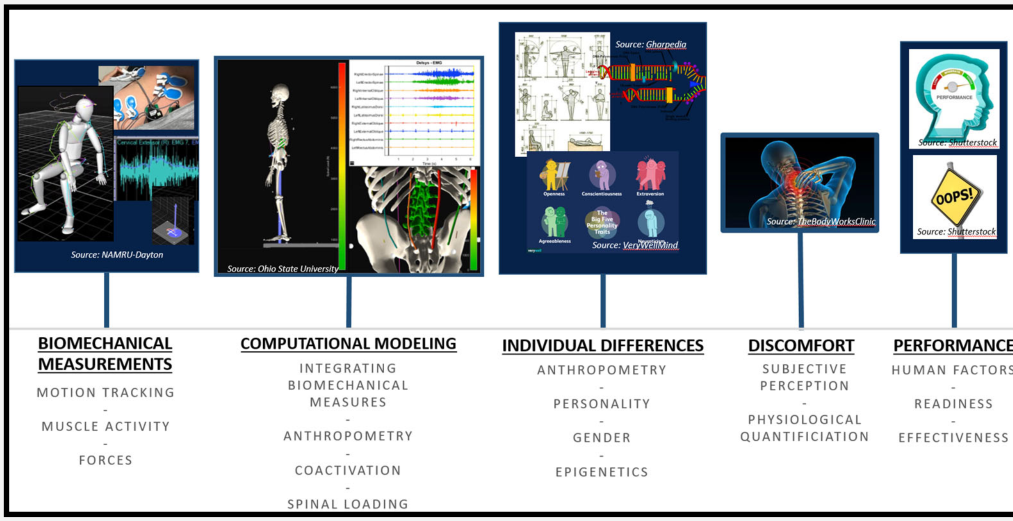
Principal Investigator
- Dr. Peter Le

Program Areas of Focus & Collaboration

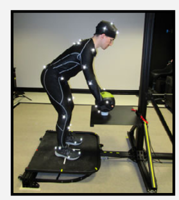
- Aviator/Aircrew Neck and Back Pain
- Quantification of Return-to-Duty
- Biomechanical Systems Evaluation
- Ergonomic & Biomechanical Tools for Warfighter Health

Leveraging the Biopsychosocial Model

Musculoskeletal research driven by the complex, multi-factorial interaction of physical, psychosocial/organizational factors, and individual differences. The OBiE Lab is able to quantify musculoskeletal effects through tools (not exhaustive) such as: full-body motion tracking, electromyography (muscle activity), force plates/ transducers, and near infrared spectroscopy (localized blood oxygenation) to understand injury mechanisms from the operational environment.



Current Research Efforts

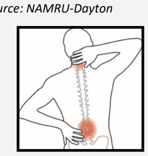


Source: NAMRU-Dayton

Causal Mechanisms
- Neck Pain as a Function of the Interaction between Physical and Visual Stressors (ONR ILIR)
- Neck Muscle Coactivation from Cognitive Workload & Individual Differences (JPC-5)
- Spinal Loading during Vertical Vibration Exposure (JPC-5)
- Motion Sickness and Spine Disorders (OFRN)

Source: NAMRU-Dayton

Methods to Quantify Return-to-Duty
- Neuromuscular Trunk Instability and Prolonged Seating (JPC-5)



Biomechanical Systems /
Ergonomic and Biomechanical Tools for Warfighter Health
- Evaluation of an IMU-Driven, Motion Analytics System for Military Use (DHP 6.7)
- Evaluation of a Markerless Motion Capture System to Assess at-Risk Airmen (DHP 6.7)

Strategic, Long-Term Target Areas

- Risk classifications for in-flight monitoring systems
- Field-deployable functional assessments
- Development and validation of transitional products
- Interventions (Prevention and Rehab)

Partnerships

- USAF 711th HPW and USAFSAM
- The Ohio State University
- University of Cincinnati
- Wright State University
- Harvard University/MGH

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August 2020

Multi-Axis Balance Perturbation Platform

Naval Medical Research Unit Dayton

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Investigators

- Dr. Daniel Merfeld

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The Multi-axis Balance Perturbation Platform (MBPP) supports basic clinical vestibular and balance function, Augmented and Virtual Reality coupled to motion, standing and seated vehicle operation (human in the loop) motion and motion sickness research. The device is housed in NAMRU-Dayton's Naval Aerospace Medical Research Laboratory (NAMRL).

