# NAVAL RESEARCH ADVISORY COMMITTEE

# *Immersive Simulation*
## *for Marine Corps Small Unit Training*
### *2009 Summer Study for Marine Corps*

***Briefing to***

***Mr. Sean J. Stackley***
***Assistant Secretary of the Navy, RD&A***

***LtGen George J. Flynn***
***Deputy Commandant of the Marine Corps***
***Combat Development and Integration***

***RADM Nevin P. Carr, Jr.***
***Chief of Naval Research***
***7 July 2009***

*Draft-not for Release*

# Core Inquiry

**What is the role of immersive simulation in training and assessing a USMC squad as an effective weapons system?**

**"We need a giant leap forward in our simulated training environment for small units in ground combat …to replicate to the degree practical using modern simulation, combat scenarios that will test our small units …"**

Gen J. M. Mattis, USMC

Commander, U.S. Joint Forces Command

**"The goal must be to take training capabilities to the next level and fuse current, emerging, and future live and virtual technologies to create a fully-immersive live/virtual training environment"**

LtGen G. F. Flynn, USMC

Deputy Commandant, Combat Development and Integration

# Sponsor and Panel Membership

## Study Panel Members

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  - Creative Technologies Inc.
- **Dr. A. Michael Andrews, II - Co-Chair**
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- **Dr. Regina E. Dugan**
  - RedX Defense
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- **CAPT R. Robinson Harris, USN (Ret.)**
  - Lockheed Martin Maritime Systems
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  - Oceaneering International, Inc.
- **Dr. Robert S. Carnes, MD**
  - Batelle Memorial Institute

## Study Sponsor

- **Mr. Sean J. Stackley**
  - Assistant Secretary of the Navy, RD&A
- **LtGen George J. Flynn, USMC**
  - DC, CD&I

## Executive Secretariat

- **Mr. E. Ray Pursel – Executive Secretary**
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  - MCWL (OSTI)

# Outline of Briefing

- Fact-Finding
- Immersive Simulation Status
- Terms of Reference
- Findings
- Conclusions
- Recommendations

# Fact-Finding

## Marine Corps/Navy

CG, MCCDC (Study Sponsor)
CG, MCWL
MCWL, Modeling and Simulations Branch
Training and Education Command
Naval Air Warfare Training Center Training Systems
ONR Code 30
USMC Program Manager, Training Systems
Naval Research Lab
Infantry Immersion Trainer Brief and Demonstration
Combat Convoy Trainer Demonstration
Yankee Huey and Zulu Cobra Trainer Demonstration

## Other Services and Agencies

TCM Virtual
PEO, Simulation, Training and Instrumentation (STRI)
Future Immersive Training Environment (FITE), JCTD
Medical Science Advisor to the CJCS
US Army Research Institute (Behavioral & Social Sciences)
US Army Armor Center
Fires Battle Lab, US Army
US Army Director(Research &Laboratory)Management
DARPA
US Army RDECOM Sim &Training Technology Center

## University/National Lab

University of Central Florida, Media Convergence Lab and Institute for Simulation and Training
Royal Military College of Canada
Sandia National Laboratories
Institute for Creative Technologies Visit and Briefs

## Industry

A-T Solutions
Boeing
Forterra Federal Systems
L-3 Communications
Lockheed Martin
MAK Technologies, Inc
MYMIC
Soar Technologies
Total Immersion Software, Inc..

# Panel Definition of "Immersive Simulation"

- A simulation that produces a state of being deeply engaged; suspension of disbelief; involvement
- Immersive Simulation Training Environment
  - A training environment that includes one or more aspects of simulation (ranges from a few special effects up to a full virtual world) that deeply engages the trainee

# Marine Corps Training Principles

- Train as you fight.
- Make commanders responsible for training.
- Use standards-based training.
- Use performance-oriented training.
- Use mission-oriented training.
- Train the MAGTF to fight as a combined-arms team.
- Train to sustain proficiency.
- Train to challenge.

