Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Air Force											Date: March 2023	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*							
COST ($ in Millions)	**Prior Years**	**FY 2022**	**FY 2023**	**FY 2024 Base**	**FY 2024 OCO**	**FY 2024 Total**	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	139.287	150.771	146.921	0.000	146.921	141.651	127.452	130.095	141.631	Continuing	Continuing
620200: *Enterprise Transformational Appld Research*	0.000	0.000	0.000	0.191	0.000	0.191	0.194	0.199	0.204	0.211	Continuing	Continuing
621123: *Learning and Operational Readiness*	0.000	9.279	21.164	22.394	0.000	22.394	21.849	21.991	23.080	25.758	Continuing	Continuing
625328: *Human Dynamics Evaluation*	0.000	94.080	43.668	32.218	0.000	32.218	31.798	32.997	33.322	33.998	Continuing	Continuing
625329: *Sensory Evaluation and Decision Science*	0.000	23.479	40.148	44.454	0.000	44.454	42.157	43.320	43.874	48.797	Continuing	Continuing
627757: *Bioeffects*	0.000	12.449	45.791	47.664	0.000	47.664	45.653	28.945	29.615	32.867	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program conducts applied research in the area of airmen training, airmen performance sustainment, bioeffects, and understanding and shaping adversarial behavior. The Learning and Operational Readiness project conducts research to increase the agility of training for readiness while advancing learning and performance assessment science and practice. The Biosciences Performance project conducts research to discover, demonstrate, and transition capabilities which optimize and safe-guard Airman and Guardian physical and cognitive performance allowing for the maximum potential of the multi-domain Airman. The Sensory Evaluation and Decision Science project conducts research to discover, develop, and transition advanced interface technology, decision aiding tools, and situationally-adaptive augmentation methods to seamlessly integrate Airmen and Guardian and intelligent machines into maximally collaborative warfighting teams. The Bioeffects project conducts novel and operational exposure bioeffects research, exposure effects analysis and national/international exposure standards for the Air Force to enable, sustain, and enhance Airman and Guardian performance and protection during deployment of directed energy systems.

This program element may include necessary expenses to support the operation and maintenance of facilities to manage, execute, and deliver science and technology capabilities. This program element may include necessary civilian pay expenses required to manage, execute, and deliver science and technology capabilities. The use of program funds in this program element would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, and 0602298F.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Air Force	Date: March 2023
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*

B. Program Change Summary ($ in Millions)	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total
Previous President's Budget	156.863	135.771	118.402	0.000	118.402
Current President's Budget	139.287	150.771	146.921	0.000	146.921
Total Adjustments	-17.576	15.000	28.519	0.000	28.519
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	15.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-17.576	0.000			
• Other Adjustments	0.000	0.000	28.519	0.000	28.519

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2022	FY 2023
Project: 625328: *Human Dynamics Evaluation*		
Congressional Add: *Pilot Hypoxia Detection and Notification*	7.000	0.000
Congressional Add: *Critical Air Transport Technology Expansion*	0.000	7.000
Congressional Add: *Advanced Warfighter Physiology and Operational Readiness*	0.000	4.000
Congressional Add: *Special Tactics Support Assessment*	4.000	4.000
Congressional Add Subtotals for Project: 625328	11.000	15.000
Congressional Add Totals for all Projects	11.000	15.000

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force			Date: March 2023
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*	Project (Number/Name) 620200 / *Enterprise Transformational Appld Research*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
620200: *Enterprise Transformational Appld Research*	0.000	0.000	0.000	0.191	0.000	0.191	0.194	0.199	0.204	0.211	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program element develops multidisciplinary applied research efforts to accelerate the technology pipeline of transformational capabilities by reducing risk and maturing the technology so it can transition in support of larger advanced technology development capability investments. These activities are selected to enable solutions to the DAFs highest priorities to include Operational Imperatives and Critical Technology Areas. The Explore effort engages traditional & nontraditional industry, government laboratories and academia through 12-24 month feasibility studies and demonstrations. The Seedlings for Disruptive Capabilities Program (SDCP) facilitates AFRL cross-disciplinary applied research to provide leap-ahead, high risk technology development. Modeling, simulation, and analyses activities will continue to explore transformational research analytic technologies to enable validated positions and provide a solid foundation with emphasis to predict future outcomes and technology needs, as well as looking for more seedlings to feed the transformational capability pipeline. Continue to advance future workforce development programs and broadening partnerships to deepen and expand the scientific and technology enterprise. Applied research efforts span a broad spectrum of activities, and established processes allow agility and flexibility to meet higher demand signals.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Enterprise Transformational Applied Research	0.000	0.000	0.191
Description: Enterprise Transformational Applied Research ***FY 2023 Plans:*** Not applicable ***FY 2024 Plans:*** This work will be executed out of and described in the plans for Program PE 0602202F Enterprise Transformational Appld Research, Project 620200 Enterprise Transformational Appld Research effort. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** FY 2024 increased compared to FY 2023 by $0.191 million. This increase is described in plans above.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	0.191

