NAWCTSD Research Project Summaries

Fiscal Years 2015-2016

Training, Human Performance, and Modeling & Simulation: R&D to Enable Fleet Success

November 18, 2015

Naval Air Warfare Center
Training Systems Division
Orlando, Florida
navair.navy.mil/nawctsd

S&T R&D Where the Mission Begins

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A Message from Our NAWCTSD Leaders:

R&D to Enable Fleet Success

Captain Frank W. Naylor, USN
Commanding Officer

John Meyers
Technical Director

At the Naval Air Warfare Center Training Systems Division (NAWCTSD), we are *conducting research* to understand and improve individual and team learning and performance. We develop education and training methodologies and technologies to reduce training time and maximize transfer of knowledge, *enabling Fleet success*.

Our *four research focus areas aligned to our core capabilities* are: Human Performance Modeling and Assessment; Human Systems Design and Decision Support; Virtual Environments and Training Technologies; and Distributed Live, Virtual, and Constructive Synthetic Training.

Our research efforts focus on where the mission begins, where the body of knowledge of human performance and training is expanded, where innovations are developed, proofs of concept are established, and prototypes are demonstrated.

We promote experimentation, creativity and encourage our people to challenge basic assumptions. We are open to reinventing ourselves based on new knowledge and understanding. This ability to adapt is our "intrinsic weapon." Ultimately, these innovations are transitioned to the Fleet and improve warfighter readiness.

Special thanks go to our principal investigators and all of our researchers for their technical excellence and innovative contributions year-round to improving the capability, quality and cost-effectiveness of the training technologies provided to the Fleet.

Research & Technology Programs Office

NAWCTSD is a key warfare center laboratory for training systems and human performance. The primary goal of our researchers is to explore and develop advanced technologies and methodologies to ensure that the Fleet of tomorrow has the skills, training, and equipment it needs to enable success against current and future threats.

In consonance with strategic plans of the Naval Forces and the Naval Aviation Enterprise, our vision is to merge behavioral, cognitive and engineering sciences to produce effective training solutions and systems, exploiting technology to increase performance, reduce risk, and reduce cost.

Our strategy includes leveraging work at universities, industry, and other government laboratories, to provide advanced technologies that transition into operational use.

We revitalize the workforce and enable technical excellence through a focus on research and development.

People – Researchers and Warfighters – Are Our Most Important Assets.

Director
Maureen Bergondy-Wilhelm

Deputy Director
Robert Seltzer

Military Deputy
CDR Henry L. Phillips IV

Science & Technology Objectives

" We continually strive to improve the way we plan and manage our S&T portfolio. Our S&T Objectives (STOs) are jointly developed by the warfighters, technologists, requirements officers and the acquisition sponsors. Roadmapping of the individual STOs coupled with our newly developed, department level, bottoms up Core Capabilities play a major role in identifying gaps to guide and help develop our investment strategies and to clearly articulate our focus areas. These approaches are guided by a common process supported by quantitative metrics, with a goal of transitioning the best technologies at the lowest cost as quickly as possible to the warfighter" -- Dr. James Sheehy, ST, Chief Technology Officer, Naval Aviation Enterprise

The STOs are aligned with the CNO's, OSD's, and ONR's S&T focus areas, as well as the Marine Corps Aviation S&T Objectives. There are 10 capability gaps supported by 33 NAE STOs that were developed interactively with OPNAV, Fleet, NSAWC/NMAWC, PEOs/PMAs, FRCs, USMC, Warfighters and Technologists.

The STOs are the goals of the NAE S&T program which are presented using a common road mapping process showing the ongoing projects, their TRL levels, and dollars invested. Roadmaps are defined by near, mid and far term quantitative metrics which provide the "plan" to mature and transition needed technologies to the current and future stakeholders.

STOs are supported by the 75 NAWC Core Capabilities which define ongoing vs. needed projects, current vs. future skill sets, and the required infrastructure. The combination of the two documents at the project level enables the NAE to define focus areas which clearly articulates our needs, requirements and desired capabilities to the resource sponsors.

Technology development is principally performed by the elements of the Naval Research Enterprise (Warfare Centers), industry, and academia which provide the critical technology and material that transition to the acquisition sponsors and ultimately the warfighter.

The responsibilities of the NAE Chief Technology Officer are to ensure alignment, leveraging, and non-duplication of efforts with the NAE's current missions and future capability needs while balancing and managing a fiscally responsible S&T portfolio with support from our resource sponsors.

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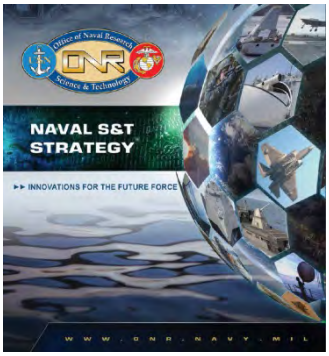
INTRODUCTION

"We are unique in this integrated role …"

Research & Technology Programs Director: Maureen Bergondy-Wilhelm

The Naval Air Warfare Center Training Systems Division (NAWCTSD) is the Navy's source for a full range of innovative products and services that provide complete training solutions. This includes research and development in human performance, learning, advanced technologies through training system acquisition and life cycle support. The research mission of NAWCTSD is to plan and perform a full range of directed Research and Development (R&D) in support of naval training systems for all warfare areas and platforms, to maintain an expanding naval-critical technology base, and to transition research results to the Fleet and other customers.

The Navy Science and Technology (S&T) Strategy, developed by the Office of Naval Research (ONR), is designed to leverage advances in knowledge and technology under a Discovery and Invention Program, and to demonstrate new technologies under a set of Future Naval Capabilities (FNC)Programs. Taken together, these programs comprise the Navy's technology base and support the vision of the Chief of Naval Operations. Guidance comes from Integrated Product Teams that include representatives from the following: Requirements, Acquisition, S&T, and Fleet/Force communities. In collaboration with academic and industry partners, the Research and Technology Programs at NAWCTSD respond to research gaps working with ONR through such venues as the Capable Manpower FNC. They also address enabling capability gaps identified in the S&T Strategic Plan developed by the Naval Aviation Enterprise, of which NAVAIR is a major component.



We pursue early advances in selected research areas under the D&I portion of the Navy S&T Strategy, with Basic Research and Applied Research as the primary components. We also are involved in Transition Research (BA4) to refine and evaluate technologies, and deliver them directly to the acquisition community or operational forces. Under the Section 219 Program, we are also able to fund critical work across the S&T budget activity levels (BA1-3) using in-house funding. This program exists to help DoD laboratories build expertise and capabilities needed to meet current and future fleet stakeholder requirements, in parallel with the DoD policy for defense contractor-funded Independent Research and Development (DFARS 231.205-18).

Another portion of our portfolio is aimed at accelerating the transition of technologies, with industry help, through such programs as the Small Business Innovation Research (SBIR) and the Small Business Technology Transfer (STTR) programs.

Additional efforts include cooperative and collaborative research with other government agencies, non-profit institutions, and commercial firms. Much of this work is done under the federally mandated Technology Transfer Program, in which capabilities developed with federal R&D funding are adapted to public and private needs. The scientists and engineers at NAWCTSD work closely, to develop and promote transitions of promising technologies.

At a high level, our Research and Technology Programs have three major goals:

1. Enhancing and measuring human performance,
2. Improving learning and retention and their assessment, and
3. Improving training system technologies, components, and processes.

NAE Science and Technology Objectives (STOs)

Naval Warfighter Performance (NWP) Science and Technology Objective (STO)-1 Training and Education: Increasing mission complexity, asymmetric warfare emphasis, high live/range exercise costs and growing operational demands driven by reduced timelines directed by Fleet Response Plans all require new metrics-driven processes, high-fidelity training environments and fully linked training and readiness competencies to achieve operator/maintainer qualifications and proficiency while reducing training life-cycle cost drivers. The rapid creation of combat readiness and operational proficiency, while optimizing the use of live, virtual and constructive assets is required.

- *Develop education and training technologies to cost effectively maximize transfer of knowledge from the classroom and trainer to the operational environment.*

NWP STO-2 Human Systems Design and Decision Support: Excessive Operator workload in a non-optimized data rich environment degrades effectiveness, resulting in extended decision timelines with potential for increased human error and injury.

- *Develop technologies to improve human systems design to reduce manned and unmanned operator workload; decision-making; model processes related to situational awareness; and mitigate stress (physiological and psychological) and injury risk; and improve our understanding of human social and cultural behavioral processes to yield improved decision making. Crewmember knowledge, skills, abilities, personality characteristics, experiential requirements, and workload targets will be quantitatively assessed. These methodologies will provide a means for more effective decisions in the context of system and platform design, manpower requirements, design tradeoffs, mission sustainability, and warfighter effectiveness.*

Information Dominance (ID) STO-1 Command & Control: Joint and coalition forces must have the ability to task, process, exploit, and disseminate information to/from the appropriate entity within the force with enough fidelity to be acted upon in a timely manner. With multiple sensors providing more information, operators must assimilate an increasing volume of data and information. All relevant and available information must be filtered, organized, and coalesced to enable timely, informed decisions in order to manage, control, and manipulate the battlespace.

- *Develop technologies to enable rapid, accurate decision making to ensure efficient battle management. Desired technologies include intelligent agents or decision aids for rapid and reliable threat/intent determination, distributed and decentralized weapons/sensor coordination and control, and improved mission planning.*

NAWCTSD Research Focus Areas

Human Performance Modeling and Assessment: Human Performance Modeling analyzes underlying knowledge, skills and abilities (KSAs) to predict performance across a variety of systems and contexts. Human performance assessment includes the ability to accurately measure and analyze performance at different levels (e.g., individual, team or multi-team) across domains and tasks. Future assessment capabilities will encompass neuro-cognitive and other physiological measures and indices. Understanding these in the context of training or operational tasks will serve both to expand this technical area beyond its current scope and to enhance warfighter performance and effectiveness.

Under Human Performance Modeling and Assessment there are two sub-capabilities:

- *Human Performance Assessment*
  - Psychometric Foundations of Performance Measurement, Prediction, and Improvement
  - Performance Assessment Support Tools
  - Measurement Authoring and Selection for Universal Re-use and Exportation
  - Configurable Database of Reusable and Exportable Performance Measurement Objects
  - Technologies for Integrating Neuro-Cognitive & Competency-Based Assessments
  - Adaptive Training Priorities and Task Loading
  - Automated Performance Assessment for Simulators
- *Human Performance Modeling*
  - Develop and Validate Algorithms and Modeling Approaches to Capture Human Performance Regularities
  - Apply Human Performance Models (HPMs) to Simulation-Based Design, Mission Planning, and Training
  - Advance Real-time Processing and Integration of HPMs
  - Innovative Predictive Modeling for Strategic Behavioral Prototyping
  - Library of Reusable HPMs Covering Relevant Military Tasks

Virtual Environments & Training Technologies: Virtual Environments (VEs) can augment warfighter preparedness by providing training opportunities that might not be available due to factors such as cost, safety and resources. Three components of VE training include technology, human, and evaluation. The technology component includes the ability to provide realistic rendering and modeling, multi-sensory input/output devices, and system interconnectivity and delivery. The human component includes the ability to train at different levels of task performance from motor skills to complex cognitive skills while taking into account user interaction issues and individual differences. The evaluation component involves assessing the effectiveness of the VE training system via formalized training effectiveness evaluations, transfer of training, and training fidelity.

- Natural Language Processing for Training Devices Immersive, Augmented Reality, Multi-Sensory Training Environment
- Adaptive Training & Intelligent Tutoring
- Medical Modeling & Simulation
- Game-based Training
- Eye-Limiting Resolution Display
- Mobile Training Technologies

Distributed Live, Virtual & Constructive Synthetic Training: The ability to train and interact in a large-scale distributed simulation network is critical to the Department of Defense (DoD) and allied partners to allow warriors to interact, train, and learn in an operationally realistic environment.

Under Distributed Live, Virtual & Constructive Synthetic Training the three major sub-capabilities are:

- *LVC Training Architecture*
  - Simulation Fidelity
  - Multi-Level Security
  - Mission Rehearsal Enabled Databases
  - Constructive Environment Improvements
- *Distributed Training*
  - Distributed Team Competencies & Training Methodologies
  - Scenario Generation and Control for Distributed Exercises
- *Human Computer Interaction*
  - Management of Information Load
  - Collaborative Tools and Techniques

Human Systems Design and Decision Support: Significant advances in Naval Capabilities, such as the increased numbers and types of sensor systems, the use of multiple autonomous vehicles, and the increased flow of intelligence information, present a significant challenge for our warfighters.

- Information Fusion, Processing, and Exploitation
- Tactical Interfaces
- Control and Monitoring of System Autonomy

This booklet is organized into the following six sections and provides a glimpse of the research being conducted at NAWCTSD.

1. Science & Technology
2. Naval Innovative Science and Engineering Program
3. Transition Research
4. SBIR & STTR Projects
5. Technology Transfer
6. Capital Investment Program
7. Other Navy, Department of Defense and Joint Programs/Projects
8. Science, Technology, Engineering, and Mathematics (STEM) Educational Outreach

We hope that you find it useful. If we can provide more information, please contact us at NAWCTSD_Research_TechnologyProgram@Navy.Mil.

SCIENCE & TECHNOLOGY PROGRAMS

"... supplying the pipeline of knowledge, concepts and prototypes...."

Program Manager: Robert Seltzer

The Department of the Navy's (DON) Science and Technology (S&T) program, includes Basic and Applied Research (BA1 and BA2), and Advanced Technology Development (ATD) (BA3) that is funded and managed by the Office of Naval Research (ONR). ONR is the S&T provider of the DoN and as such, is charged with providing the S&T products necessary for the operational concepts and visions for the Navy and Marine Corps of the future. The Naval S&T Strategic plan describes how ONR will enable the future operational concepts of the Navy and Marine Corps.

(See Naval Science & Technology Strategic Plan - Office of Naval Research)

NAWCTSD's S&T Program primarily focuses on supporting the NAE's Naval Warrior Performance Science and Technology Objectives (STOs) that are detailed in the NAE STO document dated April 2014. The NAE STOs directly align to support the Naval S&T focus area called, Naval Warfighter Performance. Other NAE STOs addressed by the S&T project portfolio include: Strike Operations, Undersea Warfare, Information Dominance, and Enterprise and Platform Enablers.

NAWCTSD Discovery and Invention (D&I) Program is comprised of basic and applied research. The purpose of D&I is to continuously generate new ideas. Its goals are to leverage advances in knowledge and technology, initiate investigations in areas of particular interest to the Navy, and maintain expertise in areas that are uniquely naval in nature. Thus, the focus of the work is on supporting unique requirements of the naval forces and on fields of inquiry that are unlikely to be adequately advanced by industry or other sponsors. The program area has a long timeframe, involving extensive experimentation and demonstration before it will have an impact on operational systems.

NAWCTSD has three sets of research projects funded under the D&I component of the Navy S&T program. The first is investigating intelligent tutoring under the general ONR Program. The second and third are the In-house Laboratory Independent Research (ILIR) Program and the Independent Applied Research (IAR) Programs, which are ONR-sponsored Basic Research and the early stages of Applied Research Programs executed by NAVAIR. All of these efforts have links to the Capable Manpower Future Naval Capabilities (FNC) Program, because they are either addressing research gaps that were identified by that program or pursuing studies that complement or extend that work.

NAWCTSD's ATD Program is comprised of six ONR projects: one supports carrier qualification pilot training, another supports marksmanship proficiency technologies and the other four projects supporting the Capable Manpower FNC. The purpose of ATDs are to mature technology into requirements-driven, transition oriented products that support the CNO, the Commandant of the Marine Corps, and their shared vision for the service. With respect to NAWCTSD's training, human performance and M&S research mission, the related ONR Naval Warfighter Performance objectives are:

Manpower, Personnel, Training and Education:

- Enhance fundamental information-processing abilities in naval recruits utilizing world-class innovative training technologies
- Accelerate and enhance training time and impact while reducing costs

- Develop tools and techniques to achieve ubiquitous, engaging, scenario-based training and automated performance-based readiness assessment
- Enable training tailored to the individual and team anywhere, anytime through simulation-based technologies for multi-mission, multi-platform training

Human System Design and Decision Support

- Reduce training and workload requirements through human-centric system design
- Create design engineering tools and standards incorporating human capacities into system performance
- Incorporate the human element into design and control of autonomous and robotic systems
- Develop effective, user-friendly decision support systems for kinetic and non-kinetic operations

Bio-engineered Systems

- Design computational cognitive models for intelligent systems and synthetic forces for operational experimentation, mission planning, real-time decision support and training systems
- Exploit understanding of neurocognitive processes to enhance combat system design and adaptive digital tutoring systems

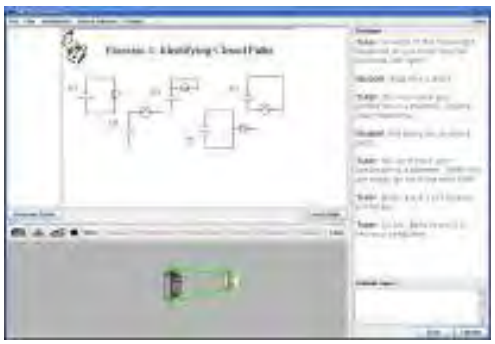
Warfighter Health and Survivability

- Improve the continuum of casualty care from the point of injury, en route, and shipboard to definitive care at treatment facilities
- Enhance warfighter resilience to physical and psychological stressors

NAWCTSD's S&T Projects are described in the subsequent D&I, ATD and Capable Manpower FNC sub-sections that follow.

BASIC ELECTRICITY AND ELECTRONICS TUTORIAL LEARNING ENVIRONMENT - HUMAN COMPUTERS AND SPEECH (BEETLE HCS)

Start: Sep 05 End: Dec 15



Need: Despite tremendous advances in technological capability, intelligent tutoring systems have yet to consistently realize the instructional effectiveness typically attributed to expert human tutors. It has been suggested that one key to a human tutor's effectiveness may be the flexibility and adaptability of the tutorial dialogue that the tutor establishes and maintains with a student.

Objective: (1) Gain insights from data collected with human tutors that will simultaneously improve our understanding of dialogue, instruction and learning, and (2) push the state-of-the-art in computer-based natural language processing by developing a computer-based system capable of conducting a tutorial dialogue with a student called the Basic Electricity Electronics Tutorial Learning Environment (BEETLE).

Benefits: Provide the Navy with a determination of the training effectiveness of such a system, with an eye toward providing the Navy with information to support a cost-benefit analysis of this training capability.

Status: In FY15, the BEETLE project was concluded. A summary of findings from our studies with human tutors and BEETLE, including the fully adaptive feedback version and a non-adaptive feedback version, were summarized. Overall, all modes of tutoring (human, adaptive computer, and non-adaptive computer) were highly effective and yielded impressive effect sizes on the order of 1.6 to 1.8 sigma improvements relative to a no-training control condition. However, there were no significant difference in learning gain between our conditions, thus we were not able to show a benefit for adaptive dialogue in our studies, but we did see that our strong curriculum was effective at teaching even with canned feedback.

Through our research on tutoring, we learned some interesting things about students, tutors, and the curriculum. More successful students spoke in longer sentences (Steinhauser, 2007; Steinhauser, 2013), used more "content" words (Litman, 2009), rarely got "stuck" during training (Campbell, 2009; Litman, 2009; Steinhauser, 2013), found an effective way to communicate with computer tutor on their own (not by copying the tutor's language) and re-used those language structures (Steinhauser, 2011; Steinhauser, 2013), and reported being more satisfied with the training (Steinhauser, 2013). We also founds that Negative metacognitive statements made during independent activities were accurate predictors of confusion, students rarely made negative metacognitive statements with a human tutor and, positive metacognitive statements made during dialogue with a human tutor were also predictors of confusion (Campbell, 2009).

As for tutoring techniques, we found that it is advantageous to ask open-ended questions to encourage and elicit student talk, elicit deep processing, elicit accountable talk (accurate and deep), and engage student's interest so that some dialogue is internally motivated. When the student gives a correct response the tutor should restate, summarize, and emphasize main point(s) and appropriate use of domain terminology. When the student is incorrect the tutor should provide activities that lead student to figure out answer (Steinhauser, 2007; Campbell, 2008; Dzikovska, 2008; Campbell, 2009). Additionally, we found that students interact differently with different types of tutors. Students are more social and positive with a human tutor. Students are more likely to respond negatively to an adaptive computer tutor than to a human tutor. Students do not attempt to interact socially and do not

make metacognitive statements to a scripted/canned tutor (Steinhauser, 2010; Dzikovska, 2010). The maturity of the Natural Language Processing technology also matters. Frequency of "uninterpretables" (times when the computer tutor didn't understand the student) correlated with low learning gain and low user satisfaction in both the adaptive and scripted computer tutors (Dzikovska, 2011; Dzikovska, 2014).

These results have attracted the attention of the Department of Defense Educational Activity (DODEA) and we are in conversations with them about possible ways to transition our approach to their middle school science curriculum under a different source of funding.

Research Products:

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Steinhauser, N. B., Campbell, G. E., Dehne, S., Dzikovska, M. O., & Moore, J. D. (2013). System Comparisons: Is there Life after Null?. In Proceedings of the 16th International Conference on Artificial Intelligence in Education (AIED 2013). July 2013, Memphis, TN, USA.

Dzikovska, M. O., Steinhauser, N. B., Farrow, E., Moore, J. D. & Campbell, G. E. (2014). BEETLE II: Deep natural language understanding and automatic feedback generation for intelligent tutoring in basic electricity and electronics. International Journal of Artificial Intelligence in Education.

TUTORING EFFECTIVELY: AN ASSESSMENT OF COMMON HEURISTICS (TEACH)

Start: Oct 12 End: Jun 15

Need: To have an effective warfighter or professional in the field, individuals need to be effectively and efficiently trained. This project aims to determine methods to train and tutor individuals effectively in Science, Technology, Engineering, and Math (STEM) domains. This additionally supports the Navy's requirement for making advances in the teaching of Science, Technology, Engineering, and Math (STEM) domains. This research will examine tutoring strategies in the application of Intelligent Tutoring Systems which could reduce instructor demands and provide more affordable and accessible training for our forces, which aligns with the Department of the Navy (DON) Objectives for FY12 and beyond to maintain warfighter readiness in an era of reduced budgets- organize, train, and equip combat-ready forces.

Objective: (1) Evaluate the value of feedback and scaffolding in a tutorial setting to determine if one or both are the key to tutoring effectiveness and the 2 Sigma effect. (2) Examine the benefits of proactive versus reactive scaffolding. (3) Provide empirically validated tutorial strategy recommendations for implementation into an Intelligent Tutoring System. (4) Determine useful methods for teaching the tutor to make use of effective tutoring techniques.

Benefits: Give guidance for effective tutoring strategies and methods for implementing those strategies and provide empirically validated design guidance to maximize the effectiveness of future STEM tutoring systems.

Status: In FY15, our team completed several milestones. Our team finalized the feedback statements and the scaffolded responses that will be available for tutoring during experimentation. Additionally, we finalized the experimental materials (e.g., demographics questionnaire, student reaction survey, pre and posttest for conceptual knowledge gain, etc.) and received CPHS approval for running participants. The networked computer interface was finalized to allow the student and tutor to communicate and work through the lessons and record all student and tutor actions and interactions, while maintaining a controlled experimental environment. The interface was setup to allow automatic coding of lesson correctness and feedback. Lastly, all experimental measures (e.g., surveys and lesson spreadsheets) were converted to excel for efficient coding. Initial pilot participants have taken part in testing and data from actual participants is expected to be collected before the end of the fiscal year.

Research Products: No publications as of yet. It is anticipated that the results from this work will be presented at the Cognitive Science Society Conference in 2016. Additionally, we plan to publish the results in a peer reviewed journal.

HUMAN SYSTEMS INTEGRATION PROGRESS & RISK SPECIFICATION TOOL (HPRST)

Start: Nov 14 End: Dec 15

Need: There is a persistent need for tools and models to help Human Systems Integration (HSI) practitioners and acquisition leadership make more informed and timely decisions regarding the recognition, definition and timely incorporation of HSI requirements into DoD acquisition programs.

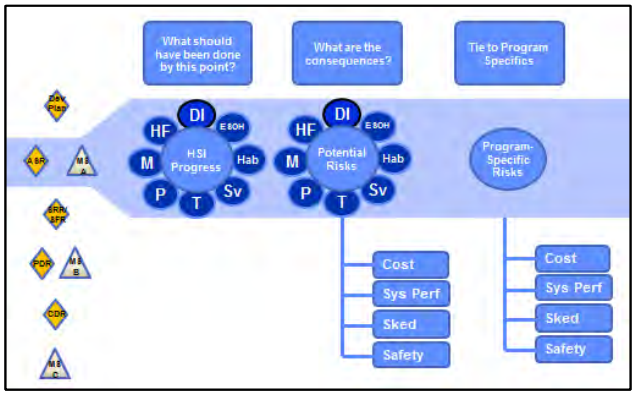


Figure 1. Components of the HPRST model.

Objective: Develop a tool for use by an HSI team lead at any point in the Acquisition Life Cycle (ALC) to provide a quick snapshot of HSI progress and as a starting point for conversations with program leadership regarding more granular data relating to HSI work conducted in system development. The scale and its supporting data are intended to produce a summary of the Systems Engineering Technical Review (SETR)-relevant system development information, acquisition artifacts, and risk management processes already being used by HSI teams and program leadership. It does not supplant or change any tools or processes already in place. It is intended to serve as a tool that program stakeholders (including HSI leads and practitioners, program management, and lead systems engineers) can incorporate into their processes with minimal additional burden placed on the teams using it. The goal of the HPRST is to provide the tools necessary for practitioners to:

- Evaluate general HSI progress requirements and activities by SETR and Milestone
- Identify the potential problems and risks linked to the failure to adequately and accurately conduct HSI domain activities by ALC timelines
- Determine potential mitigation strategies for consideration to address the identified problems and risks
- Use the general information and guidelines to develop tangible, rigorous, and defensible program-specific risks that will impact the acquisition project in terms of total cost, schedule, technical performance (both systemic and human), and safety.

