



U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – ARMAMENTS CENTER

Human Data Collection for Machine Learning and Artificial Intelligence Aid Development
Presented Virtually to the 2020 AI4SE/SE4AI Workshop, 28-29 October 2020

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Tactical Behavior Research Laboratory

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BACKGROUND



- **Mission**

- Provide analytical proof of effectiveness in performance for humans and systems through research, testing and evaluation

- **Core Competency**

- Human and systems effectiveness research using human-in-the-loop (HITL) experimentation for:
 - Warfighter-Armament Integration
 - Human Target Response

- **Staff Expertise:**

- Neuroscience, Social Behavioral Psychology, Biomedical Engineering, Statistics
- Behavior Analysis, Psycho-Social Paradigms
- Cognitive and Physiological Monitoring and Analysis
- Social Network Analysis
- Warfighter-Armament Systems Integration
- Non-Lethal Weapons Effectiveness Research
- Design of Experiments / Research Design
- Human Research IRB Protocol Development
- Human Research Subject Recruitment



FACILITIES, TECHNOLOGIES & TOOLS

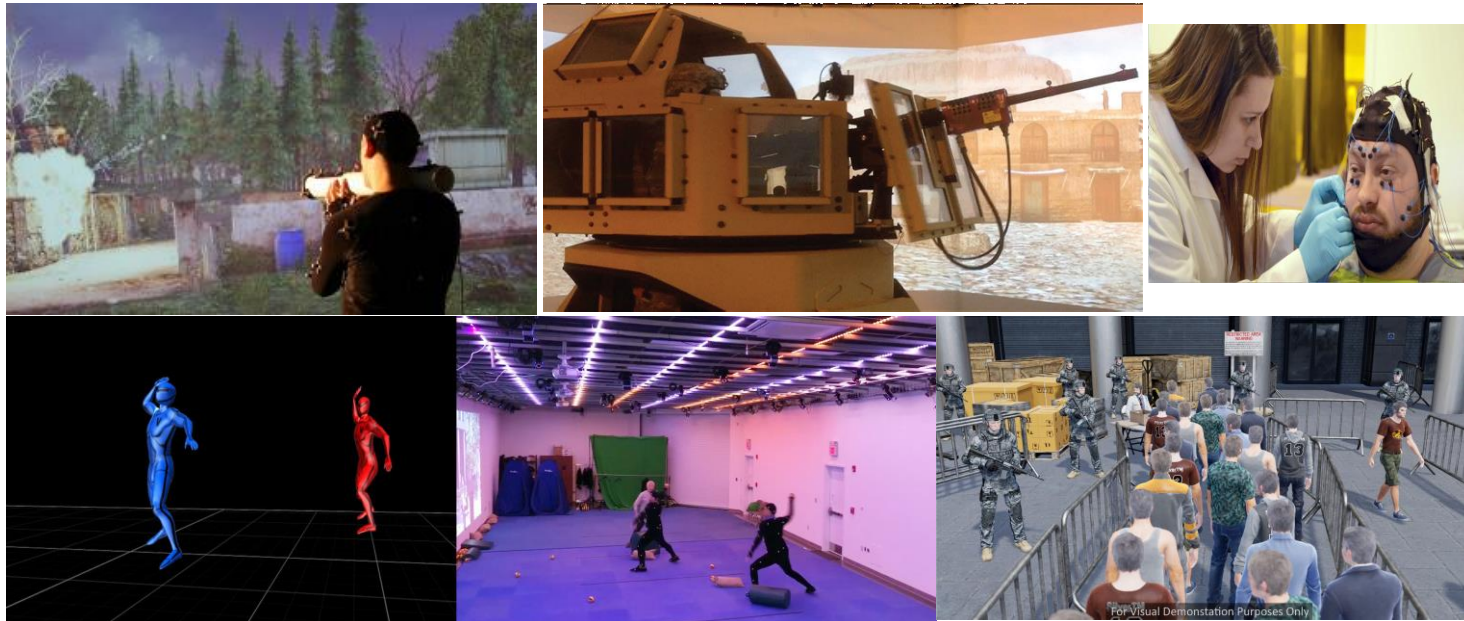


• Facilities

- TBRL Main Laboratory
 - Multiple Indoor Testbeds within a 150' x 150' Laboratory
 - Multiple Outdoor Testbeds across 150 Acres
- Experimental Verification and Validation Assessment Lab (EVVAL)
 - Configurable Virtual Reality and Motion Capture Testbeds within a 70' x 30' Laboratory

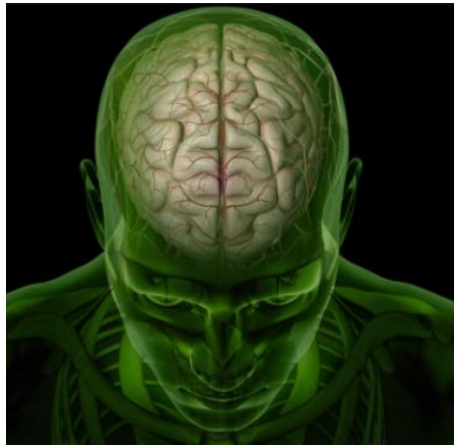
• Technology & Tools:

- Behavior Coding and Analysis
- Electrophysiology Data Collection and Analysis
 - Electroencephalography (EEG) – Brain Waves,
 - Electrocardiography (ECG) – Heart Waves,
 - Electromyography (EMG) – Muscle Activation,
 - Electro-dermal Activity (EDA) – Nervous System Response,
 - Impedance Cardiography (ICG) – Arterial blood flow
- Virtual Reality and Augmented Reality
- Motion Capture
- Eye Tracking
 - Mobile
 - On-Screen

