Naval Medical Research Unit Dayton
Wright-Patterson AFB, Ohio

Science Update

Volume 3, Issue 3 Summer

NAMRU-D MISSION:

To maximize warfighter performance and survivability through premier aeromedical and environmental health research-delivering solutions to the field, the Fleet, and for the future.

Inside this issue:

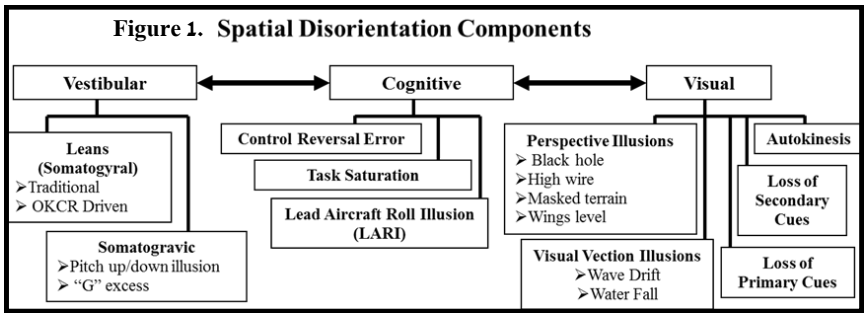
MED64 to Assess Neurotoxicity	2
Color Vision Deficiency for Special Duty Operations	3
Aeromedical Directorate at Scientific Conferences	3
Tours Support Jointness and Collaborative Research Efforts	4
Safe Exposure Levels of Carbon Dioxide on Submarines	4
Investigator Receives 2012 Etter Award	5
NAMRU-D Personnel Accept Significant Awards	5
NAMRU-D Products & Presentations	6
CO's Corner	7

Advanced Techniques for U.S. Navy and Marine Corps Spatial Disorientation Countermeasures Training

Dr. Fredrick Patterson & Dr. Henry Williams

Aviation spatial disorientation (SD) is best described as a pilot's inability to correctly interpret aircraft attitude, altitude, or airspeed in relation to the earth or other points of reference. If not recognized immediately, this sensory misperception can lead to controlled flight into the ground, midair collision, or inappropriate control inputs resulting in a serious mishap. The ubiquity of this problem has been well documented by mishap reports and surveys that indicate virtually all pilots experience some form of SD during their careers, and SD is the leading cause of Class A mishaps in Naval Aviation. Although many of the past explanations for SD have concentrated on isolated vestibular illusions as primary causal factors, the growing consensus among SD researchers is that disorientation in the cockpit is most likely generated from conflicting visual and vestibular cues that confound cognitive processing of pilot spatial strategies. This revised interpretation of causal factors has helped NAMRU-D researchers identify and classify common SD events, which has further led to the specification of vestibular, cognitive, and visual components of SD (Figure 1). To help pilots recognize and avoid SD, NAMRU-D is currently generating SD training countermeasures that incorporate emerging concepts gathered from recent mishap analysis, physiological incident reports, and ongoing aeromedical research. This work is being funded by Naval Air Systems Command PMA-205 (Aviation Training Systems). Using low cost simulators, flight scenarios are being designed, tested, and validated as training tools to teach flightcrew members how to recognize, cope with, and recover from the most prevalent forms of SD. This work is unique in that it increases the emphasis on how pilots use, or sometimes mis-use, spatial cues such as the natural horizon, the artificial horizon instrument, and aircraft structure reference points (e.g., the canopy bow or the top of the glare shield). This work is also studying how pilots develop spatial strategies that incorporate these spatial cues, and how we might be able to create training scenarios that promote better spatial strategy development and application.

Figure 1. Spatial Disorientation Components



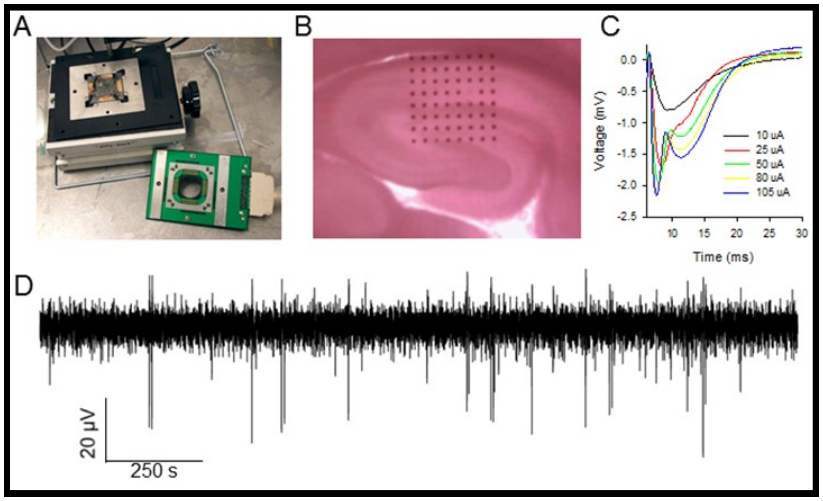
Spatial Disorientation Dome at the NAMRU-D Spatial Disorientation Laboratory.

