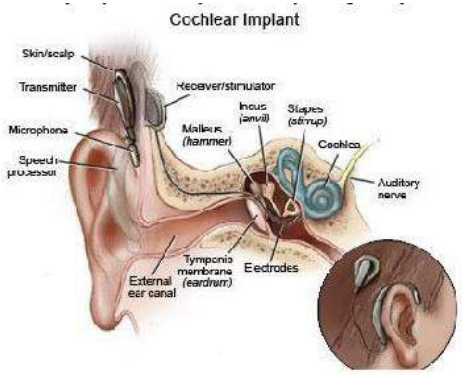
CENTER FOR ADVANCED STUDY OF LANGUAGE

Strategic Multilayer Assessment Virtual Panel Discussion:
Leveraging cognitive science and technology
for learning and action

Human/Machine Teaming via Augmented & Virtual Reality

Michael Bunting, Petra Bradley & Jared Linck
University of Maryland
Center for Advanced Study of Language

A Next Big Thing:
Technology & Information Overload



Implantable Neural Interface

Drone Vision

Vast Visual Acuity: Detect infrared & ultraviolet light

DARPA Squad X

Overcoming Information Overload

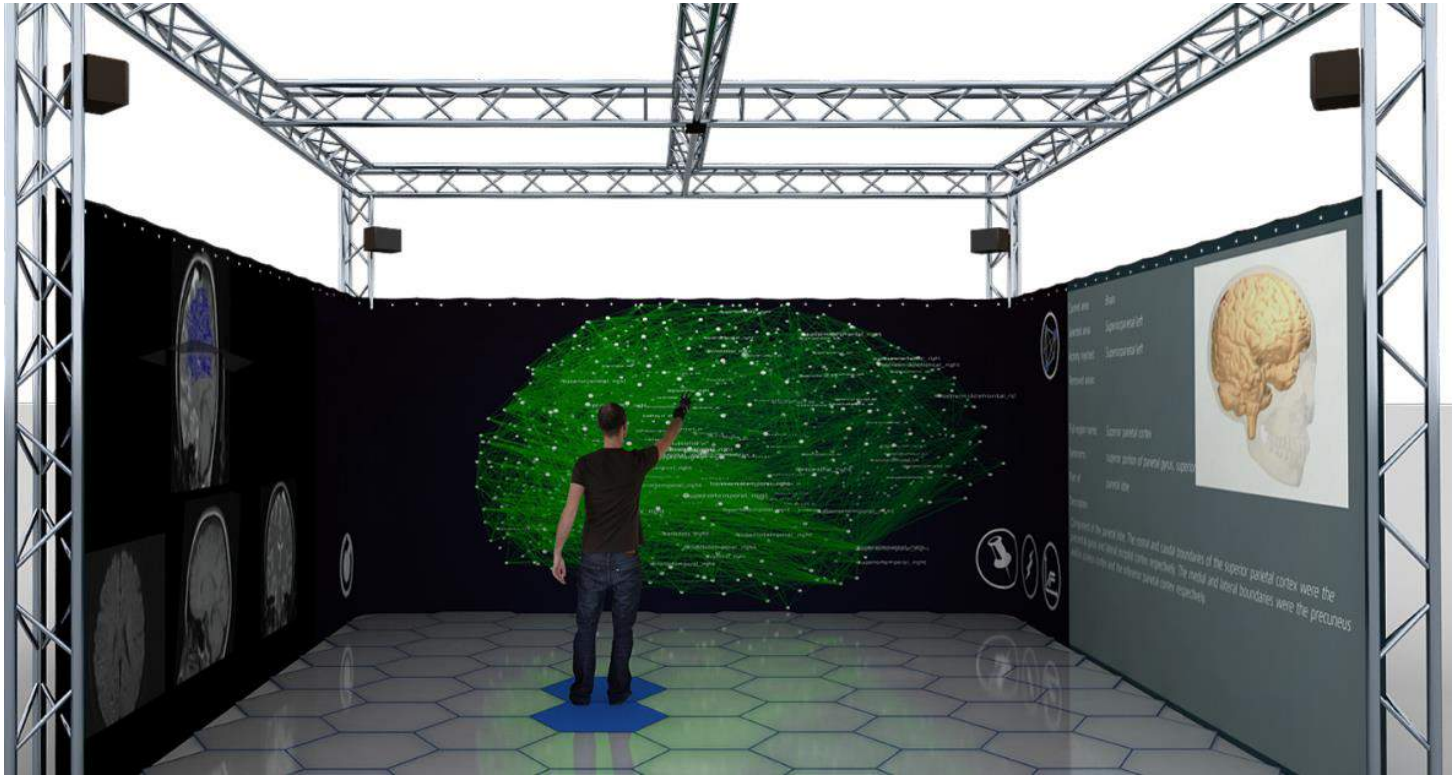
CASL research programs since 2007

- Aptitude tests to select & place those with optimal cognitive abilities for the task
- Attention & memory training
- Stress mitigation (e.g., mindfulness training)
- Achieve optimal attentional state (e.g., alpha entrainment)
- Measure cognitive load (e.g., pupil dilation)
- Optimal learning environments in virtual reality

A Next Big Thing:

Creative Visualization of Data

Can AR/VR capabilities help analysts visualize and process large and varied data sets?



Deliverable:
Conceptual Designs

- For DoD client, CASL produced preliminary design concepts for AR/VR visualization of multi-modal data
  - Developed two design concepts for use in entity definition tasks
    - Geodesic dome, virtual room
  - Developed design concepts for three context views to aid in exploring entities' activities, events, and relationships to other entities
    - Locations, social networks, timelines

Bradley, P., Michael, E., Paletz, S. B. F., Oteng-Agipong, A., Campbell, S., O'Rourke, P., Golonka, E., & Chang, V. (2018) *Conceptual designs for an entity sense-making system.*

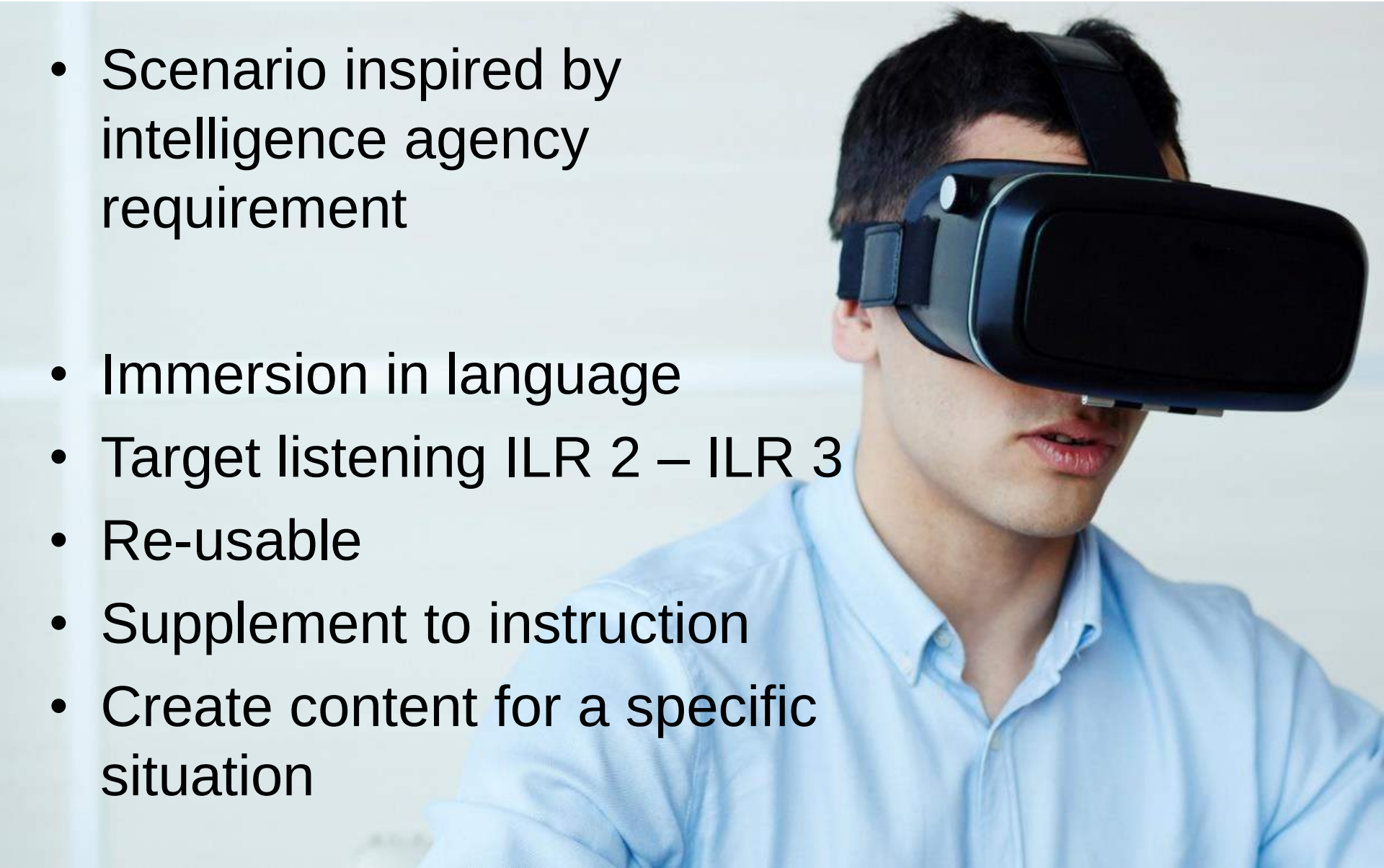
Deliverable:
Cognitive Impact & Evaluation Protocols