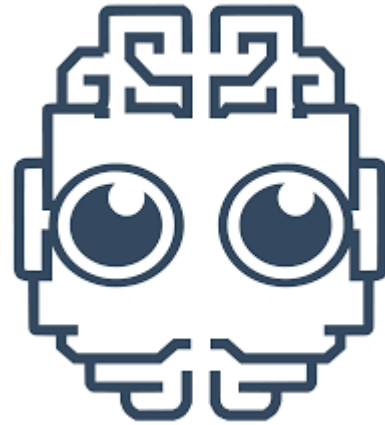




TBRL IN ML/AI V&V



Natural Intelligence



Artificial Intelligence



Artificial Intelligence Aids



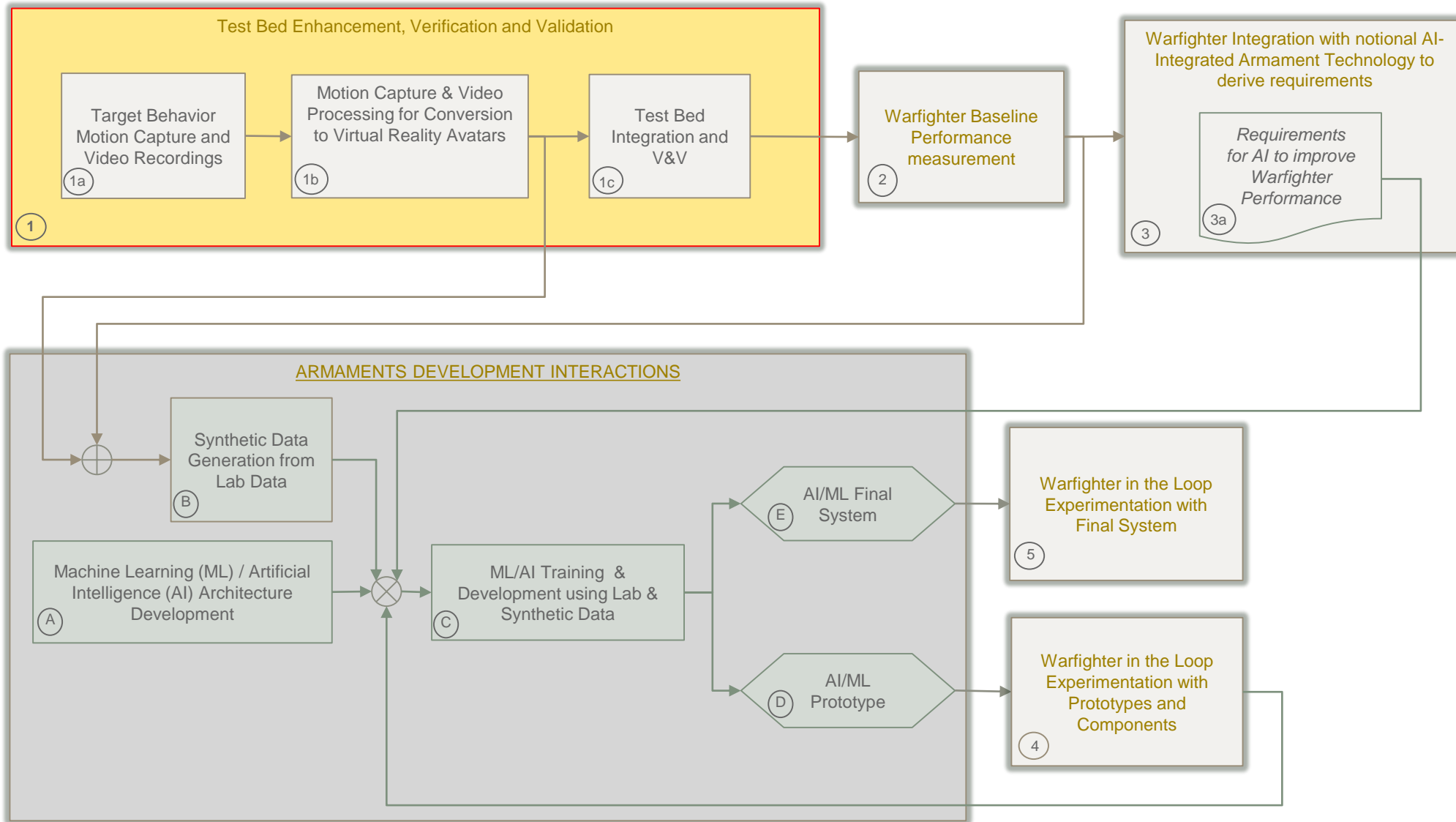
Does the AI Aid actually aid Soldier?



TBRL AI V&V Process Map



1. Develop relevant Test Bed for experimentation
 - a) Recording of OPFOR/Target behavior for scenario integration and development
 - b) Test Beds developed in real or virtual relevant battlefield environments/scenarios/use-cases. (Virtual environments integrated in Head-mounted-displays or 360 degrees projection octagon)
2. Measure Warfighter baseline performance (How does Operator perform without Armament technology?)
3. Derive performance requirements necessary to improve/optimize Warfighter performance with Armament technology.
4. Prototype experimentation with Warfighter in the loop to evaluate effectiveness metrics of Armament technology.
5. Final design evaluation to validate Armament technology performance effectiveness with Operator in the loop.