Benefits: The potential payoff of the HPRST is to help HSI practitioners define and articulate the risks of failure to adequately and accurately conduct HSI activities in a language that acquisition program management can relate to and easily understand. Over the years, one of the biggest challenges of HSI as a discipline as well as a barrier to HSI technical acceptance has been the lack of an ability to codify the HSI risks to an acquisition program. The HPRST tool is intended to address that issue and to help HSI practitioners better apply HSI processes, identify the repercussions of sub-optimal HSI application, and articulate justifications for rectifying shortcomings. With proper HSI and Systems Engineering community vetting, the HPRST has the potential to further entrench HSI considerations into the Systems Engineering process, saving DoD acquisition time and money across the total system lifecycle.

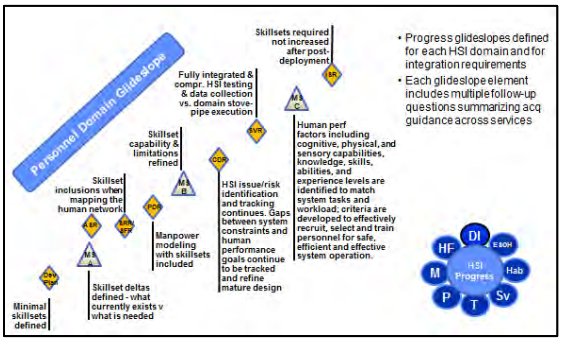


Figure 2. HSI Progress glideslope.

Status: This effort was funded by the Office of Naval Research. To date, an HRL model has been produced and vetted by SMEs across HSI domains and services. The modifications to the 2014 HRL scale to incorporate anticipated risks and mitigation

strategies are complete. FY16 activities planned involve evaluation of the HPRST tool using acquisition use cases, and additional review by OSD stakeholders.

Research Products:

Phillips, H.L. (2015, January). Human Readiness Level Considerations and Pitfalls. Panel discussion at the 3rd Annual Meeting of the National Defense Industrial Association – Human Systems Division.

Phillips, H.L. (2015, May). Human Readiness Level Working Group Report. Plenary presentation at the 69th Meeting of the Department of Defense Human Factors Engineering Technical Advisory Group.

Phillips, H.L. (2015, November). HSI Progress and Risk Specification Tool. Panel discussion at the Annual Meeting of the National Defense Industrial Association –Systems Engineering Division.

IN-HOUSE LABORATORY INDEPENDENT RESEARCH PROJECTS

MEASURING INTUITION AND ITS RELATIONSHIP TO SOMATIC MARKERS AND INDIVIDUAL DIFFERENCES

Start: Oct 13 End: Sep 16

Jewel Samad, AFP, Getty Images

Need: Military interest in intuition goes back at least as far as von Clausewitz's classic treatise "On War" (first published in 1832). Although historically intuition was recognized as an important skill to the warfighter, this construct has only recently emerged within the scientific community as a legitimate topic of study. While there are, now, many different techniques for studying intuition, there is a lack of integration between these methodologies and thus an inability to properly assess whether intuition is an innate ability or if it is trainable. Additionally, it is unclear how laboratory tests of intuition relate to real-world intuitive decision making, which can be critical to survival in a war-time environment

Objective: Military theorists have long posited that intuition is important for military decision making. If so, intuitive processing ability should be an important variable to consider when selecting among candidates for military jobs. However, intuition has historically been ill-defined and therefore unsuitable for selection use. Recent neuroimaging studies have correlated performance of laboratory intuition tasks with activity in the medial orbitofrontal cortex and limbic system suggesting that intuitive processing is related to what neuropsychologists refer to as "somatic markers." This project will examine the relationship between intuitive processing and the neuropsychological construct of somatic markers by examining the correlation between performance on neuropsychological tasks and performance on common laboratory tasks of intuition. It will then examine the potential utility of these tasks for military selection by examining the relationship between these neuropsychological and laboratory tasks and performance on a shoot-no-shoot task.

Benefits: The proposed effort advances the state-of-the-art in the measurement of intuitive processing by bringing various inventories and assorted behavioral measures together into a single study to assess their reliability and convergent validity. The innovative component of this research is the incorporation of the Iowa Gambling Task and a shoot-no-shoot decision scenario into the current research on intuition. These measures allow us to not only assess intuitive ability, but also how those abilities affect the decisions that are made. This is the crux of intuition. Not only do you have a gut

feeling, but you need to act on it appropriately and these tasks will give us those measures. The knowledge we gain from this research may be leveraged to significantly increase our capability to measure and understand intuition and how it might be used for selection. If this project is successful we will have verified our measures as being reliable measures of intuition and will have recommendations for how to test and select personnel for positions that require the use of good intuition.

Status: We began this effort by analyzing the data from previous Intuition project (ILIR 3630) to determine which tasks and assessments would be included in the current study and thus finalized our experimental design. Next, we identified a test bed for creating a shoot-no-shoot task (Virtual Battle space 2 (VBS2)) and successfully developed and finished the scenarios. We also received permission to purchase the Iowa Gambling Task (IGT) from the test creator, obtained IT approval, and acquired the software. We have received CPHS approval for the study as well. We are currently in data collection and have successfully collected data from 96 participants. Our goal is to have data from 135 participants. In addition, we have begun to code and analyze a portion of the data collected.

Research Products: No publications as of yet. It is anticipated that the results from this work will be presented at I/ITSEC in 2016.

IMPACT OF LOW-COST HAPTIC FEEDBACK ON USER PERFORMANCE AND WORKLOAD

Start: Nov 13 End: Dec 16

Need: There is a persistent need to improve operator performance and decrease mental workload when interacting with a complex system, such as those that require multitasking.

Objective: The objective of this research effort is to determine the impact of low-cost haptic feedback on operator performance and mental workload in a multitasking environment. Previous research has demonstrated that haptic feedback can be an effective means for improving certain aspects of performance and decreasing mental workload. However, significant gaps exist in terms of the overall performance benefits of haptic feedback. Although haptic feedback has shown that it can decrease response time, its effects on performance accuracy vary. In addition, there is still a need to investigate the impact of haptic feedback using low-cost and non-invasive methods. The goals of this research effort are to:

- Develop a low-cost, non-invasive, method of providing haptic feedback to an operator that can be easily integrated with multiple interfaces.
- Determine if this low-cost, non-invasive, method of haptic feedback can improve overall operator performance, in terms of response time and accuracy, and decrease mental workload.

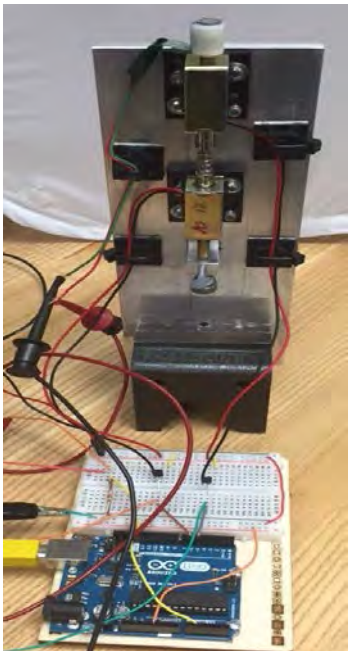


Figure 1. Haptic Button Prototype with Arduino Driver Circuit.

Benefits: One potential payoff for developing a low-cost, non-invasive, method of providing haptic feedback to an operator is the hardware itself. Providing an cost effective way to integrate haptic feedback into multiple systems can help both the operator and system designer. Another potential payoff is to yield a clearer understanding of the performance benefits to be gained by using haptic

feedback. The results of this effort can inform operational and training design across services and warfare domains.

Status: To date, a prototype of the low-cost haptic feedback hardware and the research methodology have been developed. FY16 activities involve data collection and analysis, along with an invited conference presentation at the 18th International Conference on Human-Computer Interaction later this year.

Research Products:

Phillips, H.L. (2015, October). Impact of Linear Haptics on Interface User Performance. Presentation at NAVAIR 4.6 Research Colloquium.

Rozovoski, D. (2015 August). Haptic button prototype with arduino driver circuit developed.

INDEPENDENT APPLIED RESEARCH PROJECTS

TAILORING INSTRUCTION TO THE INDIVIDUAL: INVESTIGATING THE UTILITY OF TRAINEE APTITUDES FOR USE IN ADAPTIVE TRAINING

Start: Oct 13 End: Dec 15

Need: Little research has been done to determine what makes adaptive training effective. There are many aspects of training that can be manipulated such as difficulty, content, and sequence as well as many factors that can be used as a basis for adaptation such as trainee performance, aptitude, and test scores. Further complicating this issue, training effectiveness can be mediated or moderated by many factors such as trainee motivation, perception of workload, and self efficacy. Recently, there has been a push by the DoD to create AT systems for military training. Adaptive training decisions should be made on the basis of a strong theoretical foundation, and more research is necessary to determine the optimal method for adaptation. If the research foundation to base design decisions on is deficient, AT systems created to fulfill the needs of the DoD may not be effective.

Objective: The objective of this research was to determine the optimal combination of factors to create adaptive training. More specifically, an experiment was performed to examine the relationship between trainee spatial ability, adaptive difficulty, and level of detail of feedback provided to trainees during instruction. It was hypothesized that participants who received adaptive difficulty instruction that provided feedback adapted to their level of spatial ability (i.e. trainees with high spatial ability will perform better when given minimal feedback while trainees with lower spatial ability will perform best when given more detailed feedback) would perform best on a post test and transfer test.

Benefits: Adaptive training capability gaps have been documented in several different sources such as those described in this proposal as well as the Naval Aviation Enterprise Science and Technology Strategic Plan, Naval Science and Technology Strategic Plan, and the Submarine Tactical Requirements Group's (STRG) prioritized focus areas for APB-13. These capability gaps span different warfare areas (i.e., aviation, surface, sub-surface, Marine Corps, joint). The fact that these capability gaps have been documented in several different forums points to the importance of research in this area. This project will serve to inform methodologies on how to adapt feedback to different individual difference levels of trainees.

Status: Data collection was completed in October FY15. The data was analyzed in October-December. The results indicated that providing participants with feedback matched to their spatial ability was not effective, indicating that the expertise reversal effect does not apply well to cases with complex and/or novel tasks. Data suggested that video game experience was related to spatial ability scores. The results of the study were used to complete a doctoral dissertation which was accepted in May 2015.

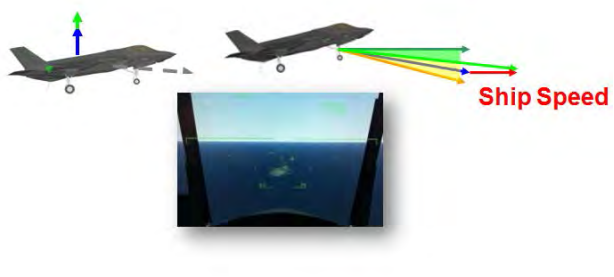
Research Products:

Landsberg, C. R. (2015). *Tailoring instruction to the individual: Investigating the utility of trainee aptitudes for use in adaptive training* (Doctoral dissertation). University of Central Florida, Orlando.

ADVANCED TECHNOLOGY DEVELOPMENT

CARRIER QUALIFICATION TRAINING REDUCTION VIA ADVANCED PILOTING SYSTEMS (CQTRAPS)

Start: Aug 14 End: Aug 16



Need: Landing on the deck of an aircraft carrier is one of the most difficult and dangerous tasks that Naval aviators must perform. While the current training continuum continues to be highly effective, the total ownership costs associated with live training and the need to maximize aircraft usage beckons for an improvement in aircraft capabilities to reduce initial training and currency requirements. The Maritime Augmented Guidance with Integrated Controls for Carrier Approach and Recovery Precision Enabling Technologies (MAGIC CARPET) integrates automated throttle control during final approach with onboard sensors, control capabilities, aircraft displays, and external visual landing aids to increase safety and reliability, and reduce pilot workload. While designed to improve pilot performance and safety, it is vital that this technology maintain (or potentially improve) training proficiency and readiness on the overall ability of aviators to perform landings. Therefore, the current effort Carrier Qualification Training Reduction via Advanced Piloting Systems (CQTRAPS) seeks to quantify performance benefits through training effectiveness evaluation to understand the impact this technology will have on proficiency and readiness, a vital step in ensuring training proficiency and readiness during training optimization through MAGIC CARPET.

Objective: CQTRAPS will develop an empirical understanding of the MAGIC CARPET system, including its training requirements, effectiveness, and impact on skill decay, learning and workload. An important overall objective is to estimate cost, throughput, and readiness considerations compared to conventional landing technology.

Benefits: The use of quantitative measures which go beyond typical training effectiveness evaluations that focus predominantly on qualitative assessments of training (i.e., trainee reactions), will provide a more robust understanding of training effectiveness and prevent limitations associated with utilizing data from a single source (i.e., same source bias). MAGIC CARPET has huge potential to reduce costs and increase safety for a high risk task and CQTRAPS will provide empirical data to support the performance, safety, and skill acquisition associated with MAGIC CARPET use when compared to traditional landing technology.

Status: Empirical research began in FY15. The contractor shall:

- Continue analyzing the temporal occlusion test (TOT) data
- Continue analyzing the simulation data
- Begin analyzing the demographic and knowledge test data
- Have the LSOs from the LSO School review the experimental passes

Research Products:

Stacey, W. & Wiggins, S. (2014). *MAGIC CARPET*. Research Report submitted to Office of Naval Research.

Priest Walker, H. A., Pagan, J., & Walwanis, M. (2014). *Improving the Safety of Carrier Landings: Maritime Augmented Guidance with Integrated Controls for Carrier Approach and Recovery Precision Enabling Technologies (MAGIC CARPET).* Paper presented at The 52nd Annual SAFE Symposium.

Wiggins, S., Pagan, J., Keeney, M.J., Bolton, A., Stacy, W., & Beaubien, J. M. (2014). *The Virtuous Circle and Contextualized Knowledge Elicitation: Application of a New Paradigm for Job Analysis.* Paper presented at the I/ITSEC 2014*, Orlando, FL.*

CAPABLE MANPOWER FUTURE NAVAL CAPABILITY RESEARCH

ADAPTIVE TRAINING FOR COMBAT INFORMATION CENTER (ATCIC)

Start: Oct 10 End: Dec 14

Need: Commander Fleet Forces Command identified requirements for shore based trainers with high fidelity simulations to support the Littoral Combat Ship (LCS) Train to Quality (T2Q) and Train to Certify (T2C) strategies to satisfy individual and team-based combat systems. To accomplish this, however, training solutions must be focused on developing higher levels of proficiency than ever for both individuals (T2Q) and for teams of individuals (T2C).

Objective: The objective this project is to conduct research, develop and transition individual and team level Adaptive Training methods and technologies to LCS in order to support efficient and effective tailored training focused on key skills necessary to support T2Q and T2C criteria.

Benefits: Based on the results of research on adaptive training, we expect the adaptive training system to improve team performance and reduce time to reach training criteria over non-adaptive systems, while minimizing the impact to instructor workload. As the ATCIC program is advancing the application of adaptive training to the tactical scenario based training environment and, as such, research conducted under this effort can provide guidance for adaptive training in complex team environments.

Status: The ATCIC program has secured a Level A Technology Transition Agreement with the LCS Program Office (PMS505). Therefore, work currently being performed in FY14 places emphasis on the transition of the adaptive training software to scenario based training for the Littoral Combat Ship shore based tactical simulations. Initial transition of ATCIC products has occurred in FY15 for LCS TAO Combat Systems Trainers for individual tactical skills training. Work has begun to support transition of team level adaptive training products to the LCS Integrated Team Trainers in the FY16 timeframe.

Research Products:

FY13 Blueprint Architecture Report Submitted to Office of Naval Research.

Prototypes:

- Portable Adaptive TRaining Instructor Operator Terminal (PATRIOT): Software demonstrating proof of concept of individual and team level scenario based adaptive training capabilities.

- TAO Sandbox/DARTS: Software tool to support assessment of individual level tactical proficiency for Tactical Action Officer and Commanding Officers. This software combines a scenario based training tool (TAO Sandbox) and a Diagnostic and Rapid Testing System (DARTS)

Pharmer, J.A. & Milham, L. M. (in press) Adaptive training for command-and-control Teams: Challenges in scenario based training. Adaptive Systems and Instructional Technologies. Theoretical Issues in Ergonomics Science. DOI: 10.1080/1463922X.2015.1111461

Milham, L. M., & Pharmer, J.A. ,Valaitis, J., & Winters, J. (2015) Adaptive Instructor Operating Systems: Design to Decrease Workload, Increase Effectiveness. Proceedings of the 2015 Interservice Industry Training Simulation and Education Conference (I/ITSEC)

Milham, L. M., Pharmer, J. A., & Fok, A. (2015). Adaptive instructor operating systems: Design to support instructor assessment of team performance. Proceedings of the 59th Annual Meeting of the Human Factors and Ergonomics Society. Los Angeles, CA.

Pharmer, J. A., & Milham, L.M. (2015). Adaptive training for combat information centers: Transitioning from research concepts to technology development. Presentation to the Department of Defense Human Factors Engineering Technical Advisory Group (DoD HFE TAG) 2015 Annual Meeting, May 2015, Orlando, FL

Pharmer, J.A. (2015). Integrated adaptive scenario based training displays. Presentation to the Department of Defense Human Factors Engineering Technical Advisory Group (DoD HFE TAG) 2015 Annual Meeting, May 2015, Orlando, FL

Milham, L. M., & Pharmer, J.A. , & Fok, A. (2013). Training effectiveness evaluation of real-time metacognitive feedback. Proceedings of the 2013 Interservice Industry Training Simulation and Education Conference (I/ITSEC)

Milham, L. M., & Pharmer, J.A., & Fok, A. (2013) Adaptive instructor operating systems: Design to decrease instructor workload and increase effectiveness. Proceedings of the 2013 Interservice Industry Training Simulation and Education Conference (I/ITSEC).

Munro, A. & Clark, R. E. (2013) Cognitive task analysis-based design and authoring software for simulation training. Military Medicine. 178 (10:7), 7-14.

Pharmer, J.A., & Milham, L.M. (2012). Development of an adaptive training capability for combat information centers. The NAVAIR Journal for Scientists and Engineers.

ADAPTIVE TRAINING FOR SUBMARINE PILOTING AND NAVIGATION

Start: Oct 09 End: Sep 14

Need: The Submarine Fleet Commander has identified requirements to improve the training of high-level decision-making skills for submarine commanders and crews, as well as the training and performance of submarine piloting and navigation teams (Prioritized Undersea Requirements Letter for POM-10, 10 August 2007). Further, there has been a push to incorporate adaptive training and tutoring capabilities into the classroom. For instance, in President Obama's Strategy for American Innovation, he called for a federal focus on learning technologies as an area of national priority. He recognized the need to invest in science and technology to improve learning and performance by announcing the creation of Advanced Research Projects Agency for Education (ARPA-ED). As a result, the Chief of Naval Research has also issued a Grand Challenge to develop software tutors to address DoN training needs. Likewise, the Submarine Tactical Requirements Group (STRG) has pushed this notion beyond the classroom and recently released their prioritized focus areas for Advanced Processor Build (APB)-13 which included developing "on-board adaptive training tools to support both individual operator instruction and integrated team training for sonar, combat control, imaging and electronic sensing systems." The Office of Naval Research has anticipated this need and is currently sponsoring a Capable Manpower (CM) Future Naval Capability (FNC) Enabling Capability (EC) entitled "Adaptive Training to Enhance Individual and Team Learning and Performance" to address the gaps in adaptive training and decision making.

Objective: The objective of this project was to advance the capability of existing and future simulation-based training programs used by the submarine community, by incorporating sophisticated performance measurement and diagnosis as well as instructional adaptivity tailored to strengths and weaknesses of individual trainees. Specifically, the focus was on providing intelligently adaptive training for the Piloting and Navigation team during surfaced submarine operations.

Benefits: In FY12, we collected data with 105 students from the Submarine Office Basic Course (SOBC) in order to evaluate the effectiveness of our adaptive training system as compared to a non-adaptive training system. We found that students in the adaptive training groups performed Angle on the Bow (AOB) calls significantly faster, completed training in less time, were more consistent in their improvement, and had higher learning gains than students who received non-adaptive training.

Status: In FY14, the NAWCTSD team continued further development of the Periscope Operator Adaptive Trainer (POAT). More specifically, the team supported POAT Step 3 and Step 4 (At Sea) Integration for Advanced Processor Build (APB)-13. This included further development of the adaptive training system including adding additional instructional content, increasing scenario content, fine-tuning the adaptive training algorithms, and integrating with the APB-13 Learning Management System (LMS). Toward this end, we developed 4 versions of POAT: 774 & 688 versions for tactical system installs and 774 & 688 laptop versions for Submarine On-board Training (SOBT) installs.

At the request of COMSUBLANT, we developed POAT+ to include adaptive training tools for Surface Ship Contact Recognition and Familiarization. Toward this end, we are created (1) a Contact Familiarization module which allows operators to review surface ship characteristics under various environmental conditions and review sensor capabilities, and (2) Contact Identification functionality within the POAT adaptive trainer.

Research Products:

- 2015 POAT was installed and integrated on tactical watchstation on-board SSN 21 (Connecticut) JUL 2015
- 2015 POAT+ was demonstrated at the Pentagon MAY 2015 as part of DoD Lab Day
- 2015 POAT+ was delivered to Submarine Onboard Training (SOBT) JAN 2015.
- 2014 POAT was delivered to Submarine Onboard Training (SOBT) AUG 2014 for training via on-board laptops as well as the schoolhouse.
- 2013 Naval Air Warfare Center Aircraft Division (NAWCAD) Commander's Award
- 2013 Admiral Luis De Florez Training and Simulation Award
- POAT+ is planned to transition as part of APB-17. POAT+ passed APB-15 Step 2 (Algorithm Assessment).
- A Level A TTA is currently in place with Tactical Systems Integration Section, Undersea Warfare Division, Office of the Chief of Naval Operations (N97) and Program Executive Office, Integrated Warfare Systems, Undersea Systems (PEO-IWS5).

Van Buskirk, W.L., Steinhauser, N.B., Mercado, A.D., Landsberg, C.R. & Astwood, R.S. (2014). A Comparison of the Micro-Adaptive and Hybrid Approaches to Adaptive Training. *Proceedings of the 2014 Annual Meeting of the Human Factors and Ergonomics Society.*

Landsberg, C.R., Mercado, A.D., Van Buskirk, W.L., Lineberry, M. & Steinhauser, N. (2012). Evaluation of an Adaptive Training System for Submarine Periscope Operations. *Proceedings of the 56th Annual Meeting of the Human Factors and Ergonomics Society* [CD-ROM].

Landsberg, C. Astwood, R. S., Van Buskirk, W. L., Mercado, A., Townsend, L., & Steinhauser, N. (2012). A review of adaptive training theory and techniques. *Military Psychology, 24*(2), 96-113.

Landsberg, C. R, Van Buskirk, W. L., Astwood, R. S., Mercado, A.M., & Aakre, A. (2010). *Adaptive training considerations for use in simulation-based systems* (Special Report 2010-001). Naval Air Warfare Center Training Systems Division.

Van Buskirk, W. L., Campbell, G, E., Landsberg, C.R., Steinhauser, N.B., Astwood, R. S., Mercado, A.M., Pittard, J.& Tolley, D. (2014). *Embedded Adaptive Training Systems: Periscope Operator Adaptive Trainer.* Functional Description Document for Advanced Processor Build (APB)-13. Naval Air Warfare Center Training Systems Division.

Van Buskirk, W. L., Campbell, G, E., Landsberg, C.R., Steinhauser, N.B., Astwood, R. S., Mercado, A.M., Pittard, J.& Tolley, D. (2014). *Embedded Adaptive Training Systems: Periscope Operator Adaptive Trainer- Plus.* Functional Description Document for Advanced Processor Build (APB)-15. Naval Air Warfare Center Training Systems Division.

DISTRIBUTED, ADAPTIVE, AND MODULAR ENTITIES FOR UNMANNED AERIAL SYSTEMS (DYADEM)

Start: Mar 14 End: Mar 18

Need: The Navy is facing limited live training opportunities due to cost, time, & fidelity constraints. There is also a lack of realism of large numbers of semi-automated force (SAF) in current constructive training technologies produces a readiness gap. Operators must put forth a significant time and effort to develop and integrate SAF into constructive exercises for UAS operators. What is needed is an activity learning and recognition technology based on sensor data to generate theatre level, realistic SAFs quickly and effectively by reproducing 'Patterns of Life', which are SAF activity patterns based on raw data that are realistic and intelligent, for training UAS operators, known as the Training Pillar for Unmanned Aerial Systems Interface, Selection, and Training Technologies

(UASISTT). The Dynamic Adaptive and Modular entities for UAS (DyAdeM) effort will deliver the tools, standards, and guidelines to generate large numbers of realistic semi-automated force (SAF) behaviors in a format that can be integrated into the Navy's SAF generation technology. The primary requirement of this product is to aid the integration of hundreds, if not thousands, of simulated entities into the overall training scenario that aviation requires. The DyAdeM approach will include replacing hand-coded rule sets with a capability to automatically generate new and appropriate SAF behaviors from one or more data sources including: data captured during live UAS exercises; data captured from experts operating their systems within a simulated environment; or data provided in a script-like format. Based on one or more of these initial data sets, it should then be possible to model those behaviors and extend those models to provide new behaviors that will drive SAF entities in a training environment. This approach will require integrating cognitive modeling approaches with machine learning techniques to generate tactically authentic behaviors.