- Proposed cognitive and non-cognitive factors that are hypothesized to be important components of aptitude for conducting entity intelligence tasks in AR/VR, e.g.,
  - Cognitive: working memory, visuospatial ability
  - Non-cognitive: technology acceptance, self-efficacy, videogame experience
- Described a research protocol for measuring AR/VR task performance

O'Rourke, P., Bradley, P., Paletz, S. B. F., Michael, E. B., Golonka, E., & Colflesh, G. (2018). *Protocols to evaluate the cognitive impact of immersive analytics and aptitude for AR/VR-based analysis: Who can benefit the most from AR/VR data visualizations?*

Virtual Reality Learning Environments

VR design goals for prototype



- Scenario inspired by intelligence agency requirement

- Immersion in language
- Target listening ILR 2 – ILR 3
- Re-usable
- Supplement to instruction
- Create content for a specific situation

Scenario: Embassy cocktail party

- Needs-based content development:
  - Interviewed Subject Matter Expert
  - Contracted native-speaking Russian actors
  - Targeted, high-level content, loosely scripted
  - Encouraged improvisation that fit with characters
- Designed for pedagogical exploitation
- Empirical study (VR vs. 2D)
  - VR significantly enhanced L2 listening comprehension
  - VR produced greater sense of presence

Thank you!

For more information

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Cognitive Science at AFRL:
Some Research Highlights

Kevin Gluck, PhD

27 NOVEMBER 2018

AFRL Mission

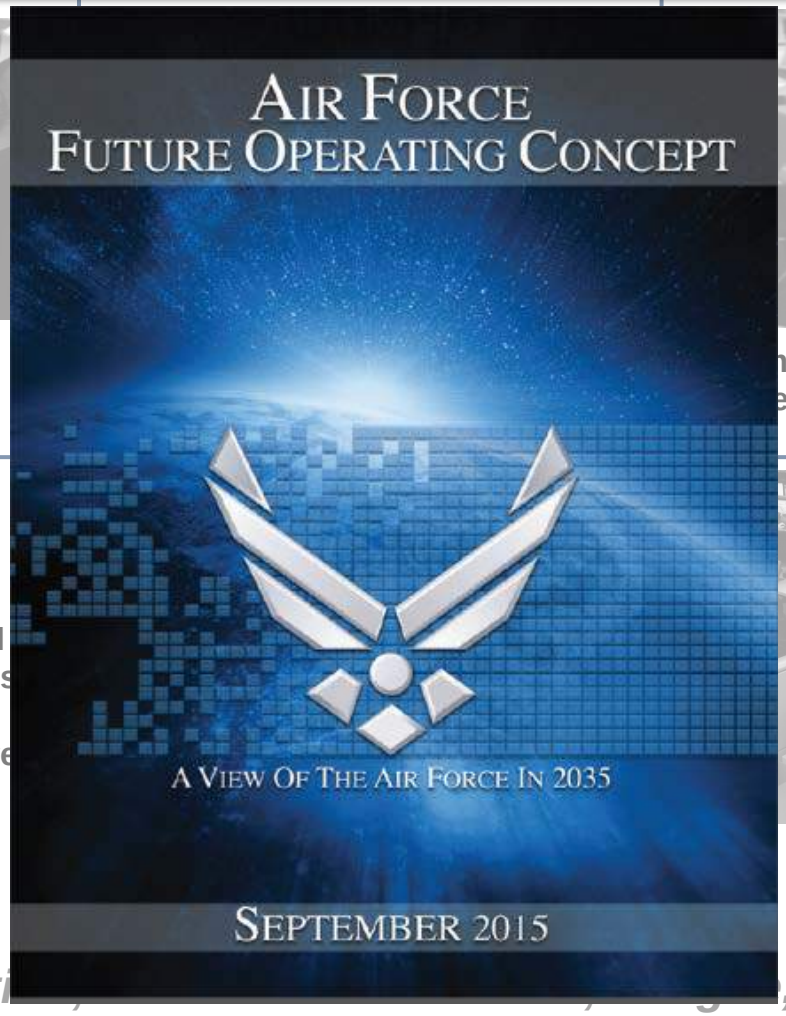
LEADING the discovery, development, and integration of affordable warfighting technologies for our air, space, and cyberspace force.

Human Performance is Fundamental to Air Force Capabilities

The Challenge: Cognitive and Physiological Demands of Tomorrow's Operational Environment

RPA Operator

- Low manning
- Long hours, shift work



ISR Analyst

…e pressure
…el data overload

Special Ops

- High physical demands
- High cognitive load

Cyber Operator

Information overload
Decreased vigilance

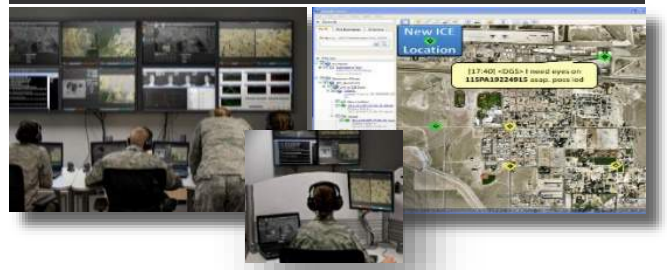
Repetiti… …, Stress

Science and Technology

Training

Accelerate, enhance and reduce costs of training to achieve and sustain combat readiness

Human-Centered ISR

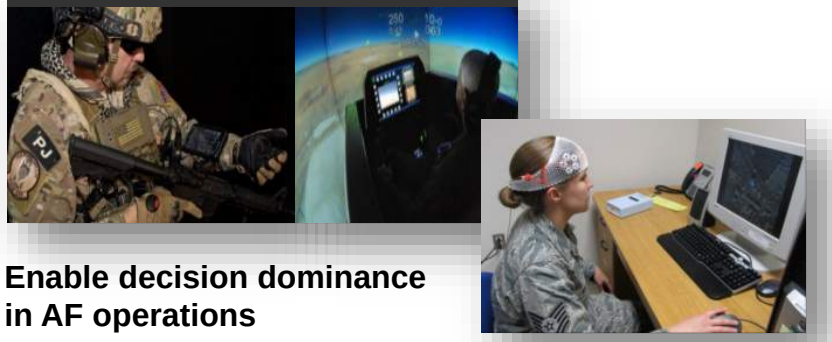


Improve situational awareness and threat detection

Bioeffects

Characterize biological effects and performance-related molecular mechanisms

Decision Making



Enable decision dominance in AF operations

Exploiting biological and cognitive Science and Technology to optimize and protect the Airman's capability to fly, fight, and win in air, space, and cyberspace.

$796M S&T investment - FY19-23 ***25+ research programs*** ***4 core technical competencies***

Cognitive Models and Agents

Science and application of software that thinks and acts like people

- Formal – computational and mathematical models of human thinking, reasoning and decision making
- Valid – credible behavior in training exercises & operational environments
- Adaptive – tailored to the mission and the Airman

Example Research Areas

1. Autonomous Training Agents
   - Synthetic Procedural Controller

2. Multi-Level Models for Airman Assessment
   - Integrated Models of Physiology & Cognition
   - Applied Research in Fatigue Management

3. Large-Scale Computation for Agent Training & Assessment
   - Enabling Infrastructure: MindModeling.org
   - Test, Evaluation, Verification, and Validation (TEV&V)

4. Robust Decision Making in Human-Machine Teams
   - Mission Planning & Debrief
   - Inferring Human Cognitive Processes

5. Interactive Task Learning

6. Models of Learning & Retention for Personalized Training
   - Adaptive Training Schedules

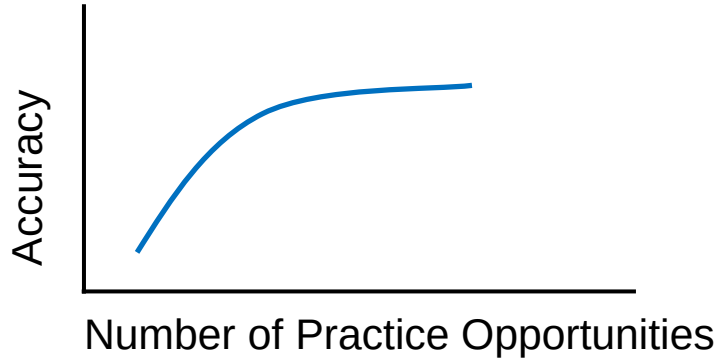
U.S. Patents: 8,568,145; 8,777,628

Foundation in Cognitive Science

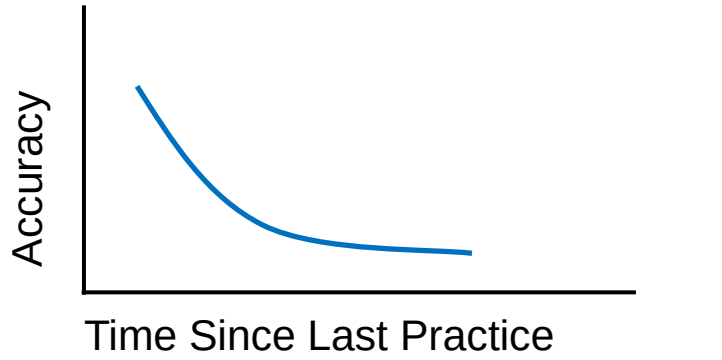
Leverage 100+ years of research in learning and memory