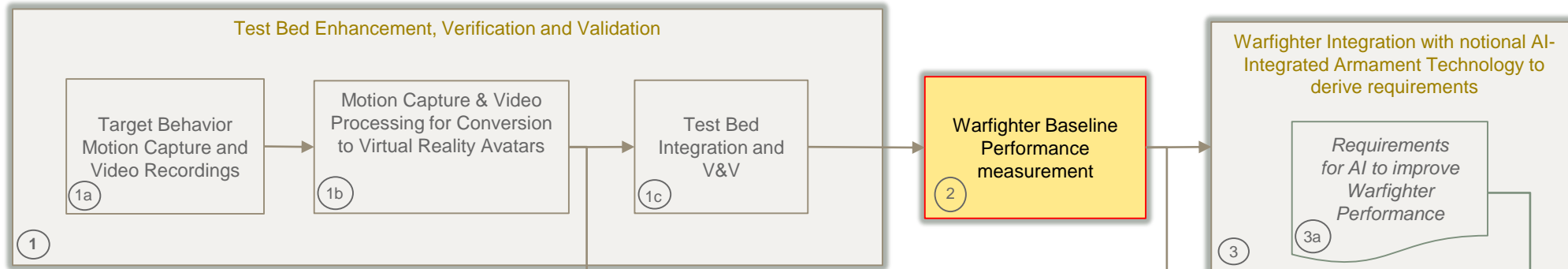




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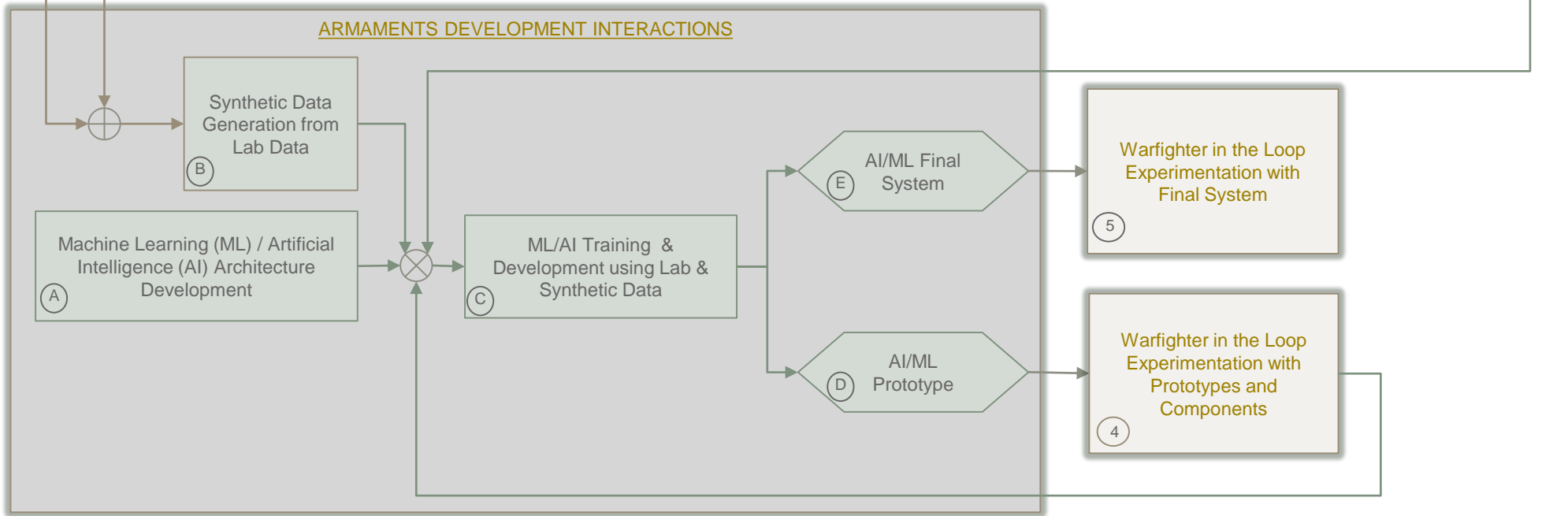


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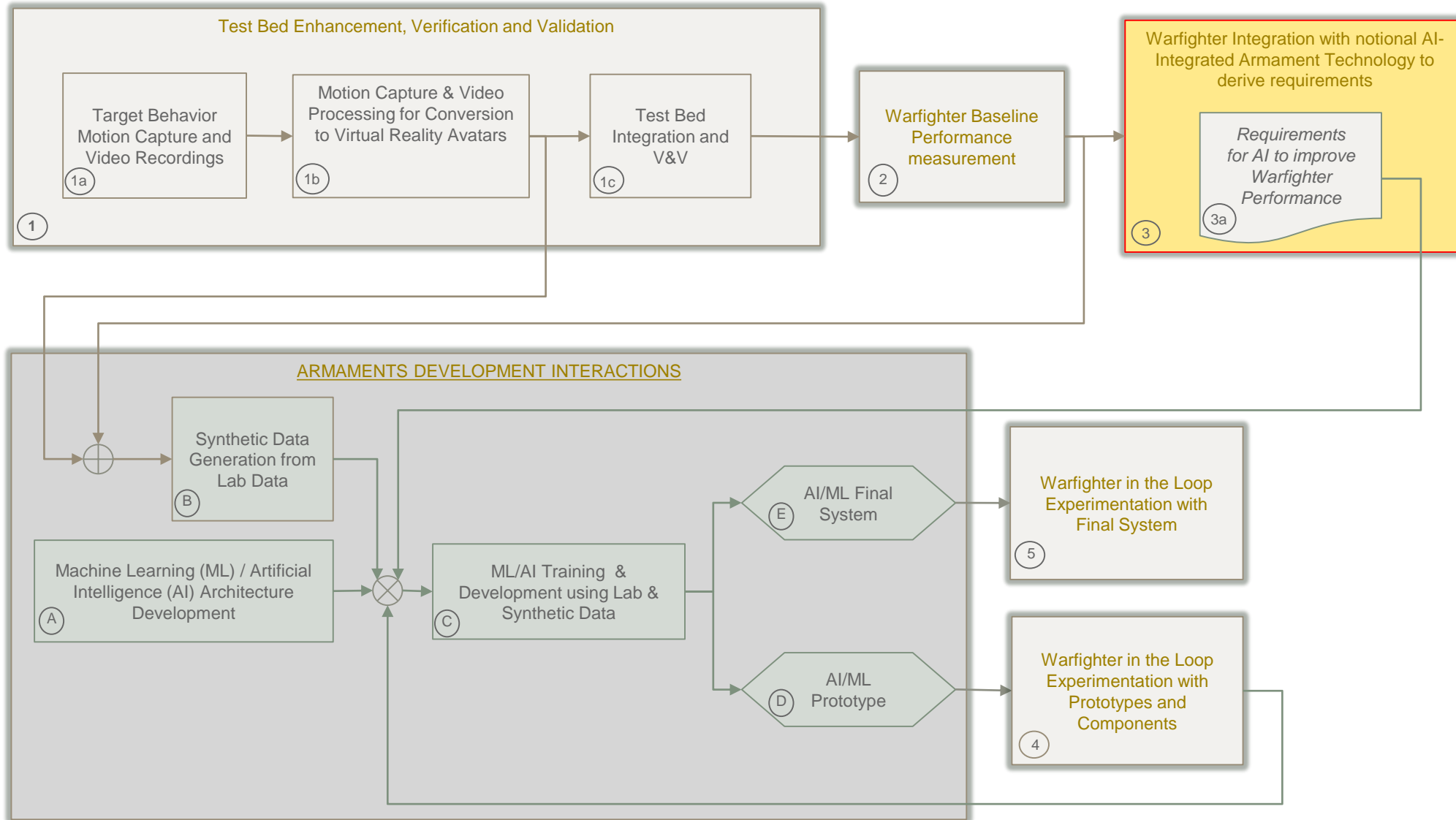




