OPERATIONAL IMPACT OF TECHNOLOGICAL ADVANCES IN ARMY AIRCRAFT: WHAT IT MEANS FOR FLIGHT SURGEONS IN THE FUTURE

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LIFE AS AN ARMY FLIGHT SURGEON OVER THE DECADES

- Keeping Army Aviators FFD
- Aviation Safety Program
- Investigating Accidents
- Advising Commanders
- Living in “The Field”
- Clinical Duties

LIFE AS AN ARMY FLIGHT SURGEON OVER THE DECADES

	1950-1970
Keeping Army Aviators FFD	✓
Aviation Safety Program	✓
Investigating Accidents	✓
Advising Commanders	✓
Living in “The Field”	✓
Clinical Duties	✓

LIFE AS AN ARMY FLIGHT SURGEON OVER THE DECADES

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LIFE AS AN ARMY FLIGHT SURGEON OVER THE DECADES

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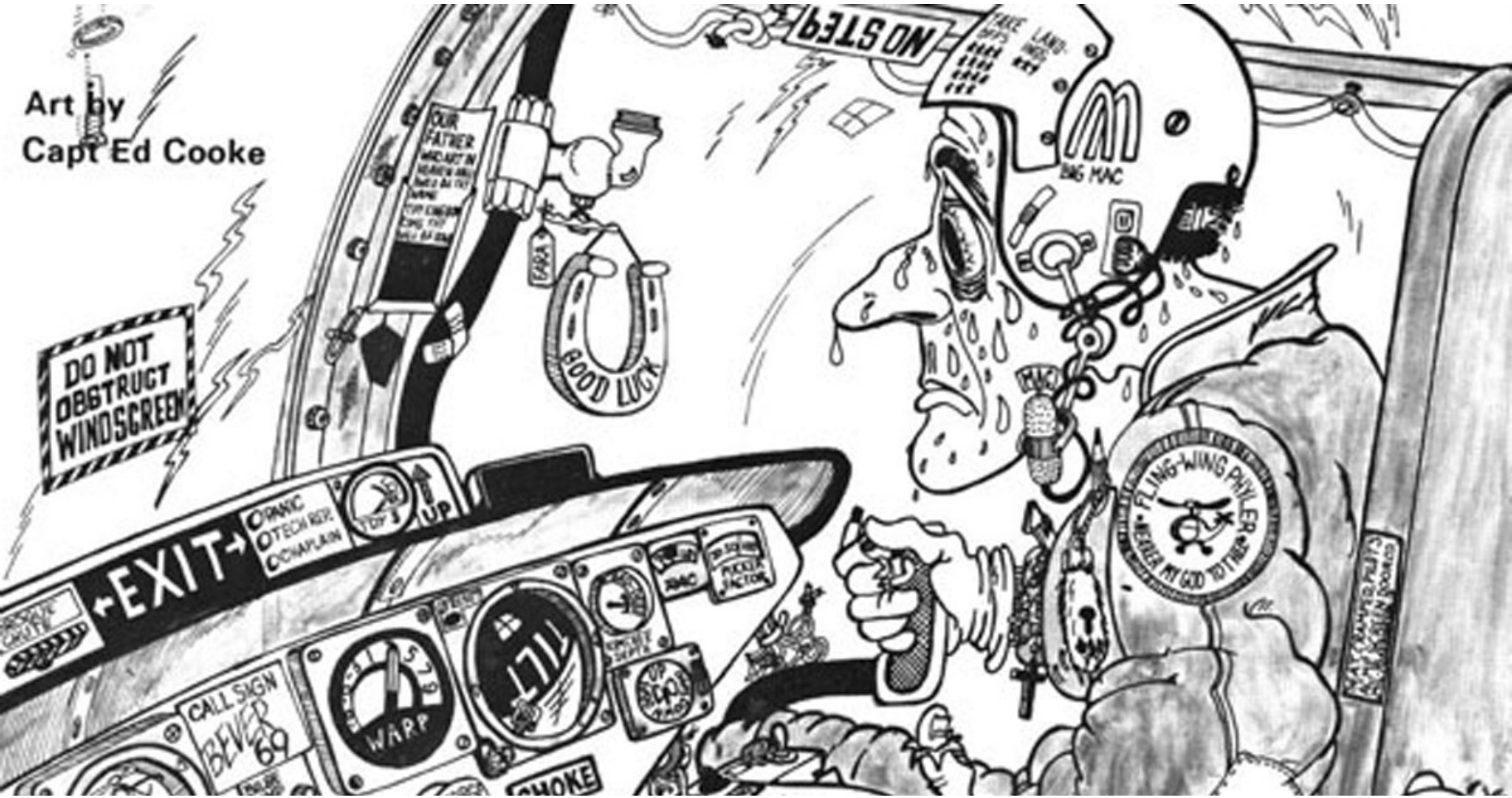
Living in “The Field”	✓	✓	✓	✓
Clinical Duties	✓	✓	✓	✓

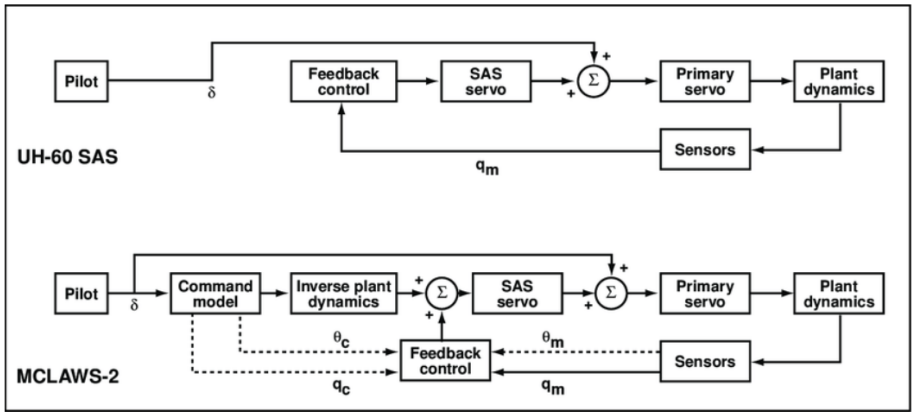
…so what’s different about the future?