Primary determinants of performance:

1. Amount of practice (*frequency*)



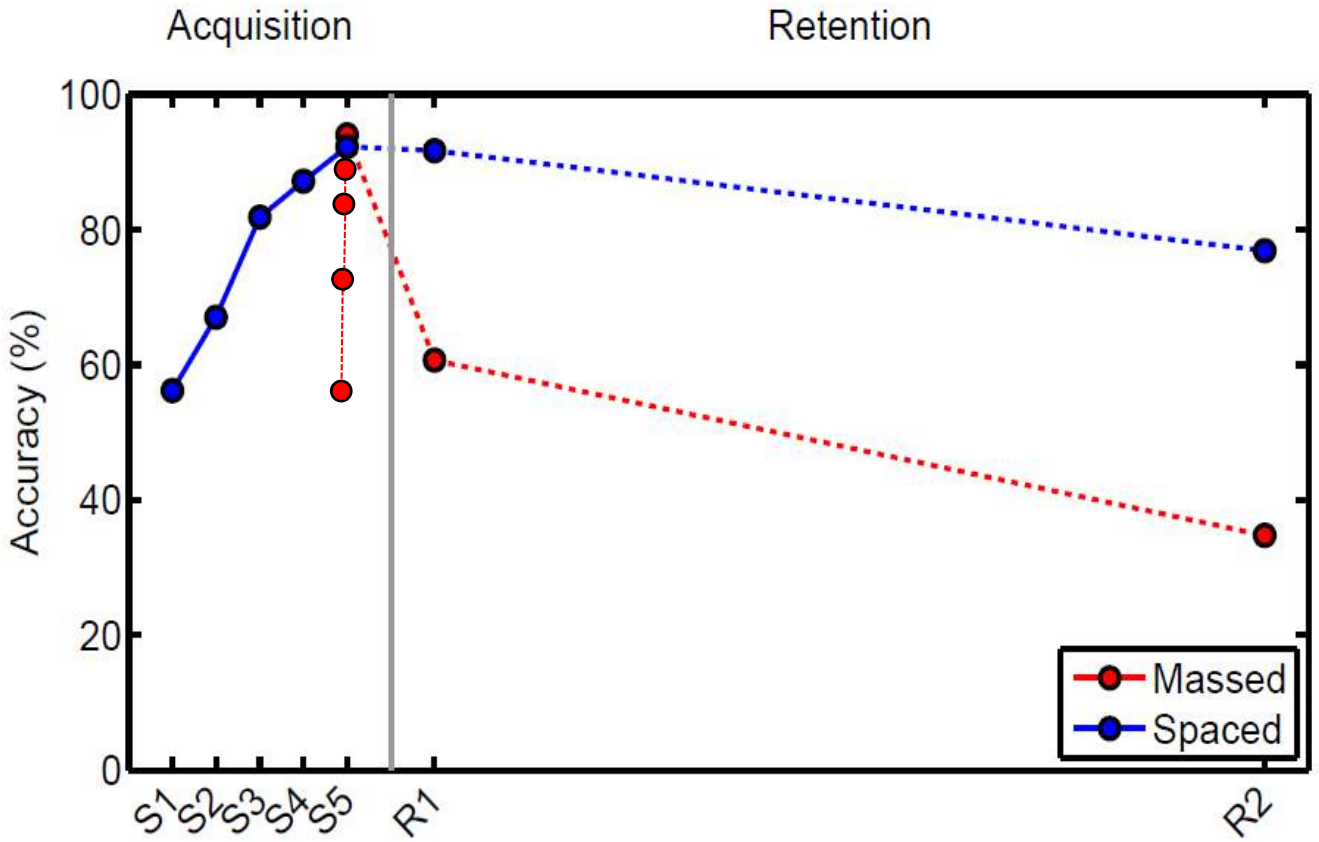
2. Elapsed time since practice (*recency*)



3. Temporal *spacing* of practice

The Spacing Effect

Increased time between study episodes often improves retention



Application Case Study: CPR

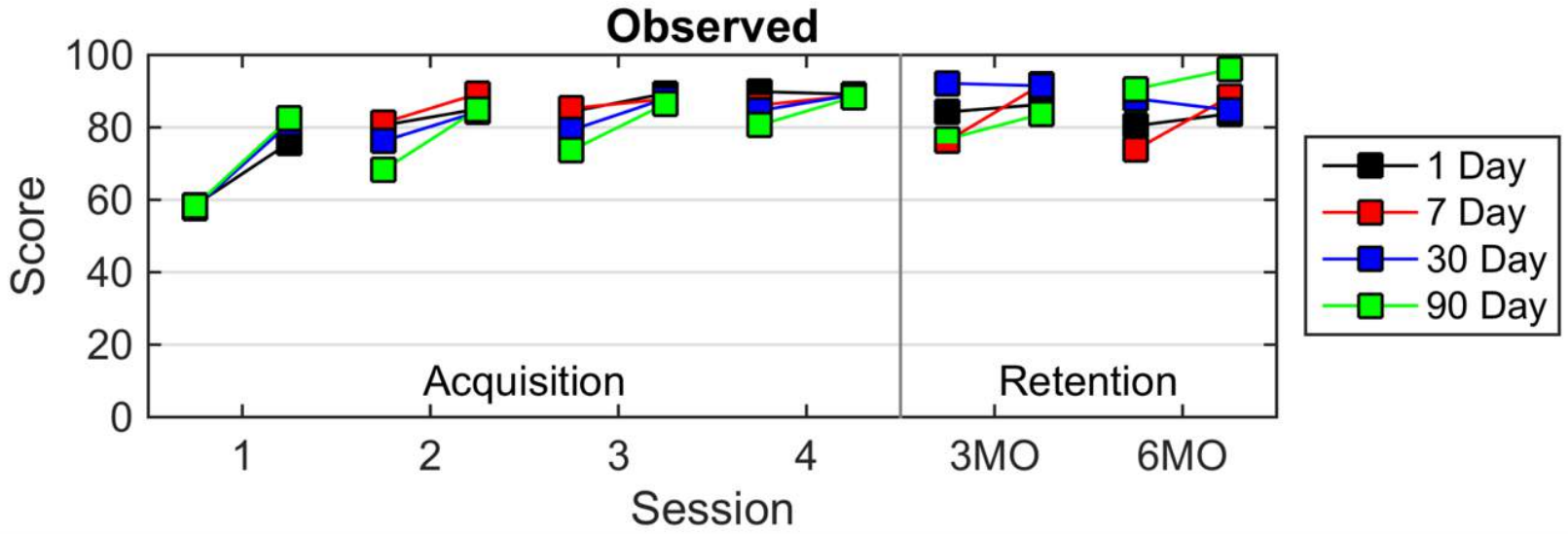
- *Current Standard*: Fixed biennial CPR refresher training
- *Goal*: Personalized learning and refresher training
  - *Reduce patient risk*
  - *Reduce training time*
- *Method:* Large, multi-site field study to compare fixed vs personalized training schedules

