Human System Technologies Strategic Vectors

15th Annual Science & Technology Engineering Technology/ Defense Tech Exposition

8 April 2014

Dr. Morley Stone, Chief Scientist

711th Human Performance Wing

Air Force Research Laboratory

Integrity ★ Service ★ Excellence

Changing Landscape

New Bio Developments
- **Genomics, proteomics**
- **Neuroscience**
- **Microbiome**

Warfighter Demand
- **Cyber, RPA, OE…**
- **Areas we didn't have 15+ years ago**
- **Extreme cognitive & physical environments**
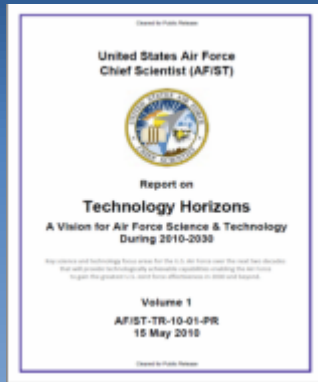- **A2AD operations**

New Tech Development
- **Human-machine teaming and autonomy**
- **LVC immersive environments**
- **Robotics**

Affordability & Sustainment
(Cost of healthcare, personnel, energy)
- **Exponential growth**
- **Unsustainable**

AF S&T Vision
Key Documents & Studies

Tech Horizons

United States Air Force
Chief Scientist (AF/ST)

Report on
Technology Horizons
A Vision for Air Force Science & Technology
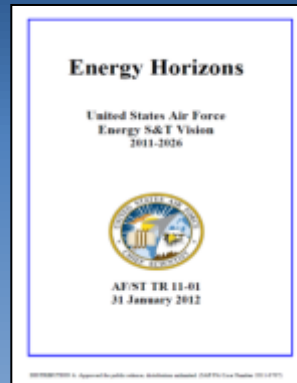During 2010-2030

Volume 1

AF/ST-TR-10-01-PR
15 May 2010

Single greatest finding is the need for gaining capability increases, manpower efficiencies, and cost reductions through:
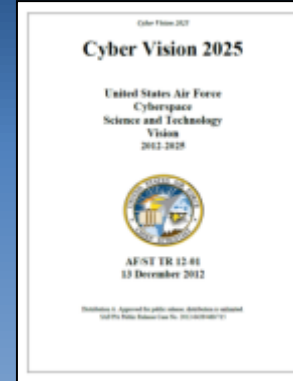- **Far greater use of autonomous systems**
- **Human performance augmentation**

Energy Horizons

Energy Horizons

United States Air Force
Energy S&T Vision
2011-2026

AF/ST TR 11-01
31 January 2012

Maximizing distributed, interactive flight simulators to:
- **Decrease the training costs of live operations**
- **Enable safe training in contested, congested conditions**
- **Enhances readiness**

Cyber Vision 2025

Cyber Vision 2025

Cyber Vision 2025

United States Air Force
Cyberspace
Science and Technology
Vision
2012-2025

AF/ST TR 12-01
13 December 2012

Assured cyberspace advantage by focusing on:
- **Mission assurance**
- **Resiliency and agility**
- **Human-machine integration**
- **Trust**

Global Horizons

Global Horizons
Final Report

United States Air Force
Global Science and Technology Vision

AF/ST TR 13-01
1 June 2013

Key game changers for the AF resulting from significant global trends in technology advancements:
- **Personalized health & performance via mobile technologies**
- **Personalized learning**
- **Flexible autonomy**
- **Weapons in Context of Human Environment**

AF Human Performance Challenges

RPA Operator

- Low manning
- Long hours, shift work
- Emotional exhaustion

- Asset losses
- Decreased mission effectiveness

Aircrew

- High physical demands
- High cognitive load

- Decreased adaptability to contested environments
- Survivability issues in high-G