  – MCO 1553.3A Unit Training Management

  – NAVMC 5300.44 Infantry T&R Manual

# Immersive Simulation Status

- **Lack of consensus on value vs. cost**
- **Lack of guidance to allow simulation to accomplish Training and Readiness Manual syllabus tasks**
- **Pre-deployment Training Plan (PTP) does not currently require immersive simulation**
- **USMC immersive trainers have limited availability and throughput**
  - Typically, one squad is trained per evolution
  - ~243 Marine Rifle Squads per division

***Conditions are not set for full utilization of immersive simulation***

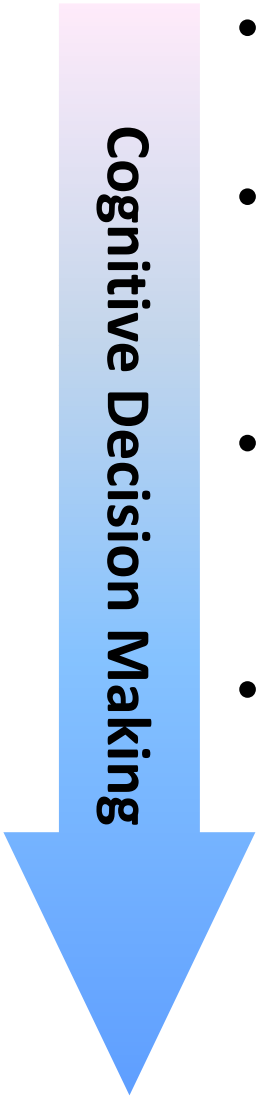
# Terms of Reference

***<u>Objective</u>: Study concepts of immersive training simulation to assist Marines in developing complex and intuitive decision skills under stress…***

- ***Decompose*** the small unit immersive simulation training problem and identify the desired effects of such training
- ***Examine*** the metrics necessary to gauge training effectiveness
- ***Identify*** the desired effects and examine the metrics
- ***Review*** current and developing virtual training methods
- ***Evaluate*** current S&T initiatives
- ***Recommend*** technology solutions, investments and developments

# FINDINGS

# Hierarchy of Training Objectives/Approaches




- **Declarative Knowledge of Facts**
  - *Issues: Difficult to practice skills and consolidate knowledge*
- **Consolidate Declarative and Acquire Procedural Knowledge**
  - *Issues: Difficult to acquire higher-order skills, strategic knowledge*
- **Higher Order Skills and Team Coordination**
  - *Issues: Cost of actors; limited availability/throughput; support staff; currently not domain transferable*
- **Higher Order Skills, Team Coordination, and Strategic Knowledge**
  - *Issues: Can overwhelm or distract early procedural learning; limited availability/throughput; domain specific; high cost of overhead*

# Immersive Simulation Technologies

## Training Continuum:

Classroom

Computer Based Training

Virtual Reality: Desktop

Virtual Reality: Projection

Full Immersive Virtual Reality

Augmented Reality

Mixed Reality

Full Simulation (does not exist for Infantry)

Live Training

Combat

# Technology Maturity

Head-Mounted Displays

Position Location Information


Stereoscopic Optical Positioning

# Current USMC Simulation Tools*

- **Deployable Virtual Training Environment (DVTE)**
  - Close Combat: Marines (CCM)
  - Virtual Battlefield System 1 & 2 (VBS)
  - Recognition of Combatants –Improvised Explosive Devices (ROC – IED)
  - Combined Arms Network (CAN)
- **Indoor Simulated Marksmanship Trainer (ISMT)**
- **Combat Convoy Simulator (CCS)**

* Infantry Training & Readiness Manual

# Status of Immersive Simulation Metrics

- **Conventional training metrics do not apply to immersive simulation.**
  - Sequential versus simultaneous execution of tasks
- **For acquisitions beyond current systems, cost, schedule and performance criteria required**
  - Absence of performance metrics for infantry simulators
  - Quantifiable proof of effectiveness desirable for all training
  - Metrics assist in evaluating reproducibility and retention of training

***"Subjective assessment by a trained evaluator is a valid metric."***
– Dr. Paul Roman, Royal Military College of Canada

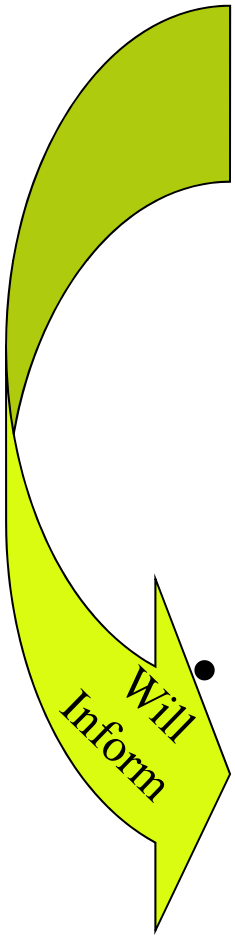
# Expert Evaluator Training Measurement

| | Control (No Simulation) | Min Sim (1 day) | Half Sim (2.5 weeks ) |
|---|---|---|---|
| % Pass on 1st Evaluation | 0 | 30% | 67% |
| % Pass by 1/2 of Evaluations | 61% | 72% | 100% |
| % Pass by End of Course | 72% | 83% | 100% |