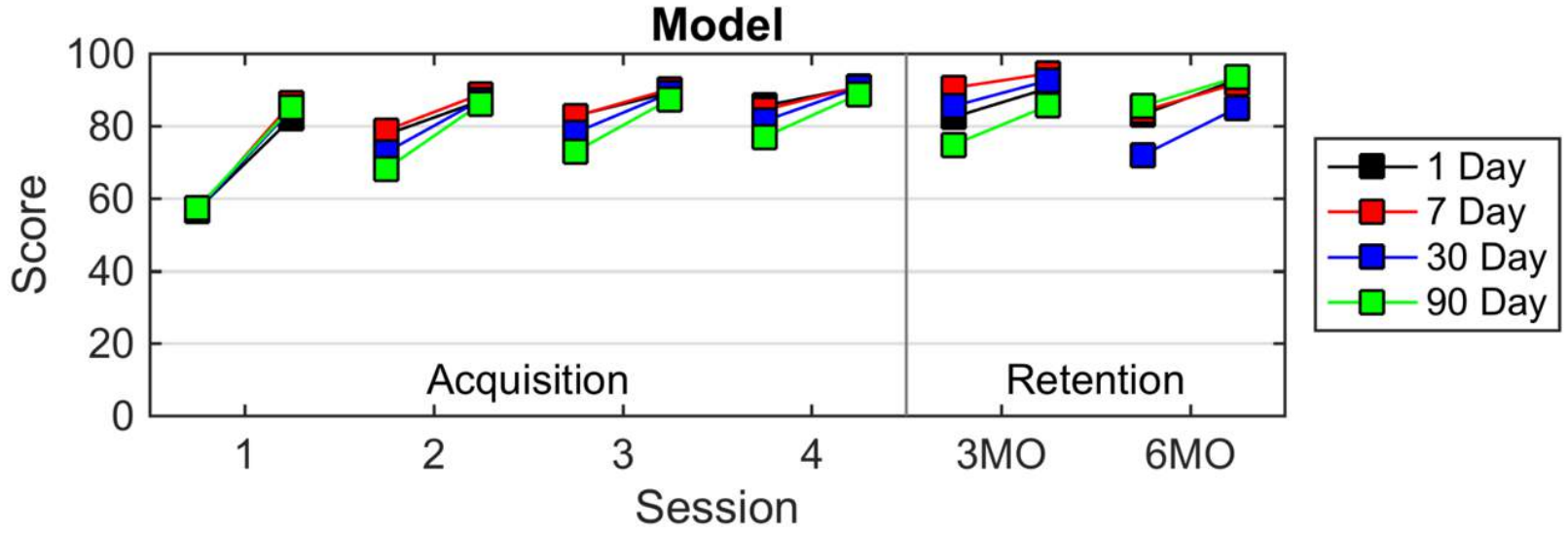
American Heart Association®

Laerdal
helping save lives

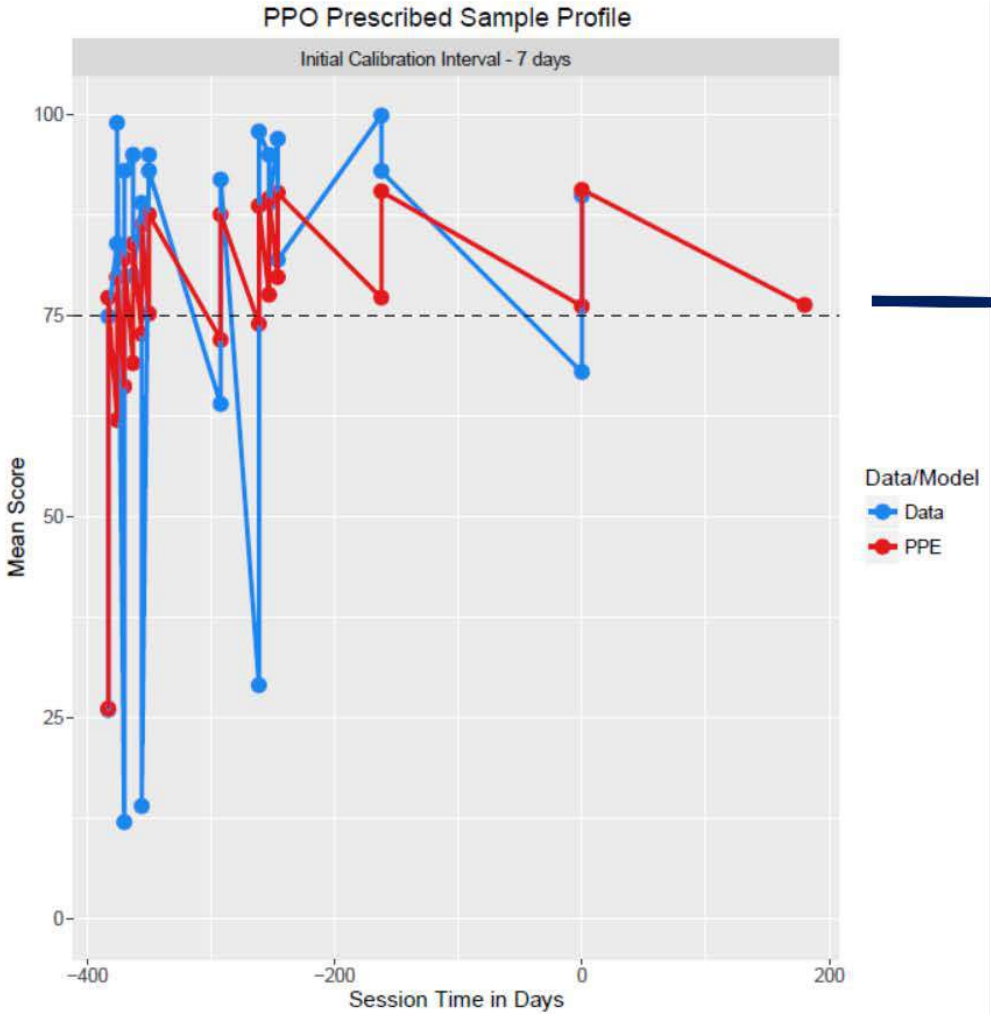
AFRL

Partial Field Study Results





An Example Participant

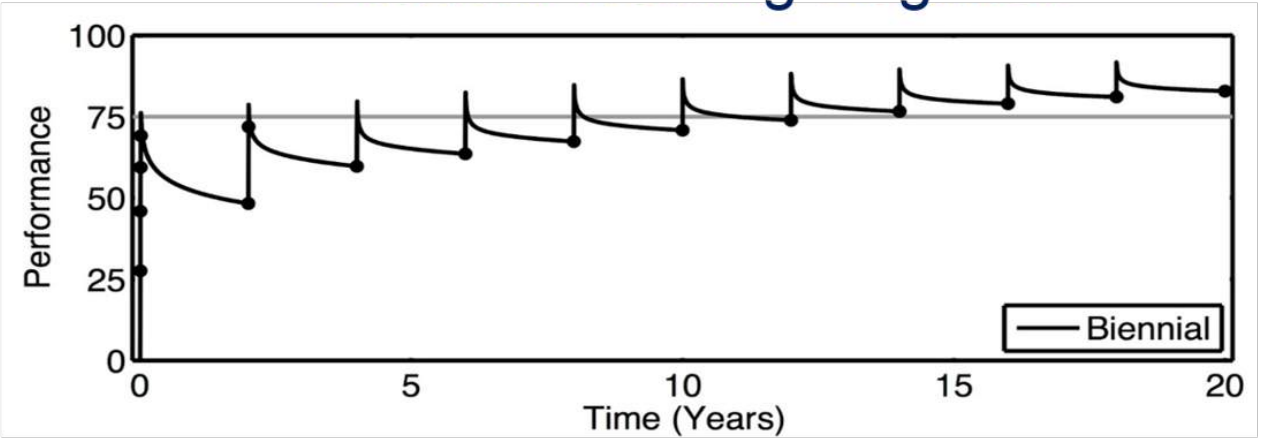


MindModeling
Powered by µBatch

Your next refresher to sustain proficiency will be in 178 days.

