



NHRC

Naval Aircrew Working Group: Recommendations for a Forcewide Aircrew Readiness Surveillance System

Lisa M. Hernández, MS^{1,2}

Michael S. Stone, PhD^{1,2}

Genieleah A. Padilla^{1,2}

Nikki E. Barczak-Scarboro, PhD^{1,2}

AWSCM Robert T. Kershaw³

AWSCM Shane H. Gibbs³

Marcus K. Taylor, PhD²

¹Leidos, San Diego, CA; ²Naval Health Research Center, San Diego, CA;

³Helicopter Sea Combat Squadron THREE, San Diego, CA

**Warfighter Performance Department
Naval Health Research Center
140 Sylvester Road
San Diego, CA 92106-3521**

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EXECUTIVE SUMMARY

Bottom Line Up Front

The Naval Aircrew Working Group was convened to *derive the highest priority operational health and readiness challenges of the Naval Aircrew community*. Out of 10 identified priorities, the top three were musculoskeletal injury, cognitive function, and nutrition optimization. All 10 priorities will be integrated into the Readiness, Resilience, and Recovery (R3) Surveillance System, which will be implemented within a hybrid (virtual and in person) platform by the Naval Health Research Center. In turn, results from the R3 system will inform *forcewide human performance programming for U.S. Naval Aircrew* by summarizing the status of the force and providing evidence-based recommendations. Ultimately, the R3 system can transition into a program specifically designed for, and led by, Naval Aircrew.

Background

Since 2011, the Naval Health Research Center (NHRC) has provided scientific support to specialized groups (e.g., U.S. Navy Explosive Ordnance Disposal operators) to optimize operational health and human performance. At the request of senior enlisted leadership from Helicopter Sea Combat Squadron THREE (HSC-3), NHRC seeks to establish a surveillance system that characterizes the highest priority operational demands of Naval Aircrew, the Readiness, Resilience, and Recovery (R3) Surveillance System.

Problem Statement

The Naval Aircrew community operates multiple type/model/series aircraft, performing various mission sets that include maritime attack, combat support, and mine countermeasures. During such missions, personnel regularly experience operational stressors and environmental exposures that can lead to increased rates of injury, illness, and downtime. This cascade of events can ultimately deteriorate individual, team, and force operational readiness. Per the Program Objective Memorandum-23 Aircrew Systems (ACS) Enabler Naval Aviation Requirements Group, the number one ranked ACS priority is aircrew back and neck injury mitigation. Currently, *there is no system to monitor, build, and sustain operational readiness across the Naval Aircrew career*. Given the unique and diverse operational demands of Naval Aircrew, systematic assessment could support the development of targeted interventions for the community as a whole, as well as for specialized subgroups, to improve performance, mitigate injury/illness, and expedite recovery.

Process

Two active duty Naval Aircrew stakeholders from HSC-3 teamed with five NHRC researchers to form the Naval Aircrew Working Group (WG).

Operational Requirements of the R3 System

The WG derived 10 aircrew operational health priorities:

1. Musculoskeletal injury

2. Mental focus and cognitive function
3. Nutrition assessment/optimization
4. Sleep and circadian function
5. Hydration/fluid balance
6. Behavioral/mental health and combat mindset
7. Environmental exposure
8. Low-level blast exposure
9. Ergonomic design
10. Habitability

Implementation Plan, Cost Estimation, and Funding for the R3 System

The 10 priorities will be integrated into the R3 Surveillance System, which will be implemented within a hybrid (virtual and in person) platform. To achieve this, NHRC will:

- Envision the R3 system in collaboration with Naval Aircrew stakeholders
- Design the R3 system with the support of Commander, Naval Air Forces, and/or subordinate commands
- Obtain NHRC Institutional Review Board approval to assess personnel across the 10 operational requirements
- Establish and operate the R3 capability, leveraging both virtual and in-person data collection tools

The foundation of the study will be survey based, with the option to add scalable and modular in-person assessments, ranging from the most field-expedient measures to in-depth, laboratory-based tests. Scalable cost estimation has been provided and candidate funding lines have been identified.