Using MED64 to Assess Neurotoxicity

Dr. Joyce Rohan, Dr. Vivian Vralsted & Mr. Shawn McInturf

The brain is a critical target of several toxins present in operational environments. In order to better understand the effects of known or potential neurotoxins, we can study what happens when brain cells are exposed to these substances in a dish were we can measure changes to their inherent electrical activity. The Environmental Health Effects Research Directorate at NAMRU-D has established an electrophysiological approach to investigate brain function by directly measuring neuronal activities using the MED64 microelectrode array system. This newly updated capability elegantly complements our existing neurobehavioral assays, enabling the assessment of brain function at multiple levels ranging from microscopic cellular events to readily observable behavior.

Neurons communicate through a tightly coupled chemical and electrical process called synaptic transmission or neurotransmission. The interconnectivity among these neurons forms a complex network of circuitry that translates molecular events into perceived actions as well as cognitive processes. Using MED64, we can measure evoked synaptic transmission from distinct brain regions triggered by electrical or chemical stimuli of varying strengths, induce long-term changes in the strength of synaptic transmission that is believed to be essential for learning and memory, and track the frequency and pattern of spontaneous synaptic activity that is indicative of neuronal stress.



(A) Our microelectrode array system, MED64, equipped with 64 electrodes arranged in an 8x8 array, is capable of simultaneously recording from 64 distinct regions within a biological sample. (B) An example image of a hippocampal slice on a MED64 probe. (C) An example graph of synaptic responses evoked by several stimuli of varying strengths. (D) An example trace recording of spontaneous synaptic activity.

Dr. Joyce Rohan (right) explains to LCDR Steele (left) from ONR MED64's ability to detect and measure neuronal activity during his visit to NAMRU-D this past June.

Such systematic analysis of synaptic transmission at multiple brain regions provides electrophysiological data that can serve as potential biological markers for disruptions in sensory, motor, and cognitive functions. We can measure neuronal function of brain tissue collected from rats either following whole animal exposure to specific environmental conditions, or during application of a chemical of interest directly onto the brain slice on the dish. Furthermore, data from the MED64 system can reveal insightful information pertaining to the mechanism of action of toxins or stressors.

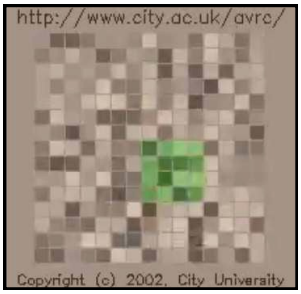
MED64's ability to detect and measure neuronal activity makes it a powerful tool that not only enhances our capability to perform various neurotoxicological assessments, but also provides mechanistic insight that can potentially lead to preventive strategies or therapeutic interventions to combat adverse effects induced by environmental hazards or stressors.

Currently, we are collaborating with the U.S. Air Force 711th Human Performance Wing to develop projects and proposals that will utilize MED64's capability to assess neurotoxicity at the cellular level.

NAMRU-D Studies Color Vision Deficiency for Special Duty Occupations

Dr. Cristina Kirkendall

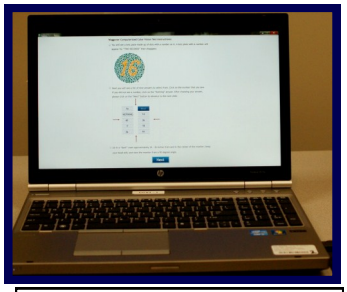
Researchers at NAMRU-D have undertaken a study to evaluate new computer-based color vision tests in the hopes that they will provide better assessment of both the type and severity of a color vision deficiency (CVD) compared to older technology. Currently, the U.S. Navy uses two color vision tests, the Ishihara pseudoisochromatic plates (PIP) and OPTEC-900 lantern test. Both tests are capable of identifying but not quantifying red/green CVDs. One may expect that both type and severity of CVD to affect human performance in color-rich environments that require military operators to accurately perceive color-coded information (e.g., color-coded icons that represent friendly vs. hostile entities in a battle space). Newer computer-based color-vision tests (i.e., Cone Contrast Test-CCT, Waggoner Computer Color Vision Test-CCVT, and Colour Assessment and Diagnosis Test-CAD) provide data that relate to both type and degree-of severity of CVD. These advanced tests facilitate development of CVD standards and provide the aeromedical clinician with methods to better assess special duty candidate suitability to operate in environments that require fast and accurate color discrimination (e.g., aviation cockpits, radar stations, combat control systems).