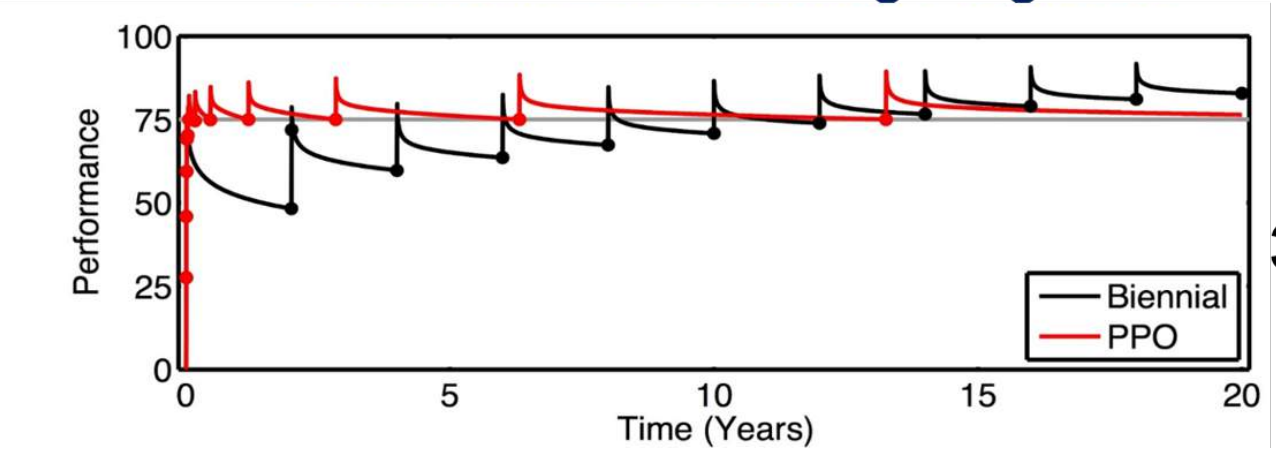
PPO Redistributes Training

Biennial Training Regimen



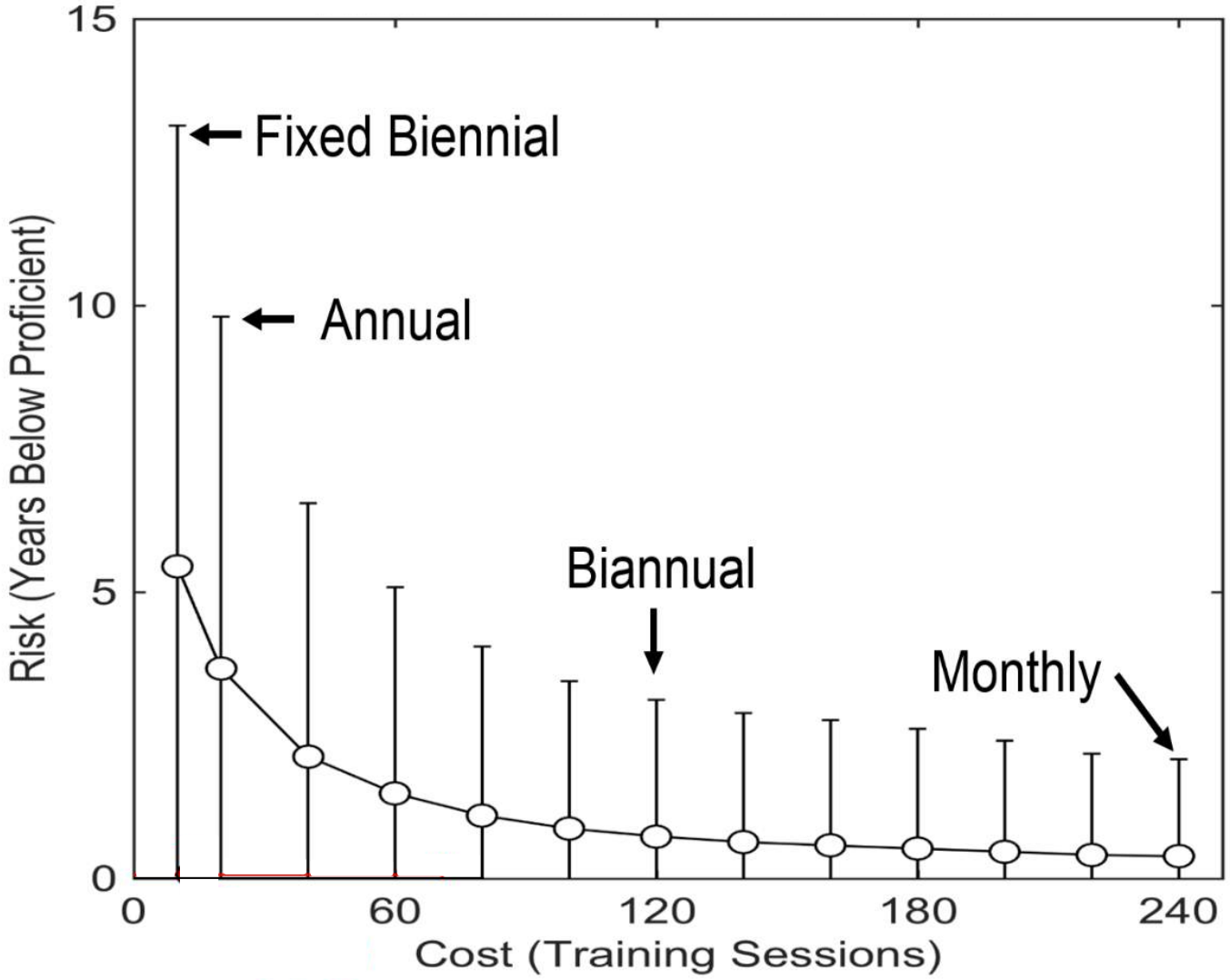
15 training sessions
3,880 days below proficient!

Personalized Training Regimen



11 training sessions
(28% improvement)
31 days below proficient
(99% improvement)

Cost-Risk Tradespace



THANK YOU

kevin.gluck@us.af.mil

Pilot Training Next

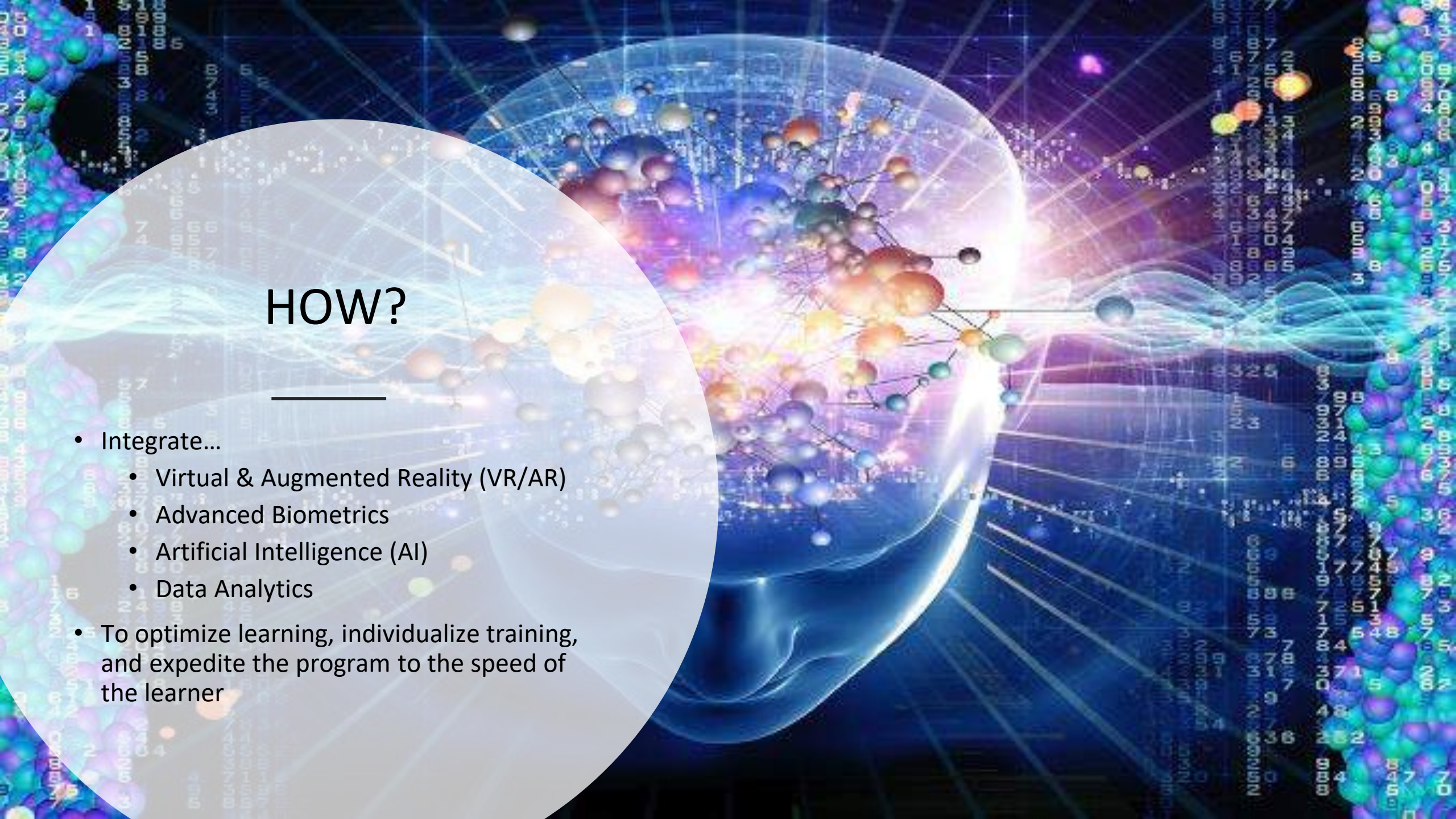
Path to Next Generation Learning

The Goal

Bring training processes from industrial age to information age by integrating new and emerging technologies and individualizing access to learning in order to capitalize on the talents of teachers and learners

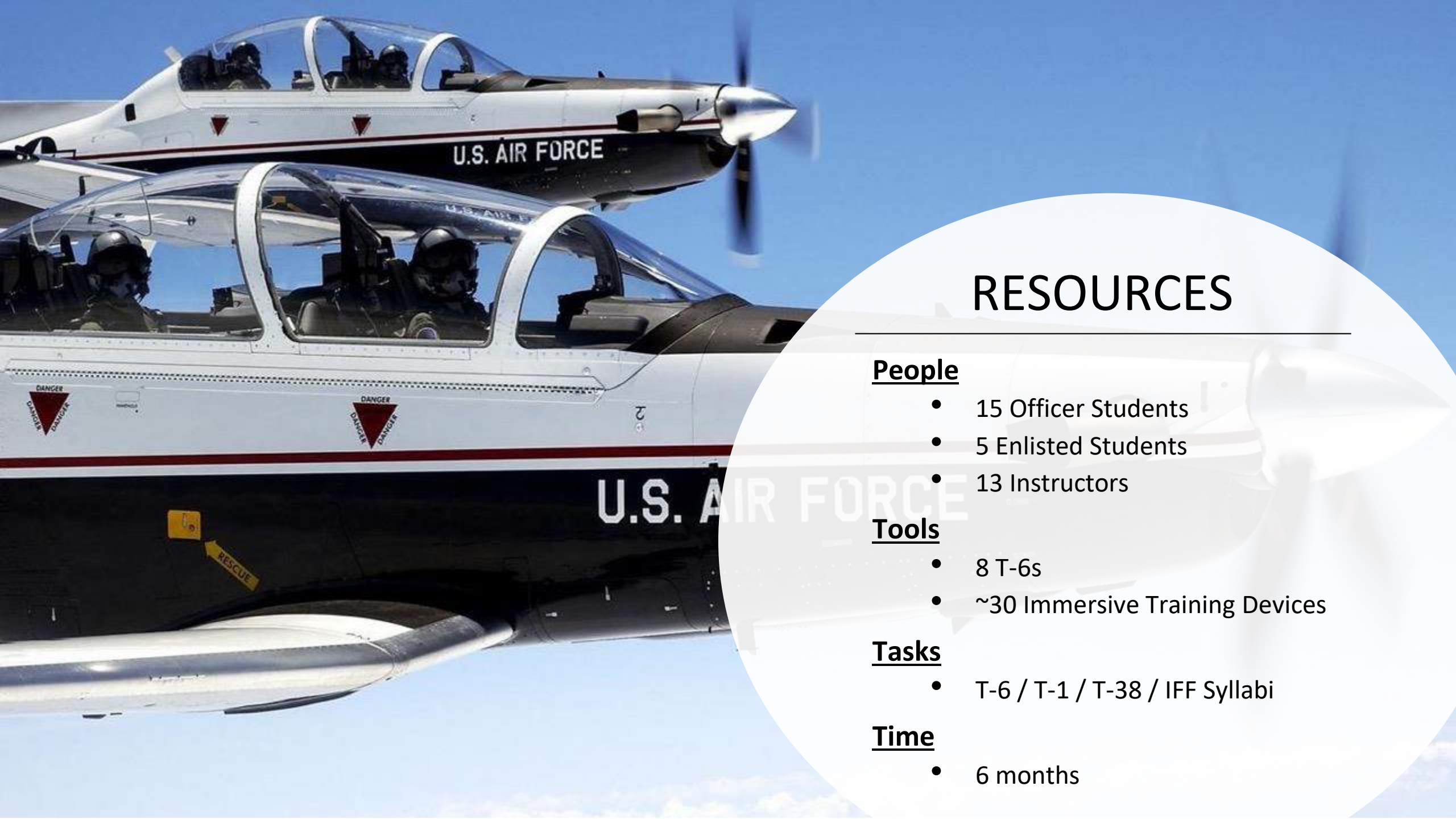
Orienting Objective (what we focus on day-to-day)

Training military pilots that are ready to begin training in their major weapons system



HOW?