Objective: Conduct advanced technology demonstration research to deliver the tools, standards, and guidelines to generate large numbers of realistic SAF behaviors in a format that can be integrated into the Navy's SAF generation technology.

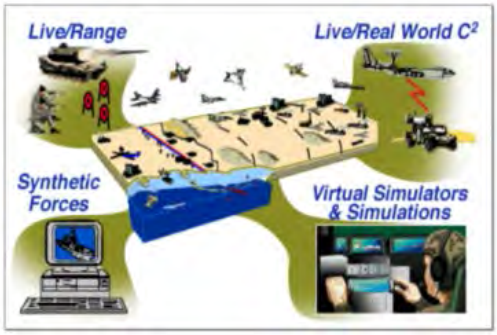
Benefits: The desired products from this technical area will provide the underlying behaviors that drive SAFs that can be integrated into the Navy's SAF generation technology. The SAF behaviors driving the large numbers of entities that provide the ecological background against which the 'Patterns of Life' scenario plays out will be the focus. SAF behaviors will provide a more realistic and effective training experience, while also requiring less input from their human operators.

Status: Contracts has been awarded and a kick off meeting conducted. The three components that make up DyAdeM, (1) Activity Learning, (2) Behavior Envelopes, and (3) Behavior Generation have been demonstrated for the ONR sponsor. Integration and demonstrations are planned for FY15.

Research Products: DyAdeM. Demonstration for ONR sponsor (Oct 14).

LIVE, VIRTUAL, & CONSTRUCTIVE (LVC) TRAINING

Start: Oct 11 End: Sep 16



Need: The Naval Science and Technology Strategic Plan cites the need for optimized physical readiness and enhanced cognitive performance as well as immersive, synthetic systems for training and education. Live, virtual and constructive (LVC) training environments may offer opportunities to bridge this gap. LVC environments are growing in size and complexity and are geographically distributed. As a result, increased demands are being placed on developers, instructors and operators and their ability to integrate, configure, and deploy these assets effectively.

Objective: This effort will define the S&T questions that underpin products of the three LVC enabling capability product pillars: Virtual Constructive Representations on Live Avionics Displays (VCR LAD), Cognitive Fidelity of Synthetic Environments (CFSE), and Tactics and Speech Capable Semi-Automated Forces (TACSAF). The proposed effort involves (1) understanding the safety concerns of blending L, V and C environments and developing mitigation strategies; (2) understanding the virtual fidelity training needs for carrier-based landings; and (3) developing a generative SAF behavior capability that accounts for trainee needs.

***Benefits*:** The payoffs of this enabling capability are the ability to enhance fleet readiness, lower total ownership costs, improve safety, and reduce security risks. First, the proposed capability will enable training complex realistic scenarios with rich authoritative tactical content. This will alleviate challenges associated with inadequate range/airspace availability, scarce live adversarial assets, and availability of training personnel. Second, enabling the use of LVC assets appropriately will mitigate frame life expenditure for operational assets, assist with increasing pressures to reduce the flight hour budget and decrease the cost of steaming days/flight operations. Third, increased use of simulation is cited as a mitigating strategy for improving safety considerations associated with Blue Threats. Finally, enhancing the use of LVC will reduce security risks by moving some tactical exercises and development off of the range and out of sight.

Status:

VCR LAD: Human Factors experimentation was completed in FY15 and the Hazard Analysis is being finalized after multiple Subject Matter Expert (SME) reviews. Drafts of the two knowledge products: Avionics and SIM Guidelines and Networking and Datalink Guidelines were delivered to the sponsors for review and feedback has been incorporated. Validation study test plans of the Networking and Datalink Guidelines are underway to be completed in FY16. IITSEC 2015 integration events currently underway for participation in the Operation Blended Warrior event.

CFSE: Component technologies of a performance assessment suite (i.e., quantitative, qualitative, physiological measures) have been integrated and tested. Further, experimentation on how motion cueing and enhanced image generation system impact performance and learning has been conducted. Findings suggest learning and retention effects for motion and visuals on novices. Experiment 2 will incorporate the performance assessment suite and will focus on Air to Air combat skills and instructional fidelity in simulated environments (FY16).

TACSAF: Scenario generation technology (Trainable Automated Forces-TAF) has been tested and demonstrated with prototype technology. Real time scenario adjustments via the Training Executive Agent (TXA) has been demonstrated and tested. Operator workload modelling experiments were completed in FY15 and testing and integration events have been conducted with the transition technology (i.e., Next Generation Threat System and TXA). Further integration and testing planned in FY16 ahead of final integration into NGTS.

- TACSAF demonstrated both component technologies to transition customer in AUG/SEPT 2014
- Integrated LVC Demonstrations at I/ITSEC 2012, 2013, and 2014.

Research Products:

Abbott, R.G. (2013). The relational blackboard. *Proceedings of the 2013 Behavior Representation in Modeling and Simulation (BRiMS) Conference, Ottawa, Canada.*

Beaubien, J. M., Stacy, W., Wiggins, S., Keeney, M. J., Bolton, A. E., Walwanis, M. M., Priest, H. A., & Riddle, C. S. (2015). Differentiating Measures of Learning (MOL) from Measures of Performance (MOP) During Aircraft Carrier Landing Practice. Paper accepted for Presentation at Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) in Orlando, FL. Awarded best paper in training category.

Blickensderfer, B. L., Neville, K., Fowlkes, J., Sherwood, S., Jimenez, C., Walwanis, M., & Bolton, A. (2013). *Live flight in a (partially) simulated world: Training benefits and challenges*. Poster session presented at the 121st Annual Convention of the American Psychological Association, Honolulu, HI.

Chladny, B., Hebert, K., & Colbert, B. (2014). Simulating Realistic Light Levels in Next Generation Image Generators. *Proceedings of the 2014 Interservice/Industry Training, Simulation & Education Conference, Orlando, FL.*

Cruit, J., Blickensderfer, B. L., Neville, K., Martin, T., Sherwood, S., McLean, T., Walwanis, M., & Bolton, A.M. (in press). Live-Virtual-Constructive training: Implications of a mishap analysis. *Proceedings of the Aerospace Medicine Association's 2014 Annual Conference, San Diego, CA.*

Cruit, J., Blickensderfer, B. L., Martin, T., Neville, K., Sherwood, S., & McLean, T. (2013). *LVC safety: Implications of naval mishaps*. Paper presented at the Human Factors and Applied Psychology Student Conference, Daytona Beach, FL.

Dykens, I., Swigert, B., & Mataafa, S. (2014). *Hypothesized strategies of metacognitive development: Debrief and active shadowing.* Research proposal submitted to the Training Technical Advisory Group of the Human Factors and Ergonomics Society.

Engler, J., & Schnell, T., (2013). *Measuring and Monitoring Cognitive Workload in Training Environments.* Paper presented at the Interservice/Industry Training, Simulation & Education Conference 2013, Orlando, FL.

Engler, J., Schnell, T., & Walwanis, M. (2013). Deterministically nonlinear dynamical classification of cognitive workload. *Proceedings of the 2013 Interservice/Industry Training, Simulation, and Education Conference*, *Orlando, FL.*

Jones, R.M., & Wray, R.E. (2014). Design Patterns for Balancing Behavior Responsiveness. *Proceedings of the 2014 Behavior Representation in Modeling and Simulation (BRIMS) Conference, Washington, DC.*

Tucker, K., & Walwanis, M. (2015). Safety Implication for Live, Virtual and Constructive (LVC) Training: Virtual and Constructive Representations on Live Avionics Displays (VCR LAD). *Proceedings of the SAFE Association Symposium*, *Orlando, FL.*

Martin, T., Sherwood, S., Neville, K. McLean, A.L.M.T., Walwanis, M., & Bolton, A. (2014). *Integrating new technology into Navy air combat training: A training guidance gap analysis.* Poster session presented at the American Society of Safety Engineers Safety 2014 Professional Development Conference, June 2014, Orlando, FL.

Neuhaus, J., Schnell, T., Walwanis, M. (2013). *Context-sensitive monitoring of human operator state.* Manuscript submitted for publication.

Neville, K., Blickensderfer, B., Sherwood, S.M., Jimenez, C., Fowlkes, J., Schnell, T., Engler, J.J., & McLean, T. (2012). *Version 1 of design requirements: Hypotheses*. Cedar Rapids, IA: Rockwell Collins.

Neville, K., Bond, A., Walwanis, M., & Bolton, A.M (2013). *Eclecticism and human-technology integration in systems development.* Manuscript submitted for publication.

Neville, K. (2013). *From technology to environment.* Paper presented at the Eighth Safety Across High-Consequence Industries Conference, Saint Louis University, St. Louis, MO.

Neville, K. (2014). *Integrating Live-Virtual-Constructive technology into the complex system of Navy air combat training*. Invited presentation in the Orlando Chapter of the International Council on Systems Engineering (INCOSE), April 18, Orlando, FL.

Neville, K., Bond, A., Walwanis, M., & Bolton, A.M. (2014). *Human-machine integration and the systems development process model*. Manuscript submitted for publication.

Neville, K.J., McLean, A.L.M.T., Sherwood, S., Tucker, K., Walwanis, M., & Bolton, A. (2015). Live-Virtual-Constructive Training for air combat: Emergent training opportunities and fidelity ripple effects. *Proceedings of the 17th International Conference on Human-Computer Interaction (HCI 2015), August 2-7, Los Angeles, CA*.

Neville, K.J., Tucker, K.P., Templin, S., Walwanis, M., & Bolton, A. (2015). *A decision support tool and methods set for minimizing unintended consequences.* Paper to be presented at the 53rd Annual SAFE Symposium, November 2-4, Orlando, FL.

Pagan, J., Tucker, K., Reni, J. F., Atkinson, B. F. W, Sciarini, L., & Walwanis, M. (2013). Next generation semi-automated forces (SAFs): A guidance model. *Proceedings of the Interservice/Industry Training, Simulation & Education Conference, Orlando, FL.*

Pagan, J., Tucker, K., Reni, J. F., Atkinson, B. F. W, Sciarini, L., & Walwanis, M. (2012). *Next generation semi-automated forces (SAFs): A guidance model for creating realistic SAFs.* Paper accepted to be presented as a poster to the BRiMs Conference 2012. Conference cancelled.

Pagan, J., Walwanis, M., Tucker, K., & Drivas, B. (in press). *Optimizing training by triangulating on the assessment of fidelity requirements*. NAVAIR Journal.

Reni, J. F., Pagan, J., & Walwanis, M. (2012). Towards a speech capable intelligent semi-automated force. *Proceedings of the 21st Conference on Behavior Representation in Modeling & Simulation, Amelia Island, FL.*

Schnell, T., McLean, A., Rediger, S. (2015). *Human-in-the-Loop Flight Simulation Study of Virtual Constructive Representation on Live Avionics Displays*. Paper to be presented at IITSEC 2015.

Sherwood, S., Cruit, J., Blickensderfer, B., Neville, K., & Martin, T. (2013). *Assessment and mitigation of hazards in the live-virtual-constructive training environment.* Abstract presented at the Human Factors and Applied Psychology Student Conference, Daytona Beach, FL.

Sherwood, S.M., Jimenez, C., Blickensderfer, B., Neville, K., Fowlkes, J., & Walwanis, M. (2013). *Live-virtual-constructive training: Safety concerns and mitigations.* Paper presented at the 2013 International Symposium on Aviation Psychology, Dayton, OH.

Sherwood, S., Martin, T., Neville, K., Blickensderfer, B., & Cruit, J. (2013). *Adapting Navy air combat training to take advantage of new technology*. Poster presentation to the Embry-Riddle Aeronautical University (ERAU) Board of Trustees, November 1, Daytona Beach, FL.

Sherwood, S., Neville, K., Blickensderfer, B., McLean, A., Walwanis, M., & Bolton, A.M. (2013). *The identification and assessment of hazards associated with the introduction of new technology into a complex air combat training system.* Manuscript in preparation.

Sherwood, S., Neville, K., Ashlock, B., Mooney, J., Walwanis, M., Bolton, A., & Martin, T. (2014). Envisioned world research: Guiding the design of live-virtual-constructive training technology and its integration into Navy air combat training. *Proceedings of the 2014 Annual Meeting of the Human Factors and Ergonomics Society, Chicago, IL.*

Sherwood, S., Neville, A., McLean III, A. L.,Cruit, L., Tucker, K., Walwanis., & Bolton, A.
(2015). A Multi-Year Study of the Safety and Training Impacts of Introducing the Live, Virtual, Constructive Training Strategy into Navy Air Combat. *Proceedings of Seventeenth International Symposium on Aviation Psychology (ISAP), Dayton, OH.*

Stacy, W., Walwanis, M., Wiggins, S., & Bolton, A. (2013). Layered fidelity: An approach to characterizing training environments. *Proceedings of the 2013 Interservice/Industry Training, Simulation, and Education Conference, Orlando, FL.*

Stacy, W., Walwanis, M., Bolton, A., Beaubien, J., & Wiggins, S. (2014). *Using Temporal Occlusion to Assess Carrier Landing Skills.* Manuscript accepted to Interservice/Industry Training, Simulation & Education Conference, 2014. Orlando, FL.

Tucker, K. P., Neville, K.J., Walwanis, M., & Bolton, A. (2015*). Exercise Management Considerations for Live, Virtual & Constructive Training*. Paper to be presented at the 2015 Interservice/Industry Training, Simulation, and Education Conference, Orlando, FL.

Wiggins, S., Keeney, M., Pagan, J., Bolton, A., Stacy, W., & Beaubien, J. (2014). *New Job Analysis Paradigm: Virtuous Circle and Contextualized Knowledge Elicitation.* Manuscript under review.

Wiggins, S., Pagan, J., Keeney. M., Bolton, A., Stacy, & Beaubien, J. (2014). *The Virtuous Circle and Contextualized Knowledge Elicitation: Application of a New Paradigm for Job Analysis.* Manuscript accepted to Interservice/Industry Training, Simulation & Education Conference 2014. Orlando, FL

Wray, R. E., Priest, H. A., Walwanis, M., & K. Tucker. (2015) Requirements for future SAFs: Beyond tactical fidelity. Paper accepted for CEU Presentation at Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) in Orlando, FL.

Wray, R.E., & Woods, A. (2013). A Cognitive Systems Approach to Tailoring Learner Practice. In M. Klenk & J. Laird (Eds.). *Proceedings of the 2013 Advances in Cognitive Systems Conference, Baltimore, MD.*

Yocius, M., & Schnell, T. (2013). *Accurately overlaying 3D eye tracking data onto a scene camera.* Manuscript submitted for publication.

NAVAL INNOVATIVE SCIENCE AND ENGINEERING PROGRAM

" … promote and maintain scientific vitality…."

Program Manager: CDR Henry L. Phillips IV, Ph.D.

The Naval Innovative Science and Engineering (NISE) Program was created under Section 219 of the Duncan Hunter National Defense Act for Fiscal Year 2009. It is intended to promote and maintain the scientific vitality of Naval laboratories by funding innovative in-house research in support of military missions, the transition of technology development programs into operational use, and workforce development activities. There are three categories of NISE projects.

The Basic and Applied Research category consists of in-house research projects to explore the fundamental aspects of military relevant phenomena and determine ways in which those phenomena can best be used by the military. There are two principle objectives to such projects. First, the projects attempt to answer basic or applied research questions that are of direct military relevance. Second, the projects allow Naval laboratory personnel to grow and maintain expertise in technical areas that are of interest to the Navy.

The Workforce Development category of projects is intended more explicitly to build the capability of Naval labs through personnel training and laboratory capability development. There are four subcategories of workforce development projects. Training projects allow laboratory personnel to attend special training courses that will enhance their ability to perform their assigned duties. Higher Education projects assist lab personnel in obtaining advanced degrees that are relevant to their Navy mission. Strategic Rotation projects promote the sharing of information across Navy laboratories and agencies by providing funding so that lab personnel can go on rotation to other laboratories, warfare centers, and agencies. Strategic Growth projects are intended to enhance laboratory core capabilities. Examples include support of strategic positions within the workforce, development of critical skill sets, or support of unfunded capability requirements.

Finally, the Transition category provides funding for pre-Milestone A bread board or brass board demonstrations and prototyping efforts to demonstrate critical performance parameters of key technologies. As such, it provides a vehicle by which concepts that were developed under In-House Laboratory Independent Research (ILIR), Independent Applied Research (IAR), and NISE Basic and Applied Research projects can be further matured.

During FY15 and 16, NAWCTSD scientists and engineers led or are leading eleven Basic and Applied Research projects, fourteen Workforce Development projects (six of which targeted Strategic Growth), and six Transition Research projects. The following pages outline Basic and Applied Research, Workforce Development: Strategic Growth, and Transition Research projects.

DEVELOPING WARFIGHTER TRAINING GUIDANCE FOR CUE RECOGNITION OF TRUSTWORTHINESS IN CULTURALLY-COMPLEX ENVIRONMENTS

Start: Oct 13 End: Dec 16

Need: Current and future warfare missions require relationship-building and negotiation skills to foster trust with locals to gain strategic information and thwart enemy forces. Personnel at all levels are expected to communicate with the local populace and leaders, Non-Governmental Organizations, and foreign military in a culturally-appropriate manner, while conveying trustworthiness. However, it is difficult to predict behavior for culturally-distant individuals. The US military was not always perceived as effective with cross-cultural trust development and rebuilding (e.g., criticisms noted from actions during and after the Ehime Maru). However, with the Pentagon reporting plans to shift 60% of the Navy's warships to potentially-kinetic Asia by 2020, it has become a mission-critical factor to understand and effectively project trustworthiness cues that are valued by non-Western cultures. With movement to other countries in which we have not sustained long-term presence for conflict missions, it is not only pertinent for training region-specific knowledge, but culture-general interpersonal strategies to increase mission success. The purpose of this research is to examine the Intercultural Model of Trust, which proposes relations between culture and perceptions of trustworthiness of another when involved in risky situations. Results will provide the empirical foundation to train cue identification and an understanding of how trust can deteriorate and be rebuilt in culturally-complex environments.

Objective: The purpose of this research is to test relationships predicted by the Intercultural Model of Trust, developed at NAWCTSD, which proposes relations among culture, trustworthiness, trust, and outcomes. The experiment allows for the ability to analyze which trustworthiness cues (i.e., ability, benevolence, integrity) are most valued by individuals and across cultures. This information is critical for the Warfighter's intellectual reservoir to leverage for effective and timely decision-making, especially when cultures are different. With this intel and enhanced decision-making strategies, they can understand cues that are often valued by the culture in which they operate, consequently, enhancing the probability of displaying behaviors that reflect these cues and increasing trustworthiness perceptions. Additionally, the authors are particularly interested in understanding the trust process when the outcome of the risk-taking relationship is *negative* (reducing the level of trust) and the parties have to collaborate in the future for a shared task. The results will provide the empirical foundation to train trustworthiness-cue identification and an understanding of how trust can deteriorate and be rebuilt in culturally-complex environments.

Benefits: The results yielded will support the Naval research labs by expanding our current knowledge of trust development and rebuilding, decision making, and culture. Consequently, they will inform training objectives that will address the needs of the Warfighter currently operating abroad to support a global force for good. Further, understanding the trust process in cross-cultural environments can also improve cross-cultural competence, which can subsequently save lives of both the Warfighter and other nationals. With this increase in cultural situational awareness, the Warfighter can become more fluent in gaining intelligence, and preventing unnecessary confrontations and situations that could escalate into insurgency.

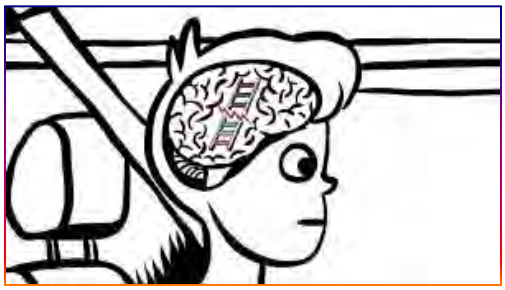
Status: During FY15, we finalized the experimental design and received data collection approval from the Committee for the Protection of Human Subjects. We were able to update our data collection method from paper- to computer-based to eliminate manual data-input efforts. We conducted training for our expanded data collection team on the experimental design and study procedure, and are poised to start data collection. Our plan is to begin the participant recruitment process, execute the experiment, and plan for publication avenues for FY16. This work supported

the Principal Investigator's acknowledgment as a Black Engineer of the Year Award – Modern Technology Leader recipient for 2015.

Research Products: It is anticipated that the research results will be presented at I/ITSEC 2016 and published in FY16 in a peer reviewed journal.

IMPROVING TEAM PROBLEM-SOLVING AND DECISION-MAKING USING COMMUNICATION PROTOCOLS

Start: Oct 13 End: Sep 15



Need: As individuals, we tend to approach our worlds by filtering information in very idiosyncratic ways. In order to solve problems in a collaborative manner, it is helpful to make our thought processes more explicit to others. The Ladder of Inference, and the related strategies of Advocacy and Inquiry, may improve decision-making and problem-solving by helping people bring their assumptions and beliefs to the surface. Carefully guided discussions, aided with communication protocols, may allow people to resolve misguided assumptions, beliefs and conclusions before they take action. This process may be especially critical in collaborative problem solving environments.

Objective: Evaluate the effectiveness of a set of communication protocols for improving team discussions, problem-solving, and decision-making effectiveness. The protocols will be based on The Ladder of Inference: a simple, metaphorical visual reference that can be used to explain the mental pathway that people often follow when reacting to an event or trying to solving a problem. The bottom rung of the Ladder represents the observation of an event, while the next rung up symbolizes the act of selecting a subset of available data to pay attention to; with the next rungs representing adding meaning, making assumptions, drawing conclusions, adopting beliefs, and taking action (the top of the Ladder). People tend to "travel up" the Ladder very quickly and without much conscious thought. We intend to evaluate the use of three communication protocols using the Ladder as the framework. One protocol will have team members focus on Advocacy (making their reasoning explicit to a teammate), a second will focus on Inquiry (asking questions in order to understand their teammate's reasoning), and a third will focus on both Advocacy and Inquiry. We will examine performance outcomes related to the task (speed and accuracy) as well as measures related to the team's social interaction and members' satisfaction with the decision.

Benefits: These approaches may improve decision-making and problem-solving by helping people resolve misguided assumptions, beliefs and conclusions before they take action. They may also be useful in the context of military or civilian after action reviews, to help people truly understand why events unfolded the way they did and where they may have gone astray in their logic, so costly mistakes can be avoided in the future. These methods may also offer a powerful leverage point in workplace communication by helping to reduce misunderstandings and tension. They have an obvious role in helping people move beyond arguments or disagreements. If proven effective, we will train our workforce to make these techniques a foundational habit. If Advocacy and Inquiry (using the Ladder of Inference) become widely used workplace habits, we will have an accepted tool and framework to inquire about others' reasoning, without being rude or worrying about hurt feelings. The Ladder of Inference can be used to reach better conclusions or challenge other peoples' conclusions by giving people a method to begin a conversation at the bottom of the Ladder, where they can talk more readily about observable reality instead of arguing about conclusions they have already drawn.

Status: Participants are being recruited from the workforce. Data collection is currently underway. Audio recordings collected during the research are being transcribed and coded.

Research Products: The research protocol,"TSD 213, Improving Team Problem-Solving and Decision-Making Using Communication Protocols." Has been approved under the authority of Department of Defense Navy Assurance Number DoD N-40037

A training video demonstrating Advocacy and Inquiry communication techniques has been created for use in the research. This video will be used for training the general workforce in the course of Learning Organization workshops once data collection has been completed.

INVESTIGATING LOW-COST UNTETHERED VIRTUAL REALITY TECHNOLOGIES AND THE ROLE OF AFFORDANCES ON TRAINING EFFECTIVENESS IN AN IMMERSIVE ENVIRONMENT

Start: Oct 14 End: Sep 17

Need: VR training solutions have the potential to reduce training cost, maximize training impact, and maximize transfer of knowledge from the classroom to the operational environment. The exploration and evaluation of low cost VR alternative technologies will help to inform designs and uses of VR technologies that may lead to adding VR to areas previously limited by program budgets. As VR equipment becomes more ubiquitous, this work will help the NAE remain at the front of applied S&T understanding on how best to make use of the technology. The results of this research have the potential to have broad implications for the role of affordances in VR technologies impact on learning.

Objectives: 1) Investigate the technology questions of feasibility and limitations pertaining to the integration of a set of the emerging low-cost VR technology devices into an operational demonstration and experimental untethered immersive testbed, 2) The technology performance parameters of accuracy and user position accuracy, latency, repeatability/precision of system, sensory fidelity, and reliability of the overall integrated system will be empirically evaluated, and subjective human factors such as simulation sickness and usability will be addressed, 3) Examine whether the affordances of an immersive VR environment enhance performance and understanding within the context of maintenance tasks. In addition, we will investigate the role of individual differences, such as spatial ability, on performance.