ISR Analyst

- Time pressure
- Intel data overload
- Continual transfer of operational SA

- Missed intelligence
- Threat/danger missed
- Manpower efficiency

Special Operator

- High physical demands
- High cognitive load

- Time/lost targets
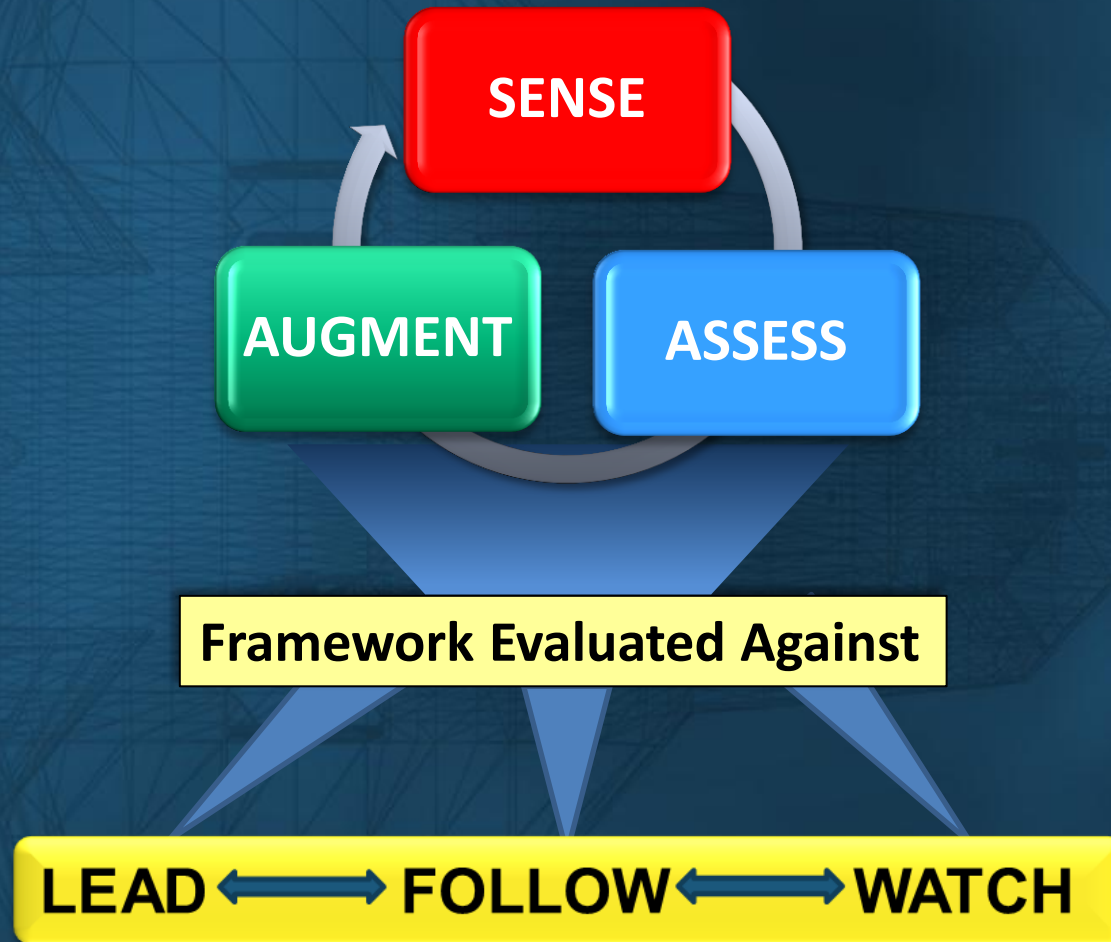- Poor decisions
- Loss of life

Cyber Operator

- Information overload
- Reduced acuity
- Decreased vigilance

- Missed interventions
- Missed intelligence
- Decreased offensive proactivity

Repetition, Information Overload, Fatigue, Stress

Human Systems Framework

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Strategic Vectors

Personalized Health & Performance

Human-Machine Teaming for Autonomous Systems

Protection

Strategic Vectors
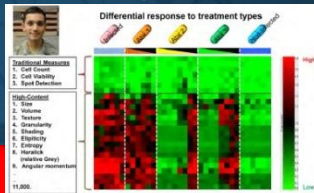
Personalized Health & Performance

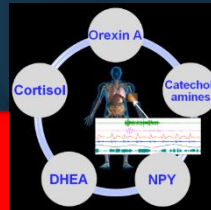Human-Machine Teaming for Autonomous Systems

Protection

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Personalized Health & Performance