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force		Date: March 2023
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 620200 / *Enterprise Transformational Appld Research*

D. Acquisition Strategy

Not Applicable

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force			Date: March 2023
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*	Project (Number/Name) 621123 / *Learning and Operational Readiness*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
621123: *Learning and Operational Readiness*	0.000	9.279	21.164	22.394	0.000	22.394	21.849	21.991	23.080	25.758	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project advances research to measure, accelerate, and expand the cognitive skills necessary to improve airmen training and mission performance. The emphasis is on developing technology to enable a more lethal force by delivering revolutionary training and readiness capabilities at the speed of operations. Research is conducted in two focus areas: personalized learning and cognitive modeling. Personalized learning focuses on exploratory application of adaptive proficiency technologies and interactive task learning capabilities to provide more effective, efficient learning that improves mission readiness. Cognitive modeling advances computational and mathematical methods to represent human information processing to facilitate the development of models capable of operating as intelligent teammates, adversaries, or coaches, and cognitive performance prediction systems.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Personalized Learning	5.567	12.698	13.436
Description: Research lays the foundation for long-term Operational Training and Test Infrastructure by creating capabilities that enhance live-virtual-constructive environment and integration, exploring environments and mechanisms to enable collaborative learning in human-machine teams, researching individual and team measurement and assessment techniques, algorithms to enable a shift toward personalized and proficiency-based training and readiness management, and researching how advanced learning technologies like augmented and virtual reality can be used to increase the effectiveness and efficiency of training. ***FY 2023 Plans:*** Continue research evaluating integrated human and machine personalized learning capabilities in mission-relevant laboratory, testbed, and field environments. Evaluation includes adaptive, multi-objective optimization methods in constrained instructional settings. Incorporate uncertainty in proficiency measurement and prediction in laboratory assessments. Initiate research evaluating the impact of training fidelity related to augmented, virtual, mixed, and extended reality on readiness. Initiate exploring methods and standards for assessing transfer of skill for just in time, novel mission training requirements for a peer fight in deployed and austere environments. ***FY 2024 Plans:*** Continue research evaluating integrated human and machine personalized learning capabilities in mission-relevant laboratory. Initiate research integrating multi-objective optimization and team proficiency assessment into a common ecosystem for synthetic operational training and testing. Initiate transition of proficiency measurement and prediction capabilities, including uncertainty quantification, to targeted domains such as language learning and recurring training areas. Continue research evaluating the impact of training fidelity related to augmented, virtual, mixed, and extended reality on readiness. Continue exploring methods			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force		Date: March 2023
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 621123 / *Learning and Operational Readiness*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
and standards for assessing transfer of skill for just in time, novel mission training requirements for a peer fight in deployed and austere environments. Initiate mobile research platform for embedding in integrated training events for data collection in controlled, naturalistic environment. Initiate mechanisms for co-learning in teams of humans and machines to maximize collaboration and performance in a laboratory setting. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** FY 2024 increased compared to FY 2023 by $0.738 million. Funding increase due to added emphasis training augmented, virtual, mixed, and extended reality on readiness and co-learning in teams of humans and machines.			
Title: Cognitive Modeling ***Description:*** Research explores application of mathematical and computational modeling to understand the human mind and factors that will enhance or degrade cognitive performance. Capabilities enable personalized learning by tracking individual learning and targeting training interventions where/when needed. Research also explores applications for computer-generated forces with greater cognitive fidelity improving realism while reducing manpower costs for large, simulated scenarios. Investigates algorithms that track and predict readiness and mission effectiveness based on influences of the mission context and individual stressors improving the fidelity of wargames, system development, and operational planning with better characterizations of human capital capacities and limitations. ***FY 2023 Plans:*** Continue laboratory capability to profile workload and cognitive performance in real time. Continue evaluating real-time, personalized tracking of fatigue in operationally relevant environments, including impacts of countermeasures. Initiate integrated physiology-cognitive models to oxygen deprivation and chemical air contaminants. Initiate demonstrating automated knowledge and skill learning through verbal instruction with knowledge gap resolution in a laboratory-based artificial learning system. Continue maturing mechanisms for adaptation in communication within human-machine teams. ***FY 2024 Plans:*** Initiate capability for real-time fatigue monitoring and prediction for mobility and maintainer community. Continue real-time, personalized tracking of fatigue in operationally relevant environments, including impacts of countermeasures. Complete integrated physiology cognitive models to oxygen deprivation and chemical air contaminants. Continue laboratory capability profile workload and cognitive performance in real-time, and assess and predict performance based on interacting effects of multiple cognitive modulators in a laboratory setting. Initiate research computational and mathematical frameworks for representing human performance across scales of analysis, components of cognition and performance, and levels of resolution for digital engineering applications. Initiate computational modeling capability for situational understanding through natural language interaction,	3.712	8.466	8.958