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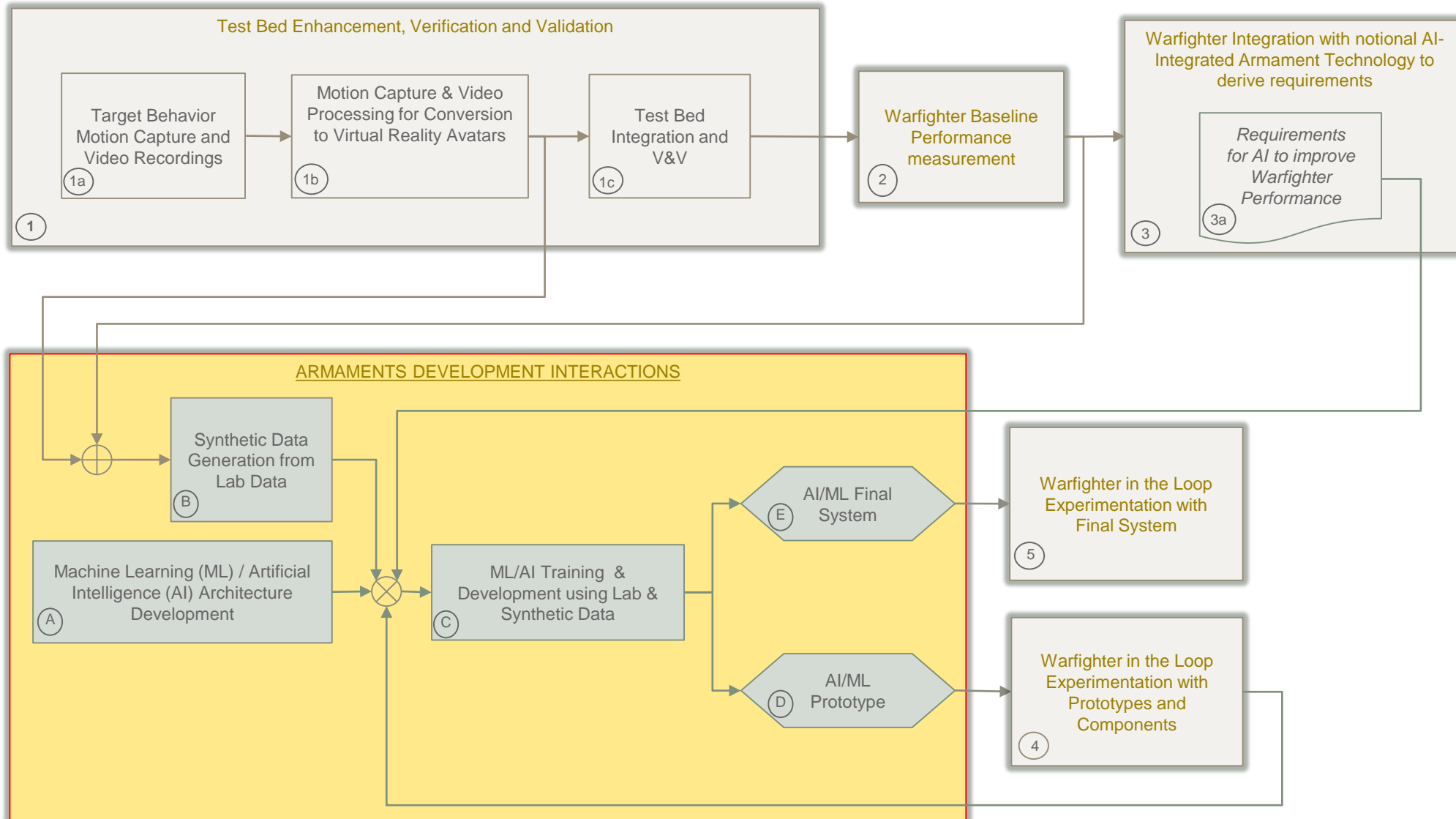