- Integrate…
  - Virtual & Augmented Reality (VR/AR)
  - Advanced Biometrics
  - Artificial Intelligence (AI)
  - Data Analytics
- To optimize learning, individualize training, and expedite the program to the speed of the learner



RESOURCES

People

- 15 Officer Students
- 5 Enlisted Students
- 13 Instructors

Tools

- 8 T-6s
- ~30 Immersive Training Devices

Tasks

- T-6 / T-1 / T-38 / IFF Syllabi

Time

- 6 months

PTNv1 Big 4 Learning Points

PTNv1 Lesson	PTNv2 Application
• (Tech) VR greatly enhances the training experience	→ • Refine and improve the VR experience for IPs and students
• (Process) The individualized approach to training can expedite training	→ • Develop and refine metrics to validate training
• (People) Re-value plan-brief-execute-debrief model and root cause analysis	→ • Conduct robust IP training plan from a wide-variety of perspectives
• (Process) “Competence is the constant and time as the variable” was untested	→ • Will develop creative options to mitigate the 179-day TDY constraint

Plans for PTNv2

People

- 15 x Officers; 5 x Enlisted
- 2 x Navy; 1 x RAF students

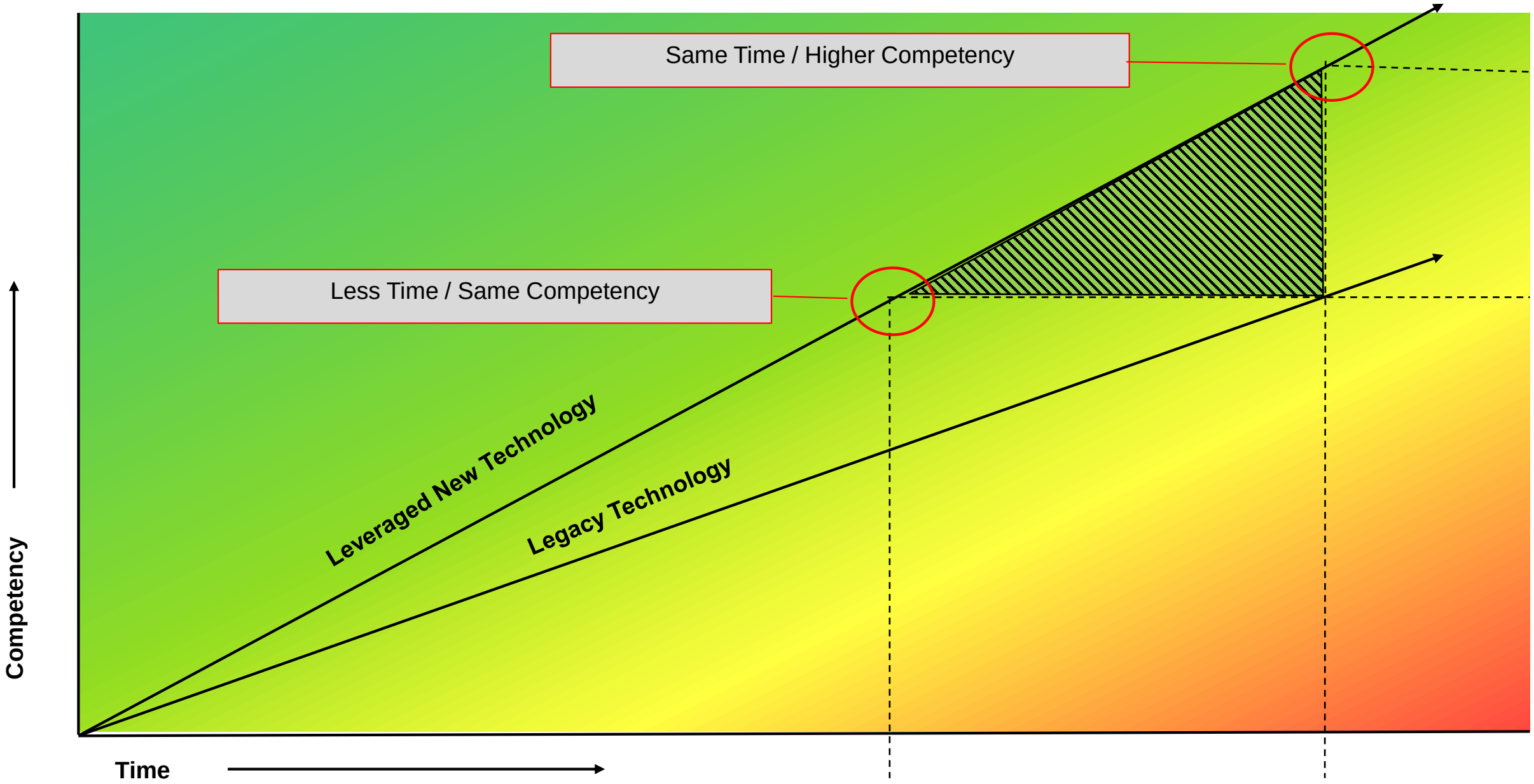
Process

- PTN Distance Learning
- More off-stations
- More solos
- Engage sim through learning management system

Tech Continued

- Analyze-able data from dorm sims
- More effective use of VIPER
- Immersive academics
- VIPER manipulate environment based on student performance/biometrics
- AI-driven search engine that tailors study recommendations based on performance
- More consistent biometric data sets

The Trade Space



PARTNERS

GOV

Industry

Academia

AMRDEC

DEFENSE INNOVATION UNIT

AFRL

AFWERX

SAIC

Redefining Ingenuity™

CAPITAL FACTORY

Discovery Machine Inc.

Zephyr BIOHARNESS

HUMANIZE TRAINING HTX LABS

FlyInside FSX

A2A simulations

ST SPECULAR THEORY

Talent+ THE SCIENCE OF TALENT.

Booz | Allen | Hamilton

Signature FLIGHT SUPPORT BBA Aviation

Senseye

htc VIVE

MILVIZ MILITARY VISUALIZATIONS

OPX

PREPAR3D®

APTIMA HUMAN-CENTERED ENGINEERING

VRS

CloudAhoy debriefing for pilots

FULL SAIL UNIVERSITY

SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

QUESTIONS

"To flourish and grow in a many-sided uncertain and ever changing world that surrounds us, suggests that we have to make ***intuitive*** within ourselves those many practices we need to meet the exigencies of that world."

–John Boyd

Mars Expedition

Immersive VR Simulation

(Development of Mindsets with Contemplative Practices for Facing Complicated and Complex Challenges)

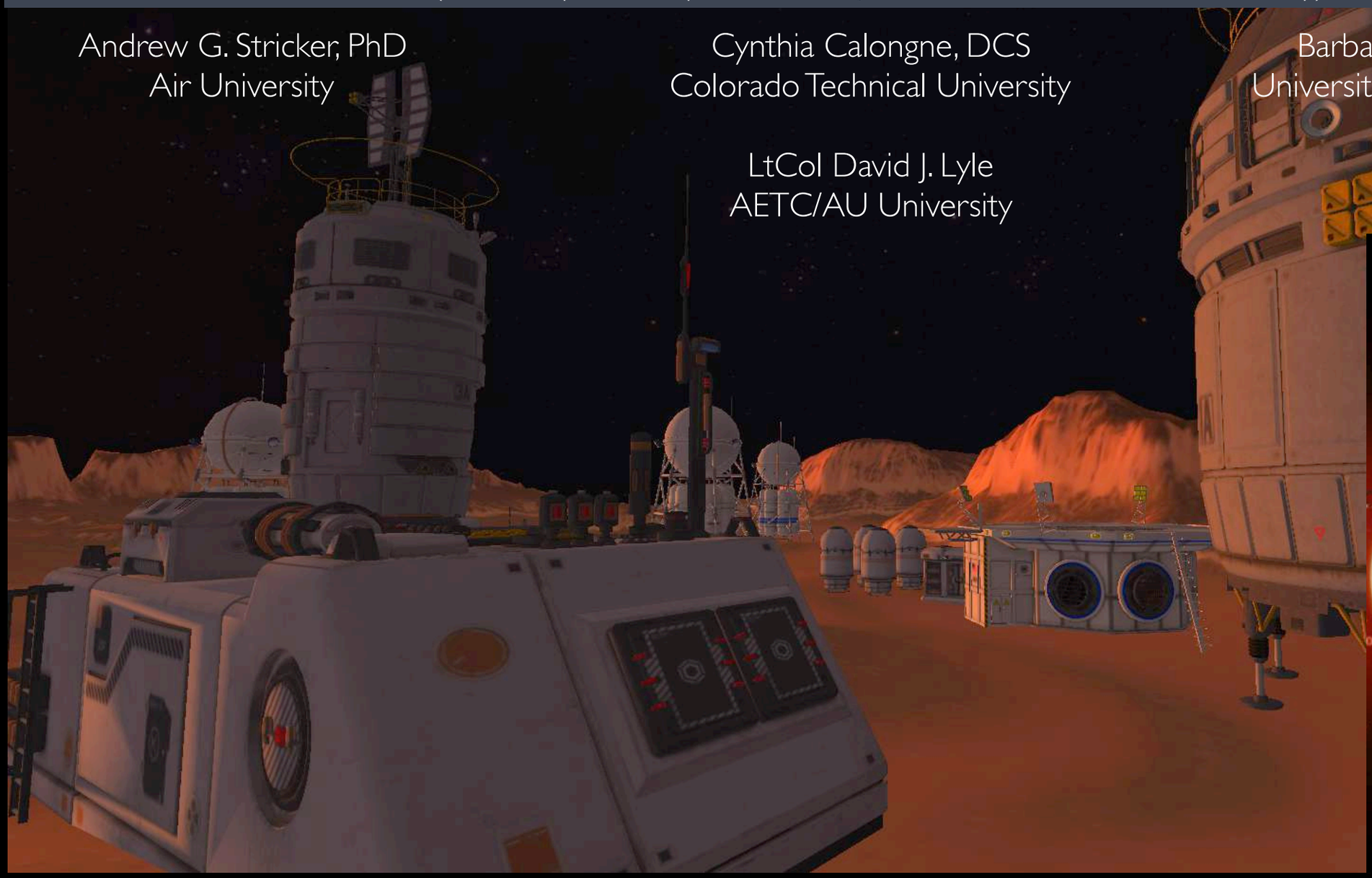
Federal Virtual Worlds Challenge
Grand Prize Winner
(AU team partnership with NASA JPL and Colorado Technical University)