Benefits: The expanding body of research continues to demonstrate VR's benefits. However, wide-scale practical application has been hindered by the high costs and integration complexity of technology devices capable of providing VR environments whose performance limitation did not detract from the benefit gains. Emerging COTS consumer products coming to market in the 3rd and 4th quarters of FY14 will possibly offer an opportunity to change this paradigm. This research will investigate the feasibility and limitations of the technology to provide practical and effective VR for training and performance support domains of interest to the Fleet. The research will also provide a documented low cost VR testbed design that could be generalized to other research applications of immersive environments for both training and operations. The empirical research that will be conducted will expand the literature on embodied cognition. Previous research in this area has focused on spontaneous gestures, rather than task-specific gestures and the value of gestures has not been systematically examined in virtual environments using adult populations. Additionally, this study is novel in that it could provide insight into the competing theories on the role of spatial ability in using immersive VR and PC-based training systems. Therefore, this study will fill multiple research gaps. Results of this effort have the potential to guide the design of more effective training systems that could reduce cognitive load and result in more retention.

Status: The operational test bed has been developed and a technical report evaluating the technology has been completed. CPHS documentation has been submitted. The study is planned for Q3 FY16.

Research Products:

- Operational VR test bed.
- Technical report on empirical evaluation of technology parameters.
- Journal manuscript documenting research results.
- Mentoring of two NAIP interns

3D Interactive Aircraft Carrier Operations Planning Tool Prototype

Start: Oct 15 End: Sep 17

Need: This research should be performed now to aid the Fleet in how they plan their shipboard operations. The process of creating, setting up, resetting, and manually processing plans into a digital drawing to document arrangements is extremely time intensive. A typical meeting of this type can include thousands of unique items in hundreds of configurations resulting in thousands of labor hours on both the front and back end of study sessions. By using an interactive 3D software tool, these studies can be expedited yielding more efficient processes for stowage and movement of aircraft and equipment

Objectives:
FY16: 1) Develop a 3D Aircraft Carrier Operations Planning Tool Prototype for Planning Mode
FY17: 1) Add Operations mode and finalize prototype, 2) Conduct heuristic evaluation and comparison of the prototype to the existing Ouija board planning tool, 3) Submit a final report on the research findings.

Benefits: The proposed 3D interactive planning tool will fill a critical capability gap by providing the Handler and AB's the necessary tools to perform their job efficiently. The 3D Prototype will provide a test bed for future research and the results from the heuristic evaluation will not only guide development of the future current tool, but provide design guidelines for using 3D representations in future platforms. This effort is an excellent example of collaboration between multiple NAVAIR commands and multiple NAVAIR teams (4.6.2.2, 4.8.1.4, and 4.6.5.1). These teams will benefit by gaining concrete knowledge on the best methods and practices for deploying 3D game engine content to the Fleet and when it is beneficial to utilize 3D data representations training and planning exercises.

Status: The effort recently kicked off in Oct 15 and is beginning data collection and development.

Research Products:

- Planned 3D Interactive Aircraft Carrier Operations Planning Tool Prototype
- Heuristic evaluation of 3D Aircraft Carrier Operations Planning Tool Prototype
- Evaluation of suitability of 3D graphical representations for carrier planning tasks research study
- Mentoring of two NAIP Interns

INFORMATION PRESENTATION MODALITY: A PHASED SOLUTION

Start: Aug 11 End: Sep 15

Need: Operators of Unmanned Aerial Systems (UASs) must take advantage of every opportunity. When the operator is presented with a dizzying array of information, the most complex and difficult requirement of the job may be processing and attending to the varying displays with the proper sense of urgency. Multiple screens and interfaces demand sensation and perception in multiple modalities, often triggering the Modality Shifting Effect (MSE), a dip in performance associated with unexpected or uncertain information sources. Eliminating or mitigating MSE can improve operator reaction time and accuracy by removing this uncertainty.

Objective: Develop a technique for changing from one modality to another which does not distract, confuse, or compromise the operator. This effort is intended to mitigate MSE, which is otherwise a detriment to both operator accuracy and reaction time.

Benefits: A more efficient operator may be able to monitor or operate multiple UASs simultaneously. Conversely, an operator may be able to monitor a single UAS using fewer resources, thus enhancing performance, improving operator efficiency, and minimizing negative consequences associated with cognitive overload.

Status: The PI has completed data collection and analysis and this study is complete. The PI acquired an experimental testbed on which to conduct hypothesis testing to determine the appropriate modality switching technique. This testbed was subsequently tailored to allow the experimenter to intentionally overload the visual/auditory sensory channels of the participant, change the information presentation modality in real time, and assess participant performance all while the participant is conducting realistic UAS operator tasks. Results did not support the hypotheses with statistical significance. Nevertheless, the data still suggested the bridging technique may have merit and follow-on research may yield successful results as originally hypothesized.

Research Products:

Alicia, T. J., (2015, April). *The bridging technique: Crossing over the modality shifting effect.* Unpublished doctoral dissertation, University of Central Florida, Orlando.

Alicia, T. J. (2014, May). *The bridging technique: Crossing over the modality shifting effect.* Presentation given at the 68th Department of Defense Human Factors & Engineering Technical Advisory Group, Aberdeen Proving Ground, MD.

Alicia, T. J. (2012). Utilizing a phased technique to mitigate the modality shifting effect: An initial examination. Proceedings of the Human Factors and Ergonomics Society 56th Annual Meeting, Boston, MA.

NEXT GENERATION OF AVIATION SELECTION: UNMANNED AERIAL SYSTEMS

Start: Oct 11 End: Sep 16

Need: Over half of the Unmanned Aerial System (UAS) mishaps documented from 1980-2003 point to human factors/human causal factors as the predominant cause. One solution that will help mitigate and reduce these types of mishaps is the implementation of a selection tool that will select personnel that have the ability to acquire the proper skill sets needed to deal with emerging UAS systems and technologies. However, the only existing tool designed for unmanned aviation platforms is the Computer Based Performance Test (CBPT) that was developed for the legacy system, Pioneer. A great need exists to determine whether the skills assessed by existing selection tools used for manned aviation also predict success in unmanned aviation.

Objective: Investigate the utility/generalizability of a manned aviation validated selection tool (i.e., Performance Based Measurement Battery (PBMB)) for Unmanned Systems.

Benefits: Providing a validated selection tool designed for UAS platforms will yield a significant cost avoidance by supporting the selection of those individuals who are most likely to succeed in training, thereby improving performance, minimizing attrition, and reducing training costs overall. This effort will define the way forward for the Navy in the burgeoning area of UAS selection by providing leverage points and gaps for future selection test development efforts.

Status: Construct validation data collection is to identify whether the PBMB measures the constructs that it says it measures (i.e., construct validity) was completed. Investigation of whether or not the PBMB predicts UAS task performance (i.e., criterion/predictive validity) will be conducted in FY16.

Research Products:

Astwood, R., & Pagan, J. (2015). *Unmanned Aerial System (UAS) selection: Construct validating the Performance Based Measurement (PBM) battery results*. Presentation given at the Aerospace Medical Association, Orlando, FL.

Pagan, J. (2014). *Unmanned Aerial System (UAS) selection: Construct validating the Performance Based Measurement (PBM) battery*. Presentation to be given at the 68th Department of Defense Human Factors & Engineering Technical Advisory Group, Aberdeen, MD.

Pagan, J., Issen, H. (2014). *Next generation of aviation selection: unmanned aerial systems phase 1*. Technical report in progress.

Pagan, J. (2012). *Unmanned Aerial System (UAS) selection: Validating the Performance Based Measurement (PBM) battery*. Presentation given at the 67th Department of Defense Human Factors & Engineering Technical Advisory Group, Dayton, OH.

Pagan, J. & Vincenzi, D. (2012). *Unmanned Aerial System (UAS) Selection: A Path Forward*. Presentation given at the 67th Department of Defense Human Factors & Engineering Technical Advisory Group, Dayton, OH.

OPTIMIZING PERFORMANCE OF TRAINEES FOR UAS MANPOWER, INTERFACE & SELECTION (OPTUMIS)

Start: Oct 12 End: Sep 16

Need: Unmanned Aerial System (UAS) platforms that employ winged aviators (e.g., Predator) have shown significantly higher mishaps than those that select operators that are non-pilots (e.g., Shadow). One explanation for these findings may be negative training transfer from manned to unmanned platforms as operators are separated from the aircraft, thus depriving them of a range of sensory cues (e.g., visual information, kinesthetic/vestibular input, sound). Another explanation for the high Predator mishaps may be associated with Ground Control Station (GCS) design. Some researchers cite interface and automation confusion and difficulty with system management as primary causes for Predator human factors related mishaps. These findings suggest that poor system design may be a large contributor to UAS mishaps. These varying explanations for differences in mishap rates across platforms indicate that manpower/personnel, training and design issues should all be considered when developing a mitigation strategy.

Objective: Investigate differences in Knowledge, Skills, and Abilities (KSAs) and performance among UAS operators, Air Traffic Controllers (ATCs), and manned pilots to support identification of the right people to operate UASs who will be most likely to succeed in training and operations. Additionally, this effort will investigate methodologies that provide interface design guidance directly linked to KSAs to support GCS development optimized for operator performance; thereby improving safety and reducing mishaps.

Benefits: Currently, there is no validated qualification standard for UAS operators. For example, some Naval and Air Force UAS platforms (e.g., Triton, Firescout, Predator) require their operators be winged aviators. This requires a roughly $1 million investment per pilot and years of pilot training. In addition, UAS platform specific training is necessary. The Shadow UAS program, on the other hand, uses junior to mid-grade enlisted personnel with no pilot experience. The training program for Shadow pilots is about 10 weeks long and about a fourth of the investment (about $347K) of manned aviators. Adapting a personnel model similar to that of the Shadow, if supported by analyses underway, could yield a significant cost avoidance of about $653K per operator. This effort seeks to provide baseline data for future efforts regarding selection testing, manning requirements, training, and system design.

Status: Data collection to support the classification of KSAs into those most suitable for selection and training was completed. Automation allocation based on task workload analysis completed. Experiment investigating performance differences among pilots, video gamers, and non-pilots to begin FY16.

Research Products:

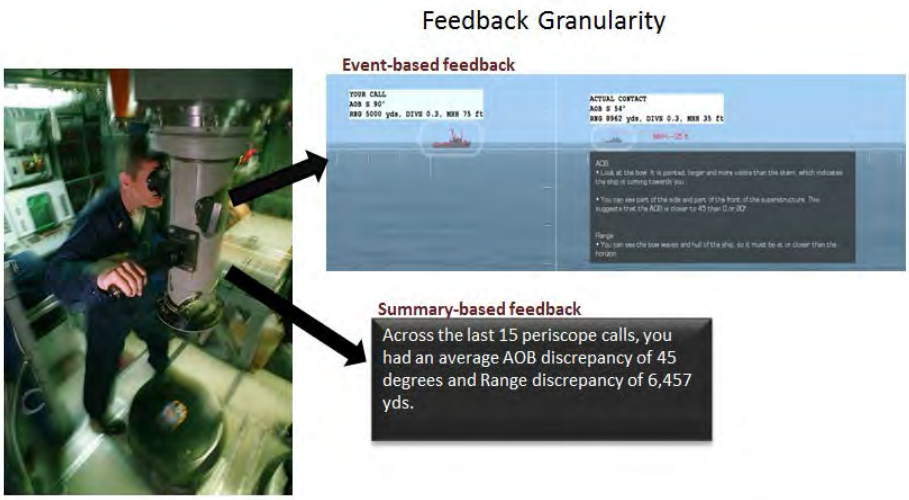
Pagan, J., Astwood, R. & Phillips, H. (2014). Operator qualification differences between manned & Unmanned Aerial System (UAS). *Proceedings of the Interservice/Industry Training, Simulation & Education Conference, Orlando, FL.*

Pagan, J., Astwood, R. & Phillips, H. (2015). Optimizing performance of trainees for UAS manpower, interface and selection (OPTUMIS): A human systems integration (HSI) approach. *Proceedings of the International Society of Aviation Psychology.*

Astwood, R., Pagan, J., Phillips, H. (2015). *Manned to Unmanned Aerial System (UAS) knowledge, skill, and ability comparison.* Presentation at the 69th Department of Defense Human Factors & Engineering Technical Advisory Group, Orlando, FL.

THE EFFICACY OF FEEDBACK PARAMETERS IN ADAPTIVE TRAINING SYSTEMS

Start: Oct 13 End: Sep 16



Need: The DoN, along with other DoD services and private industry, is exploring innovative methods and technologies to train its workforce. Recently, the Submarine Tactical Requirements Group has decided to leverage the capabilities of emerging technologies such adaptive training (AT) tools to provide on-board training to individual operators as well as teams. Despite the potential for success of AT systems, there is much that is unknown regarding the best ways to optimize AT systems. For example, when providing feedback to trainees, AT system designers can manipulate a number of different parameters of the feedback (e.g., content, timing, modality, granularity, etc.). However, the AT research literature provides little guidance as to the optimal approach for implementing and delivering feedback within the system.

Objective: The objective of this study is to examine the relationship between feedback granularity [e.g., feedback presented after each response (event-based) or feedback presented over a series of responses (summary based)], feedback timing (e.g., feedback presented immediately or after a delay), and environmental feedback (e.g., present or absent) within an AT system. Specifically, the researchers will seek to determine the combination of feedback parameters that leads to optimal performance within an AT system. The results will help provide system designers guidance on the development of feedback in future AT systems.

Benefits: Previous research results have shown that an AT system can improve performance while requiring less training time. For instance, when using a submarine periscope task, previous researchers found that an adaptive training approach lead to higher learning gains, trainees made faster periscope calls, and over 33% of trainees were able to end training earlier than were students trained using a non-adaptive training system. Further, this adaptive training approach lead to higher effect sizes as compared to traditional simulation based training techniques - d= .50 compared to d = .28 and .37 found in previous meta-analysis. Further development and refinement of adaptation techniques could be expected to lead to higher effect sizes and learning gains than those outlined above. Therefore, these outcomes can be expected to improve the Navy's ability to provide tailored, individualized instruction to operators without increasing overall training costs, time, or number of instructors. The findings of this body of research are expected to improve training effectiveness and mission performance across a broad range of tasks and missions. The automated aspect of adaptive tutoring is expected to do this in less time and at lower cost than current simulation and training practices.

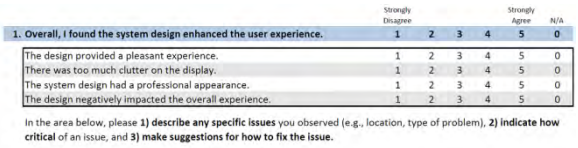
Status: In FY15 the study was approved by NAWCTSD's Committee for the Protection of Human Subject's (CPHS) to begin data collection. The experimental testbed was completed and pilot testing of the software and experimental procedure was performed. Data collection is currently taking place.

Research Products:

- Committee for the Protection of Human Subjects protocol developed and approved.
- Feedback capabilities incorporated into existing fielded system (Periscope Operator Adaptive Trainer (POAT)) to support experimentation.
- STEM outreach activities:
    - Demonstrated experimental testbed at Women in Science event at the Orlando Science Center MAY 2015
    - Demonstrated experimental testbed at Take Your Sons and Daughters to Work event at NAWCTSD APRIL 2015

USABILITY SURVEY ENABLING RESEARCH AND ASSESSMENT FOR INTUITIVE DESIGNS (USER AID)

Start: Apr 10 End: Mar 15



	Strongly Disagree				Strongly Agree	N/A
1. Overall, I found the system design enhanced the user experience.	**1**	**2**	**3**	**4**	**5**	**0**
The design provided a pleasant experience.	1	2	3	4	5	0
There was too much clutter on the display.	1	2	3	4	5	0
The system design had a professional appearance.	1	2	3	4	5	0
The design negatively impacted the overall experience.	1	2	3	4	5	0

In the area below, please **1) describe any specific issues** you observed (e.g., location, type of problem), **2) indicate how critical** of an issue, and **3) make suggestions for how to fix the issue.**

Need: System design for the development of operational and training capabilities requires a balance between meeting functional requirements and system usability.

Objective: Develop an empirically validated heuristic-based tool to support usability assessment and generation of design guidance.

Benefits: The results of this work will impact the systems engineering communities' ability to develop systems in two key ways: accessibility and generalizability. First, a survey-based assessment tool will increase accessibility to testing; thereby supporting early and consistent identification of usability issues by providing a means of data collection that does not rely on gathering a group of usability experts. Second, a generalizable tool can be leveraged by any operational or training device providing widespread benefits.

Status: A qualitative analysis of existing heuristic and usability survey approaches was followed by a card sort analysis to validate those heuristics and example design guidance groupings. These analyses resulted in the development of UI-TEACH (User Interface - Table for Evaluating & Analyzing Composite Heuristics). A pilot reliability study was conducted to refine the survey, entitled EQUATE (Experience-based Questionnaire for Usability Assessments Targeting Elaborations). This was followed by psychometric testing which demonstrated the reliability and validity of survey items. Lastly, data collection and preliminary analyses for the empirical study are complete. Those results have documented the benefits of prescriptive feedback and demonstrate the ability of EQUATE to collect feedback from usability experts and novices.

Research Products:

Atkinson, B. F. W., Tucker, K., & Tindall, M. (In progress). The Psychometric development and validation of the EQUATE. *Theoretical Issues in Ergonomics Science. Manuscript ready for submission**

Atkinson, B. F. W., Tindall, M. J., & Igel, G. (In progress). A historical review of heuristic and survey-based usability testing: A call for a hybrid approach. *Conference or journal manuscript.*

Atkinson, B. F. W., Tindall, M., & Ponto, S. (In Progress). Post-mission assessment for tactical training-trends analysis (PMATT-TA): Usability analysis report. *Navy Special Report (*NAWCTSD-TR-2014-0001*).*

Atkinson, B. F. W., Tucker, K. The importance of usability analysis in functional design: State-of-the-practice vs. state-of-the-possible. *NAVAIR Journal.* Submission accepted.

Atkinson, B. F. W., Tucker, K., & Tindall, M. (2015). Content validation from card sorting: A comparison of hierarchical cluster analysis and confirmatory factor analysis*. Proceedings of the Human Factors and Ergonomics Society Conference.*

Atkinson, B. F. W., Tindall, M. J., & Igel, G. (2015). Validated usability heuristics: Define categories & design guidance. *Proceedings of the Human Computer Interaction International Conference.*

Tindall, M. J., & Atkinson, B. F. W. (2015). Assessing usability of a post-mission reporting technology. *Proceedings of the Human Computer Interaction International Conference.*

Ponto, S. J., Atkinson, B. & Tindall, J. M. (2014). Open-ended feedback to enhance survey data: Evaluating a novel heuristic-based usability assessment tool. *Naval Engineering Journal.*

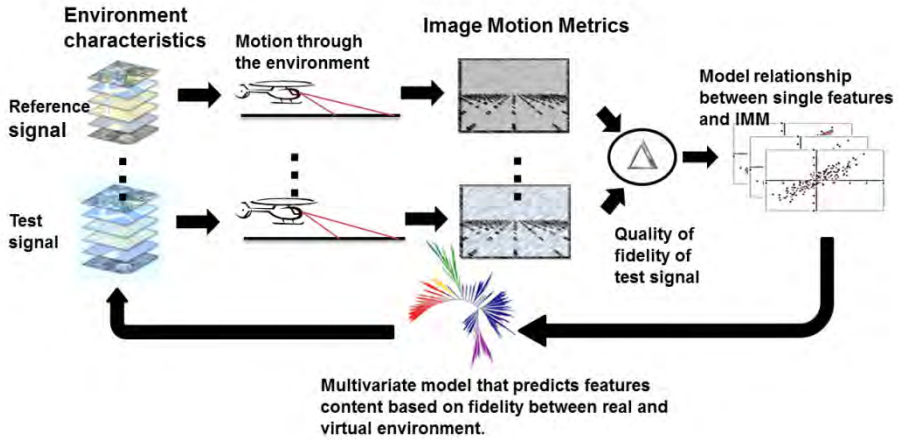
Government Colloquium. Atkinson, B., (2013, August 28). USER AID: Usability Survey Enabling Research & Assessment for Intuitive Designs. NAVAIR Fellows NISE Workshop-Patuxent River, MD/DCO Chat. NAVAIR Fellows.

USER AID: Usability Survey Enabling Research & Assessment for Intuitive Designs. (August 2013). Presented at the NAVAIR Fellows Naval Science and Engineering Innovation Workshop, Patuxent River, MD/DCO Connect

Briefing on data analysis process to staff, students, and interns who supported initial data collection efforts. (2010, November 29 - 2010, December 02). Embry Riddle Aeronautical University/University of Central Florida.

VIRTUAL ENVIRONMENT MOTION FIDELITY MODEL

Start: Oct 15 End: Sep 16



Need: High fidelity aircraft simulators make use of geo-specific visual and sensor terrain databases, image generation hardware and the display system (i.e. visual system) to provide the pilot with the visual representation of the virtual environment. Helicopter low altitude flight operations include tasks such as takeoff, hovering, landing, and low level terrain flight. During low altitude flight pilots make continuous adjustments in speed, height and heading guided by a mental model of where the aircraft will be in the future. The pilot transforms the perceived motion in the optical frame of reference into relative self-motion and applies feedback regulation to minimize errors between the commanded and perceived motion. Among other things the pilot extracts optical flow-field information generated by motion over the terrain and obstacles from surfaces in the field of vision. The optical flow-field defines the way in which points in the visual scene move relative to the pilot's viewpoint motion. In other words the pilot's low altitude flight performance is affected by the optical flow-field generated by the environment surfaces and features. Significant differences in optical flow between real world scenes and virtual environment may result in motion cues that result in the

incorrect visual perception of speed, height and heading. This situation may develop pilot mental models in simulated environments that do not transfer well to real world situations. A computational model with corresponding metrics that can quantify the fidelity-relevant differences between virtual environment and the real world, as captured using video footage, can be used to predict and measure the level of fidelity yielded by a given simulation.

Objective: The goal of this project is to develop a virtual environment motion fidelity model that can quantify low level flight motion visual cues and predict the correct combination of visual and sensor terrain database features for low altitude operations in flight simulators. This approach involves image motion metrics captured for reference and test scenes, and compared to generate a quality metric.

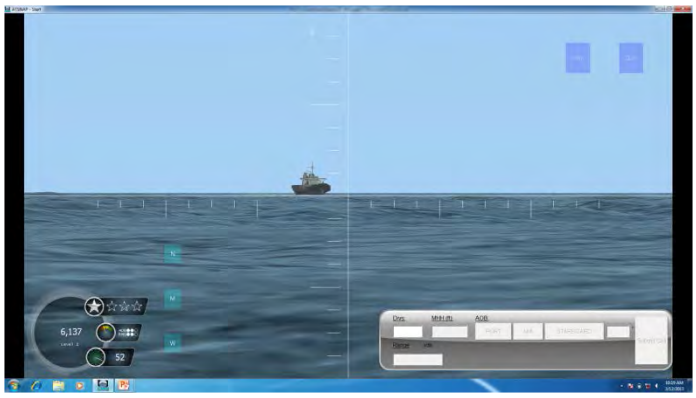
Benefits: This virtual environment motion fidelity model has many useful applications. It could be used in the development, testing and acceptance of visual databases: First the model can be used to predict the virtual environment characteristics necessary to meet or exceed fidelity requirements; and secondly it can be used as a validation tool for assessing achievement of visual database and visual system requirements. These applications have the potential to yield enhanced visual cues for low level flight and increased simulator virtual environment fidelity and use.

Status: The current image motion metrics approach with the most promise uses a histogram of oriented optical flow to capture the unique arrangement of the optical flow vector distribution per image generator frame. This histogram serves as a descriptor of the optical flow cues along a particular path at any one point in time. The histogram of oriented optical flow is invariant to scale and directionality of motion, and in preliminary laboratory tests has been capable of capturing differences between high, medium and low fidelity visual system environments. The current implementation of the image motion metrics is based on the work on histograms of oriented optical flow by Rizwan Chaudhry (2009) at Johns Hopkins University. Using this technique, optical flow vectors are binned according to angle (i.e., optical flow orientation) and weighted according to magnitude. In 1950s Gibson proposed that animals guide their locomotion by maintaining the outflow of the optical flow on the intended target and control direction and speed with reference to the rate of flow. In this way, movement towards an object is a dynamic relationship between environmental features and self-produced patterns in optic flow. Optical flow is the pattern of apparent motion of objects, surfaces, and edges in a visual scene caused by the relative motion between an observer and the scene. The upper right image in the figure shows a color representation of the optical flow orientation angles which has been used to visualize the direction of the optical flow per frame. The lower left image in the figure shows the magnitude of the optical flow which can be used to determine how strong the optical flow is at any one point in the scene. In both the real world and in virtual environments, such as those used in aircraft simulators, the optical flow observed is directly related to the environment content.

Research Products: Pending.

EXAMINING THE EFFECTS OF GAME FEATURES ON LEARNING IN SCENARIO-BASED TRAINING

Start: Oct 15 End: Sep 18



Need: In light of budget declines, there has been a strong push across the DoD for low-cost training techniques that are engaging, realistic, and can be delivered anytime, anywhere. Game-based training techniques hold promise to meet this demand as they are purported to enhance player motivation, but existing research on the effectiveness of game-based training is mixed and often nonsystematic, resulting in a failure to identify specific game features that lead to better learning and performance outcomes. Yet game-based training systems are already being delivered to the Fleet without evidence of the utility of game features, such that the training being delivered may not represent a cost-benefit over more traditional systems.

Objective: The objective of this research is to test the impact of two game features on performance and motivation: score/performance gauges and competition. First, providing a score and performance gauge gives the player a level of feedback on his/her progress in the game and is considered a fundamental feature of a "game." To date, there is no previous research in this area to suggest that adding this game feature increases motivation and/or enhances performance; therefore one of the goals of this research is to directly test whether adding the score and performance gauge has the desired effect on players. Second, we will explore the role of competition on performance and motivation, which some consider an important game feature but not necessarily a defining characteristic. Competition is also theorized to increase players' motivation to persist in a game because they find that playing is intrinsically rewarding, which again may lead to better performance. Likewise, there has been little research on the effect of competition on learner performance and motivation in game-based training.