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force		Date: March 2023
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 621123 / *Learning and Operational Readiness*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
information extraction, and information seeking in a laboratory context. Initiate research to demonstrate autonomy-based dynamic task allocation based on operator workload with context sensitivity. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** FY 2024 increased compared to FY 2023 by $0.492 million. Funding increase due to added emphasis in autonomy-based autonomy-based dynamic task allocation based on operator workload.			
Accomplishments/Planned Programs Subtotals	9.279	21.164	22.394

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

None

D. Acquisition Strategy

Not Applicable

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force			Date: March 2023
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*	Project (Number/Name) 625328 / *Human Dynamics Evaluation*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
625328: *Human Dynamics Evaluation*	0.000	94.080	43.668	32.218	0.000	32.218	31.798	32.997	33.322	33.998	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project conducts bioengineering and biotechnology research to optimize, safe-guard, and restore the performance of the multi-domain Airman and Guardian in all environments. Research is focused in the areas of 1) Cognitive and physiological performance: technologies to sustain, augment, and recover operator performance; 2) Biotechnology for performance: research in systems biology, synthetic biology, and risk assessment; 3) Performance sensing and assessment: technologies to sense and forecast operator state based on physiological, molecular, and environmental signatures related to mission performance; and 4) Performance impact of space and flight: elucidate how air and space environments affect processes of life and the ability to maintain physiological equilibrium and develop countermeasures and solutions to sustain, enhance, and restore operator performance.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Performance Sensing and Assessment	20.770	7.167	6.444
Description: Develop technologies to sense and forecast operator state based on physiological, molecular, and environmental signatures related to Airman and Guardian performance. Develop solutions optimized for real-time, minimally-invasive, and autonomous sensing and assessing capabilities to enhance and protect the Airman and Guardian across the spectrum of operational environments. In FY 2023, this effort changed names from Molecular Sensing and Physiology to Performance Sensing and Assessment. ***FY 2023 Plans:*** Initiate rapid Biological Recognition Element selection and optimization strategies. Initiate electrochemical and Field Effect Transistors-based biomarker sensing platforms, including synthetic biology developed components. Continue optimizing sensor form factor for deployment with focus on platform miniaturization. Continue wearable and implantable/biodegradable sensors for continuous biomarker monitoring. Initiate platforms to deliver augmentation strategies in an autonomous fashion. Continue evaluating commercial, off-the-shelf molecular-based sensing technologies for Air Force and Space Force applications. In FY 2023, the research performance of On-board Oxygen Generation System and implications on human physiology for current and next-generation aircraft is being performed under the Project 625328/Performance Impact of Air and Space effort. ***FY 2024 Plans:*** Continue rapid Biological Recognition Element selection and optimization strategies. Continue electrochemical and Field Effect Transistors-based biomarker sensing platforms, including synthetic biology developed components. Complete sensor form factor for deployment with focus on platform miniaturization. Complete wearable and implantable/biodegradable sensors for			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force		Date: March 2023
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625328 / *Human Dynamics Evaluation*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
continuous biomarker monitoring. Complete platforms to deliver augmentation strategies in an autonomous fashion. Complete the evaluation of commercial, off-the-shelf molecular-based sensing technologies for Air Force and Space Force applications. Initiate the identification and optimize bio-molecular mechanisms to sense cognitive function, performance, fatigue, and stress in console operators (i.e. Intelligence, Surveillance, Reconnaissance; Cyber; Space). Initiate data analytics based on sensor output to assess operator cognitive status, and facilitate decision making. Initiate integrating sensing and intervention mechanisms to sustain and augment operator performance. Utilize these sensors and intervention inputs/outputs to optimize human-machine learning. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** FY 2024 decreased compared to FY 2023 by $0.723 million. Funding decrease due to reduced emphasis in wearable and implantable/biodegradable sensors for continuous biomarker monitoring.			
Title: Biotechnology for Performance	20.770	7.167	6.444