Andrew G. Stricker, PhD
Air University

Cynthia Calongne, DCS
Colorado Technical University

LtCol David J. Lyle
AETC/AU University

Barbara Truman, DCS
University of Central Florida

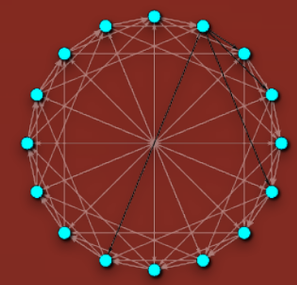


DEVELOPING AGILE MINDSETS FOR COMPLICATED AND COMPLEX CHALLENGES*

Chessboard Mindset

Knowing about and having the means to balance usage of mindsets

Web-network Mindset



- Using procedures can help you to perform tasks more skillfully in alignment with accepted practices for addressing complicated problems or challenges (problems involving considerable challenge but all elements needed for a correct solution can be discovered and fitted together given enough time and expertise)
- Be aware of how decision biases can distort your thinking
- Successful decision making when addressing complicated problems relies upon logic and statistics instead of intuition
- To make a decision, generate several options and compare them to pick the best one
- Reduce uncertainty by gathering more information
- It's bad to jump to conclusions—wait to see all of the evidence
- To make sense from a situation draw inferences on the basis of data
- The starting point for any effort to address a complicated problem is to get a clear description of the goal
- A plan will succeed more often for addressing complicated problems if the biggest risks are identified and ways are found to eliminate them

*see Gary Klein's *Streetlights and Shadows* and Anne-Marie Slaughter's *The Chessboard and the Web: Strategies of Connection in a Networked World*

- In complex environments, what you may need isn't the right information but the right way to understand the information you have
- In complex situations, you'll never figure out all that is going on
- Sense-making is at the heart of addressing complexity. You aren't just acquiring new knowledge, you can change the way you see things and think about them. You can make sense of conflicting and confusing data. Key questions: what led up to the events that are happening? How can you anticipate how your actions are likely to influence future events?
- Means to recognize a "wicked problem:" solutions to wicked problems aren't true or false. Instead, they are judged as good or bad because there is no way to test a solution to a wicked problem —when the goals just aren't clear—there aren't any objective ways to gauge success. Goals may become clearer as you learn more about a wicked problem (they're emergent goals)
- Breakthroughs depend on the ability to learn by making new connections, not on doggedly pursuing the original goal; networking matters for creative insights via divergent perspectives
- It is important to be able to face ambiguous situations, in the world of shadows, to better discern what you are not able to control everything that matters. Instead, you'll need to adapt…and should expect to adapt.
- Expect to run into problems when encountering complexity and to prepare yourself to recover, to be resilient…to improvise, to discover workarounds

AI-Augmented Mindset Aid

AI-Augmented Mindset Aid

- Uses the Web Ontology Language (OWL)

  (a semantic web language designed to represent rich and complex knowledge about things, groups, and relations between them)

- OWL was developed as a vocabulary extension of the Resource Description Framework and is derived from the Defense Advanced Research Projects Agency (DARPA) Agent Markup Language (DAML) and Ontology Interchange Language (OIL) Web Ontology Language

- The AI-Augmented Mindset Aid, used in the simulation, is designed to describe and reason about the relevant concepts of a domain addressing a variety of STEM topics related to space from web content

- The description logic is tuned for assisting with reasoning complexity associated with domain constructs, challenge context, and purpose

Semantic

Pragmatics in Contemplative Practice

ONTOLOGY
Reasoning between "[Things] & [Groups] with [Ideas]"

Formalizes

Expresses

Structures

Content

Granularity

Relations between [Things] & [Groups]

Things

Groups (Constructs)

Construct Rigor & Validity

Purpose

Design Methods & Tools

Ideas

Context (Complicated ~ Complex)

Reasoning with Mindset(s)

Domain

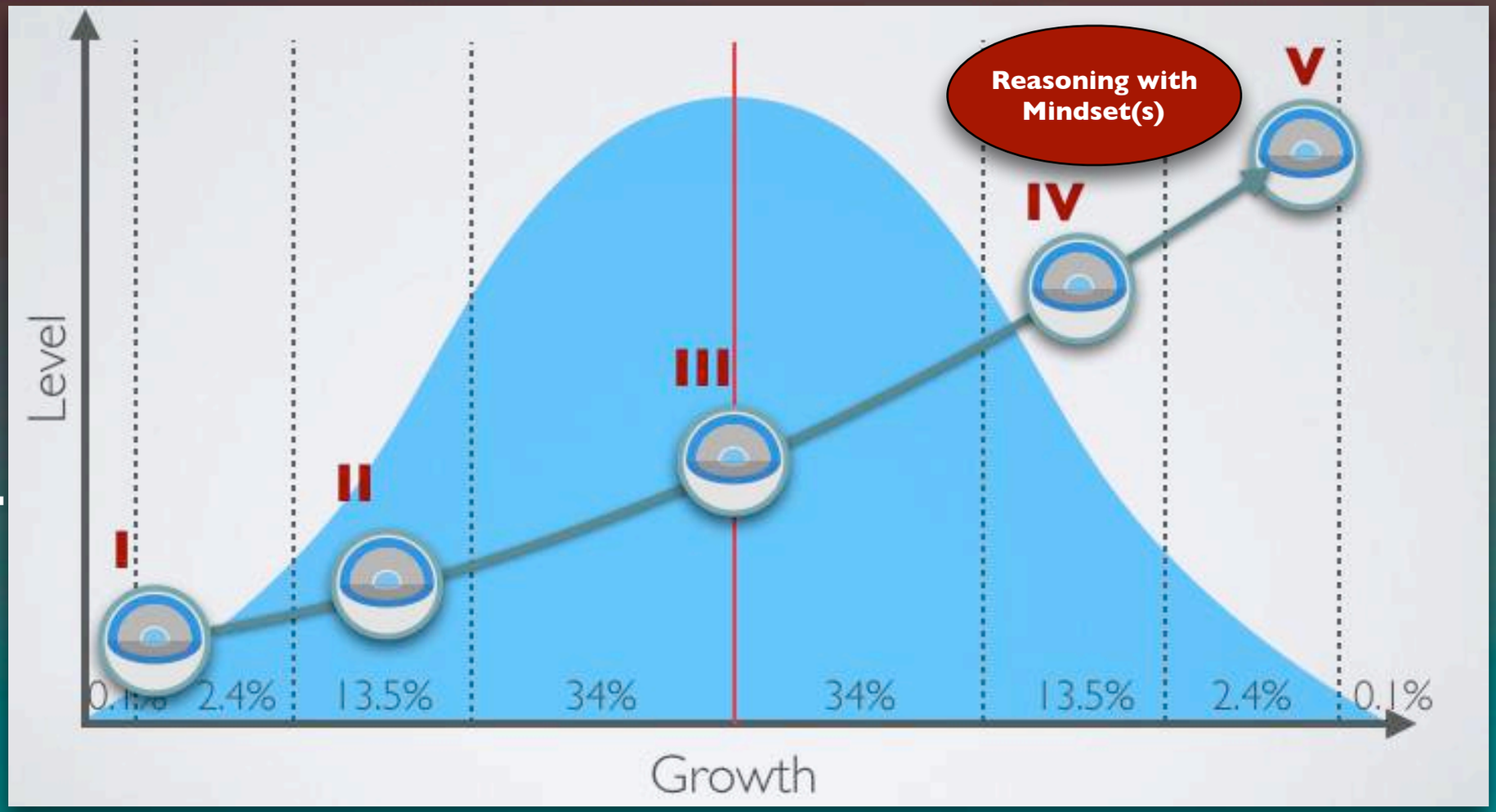
Groups (Org)

