# Biosystems and Human Performance Computing

**Jerry Heneghan**
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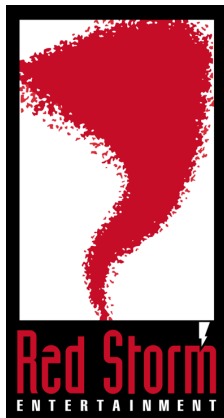
# Jerry Heneghan

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# Jerry Heneghan

*Advancing Human Performance*

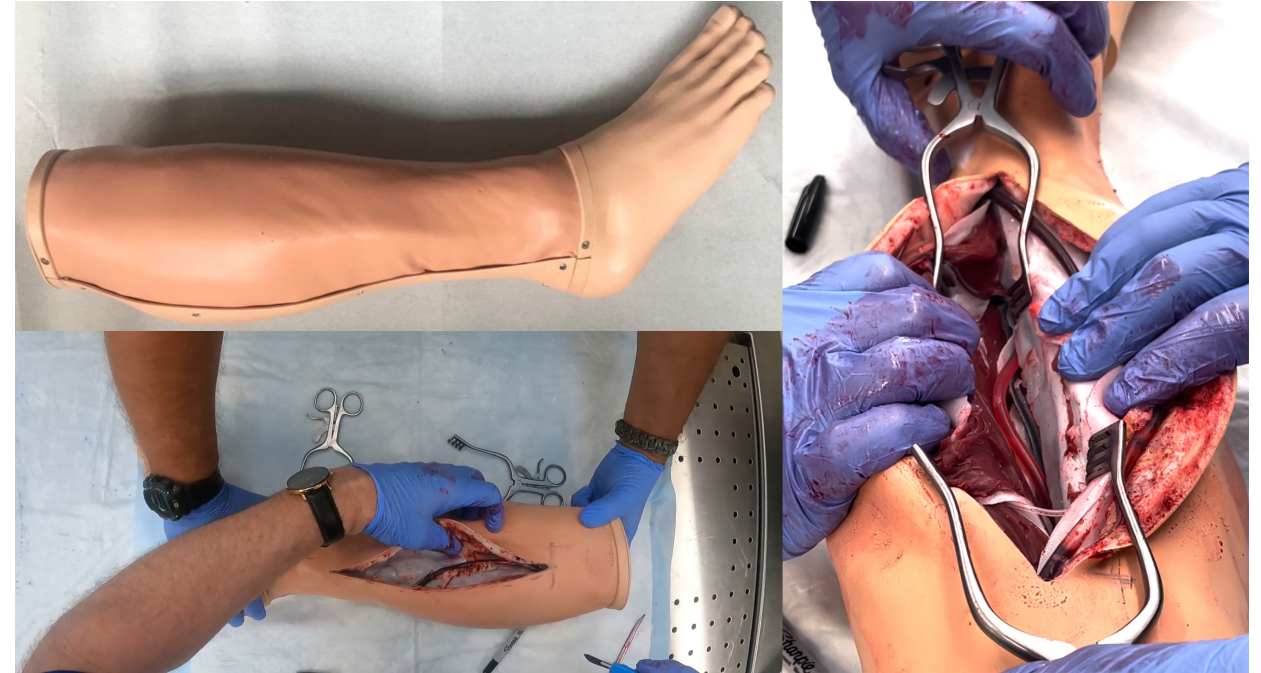Computational Biology

Synthetic Human Anatomy

XR Training Simulation Software

Digital Therapeutics, DTx

Tactical Augmented Reality

Application of Wearable Sensors for Performance Optimization

Medical Device Prototypes



Source: Phacon/BioMojo



Source: DigiLens

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# Computational Biology – Virtual Patients



Source: BioMojo

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# Digital Therapeutics



Source: BioMojo

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# Tactical Augmented Reality