Diagnosis Test - CAD

Cone Contrast Test - CCT

A BUMED-sponsored NAMRU-D research project titled "Assessment of Color Vision Screening Tests for Special Duty Occupations" has three objectives: a) evaluate the two current color vision tests along with the three computer-based tests and determine their sensitivity and specificity with respect to detecting both type and severity of CVDs, b) assess the degree to which each test predicts normal and color-defective human performance in operationally-relevant in- and out-of-aircraft cockpit tasks, and c) provide an evaluation summary to the U.S. Navy Bureau of Medicine and Surgery regarding the capabilities of computer-based color-vision diagnostic tools in the screening and selection of special-duty candidates, to include aviation.



Waggoner Computer Color Vision Test - CCVT

Phase 1 of data collection began at the United States Air Force Academy (USAFA) in February 2013 and concluded in May 2013. Phase 2 of data collection will begin in July 2013 and conclude in November 2013. This second phase of data collection will again utilize USAFA participants and will also include participants at Naval Aerospace Medical Institute, Naval Air Station, Pensacola.

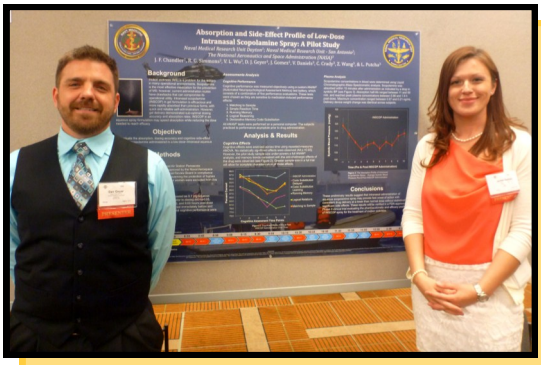
Aeromedical Directorate Participates in Scientific Meetings

NAMRU-D Public Affairs

NAMRU-D researchers participated in the 17th International Symposium on Aviation Psychology (ISAP), held in Dayton, OH May 6-9 2013. Dr. Richard Arnold, NAMRU-D Aeromedical research director, served on the conference organizing committee, and was one of three NAMRU-D staff members who made scientific presentations at the meeting. The meeting was attended by over 200 US and international aviation psychologists. The week concluded with tours of Navy and Air Force facilities at Wright-Patterson AFB, which included stops in several NAMRU-D laboratories.

Dr. Richard Arnold, NAMRU-D Aeromedical Research Director, served on the conference organizing committee and introduces speakers as the chair of the Cognitive & Physiological Workload Indices session.

In addition to the local ISAP meeting, NAMRU-D's Aeromedical research directorate also made a presence at the 84th annual meeting of the Aerospace Medical Association (AsMA) held May 13-17 in Chicago, ILL. A total of six presentations were given by NAMRU-D researchers. Highlighted NAMRU-D projects covered research on acute hypoxic events, intranasal scopolamine spray, sleep deprivation versus chronic sleep restriction, spatial disorientation countermeasures, and an overview of the Aeromedical Research at NAMRU-D in support of naval aviation priorities. Overall, the conference experience provided opportunity for our NAMRU-D scientists to answer questions others had regarding our lab research.



Mr. Daniel Geyer (left) and Ms. Jacqueline Gomez (right) presented NAMRU-D research they contributed to at the AsMA conference.

Tours Support Jointness and Collaborative Research Efforts

NAMRU-D Public Affairs

Enthusiasm from our researchers and leadership propel each laboratory tour at NAMRU-D and this quarter was no exception. NAMRU-D welcomed groups and individuals from neighboring Air Force research directorates at Wright-Patterson AFB to exchange scientific knowledge and experience during each of their visits. Dr. Lloyd Tripp, USAF 711 HPW, placed an emphasis on collaborative research between Navy and Air Force during a visit to NAMRU-D labs this past April. Dr. Tripp was interested in the Environmental Health Effects' inhalation toxicology capabilities, including whole body and nose-only systems, as well as NAMRU-D's abilities in measuring respiratory parameters in rodents, taking chambers to altitude, and generating inhalation exposure atmospheres of nanomaterials and particulate matter.