Procedural Domain

Declarative Domain

Systems & Systems-to-Systems Domain

SIMULATION TARGETS DEVELOPMENT OF MINDSETS FOR GROWTH LEVELS IV AND V



I Relies primarily upon personal assumptions, experiences; can also consider assumptions and experiences of close family or associates; rarely challenges social norms and rules held by self, family, and close associates;

II Displays awareness of personal bias and assumptions; can reinterpret experiences on basis of input from 3rd-party observations from Mode 1 scientific disciplinary boundaries, collected data, and analysis;

III Able to consider knowledge arising from multidisciplinary viewpoints; perceives there are multiple ways of knowing; can perceive limits with reductionist thinking and compartmentalization of knowledge; shows early signs of valuing and being able to use multiple ways of knowing to reframe challenges or problems from Mode 1 to Mode 2;

IV Able to perceive porous connections among divergent ideas; perceives value of network associations among disciplines; displays understanding of systems and design thinking and possible interdependencies among opposing ideas, perspectives and observations; places considerable value on multiple ways of knowing and sources of evidence and can collectively and distributively engage others in Mode 2 efforts; can recombine new knowledge from across disciplines into new disciplines and boundaries;

V Can envision and creatively leap to new insights and innovative problem reframing yielded from transdisciplinarity fusion (by sustained collective effort among people spanning porous disciplinary boundaries); sympathetic and persuasive in communicating value of new insights and building trust-based relationships and dialogue among and across porous disciplinary boundaries to accomplish what has not been done before; displays synthesis-based, self-reflective transdisciplinary and ethical spirit in actions;

*Stricker, A.G. & Lyle, D.J., 2018

Journeying With the Red Queen to Mars*

1

Red Queen**

Initial presentation of complicated and complex problems at Launch Facility

2

Red Queen

Identification of initial constraints and perspectives solicited at Space Station

3

Red Queen

Juxtaposition of ideas and internal reframing of problems and approach solicited at Spaceship in orbit around Mars

4

Red Queen

Social reframing and solution frameworks solicited at Mars Surface and Underground facilities

5

Red Queen

Communication and application of solution frameworks solicited at Mars Station Lab

**The phrase "Red Queen" comes from Through the Looking Glass (Carroll 1872). In Alice's dream about the looking glass house, she first finds that things appear left-to-right, as if shown in a mirror. The Red Queen then leads Alice directly to the top of the hill. Along the way, the Red Queen explains that hills can become valleys, which confuses Alice. Already, in this world, straight can become curvy, and progress can be made only by going the opposite direction; now, according to the Red Queen, hills can become valleys and valleys can become hills.

At the top of the hill, the Red Queen begins to run, faster and faster. Alice runs after the Red Queen, but is further perplexed to find that neither one seems to be moving. When they stop running, they are in exactly the same place. Alice remarks on this, to which the Red Queen responds: "Now, here you see, it takes all the running you can do to keep in the same place".

The Red Queen helps Alice to discern and face complexity.

*Red Queen: AI-augmented mindset aid

AI-Augmented Mindset Aid

High-level Architecture

Lambda on the Cloud is triggered

API Gateway

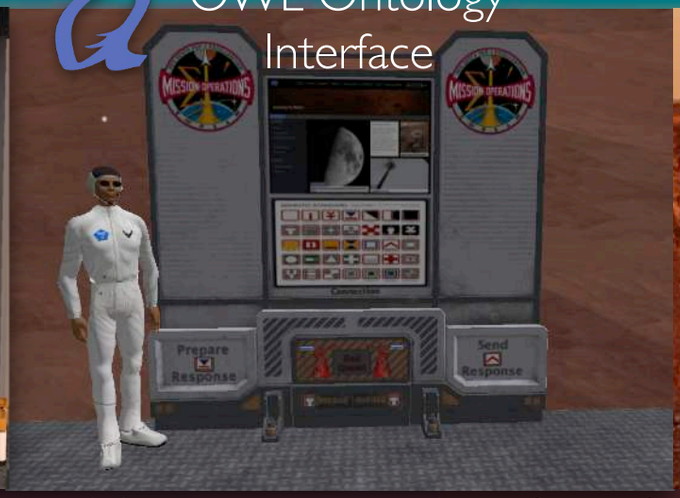
Lambda runs code and returns stored data back using node js

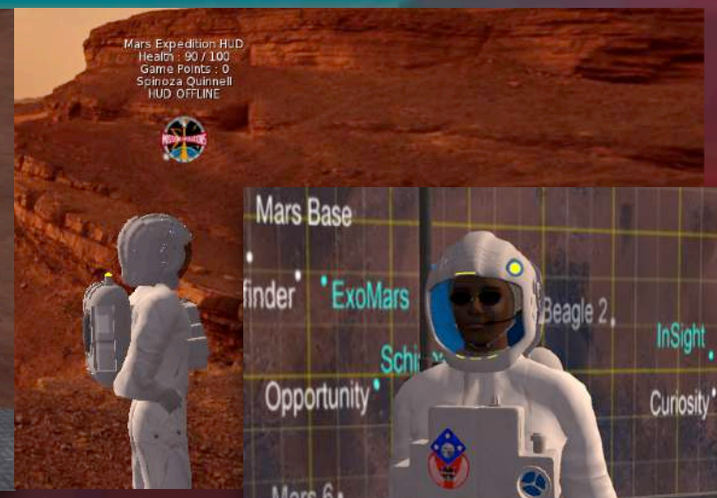
Simulation data stored on the Cloud

OpenSim
And Unity3D
game engine platforms
on Cloud Linux VMs

Optional Echo Device Usage
(for activation connections between physical and virtual spaces)

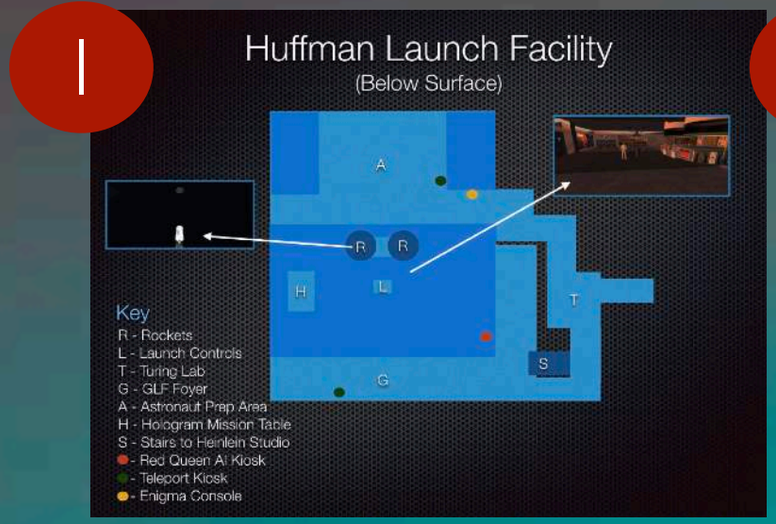
OWL Ontology Interface

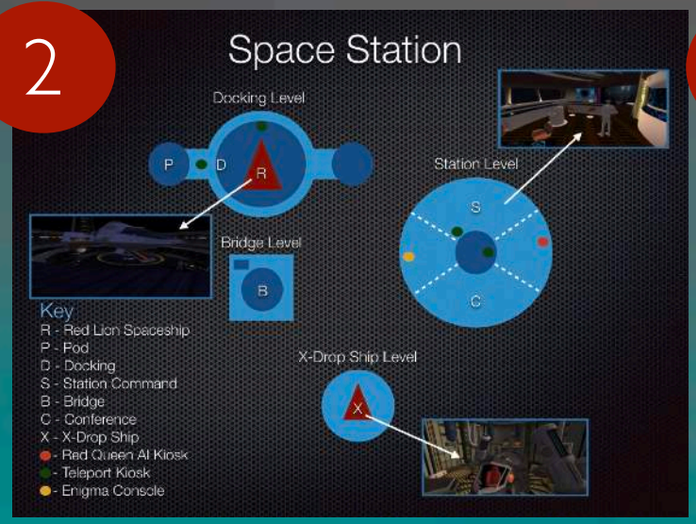


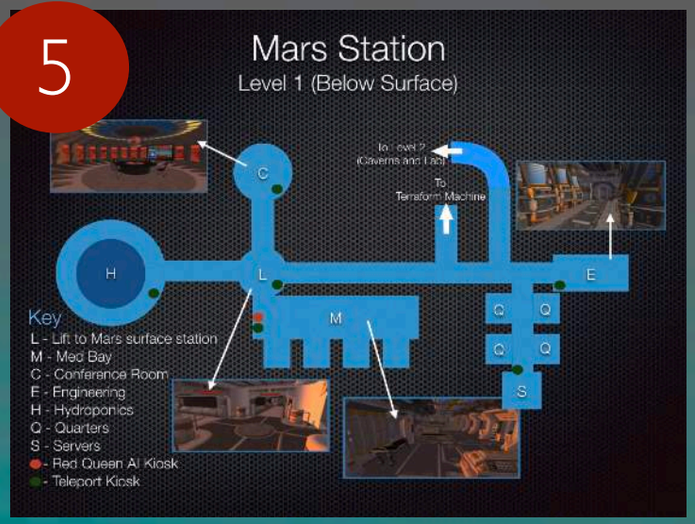


Immersive VR 3rd- and 1st-person user interfaces (voice, chat, and MBR devices) supported with physics engine

SEVEN SIMULATION GAME-PLAY LEVELS







Simulation HUD with health and performance factor weights across 7-levels of game play