Fleet Impact and Transition

Data derived from the R3 system will be used to estimate the status of the force (Naval Aircrew overall as well as subpopulations) with respect to readiness, resilience, and recovery. Reports will be routinely provided to aircrew command/training leadership to guide data-driven decisions, and the R3 system will inform *forcewide human performance programming for U.S. Naval Aircrew*. Ultimately, the R3 system can transition into a program specifically designed for, and led by, Naval Aircrew.

BACKGROUND

The Naval Health Research Center (NHRC) has a strong reputation for supporting chronically stressed military populations. Since 2011, NHRC has provided scientific support to specialized groups (i.e., U.S. Navy SEALs, Navy Explosive Ordnance Disposal [EOD] operators, and Air Force pararescuemen) to optimize operational health and human performance. Most recently, our scientific work for the Navy EOD community *fully transitioned to the EOD STRIKE human performance program* (EOD Quarterly Communications Guide, 2020). At the request of senior enlisted leadership from Helicopter Sea Combat Squadron THREE (HSC-3), NHRC seeks to establish a surveillance system that characterizes the highest priority, human-centric operational demands of Naval Aircrew, the Readiness, Resilience, and Recovery (R3) Surveillance System.

The Naval Aircrew Working Group (WG) was convened to *derive the highest priority operational health and readiness challenges of the Naval Aircrew community*. This population includes pilots, naval flight officers, aircrew, and rescue swimmers who are assigned to fleet rotary wing, tiltrotor, fixed-wing ejection seat, and fixed-wing non-ejection seat aircraft.

PROBLEM STATEMENT

The Naval Aircrew community operates multiple type/model/series aircraft and performs various mission sets including maritime attack, combat support, and mine countermeasures. Missions can include the interception and destruction of enemy aircraft and missiles under any and all weather conditions; all-weather offensive air-to-surface attacks; detection, localization, and destruction of enemy ships and submarines; aerial photographic, sighting, and electronic intelligence for naval and joint operations; airborne early warning service to fleet forces; airborne electronic countermeasures; in-flight refueling operations, and personnel recovery operations. During such missions, personnel regularly experience operational stressors and environmental exposures that can lead to increased rates of injury, illness, and downtime. This cascade of events can ultimately deteriorate individual, team, and force operational readiness.

The Aircrew Systems (ACS) Enabler Naval Aviation Requirements Group (ENARG) was established as a platform for the fleet to identify ACS capability deficiencies and propose solutions that optimize aircrew safety, survivability, readiness, and warfighting effectiveness. Per the Program Objective Memorandum-23 ACS ENARG Executive Steering Committee, the number one ranked ACS priority is aircrew back and neck injury mitigation, followed by six additional areas that include hearing protection and visual situational awareness (Commander, Naval Air Force Atlantic/Pacific, coordinated message, June 2020). Physiological episode protection is an overarching concern and while no root cause has been identified, human factors (e.g., fatigue, dehydration) may contribute to these unexplained occurrences (Elliott & Schmitt, 2019). Back and neck injury were the top System Safety Working Group priorities in 2018 and 2019 and are well-established occupational risks of aircrew personnel (Gaydos, 2012; Vail et al., 2021). The fleet has requested formal prehabilitation and protection programs for such injuries and seeks a systematic approach to identify mitigation strategies for musculoskeletal fatigue/injury.

U.S. Naval Aircrew must perform under extreme conditions in austere environments and yet, there is no forcewide program to build and sustain readiness and performance across the aircrew career. Given the unique and diverse operational demands of Naval Aircrew, systematic assessment could support the development of targeted interventions for the community as a whole, as well as for specialized subgroups, to improve performance, mitigate injury/illness, and expedite recovery. Thus, there is an immediate need to develop, implement, and institutionalize the R3 Surveillance System.