FLYING HELICOPTERS HAS TRADITIONALLY BEEN HANDS-ON



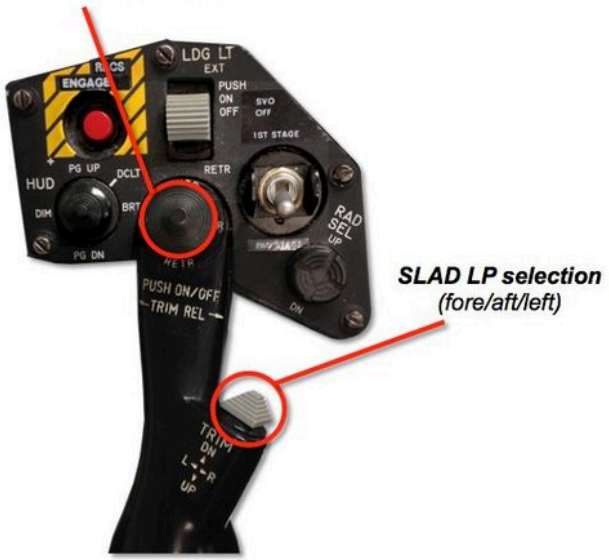
MODERN HELICOPTERS ARE MUCH EASIER TO CONTROL

Garmin GFC 600H helicopter flight control system (HFCS)



Standard UH-60 and MCLAWS schematic diagrams.

OFN destination and mode *(fore/aft/left/right/plunge)*

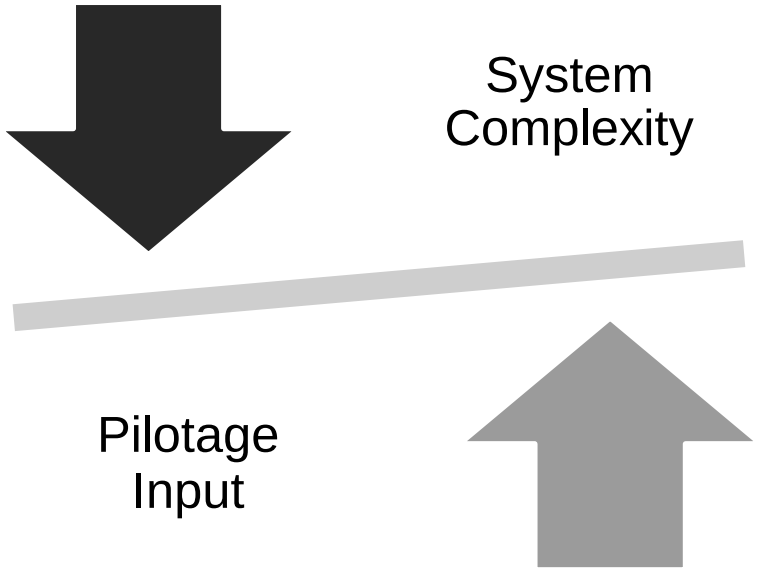


SLAD LP selection *(fore/aft/left)*

OFN max speed *(fore/aft)*
Control couple/decouple *(plunge)*

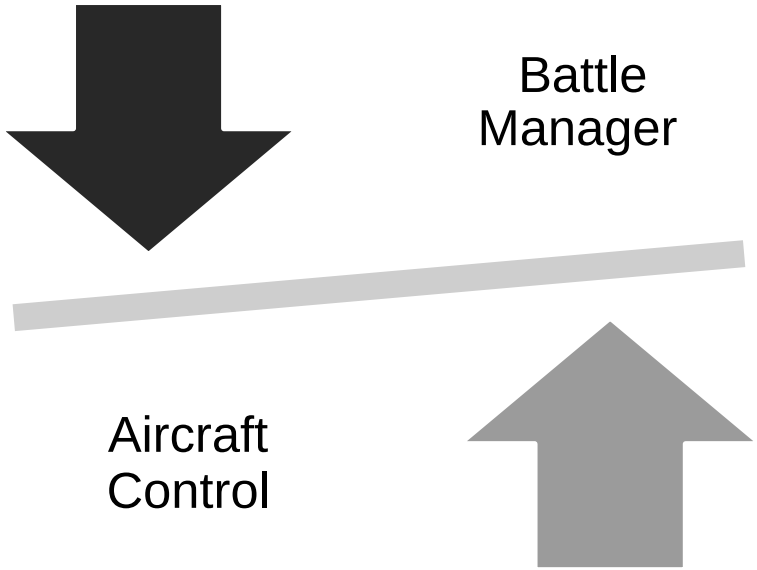
New Mission-Adaptive Autonomy System on the RASCAL JUH-60A Black Hawk

CHANGING ROLE OF ARMY AVIATOR



(Big Picture)

CHANGING ROLE OF ARMY AVIATOR



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SOMETIME IN THE NOT-TOO-DISTANT FUTURE, IN A TREELINE SOMEWHERE…

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0000 – CW3 Jones is awakened by his alarm clock after 7 hours of refreshing sleep, despite the noise of a nearby generator

SOMETIME IN THE NOT-TOO-DISTANT FUTURE, IN A TREELINE SOMEWHERE…

0000 – CW3 Jones is awakened by his alarm clock after 7 hours of refreshing sleep, despite the noise of a nearby generator

- *area noise-cancelling systems around his head*
- *trans-cranial electrical stimulation maximizing restful sleep*

> Sleep Med. 2021 May;81:350-357. doi: 10.1016/j.sleep.2021.03.001. Epub 2021 Mar 8.