- Telestration

- Contested Logistics

- Clinical Decision Support

Tyler E Harris, Stephen F DeLellis, Jerry S Heneghan, Robert F Buckman, Geoffrey T Miller, J Harvey Magee, William N Vasios, Kenneth J Nelson, Shawn F Kane, Y Sammy Choi, **Augmented Reality Forward Damage Control Procedures for Nonsurgeons: A Feasibility Demonstration** *Military Medicine*, Volume 185, Issue Supplement_1, January-February 2020, Pages 521 525.
https://doi.org/10.1093/milmed/usz298



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Source: BioMojo

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# High Consequence Work Environments

*Where the potential exists for catastrophic situations*

**Examples:**
- Aerospace
- Medicine
- Military
- Public Utilities
- Communications Networks
- Transportation Systems (Road, Rail, Water)
- Oil Refineries
- Chemical Plants
- Construction
- Manufacturing

**Operational Parameters**
- Hazard Identification
- Risk Assessment
- Safety Standards
- Establishment of Preventive Measures
- Process and Protocols
- Individual and Team Training
- Staffing Levels

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# Resilience

Defined as a system's capacity to resist, recover, recover better, or adapt, to perturbation from a challenge or stressor...  It is a critical factor in assuring the health and safety of military personnel. In recent years, the Department of Defense (DoD) has funded research programs assessing the physiological basis of resilience.

Physiological factors influencing or predicting resilience in US military populations, including physical performance, anthropometrics and body composition, nutrition and dietary supplements, and other biomarkers...

McClung JP, Beckner ME, Farina EK. Assessing the physiological basis for resilience in military personnel. Stress Health. 2023 Sep;39(S1):33-39. doi: 10.1002/smi.3271. Epub 2023 Jul 3. PMID: 37395310.

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# Human Performance and Biosystems

- Successful performance does not stop with psychomotor abilities and cognition…

- There has been a dramatic increase in technological advances in the areas of artificial intelligence and machine learning, wearable sensors, decision support, **hybrid teaming**, and more.

- With these advances, critical questions emerge about the role of the human in these systems. Understanding the fundamentals of human factors design is key to optimizing the performance of new technology as well as the humans equipped with those technologies across a full spectrum of operations.

- As technology evolves, so do human performance dynamics. Research is required to understand these new dynamics. Human systems design is optimized by taking the insights from both research and practice.

# Human Performance and Biosystems

*Department of Defense Research Interest Area*

**Technologies that increase critical reaction time.**

Law enforcement officers, first responders, Formula One race drivers, and e-sport professionals require a combination of cognitive and physical performance to act quickly and precisely to achieve the intended outcomes.

In high-consequence environments, human operators must sustain a high coupling of cognitive and physical capabilities to maintain complete motor control for events in the field, process decisions, and eliminate threats/risks.

Source: www.armyvertex.com

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# Human Performance and Biosystems

*Department of Defense Research Interest Area*

**Exploring models and tech for cognitive and physical state analysis during close-combat scenarios…**

Sustained performance of stressful and cognitively demanding tasks can deplete energy stores in the brain, alter the balance of key neurotransmitters, and cause motivational loss — all leading to cognitive fatigue that can reduce Soldier readiness.

The Army is interested in the ability to (1) quantify the relationship between stress, cognitive fatigue, and physical and cognitive performance outcomes; (2) sense and predict imminent and emergent stress and cognitive fatigue states; and (3) accelerate recovery from the cognitive and physical degradations associated with these states.

There is current exploration into solutions that monitor cognitive and physical states and provide real-time/near-real-time data interpretation and intervention.

Source: www.armyvertex.com

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# Human Performance and Biosystems

*Department of Defense Research Interest Area*

**Developing a hyper-resilient capability through available tools and resources…**

The Army needs hyper-resilient Soldiers who can self-regulate and persevere under stress, effectively reset and recover, and maintain optimal performance and mental health — while cultivating stronger social networks among teams.

There is current exploration of technologies that provide real-time monitoring of bio-measures for moment-to-moment insights into individual and team mental states.