Specifications

Base Footprint	36.25" × 36.25"	Total Weight	395 lbs.
Motion Limits	40" × 40" × 25"	Platform Area	39" × 25"
Power	10 Amps @ 220 VAC, 2 phase		

Motion Capabilities

- The MBPP is a motion device capable of multi-dimensional motion in the pitch, roll, and vertical heave directions with a functional surface area of 980.6 square inches. This device is capable of over 16 degrees of tilt motion in both roll and pitch directions as well as over 4 inches of vertical (heave) motion.

System Safety

- The MBPP is approved for use with human subjects by the NAMRU-Dayton Device Safety Certification Committee. The MBPP has conducted Institutional Review Board (IRB) approved research studies on 1) Evaluating simulator sickness in mixed reality environments[1], and 2) Postural instability and simulator seasickness[1].

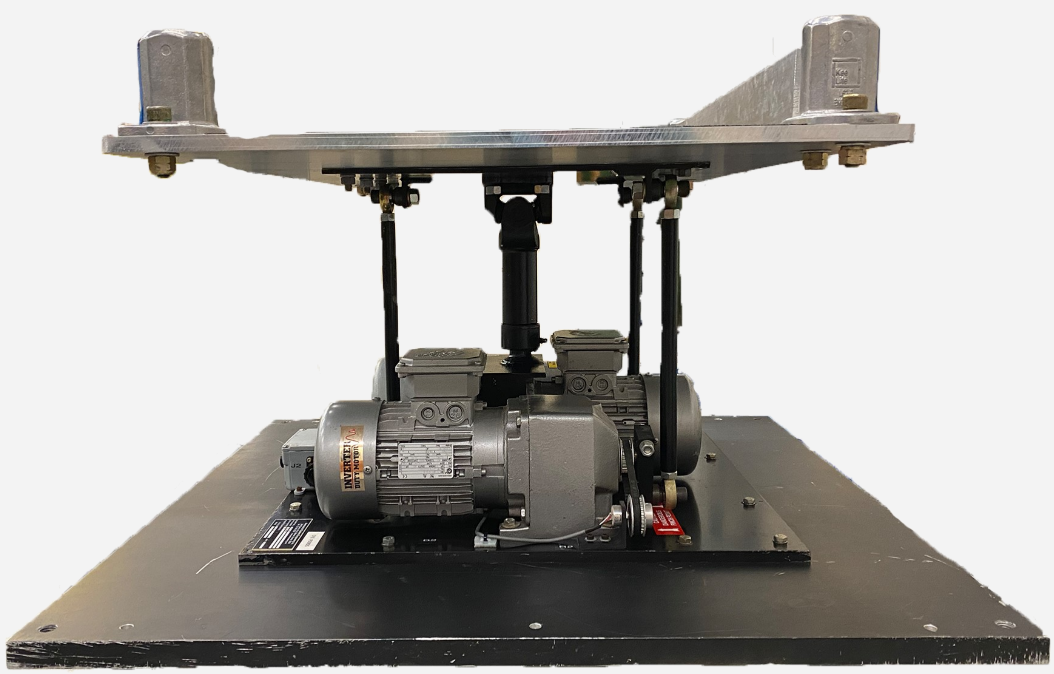

Photo courtesy of NAMRU-Dayton

[1] Pettijohn KA, Geyer D, Gomez J, Becker WJ, Biggs AT. Postural instability and simulator seasickness. Aerosp Med Hum Perform. 2018; 89(7):634–641.