Transcranial Electrical Stimulation targeting limbic cortex increases the duration of human deep sleep

Evan Hathaway [1], Kyle Morgan [1], Megan Carson [1], Roma Shusterman [1], Mariano Fernandez-Corazza [2], Phan Luu [1], Don M Tucker [3]

Affiliations + expand

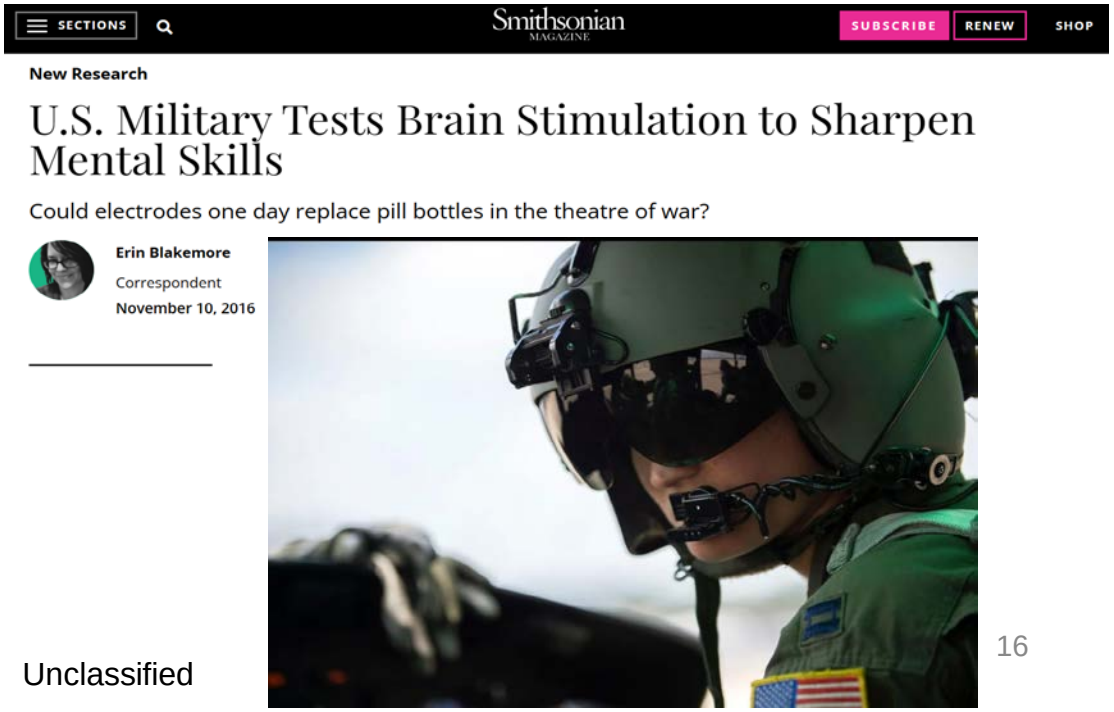
PMID: 33812203 PMCID: PMC8108560 DOI: 10.1016/j.sleep.2021.03.001

Free PMC article

SOMETIME IN THE NOT-TOO-DISTANT FUTURE, IN A TREELINE SOMEWHERE…

0000 –WO1 Smith only obtained 2 hours of sleep due to mission-planning tasks, but has selected an approved and authorized countermeasure

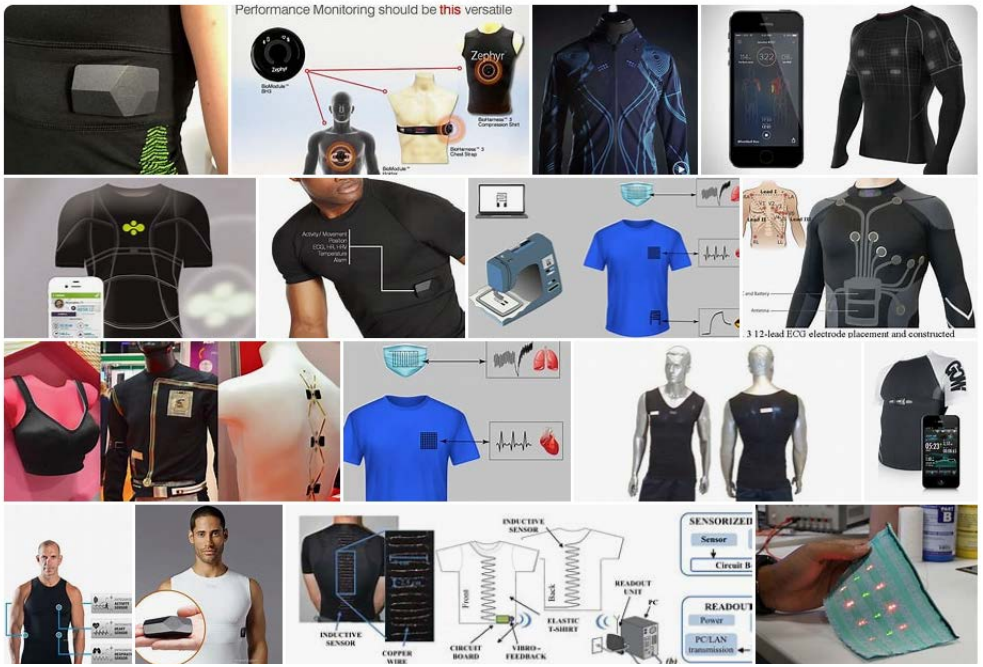
- *pharmacological assistance*
- *trans-cranial electrical stimulation for performance restoration*