Benefits: The 2014 DoN Science and Technology Warfighter Performance Focus Area, Manpower, Personnel, Training and Education Objectives calls for the development of training technologies to enhance Sailors' information-processing abilities. Game-based training is particularly well-suited to meet this demand given the popularity of computer games with today's young adults. This research seeks to examine the effects of incorporating game features into simulation-based training, a topic that has not been systematically investigated in the training literature. Previous studies have assessed the value of game-based training over traditional methods of instruction, but few have investigated individual game features and their impact on performance and motivation. The findings of these experiments may have a broad impact on current and future training systems by offering empirically-based guidance for designing and incorporating game features to enhance training effectiveness.

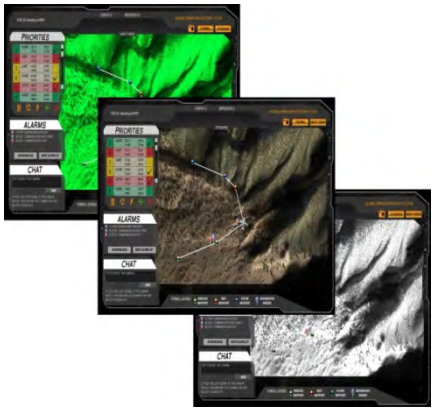
Status: In FY16, the research team will be designing the experiment, obtaining NAWCTSD's Committee for the Protection of Human Subjects (CPHS) approval, and making changes to the experimental testbed.

Research Products: Planned products include CPHS approval, peer-reviewed publication in a scientific journal, book chapter in upcoming volume on Learning and Motivation in Serious Games, mentoring of NADP and NREIP interns.

WORKFORCE DEVELOPMENT: STRATEGIC GROWTH

A BRAVE NEW "VIRTUAL" WORLD: THE USE OF VIRTUAL WORLD APPLICATIONS FOR MILITARY TRAINING

Start: May 14 End: Sep 17



Need: The DON has been successfully employing digital technology to enhance training for decades and continuously seeks emerging technological capabilities to keep pace with military challenges and to maintain the technological edge over those entities that may threaten us. The Naval Aviation Enterprise (NAE) Science and Technology Objectives (STO), Naval Warrior Performance (NWP) Capability Gap STO-1 (Training and Education) calls for the development of education and training technologies that cost-effectively maximize transfer of knowledge from the classroom and trainer to the operational environment.

Objective: To develop a secure unclassified in-house 3D Multiuser Virtual Environment (MUVE) or Virtual Word (VW) Unmanned Air System (UAS) training capability at NAWCTSD to assist in filling the 4.6 Core Capability 3.3.5, persistent VWs for training, capability gap.

Benefits: The critical skills and expertise that will be developed through this effort fall into two categories:
a) Supportability: Model rendering, development, utilization, and maintainability of 3D MUVE/VW assets and training content.
b) Research-based: Experience at development, evaluation, and validation of training scenarios and content in 3D MUVE/VW environments. The lessons learned and practical experience developed through hands-on design and execution of VW training validation research will be critically important to 4.6's ability to execute the VW elements of its S&T roadmap. Hands-on experience in understanding how to evaluate environment, avatar, and physics-based fidelity requirements as they relate to training scenario scope, design, modeling, and evaluation are critically needed.

Status: In FY15 a Front End Analysis indicated that the most appropriate use-case would be an UAS focused task. Specifically, we now seek to investigate the utility of cross training, within a 3D VE, for improving UAS team (i.e., Air Vehicle Operator and Sensor Operator) performance. Fiscal Year 15 accomplishments include the development of Government owned night vision and thermal shaders for Unity game engine, development of Government owned multiplayer networking solution for Unity game engine, development of two environments (ocean and mountainous terrain), development of pilot GUI / finalizing changes to camera operator GUI, and the purchase of hardware for test rigs. The Hardware is set up and ready for use. In regards to the UAS cross-training portion of the project, FY15 accomplishments include the identification of the state-of-the-art in cross-training and 3D Multiuser VE training effectiveness, review of the "Analysis of Cross-Platform Naval Unmanned Aircraft System Task and Competency Requirements" in order to identify appropriate UAS tasks, selection of Cross-Platform Naval UAS tasks, linkage of relevant communication and coordination performance metrics with selected Cross-Platform Naval UAS Tasks, and the initial development of UAS scenarios.

Research Products:

- Workforce development: Mentoring. Mentee Alyssa Mercado mentored by Randy Astwood (2014, October 01 – 2015, September 30).
- Government Colloquium. Astwood, R., Slosser, S., Maxwell, D., (2014, May 20). Military Open Simulator Enterprise Strategy (MOSES) Information Exchange. University of Central Florida's Institute for Simulation and Training-Orlando, FL. Milano Hyacinthe - NAWCTSD's Human Engineering Performance Lab Information Assurance Officer.

REVERSE ENGINEERING CAPABILITY OF 3-DIMENSIONAL PHYSICAL OBJECTS

Start: Jun 14 End: Sep 15

Need: The NAWCTSD Rapid Design, Development and Fabrication Lab's mission is to provide NAWCTSD a rapid and responsive mechanical, electronic, application software and virtual environment development capability for the creation and support of advanced training technologies, components, assemblies and turnkey systems.

The Lab's mechanical design, reverse engineering, simulation and manufacture capabilities all rely heavily on 3D parametric solid models. The time and effort required to create these models can be significant. Reverse engineering of existing objects often requires the most time due to the necessary measurement and metrology processes. The Lab sought to increase its reverse engineering model creation and confirmation throughput by capturing the efficiency of digitization through 3D scanning.

Objective: The objective of this project was to obtain and gain experience with reverse engineering software capable of taking in 3D scanner point cloud data and producing 3D parametric models suitable for virtualization, simulation, modification and manufacture, either through traditional machining or additive manufacture techniques. While the Lab already possessed a 3D scanner to obtain point cloud data, a parametric modeling environment and a robust manufacture capability, the critical reverse engineering ability to translate from point cloud data to parametric model was missing. This effort provided that missing piece by providing the Lab with a seat of Geomagic Studio reverse engineering software and an opportunity to gain experience in its use.

Benefits: The Lab's in-house reverse engineering capability and experience has been increased and its reverse engineering workflow made more efficient. Lab personnel have had an opportunity to use the Geomagic Studio software package to complete the design flow from captured scan data to useful parametric model. The capability is self-supporting; the knowledge gained is now organic to the NAWCTSD Rapid Design, Development and Fabrication Lab and will be used in support of future work and sponsors. The ability to offer this capability to future customers expands the scope of projects the Lab may undertake.

Status: The project is complete. Several hard to model weapon parts were scanned and that point cloud scan data used to create parametric solid models. The models were immediately of benefit to Laboratory projects, enabling the design and fabrication of novel system components that would have been difficult, if not impossible, to model any other way. The reverse engineering capability, the enabling software package and the experience in its use are now organic to the Lab.

Research Products:

- Increased capability – The Lab now possesses the capability to execute a complete reverse engineering workflow, from captured 3D scan data to parametric solid model.
- Reverse engineering experience – A new organic skill to support current and future laboratory work.

HUMAN PERFORMANCE MODEL VALIDATION PROCESS

Start: Jun 13 End: Oct 15

Need: The Navy has recognized the value of human performance modeling as a means of determining optimal manpower requirements to meet mission effectiveness capability objectives for developing platforms, systems, and subsystems. More specifically, discrete event modeling of the interaction of operators and maintainers in the context of a design reference mission allows opportunities to cost effectively conduct design tradeoffs that include hardware/software/human considerations.

However, one impediment to fully capitalizing on the power of these models, once developed, is the time and resources required to verify, validate, and accredit these models and their outputs for a specific acquisition program within tight timelines. Modeling techniques used for acquisition decisions should be verified and validated by the acquisition program for use to assess the system design against capability requirements Often, by the time these tools are fully validated within programs, their predictive capability is no longer needed because the decisions they could have supported have long since been made. Therefore, approaches that minimize the verification and validation timeline (e.g., "pre-validation" of reused/modular code, validated test procedures for classes of model requirements, and improvement in efficiency of validation procedures and standards) are being investigated as part of this effort.

Objective: The proposed effort has two objectives:

1) **Develop methods/guidance/and requirements language** for efficiently validating discrete event human performance models. These deliverables will leverage performance models developed as part of the Virtual CVN 78 (VCVN 78) program to predict sortie rates in support of design tradeoffs of various human/hardware configurations.
2) **Disseminate the validation process requirements** derived from this effort into Human Systems Integration (HSI) process standards currently being developed by the Navy HSI Working Group (NHSIWG). The principle investigator for this proposed effort is currently the lead of the NHSIWG whose membership consists of representatives from each of the Navy Systems Commands (SYSCOMs). The charter of the NHSIWG is to develop common HSI policy and processes across these SYSCOMs.

Benefits: As a result of this effort, personnel within AIR465 who are working on system acquisition programs will be able to more effectively participate in systems engineering and design tradeoff decisions using validated tools to support them.

Status: The Human Performance Model Validation Process project was initially funded and kicked off in late FY14. The focus of this effort was to support the VCVN 78 Integrated Product Team (IPT) in prioritizing system requirements and developing and refining a process for change control, risk assessment, verification, and validation.

Research Products: Products are forthcoming consisting of standards and guidance for validation of human performance models to be incorporated into Navy HSI Process Standards.

NAWCTSD Knowledge and Laboratory Expertise Advancement Regarding the Application of Cutting-Edge Embedded Signal Processing Designs to Military Training and Simulation

Start: Oct 13 End: Sep 15

Need: Due to DoD's and DoN's widespread adoption of Commercial-Off-The-Shelf (COTS) PC-based hardware, the NAWCTSD Concept Development & Integration Laboratory (CDIL) and Weapons Simulation & Integration Laboratory (WSIL) have gained extensive knowledge and experience over the past two decades developing PC-based, Microsoft Windows software applications to meet digital signal processing requirements for military training and simulation. New and emerging operational requirements posed by the military training and simulation community are similar to consumer demands for mobile devices (i.e. harsh environmental conditions, strict power limitations, small footprint, and parallel processing capabilities), and such requirements are difficult to meet using COTS PC hardware. Signal processing requirements can likely be met more cost-effectively by using the latest generation of embedded technologies, which offer simplified design and development cycles, orders of magnitude greater performance over PC-based systems, higher efficiency, and more reliable operation.

Figure 1: Current PC-based solution which leverages COTS and custom based solution

Figure 2: Leverage state of the art embedded technology for a fully custom small scale, environmentally robust design

Objective: A proof-of-principal prototype of an embedded two-channel version of a Virtual Tactical Bridge (VTB) will be designed and built using an embedded processor executing the critical portions of PC based software libraries. VTB is a live-to-virtual radio communications interface in use by the Navy, Marine Corps, Army, and Air Force training.

Benefits: Enhance the expertise and capabilities of the labs while developing a technology that can be evaluated and used by the fleet. Practical knowledge and experience will be achieved through the proposed VTB design and development cycle. The prototype system will be used as a reference design for future work and as a technology demonstration for DoN and DoD sponsors with emerging requirements that emphasize reliability, form factor, power efficiency, and duty-cycle.

***Status*:** Manpower constraints and new customer requirements precipitated a modification of this effort from its original plan to investigate mobile operating systems as a platform for an embedded VTB. An investigation of the performance of VTB when executing on various Microsoft Windows 7 & 8 Operating Systems (including embedded OS's) on various Intel-based embedded motherboards was conducted in accordance with the needs of NSWC Corona. Three low cost mini PCs known as the Next Unit of Computing (NUC) were tested in the lab for feasibility. Specific platforms tested include the i5, i3, and Atom. The results of the testing indicated that NUC i3 and NUC i5 perform VTB better than the single core Atom processor. From a processing perspective, the NUCi3 and NUCi5 are better suited for VTB. However, the NUCi3 and NUCi5 boards do come with internal fans which may necessitate modification or an alternative solution. One modification that makes use of the NUCi3 and NUCi5 possible is removing the onboard fan and installing an aluminum casing. The aluminum casing will distribute the rising heat from the CPU resulting in a fanless CPU cooling system. This would successfully produce a system that is stable for VTB with a fanless CPU cooling design.
The investigation concerning setting up a functional embedded Linux environment when running on a Xilinx Zynq processor was also conducted. This included the process of generating custom HDL bitstreams, device tree modification, driver development, kernel configuration and general application development for utilizing the custom hardware layers. The viability of the alternative was successfully tested following a procedure to detach the LEDs from the AXI GPIO core, implement myLed core in Programmable Logic (PL), add a LED controller into the device tree, write a driver for it, and develop user applications to control the status of the LEDs.

Research Products:

- Hardware/Software Prototype (Sep 2015)
- Technology Demonstration (Sep 2015)

DEPLOYING 3D GAME ENGINE TRAINING CONTENT ON A WEB BASED LEARNING MANAGEMENT SYSTEM

Start: Oct 15 End: Sep 16

Need: The Navy has an immediate need to distribute 3D game engine based training content across a multitude of sites. Deploying content on online LMSs reduces total ownership cost to the Navy, by reducing instructor workload and trainer hardware footprints. In addition, 3D game engine based training is currently in high demand due to its cost effectiveness, interactivity, and immersive/realistic environments. Current and future acquisition programs have a direct need to procure this new type of 3D game engine based training content and have very limited knowledge and examples of how to post and utilize this content on existing LMSs. This research, final deployed course, and white paper will help provide the needed examples and knowledge in this area.

Objectives: 1) Investigate and gain experience with this new SCORM standard, 2) Modify an existing 3D game based trainer to comply with the standard, 3) Deploy the modified trainer to an existing web based LMS (NKO or CNETU), 4) Capture findings in white paper.

Benefits: This effort will help the command gain concrete knowledge on the best methods and practices for deploying 3D game engine content on web based LMSs and gain hands on experience with the newest SCORM standard. This experience will help the branch serve as technology Subject Matter Experts (SMEs) in this field and provide the AGILE team with a critical new capability with directly ties back to the Advanced Modeling and Simulation branch's existing core capability of developing and presenting training materials. The knowledge gained will close a critical skill gap between a number of NAVAIR teams including, Engineering, Research and Development, and Instructional Systems Design. The knowledge and experience will be used to support future and on-going acquisition efforts at NAWCTSD and support future branch customers who have a need to deploy 3D game based training content online. The branch will also have the opportunity to test and evaluate a deployed LMS course.

Status: The effort recently kicked off in Oct 15 and is beginning development.

Research Products:

- Government Technical Report detailing how to create/modify 3D game engine content to comply with new Experience API SCORM standard and how to deploy this content on a web based LMS. (Planned Sep 16).
- E-28 Maintenance Trainer deployment to a web based LMS.
- Mentoring of two NAIP Interns.

FUSING HIGH DIMENSIONAL DATA SOURCES (FHDDS)

Start: Oct 15 End: Sept 16

Need: Today, finding the best solution for a complex problem, where exercising all permutations using brute force search is incomputable, is one of the foremost, unsolved problems in computer science, as identified by the Clay Mathematics Institute.

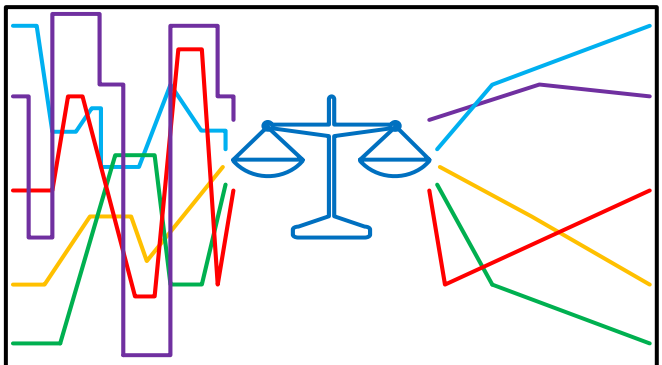
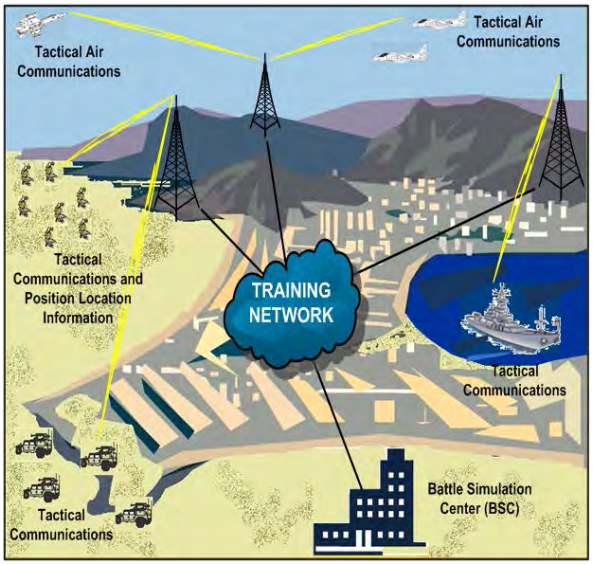


Figure 1: Concept of Operations

Objective: Improve the accuracy of a fast algorithm, used to solve complex problems, through the mechanical application of mathematical steps by applying a reduction technique to quickly downsize the magnitude of the problem. Advancements in algorithm technology will enable rapid decision making with the main, principle objective to improve existing capabilities for data matching, data merging, and data search.

Challenge #1: Accuracy: Consistently reach a good solution, defined as being a solution in the top percentile of all combinations, for test cases that include large numbers of combinations for multi-dimensional data sets.

Challenge #2: Real-Time Computational Implementation (Speed): Quickly converge on a good solution in real time where the fall back, brute force method of checking every possible solution may be unrealistic due to the incomputable nature of the problem.



Benefits: The potential payoff of FHDDS is an enabling technology for real-time decision making that provides solutions in the top percentile. The algorithm implementation may be applied to any decision making process defined by a rule set and is domain agnostic. The core algorithm was developed for the Smart Antenna Algorithm project and supports the decision making process of frequency deconfliction, quickly and accurately. The algorithm replaces the past, laborious and lengthy method of performing calculations to enable decisions for frequency deconfliction. Although the Smart Antenna Algorithm solves a specific decision-making process, i.e. frequency network assignment, the algorithm is implemented in a set of logical steps such as could be implemented in a Turing machine and is universal. The effort is intended to support this thesis.

Status: This effort was funded for an FY16 start.

Research Products:

University of Central Florida Independent Study: Professor Dr. Kincaid, Graduate Student Jeff Gleacher, Diane Richie, Dr. Long Nguyen and Dave Kotick.

Richie, D.P. (2012, Dec). "Can You Hear Me Now? Understanding the Cosite Interference Hurdle" Interservice/Industry Training, Simulation, and Education Conference.

Richie, D.P. (2014, Dec). Poster Session "Smart Antenna Algorithm". Interservice/Industry Training, Simulation, and Education Conference.

TRANSITION

HUMAN PERFORMANCE BASED SIMULATION CERTIFICATION CRITERIA TEST AND EVALUATION JOB AID – REQUIREMENTS TRACING TOOL (RETT)

Start: April 14 End: Sep 16

Need: There is a critical need for developing new processes that supports the development and evaluation of training simulations (AIR-46 Core Capabilities and Future Directions document, 2012). To address this, this effort will develop a job aid to guide the development and tracking of required training capabilities with physical training system attributes from initial concept to test, evaluation, and certification procedures. This approach will facilitate verification and validation of whether simulations actually meet training performance requirements by insuring a tight coupling between simulation "build to" specification to training performance requirements across the acquisition lifecycle.

Objective: The objective of this work is to develop a job aid to improve the integration of performance requirements and specifications. Current simulator requirements and evaluation processes do not address whether the simulator's *training* capabilities are achieved. This effort speaks to that shortfall by coupling design and test of human performance-based requirements and simulation "build to" specifications.

Benefits: The tools and processes developed under this effort can support both systems engineering and test and evaluation by supporting the acquisition of effective training devices with *training capabilities* as the central focus of the design and evaluation. This effort will improve the capability of developing, verifying, and validating whether simulations, as defined in "build to" specification also meet training performance requirements.

Status: Requirements complete. Job aid development started Oct 15.

Research Products: Functional Requirements Traceability Matrix. It is anticipated that the results from this work will be presented at I/ITSEC in 2016.

SYSTEM EVALUATION FOR TRAINING AND TEST TOOL (SETT)

Start: Sep 15 End: Sep 17

Need: The Integrated Systems Evaluation, Experimentation and Test (ISEET) Department (AIR-5.1) has the responsibility to evaluate integrated systems capabilities across the Naval Aviation Enterprise (NAE). The Naval Air Warfare Center Training Systems Division (NAWCTSD) Test and Experimentation Department (AIR-5.1.1.9) is responsible for training systems T&E products. AIR 5.1.1.9 performs this function, in close partnership with AIR 4.6 Training Systems Integration, Developmental Test Squadrons, Commander of Operational Test and Evaluation Force, through the construct of an integrated test environment. To date, current test methods for training systems have been built upon legacy systems and as a result the validation of training and readiness, operational effectiveness, and operational suitability has been lacking. Current methods only address the specification compliance of training systems and fail to address the validity of training devices to meet current and future training and readiness needs established by the NAE.

Objective: The objective of SETT is an end-to-end framework that integrates human performance and training Test and Evaluation (T&E). The SETT tool will create a rigorous process to identify test requirements, test points, test plans, detailed method of tests, deficiencies and reports that will facilitate the validation of whether training devices are capable of meeting Training and Readiness (T&R) requirements. To accomplish this, this effort will leverage the Requirements Tracing Tool (RETT) effort to provide details that link the front end performance specification to test points.

Benefits: The tools and processes developed under this effort can support the SIMCERT process by resulting in acquisition of effective training devices with training capabilities as the central focus of the analysis, and thereby, better trained warfighters. This effort will improve the capability of developing, verifying, and validating whether simulations, as defined in “build to” specification also meet training performance requirements. This capability, the System Evaluation for Training and Test Tool, can be used to support the acquisition process of planning, implementing, testing, and certifying training devices.

Status: System requirements are currently being finalized in partnership with the RETT team.

Research Products: A demonstrable job aid tool is planned for FY16.

PERFORMANCE ASSESSMENT TRENDS IN TRAINING ENHANCING READINESS REPORTING FOR NAVAL SYSTEMS (PATTER2NS)

Start: Oct 13 End: Sep 16

Need: The current state-of-the-practice in assessing performance often involves instructors monitoring multiple members of an aircrew simultaneously, making it challenging to keep track of each student's performance.

Objective: The objective of PATTER^{2}NS is to increase training effectiveness and efficiency with improved capabilities for automated performance measurement and trend analysis through the development of an intuitive user interface design and thoroughly tested technologies.

Benefits: This technology is anticipated to provide up to a 28% improvement in training effectiveness/enhanced fleet readiness due to standardized, real-time and longitudinal diagnostic feedback. Utilizing this data will increase instructors' ability to provide readiness generating feedback for P-8 crews. The use of automated technologies and simulator data (e.g., network data from simulator subsystems, performance measures) is anticipated to result in a 70%-80% reduction in manual data entry, thereby reducing manpower requirements and costs. While P-8A is the target transition platform, the benefits of these technologies (as outlined above) have applicability to virtually any live or simulated training platform. Due to the focus on Anti-Submarine Warfare (ASW) training for P-8A, the technology will be adaptable to meet other ASW platforms (e.g., MH-60R/S, BAMS) with relatively minor enhancements. Additionally, because of the extensibility to post-mission and readiness reporting, there is applicability for meeting operational requirements.

Status: An iterative round of usability assessments were conducted on the Post Mission Assessment for Tactical Training & Trend Analysis (PMATT-TA). A technical report documenting the results has been completed. Testing was conducted on the Performance Measurement (PM) Engine to verify generalizability and reliability of measures for an alternative platform. Integrated testing of PMATT-TA and PM Engine is on-going at a contractor's facility. Additionally, two test and integration events have occurred within the target training system environment for P-8A. A study protocol to baseline the current debrief process and compare it with debriefing augmented by post mission reporting and real-time performance assessment technologies has been completed. Preliminary efforts for certification and accreditation of technologies at the conclusion of the effort are underway.

Research Products:

- The Post Mission Assessment for Tactical Training & Trend Analysis (PMATT-TA), a web-based software application to collect and store mission data, generate post mission reporting documents and facilitate trend analysis of post mission data.
- The Performance Measurement (PM) Engine software collects simulator and instructor input data to calculate performance indicators for individual and crew measures.
- Performance Analysis & Trends in Training Enhancing Readiness Reporting for Naval Systems (PATTER2NS). Exhibit accepted for display in the US Navy booth at the 2012 Interservice/Industry Training, Simulation and Education Conference.

Government Colloquium. Atkinson, B., Grubb, L., Fiacco, R., (2014, June 05). PMA-205 Air Warfare Training Development (AWTD) IPT Meeting. NAWCTSD-Orlando, FL.

Atkinson, B. Tindall, M., & Ponto, S. (2014) Post-Mission Assessment for Tactical Training-Trends Analysis (PMATT-TA) Usability Report (NAWCTSD-TR-2014-0001).

UNMANNED AERIAL SYSTEM COMMON CONTROL STATION PROTOTYPE-BASED TRAINING RESEARCH

Start: Jun 13 End: Dec 16

Need: To meet the demand for cost effective training for unmanned aerial systems (UAS) operators, research and development on appended training approaches for future UAS systems requires a CCS prototype to ensure effective transition to operational systems. Safety of flight issues make inclusion of embedded training approaches expensive and time consuming due to the requirement for an extensive certification process. This prototype must be used to design, develop, and evaluate appended training approaches.