Disorientation Research Device: The Kraken™

- Research Capabilities
- Specifications
- System Safety
- Motion Capabilities

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Research Capabilities

- Authentic vehicular replication or other dynamic motion in six degrees of freedom can be programmed or man-in-the-loop with appropriate motion washout.
- Realistic simulation of aviation environments with customizable capsule configurations supporting one or two side-by-side occupants.
- Real-time data acquisition system for physiological monitoring.
- On-board real-time data acquisition system & point to point (to control room) wireless network for physiological monitoring, data collection and scenario control.
- Low Electromagnetic Interface (EMI) capsule environment supports Bluetooth subject mounted sensors.
- State of the art eye & head tracking; up to two occupants.
- High resolution, wide field of view, & reconfigurable motion synchronized visual display.
- Active noise reduction capable headsets, helmets or ambient capsule subject communications supported.

System Safety

- Motion & Safety computers together monitor over 450 interlocks 125 times per second.
- Fail-safe braking system & Uninterruptible Power Supply for capsule homing.
- Complete System Safety Analysis provided under contract with delivery.

Specifications

- Motion base is a 35.5 ft. diameter platform turning 245,000 lbs. of rotating mass and two 50 ft. arms.
- Capable of sustained planetary acceleration field up to 3.0 G.
- Up to 680 lbs. of customer payload and 32 cubic ft. configurable payload space with Original Equipment Manufacturer (OEM) single seat installed.
- Time max G ≤ 5 seconds.
- All six axes are bi-directional and all six can operate simultaneously.

Motion Capabilities

Axis	Motion Range	Position Accuracy	Velocity	Velocity Accuracy	Acceleration	Acceleration Accuracy	Dynamic Bandwidth
Planetary	360°	±0.4°	±150°/s	±0.7°/s	$30°/s^2$	$±1.0°/s^2$	0.5 Hz
Roll	360°	±0.4°	±180°/s	±0.7°/s	$±200°/s^2$	$±1.0°/s^2$	1.0 Hz
Yaw	360°	±0.4°	±180°/s	±0.7°/s	$±200°/s^2$	$±1.0°/s^2$	1.0 Hz
Pitch	360°	±0.4°	±180°/s	±0.7°/s	$±200°/s^2$	$±1.0°/s^2$	1.0 Hz
Vertical	±3 ft.	±0.45 in.	±6.6 ft./s	±1.5 in./s	$±16\ ft./s^2$	$±2.3\ in./s^2$	0.5 Hz
Horizontal	±16.5* ft.	±0.45 in.	11 ft./s	±1.5 in./s	$±16\ ft./s^2$	$±2.3\ in./s^2$	0.5 Hz

Investigators

- CAPT Richard Folga
- Dr. Henry Williams
- Dr. Daniel Merfeld

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Altitude Effects Laboratory

- Respiratory Physiology
- Alternobaric Effects

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Investigators

- Dr. Eric Robinson
- Dr. Matthew Funke
- Megan Gallo
- Stephanie Warner
- Dr. Dan Warkander

More from NAMRU-D Altitude Effects Program

- Aircrew Status Monitoring
- Mitigation & Related Research

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Combined Effects of Hypoxic Exposure

Evaluating hypoxic environments to determine if multiple exposures to varying severities of hypoxic events cause a change to their effects on the body. Task efficiency to be determined after the exposures to examine if the interactions between the events causes different symptoms to arise or changes the results of the flight efficiency.

Effects of Breathing Gas Mixtures

Researchers are evaluating how differing combinations of oxygen, nitrogen, and carbon dioxide breathing gas mixtures affect operators and aircrew. Task performance, electroencephalography, visual perception, and respiratory physiology will be measured to determine the response to each inhaled compound.