Cellular Fingerprints

Biomarkers and Cognitive Performance
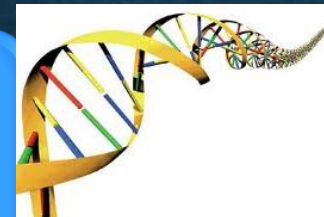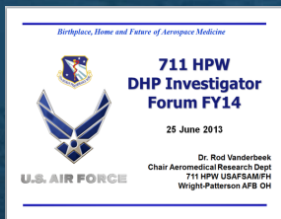
Wearable Sensors & Apps

Novel Micro Sensing Devices

SENSE

Seamless En Route Care
Precision Care via Genomics
Pharma/nutraceuticals for Performance

Genetic Models of Performance

AUGMENT

ASSESS

Personalized Learning

Assessment from Integrated Sensors

Personalized Health & Performance

Blood Flow Sensor
IDF/Elbit of Israel

Cerebral Oximeter
RHC/JASDF

Hydration Sensor
RHX/USAFSAM

Helmet Pulse Ox
RHC

Cognitive VOC
RHX
VOC – Acetone
RHX

Mask O_2 / CO_2
USAFSAM
NAMRU-D
Lockheed

O_2 Flow Meter
USAFSAM/
NAMRU-D
Lockheed
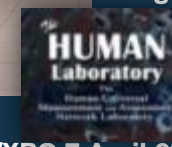
- **Technologies that Provide:**
  - **Unprecedented real-time and continuous feedback**
  - **Quantification at the individual level with complex data resolution across scales from genes to whole body**

- **Technologies that Enable:**
  - **Assessment of the physical and cognitive state of the operator**
  - **Optimization of health and performance lifecycle needs of the warfighter**
  - **Individualized solutions**

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Strategic Vectors

Personalized Health & Performance

Human-Machine Teaming for Autonomous Systems

Protection

Protection

Physiology

Advanced Hearing Protection

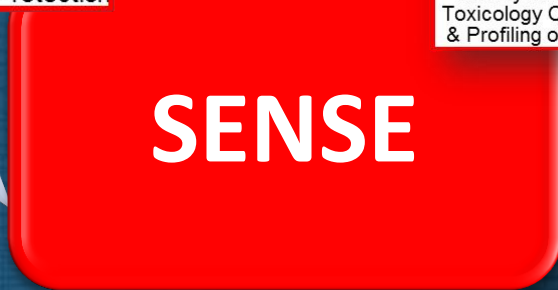**Toxicology**

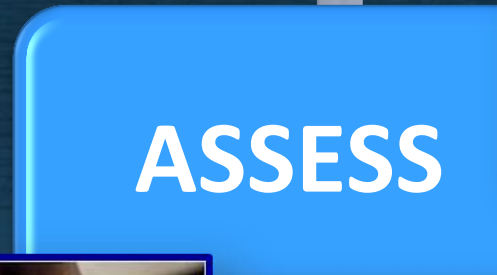Toxicity Assessments and Toxicology Characterization & Profiling of Aircraft Fluids

Cognitive

Stress & Resilience Biomarkers

SENSE

AUGMENT

Laser Eye Protection

ASSESS

Neuropsychological Performance Assessment Tools

Cognitive

Application of Toxicology Exposure Sensors
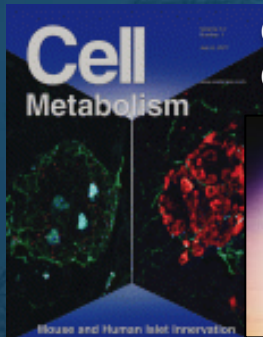
Toxicology

Centrifuge Testing

Physiology

Altitude & Decompression Studies

Protection

Aerospace Fuel and Materials Toxicology

Cellular Signaling Cascades

Cognitive Performance Optimization

RF, Laser, and Nanomaterial Combined Effects

Epithelial Cells

Al-NM

Internalized Al NM

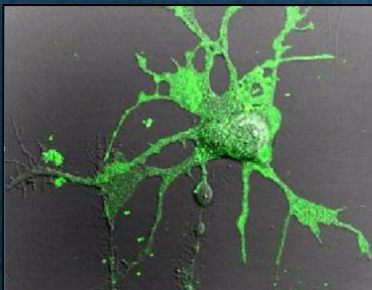Immune Cell

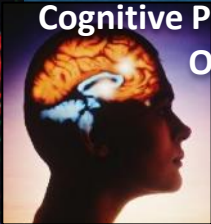**Neural Effects of ns Electrical Pulses**