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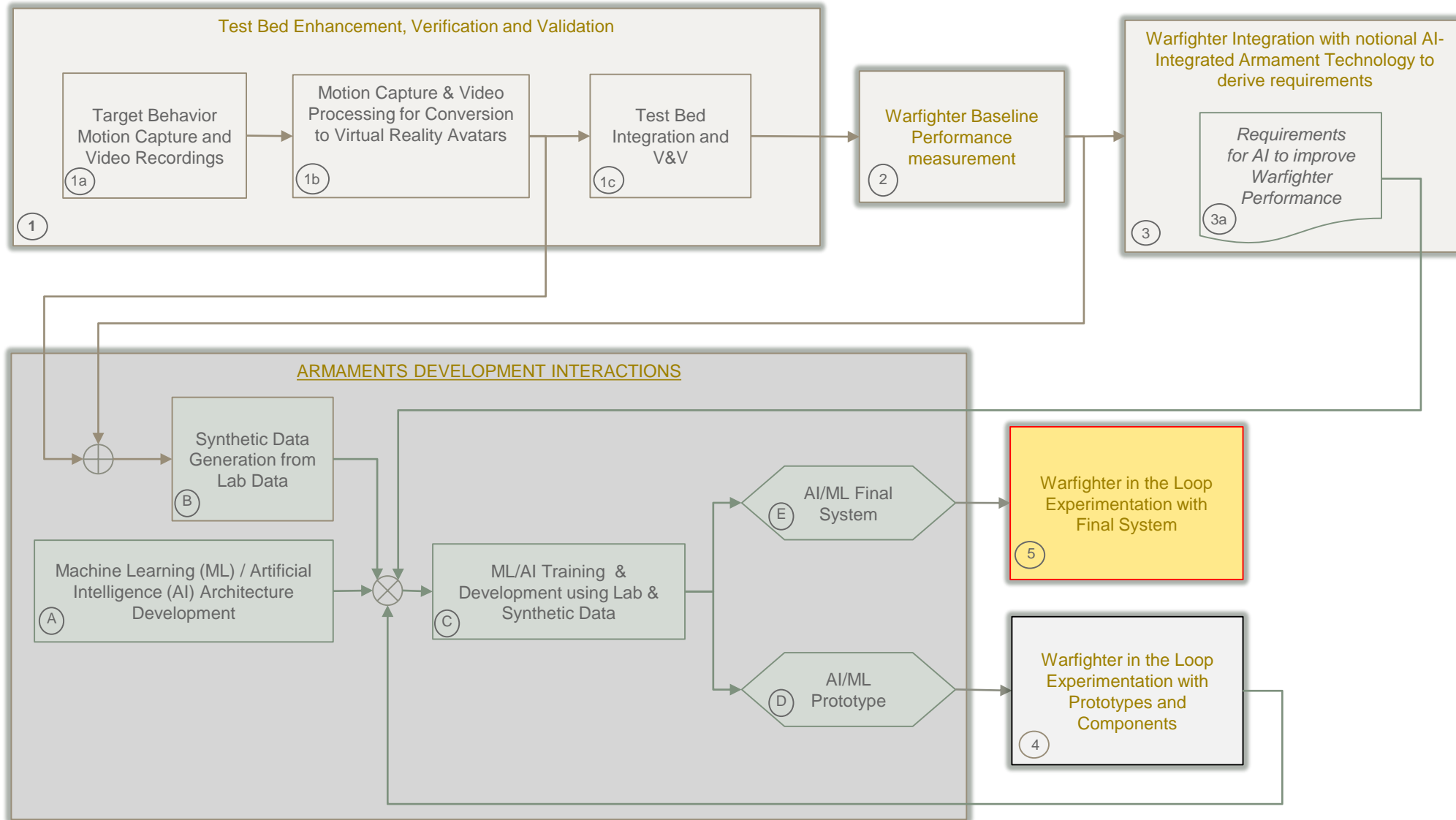




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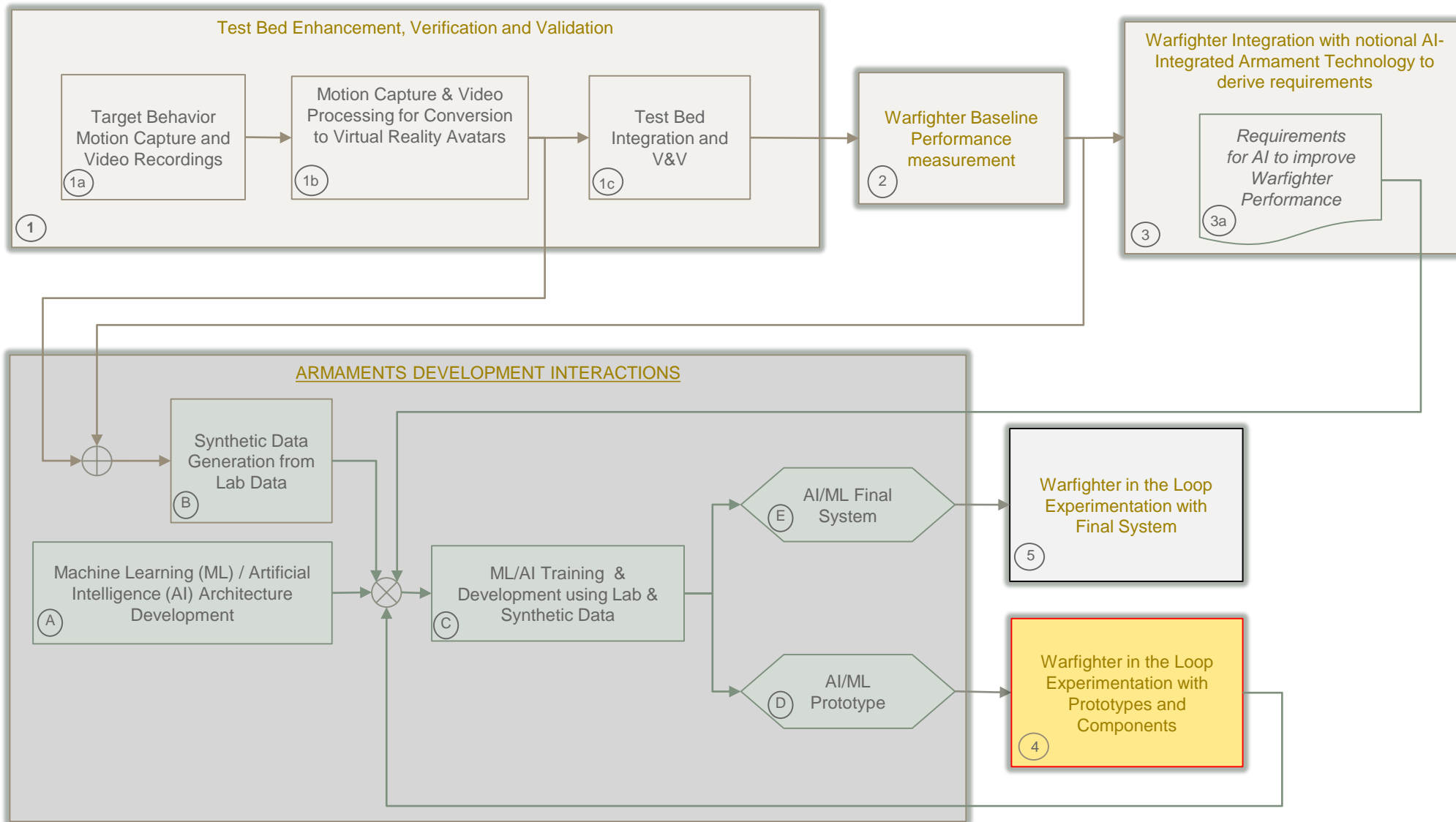