Hypocapnia

Joint research effort between NAMRU-D and 711th Human Performance Wing (711 HPW) looking to measure systemic carbon dioxide via transcutaneous monitoring, exhaled breath, and venous blood draws at select altitudes in a hypobaric chamber in attempt to identify hypocapnia or suggestive trends thereof.

Atelectasis

This multi-year effort seeks to measure atelectasis induced by factors that aircrew are regularly exposed to, such as, high oxygen concentrations and accelerations >1Gz. Ultimately, this effort will provide recommendations for ideal breathing gas mixtures to minimize the risk of atelectasis in fighter aircrew.

F-35 Pulmonary Function Testing

Joint research effort between NAMRU-D and USAFSAM to measure pulmonary function, static atelectasis, and airway inflammation in a laboratory comparable F-35A seat configuration, pilot flight ensemble, and breathing system.

Hypoxia Ventilation Research Device

This multi-year collaborative effort with USAFSAM includes the development, validation, and miniaturization of the HVRD - a normobaric gas delivery system designed to recreate the aviator's breathing experience in the cockpit through the dynamic manipulation of gas concentrations, pressure, and flow.

Effects of In-line Breathing Resistance

A three year effort examining the effects of breathing resistance caused by various components of the aircraft life support system (LSS), to include gas flow, external harnesses/equipment and seat ergonomics. Research findings aim to identify areas where the LSS can potentially be modified to better support pilot respiratory demands.

Pressure Fluctuations

This effort will examine task performance and physiological changes brought about pressure changes created within a hypobaric altitude chamber. Performance will be evaluated through a cognitive task, while physiological changes will be assessed via blood oxygen saturation, blood-bound carbon dioxide, heart rate, respiration rate, and biomarkers of pressure-related stress found in circulating hemoglobin. PMA 265 sponsored.

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Aircrew Status Monitoring

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Investigators
- Stephanie Warner
- Dr. Richard Arnold
- Dr. Barbara Shykoff
- Dr. Dana DiPasquale

More from NAMRU-D
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- Mitigation & Related Research

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Hypoxia Sensor Evaluation
Joint project with 711 HPW and USAFSAM. Candidate O_2, CO_2, pressure, and flow sensors are tested in simulated tactical aviation environments using the hypobaric chamber in NAMRU-D's Sensors Laboratory. Successful devices are anticipated to be integrated into aircrew flight equipment for hypoxia detection. USAF (711 HPW) sponsored.

Forehead Mounted Oximetry for Naval Aviation
Collaboration with Thera Tactics to develop, test, and integrate a proprietary enhanced pulse oximetry solution to reliably capture real time arterial oxygen saturation (SpO_2) under the extreme conditions of high performance flight. BUMED sponsored.

Real Time Air Quality Sensor System
U.S. Air Force 711 HPW and NAMRU-D Environmental Health Effects Laboratory (EHEL) collaboration to look into the connection between physiological episodes (PEs). Team will install USAF-developed RTAQS in T-45 and FA-18 to take data from breathable air and determine the effectiveness of the On-Board Oxygen Generation System at producing non-contaminated air at appropriate rates. The data collected will inform possible redesign of the RTAQS.

Physiological, Gas, & Chemical Sensors
This effort aims to evaluate the efficacy of aviation-specific sensors developed to address physiologic episodes. Research involves environmental and manned testing of the performance and reliability of each sensor. Additionally, an evaluation of the physiologic and structural impact that each sensor, independently and in combination, may have on the aviator during flight will be conducted.

Fast-jet Physiologic Sensors
Collaborative effort with NAVAIR and 711HPW to develop a physiologic monitoring and warning system. Research involves evaluation and adaptation of aviation-specific sensor suites for inclusion in algorithms developed to alert the aviator of potential physiologic threats.

T-45 Life Support System
Examining the effect of transient periods of low on-board oxygen generation system (OBOGS) inlet pressure on pilot physiology and performance. Research findings will be used to help set thresholds for alarms or supplemental systems.