- **Technologies that Provide:**
  - Physiological effects of USAF environmental stressors
  - Fundamental mechanisms for cognitive decrement
  - Emerging fuels and materials toxicology
  - Directed energy system bioeffect protection
  - Data for exposure limit standards

- **Exploitation of Technologies**
  - Novel weapon concepts
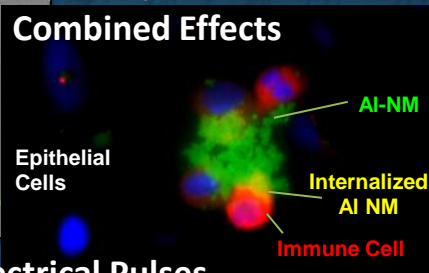 - Optimized concepts of operation and technology blends

Strategic Vectors

Personalized Health & Performance

Human-Machine Teaming for Autonomous Systems

Protection

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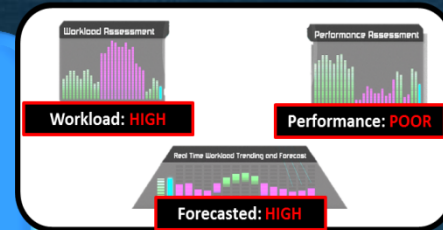
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Human-Machine Teaming for Autonomous Systems

Leverage Developments in Personalized Health & Performance

SENSE

Augment Human Performance with Autonomous Systems

AUGMENT

ASSESS

Implement a Controlled Feedback Cycle

Human-Machine Teaming for Autonomous Systems

HUMAN DECISIONS GUIDE MACHINE BEHAVIOR

HUMAN OPERATOR — INTERFACE — AGENT

Informational Flow

HUMAN AND MACHINE TEAM TOGETHER TO MAKE DECISONS

HUMAN OPERATOR — INTERFACE — AGENT
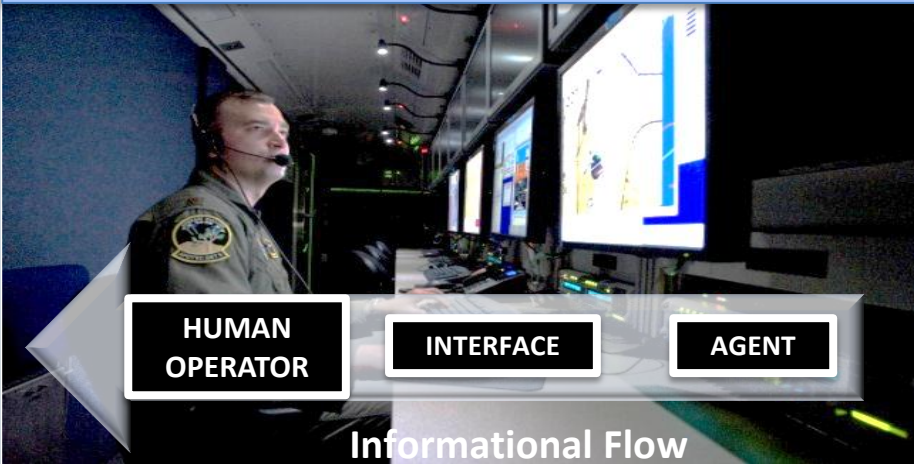
Information Flow

Current Status

Future Status

Bi-Directional Flow of Information

Human-Machine Teaming for Autonomous Systems

- **Technologies that enable:**
  - **Objective measurement and assessment of human's state (physiological, performance, behavioral)**
  - **Humans and machines to communicate and share information**
  - **Tasks and function allocation for workload and decision-making balance**
  - **Adaptive, learning and extended mutual training between H & M**
  - **Integrated human and machine data (context, time, format) for a shared world model**

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Partnering Opportunities

- **Personalized Performance Monitoring**
  - AF Mission-Relevant Human Sensing Technologies (leveraging current personalize performance developments in sports and health)
  - Assessment & Augmentation Technologies
- **Protection**
  - Physiology, Cognitive & Toxicology Sense & Assessment Technologies
- **Human-Machine Teaming**
  - Mission-based Assessment Technologies
  - Intelligent Machines to Augment Airman Performance

Questions