PREFLIGHT

0100 – Crew dons their flight gear and completes preflight checks

- *state-of-the-art crash and combat protection*
- *garments with biometric sensors*



PREFLIGHT

0100 – Crew dons their flight gear and completes preflight checks

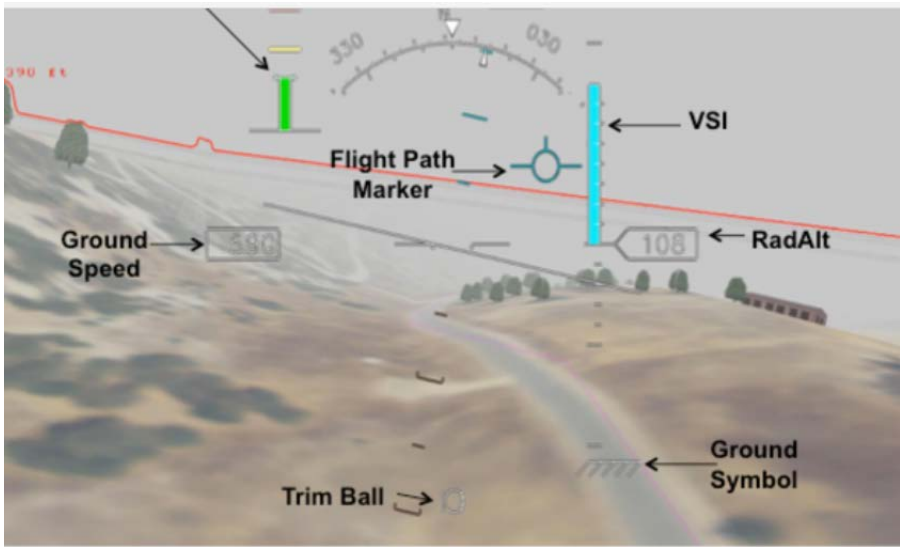
- *state-of-the-art crash and combat protection*
- *garments with biometric sensors*
- *aviator data automatically downloaded into aircraft*

  - *control-display preferences*
  - *physiological norms*
  - *preflight condition*

MISSION BEGINS

0130 – After take-off, WO1 Smith coordinates with other aircraft and data sources

- visual and cognitive displays and workload optimized to individual



MISSION BEGINS

0130 – Although WO1 Smith just joined the unit, he has mastered an enormous amount of operational data

- new enhanced learning techniques en route to theater

EN ROUTE TO OBJECTIVE

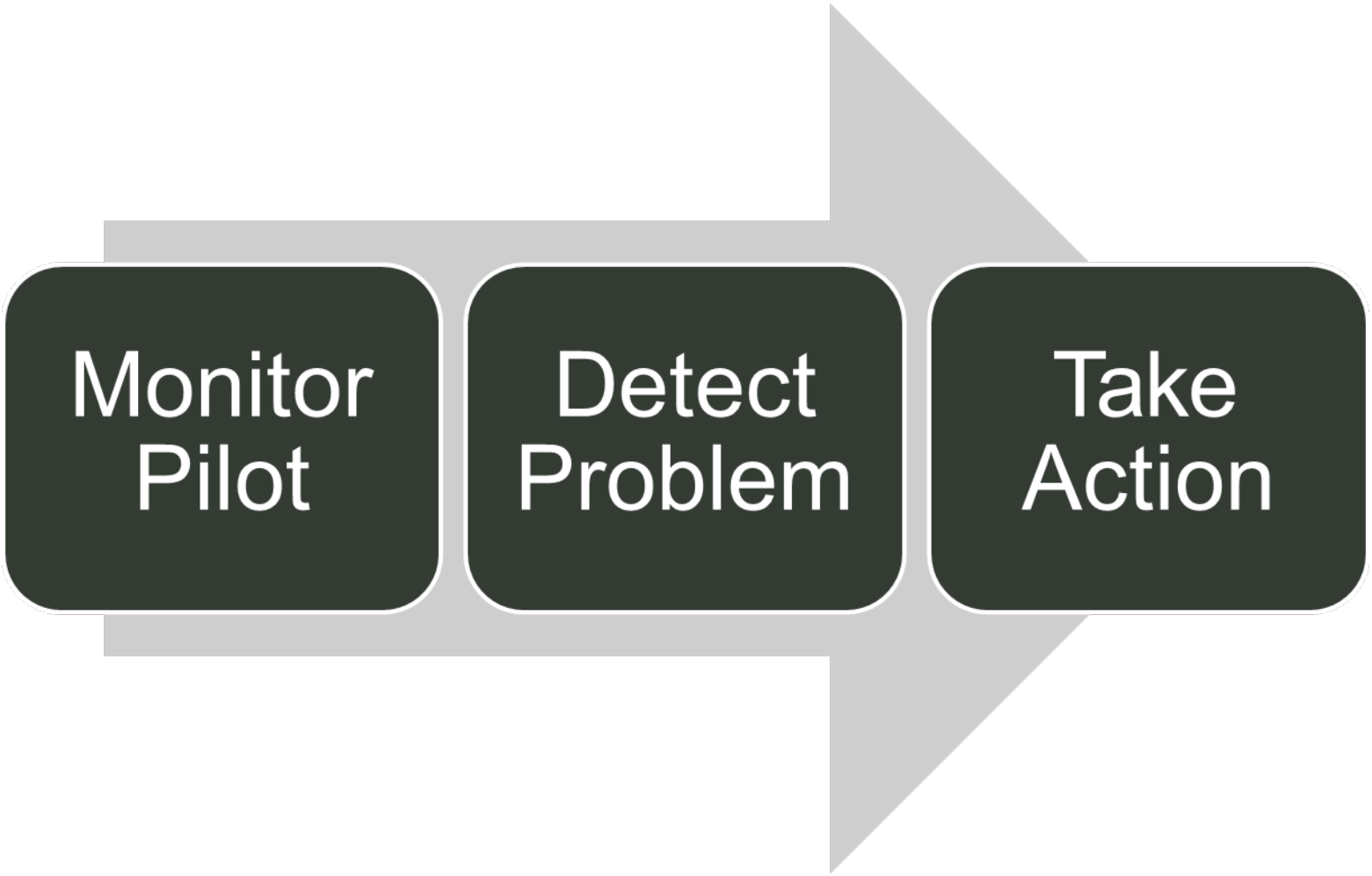
0430 – 2-3 hours into mission, CW3 Jones deftly handles complex interactions with