Smart Regulator
Joint collaboration with 711HPW and industry to develop and test a dynamic breathing regulator driven by aircrew physiologic status in real-time.

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Altitude Effects Laboratory

» Mitigation & Related Research

3-Way Hypoxia Training Comparison
NAMRU-D and USAF 711th Human Performance Wing (711 HPW) collaboration investigating symptomology, physiologic response, and reaction time in three hypoxia familiarization trainers: the normobaric ROBD, hypobaric chamber, and normobaric hypoxia chamber. USAF 711 HPW sponsored.

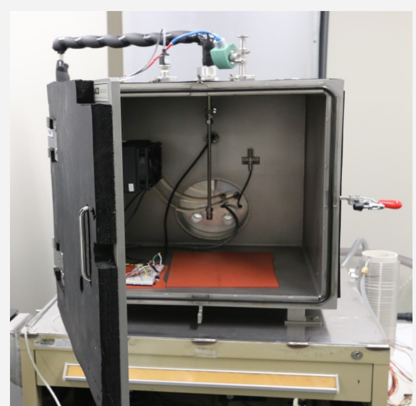
En Route Care Provider Performance
USAF 711 HPW collaboration. NAMRU-D examining effects of long transport flights at low altitudes (4k and 8k ft.) on the providers of en route care to wounded service members. USAF 711 HPW sponsored.

Improved Resistance and Recovery with Ketones
NAMRU-D researchers investigate ketone supplement as nutritional intervention for both hypoxia resistance and recovery. JPC5 sponsored.

Neural Signatures of Hypoxia
The objective of this research is to examine the efficacy of an EEG signal complex, known as Mismatch Negativity/P3a, in predicting the onset of performance deficits in hypoxia earlier and more accurately than pulse oximetry. This passive method of assessing brain functioning during hypoxia has the promise of overcoming the idiosyncratic physiological symptom sets that make the characterization and mitigation of physiological episodes extremely difficult.

Vision Impairment-based Hypoxia Display
NAMRU-D supporting Rensselaer Polytechnic Institute display testing using the Reduced Oxygen Breathing Device (ROBD). ONR sponsored.

Reduced Oxygen Breathing Device (ROBD); NAMRU-D houses 6 ROBDs.



Small Hypobaric Environmental Chamber or sensor testing in aviation-relevant environmental conditions. Can vary pressure, temperature, humidity, & airflow on sensors of interest.

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Investigators
- Megan Gallo
- Dr. Leslie Drummond
- Dr. Matthew Funke

More from NAMRU-D Altitude Effects Program
- Respiratory Physiology & Alternobaric Effects
- Aircrew Status Monitoring

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Fatigue Assessment and Countermeasures Laboratory

- Differential Effects of Modafinil
- Using Event-related Potentials
- Effects of Strategic Napping and Modafinil
- Research Polysomnography Lab

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Differential Effects of Modafinil on Performance of Fatigue-Susceptible and Fatigue-Resistant Individuals

Comparison of fatigue-susceptible individuals to fatigue-resistant individuals to determine whether modafinil affects performance differently in these two groups. JPC-5 sponsored.

Using Event-related Potentials to Quantify the Impact of Sustained Wakefulness and Fatigue Countermeasures on Cognitive Processing

Examination of how auditory P300 event-related potential component peak amplitude and latency vary with human performance metrics traditionally used to assess cognitive attributes of sustained wakefulness, to include stimulus evaluation and response selection. JPC-5 sponsored.

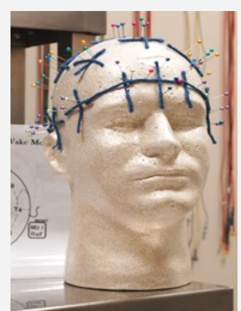
Effects of Strategic Napping and Modafinil

Examination of whether combination of short naps and low doses of the anti-fatigue medication modafinil (ProvigilTM) can reduce the severity and duration of sleep inertia and improve performance during long hours of wakefulness. Collaboration with 711 HPW; JPC-5 sponsored.