Source: "Games – Just How Serious Are They?", Dr. Paul A Roman, Mr. Doug Brown, Interservice/Industry Simulation and Education Conference 2008

# USMC Immersive Infantry Efforts

- **Infantry Immersive Trainer (IIT)**
  - Testbed for training rifle squads in current theater tactics and decision-making
  - Initial implementation at Camp Pendleton (I MEF)
    - Simulates a small Iraqi village
    - Portrays realistic engagements with indigenous populations (role players), to include sights/sounds/smells
  - Expanding to entire Marine Corps
    - I MEF expansion; II MEF facility; III MEF implementation in MOUT facility




- **Squad Immersive Training Environment (SITE)**
  - Planned as a POM12 POR to provide a truly immersive training environment enabling squads to train across a full range of missions.
  - Capabilities-Based Assessment (CBA) ongoing to identify gaps

# IIT Video Clip

# Observations

- Immersive human-in-the-loop live environments like the IIT will remain a scarce resource
- To maximize benefit of IIT, users could utilize inexpensive (e.g. desktop) pre-training resources
- Decomposition of training could reduce dependence on live-environments such as IIT

# Training Decomposition: Example

| TASK | EXAMPLE VENUE |
|---|---|
| Cultural “Norming” | Desktop |
| Cultural “Taboo” | Desktop |
| “Freezing” / PTSD | Virtual Reality |
| Decisions Under Stress | Mixed or Augmented Reality |
| Crowd Control | Mixed Reality |

# ONR Codes 30 / 341
# SITE Enablers ($K)

## Total: $33,676,000 Over 8 Years

| Effort | FY08 | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15 |
|---|---|---|---|---|---|---|---|---|
| Expressive Interaction for Infantry Simulation | | | $400 | $440 | | | | |
| EC: Naval Next-generation Immersive Technology (N2IT) | | | | $2,400 | $3,950 | $4,900 | $4,500 | $3,100 |
| STTR: Development of Low-Cost Tracking System for Infantry Training | | $280 | $500 | $500 | | | | |
| STTR: Development of Low-Cost Augmented Reality HMD | | $280 | $500 | $500 | | | | |
| Virtual Environment Prototyping | $215 | $775 | $700 | $850 | $850 | $900 | $925 | |
| Workload, Stress, and Performance in Immersive Training | | $130 | $480 | $650 | | | | |
| Tools for Games-Based Training & Assessment of Human Performance | $1,000 | $260 | $2,000 | $1,451 | | | | |
| Predictive Modeling of 3D-Cued Audition in a Complex Naval Task | $110 | $110 | | | | | | |
| SITE Support: | $1,325 | $1,855 | $4,580 | $6,791 | $4,800 | $5,800 | $5,425 | $3,100 |

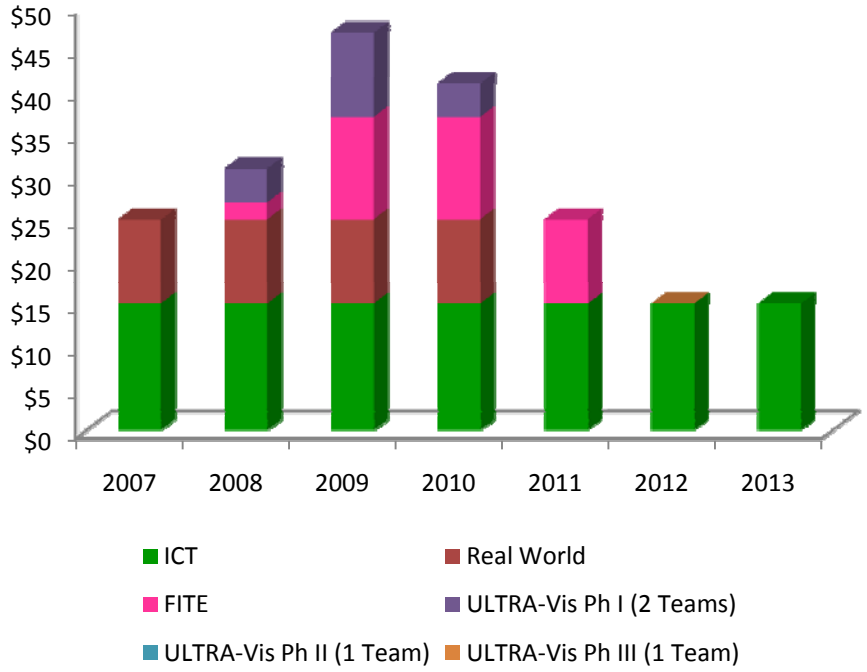
# Specific Marine Corps S&T Top Level View