Dr. Karen Mumy displays some of the current in vitro research conducted at NAMRU-D to Dr. Lloyd Tripp.

Mr. Ricky Peters, Senior Executive Service, Executive Director of the Air Force Research Laboratory, toured our aeromedical labs and inhalation labs on 12 April 2013. Mr. Peters was provided an overview of projects and capabilities. During his visit he was briefed on the collaborative research that currently takes place between NAMRU-D and the Molecular Bioeffects group of the 711th HPW.

The Administrative Lead for the Hearing Center of Excellence's Pharmaceutical Interventions for Hearing Loss (PIHL) sub-committee on Sound Exposures, Ms. Sarah Sullivan of 711 HPW/RCHP, Battlespace Acoustics was particularly interested in NAMRU-D Environmental Health Effects' unique Jet Fuel and Noise Induced Hearing Loss laboratory and inhalation chambers.

Dr. Joseph Chandler explains the NAMRU-D fatigue lab capabilities to Mr. Peters, SES, Executive Director of the Air Force Research Laboratory.

Opportunities for continuing and expanding collaboration with the 711 HPW/RHCP, Applied Neuroscience Branch, were made evident on 14 May 2013 when members of the Applied Neuroscience Branch toured through some of the labs in each science directorate. The RHCP members were impressed by the capabilities and research discussed, and saw many opportunities for continuing and expanding collaboration with NAMRU-D.

Since NAMRU-D's founding date, October 6, 2010, our command's number one goal remains the same. To maximize warfighter performance and survivability through world-class aeromedical and environmental health research by delivering solutions to the field, the Fleet and for the future.

Study Seeks to Clarify Safe Exposure Limits of Carbon Dioxide On Submarines

LCDR William R. Howard

The process of setting a safe exposure standard level for contaminants in some cases can begin with the collection of controlled animal exposure data that is then extrapolated to a safe level for humans. How the experiments are designed is crucial, since the highest dose used that does not show an adverse effect is frequently used as the basis for a safe exposure level. In the case of carbon dioxide aboard submarines, the British Royal Navy sponsored a 2010 study that reports "a slight delay in fetal development" in pregnant female rats exposed to carbon dioxide at about 3%. While the authors considered the effect to be "potentially reversible" and not to represent an adverse effect, the interpretation of skeletal variations as either adverse or not adverse is highly debatable. The described effects were observed only at the highest dose (about 3% CO2), with a three-fold concentration difference between high and medium doses.

USS Georgia. *Photo by US Navy.*

The significance of the three-fold concentration difference between the dose with a noted effect and the next lower dose is that this lower dose will be used as a starting point for establishing allowable exposure levels for carbon dioxide. A threefold difference in effect could mean the difference between what is easily accomplished and what would require new engineering methods in place to keep carbon dioxide at a safe level.

To address this concern, the NAMRU Dayton study essentially repeated the British Royal Navy study with the addition of doses of carbon dioxide that were between the threefold difference of effect to no effect noted in the Royal Navy study. There were statistically significant findings of fetal resorptions occurring in the early phase of pregnancy and a corresponding statistically significant lower mean litter proportion of viable fetuses for the 3% group. Since the highest dose that showed no effect was 2.5% for carbon dioxide, the NAMRU Dayton study has given better clarification as a basis for developing a meaningful standard of protection from adverse effects of carbon dioxide on submarines.

NAMRU Dayton Investigator Receives 2012 Etter Award

Dr. Richard Arnold

Dr. Jeffrey Phillips recently received the Assistant Secretary of the Navy (Research, Development and Acquisition) Dr. Delores M. Etter Top Scientists and Engineers of 2012 Award, in the category of Emergent Investigator. This prestigious award was created "to highlight the excellence of (the Department of the Navy's) top performing scientists and engineers". Dr. Phillips was recognized for his outstanding applied research on the use of physiologic sensors to detect in-flight hypoxic events, and for pioneering basic research in which he discovered and characterized significant delays in the recovery of certain cognitive functions after individuals experience hypoxia. In the span of a few years Dr. Phillips has established himself as a leading DoD researcher on in-flight hypoxia detection technologies, and on the effects of hypoxia on pilot performance. At Wright-Patterson AFB, Dr. Phillips serves as a key member of the US Air Force team formed to address hypoxia-related issues in the F-22 Raptor.