Objective: Via cross-warfare center coordination (WD, AD, TSD, and Navy Yard), low cost CCS hardware and software will be reviewed, procured and integrated to support development and evaluation of training for PMA-281's CCS development program. The primary focus of the proposed effort is to develop and evaluate appended training approaches for the employment by the CCS. The R&D lab currently has software and media development capabilities that will be employed to develop and evaluate augmented reality (AR) training approaches that can deliver training that will not impact the safety status of the tactical CCS. Employment of AR technologies holds the promise of providing rapid training update capabilities by avoiding the safety of flight certification requirements. This independence of the training from the tactical system will enable training capabilities to keep pace with the rapidly evolving development of the tactical CCS prototype without impacting its schedule.

Benefits: Leverage multiple professional disciplines to develop training with human system interface orientation, and adaptability for different UAS platforms. NAWCTSD will expand its design, development/research capabilities into UAS control station training issues. By working with Patuxent River and China Lake on CCS issues, risk of stove piped training development will be avoided and research findings can be leveraged by all development efforts.

Status: FY13 start-up funding was used to perform document review, technical discussions, and telephone meetings to evaluate work to date and current requirements for the Patuxent River CCS Prototype. Two NAWCTSD computer scientists conducted hardware and software specification reviews and a site visit to NAS Patuxent River to further clarify future requirements. FY14 resulted in hardware and software specification development, hardware and software license procurement and integration to develop the CCS prototype. Additional procurements were made in FY15 to complete the prototype, and AR hardware and delivery and development licenses were selected and procured. In FY16, AR applications will be developed to address familiarization and procedural training, and usability research will be executed.

Research Products:

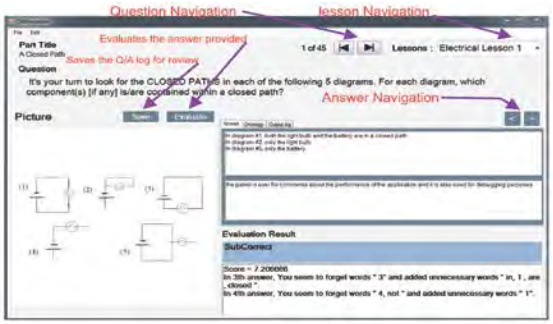
Hadden, K., Prince, M., (2015, September 15). Augmented Reality Common Control System training application. Not archived

Yelverton, R., Bowens, L., Garris, R., (2015, September 15). Augmented Reality usability study report. Not archived.

Hadden, K., Prince, M., Bowens, L., (2015, September 30). Lessons Learned in Developing Training for the Common Control System (CCS). Not archived.

BASIC ELECTRONICS AND ELECTRICITY LEARNING ENVIRONMENT (BEETLE) II TRANSITION

Start: Oct 14 End: Sep 17



Need: Originally, BEETLE II was developed in partnership with the University of Edinburgh to advance the state-of-the-art in Intelligent Tutoring System (ITS) capability. Research funded through the ONR D&I program was conducted to advance methods natural language processing (NLP) to support unrestricted student natural language input in ITS. Both the Navy's Submarine Learning Center and the Department of Defense Educational Activity have expressed interest in using BETTLE II as an instructional tool if the tool could be transitioned to a more accessible web based application. Furthermore, they have expressed an interest in development of course content in additional subject areas should the transition to prove successful.

Objective: Investigate feasibility of transitioning the Office of Naval Research (ONR) Discovery and Invention (D&I) sponsored research in BEETLE II from a closed Linux-based system to a web accessible application. BEETLE II was developed in partnership with the University of Edinburgh to advance the state-of-the-art in Intelligent Tutoring System (ITS) capability. Research funded through the ONR D&I program was conducted to advance methods in dynamic adaptive feedback generation and natural language processing (NLP) by extending symbolic NLP techniques in the context of a dynamically changing simulation environment in a moderately complex domain. This research seeks to provide an interface to the application that would permit educational institutions the ability to use this courseware as an education tool or as part of the curriculum for students.

Benefits: Transitioning BEETLE II from a closed Linux-based system to a web accessible application would provide an interface to the application that permits educational institutions the ability to use this courseware widely as an education tool or as part of the curriculum for students. As a web application, educational institutions would be able to use the tool without requiring specialized hardware and eases their burden with centralized maintenance of the system. Furthermore, it offers the opportunity to develop the platform from which additional courseware for other subject matter could be developed to deliver an efficient and effective learning experience for participating students. Newly developed courseware could be readily shared among educational institutions maximizing benefit to instructors and students.

Status: Utilizing existing parts of the BEETLE II as designed in the original application in a web environment proved to be a challenging task. Specifically, the knowledge base that was designed for the original application was not developed with web friendly tools. Further, licensing fees and restrictions created more obstacles in deployment of some portions of the application on the web. As an alternative, a new knowledge base was created using the course material and data gathered from the previous effort. A decision was made to use OWL Web Ontology Language as the basis for a new knowledge base for Beetle. The ontology is a knowledge base populated with courseware questions, answers and words set. Protégé is a free, open-source ontology editor and framework for building intelligent systems developed at Stanford University. It is extensible fully supports the latest OWL 2 Web Ontology Language as recommended by the W3C. The initial BEETLE ontology has been deployed to the web. The ontology and interface are still being improved for robustness. The initial deployment demonstrates the feasibility of making BEETLE available to a wider audience through the web. We have also worked with researchers at Worcester Polytechnic Institute to successfully embed BEETLE into the ASSISTments website. ONR sponsored some research with Worcester Polytechnic Institute to develop ASSISTments (www.assistments.org) to provide a platform where teachers can author and assign course material to students online. Sponsor at ONR have expressed the goal of delivering intelligent tutoring courseware through this platform.

Research Products: Planned research products include collaboration with academia, hardware/software prototype, technology demonstration and final report.

AUGMENTED TRAINING FOR EXPERIENTIAL LEARNING FOR LANDING SIGNAL OFFICERS

Start: Oct 16 End: Sep 18

Need: The Navy's objective to minimize training costs without sacrificing safety has led to the development of technology to reduce workload and complexity (e.g., MAGIC CARPET for carrier qualification {CQ}) combined with an effort to increase the level of LVC training across the FRTP, as part of the training optimization effort. For aviation in particular, this has meant an effort to reduce the number of live flight training hours focused on CQ, which has a significant costs associated with it. However, the potential for reduction in live flight hours focused on CQ facilitated by innovations like MAGIC CARPET effects more than just the pilot in the seat. For example, a majority of current training for Landing Signal Officers (LSOs) is done at Field Carrier Landing Practice (FCLPs) and on the carrier using live pilot qualifications (supplemented by classroom and simulation-based training).

Objective: In an effort to mitigate the predicted impact of training optimization on the LSO training pipeline, we are working to 1) identify training challenges for LSOs in reaction to Navy training optimization, 2) identify and develop technologies to supplement live training opportunities for LSOs (e.g., heads up augmented displays for training) and 3) develop and validate methods for implementing this technology (e.g., fading, adaptive training of velocity vector overlays in augmented displays) within the LSO curriculum that can supplement LSO training issues resulting from reduced live training.

***Benefits*:** LSOs have a unique and important role in US Naval Aviation. Specific to ship board landings, LSOs are tasked with the "safe and expeditious recovery" of naval aircraft aboard aircraft carriers and are required to assess, coach, correct, and mentor pilots landing at the ship (LSO NATOPS Manual). While the method and technology associated with Naval Carrier landings, supported by LSOs, has proven to be quite safe in recent years leading to a substantial decrease in Class A and B mishaps since the early 2000's, carrier landings remain a highly resourced, extremely dangerous, but necessary activity in US Naval Aviation. In fact, training to land at the ship costs the Navy over one billion dollars a year in flight hours and fatigue life costs (approximately over $1B in FY12 in Flight Hour & Fatigue Life Costs; Northrop Grumman Corp, 29 Mar 2013). Because of the expense and inherent risk, there is a significant effort to introduce augmented technology in landings to increase safety and decrease live training time to reduce cost. However, the efforts to reduce flight workload and errors have not traditionally extended to training for LSOs. While the LSO School leverages simulation based training, currently undergoing upgrades at NAS Oceana, it is estimated that LSOs currently still require up to 1000 live landings to accurately calibrate their visual perception of aircraft deviations. Their ability to maintain these numbers in the face of reduced live flights for CQ in general will be a challenge. The introduction of supplemental training that can enhance this calibration could address some of these challenges and is essential in moving forward with optimized training.

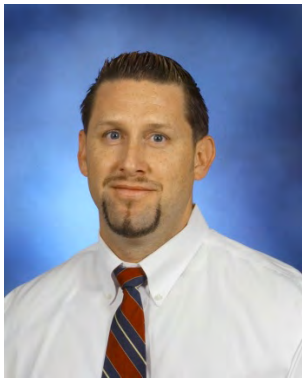
Status: Work on this effort has just begun. Plans for FY16 include a task analysis to identify specific LSO training needs, as well as software development for Augmented Reality Display overlay to enhance LSO training and for experimentation planned for FY17-FY18.

Research Products: Pending.

TRANSITION RESEARCH PROGRAMS

" ... reduce the level of risk associated with a newly demonstrated technology ... "

Program Manager: John Hodak



Most technologies are developed and demonstrated in the usual progression from Basic Research (BA1) through Applied Research (BA2) and Advanced Development (BA3). In the Navy's S&T program, a series of demonstrations occurs that starts with simple experiments and finally leads to proofs of concept. As the technologies become mature during this progression, some need additional demonstration or refinement before they can be transitioned to the Fleet. These transition efforts are supported with Advanced Component Development and Prototype (BA4) and Operational System Development (BA7) research category funds, and occasionally by Congressional funding designated for technology transition efforts.

The purpose of transition research is to reduce the level of risk associated with a newly demonstrated technology to make it ready for direct implementation by the Fleet or transition to the acquisition community. The transition research step demonstrates final products and prepares them for procurement, bridging the gap between progressive demonstrations of technology and full-scale implementation.

The current transition research at NAWCTSD is being conducted under the Air Warfare Training Development (AWTD) Program, sponsored by Program Management Activity for Aviation Training Systems (PMA 205). The research efforts in this program focus on the following technologies: learning methodologies for large-scale simulations, integration of intelligent components into training, automated measurement, and advanced visual system and sensor technology.

The Phase III portion of the Small Business Innovation Research Program is also considered a part of the Transition Research Portfolio.

The NAWCTSD transition research projects are described on the following pages.

INTELLIGENT TUTORING AND AUTHORING DELIVERY SYSTEM (ITADS)

Start: Aug 13 End: Dec 15

Need: Intelligent Tutoring Systems (ITS) offer an impressive capability to the military training community, but the government cannot afford to continue to purchase single-point solutions. The government needs non-proprietary tools to author and delivery ITS capability – tools which will increase the affordability of future ITS development.

Objective: This project developed a government-owned suite of Intelligent Tutoring authoring and delivery tools, complete with content that supplements existing "A" school training for the Information Technology (IT) rating with simulation-based, hands-on trouble shooting exercises.

Benefits: By developing a suite of Intelligent Tutoring authoring and delivery tools, the government is better prepared to address current and future training needs with Intelligent Tutoring technology in an affordable and effective manner.

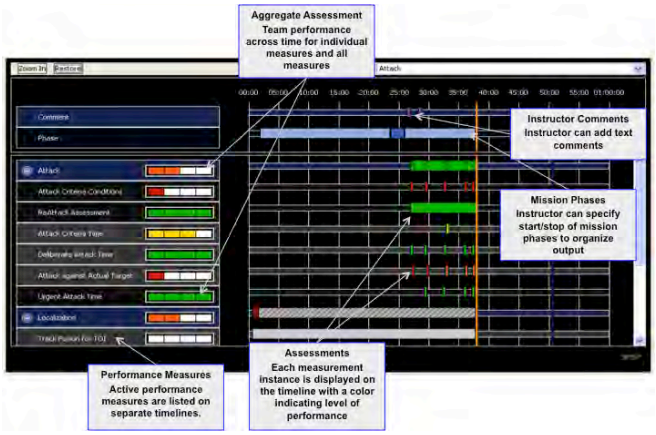
Status: Significant progress has been made in FY15. System Requirements Review / System Functional Review (SRR/SFR), Preliminary Design Review (PDR), and Critical Design Review (CDR) are complete. Three requirements analysis workshops, two design analysis workshops, and one development workshop have been held to solicit feedback on user requirements, system design, and user interfaces for the tutoring system and the authoring system from typical students and instructors at the Center for Information Dominance. The shipboard virtual computer network environment has been built. Seventeen training scenarios based on knowledge gaps were designed. Two interfaces for teaching the six-step troubleshooting process have been developed and, based on student input, the final system incorporated both versions. The tutoring and virtual shipboard environments were incorporated into the research. The testing and student/instructor evaluations were completed on schedule thanks to the government team that included Dr. Gwen Campbell, Dr. Judy Hale, Tashara Cooper and Jeff Hinzy. The contractor, TCS, was very cooperative in meeting the contract requirements. This research effort received very favorable reviews by the client. The team will demonstrate this research effort at I/ITSEC 2015. The contractor's research evaluation report is due 15 Dec 15.

Research Products:

- ITADS Software Requirements Specification (SRS) (Aug 2014)
- ITADS Software Design Specification (SDD) (Aug 2014)
- DIACAP Certification and Accreditation (April 2015)
- ITADS Trainer Engineering Report (TER) (July 2015)
- ITADS Test Procedures (TP) (July 2015)
- ITADS Test/Inspection Report (July 2015)
- Computer Software Product End Item (CSPEI) (July 2015)

PERFORMANCE MEASUREMENT (PM) ENGINE

Start: Oct 08 End: Sep 16



Need: A critical aspect of scenario-based training is the ability to provide students with performance feedback, resulting in a call for technologies that aid instructors in providing the right feedback.

Objective: The PM Engine work focuses on developing capabilities for individual and team level performance measures that are competency-based and automated to support real time feedback and debriefings.

Benefits: Development of automated performance measurements and trend analysis tools will facilitate distributed After-Action Review (AAR) and allow Navy aviation users to select and automate the collection of mission-relevant data and performance measures as part of distributed, networked simulator events. Such tools provide cost avoidance through meeting reduced manning requirements, decreasing the time required for preparation of post-mission debriefs, and increasing training focus to ensure that training objectives are met to support fleet readiness.

Status: A baseline technology for collection of automated performance measures was developed, with necessary standards defined for collecting performance related data from simulator network traffic established. A set of measures were defined and implemented for Anti-Submarine Warfare (ASW), Anti-Surface Warfare (ASuW), and Intelligence, Surveillance, Reconnaissance and Targeting (ISR&T) for the P-8A. Preliminary performance testing was completed in a lab environment. A certification and accreditation for the software application is underway. Testing within a relevant environment has occurred twice, with a follow on event in the planning phase. Continued development will focus on configuration, real-time display, and after action review of performance measurement results.

Research Products:

- The Performance Measurement (PM) Engine software collects simulator and instructor input data to calculate performance indicators for individual and crew measures.
- *Performance Analysis & Trends in Training Enhancing Readiness Reporting for Naval Systems (PATTER2NS).* Exhibit accepted for display in the US Navy booth at the 2012 Interservice/Industry Training, Simulation and Education Conference.
- *Training Objectives & Performance Measures for Optimal Scenario- Based Training (TOPMOST).* Exhibit in the US Navy booth at the 2008 Interservice/Industry Training, Simulation and Education Conference.

Pagan, J., Atkinson, B. F. W., & Walwanis, M. M. (2011). Enhancing performance assessment, at what cost? Challenges & benefits of an Integrated Performance Assessment Toolset (IPAT). *Proceedings of the American Society of Naval Engineers Human Systems Integration Symposium,* Vienna, VA.

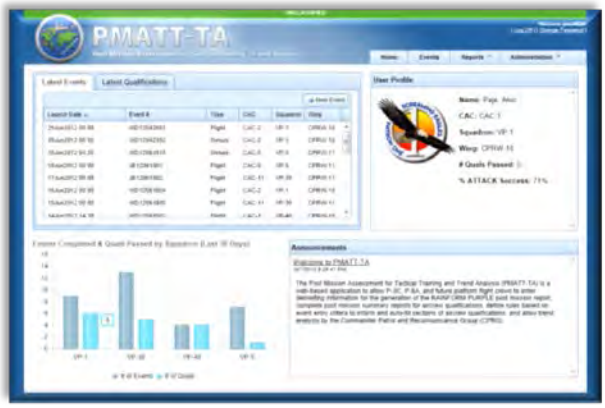
Wiese, E., Atkinson, B. F., Roberts, M., Ayers, J., & Ramoutar, D. M. (2012). Automated human performance measurement: Data availability and standards. *Proceedings of the 34th Interservice/Industry Training Simulation & Education Conference*, Orlando, FL.

Atkinson, B. F. W., Abbot, R., & Merket, D. (2013). Measuring up: Benefits and trends in performance measurement technologies. In C. Best, G. Galanis, J. Kerry, & R. Sottilare (Eds.), *Fundamental Issues in Defense Training and Simulation*. Ashgate.

POST MISSION ASSESSMENT FOR TACTICAL TRAINING & TREND ANALYSIS (PMATT-TA)

Start*:* Oct 10 End*:* Sep 17

Need: Shortfalls in debriefing and post mission assessment capabilities require readiness enhancing and workload reduction technologies to support assessment of tactical readiness. Additionally, the POM-15 Training System ENARG VP and HSM #3 Strategic Priority highlighted the need for post mission assessment.



Objective: Increase training effectiveness & efficiency & reduce costs with enhanced performance measurement, reporting & trend analysis.

Benefits: The benefits of PMATT-TA include compensating for the loss of flight hours with simulation-based training and assessing capabilities-based performance with increased standardization & longitudinal data to enhance fleet readiness.

Status: A prototype web-based interface was developed to provide single point access for data entry of post mission data and qualification sheets. Iterative feedback was provided by end users from the Command, Patrol Reconnaissance Group (CPRG) and P-3C community throughout the design and development to ensure product meets requirements. The product has undergone the necessary information assurance testing and approvals for use on Navy SIPRNET. The initial technology has been introduced to the P-3C community at MCAS Kaneohe Bay. Feedback based on this initial fielding has been captured to refine the product with 2 software updates released to date and a third in progress. Continued rollout of the Increment 1 software is anticipated in FY16.
Additional development of an Increment 2 has been on-going, producing an integrated capability with the Performance Measurement Engine (PM Engine). Additional testing to complete future certification and accreditation processes for use on Navy systems is underway. Two rounds of testing within a relevant environment have been completed.

Research Products:

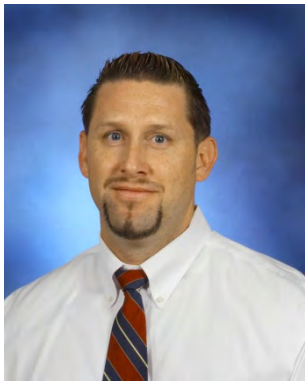
- The Post Mission Assessment for Tactical Training & Trend Analysis (PMATT-TA), a web-based software application to collect and store mission data, generate post mission reporting documents and facilitate trend analysis of post mission data. (PMATT-TA Increment 2 software release, Sept 16)
- *Performance Analysis & Trends in Training Enhancing Readiness Reporting for Naval Systems (PATTER2NS).* Exhibit accepted for display in the US Navy booth at the 2012 Interservice/Industry Training, Simulation and Education Conference.

Atkinson, B. Tindall, M., & Ponto, S. (2014) Post-Mission Assessment for Tactical Training-Trends Analysis (PMATT-TA) Usability Report (NAWCTSD-TR-2014-0001).

SMALL BUSINESS INNOVATION RESEARCH (SBIR) SMALL BUSINESS TECHNOLOGY TRANSITION RESEARCH (STTR)

"... vehicles through which NAWCTSD funds small companies to perform R&D."

Program Manager: John Hodak



The Small Business Innovation Research (SBIR) & Small Business Technology Transition Research (STTR) programs differ only in the fact that small companies perform exploratory R&D in partnership with universities and larger nonprofit research institutions in the latter program and by themselves in the former. They share the same goals:

- Stimulate naval training technological innovations,
- Strengthen the role of small business in meeting government R&D needs,
- Foster and encourage participation by minority and disadvantaged persons in technological innovation, and
- Increase the commercial application of DoD-supported research or R&D results.

The SBIR & STTR programs are divided into three phases. Phase I is to determine the scientific or technical merit and the feasibility of new and innovative ideas. This will typically be a six-month exploratory effort. Successful completion is a prerequisite for funding in Phase II. Phase II awards are based on the results from Phase I and on the scientific and technical merit of a more comprehensive Phase II proposal. This second phase is the principal R&D effort. Companies are asked to consider the commercial possibilities of the proposed R&D, and encouraged to obtain a private commitment for follow-on funding to pursue their commercial potential. Phase II periods generally do not exceed 24 months. Phase II is expected to produce a well-defined deliverable, such as a prototype or process that the Navy is interested in acquiring. Phase III requires the use of non-SBIR/STTR capital by the small business to pursue commercial applications of the R&D and to deliver products to the Navy. This third phase is designed, in part, to provide incentives for converting DoD-funded R&D innovations to the public and private sectors. The Phase III summaries are described in the Transition Research Section.

Sources of SBIR/STTR funding include the Office of the Secretary of Defense (OSD), Office of Naval Research (ONR), the Naval Air Systems Command (NAVAIR), the Army SBIR programs, and the Joint Strike Fighter program.

Current NAWCTSD Phase I and Phase II efforts are described on the following pages.

METHODS FOR ACTIONABLE MEASURES OF ABSOLUTE COGNITIVE WORKLOAD [N16A-T002]

Start: Jun 16 End: Jan 17

Need: In the Naval community, improving affordability is one of the three main focus areas in the 2013 - 2018 guidance (VADM David Dunaway). Specifically, standardized workload management systems have been deemed one essential component to gain increased affordability. This is partly because, as the capabilities of information technology systems and networks continue to grow, workers are increasingly challenged to process more information, interact with more interconnected systems, and juggle more tasks that compete for their simultaneous attention. These challenges could increase the impacts of threats as they impede cognitive fluency. In order to overcome these challenges, the Naval community needs to increase the ability to assess and take action within the adversary's decision cycle.

Objective: Develop an innovative and cost-effective capability that will provide an objective, measurable means of workload for determining impacts on individual operator, crew-level, and/or multi-team system level performance when life support or aircrew systems are added or modified.

Benefits: In the Naval community, improving affordability is one of the main focus areas. Specifically, standardized workload management systems have been deemed one essential component to gain increased affordability. This is partly because, as the capabilities of information technology systems and networks continue to grow, workers are increasingly challenged to process more information, interact with more interconnected systems, and juggle more tasks that compete for their simultaneous attention. That is, it is critical to know human performance limitations when introducing complex, cognitive tasks and state-of-the-art technologies, equipment and new environments to warfighters. Knowledge of these limitations can help researchers and developers understand and evaluate the potentially negative impacts on safety and the efficiency of operations. Frequently, this involves assessing workload impacts; however, current workload assessment methods do not adequately support system development or enhanced decision making with objective measurements.

This effort seeks to investigate a hybrid approach that would allow for the real-time measurement (e.g., measurement results as an operator tests new equipment) of physical and cognitive workload and, with the results and modeling capabilities, understand how variations in the associated factors might impact operator safety and performance. Finally, as integrated technologies and operations continue to expand, consideration beyond the individual operator to crew-level and multi-team systems is required.

This capability will benefit the Navy by the range of applicability from aircrew systems through investigation of life support systems, to training systems development and effectiveness evaluations. As we pipe more and more data into our control centers, aircraft cockpits, and automobile consoles, it becomes more and more critical that we be able to determine when workload affects the operator’s ability to compensate safely.

Status: Phase I shall begin in June 2016.

IMMERSIVE PARACHUTE DESCENT PROCEDURE, MALFUNCTION AND DECISION-MAKING TRAINING SYSTEM [N161-007]

Start: Jun 16 End: Jan 17

Need: The Chief Naval Office (CNO) mandates Naval survival training include parachute descent training. This training is outlined in OPNAVINST 3710.7U. Current training technology lacks the quality and sustainability needed to ensure standard efficient and effective training can be delivered at Naval training centers. The Naval Aviation Survival Training Program Trainer Management Team (TMT) has identified the need for alternative training devices as a top 5 strategic priority.

Objective: Develop a novel reconfigurable device training system that provides immersive Parachute Descent Procedure (PDP), malfunction and decision-making training to allow the survival training community to deliver cross-platform training without the need for multiple training systems or platform specific peripherals

Benefits: Current PDP training is based on antiquated virtual reality technology that has inadequate effectiveness and realism. Additionally, existing training is problematic due to limitations that prevent interfacing with standard flight and parachute equipment. A novel, immersive training system that provides the ability to train aviators on PDPs, malfunctions and decision-making is desired. The training system should address three capabilities gaps: 1) training quality and effectiveness, 2) supportability, and 3) training realism.

The training system should benefit the Navy by providing a reconfigurable interface that supports all Navy standard flight equipment and parachute equipment. All necessary equipment will be identified during the Phase I and Phase II execution, with hands on opportunities at the safety center facilities during kickoff or other collaboration meetings. This would include, but is not limited to, parachute harnesses and riser assemblies for all models of parachutes. Developed technology would provide the ability to demonstrate effectively both standard PDPs (e.g., inflation of the life preserver, releasing the raft when applicable) and parachute malfunction. Malfunction training should allow students to perform corrective actions and provide mechanisms to deliver feedback on performance through performance assessment and debriefing capabilities. The system should support scenarios for training that include both over land and over water options and procedures.