- **ONR Submitted PRESBUD FY10 ~$1.8B**
  - Marine Corps is ~$146M (8.1% of ONR budget)*
  - ONR Code 30: ~$110M; MCWL: ~$36M
- **Panel Observation 1**
  - Significant percentage increase in Marine Corps support from ONR budget allocated to S&T underpinning of Expeditionary Maneuver Warfare Applications (approx. 46% increase over past four years)
- **Panel Observation 2**
  - Establishment of Code 30 at ONR affords Corps opportunity for strategic leverage and focus
  - For the SITE initiative, Code 30 investments covering many areas ( eight) with too little funding (~$5M/year)-- unlikely to produce leap-ahead capability or achieve significant leverage

*Note: Does not include $17M Joint Non-Lethal Weapons S&T

# Other Current DoD S&T IS Investments

- **FITE JCTD**: An effort to integrate current capabilities to develop an overarching operational utility assessment. Emphasis is on scenario-based training.
- **ICT**: Army-backed university research center focused on the artificial intelligence aspect of the immersive simulation challenge
- **RealWorld**: DARPA program developing a simulation software application authorable by non-technical users




- **ULTRA-Vis**: DARPA program… While not focused on training per se, this effort to create a lightweight augmented reality display and gesture-based control system may have application in the training community; Funded in Phase I; Phase II? FY09-11

# CONCLUSIONS

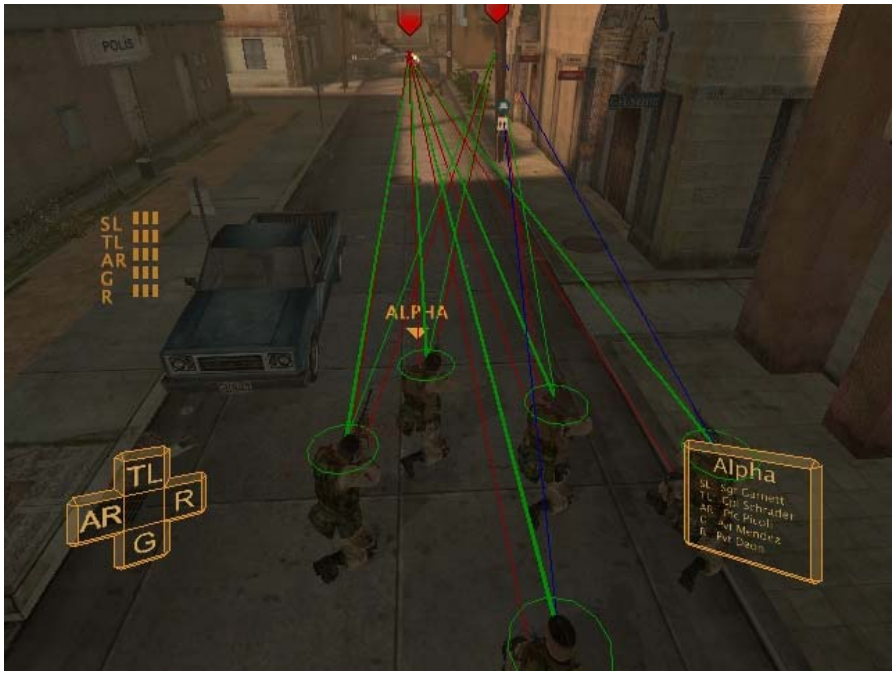
# Current Immersive Simulation Limitations

- Cost/flexibility of fixed infrastructure investment (layout, buildings, scenic)
- Cost of role players
- Absence of systematic measurements
- After Action Review (AAR)