Research Polysomnography Lab (Sleep Lab)

Two bed unit with ability to monitor brain waves & other physiologic functions of both subjects simultaneously.

One of the two bed units in the NAMRU-D state-of-the-science Sleep Lab.



Polysomnographic recording used to assess effects of countermeasures on sleep.

<u>Investigators</u>

- Dr. Lynn Caldwell

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Motion Sickness Countermeasures Laboratory

- Pharmacokinetic & Efficacy Profile of Low-Dose Intranasal Scopolamine
- The Effects of Active Behavior vs. Passive Kinesis on Motion Sickness
- Evaluating Simulator Sickness in Mixed Reality Environments

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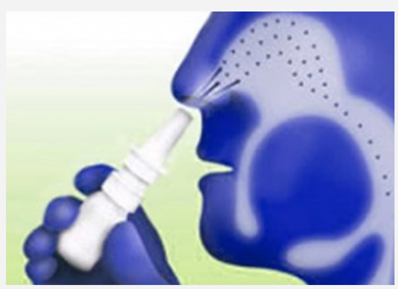
Investigators
- LT Adam Biggs, PhD
- LCDR Matthew Doubrava, MD
- Daniel Geyer
- Jacqueline Gomez

Pharmacokinetic & Efficacy Profile of Low-Dose Intranasal Scopolamine
Testing to determine efficacy, pharmacokinetics, & side effects of intranasal scopolamine, as potential "just in time" motion sickness (MS) countermeasure. BUMED sponsored.

The Effects of Active Behavior vs. Passive Kinesis on Motion Sickness
Comparison of the two primary theories of motion sickness etiology: Sensory Conflict Theory and Postural Instability Theory using a motion platform operation driven from real-world small boat accelerometer data.

Evaluating Simulator Sickness in Mixed Reality (MR) Environments
Assessment of current state-of-the-art MR technologies for the presence and absence of simulator sickness (SS) by comparing head-mounted immersive displays (Oculus Rift) with new augmented reality displays (Microsoft Hololens). ONR ILIR supported.

User-Worn Display to Mitigate Motion Sickness
Testing to determine efficacy of Heads-Up Display (HUD) symbology for potential motion sickness countermeasure. USAF sponsored collaboration with Wyle.



Barany Chair in the NAMRU-D Neuro-Otologic Test Center (NOTC).

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UAS Personnel Selection

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Investigators

- CDR Tatana Olson, PhD
- Dr. Henry Williams

》 Selection of Unmanned Aircraft System Operators (SUPer)

Selection of Unmanned Aircraft System (UAS) Operators

Development and validation of cognitive and personality measures predictive of Unmanned Aircraft System (UAS) operator job performance. Collaboration with Naval Aerospace Medical Institute, Naval Health Research Center, NAVAIR, USAF 711 HPW, Air Force Personnel Center, and Georgia Tech. Office of Naval Research sponsored.

A simulator of an Unmanned Aircraft System (UAS) in the aeromedical laboratory at NAMRU-D.

A Firescout unmanned aerial vehicle takes off from the flight deck of a littoral combat ship USS Coronado (LCS 4) off the coast of Guam. (U.S. Navy)

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Spatial Disorientation

- The Spatial Disorientation Problem
- In-House and Collaborative SD Research
- Spatial Disorientation Trainer Night Vision Device Upgrade

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Investigators
- Dr. Henry Williams
- Dr. Michael Reddix

The Spatial Disorientation (SD) Problem

Spatial Disorientation (SD) remains a leading cause of catastrophic flight mishaps across DoD in all manned platforms. Between 1980 & 2008, SD was causal in 28.6% of Naval Aviation Class A Mishaps. The Naval Safety Center cites SD as the number one Aeromedical causal factor in Aviation Class A* mishaps between 1991-2011.