Description: Conduct research in systems biology, synthetic biology, and physiologic risk assessment research to focus on the underlying mechanisms contributing to individual performance in various operational environments through the integration of multiple genetic and biomarker technologies. Conduct research to utilize biomarker technologies to determine the risk associated with exposure to toxic compounds and materials. Resulting research will generate biomarker candidates for sensing personalized predictions of response to stressors and novel interventions to optimize, safeguard, and restore Airman and Guardian performance. In FY 2023, this effort changed names from Systems Biology for Performance to Biotechnology for Performance. ***FY 2023 Plans:*** Initiate a microfluidic "brain-on-a-chip" platform simulating the dynamic environment and physiologic conditions of brain cells/tissue to include blood brain barrier oxygen dynamics. Continue utilizing advanced bio-data analytics and bioinformatics processing to analyze baseline multi-omics data collected on large scale research cohort--identify relevant biomarkers, mechanisms of action, and intervention strategies providing predictive performance assessment algorithms for physical and cognitive augmentation. Initiate identifying nasal microbiome strain suitable for peptide delivery to improve stress resilience. ***FY 2024 Plans:*** Complete a microfluidic "brain-on-a-chip" platform simulating the dynamic environment and physiologic conditions of brain cells/ tissue to include blood brain barrier oxygen dynamics. Continue utilizing advanced bio-data analytics and bioinformatics processing to analyze, and leverage these comprehensive baseline biomarker validation in a large-scale cohort developing Airman-specific predictive algorithms for physical/cognitive state, as well as personalized sustainment/augmentation strategies utilizing advanced bio-data analytics and bioinformatics processing. These relevant biomarkers will be used to generate optimal			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force		Date: March 2023
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625328 / *Human Dynamics Evaluation*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
targets for sensor development for personalized state assessment enabling real-time feedback and performance optimization. Complete the identification of a nasal microbiome strain suitable for improved stress resilience. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** FY 2024 decreased compared to FY 2023 by $0.723 million. Funding decrease due to reduced emphasis in microfluidic "brain-on-a-chip" platforms, and nasal microbiome strains for improved stress resilience.			
Title: Cognitive and Physiological Performance ***Description:*** Develop technologies in cognitive neuroscience and physical performance to sustain, augment, and recover operator performance and determine performance attributes/metrics for optimal career field alignment. Includes research focused on developing and validating physiological and behavioral assessments of current and predicted cognitive state combined with personalized cognitive performance enhancement techniques and technologies to augment operator performance. In FY 2023, this effort changed names from Cognitive Neuroscience to Cognitive and Physiological Performance. ***FY 2023 Plans:*** Continue evaluating Brain Machine Interface devices optimized for extended reality applications or alternate Air Force relevant application. Continue research determining feasibility of sending interpretable information directly to the brain. Initiate longitudinal study evaluating passive sensing technologies for cognitive state assessment. Transition artifact correction algorithms necessary for accurate cognitive state assessment to advanced development projects. Update real-time analytics testbed with additional capabilities and utilize for cognitive probing validation and replication experiments. Complete research detailing differences between effects of transcranial direct current stimulation and transcutaneous vagal nerve stimulation on brain physiology and structure. Initiate neuromodulation paradigms for cognitive enhancement across Air Force career fields (i.e., piloting; intelligence, surveillance, and reconnaissance; cyber operations; special operations). ***FY 2024 Plans:*** Continue evaluating brain machine interface technology applications that enhance human machine teaming performance. Continue maturing existing brain machine interfaces, neurotechnology, and advanced algorithms towards a candidate product capable of monitoring brain state, and applying non-invasive interventions that accelerate training and enhance skill retention. Initiate modeling for neural and physiological patterns associated with decision making, and evaluate neuromodulation approaches for inducing an optimal decision making state. Complete transition of neuromodulation technologies for mature devices and applications (e.g. accelerated training of image analysts) while simultaneously exploring and maturing neuromodulation technology (e.g. focused ultrasound and magnetic devices) paradigms for new cognitive enhancement/	20.770	7.167	16.109