PROCESS

To address the surveillance capability gap, two active duty stakeholders from HSC-3 teamed with five researchers from NHRC to form the Naval Aircrew Working Group (WG). The goal of this WG was to *derive the highest priority operational health/readiness challenges of the Naval Aircrew community*, which includes pilots, aircrew, and rescue swimmers who are assigned to aircraft, including F-35 Lightning II, F/A-18E/F Super Hornets, CMV-22 Osprey, EA-18G Growlers, E-2C Hawkeyes, C-2A Greyhounds, MH-53E Sea Dragons, and MH-60R/S Seahawks. The WG was held on 04 Mar 2022, at the NHRC Warfighter Performance Department facilities in San Diego, California.

OPERATIONAL REQUIREMENTS OF THE R3 SYSTEM

The WG derived the following 10 Aircrew operational readiness priority areas. Candidate surveillance elements (measures) are provided for each priority area and summarized in the **Table**.

1. Musculoskeletal injury: The prevalence of neck, back, and shoulder pain has been reported to be very high among helicopter aircrew (Posch et al., 2019). Various factors of helicopter flight, including the weight of the survival vest, helmet mass, use of night vision goggles, and seating may influence pain (Posch et al., 2019). A survival vest with essential supplies and armor plates can range from 55 to 65 pounds. When combined with other gear (e.g., helmet, plates), the total weight can cause tremendous, whole-body musculoskeletal strain that is further exacerbated by prolonged seating. A recent report revealed that 58% of helicopter aircrew within the U.S. Army experienced flight-related neck pain (Walters et al., 2012). Low back pain has also been reported in helicopter pilots, with prevalence ranging from 50 to 92% (Gaydos, 2012). Exercise training that targets neck and shoulder musculature has been shown to be effective in improving strength in aircrew personnel (Murray et al., 2015; Murray et al., 2020).

Candidate R3 elements for musculoskeletal injury: injury history, genetic disposition, functional movement, dynamic balance, and bone mineral content/density.

2. Mental focus and cognitive function: Naval Aircrew must maintain focus despite extreme physical and psychological stress. Aircrew operational requirements often lead to

sleep deprivation and fatigue (Good et al., 2020), dehydration (Lindseth et al., 2013), and heat stress (Froom et al., 1993), all which have been shown to impair cognitive function.

Candidate R3 elements for mental focus and cognitive function: attention skills, cognitive rapid assessment, neuropsychological tests, and postural sway.

3. Nutrition assessment/optimization: Diet quality directly influences the overall health and operational readiness of service members. Most dietary assessment research on active duty service members has been conducted in Army populations during basic or cadet training (Collins et al., 2020). Nutrition research in military populations across the world is taking on a more integrated approach with an appreciation for environment-specific requirements and an individual's dietary behaviors/knowledge (Karl et al., 2022).

Candidate R3 elements for nutrition assessment/optimization: food frequency, food diary, blood biomarkers (e.g., cholesterol, vitamin D), and dietary recall.

4. Sleep and circadian function: Aircrew personnel often must perform while in a sleep-deprived state (Caldwell & Gilreath, 2002; Wingelaar-Jagt et al., 2021). Chronic sleep disruption can influence judgment, decision making, and concentration (Drummond et al., 2006). Fatigue resulting from insufficient sleep is a well-documented operational threat to military aviation and is detrimental to performance and safety (Caldwell et al., 2009). Poor sleep, fatigue, and long-term circadian rhythm disruptions have been linked to cardiovascular disease and mood disorders in military personnel (Good et al., 2020).

Candidate R3 elements for sleep and circadian function: fatigue, sleep quality, insomnia symptoms, telomere length, salivary biomarkers (e.g., cortisol), and sleep tracking with wearable devices (e.g., actigraphy watch).

5. Hydration/fluid balance: Voluntary dehydration is a common practice among aircrew personnel primarily because of busy flight schedules and the complexities of in-flight biological relief (Levkovsky et al., 2018). Dehydration can negatively affect physical performance, increase cardiovascular strain (Cheuvront et al., 2010), and impede cognitive function (e.g., alertness, sustained attention) (Adan, 2012; Lieberman, 2007).