The requested training solution will also benefit the Navy by providing a reconfigurable connection for a variety of aircrew equipment and seat kits, which differ by platform. This is necessary to ensure the delivery of an integrated training solution without the need for a platform specific trainer or simulated/replica equipment only utilized within the trainer. Development a single, reconfigurable device will allow the survival training community to deliver cross-platform training without the need for multiple training systems (variations by platform), and limiting significant single or recurring peripheral costs if a system was designed with simulated/replicated equipment. These costs saving factors increase affordability of the requested system, while also increasing the training fidelity for delivering a critical safety-training curriculum.

Status: Phase I shall begin in June 2016.

CREW ROLE-PLAYER ENABLED BY AUTOMATED TECHNOLOGY ENHANCEMENTS (CREATE) [N142-090]

Start: Oct 14 End: On-going

Need: Current Navy crew training requires the assembly of an entire crew, or the use of Subject Matter Experts (SMEs), to support crew training. While training benefits from the additional costs associated with bringing a full crew together (e.g., crew coordination, team building), some individual training could benefit from the added realism provided by crew interaction. For example, when attaining skills associated with crew roles, team members often conduct a series of training events in Part Task Trainers (PTTs). During these events, the emphasis is on the crew member's individual skills; however, many tasks associated with their role may rely on inputs from other crewmembers. Developing a synthetic role-playing capability will serve to enhance the training pipeline and potentially avoid costs and provide value added without the use of training aids.

Objective: Develop a software application/suite that provides a synthetic crew role player to support complex crewmember interactions during dynamic training events.

Benefits: Current Navy crew training requires the assembly of an entire crew or the use of SMEs to support crew training. While training benefits from the additional costs associated with bringing a full crew together (e.g., crew coordination, team building), some individual training could benefit from the added realism provided by crew interaction. For example, when attaining skills associated with crew roles, team members often conduct a series of training events in PTTs. During these events, the emphasis is on the crew member's individual skills; however, many tasks associated with their role may rely on inputs from other crewmembers. Developing a software application/suite that provides a synthetic role-playing capability will serve to enhance the training pipeline and potentially avoid costs and provide value added without the use of training aids.

In order to successfully implement a synthetic role-player capability for Navy crew-based training, a technology solution that integrates speech capabilities (i.e., recognition, understanding, synthesis), SME level tactical domain information, reaction to multitasking and high stress situations, and relay of information via means other than speech communication (e.g., software inputs), are required. However, current technologies have not been developed to interact in this manner.
The Navy would benefit from this proposed technology by being able to supplement training for the Tactical Officers (TACCOs) in the P-8A PTT. TACCOs are responsible for synthesizing information from multiple sensor operators in order to make tactical decisions about how to pursue targets of interest.

Status: Phase I demonstration and Final Report shall be delivered in December 2015. Phase II begins January 2016.

EFFECTIVE MEASURES OF TRAINING DISPLAY SYSTEM PERFORMANCE [N142-104]

Start: Sept 14 End: On-going

Need: Despite significant technological advances, the Navy's visual system acceptance tests are still manual, time consuming, and often inconsistent across programs. Significant improvements in the certification process are available through the application of modern metrics and more automated methods of measuring display systems. These improvements would save both time and cost of training display system certification, as well as improve the performance level of such systems.

Objective: To develop an objective and efficient measurement toolkit for conducting validated acceptance tests for simulation training display systems.

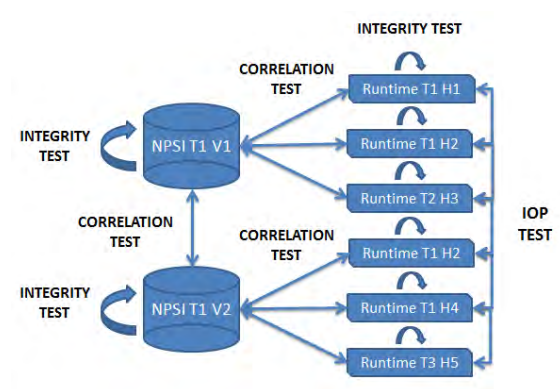
Benefits: Over the past decade, the ability to measure essential display system attributes has advanced to the point where the simulation training industry has multiple suppliers who offer automated display calibration systems, capable of accurate geometry and channel-to-channel co-alignment. Several of these systems can also measure and correct edge blending, electro-optical response (gamma), color, and uniformity. Recent publications describe reasonable new metrics for mirror distortions, motion-induced blurring, uniformity, and Night Vision Goggles (NVG) stimulation capability. Despite these significant advances, the typical acceptance tests used to certify training display systems are still manual, incomplete, time consuming, and often inconsistently applied across programs.
This effort will benefit the Navy by developing innovative metrics and measurement procedures that are needed to support the certification of simulation training devices in the field. Candidate metrics include: system resolution, sampling artifacts, update rate, motion-induced blur, contrast, luminance, geometry, mirror distortion, electro-optical response (gamma), color, NVG stimulation (infrared (IR) balance), and uniformity. Where practical, the metrics and procedures should correspond with those currently in use in the simulation training industry. Correlation with training effectiveness or task performance must be demonstrated for metrics that deviate from standard practices.

Status: SBIR Phase I demonstration and Final Report shall be delivered in November 2015. SBIR Phase II begins January 2016.

SBIR PHASE II PROJECTS

DISTRIBUTED SYNTHETIC ENVIRONMENT CORRELATION ASSESSMENT [N141-006]

Start: May 14 End: On-going



Need: Correlation errors today include: numerical accuracy and consistency in algorithmic, parametric and temporal models. The differences in the representational of the environment representations result in interoperability problems such as fair fight and negative training. Even if the same source datasets and common terrain database representation are used for the generation of runtime database formats, differences in abstraction or representations of each runtime format often induce line of sight, detection, mobility and other correlation problems. The result can be unrealistic simulation results or negative training, and a corresponding degradation of war time interoperability. No clear solution exists at this point for the assessment of correlated and interoperable environments (Shufelt 2006).

Objective: To develop an innovative prototype that would allow the NAVY / Marine Corps to verify synthetic environment database and sensor simulation capability correlation for NAVAIRs' simulators. This comparison of formats and versions of databases to each other, with a particular emphasis on airports and ranges (including corridors of approach, surrounding area of interest, and key landmarks, and capability for sensor simulation) should be automated. Furthermore, it will need to be extensible and allow for the addition of new runtime and source formats as well as allow for the addition of additional tests and analysis modules.

Benefits: Naval / Marine Corps flight simulators are often run in isolation, however there are growing requirements for distributed networked simulation. Simulation communication, processing models and synthetic environments are some of the components that are affected by distributed system interoperability. Interoperability of distributed systems is achieved only when the perception of the same events and models by different systems is similar, thus enabling the linked war fighters to work together and achieve a common goal. Working together is dependent on the consistency between the synthetic environments, yet today aircraft simulators rely on manual inspection and limited testing to determine if the simulated environments are a match between NAVAIRs' networked simulators.

Correlation errors occur between different simulation systems when environmental representations features are rendered differently between simulation applications. Although some metrics and tools have been proposed in the past an automated process for determining the degree of correlation between heterogeneous human in the loop simulators in a distributed environment still does not exist. As a result programs must spend many months determining the degree of similarity between simulators and its impact on a successful networked exercise.

The Navy will benefit by the delivery of an automated process for determining the degree of correlation between the heterogeneous human in the loop simulator prototype system using selected flight simulation facilities and trainers. Phase II shall include test techniques for the validation of the metrics.

Status: Phase I demonstration and Final Report delivered in August 2015. Phase II begins October 2015.

MASK-ON HYPOXIA TRAINING DEVICE [132-093]

Start: Nov 13 End: On-going

Need: Annual hypoxia training, required for all ejection seat equipped aircraft aviators, addresses both recognition of symptoms and recovery procedures to mitigate the risks associated with hypoxia incidents that occur each year. The training is currently accomplished either by the command's Aeromedical Safety Officer in the fleet simulators or at the local Aviation Survival Training Center.

Current technologies have several limitations including the lack of mobility (e.g., large chamber training, need for large gas bottles), high maintenance requirements (e.g., filter replacements, calibration, gas bottle replacement), obsolesce issues, and lack of training realism that can lead to negative training (e.g., risk of generating air hunger). Limitations of current training solutions, as well as increased fiscal pressures to reduce training costs, necessitate consideration of alternatives for providing hypoxia training.
A small, portable system capable of pressure-demand airflow is needed to fill this training gap. A low cost, low maintenance and fully mobile device free of gas bottle connections would significantly improve and expand the capability, efficiency and quality of training provided to the fleet.

Objective: Design and develop a mobile-sized hypoxia training device capable of delivering continuous pressure-on-demand airflow to an aviator's oxygen mask with varying oxygen levels simulating sea level (ambient air) to 30,000 ft.

Benefits: An enhanced hypoxia training capability that does not rely on gas bottles to supplement the simulation of altitude will increase the capabilities for survival training by support mobility of training to high fidelity simulators and provide increased opportunities for hypoxia awareness training at reduced operational lifecycle costs (e.g., maintenance, sustainment). Additionally, such a replacement lowers life-cycle costs, and decreases maintenance requirements. Naval Aviation hypoxia training has grown into an annual requirement due to the number of hypoxia incidents that occur. The current generation of individual mask-on hypoxia training devices can be greatly improved upon with new available technology. The mobility is restricted due to gas bottle connections and the realism is reduced due to the use of non-pressure demand system. The proposed capability has the potential to provide more realistic training in fast-paced training scenarios and increase the training capability to nearly any environment.

Status: Phase I base demonstrations were concluded in FY15. Down select to a single Phase I option award was completed. A Phase II award was made in Q1 FY16 for a two year Period of Performance. Coordination with the P-8A fleet project team continues to ensure relevance to the target transition. Secondary transition discussions are underway for augmenting constructive entities with intelligent speech reactions.

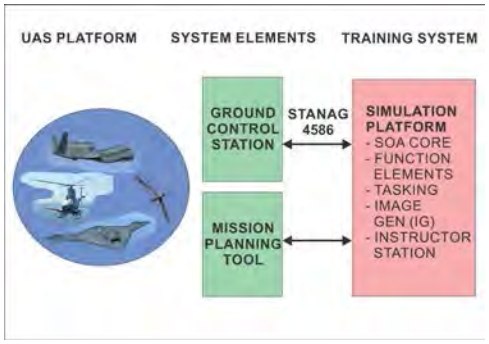
Research Products:

- Brief technology approaches to Fleet Customer (Dec 13).
- Demonstration of prototypes provided to technical team (Apr 14)

Scheeler, W. T., Atkinson, B. F. W., & Tindall, M. J. (Nov 14). Training naval aviators to recognize hypoxia symptoms: Advancing technologies to address a continued safety threat. *Presented at the annual SAFE Symposium.*

COMMON UNMANNED VEHICLE CONTROL PROCEDURES TRAINER [N111-008]

Start: Sep 13 End: Mar 15



Need: The Navy has an immediate need to develop a highly adaptive simulation platform to support existing and near future Naval UAVs. The Navy currently supports several platforms, including the Navy's Scan Eagle, Global Hawk, BAMS, RQ-7 Shadow, JTA-Fire Scout, RQ-11B Raven and several others. In development are also UCLASS carrier based options, such as the X-47B. Dedicated training platforms do not currently exist for these devices. Suppliers have provided the ability to stimulate their UAV control stations, allowing operators to train when the platform is not in use. However, this method has several disadvantages, including taking a deployable platform off line during training and requiring the use of sophisticated and costly equipment. A dedicated simulator system was never developed for these systems. Given the number of differing UAV platforms now deployed, developing a unique simulator system for each vehicle would require many large programs at significant cost. Thus, it is highly desirable to develop a highly adaptable simulation platform that incorporates the common elements of all platforms, with the ability to readily tailor the solution to virtually any vehicle simulator (air, ground, or sea).

Objective: A service oriented architecture (SOA) is capable of providing several unique benefits. This architecture would allow tailoring to be done with reasonable effort, not requiring the user to become fully versed in every aspect of the simulation system. The SOA provides a set of interface points between a primary interface module (PIM), and individual simulation functions, such as engine models, flight dynamics, auto-pilots, human interface systems, sensor simulations, etc. Each discrete functional simulation element communicates to the PIM, which directs real-time data to and from those elements via socket layers. Socket layers provide a structure for data packets to and from each element module in a predefined manner, allowing such element models to be designed to match socket definitions so that element models can be easily interchanged.

Benefits: This solution will be in line with the Navy's Open Architecture goals for all new Navy systems, allowing competing interests to have access to the same core software and tools to more efficiently develop future UAV training systems. The open source nature and licensing rules of the core simulation engine will also lead to enhancements from many contributors, rather than relying on such improvements made only by each vendor for their own products. The result will be better, cheaper, more consistent training across all UAS platforms.

Status: This Phase I effort provided a starting point toward development of the SOA model. That effort took advantage of an open source flight simulator software package (FlightGear) to investigate its available functional modules and methods by which they could be separated and then reconnected via the PIM. The success of this effort provided a basis for a more sophisticated solution that will be pursued via this Phase II SBIR.

This effort has been demonstrated and completed. Much interest has been received about this project from PMA 281, PMA-266, PMA-205 and related vendors resulting in cooperative partnerships to complete the project and attract future funding for continuation of the project beyond Phase II.

Research Products: Demonstrated prototype Level 2 STANAG Sim Element at the Navy Opportunity Forum as part of participation in the Navy Transition Assistance Program (TAP). (June 15)

DECOUPLED RENDERING CHANNELS TO REDUCE LOGISTICAL SUPPORT SPARES REQUIREMENTS OF LARGE SCALE TRAINING CENTERS [N131-018]

Start: Jul 14 End: Feb 17

Need: Currently, the hours of availability provided by each stand-alone simulator are constrained by each trainer's dedicated image generation (IG) hardware functionality and the currency of the images on that hardware. Moreover licensing and maintenance of today's image generators is fragmented, duplicative, and costly.

In order to better keep pace with continually updated and increasingly detailed imagery being made available, research is needed to determine how image generation architecture could be improved. Experts predict that large scale training centers may be not viable in the long term without this type of innovation, due to the complexity and detail available for rendering. Just as image generation architecture has moved from dedicated purpose computing into PCs, it is inevitable that the next step would be into distributed fiber optic video distributed network, thus providing better logistical/maintenance support and sparing for large scale simulation (e.g., see reference for the new P-8A aircraft) training centers, and commercial training facilities that provide multiple flight simulators at one location.

Objective: Demonstrate on a suite of flight simulators how to innovatively decouple image rendering channels from individual trainers, and instead provide imagery to multiple trainers simultaneously via a centralized pool of logistical support/spares resources, over a local fiber optic video distributed network.

Benefits: The resulting centralized Image Generation (IG) should improve availability, reduce costs and space requirements, and make possible uninterrupted training to occur - while conducting simultaneous imagery updates.

Status: Diamond Visionic's approach uses a centralized IG system that renders each frame from disparate observer positions and sends those frames out as network packets, which can be routed to different training environments. A normal IG system is composed of multiple computers in a server rack, but with Diamond Visionic's system each IG is a single computer with multiple video cards (further reducing the need for multiple spare computers in case of failure). Diamond has also innovated on how they are approaching distributed rendering by using both the latest OpenGL rendering techniques and taking advantage of the new frame encoding/decoding and hardware/software technology developed by NVIDIA.

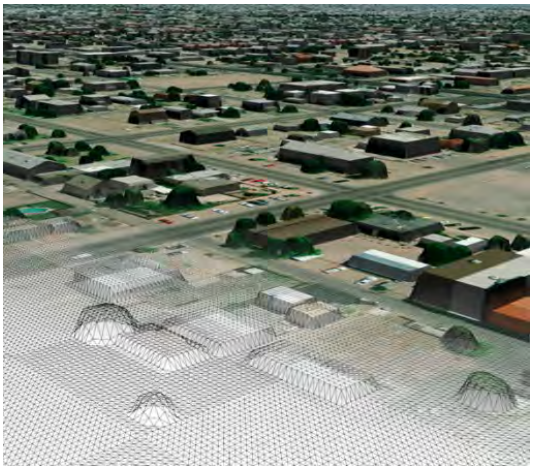
During Phase I, a four channel prototype was developed, consisting of four Quadro K6000's in one system. The prototype was demonstrated running a LCD display configured as a 2x2 matrix. The imagery was sent to the display over a network and ran at 60hz. The prototype was also attached to 4K projectors, driving at 1920x2160, each powered by two video cards. This resulted in an 8 to 1 reduction in the number of IG computers required in a traditional approach. Again, the system ran at 60hz in a very demanding scene.

Now in Phase II, Diamond has moved to an 8 channel system using the dedicated encoding technology built into the latest Quadro video cards. Their system was selected over a Rockwell-Collins IG to support AVT in a series of "whisper suite" demonstrations at the AAAA and AUSA trade shows. The system ran a combination of OTW and sensor channels, with each instance of the software driving 2 outputs, all running at 60hz.

Research Products: Phase I demonstration and Final Report delivered in Dec 13.

GEOSPECIFIC DISPLACEMENT MAPS FOR REAL TIME, STEREOSCOPIC TRAINING SIMULATION [N102-116]

Start: Dec 12 End: Apr 15



Need: A widely used technique for controlling modeling cost is to concentrate the level of detail on areas of interest such as airfields, landing zones, confined area landing sites, and terrain following routes. The placement and alignment of buildings and vegetation in and around these areas can be time consuming for large areas and therefore is limited in scope. This limitation in feature content can affect the visual cues needed by the pilot for the accurate perception of motion. Process and tools that reduce modeling cost while providing sufficient visual cues for training are needed.

Objective: Develop an innovative automated process that unlocks the advantages of real-time displacement maps and other tessellation technologies along with geo-specific two and three dimensional source imagery for implementing high complexity terrain surface regions in virtual environments for real-time training simulators.

Benefits: The outputs of this R&D effort have the potential to provide the Navy with an opportunity to significantly advance the state-of-the-art in visual realism, visual cues and overall quality of aviation simulators while reduce database production costs. State-of-the-art GPUs are increasing in performance and now incorporate displacement mapping and tessellation technology which allow for more detail on three dimensional models at no extra performance. Displacement mapping, edge detection analyses, and other new tessellation technologies have the potential to allow rapid incorporation of geo-specific regions in a virtual world for real time training simulation.

Status: The Renaissance Sciences Corporation (RSC) and Arizona State University (ASU) approach includes an end-to-end framework for the generation of the displacement maps, the mapping to a generic specification (i.e. Naval Portable Source Initiative or NPSI) and a real-time rendering solution. ASU has developed a framework for the generation of displacement map data from NPSI datasets and other geospatial datasets. The DMRI prototype uses OpenSceneGraph to visualize the generated displacement map data using geometry and tessellation shaders. DMRI has also evolved to include higher resolution polygonal models at arbitrary ranges. This allows for high level of detail models at close range. This effort has ended and contractor demonstrated the capabilities for the government.

Research Products:

- Chladny, Brett (2015, March). Presentation at the GPU Technology Conference.
- Phase II - DMRI demo at the Navy Opportunity Forum (June 14).

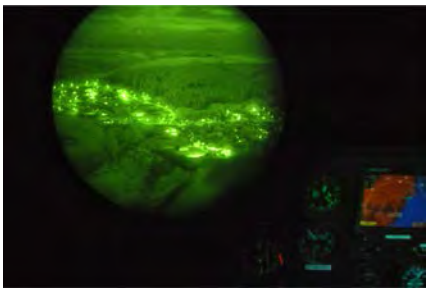
Chladny, B., Femiani, J., & Graniela, B. (2013, January). Realistic Geo-Specific Feature Densities in Real-Time Synthetic Environments. In The Interservice/Industry Training, Simulation & Education Conference (I/ITSEC) (Vol. 2013, No. 1). National Training Systems Association.

Chladny, B., Femiani, J. (2014 July), Method for Incorporating Displacement Mapping into Existing Image Generators, In the IMAGE 2014 Conference Dayton, Ohio – July 14.

Femiani, J. (2014 July), Graph Cuts to Combine Multiple Sources for Feature Extraction, In the IMAGE 2014 Conference Dayton, Ohio – July 14.

HYPER-ELEVATION MODELING OF TERRAIN, TOPOGRAPHY, & URBAN ENVIRONMENTS [N091-026]

Start: Apr 09 End: Apr 16



Need: Current standards used for representing terrain digital elevation models do not provide for the description of topographical features such as tunnels, caves/bunkers, overhangs, multi-level highways/interchanges, and other unique aspects of strategic rural environments and urban infrastructures. Abstract methods for defining these topographical features are desired, to allow for embedding realistic targets and simulated lasing of those targets, as well as ability to accommodate temporal/diurnal changes to the topography.

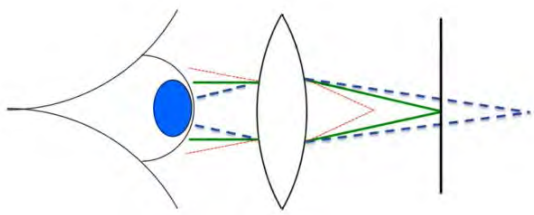
Objective: Develop abstract definitions for mixed topographical features on rural and urban terrain, (e.g., adjoining man-made and natural objects, having complex geometrical solutions, such as caves, highway interchanges with multiple level ramps, walkways between high-rise towers etc. For the purposes of training: lasing of targets, damage assessment after strikes, supporting complex interaction of simulated weapon platforms with targets of interest, and for training situational awareness, battle-state assessment, and low level navigation.

Benefits: Commercial applications range from environmental studies to emergency (natural disaster and/or terrorism) planning, construction management and training. Both military and nonmilitary sectors require more sophisticated models using the wealth of data that is now being generated from commercial enterprises and by local, state, and federal governments. The depiction of dynamic terrain is particularly important in the visualization of construction operations as well as in combat because terrain is seen and manipulated at close range.

Status: SBIR Phase II.5 awarded in April 2014. This effort has a 24 month period of performance. Cognitics has named the technology developed under this SBIR topic, Spawn. The primary goals are to improve the fidelity of transportation features in simulation systems and to provide terrain generation tools that work across multiple systems. The contractor is beginning to develop requirements and design a software tool that will analyze elevation and vector data to infer attributes on hydrology features. This tool will be intended to supplement existing available GIS data and provide attribution such as width and seasonality of rivers, streams, etc. Contractor shall demonstrate software capabilities in April 2016.

INNOVATIVE COLLIMATED DISPLAYS [N121-041]

Start: Oct 13 End: Dec 15



Need: Rotary wing platforms require a complex set of flight regimes and close proximity visual cues during hovering, take-off and landing, search and rescue, confined area and emergency landing, and cargo loading/unloading operations. Current aircraft simulator visual displays provide monoscopic visual cues using either real image or fixed collimated displays. No optimal solution exists today for low altitude operations that provide binocular disparity, and correct vengeance-and-accommodation at low altitudes.

Objective: Develop innovative visual displays to provide variable collimation and improved 3D depth perception for rotary wing chin windows and cargo hatch operation.

Benefits: A variable collimation display will provide accurate accommodation and vergence based on the aircraft distance to the ground. It is expected that this innovative display technology would improve the visual cues provided to pilots and therefore improve safety and training. Furthermore this display technology may also contribute to enhancements on numerous other display applications currently limited by a lack of accurate depth cues.

Status: Holochip Incorporated was awarded PH II option. Contractor shall deliver a demonstration in December 2015. The Holochip approach to variable collimation is based on its own variofocal lens technology and patents. A variofocal lens allows for an image plane (i.e. focal point) to be translated. This type of optical element allows for an image plane to the translated from a far to a close plane. Using this technology Holochip is expecting to develop an optical system and display that can stimulate the HVS vergence and accommodation therefore enhancing depth cues.
At this time Holochip has finished the design and manufacture of the first ever 140 mm variofocal lens in history. A number of challenges had to be overcome related to moving large quantities fluid in and out was well as the control system and pumps needed to perform this at 60 fps. The figure below shows the initial prototype which is currently undergoing tests at Holochip.

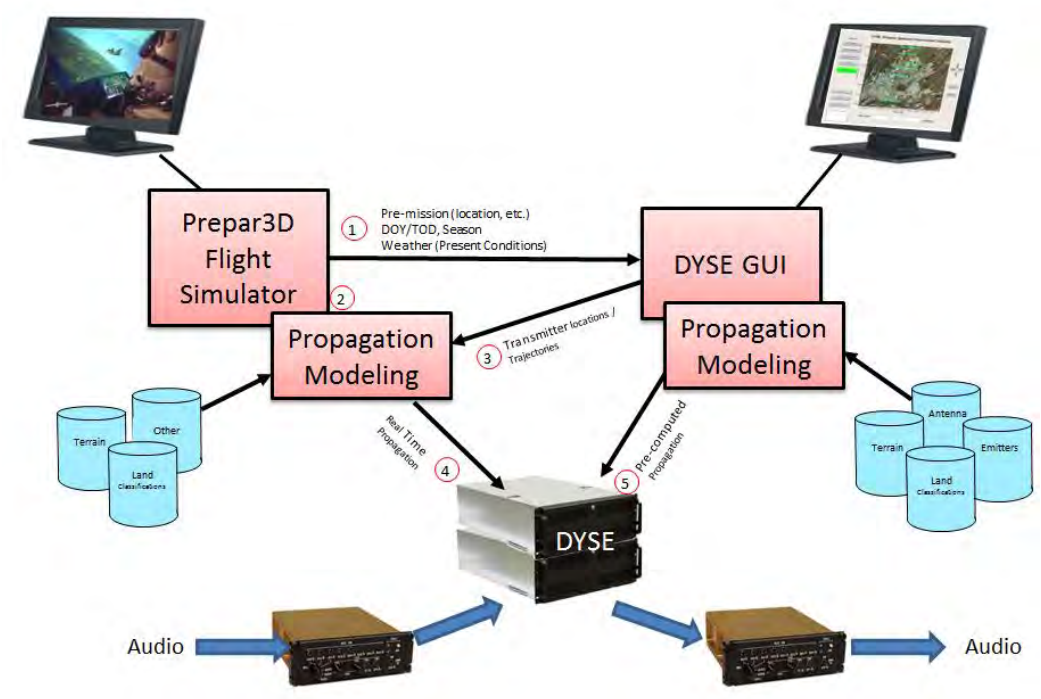
Research Products:

- Demonstration of prototype provided to TPOC (Feb 14).