- Intelligence
- Enemy
- Multiple UAS
- Command
- Refueling

- *onboard systems predicted a decline in human performance and took over several critical functions based on*
  - *aviator physiological monitoring*

Physiological Monitoring

Physiological Monitoring



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  - *aviator physiological monitoring*

Trusting aircraft computers to execute the assumed tasks, CW3 Jones focuses his attention on the primary mission.

EGRESS

0730 – During egress, the formation comes under enemy fire. As both aviators are managing aircraft systems, they fail to recognize impending CFIT.

Need pic of target fixation

EGRESS

0730 – During egress, the formation comes under enemy fire. As both aviators are managing aircraft systems, they fail to recognize impending CFIT.

- *onboard systems predicted a ground impact and took over aircraft control, based on*
  - *aircraft parameters and trends*

The aircraft self-recovers safely.

AMBUSH

0800 – During an ambush, an aircraft is forced to crash-land.

Aircrew are protected from serious injury…

- *future occupant protection systems will protect aircrew from impact forces better than ever before*

AMBUSH

0800 – During an ambush, an aircraft is forced to crash-land.

…one passenger requires urgent life-saving treatment. An available UAS flies the casualty to a nearby rendezvous point where a MEDEVAC aircraft is waiting.

AMBUSH

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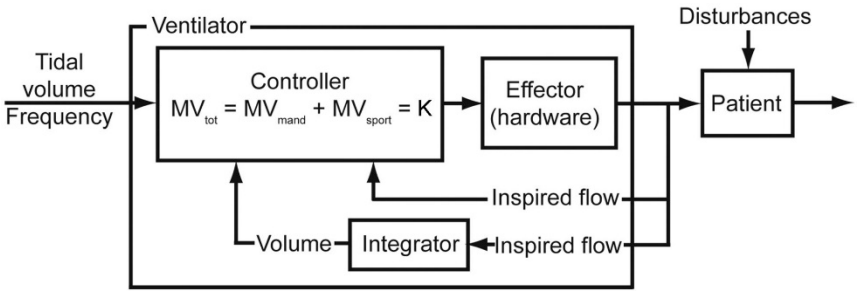
…one passenger requires urgent life-saving treatment. An available UAS flies the casualty to a nearby rendezvous point where a MEDEVAC aircraft is waiting.

- *UAS flight envelope and environmental controls are tuned to the casualty's condition (temperature, flight profile, respiratory control)*



RETURN TO BASE

0930 – Safely back over friendly territory, workload is low. Relieved, CW3 Jones grows drowsy. The operator state monitoring system senses his reduced attention and delivers an alerting stimulus.

- *biomedical monitoring of aircrew will allow real-time detection of degraded aircrew performance—in this case, fatigue and cognitive underload.*

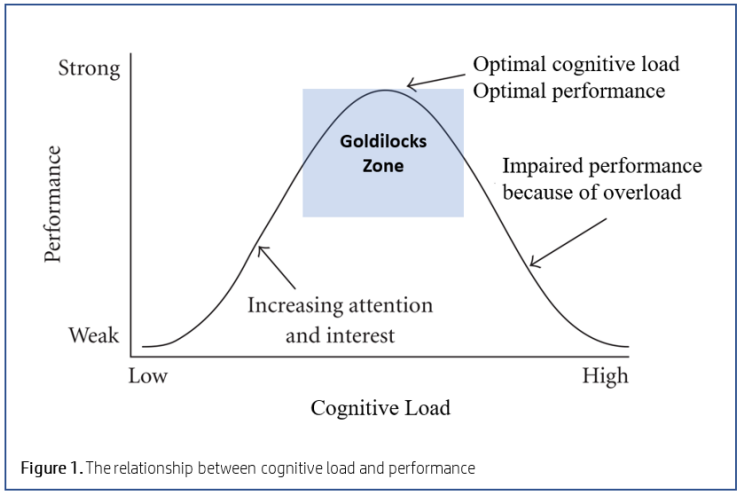


Figure 1. The relationship between cognitive load and performance

MISSION COMPLETE

1030 – CW3 Jones and WO1 Smith return safely to base and well-deserved rest.