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force		Date: March 2023
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625328 / *Human Dynamics Evaluation*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
sustainment applications. Continue real-time analytics testbed with additional capabilities and utilize for cognitive probing validation and replication experiments. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** FY 2024 increased compared to FY 2023 by $8.942 million. Funding increase due to an added emphasis in brain machine interfaces, and models for neural and physiological patterns associated with decision making.			
Title: Performance Impact of Air and Space ***Description:*** Conduct research investigating Airman and Guardian performance degradation resulting from exposure to air and space environments, and seek understanding the fundamental mechanisms driving environmental and operational risks. Develop technologies to mitigate or eliminate the root physiologic causes of these degradations and to ultimately optimize Airman and Guardian performance resulting in the capability to fly faster, higher, and longer than our adversaries. In FY 2023, this effort changed names from Aircrew Biodynamics and Protection to Performance Impact of Air and Space. ***FY 2023 Plans:*** Continue research developing next generation onboard oxygen generation system technologies. Continue research to characterize aircrew body motion, and biomechanical sensitivity related to acute and chronic back/neck pain and musculoskeletal injuries. Continue mitigation strategies such as physical conditioning, system design improvements, and interventional strategies to repair post-sortie injury from high-G exposures. Initiate human digital engineering algorithms and models for fighter and bomber aircraft system design and human factors analysis applications. In FY 2023, Onboard Oxygen Generating System research moved from the Project 625328, effort Performance Sensing and Assessment. ***FY 2024 Plans:*** Continue applied research for Air Force customers in areas of aircrew injury assessment/mitigation and Onboard Oxygen Generation System operational performance assessment and enhancement. Continue research to characterize aircrew motion, biomechanical sensitivity to aircrew flight equipment and systems, the cause of acute and chronic back/neck pain, and musculoskeletal injuries towards the development of a Multi-Axial Neck Injury Criteria and Lumbar Injury Criteria. Complete mitigation strategies such as physical conditioning, system design improvements, and interventional strategies to repair post-sortie injury from high-G exposures. Continue human digital engineering algorithms and models for fighter and bomber aircraft system design, and human factors analysis applications. Initiate development of air supply pressure stabilization system to mitigate air supply pressure degradations. Initiate investigation into system integration approaches for fighter/trainer/bomber aircraft of onboard oxygen generation systems. ***FY 2023 to FY 2024 Increase/Decrease Statement:***	20.770	7.167	3.221

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force		Date: March 2023
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625328 / *Human Dynamics Evaluation*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
FY 2024 decreased compared to FY 2023 by $3.946 million. Funding decrease due to reduced emphasis in mitigation strategies of post-sortie injury from high-G exposures, and efforts in onboard oxygen generation system performance impacts.			
Accomplishments/Planned Programs Subtotals	83.080	28.668	32.218

	FY 2022	FY 2023
Congressional Add: Pilot Hypoxia Detection and Notification ***FY 2022 Accomplishments:*** Conduct Congressionally directed efforts ***FY 2023 Plans:*** Not Applicable	7.000	0.000
Congressional Add: Critical Air Transport Technology Expansion ***FY 2022 Accomplishments:*** Not Applicable ***FY 2023 Plans:*** Conduct Congressionally directed efforts	0.000	7.000
Congressional Add: Advanced Warfighter Physiology and Operational Readiness ***FY 2022 Accomplishments:*** Not Applicable ***FY 2023 Plans:*** Conduct Congressionally directed efforts	0.000	4.000
Congressional Add: Special Tactics Support Assessment ***FY 2022 Accomplishments:*** Conduct Congressionally directed efforts ***FY 2023 Plans:*** Conduct Congressionally directed efforts	4.000	4.000
Congressional Adds Subtotals	11.000	15.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not applicable