Candidate R3 elements for hydration/fluid balance: fluid intake, physical activity, and osmolality tests (blood, urine, or saliva).

6. Behavioral/mental health and combat mindset: Naval Aircrew personnel frequently experience extreme psychological stress from combat deployments and/or personnel recovery missions. Operational stress (e.g., mission organization) is also related to psychological strain (e.g., posttraumatic stress disorder [PTSD], nervousness) in aircrew personnel (Stetz et al., 2014).

Candidate R3 elements for behavioral/mental health and combat mindset: symptoms of depression, anxiety and posttraumatic stress, social support, resilience, self-efficacy, aggression, and psychological skills.

7. Environmental exposures: Aircrew personnel are routinely exposed to various types of stimuli, including vibration, radiation, electrical shock, noxious fumes, and airborne particulates, as well as extreme environmental conditions related to temperature, humidity, and altitude. Whole-body vibration (WBV) resulting from operations may negatively affect cognitive tasks and attention (Patterson et al., 2021), as well as the musculoskeletal, neurological, digestive, and cardiovascular systems (Johanning, 2015).

Candidate R3 elements for environmental exposures: environmental exposure history (e.g., type, frequency), blood biomarkers, and spirometry.

8. Low-level blast exposure: Blast-related injuries have become a predominant military health concern. Blast exposure rates have increased, in part, due to Operations Enduring Freedom, Iraqi Freedom, and New Dawn (Engel et al., 2018). Repeated exposure to blast overpressure has been associated with neurological deficits (Carr et al., 2016; Stone et al., 2020) and poor mental health, including depression, anxiety, and PTSD (Caplan et al., 2015).

Candidate R3 elements for low-level blast exposure: blast exposure history (e.g., type, frequency) and traumatic brain injury risk.

9. Ergonomic design: Ergonomic considerations with respect to the airframe, seats, vertical lift, and the overall gender-specific human-aircraft design were discussed during the WG. Spinal degeneration (cervical and lumbar) has been reported in military helicopter pilots resulting from both WBV and other ergonomic factors (e.g., helmet mass, flight posture) (Byeon et al., 2013; Van den Oord et al., 2012).

Candidate R3 elements for ergonomic design: self-reported ergonomic assessment and ergonomics risk assessment.

10. Habitability: Aircraft habitability is an important human performance factor, especially for long-duration missions. The primary goal of aircraft design is to produce an aircraft that is strong and lightweight, thus the interior spaces for personnel are inherently small in size and layout. Such design elements can influence the operational performance at the individual and/or team level (Roma et al., 2022).

Candidate R3 elements for habitability: self-reported habitability and acceptability.

Table. Operational readiness priority areas mapped to candidate R3 elements

Priority Area	Candidate R3 Element(s)
1. Musculoskeletal injury	injury history, genetic disposition, functional movement, dynamic balance, bone mineral content/density
2. Mental focus and cognitive function	attention skills, cognitive rapid assessment, neuropsychological tests, postural sway
3. Nutrition assessment/optimization	food frequency, food diary, blood biomarkers, dietary recall
4. Sleep and circadian function	fatigue, sleep quality, insomnia symptoms, telomere length, salivary biomarkers, sleep tracking with wearable devices
5. Hydration/fluid balance	fluid intake, physical activity, osmolality tests
6. Behavioral/mental health and combat mindset	symptoms of depression, anxiety and posttraumatic stress, social support, resilience, self-efficacy, aggression, psychological skills
7. Environmental exposures	environmental exposure history, blood biomarkers, spirometry
8. Low-level blast exposure	blast exposure history, traumatic brain injury risk
9. Ergonomic design	self-reported ergonomic assessment, ergonomics risk assessment
10. Habitability	self-reported habitability, acceptability

ANALYTICAL REQUIREMENTS OF THE R3 SYSTEM

The R3 will provide estimates of factors inherent to readiness, resilience, and recovery, which will include prevalence, causes, and consequences. For example, the prevalence of inadequate sleep can be quantified by determining the percentage of aircrew personnel who report getting less sleep than they need to perform optimally. Candidate causes may include chronic operational stress and trauma history, while consequences may include vigilance lapses, fatigue, and morale degradation.