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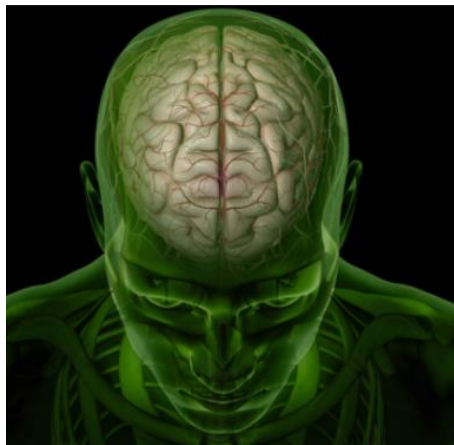


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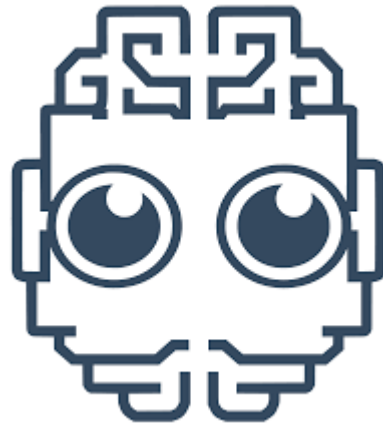


TBRL IN ML/AI V&V



verywellmind.com

Natural Intelligence



robobrain.me

Artificial Intelligence



techcrunch.com

Artificial Intelligence Aids



Does the AI Aid actually aid the Soldier?



HUMAN DATA FOR MACHINE LEARNING/AI DEVELOPMENT & TESTING FOR VALIDATION OF ARTIFICIAL INTELLIGENCE



- **Human Data for Machine Learning/AI Development**

- Artificial Intelligence based on Natural Intelligence

- General Paradigm: Observe decision-making, weapons operation in virtual environment. Analyze relationships among operator decisions, operator physiology, performance, scenario characteristics.

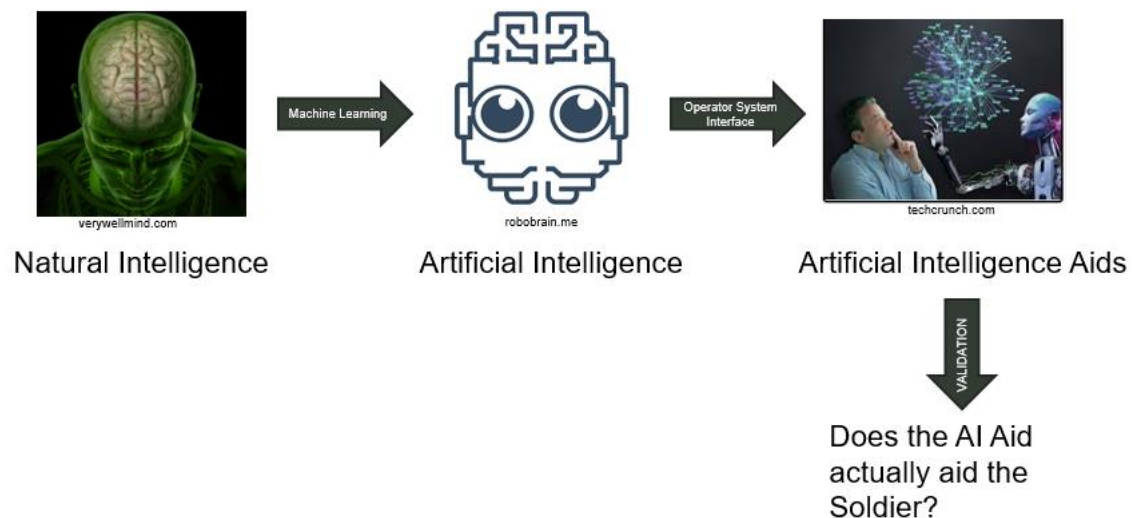
- **Testing for Validation of Artificial Intelligence**

- Human in the Loop Testing with Artificial Intelligence

- General Paradigm: Subjects (Soldiers) in virtual scenarios using artificial intelligence aids – compared with baseline no artificial aids, different configurations, or response to artificial aids

- **Lab Infrastructure to support ML/AI Development**

- DATA!!
- Scenario Creation
- Immersive Virtual Environments
- Sensors for Human Data Collection
- Data Multiplication