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force			Date: March 2023
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*	Project (Number/Name) 625329 / *Sensory Evaluation and Decision Science*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
625329: *Sensory Evaluation and Decision Science*	0.000	23.479	40.148	44.454	0.000	44.454	42.157	43.320	43.874	48.797	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project conducts research to discover, develop, and transition advanced interface technology, decision aiding tools, and situationally-adaptive augmentation methods to seamlessly integrate Airmen and intelligent machines into maximally collaborative warfighting teams. Advanced technologies will enhance how Airmen and Guardian fight through improved team interactions and adaptive information throughput. Airman-Machine interaction design is critical for achieving mission success and maintaining meaningful human control in highly complex, uncertain, and rapidly evolving environments.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Collaborative Interfaces and Teaming	6.339	10.840	12.003
Description: Research new Human-Machine Teaming technologies and concepts (e.g., information portrayal, control devices, decision aiding algorithms and adaptive agents) for effective human-machine interaction and teamwork. ***FY 2023 Plans:*** Initiate the validate of effects of multiple interface designs for teaming solutions based on research on swift trust development and effective teaming methods between human operators in a Joint All Domain Command and Control (JADC2) context; expand a multi-domain playbook for JADC2 operators to include Air, Space and Cyber effects; continue research and experimentation focused on human-machine-teaming and collaborative interface design among mixed human-human and human-machine teams in applied and simulated domains; continue research on trust development within mixed human-synthetic agent teams; continue research on human implications of machine learning and run-time assurance technologies; continue research focused on development of software architectures and platforms to enable human-machine-teaming for pilot-vehicle interfaces in operationally relevant scenarios, Unmanned Aerial System teaming, base defense, and air battle management; apply research methodologies to conduct operator-centric field evaluations of fielded automation/autonomy systems; synthesize guidelines for engendering trust in human-human and human-machine teams. ***FY 2024 Plans:*** Initiate research effort on team resilience; build upon foundation of novel teaming metrics research to develop prototype team health scanner tool. Initiate research on transparency for distributed teams; build upon Joint All Domain Command and Control playbook research to develop prototype support tools for multi-domain teaming. Continue research on human autonomy collaboration tools to enhance resiliency. Complete research on human implications of machine learning and run-time assurance technologies. Complete research focused on development of software architectures and platforms to enable human-machine-teaming for pilot-vehicle interfaces in operationally relevant scenarios, Unmanned Aerial System teaming, base defense, and air			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force		Date: March 2023
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625329 / *Sensory Evaluation and Decision Science*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
battle management. Initiate the exploration of test methods for achieving bi-directional transparency in human-machine teaming. Complete research on trust development within mixed human-synthetic agent teams. Continue transfer of authority research to facilitate rapid acquisition of situation awareness for unexpected custody of assets. Continue research methodologies to conduct operator-centric field evaluations of fielded automation/autonomy systems. Experiment with interface technologies for control of unmanned assets from aerial platforms. Continue to refine guidelines for engendering trust and/or suspicion in human-human and human-machine teams. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** FY 2024 increased compared to FY 2023 by $1.163 million. Funding increase due to added emphasis Human-Machine Teaming technologies.			
Title: Multisensory Perceptions and Communication	8.922	15.256	16.892
Description: Multisensory Perception and Communication focuses on identifying and exploiting the underlying sensory and cognitive mechanisms mediating human perception and communication in order to inform the development of multimodal interfaces and speech/language technologies. Research examines sensory processing, multisensory integration, and human communication processes in simple and complex environments to identify the barriers to effective information transmission and inform the development of technologies to overcome, or exploit, those barriers in order to enhance Airmen performance. ***FY 2023 Plans:*** Continue behavioral research on team communication; collect operationally-relevant speech databases; develop models of dialogue processes; build and integrate algorithms from these models into an existing communication interface for identifying intelligent interruption capability; identify characteristics of effective/ineffective communication informing miscommunication