LIFE AS AN ARMY FLIGHT SURGEON OVER THE DECADES

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Keeping Army Aviators FFD	✓	✓	✓	✓	
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…so what’s different about the future?

AEROMEDICAL RELEVANCE?

Mission Phase	Aeromedical Factor Cited	Flight Surgeon Involvement
Day Begins	Sleep Deprivation	
Preflight	Physiological Monitoring	
Mission Begins	Accelerated Learning	
En Route to Objective	Operator State Monitoring	
Egress	Target Fixation / Auto-GCAS	
Ambush	Crash / UAS	
Return to Base	Low Workload / Fatigue	

AEROMEDICAL RELEVANCE?

Old FS Role

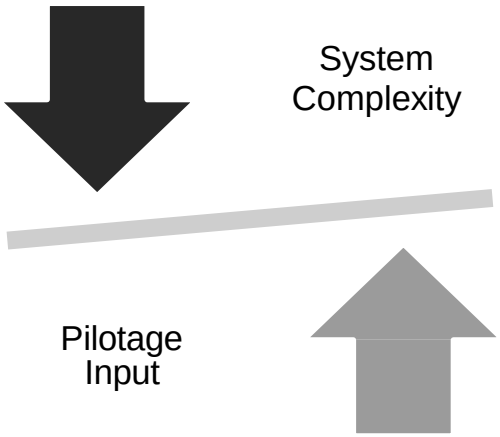
Mission Phase	Aeromedical Factor Cited	Flight Surgeon Involvement
Day Begins	Sleep Deprivation	Transcranial Electrical Stimulation, **Pharmacology**
Preflight	Physiological Monitoring	
Mission Begins	Accelerated Learning	
En Route to Objective	Operator State Monitoring	
Egress	Target Fixation / Auto-GCAS	**Aeromedical Training**
Ambush	Crash / UAS	**ALSE Fit**
Return to Base	Low Workload / Fatigue	**Aeromedical Training, Pharmacology**

AEROMEDICAL RELEVANCE?

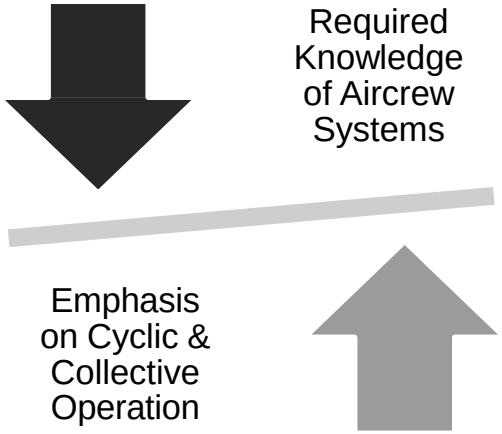
New FS Role **Old FS Role**

Mission Phase	Aeromedical Factor Cited	Flight Surgeon Involvement
Day Begins	Sleep Deprivation	**Transcranial Electrical Stimulation**, **Pharmacology**
Preflight	Physiological Monitoring	**Biometric Sensor Function**
Mission Begins	Accelerated Learning	**Neurocognitive Effects**
En Route to Objective	Operator State Monitoring	**Aircrew Physiology, Performance, Individual Differences**
Egress	Target Fixation / Auto-GCAS	**Aeromedical Training**
Ambush	Crash / UAS	**ALSE Fit**, **Casualty Transport**
Return to Base	Low Workload / Fatigue	**Biometric Sensor Function**, **Aeromedical Training, Pharmacology**

CHANGING ROLE OF ARMY AVIATOR AND FLIGHT SURGEON



Aviator



Flight Surgeon

CONSTANT ROLE OF ARMY FLIGHT SURGEON INTO FUTURE…

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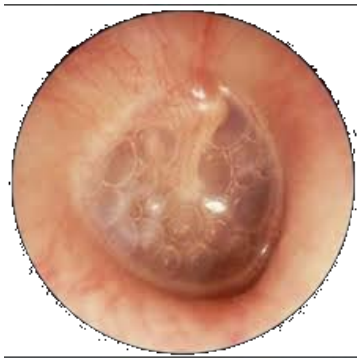
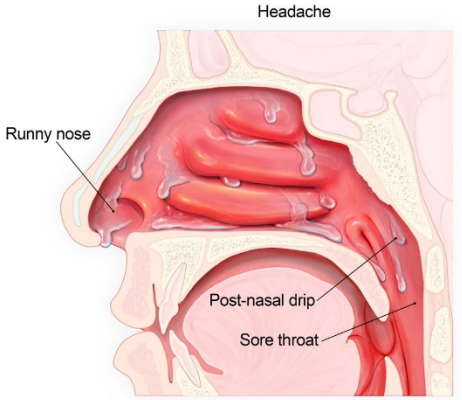
Living in “The Field”	✓	✓	✓	✓	✓