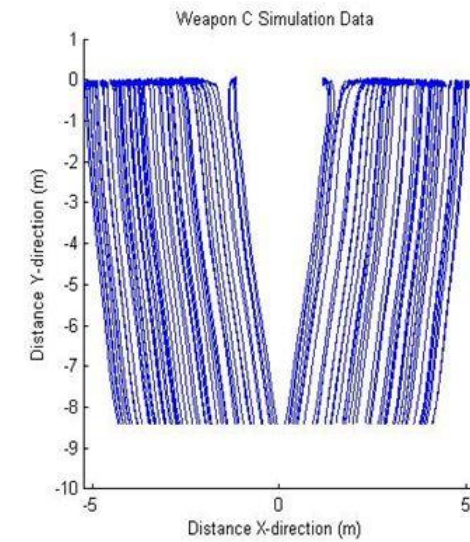
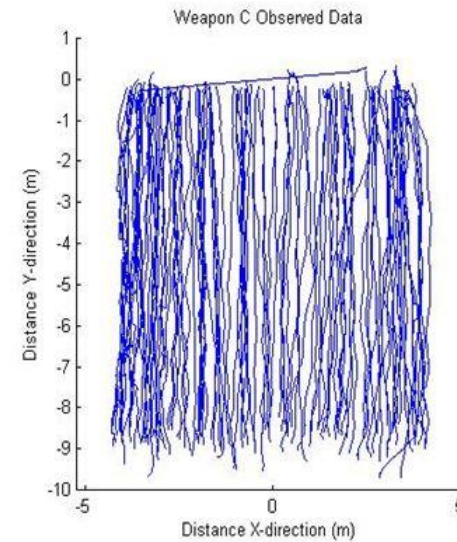
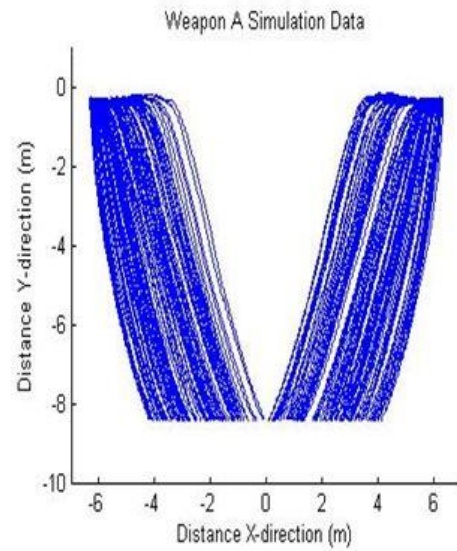
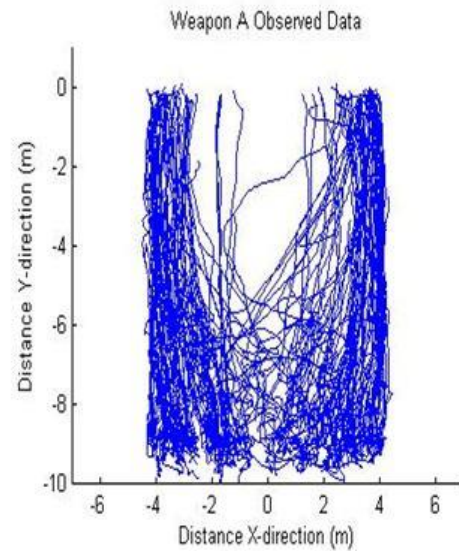
Human Data for Machine Learning/AI Development



PAST PROJECTS: HUMAN DATA FOR MACHINE LEARNING



- Prediction of Behavioral Response to Non-lethal Weapons Fire





CURRENT PROJECTS: HUMAN DATA FOR MACHINE LEARNING



- **Tank Targeting**

- AI aid for Target Prioritization
- Scenario generation by Subject Matter Experts
- Data gathering 32K trials for ML for AI aid development

- **Battlefield Sensors**

- Multi-sensor detection of adversarial activities in “village”

- **Machine Teaching**

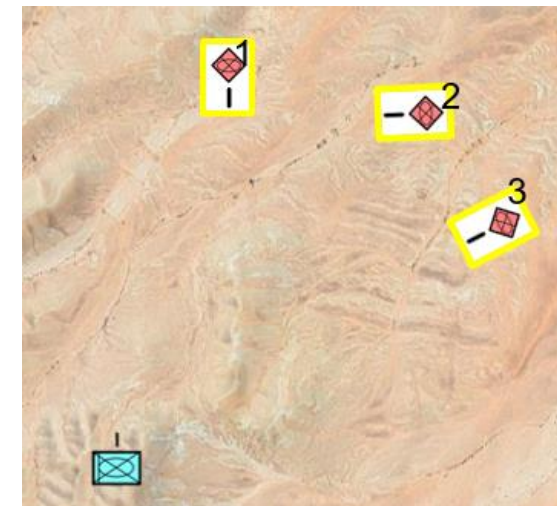
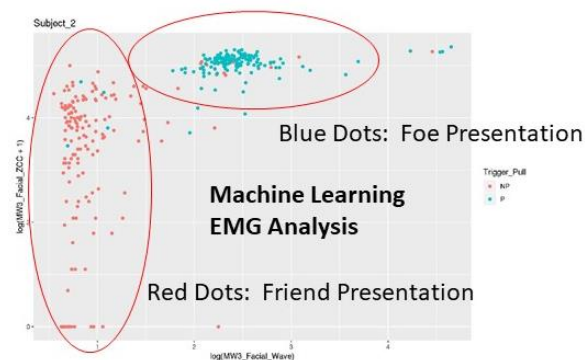
- Data collection supporting development of AI aid for adversarial behavior in a crowd urban environment

- **Human Electrophysiology for Soldier-Armament Integration**

- Data collection for identification of biosignals associated with friend/foe identification, trigger squeezing

- **USSOCOM: In-ear sensor (EEG, EKG, movement)**

- Novel method of electroencephalographic, electrocardiographic recording
- Collaboration with ARL and Imperial College (UK)





