Altitude Effects Laboratory

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.

Investigators
- Dr. Eric Robinson
- Dr. Matthew Funke
- Megan Gallo
- Stephanie Warner

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.

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.

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.

More from NAMRU-D
- Altitude Effects Program
  - Aircrew Status Monitoring
  - Mitigation & Related Research
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**Investigators**
- Stephanie Warner
- Dr. Richard Arnold

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**Altitude Effects Program**
- Respiratory Physiology & Alternobaric Effects
- Mitigation & Related Research

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**Aircrew Status Monitoring**

**Hypoxia Sensor Evaluation**
Joint project with 711 HPW and USAFSAM. Candidate O2, CO2, 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 (SpO2) 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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**More from NAMRU-D**

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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.

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 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.

Investigators
- Dr. Lynn Caldwell
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

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.

Investigators
- LT Adam Biggs, PhD
- LCDR Matthew Doubrava, MD
- Mr. Daniel Geyer
- Ms. Jaqueline Gomez

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UAS Personnel Selection

Selection of Unmanned Aircraft System Operators (SUPer)

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Investigators:
- CDR Tatana Olson, PhD
- Dr. Henry Williams

Selection of Unmanned Aircraft System (UAS) Operators

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
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.

Investigators
- Dr. Henry Williams
- Dr. Michael Reddix

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Investigators:
- CAPT Richard Folga
- Dr. Henry Williams
- Dr. Dan Merfeld

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

<table>
<thead>
<tr>
<th>Axis</th>
<th>Motion Range</th>
<th>Position Accuracy</th>
<th>Velocity</th>
<th>Velocity Accuracy</th>
<th>Acceleration</th>
<th>Acceleration Accuracy</th>
<th>Dynamic Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planetary</td>
<td>360°</td>
<td>±0.4°</td>
<td>±150°/s</td>
<td>±0.7°/s</td>
<td>30°/s²</td>
<td>±1.0°/s²</td>
<td>0.5 Hz</td>
</tr>
<tr>
<td>Roll</td>
<td>360°</td>
<td>±0.4°</td>
<td>±180°/s</td>
<td>±0.7°/s</td>
<td>±200°/s²</td>
<td>±1.0°/s²</td>
<td>1.0 Hz</td>
</tr>
<tr>
<td>Yaw</td>
<td>360°</td>
<td>±0.4°</td>
<td>±180°/s</td>
<td>±0.7°/s</td>
<td>±200°/s²</td>
<td>±1.0°/s²</td>
<td>1.0 Hz</td>
</tr>
<tr>
<td>Pitch</td>
<td>360°</td>
<td>±0.4°</td>
<td>±180°/s</td>
<td>±0.7°/s</td>
<td>±200°/s²</td>
<td>±1.0°/s²</td>
<td>1.0 Hz</td>
</tr>
<tr>
<td>Vertical</td>
<td>±3 ft.</td>
<td>±0.45 in.</td>
<td>±6.6 ft/s</td>
<td>±1.5 in./s</td>
<td>±16 ft/s²</td>
<td>±2.3 in./s²</td>
<td>0.5 Hz</td>
</tr>
<tr>
<td>Horizontal</td>
<td>±16.3 ft.</td>
<td>±0.45 in.</td>
<td>11 ft/s</td>
<td>±1.5 in./s</td>
<td>±16 ft/s²</td>
<td>±2.3 in./s²</td>
<td>0.5 Hz</td>
</tr>
</tbody>
</table>
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*Investigators*
- Dr. Michael Reddix
- LCDR Micah Kinney, OD, PhD
- Dr. Matthew Funke

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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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**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.

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**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.

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**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.

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

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Laser Eye Protection solutions are evaluated at NAMRU-D.

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

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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.

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**Experiments with the Indoor Simulated Marksmanship Trainer System (ISMT)**

**Virtual reality (VR) and augmented reality (AR) studies with the motion platform**
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.
Investigators
• LCDR Matt Doubrava, MD
• Dr. Peter Le

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Spine Health Improvement Program (SHIP)

» Semi-Active Magnetorheologic Seat Suspension (SAMSS)
» Treatment Effectiveness for Chronic Back Disorders Using Quantitative Measures (TEC Back)
» SensOR Evaluation for Back and Cervical Spine (SORE BACS)
» Military Women’s Health: Neck Pain in Aviators

SAMSS
Aircraft generate vibrations from flight that are transmitted to aircrew. This vibration may increase neck and back fatigue and injury risk. Collaboration with 711th HPW to evaluate a NAVAIR-designed system that reduces vibration transmission.

TEC Back
NAMRU-D is partnering with The Ohio State University’s Spine Research Institute to validate objective measurements of back function in military populations and assess treatment efficacy and return to work metrics.

SORE BACS
Sensors exceeding simple Range-Of-Motion (ROM) measures to accurately and reliably obtain motion kinematics exist. Such sensors use multivariate data and advanced algorithms to provide objective measurements of back and neck function, independent of pain. NAMRU-D is looking to conduct lab and field sensor assessments to independently validate manufacture claims and generate clinical usability assessments to identify best solutions for DoD healthcare providers.

Military Women’s Health Research
NAMRU-D and U.S. Army Aeromedical Laboratory are looking to partner to identify causal factors for neck pain in female aviators through objective biomechanical measures.

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