identification systems; evaluate these capabilities in operationally-relevant testbeds. Build and evaluate new communication management technologies and explore new domain-specific features and form factors. Continue evaluating Augmented and Virtual reality capabilities for providing information through additional perceptual channels (visual, haptic/tactile along with speech communications) for distributed, collaborative tasks, supporting multi-capable airmen. Initiate multimodal symbologies and evaluate, with subject matter experts from flight community and Special Forces, in simulation and real-world operating environments with appropriate environmental/task complexity. Continue collecting behavioral and neurophysiological data, use to refine real-time model of attention and processing capacity, integrate into testbeds to evaluate as driver for adaptive interfaces. Continue evaluating new technologies focused on perceptual and communication disruption in field tests. ***FY 2024 Plans:*** Continue behavioral research on issues associated with disrupted and degraded communication channels. Initiate natural ad hoc team coordination in emergency response and Joint-All Domain scenarios. Initiate the collection of communication data from live and simulated events in these domains, and use data to develop new models of natural human communication			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force		Date: March 2023
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625329 / *Sensory Evaluation and Decision Science*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
processes. Continue operationally-relevant speech databases and dialogue processes. Build and integrate algorithms from these new models into novel communication interface prototypes for effective and efficient human-autonomy teaming. Initiate the development of new tools for integrating situation awareness displays with language based communication systems, and evaluate these capabilities in laboratory studies and operationally-relevant testbeds. Complete the evaluation of Augmented and Virtual reality capabilities for providing information through additional perceptual channels (visual, haptic/tactile along with speech communications) for distributed, collaborative tasks, supporting multi-capable airmen. Complete multimodal symbiologies and evaluate, with subject matter experts from flight community and Special Forces, in simulation and real-world environments with appropriate environmental/task complexity. Complete the collection of behavioral and neurophysiological data, use to refine real-time model of attention and processing capacity, integrate into testbeds to evaluate as driver for adaptive interfaces. Complete the evaluation of new technologies focused on perceptual and communication disruption in field tests. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** FY 2024 increased compared to FY 2023 by $1.636 million. Funding increase due to added emphasis in team coordination in Joint-All Domain scenarios.			
Title: System Analytics	8.218	14.052	15.559
Description: System Analytics studies the macro-cognition of the Airman using computational tools to accomplish mission objectives, encompassing interactions between operators, analytics, and environment. The goal of this research area is to describe, assess, and design for effective integration of analytics into mission systems. ***FY 2023 Plans:*** Continue accelerating design and assessment of mission relevant, Airman-centric data analytics capabilities at speed and scale. Complete research of cognitive and physiological performance assessment, development of analytics for insider threat identification, and decision support for joint all domain mission planning and execution. Complete single-INT analytics studies, data visualization for wide area monitoring, and technologies for intelligence requirement management. ***FY 2024 Plans:*** Continue the assessing design systems and methods to effectively blend data analytics with human cognition, with the goal of enhancing Airman and Guardian decision-making and improving joint cognitive systems performance in the face of massive volumes of complex and fast-changing information. Initiate assessing and enhancing the impact of analytics on thinking and reasoning in order to tailor capabilities to the context-specific cognitive requirements of our Warfighters. Initiate sensemaking studies, improve situational awareness, and mitigate data overload in order to enable Warfighters to rapidly extract meaning from complex, uncertain, and multi-dimensional data sources. Specific work is being vectored to directly support Joint All-Domain			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force		Date: March 2023
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625329 / *Sensory Evaluation and Decision Science*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Command and Control, with attention to experiments, studies, guidelines, and publications in high-priority and related strategic investment areas. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** FY 2024 increased compared to FY 2023 by $1.507 million. Funding increase due to an added emphasis in the enhancement of sensemaking to improve situational awareness, and the support of Joint All-Domain Command and Control activities.			
Accomplishments/Planned Programs Subtotals	23.479	40.148	44.454