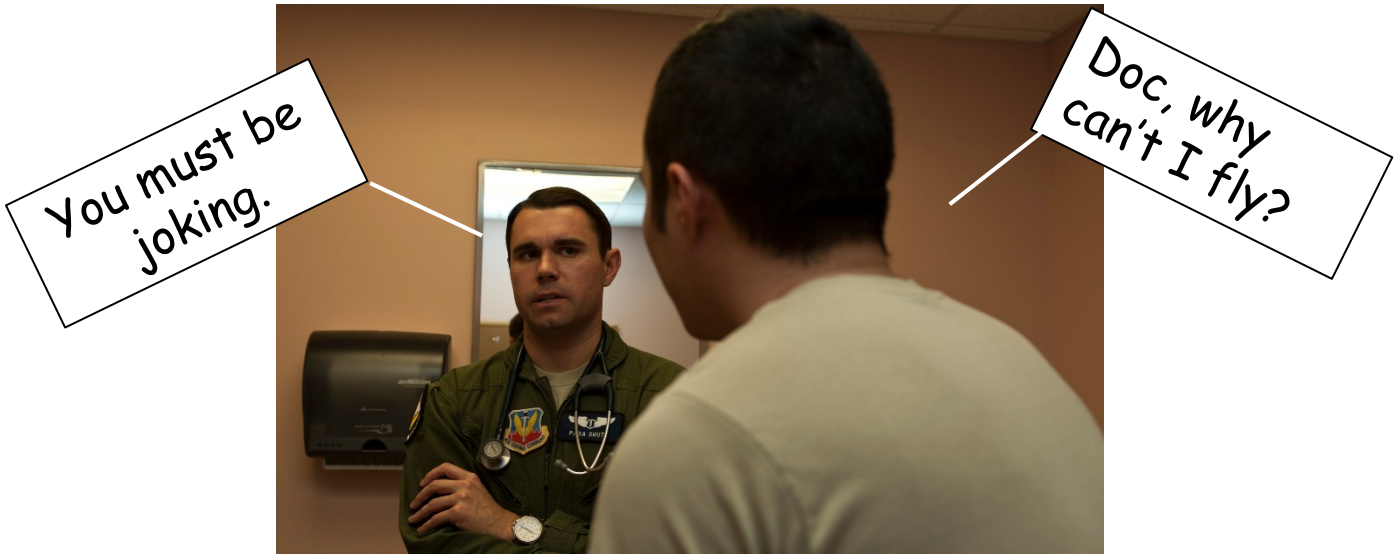
THE NEXT DAY…

THE NEXT DAY…

0700 – WO1 Smith c/o runny nose, decreased hearing and inability to clear R ear







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Clinical Duties	✓	✓	✓	✓	✓

CONCLUSION

- **Changes**
  - **More involvement with cockpit technology**
  - **Aeromedical standards not only based on flying skill**
- **Role of the Army Flight Surgeon will expand, not contract**
  - **Caveat: Support of Ground Forces vs High Altitude Ops (??)**
- **Some things will never change**

OPERATIONAL IMPACT OF TECHNOLOGICAL ADVANCES IN ARMY AIRCRAFT: WHAT IT MEANS FOR FLIGHT SURGEONS IN THE FUTURE

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US Army Aeromedical Research Laboratory

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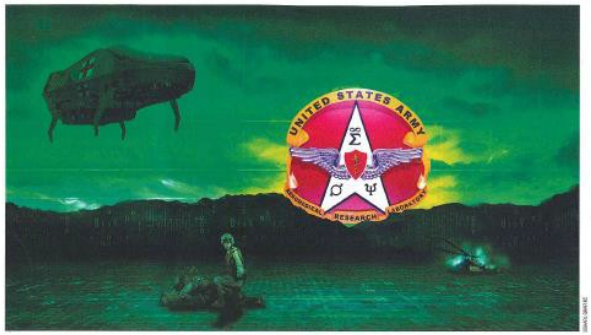
BASED ON
TAYLOR & CROWLEY (2017) AEROMEDICAL RESEARCH HELPING THE FUTURE FIGHT. *ARMY AVIATION MAGAZINE*, 31 DEC 17, P74-75.

Aeromedical Research Helping the Future Aviation Fight

By COL Jonathan Craig Taylor and John S. Crowley, MD



The U.S. Army Aeromedical Research Laboratory (USAARL) has a proud tradition of research that has delivered solutions to Army Aviation's protection and performance challenges for over 50 years. Game-changing products – including standards for crashworthy systems, helmets, night vision goggles, and aviation life-support equipment – have saved many lives and prevented countless injuries. Other examples include USAARL's research into the safe use of sedatives and stimulants under the most severe operational conditions.

Several USAARL research programs directly contribute to current and future Army Aviation operations. Consider this vignette, set sometime in the not-too-distant-future…

0000 hrs. – CW3 Jones is awakened, feeling refreshed after a good night's sleep despite the noise of a nearby generator. After reviewing mission plans, he is joined by WO1 Smith, whose sleep was unavoidably disrupted, preventing him from getting enough of the best fatigue countermeasure – sleep. Since he's mission-essential, WO1 Smith has selected an appropriate and authorized countermeasure, and is now mission ready.

USAARL's "Aircrew Health and Performance" research program has produced a suite of fatigue countermeasures, including nap-timing and pharmacological aids. Noise-cancelling systems will provide quiet areas despite high ambient noise. Current research will lead to the approval of other safe and effective techniques, including electrical brain stimulation (brain-tickling) to restore (or enhance) cognitive function.

0100 hrs. – Donning their flight gear, which includes the latest crash protection systems and fire-protective garments incorporating biometric sensors, the crew completes preflight checks. Automatically downloading their personalized control-display preferences, their state-of-the-art aircraft senses their rest status, cognitive fitness and other physiological parameters that could affect flight safety or mission success.