# Mitigating Current Limitations

- **Cost/flexibility of fixed infrastructure investment**
  - ***Need: Practical Augmented Reality***
  - ***Enabling Technologies: Practical Head-Mounts, Position/Location Information***
- **Cost of role players**
  - ***Need: Compelling Virtual Characters***
  - ***Enabling Technologies:***
    - ***Near Term: No solution***
    - ***Medium Term: Supervisory control***
    - ***Long Term: Artificial intelligence research***
- **Absence of systematic measurements**
  - ***Need: Measurement Protocol***
  - ***Enabling Technology: Data capture and analysis***
- **After Action Review (AAR)**
  - ***Need: Three Dimensional Navigable AAR***
  - ***Enabling Technology: Position/Location Information***

# Navigable AAR




*Blue and red force threat lines: indicates vulnerability (POV USMC Fire Team; OPFOR below red pointers)*


*Vision cones: instantaneous field of view of USMC Fire Team viewed from above*

# RECOMMENDATIONS

# Immediate Implementation

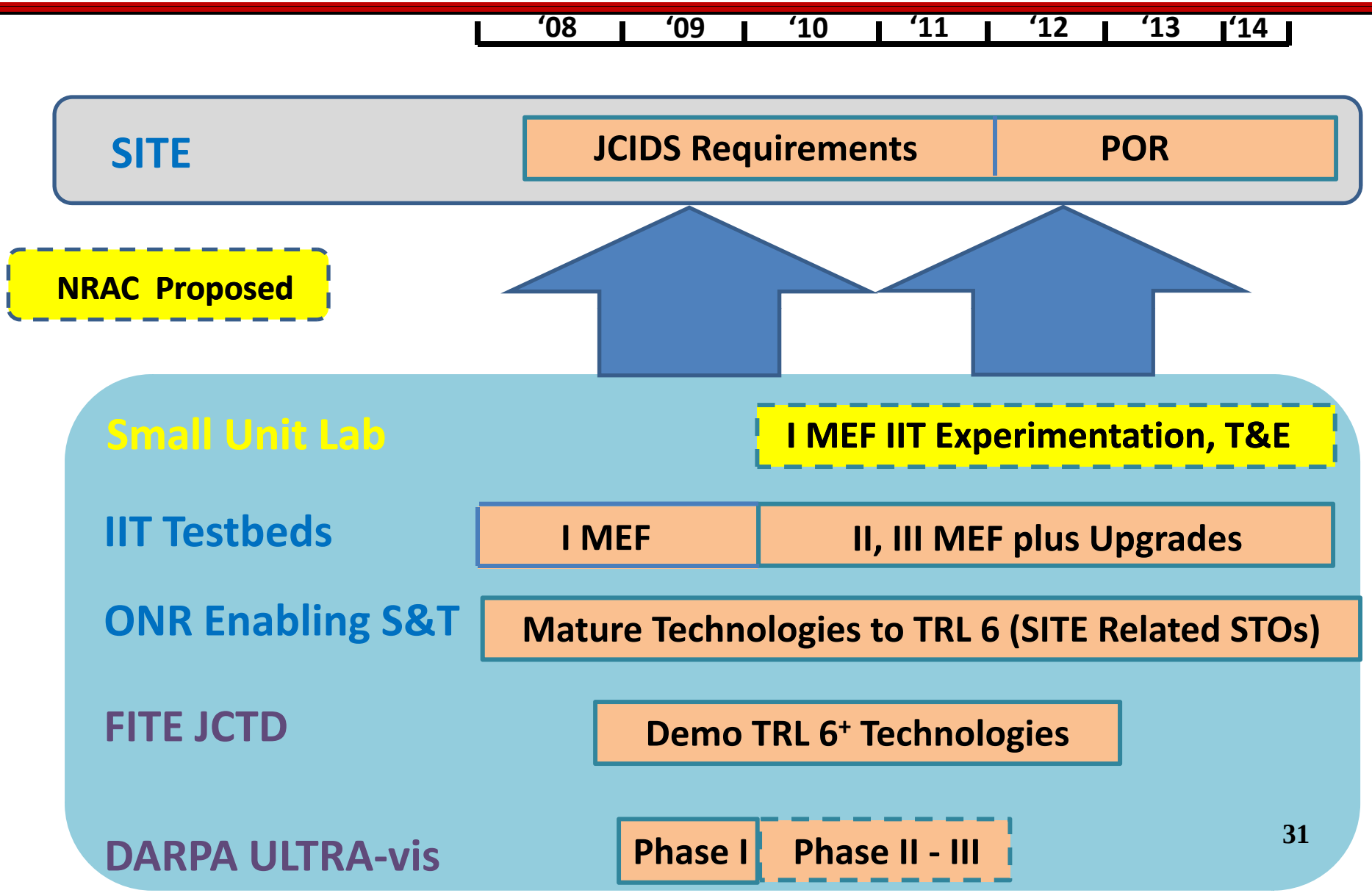
- **Create systematic measurement**
  - Subjective assessment by a trained evaluator is a valid metric
- **Develop T&R Manual METs to include cognitive aspects of irregular warfare training requirements**
  - Approve developed METs for the IIT and Next-Gen MOUT
  - Map deconstructed METs to available alternatives
- **IIT improvements: "low-hanging fruit"**
  - Employ alternative face protection for improved transparency
  - Enhanced "4D" cues
    - E.g. Sound reinforcement/propane effects to emphasize explosives/energetics events.
- **Cognitive task analysis**
  - Decompose training objectives for "end-to-end" solution
- **Implement small unit system prototype laboratory facility**
  - Create experimentation, test and evaluation schedule at Camp Pendleton IIT (requires indoor/outdoor facility)