Dr. Jeffrey Phillips, winner of the 2012 Dr. Delores M. Etter Top Scientists and Engineers Award.

This joint collaboration has benefitted USAF hypoxia detection and mitigation efforts by incorporating recommendations based on discoveries and analyses by Dr. Phillips and his team. In turn, US Navy in-flight hypoxia detection and mitigation initiatives are benefitting directly from Dr. Phillips' research and lessons learned from initial USAF use of physiologic sensors in the F-22. Etter Awards are traditionally presented annually at a ceremony held at the Pentagon. However, as a result of sequestration the 2013 ceremony was cancelled.

NAMRU-D Deputy Director for Administration and Department Head Accept Significant Awards

NAMRU-D Public Affairs

Two NAMRU-D family members were honored this quarter by receiving significant awards pertaining to their respective fields. Mr. Nicholas Roberts, Deputy Director for Administration and CDR Richard Folga made the command proud with their achievements and contributions to Navy Medicine .

Col Cassie B. Barlow, Commander of the 88th Air Base Wing at WPAFB presents the IPMA-HR Human Resources Employee of the Year award to Mr. Nicholas Roberts, NAMRU Dayton's Deputy Director for Administration.

Mr. Roberts was recognized by the International Public Management Association for Human Resources (IPMA-HR), greater Dayton Chapter, during the association's 51st Annual Award Luncheon held at Wright-Patterson Air Force Base, May 1, 2013.

The association recognizes outstanding civilian human resources employees in the Dayton Metropolitan areas. This year, Roberts, surrounded by several supporters, not only heard his name once, but twice, and walked away with applause at receiving two awards; the HR Specialists award and the IPMA-HR Human Resource Employee of the Year.

Roberts was recognized for his management of the laboratory's human resources functions and his leadership in growing the Navy command by 15 percent in the last year. He streamlined the preparation of new position descriptions and reduced the turnaround time from three months to two weeks. He also developed a command-wide civil service appraisal cycle process and an automated calculation process that relies on a formula based spreadsheet to calculate bonus payouts in a fair and non-arbitrary manner. He also developed numerous human resource electronic products that have been sought after by government and civilian organizations throughout the country.

CDR Richard Folga stands between Dr. Malcolm Cohen, left, a good friend of the Goldenraths and P. Glenn Merchant, CAPT, USN ret., President of the Aerospace Medical Association 2012-2013.

CDR Richard Folga, Acceleration and Sensory Sciences Department Head, received the 2013 Walter and Sylvia Goldenrath Award at the 84th annual meeting of the Aerospace Medical Association held 13-17 May in Chicago, Illinois. The annual award symbolizes a member of the Aerospace Medical Association who has made the most significant contribution in Aerospace Physiology in the previous year.

CDR Folga had a direct, positive impact with his applied research on education and training in aerospace physiology worldwide. He led the USN's Reduced Oxygen Breathing Device (ROBD) Training Development Team and created the ROBD simulator training concept. His team also conducted empirical studies to examine the impact of device modifications to ROBD training which resulted in evidence-based improvements to that training.

NAMRU-D Products & Presentations

Arnold, R. D. (2013, May). *Aeromedical Research at NAMRU-Dayton in support of naval aviation human weapons system priorities*. Panel discussion at the 84th Annual Scientific meeting of the Aerospace Medical Association, Chicago, ILL.

Chandler, J. F., Simmons, R. G., Qu, Geyer, D., Gomez, J., Daniels, Crady, & Putcha. (2013, May). *Absorption and side-effect profile of low-dose intranasal scopolamine spray: A pilot study.* Presentation given at the 84th Annual Scientific meeting of the Aerospace Medical Association, Chicago, ILL.

Folga, R. & Dory, R. (2013, May). *Build it and they will come: The future is now for advanced spatial disorientation research capabilities.* Proceedings of the 84th Annual Scientific meeting of the Aerospace Medical Association, Chicago, ILL.

Funke, M. E. (2013, May). *Event-related cerebral hemodynamics reveal target-specific resources allocation for both "go" and "no-go" response-based vigilance tasks.* Panel discussion presented at the 17th International Symposium of Aviation Psychology, Dayton, OH.

Gao, H., Reddix, M., Williams, H. P., & Kirkendall, C. (2013, May). Can *computer based color vision rest results predict performance in operational environments?* Proceedings of the 84th Annual meeting of Aerospace Medical Association, Chicago, ILL.