**Class A Mishap: $2 Million in material property damage, fatality or permanent total disability.*

In-House and Collaborative SD Research

Existing flight simulator training programs do not adequately teach pilots how to recognize & recover from SD. Current research efforts are focused on the development and validation of seven SD simulator training scenarios and collaborations with the Army, Air Force, and the University of Iowa on improved SD models, SD in Rotary Wing DVE, and in-flight HMD evaluation.

Spatial Disorientation (SD) Trainer Night Vision Device (NVD) Upgrade

The purpose of this effort is to reduce mishaps & improve cockpit performance by creating training scenarios that will prevent SD under NVD flight conditions. NAVAIR sponsored.


Spatial Disorientation Dome housed at NAMRU-D Spatial Disorientation lab.
Specs: 180° x 90° FOV


Spatial Disorientation simulator housed at NAMRU-D Spatial Disorientation lab.
Specs: 87° x 49° FOV


Spatial Disorientation simulator housed at NAMRU-D Spatial Disorientation lab.
Specs: 130° x 60° FOV

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Vision Sciences Laboratory

- Validation of Computer-Based Color Vision Tests for Use in Naval Aviation Selection
- Laser Veiling Glare and Laser Eye Protection (LEP)
- Impact of Low-level Neurotoxin Exposure on Aircrew Performance

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Investigators
- Dr. Michael Reddix
- LCDR Micah Kinney, OD, PhD
- Dr. Matthew Funke

Validation of Computer-Based Color Vision Tests for Use in Naval Aviation

Color-rich informational displays in modern military aircraft have increased color-discrimination demands. Current efforts involve evaluation of new color-vision tests and development of selection criteria for use in aviation candidate screening. NAMRU-D research has resulted in NAMI & CNAF recommendations to adopt three new color-vision tests.

Laser Veiling Glare and Laser Eye Protection (LEP)

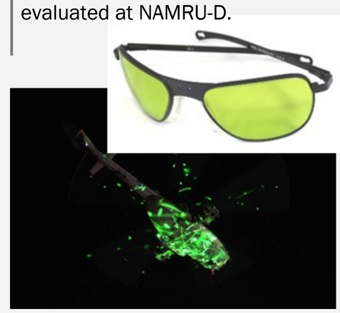
Increasingly powerful hand-held laser pose a threat to aviation safety when they are used to illuminate aircraft cockpits. Collaboration with AFRL/RXAP to evaluate laser eye protection solutions designed for a) mitigating veiling glare, b) night use, c) NVG/HUD compatibility, and d) NIR threat protection.

Impact of Low-level Neurotoxin Exposure on Aircrew Performance

Non-lethal neurotoxin exposure (e.g., sarin/soman) poses a threat to aircrew, inducing miosis and accommodative spasm and adversely affecting vision. Partnership with DTRA and AFRL/RHXM to evaluate aviation, NVG, and marksmanship performance using a FDA-approved surrogate with labeled use to induce miosis.

NAMRU-D's Vision Science Laboratory houses the Bug Eye.

Laser Eye Protection solutions are evaluated at NAMRU-D.



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Training and Virtual Environments Laboratory

- Cognitive Control in Lethal Force Decision-making
- Simulator Sickness and Human Performance in Mixed Reality Environments
- Effect of Active Behavior versus Passive Kinesis on Motion Sickness

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Cognitive Control in Lethal Force Decisions

Sailors and Marines often have mere seconds to make critical decisions in forward operating environments. Efforts focus on examination of the cognitive abilities that contribute to fast and accurate lethal force decision-making through a mixture of simulated-fire and live-fire shooting exercises.

Evaluating Simulator Sickness in Mixed Reality Environments

Investigation of whether virtual reality (VR) or augmented reality (AR) creates the better training platform by answering: 1) to what extent each approach induces simulator sickness, 2) whether any sickness symptoms impact human performance, 3) how much human performance is impacted by motion in each environment, and ultimately 4) can we use VR or AR for training aboard ships? Partnering with the Battlespace Exploitation of Mixed Reality (BEMR) laboratory to use the GunnAR scenario and simulate firing a .50 caliber machine gun from the bow of a ship.