IMPLEMENTATION PLAN, COST ESTIMATION, AND FUNDING FOR THE R3 SYSTEM

The 10 priorities will be integrated within the R3 Surveillance System, which will be *implemented within a hybrid (virtual and in person) platform*. To achieve this, NHRC will design the R3 system and, with the support of Commander, Naval Air Forces, and/or subordinate Commands, obtain NHRC Institutional Review Board approval to assess personnel across the 10 operational requirements, and then build and operate the system. The foundation of the system

will be survey based, with the option to add scalable and modular in-person assessments, ranging from the most field-expedient measures to in-depth, laboratory-based tests. Scalable cost estimation has been provided and candidate funding lines have been identified.

FLEET IMPACT AND TRANSITION

Data derived from the R3 System will be used to *provide near-real time estimates of the status of the force with respect to readiness, resilience, and recovery*. Our lab's research findings about U.S. Navy EOD operators have supported the establishment of the EOD STRIKE human performance program, which demonstrates our ability to:

- Translate basic research into actionable intelligence for the military community
- Transition a surveillance system into a forcewide human performance program

While the 10 priorities have universal applicability across the Naval Aircrew community, we acknowledge that there will be differences between the subpopulations/specialized groups (e.g., rotary wing/tiltrotor, fixed-wing ejection seat, fixed-wing non-ejection seat). Reports derived from the R3 will be routinely provided to aircrew command/training leadership to support data-driven decisions and inform *forcewide human performance programming for U.S. Naval Aircrew*. Additionally, the R3 system has the potential to deliver scientific models to guide the development of risk/injury screening tools for practitioners and to optimize resilience/recovery. Ultimately, the R3 Surveillance System can transition into a program specifically designed for, and led by, Naval Aircrew.

DEDICATION

This work is dedicated to all U.S. Naval Aircrew personnel.

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APPENDIX

Meeting Agenda

Naval Aircrew Working Group

Fri, 04 Mar 2022

VISION

Establish the way forward for the aircrew readiness program

MISSION

3Ds

- DEFINE the highest priority operational health/readiness challenges faced by Naval Aircrew
- DESIGN the aircrew readiness program and identify who does what
- DEVELOP and establish the program

ATTENDEES

Aircrew Stakeholders

- AWSCM Shane Gibbs, N3/5/7/8 SNCOIC/LCPO, HSC-3
- AWSCM Robert Kershaw, Training DLCPO, HSC-3

NHRC – Biobehavioral Sciences Lab (BSL)

- Marc Taylor, PhD
- Lisa Hernández, MS
- Mike Stone, PhD
- Gen Padilla
- Nikki Barczak-Scarboro, PhD

SCHEDULE

Fri, 04 Mar 2022

- 1230 ARRIVE / COFFEE / INFORMAL
- 1240 Welcome & Introductions (PI – Dr. Taylor)
- 1250 Mission Overview: 3Ds
- 1300 Way Forward
- 1430 BREAK
- 1440 Resume Discussion
- 1550 Wrap Up
- 1600 ADJOURN

3Ds Worksheet

Please share your vision of the aircrew readiness program ...

DEFINE:

DESIGN:

DEVELOP:

REPORT DOCUMENTATION PAGE

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14. ABSTRACT

The Naval Aircrew Working Group (WG) was convened to derive the highest priority operational health and readiness challenges of the Naval Aircrew community. Out of 10 identified priorities, the top three were musculoskeletal injury, cognitive function, and nutrition optimization. All 10 priorities will be integrated into the Readiness, Resilience, and Recovery (R3) Surveillance System, which will be implemented within a hybrid (virtual and in person) platform by the Naval Health Research Center. In turn, results from the R3 system will inform forcewide human performance programming for U.S. Naval Aircrew by summarizing the status of the force and providing evidence-based recommendations. Ultimately, the R3 system can transition into a program specifically designed for, and led by, Naval Aircrew.

15. SUBJECT TERMS
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