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not applicable

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force			Date: March 2023
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*	Project (Number/Name) 627757 / *Bioeffects*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
627757: *Bioeffects*	0.000	12.449	45.791	47.664	0.000	47.664	45.653	28.945	29.615	32.867	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project conducts applied research on the effects of human exposure to electromagnetic energy (direct current to radio frequency to optical, scalable directed energy weapons, and other novel weapons). This research addresses mechanisms of interactions through fundamental physical principles, biological responses, and physiological outcomes. Research is divided into two core focus areas: novel directed energy bioeffects and mechanisms and directed energy modeling, simulation, and analysis. The research enhances combat survivability and systems effectiveness through technologies that enable deployed forces to counter optical threats and exploit optical systems for offensive applications. In addition, basic biological investigations into the mechanisms associated with high peak power and high average power radio frequency exposure allow for the exploitation of directed energy systems for offensive capabilities while protecting the warfighter from adversarial use of radio frequency technologies. The novel directed energy bioeffects mechanisms research examines the physical, physiological, behavioral, and neural interactions of electromagnetic energy with tissues to understand dose-response effects as well as reveal the means to cause or prevent a specific effect. The directed energy modeling, simulation, and analysis research is focused on new software components that represent and optimize concepts of novel system employment from the Airman standpoint. These components are matured for future transition and application for engagement-to-mission level simulations in which directed energy weapons are employed.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Novel Directed Energy Bioeffects and Mechanisms	4.357	16.027	16.682
Description: Conduct laboratory experiments to provide fundamental knowledge of mechanisms of interaction of directed energy with molecules, cells, tissues, organs, and whole organisms in support of military directed energy systems. Conduct laboratory experiments to understand the mechanistic and behavioral effects of novel weapon incidents to the Airman and to understand the effects of protection strategies on Airman performance. ***FY 2023 Plans:*** Continue collection and transition of data from multiple parameterization, validation and verification experimental studies to candidate products that support high peak power microwave, high energy laser, and other emerging directed energy weapon concepts in order to assure valid modeling of real-world concerns. Continue studies to further the understanding of suprathreshold effects on critical tissues including dynamic tissue characteristics under suprathreshold insult. Initiate methodologies to represent human vulnerabilities and vision effects within the modeling and simulation environment. Continue research of mechanisms emerging from subcellular and cellular level response to radio frequency and optical radiation. Continue research that underpins enhanced assessment of operational exposures to battlefield directed energy environments. Continue			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force		Date: March 2023
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 627757 / *Bioeffects*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
research data and expertise to activities that further the development of directed energy policy and exposure standards to maximize interoperability and safe use of technology. ***FY 2024 Plans:*** Continue collection and transition of data from multiple parameterization, validation and verification experimental studies to candidate products that support high peak power microwave, high energy laser, and other emerging novel weapon concepts in order to assure valid assessments of real-world concerns and manage the risks associated with technological surprise. Continue studies to further the understanding of high energy effects on critical tissues including dynamic tissue characteristics under high power insult. Extend prior-year studies to include additional near-to-mid infrared parameters to fill data gaps required for materiel selection of laser systems. Continue developing methodologies to understand vulnerabilities and vision effects, including impact of protective systems on color vision. Continue examining mechanisms emerging from subcellular and cellular level response to electromagnetic energy. Continue research that underpins enhanced assessment of operational exposures to battlefield directed energy environments to include counter directed energy weapon technology. Expand research data sets and expertise to activities that further the development of directed energy policy and exposure standards to maximize interoperability and safe use of technology. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** FY 2024 increased compared to FY 2023 by $0.655 million. Funding increase due to a multi-year surge of funding supporting high priority, real-world events.			
Title: Directed Energy Bioeffects Modeling, Simulation and Analysis	8.092	29.764	30.982
Description: Conduct physics-level modeling and simulations to represent and optimize directed energy bioeffects to include direct, scalable, and collateral effects. ***FY 2023 Plans:*** Continue advancing dose-response models to include probability of injury as a function of depth within the skin. Continue maturing approaches for utilizing high performance computing to quantify the uncertainty within multi-physics bioeffect simulations of directed energy engagement. Continue extending prototype approaches for surrogating physics-level simulations through machine learning applications. Initiate advanced three-dimensional digital anatomical models for use within physics-level software, and leverage these models against empirical datasets for advanced validation purposes. ***FY 2024 Plans:*** Continue advancing dose-response models to include severity of injury as part of employment risk as a function of directed energy weapon parameters. Continue advancing three-dimensional digital anatomical models for use within physics-level software, and leverage these models against empirical datasets for advanced validation purposes. Continue maturing approaches for utilizing high performance computing to quantify the uncertainty within multi-physics bioeffect simulations of directed energy in end-to-			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Air Force		Date: March 2023
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 627757 / *Bioeffects*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
end simulations at the engineering, engagement and mission levels, incorporating models from other collaborative organizations. Continue extending modeling approaches for surrogating physics-level simulations through machine learning approaches, and suitable for integration for digital representation of human throughout analyses. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** FY 2024 increased compared to FY 2023 by $1.218 million. Funding increase due to a multi-year surge of funding supporting high priority, real-world events.			
Accomplishments/Planned Programs Subtotals	12.449	45.791	47.664

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not applicable