Gunasekar, P. and Krishnan. (2013, April). *In Vitro cytotoxic potential of Afghanistan sand extract.* Retrieved from http://www.dtic.mil/docs/citations/ADA578524

Hartzler, B.M. & Chandler, J. F. (2013, May). *Total sleep deprivation versus chronic sleep restriction: Dichotomy or continuum? What we know and where we need to go. Aerospace Medical Association.* Poster presented at the 84th Annual Scientific meeting of the Aerospace Medical Association, Chicago, ILL.

Patterson, F. R., Arnold, R. D., & Williams, H. P. (2013, May). *Visual Perspective Illusions as Aviation Mishap Causal Factors*. Panel discussion at the 17th International Symposium of Aviation Psychology, Dayton, OH.

Patterson, F. R., Arnold, R. D., Williams, H. P., & Folga, R. (2013, May). *Advanced techniques for U.S. Navy and Marine Corps spatial disorientation countermeasures training.* Poster presented at the 84th Annual Scientific meeting of the Aerospace Medical Association, Chicago, ILL.

Phillips, J. B., Robinson, F. E., Riffle, R., Drummond, L., Funke, M.E., Auld, S. (2013, May). *Time course to recovery of cerebral blood oxygen saturation following an acute hypoxic event.* Panel discussion at the 84th Annual Scientific meeting of the Aerospace Medical Association, Chicago, ILL.

Phillips, J. B., Robinson, F. E., Riffle, R., Turnmire, A. E., Drummond, L., Auld, S., Funke, M. E. (2013, May). Subtle *performance deficits associated with an acute hypoxic event*. Poster presented at the 84th Annual Scientific meeting of the Aerospace Medical Association, Chicago, ILL.

Shaw, T. H., Funke, M. E., Dillard, M., Funke, G. J., Warm, J. S., & Parasuraman, R. (2013, June). Event-related cerebral hemodynamics reveal target-specific resource allocation for both "go" and "no-go" response-based vigilance tasks. *Brain and Cognition Journal, 82*, 265-273.

Sweeney, L. M., Prues, S., James, R.A., & Reboulet, J. (2013, April). Subacute effects of inhaled jet fuel-A (Jet A) on airway and immune function in female rats. *Inhalation Toxicology Journal.*

Sweeney, L. M., Sharits, B., Gargas, N., Doyle, T., Wong, B., & James, R.A. (2013,). Acute lethality of inhaled hydrogen cyanide in the laboratory rat: Impact of concentration x time profile and evaluation of the predictivity of "Toxic Load" models. Defense Technical Information Center.

Commanding Officer's Corner

CAPT C. Douglas Forcino

Captain C. Douglas Forcino, MSC, USN
Commanding Officer

I hope that after reading through this Science Update that you are as impressed by the people who comprise the NAMRU Dayton family as I am. Frankly, it's hard to image how you couldn't be. One of the many positive features of NAMRU-D that I noticed upon coming here just a little over a year ago is the quality of the people. You've read in this edition that the word about them is getting out and others are noticing, too. Mr. Nick Roberts, CDR Rich Folga and Dr. Jeff Phillips are the tip of the iceberg – currently the most publicly visible and recognized members of our superb staff. But you may not know that we recently stood up a Civilian of the Quarter Recognition Program and our first two selectees were Ms. Susan Williams from our fiscal team and Ms. Debbie Bachman, our IRB Administrator. I am extremely proud of our entire staff – military, government civilians and contractors, alike.

You've also noticed in this update that the capabilities of NAMRU-D continue to expand, even in the fiscal environment that we all face. The addition of capabilities in our Aeromedical Research Directorate's spatial disorientation lab has already led to some interesting preliminary findings that show that even trained, licensed, rated aviators succumb to some common illusions. There is a training component to this study as well, but currently the data are not yet robust enough to show an effect of the training on an aviator's ability to avoid the illusions. This work has huge implications for naval aviation and aviation across the DoD, as well as commercial and civil aviation.

In the Environmental Health Effects Directorate our very talented inhalation exposure staff has expanded our inhalation capability by a factor of four, allowing us to conduct studies on four different inhaled chemicals simultaneously. Additionally, we've reinvigorated a capability that had been on the shelf by dusting off the MED64 device, which once again gives us another tool to observe the effects of toxic compounds on neuronal activity.

As summer in Dayton begins to heat up, the work of the lab continues to flourish. If you are in the neighborhood, please stop by for a visit. I'm sure you'll be impressed.

Taking the Helm of Navy Medicine's Aeromedical & Environmental Health Research

NAMRU Dayton

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