Also explored - technologies to monitor physiological activity in humans for improved performance. These include heart and respiratory rate, electrodermal activity, functional brain activity, and biomarkers of stress.

Source: www.armyvertex.com

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# Human Performance and Biosystems

*Department of Defense Research Interest Area*

**Advancing Soldier awareness with heads up/heads down displays**

The military wants to use interactive, adaptive, and multimodal intelligent technologies to improve situational awareness during training, mission execution, and after-action reviews.

One challenge lies in effectively transforming data into information that can be consumed, manipulated, and ultimately understood by the human user through intuitive interactions with these information displays.

DOD is exploring immersive and multimodal display technologies, including those that leverage augmented and virtual reality, to improve situation awareness, reduce digital noise, and help Soldiers analyze and understand critical information.

Source: www.armyvertex.com

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# Human Performance and Biosystems

*Department of Defense Research Interest Area*

**Exploring technologies that improve sleep health to maintain mental and physical wellness…**

Mission requirements, jet lag, and shift work can limit the amount of sleep a Soldier is able to achieve — resulting in degraded performance.

Since sleep is limited in an operational environment, the Army needs technologies that can enhance deep sleep and reduce the total time needed for restorative sleep.

There is current exploration of non-pharmacological technologies that can help Soldiers sustain alertness in an operational environment when sleep is not possible due to mission requirements.

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# Human Performance and Biosystems

*U.S. ARMY Future Platform Requirements*

The Army needs a digital information and education platform to help Soldiers embrace human performance optimization.

This platform must be accessible across a range of modalities — mobile phone, tablet, laptop, CAC enabled systems, with and without internet — and integrate via two-way APIs to things like wearables, athlete monitoring systems, and data visualization toolkits.

On top of that, it must also have a data-centric backend to quantify utilization metrics and arm leaders with the tools they need to support technology adoption and encourage Soldiers with strategies to enhance performance.

*"Soldiers are the US Army's greatest resource. We must safeguard their physical, mental, and emotional health by investing in tools to aid and support them"...*

Source: www.armyvertex.com

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# Human Performance and Biosystems

"Discovering the Best Methods and technologies to Support Safe, Productive Human Space Travel…

From the enormous challenges of providing appetizing food and vital nutrition to analyzing the environmental risks posed by radiation and lunar dust, scientists at NASA's Human Research Program (HRP) and engineers work to predict, assess, and solve the issues that humans encounter in space.

Future exploration to space will drastically widen the scope of the challenges and demands NASA's astronauts will face. Research is needed to improve the astronaut's ability to collect data, respond to pressing challenges, & remain healthy during prolonged space travel"…

Steven H. Platts, PhD
Chief Scientist, HRP NASA

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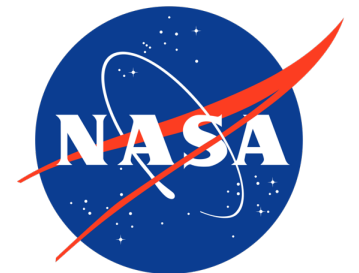
# The Virtual Physiological Human Project

The VPH is a European initiative that aims to develop a methodological and technological framework to enable investigations of the human body as an integrated (though hugely complex) system. It started in 2005. VPH-Sharing received € 14 332 963,00 /$15.1M

The main objective is to develop a systemic approach to organizing in silico modeling—by dimensional scales (body, organ, tissue, cells, molecules), scientific discipline (biology, physiology, biophysics biochemistry, molecular biology, bioengineering) and anatomical sub-systems (cardiovascular, musculoskeletal, gastrointestinal, etc.).