# SITE S&T Way Ahead:

## *A Game-Changer in Training Capability*

- **Establish a 3-5 year program at the Camp Pendleton IIT small unit-level system laboratory to provide capability and system integration to advance next-generation immersive simulation capability – practical Augmented Reality**
  - **Augmented reality display: an HMD with high resolution/fidelity, zero latency, and minimal "overhead."**
  - **Position/Location Information capability: High accuracy tracking of all entities.**
  - **Compelling virtual characters with supervisory control**
  - **High-fidelity After Action Reviews**
- **Review and assess alignment of currently funded ONR Code 30/34 Enabling Capabilities to support SITE needs**

# Immersive Simulation Road Map



# ONR Long-Term Research Questions

- **How realistic can this be made:**
  - Automated scenario creator and controller
  - Automated role-players (individuals and crowds)
  - Ability to move in real 3D space while in simulation
  - Quickly inducing physically and mentally stressed trainee
  - Rapidly reconfigurable settings
- **Need to understand:**
  - Role of stress in decision-making, and learning & retention
    - Need to measure (lab & in the field)
    - Need to understand types & effects
    - Ability to induce & modulate high stress

# Summing Up

- **ASN RDA**
  - Establish a Community of Interest to address issues related to Infantry Immersive Simulation. Participants to include Navy, Marines, Army, DD&RE, and DARPA. Expand as appropriate.

- **DC, CD&I**
  - Implement systematic evaluation of immersive training alternatives.
  - Enhance IIT: “Low-hanging fruit”

- **CNR**
  - Establish the Small Unit S&T Laboratory capability for the proposed SITE POR
  - Examine Code 30/34 budget priorities for immersive simulation training needs
  - Increase long-term research for immersive training.

# Acronyms

| | | | |
|---|---|---|---|
| AAR | After Action Review | MAGTF | Marine Air-Ground Task Force |
| AR | Augmented Reality | MET | Mission Essential Task |
| CBA | Capabilities-Based Assessment | MOUT | Military Operations on Urban Terrain |
| CCS | Combat Convoy Simulator | MR | Mixed Reality |
| CDD | Capability Development Document | POR | Program of Record |
| DVTE | Deployable Virtual Training Environment | PLI | Position/Location Information |
| FITE JCTD | Future Immersive Training Environment Joint Capability Technology Demonstration | PTP | Pre-deployment Training Plan |
| HMD | Head/Helmet Mounted Display | ROC - IED | Recognition of Combatants – Improvised Explosive Devices |
| HPT&E STO | Human Performance, Training and Education S&T Objective | SITE | Squad Immersive Training Environment |
| ICD | Interface Control Document | T&R | Training and Readiness |
| ICT | Institute for Creative Technology | TRL | Technology Readiness Level |
| IIT | Infantry Immersive Trainer | ULTRA-vis | Urban Leader Tactical Response, Awareness & Visualization |
| INP | Innovative Naval Prototype | VBS | Virtual Battle Space |
| ISMT | Indoor Simulated Marksmanship Trainer | VR | Virtual Reality |