As engineering techniques and materials advance, survival systems will provide more protection than ever before. Current research in biometrics and physiological monitoring will incorporate unobtrusive sensors to be incorporated in flight clothing, allowing continuous physiological and neurological monitoring of aircrew function and performance. These sensor packages and the associated algorithms are being developed under USAARL's "Medical Aspects of MUM-T" program in direct support of Future Vertical Lift.

0130 hrs. – After taking off, WO1 Smith coordinates with other mission aircraft and information sources – manned and unmanned. Visual and audio displays provide information matched to the crew's neuropsychological profiles, keeping cognitive workload and performance optimized throughout the mission. WO1 Smith, who is new to the unit, has quickly learned an enormous amount of operational data using new enhanced learning techniques. The mission team is able to travel far into the remote target area, due to the increased speed and endurance of this generation of rotary-wing aircraft. Increased capabilities have led to increased physiological and psychological stresses on the aircrew, but these have been minimized through training (e.g., g-forces, spatial disorientation) and well-designed technology.

Workload on the future aviation battlefield will, at times, exceed human capacity. The control of multiple aviation and ground platforms, the assimilation of vast amounts of rapidly changing data, and environmental austerity are just some of the critical factors. USAARL's "Human Performance Optimization and Enhancement" research program is seeking new ways to enhance learning (through brain activity reactivation, for example), as well as delivering new pharmacological and non-pharmacological ways to enhance cognitive performance. USAARL researchers are studying ways to personalize operator displays to automatically tune the aircraft to the human.

0430 hrs. – Three hours into the mission, which has featured complex interactions with friendly and hostile forces, the objective is reached. During particularly high workload phases of the ingress, onboard computers predicted a decline in human performance, and took over several critical functions from CW3 Jones. Trusting aircraft computers to execute the assumed tasks, CW3 Jones was able to focus his attention on his primary mission tasks.

Adaptive automation systems will not only sense aircrew physiological parameters, but will anticipate aircrew behavior based on evolving mission parameters. Under the "Medical Aspects of MUM-T" research program, USAARL is studying ways to enhance operator trust in the potentially life-saving automation system.

0530 hrs. – After accomplishing the mission with the assistance of numerous unmanned aerial vehicles, friendly forces reassemble for the return to base.

Mission workload, such as controlling multiple UAVs/UGVs, will exceed the capacity of even well-rested human operators; USAARL's "Human Performance Optimization and Enhancement" research program is developing ways to increase performance above baseline. During critical operations (e.g., remote, austere, life-or-death), Soldiers may benefit from cognitive enhancers—pharmaceutical or non-pharmaceutical.

0630 hrs. – During a critical phase of egress, the formation comes under enemy fire. As both aviators are busy managing defensive and suppressive systems, they fail to recognize impending controlled flight into the terrain. Sensing this, onboard computers take control of the aircraft, preventing the certain impact.

Adaptive automation systems will detect impending mishaps and will be empowered to auto-recover the aircraft. Keeping the human "in the loop" with these autonomous systems is critical to ensure 'trust' as well as enabling transition back to human operator control once the emergency has passed. USAARL research addresses the human element in this man-machine interface.

0700 hrs. – During the ambush, one of the manned mission aircraft is forced to crash-land. Enhanced aircraft crashworthiness and personal protective equipment protects the crew from serious injury, but one passenger requires urgent life-saving treatment. As dedicated MEDEVAC aircraft are hours away and hostile forces are nearby, it is decided to use an unmanned aircraft to transport the casualty to a nearby friendly rendezvous point where a MEDEVAC aircraft will be ready and waiting.

Future occupant protection and crashworthiness systems will protect aircrew from impact forces better than ever before – USAARL engineers are developing improved spinal fracture criteria and improved head/brain protection strategies that will directly benefit the Future Vertical Lift crewmember.

USAARL researchers in the "Enroute Care and the Future Battlefield" program are helping develop design envelope limits for UAVs that consider the physiological limits of seriously wounded Soldiers, should the need arise for UAV evacuation.

0730 hrs. – After a short flight in the UAV, the wounded Soldier is transferred to a state-of-the-art MEDEVAC aircraft and advanced trauma care is provided by the skilled flight paramedic during the flight to Role 3 medical care.

USAARL transport medicine researchers are determining optimal space requirements for advanced onboard medical care; medical care aboard Future Vertical Lift aircraft will incorporate unprecedented autonomous monitoring and treatment systems.

0830 hrs. – Safely back over friendly territory, workload is low. Relieved, CW3 Jones grows drowsy. The onboard computer senses his reduced attention and delivers an alerting stimulus. Once again back in the loop, CW3 Jones re-engages with the mission.

Biomedical monitoring of crew will enable the real-time detection of degraded aircrew performance – in this case, the onboard computer detects fatigue and cognitive underload, which may not yet have affected aircraft parameters, and has alerted the crew.

0930 hrs. – CW3 Jones, WO1 Smith, and the rest of the manned/unmanned team return safety to base and well-deserved rest.

The USAARL research team, consisting of flight surgeons, psychologists, audiologists, optometrists, aviators, engineers, and Soldiers, is proud to be a part of the Army Aviation team. We welcome comments and suggestions to help us ensure our programs align with warfighter needs!

COL Jonathan Craig Taylor is the commander and Dr. John S. Crowley the science program director of the U.S. Army Aeromedical Research Laboratory at Fort Rucker, AL.

USAARL Programs