It is hoped that the VPH will produce the following benefits:
• Personalized care solutions
• Reduced need for experiments on animals
• More holistic approaches to medicine
• Preventative approaches to treatment of disease

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# The Virtual Physiological Human Project
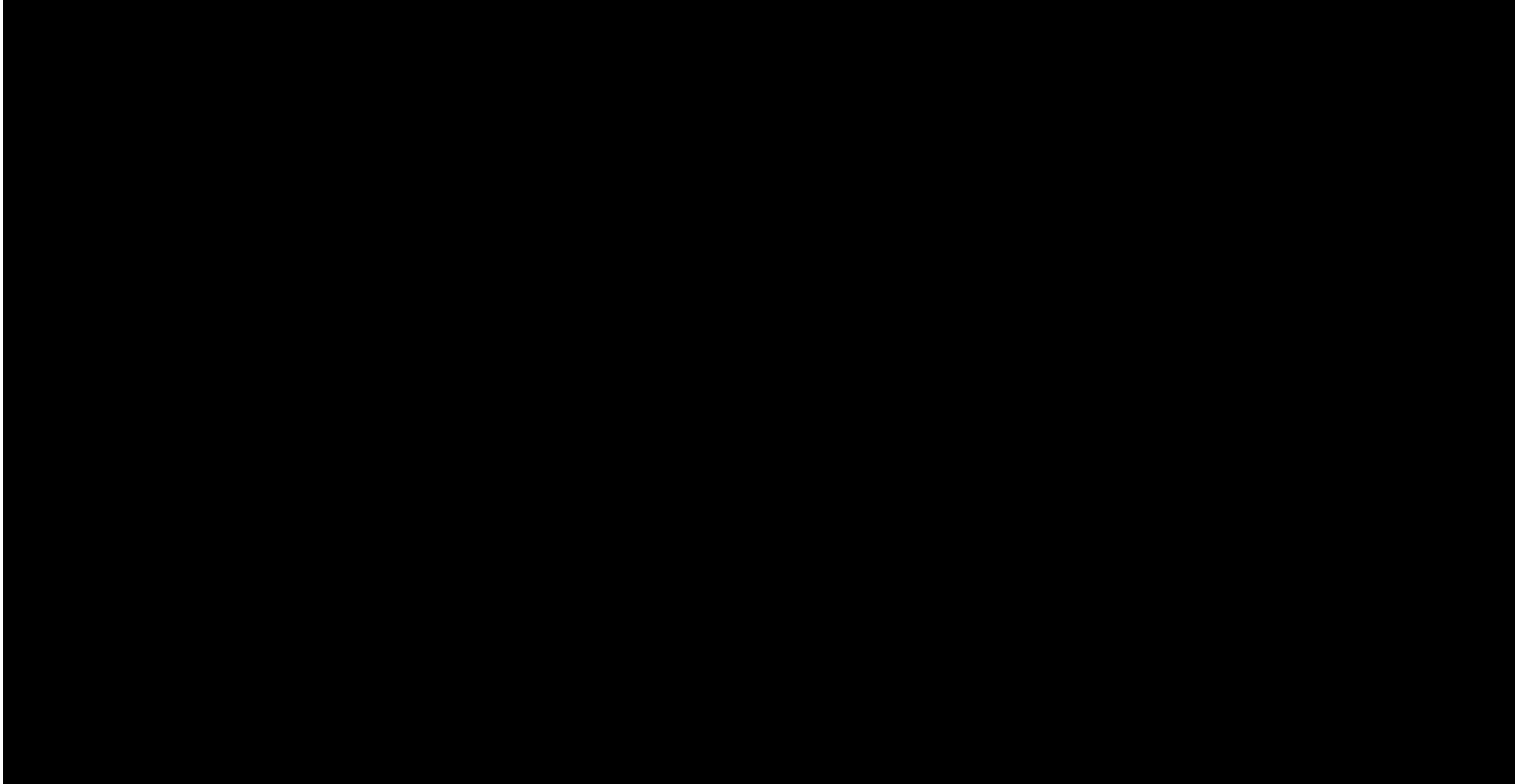


*Source: Produced by the Centre of Excellence in Computational Biomedicine (www.compbiomed.eu)*

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