Effect of Active Behavior versus Passive Kinesis on Motion Sickness

Motion sickness is a pervasive challenge facing Sailors and Marines in a wide variety of environments. Research involves examination of several theories about why motion sickness occurs so that we can design better and more informed interventions in the future.

Investigators

- LT Adam Biggs, PhD
- Dr. Kara Blacker
- Dr. Kyle Pettijohn

Experiments with the Indoor Simulated Marksmanship Trainer System (ISMT)

Virtual reality (VR) and augmented reality (AR) studies with the motion platform

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Public Affairs
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Approved for Public Release
September 2018

Aerospace Neuroscience Laboratory

- Novel EEG Methodology, Real-Time Hypoxia Detection
- Neurofeedback Training, Fatigue Symptom Mitigation
- White Matter Hyperintensities using MRI

Naval Medical Research Unit Dayton

Mission:
To maximize warfighter performance and survivability through premier aerospace medical and environmental health effects research by delivering solutions to the Field, the Fleet and for the Future.

Vision:
By working with military, government, academic and industry partners, we will develop innovative solutions for the aeromedical and environmental health threats faced by our Navy and Marine Corps.

Novel EEG Methodology for Real-Time Hypoxia Detection

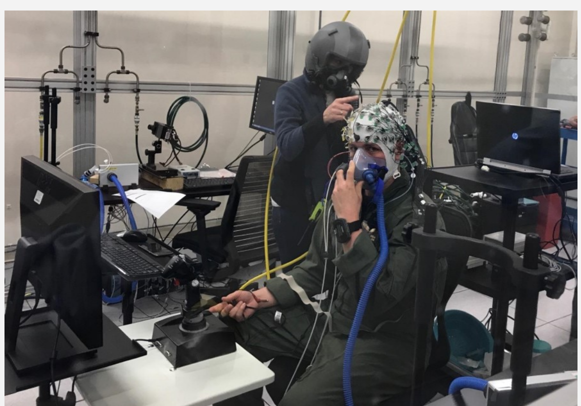
Existing methods of detecting hypoxia in aircrew have poor fidelity and poor links to human performance. Examination of an experimental EEG paradigm known as Mismatch Negativity as a hypoxia detection biomarker. Goal is to establish a proof-of-concept that this method is a superior predictor of performance relative to other wearable biosensors.

Neurofeedback Training for Fatigue Symptom Mitigation

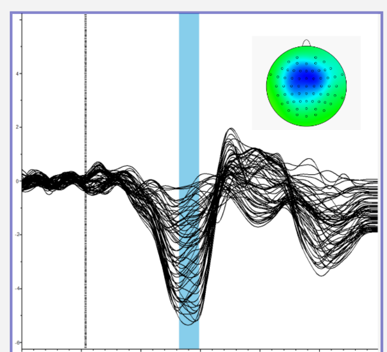
Fatigue is ubiquitous in the military aviation community and pharmacological fatigue countermeasures have significant side effects. Current efforts are focused on designing an individually-tailored training protocol to teach military personnel to activate brain regions associated with wakefulness using real-time neurofeedback training in an MRI scanner.

White Matter Hyperintensities in F/A-18 Aircrew

Increased frequency of neurotrauma in has been observed in certain military aviation communities (e.g., U-2 aircrew). White matter hyperintensities may be a biomarker of neurotrauma related to hypoxia, rapid pressure changes, and/or contaminants. Research efforts involve scanning a large sample of F/A-18 aircrew to identify the prevalence of WMHs and possible links to physiological episodes.



EEG Testing in NAMRU-D's Reduced Oxygen Breathing Environment (ROBE)



Real-time data collection and artifact rejection of EEG data

<u>Investigators</u>

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