PROPOSALS: HUMAN DATA FOR MACHINE LEARNING/ AI DEVELOPMENT



- **Effectiveness T&E for tank target prioritization**
 - Submitted to AC S&T
- **Artificial Intelligence for Threat Classification**
 - Submitted to Combat Lethality Task Force (CCLTF)
- **Human Electrophysiology for Soldier-Armament Integration**
 - Submitted to AC S&T
- **Bioelectrically-Linked Interface for Novel Control of Systems (BLINCS)**
 - Revising for resubmission
- **Biosignal Data for Machine Learning and AI Development**
 - Submitted to AC S&T
- **Electromyographic Soldier Armament Integration**
 - Submitted to AC S&T
- **Impact of Cardiac Cycle on Soldier Shooting Performance**
 - Submitted to AC S&T
- **Declined: Vigilant Keeper**
 - Data processes for ML to predict adverse Soldier psychological states



Testing for Validation of Artificial Intelligence



PAST TESTING FOR ARTIFICIAL INTELLIGENCE VALIDATION





CURRENT PROJECTS: TESTING FOR ARTIFICIAL INTELLIGENCE VALIDATION



- **Trust and Reliability**
 - Examines baseline Soldier performance in identification of adversary in virtual crowd urban scenario
 - Examine association among AI reliability, AI trust, AI use, and performance
- **Human-in-the-loop testing for AI**
 - Examines impact of AI aid on Soldier performance in identification of adversary in virtual crowd urban scenario
- **Support to targeting aids**
- **Support to future aerial vehicles**
 - Virtual testing of Door Gunner targeting aid
 - Collaboration with SWEet Lab
- **Artificial Intelligences for crowd monitoring**
 - Collaboration with Department of Homeland Security
 - Market Survey of COTs devices
 - SME evaluation of AI
- **Social Network Analysis (SNA) [M&S experimentation on Remote Autonomous Systems, no humans]**
 - Impact of drone swarm configurations and performance in target identification (survivor search)
 - Design and Analysis of Swarm Computer Experiments
 - Collaboration with Statistics Group, other Armament Center engineers

UNCLASSIFIED

VOLUNTEER!

PARTICIPATE IN A VIRTUAL REALITY STUDY

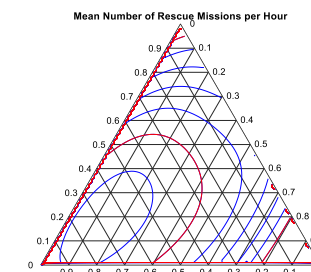
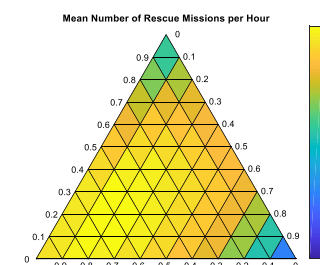


The U.S. Army needs healthy individuals with military experience (18+ years old) for a virtual reality mission that would last 2-4 hours. Participants will wear virtual reality headsets while looking for targets.

CALL US TO PARTICIPATE:

973-724-9620

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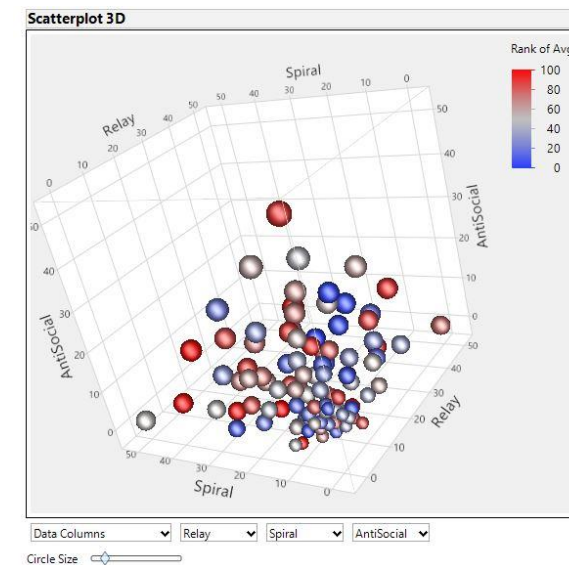
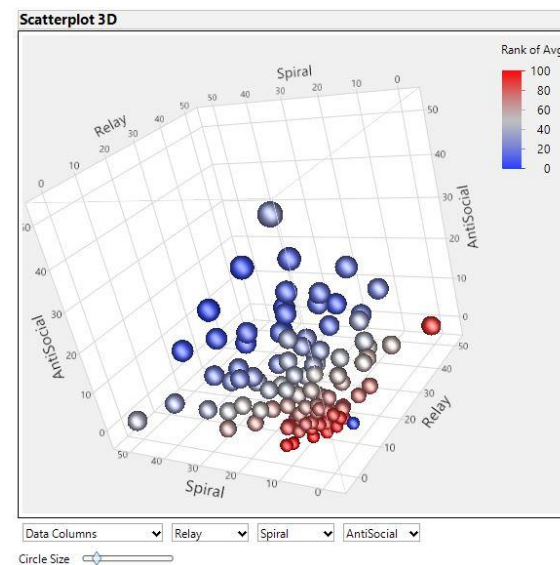
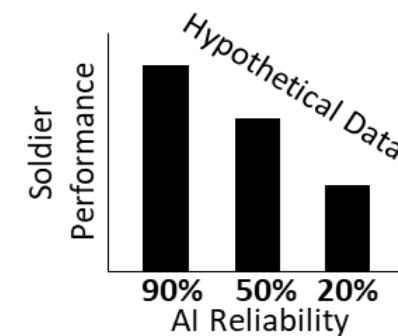




PROPOSALS: TESTING FOR ARTIFICIAL INTELLIGENCE VALIDATION



- Validation of Target Prioritization AI aid for vehicles
- Design and Analysis of Computer Swarm Experimentation





Lab Infrastructure for ML/AI V&V



PROPOSALS: LAB INFRASTRUCTURE FOR ML/AI V&V



- **Comparing Electrophysiological Devices**
- **Impact of Fidelity on Virtual Training**
- **Synthetic Data Sets**



QUESTIONS?



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