Batchko, R., Robinson, S., Schmidt, J., & Graniela, B. (2014, March). A variable-collimation display system. In *IS&T/SPIE Electronic Imaging* (pp. 901109-901109). International Society for Optics and Photonics.

NEW AND IMPROVED RADIO FREQUENCY (RF) MODELING FOR CORRELATED ENVIRONMENT COMMUNICATION SYSTEM SIMULATORS WITH SENSOR SIMULATORS [N121-011]

Start: Apr 12 End: Jul 15



Need: Military aviation simulators need to develop a set of rules and 'RF signal propagation algorithms' based upon select, critical environmental factors (i.e., weather, attenuation, backscatter, tropo-scatter, refraction, ducting, etc.) to include and incorporate essential flight parameters affecting airborne tactical communications and tactical aircrew sensor operations (e.g., antenna shielding, terrain masking, etc.).

Objective: To develop accurate RF, sensor-systems, and communications systems links for military aviation flight simulators through modeling links between aircraft and a multitude of representative sea, land, airborne, and satellite-based systems, combining physical hardware with virtual training devices and emulated RF/Sensor tactical environments to create realistic mission scenarios. Echo Ridge LLC will enhance electronic jamming functionality. Improved enhancements of T-45 Aircraft scenarios, using an upgraded version of 'Prepar3D' software.

Benefits: Echo Ridge's Dynamic Spectrum Environment Emulator (DYSE) Hardware system emulates realistic physical environments for communications, including key sensor process standardization, and facilitates reduced life cycle acquisition costs for new-start system acquisitions, training device procurements, and legacy visual system upgrades to trainers via operational features during simulated airborne training events.

Status: Completed the Dynamic Spectrum Environment Emulator (DYSE) integration to remote flight simulators. The contractor developed a prototype system that allows multiple remote flight simulators to share position and orientation information and send audio to each other using a single instance of DYSE. DYSE adds radio communication channel effects to the audio between the multiple flight simulators. Contractor completed effort in July 2015.

Research Products: Prototype demonstration and Phase II Final Reports delivered in July 15.

RECONFIGURABLE AERIAL REFUELING TRAINER [N102-124]

Start: Oct 10 End: Mar 15

Need: Part-task trainers eliminate the need to field additional full-task trainers, and can also reduce the expense of maintaining the existing large training systems. Only a fraction of the cockpit functionality and instrumentation is required (as compared to a traditional flight simulator) thus significantly reducing costs. Higher fidelity air refueling training will improve pilot performance especially for first timers.

Objective: Cost-effective aerial refueling training technology suitable for use in different aircraft trainers or in a part-task trainer configuration. There is a need for accurate stereoscopic and parallax cuing which is correlated with the aerodynamics and motion/haptic effects experienced by pilots in this unique flight regime. The collimation distance of displays in conventional flight simulators is fixed and incorrect for training the aerial refueling task. It often requires intervention from an instructor to perform the task, which is artificial and potentially a source of negative training.

Benefits: There are not enough hours available on fielded training systems to conduct all types of training required. Supplemental trainers are needed to reduce the burden of the full-function weapon system trainers. These part-task trainers can be made smaller and less-expensive, yet provide higher fidelity training for specific training objectives, than our full-mission trainers. Reconfigurable capability can further improve cost effectiveness. Advancements, however, are needed to improve the fidelity/effectiveness of simulation based training and lower the cost of individual components. Current training does not provide the stereoscopic cue critical for determining close distance and closure rate when performing air refueling.

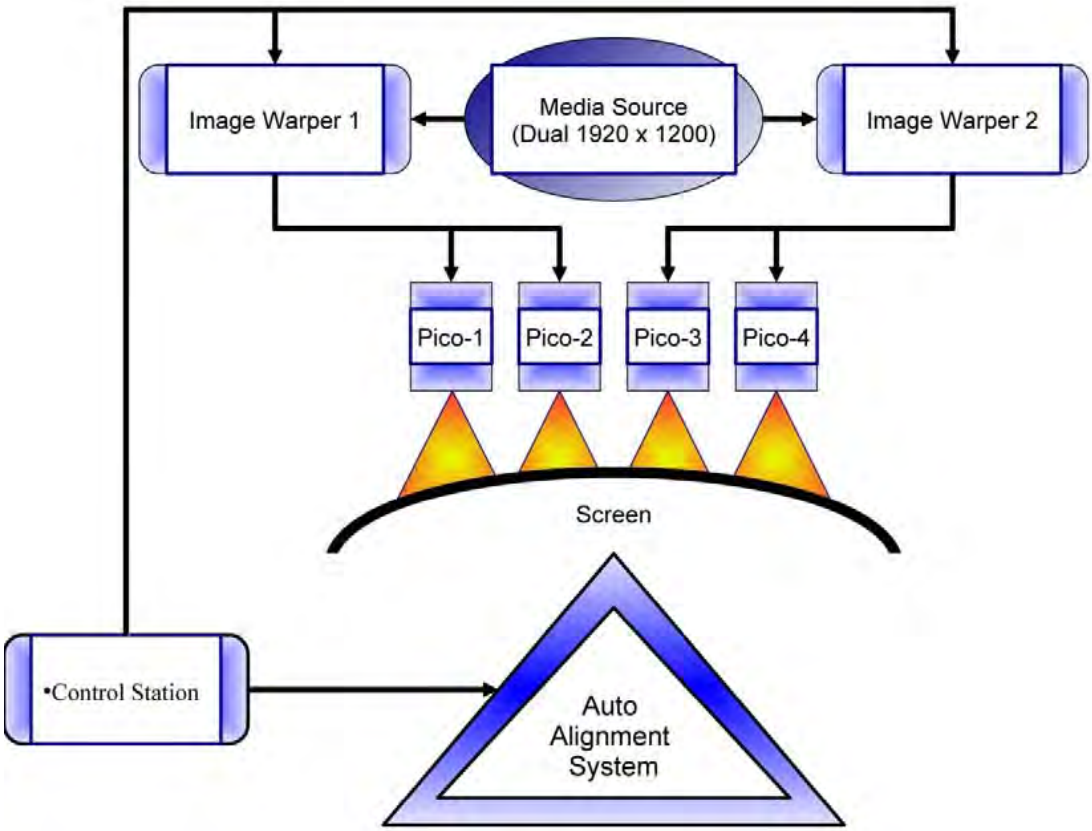
Status: A prototype was developed by AVT simulation and demonstrated to NAWCTSD. The training system effectively simulate the dynamics of the receiver aircraft and its probe connecting with the tanker hose-and-drogue, maintaining contact for fuel flow within the tanker's refueling envelope and disconnect. Provide a stereo view for the receiver pilot to provide proper perception of all the cues and optical flow patterns the pilot sees flying the up-close refueling view, including his own cockpit interior visually interacting with the exterior view of the tanker and its hose-and-drogue during closure, contact, and maintaining contact for fuel flow. Current system challenges are the tradeoffs between comfortable and high-resolution HMDs. The compact trainer design allows for low cost part task trainer.

Research Products:

- Prototype demonstrations provided to NAWCTSD on various HMD configurations (2015).

SMALL PROJECTOR ARRAY DISPLAY SYSTEM [N121-005]

Start: Sep 13 End: Sep 15



Need: In order to support reducing initial and life cycle costs while increasing performance, this Small Business Innovation Research (SBIR) effort takes a look at the ability to integrate several small, inexpensive projectors into a larger array in order to attempt to meet or exceed the performance of existing simulation-grade Commercial off the Shelf (COTS) projectors.

Objective: Develop innovative technology leveraging small COTS Light Emitting Diode (LED) based projectors to create a cost effective, high performance, immersive, rear-projection display system with small footprint.

Benefits: (1) The cost per pixel can potentially be minimized using an array of pico projectors; (2) The smaller footprint that can be achieved using short throw lenses; (3) The potential for achieving eye-limiting resolution in terms of the number of pixels required.

Status: The contractor conducted their final demonstration display system including rear projection screen with arc minute resolution display. The contractor enhanced software that provided multi-channel output support from a single generator channel.

Research Products: Contractor demonstrated prototype and delivered Phase II Final Report. (Sep 15).

STTR PHASE II PROJECTS

AUTOMATED HUMAN AND SYSTEM PERFORMANCE ASSESSMENT IN OPERATIONAL ENVIRONMENTS [N11A-T001]

Start: Jul 11 End: Dec 14

Need: Mission success depends equally on the proper function of the hardware and software that make up the weapon system and on the function of the operator who uses that weapon system. During system design and test and evaluation, a highly skilled operator can compensate for adverse system design though acquired skill and natural ability. As such, the adverse traits of the system may not become apparent until the system reaches fleet users. Conversely, a good system may hide a struggling student's difficulties sufficiently to allow that student to meet minimum performance requirements without attaining the skill the training event was meant to impart. A means to record and interpret both operator and system state data is needed to adequately test system design and trainee progress.

Objective: Develop a self-contained deployable system to automatically quantify combined human and system performance in real-time and for after-action-review. This technology combines inputs from Commercial Off the Shelf physiological sensors and networked data with normative models of human and system behavior to provide an objective assessment of combined operator-system performance that helps to identify the cause of performance limitations.

Benefits: By looking at both components in the warrior-weapon system, this project will allow designers of weapon systems and training systems to identify shortcomings that limit overall mission performance. Future weapon systems will be better tailored to the abilities of average fleet personnel and the progress of trainees to fleet qualification will be better documented.

Status: Phase II has been completed. During Phase II, the Fused Realities Assessments Module (FRAM) suite tested using the Small Unmanned Aircraft System (SUAS) simulated environment at Fort Benning, GA. Final results were briefed to PMA-205 and potential transition for Phase III are under investigation.

Research Products:

- Field test and data collection successful completed at Fort Benning, GA
- Successful demonstrations and press coverage of Anthropomorphic Augmented Robotic Controller (AARC) ("Wear Your Robot") spin off product

TECHNOLOGY TRANSFER PROGRAM

" ...increase development of partnerships with both public and private sectors "

Program Manager: Sunny Simmonds

The NAWCTSD Technology Transfer Program operates under the auspices of the Federal Technology Transfer Act, related laws, executive orders, directives and guidance. The anticipated benefits of sharing the results of Navy modeling, simulation, training, and human performance research and development (R&D) with public and private research organizations are: improved national, state and local training and education, new commercial products and additional national employment opportunities, access to federal government subject matter experts and resources, and feedback on R&D products that can be used to improve future government systems.

Federal technology transfer has been in place since 1980 to facilitate the transfer of federally developed technologies to the private sector as well as academic institutions and state & local governments. Federal and non-federal partners have the opportunity to work together on mutually beneficial research and development using instruments called Cooperative Research and Development Agreements or CRADAs. Technology transfer legislation also promotes the licensing of inventions/patented technologies developed in the federal laboratories for commercial applications. Through technology transfer, the nation's investment in federal research and development leads to products, services, and capabilities for the good of the public.

The objective of the NAWCTSD Technology Transfer Program is to increase the development of partnerships with both the public and private sectors in order to share the cost, development, and application of technologies, and to foster development of commercial sources for NAWCTSD technologies/innovations. This is accomplished through technology transfer vehicles such as CRADAs, Commercial Services Agreements, Licensing Agreements, and Education Partnership Agreements with academia, industry, and state and local governments. Agreements such as CRADAs can provide a vehicle for NAWCTSD to receive feedback on, and to further develop, R&D products, which can be used to improve future systems. NAWCTSD also partners with other federal government agencies through Interagency Agreements.

There are benefits to the public from the exchange of knowledge and products within the government. Exchange includes sharing information and products with other federal agencies, as well as with state and local governments. By sharing knowledge and products on a wide basis, the public reaps the benefits from research conducted for one purpose or agency in many new ways. The return on the investment of the tax dollar is increased.

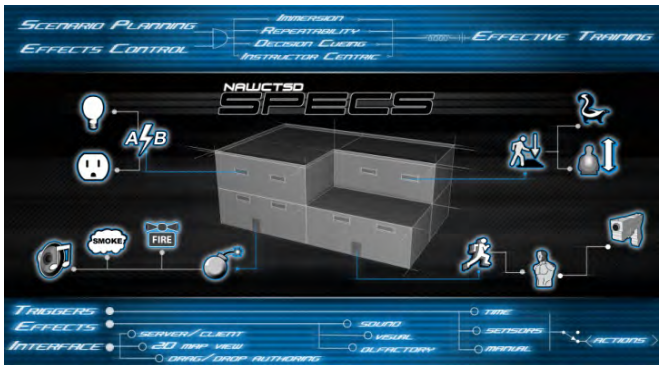
Another benefit of Federal Technology Transfer legislation has been the establishment of the Federal Laboratory Consortium (FLC). This consortium is a network of more than 700 federal laboratories and research centers. The FLC provides a nationwide laboratory forum to develop strategies and opportunities for linking federal laboratory technologies and expertise with the marketplace. NAWCTSD is a voting member of the FLC.

The technologies/products/services described in this Technology Transfer section offer opportunities for partnerships with NAWCTSD through CRADAs or licensing agreements. For additional partnering opportunities, refer to http://www.navair.navy.mil/nawctsd/Programs/Files/T2NAWCTSDProducts31Mar15.pdf.

For more information, please send an email to: ORLO_Orlando_Tech_Transfer@navy.mil.

SCENARIO PLANNING AND EFFECTS CONTROL SYSTEM (SPECS) AND AFTER-ACTION-REVIEW TECHNOLOGY

Start: Oct 09 End: Sep 15



Need: A need exists for flexible and cost-affordable scenario control and After-Action-Review technologies for highly immersive, tactical training environments designed around the concept of the instructor as the operator.

Objectives: (1) Develop and deploy a network-based system of Government and Commercial components designed to provide manual and automated control of scenario cueing and environmental effects within immersive training environments. (2) Demonstrate the cost effective use of a modified commercial, network-based video management system to support after-action-review of training scenarios. (3) Deploy an integrated suite of the scenario control and after-action-review technologies within operational immersive training environments.

Benefits: The NAWCTSD Scenario Planning and Effects Control System enables instructor/operators to provide highly detailed and repeatable immersive training scenarios by defining combinations of cause/effect, time, and manual trigger actions between various types of sensor and environmental stimuli for increased training effectiveness, trainee immersion, and reduced instructor/operator workload. The system's audio distribution engine is capable of simultaneous streaming of sound effects to any user defined speaker location or time synchronized group of speaker locations within the training environment utilizing real-time mixing of source files. The RaidFX special effect device and training stimuli control architecture is fully extensible and capable of integrating numerous devices and training aids based on common control and communication standards. The client Graphical User Interface (GUI) is designed around the concept of the instructor as the operator, and provides for the authoring and control of scenarios within the distributed system architecture. The architecture utilizes a combination of Government and Commercial-Off-the-Shelf components providing for a high degree of flexibility and sustainability. Data integration with commercially available digital video management and debriefing systems enables event-based navigation and remediation support during after-action-review.

Status: The SPECS architecture has been successfully installed and is operational within a number of immersive and mixed-reality training environments. The technology suite continues to evolve through new developments. Research and development to demonstrate compliance to the Army Live Training Transformation (LT2) architecture including integration with the Common Training Instrumentation Architecture (CTIA) was accomplished in FY14 and FY15. The USMC SPECS baseline became a LT2 software component in FY14, and a demonstration was conducted showcasing interoperability with the USMC Range Instrumentation Control (RISCon) v1.1 baseline.

Research Products:

- SPECS has transitioned and is in operation across multiple sites including non-Navy customers through the NAWCTSD Technology Transfer office.
- USMC Infantry Immersion Trainers (IIT)
- Navy's Group Two EOD Training and Evaluation Unit 2 Full Immersion Scenario Training Facility
- The Federal Law Enforcement Training Center (FLETC)
- Northeast Counterdrug Training Center High Risk Entry Facilities
- Component of USMC Range Instrumentation Control (RISCon) and Live Training Transformation

MODULAR ADVANCED TECHNOLOGIES MARKSMANSHIP PROFICIENCY

Start: Oct 12 End: Sep 16

Need: Basic marksmanship training can consume a large number of resources (manpower, range time, ammo). Approximately 15-20% of trainees that are problem shooters can consume 50% or more of these training resources. Therefore, rapid and accurate identification of performance problems is essential to reducing the total cost of basic rifle marksmanship training. However, instructors/coaches do not have access to direct measures of student performance on key marksmanship concepts (trigger control, aim point, hold, stability, breath control, etc.) at the live-fire range to assist with assessment and diagnosis of performance. Rather they must rely on fall of shot heuristic and indirect observation, unlike in simulators where instrumentation can often provide this additional information. A need exists to provide instructors access to additional measures of basic marksmanship performance at the live-fire range.

Objectives: MAT-MP is focused on providing marksmanship instructor support technologies for use at the live-fire range. These technology tools shall (1) provide instructors with additional direct measures of marksmanship performance to assist in the assessment and diagnosis of the problem shooter performance, (2) reduce instructor workload by helping to focus attention on the root cause(s) of deficient performance, and (3) support rapid evaluation of alibi claims using actual archived shot data. The goal for these technologies is to ultimately help decrease the time to qualify and increase throughput of problem shooters by helping to reduce the total number of re-shoots and non-qualifications.

Benefits: MAT-MP provides instructors at the Known Distance range a kit of tools to assist in the assessment and diagnosis of problem shooter performance. The shooter's performance can be assessed using his table of order rifle and zero. A set of sensors can be temporarily attached to the rifle platform in under five minutes that stream wireless data back to a software-based instructor assistant application hosted on a tablet computer. The data and assessment information is displayed in a graphical user interface and archived for use in delayed debrief or for alibi purposes. MAT-MP sensors provide data on basic weapon handling including trigger squeeze, trigger follow through, cant angle, buttstock pressure, and steadiness. A camera unit attached to the rear eyepiece of the combat optic provides the instructor with visual evidence of aim point and hold for each shot or series of shots. A replay feature gives instructors the option to step through the video/data frame by frame and compare different shots side-by-side. The instructor graphical interface provides for observation of up to four students at a time.

Status: MAT-MP was successfully developed and demonstrated as an advanced prototype (TRL 7) under sponsorship by the Office of Naval Research Code 30 Human Performance, Training and Education portfolio. The Mk1 version of the kit was field tested in April 2014 with Marines from Weapons Training Battalion, Quantico. Mk2 version of the kit was demonstrated in December 2014. An expanded capability Mk3 version of the kit is being transitioned in October 2015 to the Federal Law Enforcement Training Center under support by the DoD Domestic Preparedness Support Initiative. The technology is patent pending.

Research Products:

- Field test of the Mk1 version of the MAT-MP technology kit completed in April 2014.
- Mk2 version prototype demonstration completed December 2014.
- Technology assigned Patent Pending status September 2015.
- Mk3 low-rate production version transferred to Federal Law Enforcement October 2015.

CAPITAL INVESTMENT PROGRAM

" ...increase the capability of in-house laboratories..... "

As the principal Navy center for research, development, test and evaluation, acquisition and product support activity for training systems, the laboratories at NAWCTSD provide a vital capability to ensure that we deliver the latest products and services to the fleet that are rooted in the science-of-learning. NAWCTSD's laboratory environments allow our scientists and engineers to perform the latest in research and development and accelerate the state-of-the-art for a broad spectrum of customers and warfare areas.

Since FY12, the NAWCAD Capital Investment Program (CIP) has become instrumental in ensuring that NAWCTSD laboratory capabilities will be well positioned to address future warfighting needs. As a working capital funded organization, NAWCTSD competes yearly for CIP funds to enhance our laboratory capabilities. CIP is funded by depreciation of prior acquired assets and are included in the labor rates charged to direct customers.

Currently, NAWCTSD has been approved for eight significant investment projects through FY15, with more on the horizon. This includes modernization or our Weapon Systems Integration Lab; standup of a new Software Integration & Information Assurance Lab; two projects that will significantly enhance our electrical & mechanical fabrication lab with a state-of-the-art CNC machine and 3D printing capabilities; an interoperability toolset for automating test compliance with the Navy Continuous Training Environment; a modern neurophysiological assessment system for performing the latest science-of-learning research; modernization and standardization of our communications and speech technology development capabilities; and a new Unmanned Systems lab. Together, these and future investment projects will keep NAWCTSD at the forefront of the R&D community associated with delivering the latest modeling, simulation, training and education products to the fleet.

The following pages describe the NAWCTSD labs that are currently operational.

DISTRIBUTED TRAINING NETWORK GUARD (DTNG)

Start: Sep 14 End: Sep 16

Need: Distributed training environments are in need of a Cross Domain Solution (CDS) that enables system connectivity operating at differing classification levels along with the ability to process multiple live, virtual and constructive (LVC) protocols.

Objective: Develop a CDS that allows for enhancements in a cost effective, short time period. The CDS must bridge two dissimilar simulation network classification domains via filter rule sets that pass, fail or sanitize HLA, DIS or TENA protocols.

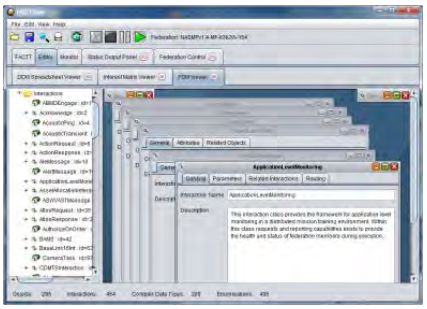
Benefits: The Distributed Training Network Guard (DTNG) is a government-owned CDS which enables LVC systems operating at differing classification levels to connect in a cost effective short timeframe. DTNG is being developed in synergy with the Air Force (AFAMS, DMOC), Army (KORCOM), Joint Staff J7, Test Resource Management Center (TRMC) and the Navy (NAWCTSD), with NAWCTSD leading the development. DTNG provides an economical first step in establishing Cross Domain Information Sharing (CDIS) enterprise services. DTNG supports multiple protocols including High Level Architecture (HLA 1.3); Joint Live Virtual Constructive (JLVC) HLA 1516e; Distributed Interactive Simulation (DIS 6); and the Test and Training Enabling Architecture (TENA).

Status: DTNG is currently being developed in the Interoperability, Design, Engineering & Application (IDEA) lab, with the first phase supporting HLA and DIS protocols. This development phase is nearing completion and heading for Certification, Test and Evaluation (CT&E) in late Q2 of FY16. The TENA protocol will be completed in a future development phase.

Research Products: Common domain solution software algorithm (Sept 15).

INTEROPERABILITY TOOL

Start: Sep 13 End: Sep 16



Need: NAWCTSD requires the capability to fully test training systems interoperability requirements during Developmental Test (DT), Operational Test (OT), and Fleet Synthetic Training (FST).

Objective: Develop an automated software product to test training system interoperability interfaces. Combine existing individual tools into a single application that uses a plug-in based architecture. Provide toolset to the training system developer and deploy to nine In-Service engineering sites to test and verify new and modified aviation training systems.

Benefits: Automated testing will prevent loss of training due to inability to test all interoperability requirements. Shortens the testing and integration time needed for distributed training events. Federation Object Model (FOM) agnostic application allows migration between different FOM versions without the need to rewrite High Level Architecture (HLA) interfaces.

Status: Federation Agreements Compliance Test Tool (FACTT) Suite version 1.0 is scheduled for release during the first quarter of FY16. Future versions with extended capability are scheduled for later in the fiscal year.

Research Products: Interoperable interface software product (Oct 15).

NAVY AVIATION DISTRIBUTED TRAINING CENTER – PROOF OF CONCEPT

Start: Sep 14 End: Sep 16

Need: NAWCTSD does not have an efficient method to integrate Navy Aviation trainers into Navy Aviation Simulation Master Plan (NASMP) and Fleet Synthetic Training – Aviation (FST-A) exercises. Unlike Fleet Synthetic Training – Joint (FST-J) exercises, NASMP and FST-A exercises do not have a centralized, dedicated team to run integration, scheduling, exercise execution and brief/debrief. Currently, site instructors must coordinate, plan, and execute distributed FST-A and NASMP exercises without the required external technical expertise and support. This leads to lost training opportunities, including Training and Readiness (T&R) credit and frustration within the Fleet. As more NASMP trainers come on line, the opportunity for more dynamic and complex missions, along with LVC training, will be possible.

Objective: Design and implement a proof of concept for a Navy Aviation Distributed Training Center (NADTC). This proof of concept will be used as the basis for two Navy Aviation Distributed Training Centers; one on the west coast and one in the east coast. These centers will be able to coordinate, plan, schedule, integrate and execute NASMP and FST-A exercises with participating Navy Aviation trainers.

Benefits: Designing and implementing a NADTC will enable Navy Aviation to conduct distributed training exercises more efficiently, provide more opportunities for Navy Aviation trainers to participate in distributed training exercises, provide more opportunity for crews to earn T&R credit and reduce the workload of the participating sites' instructors by removing technical barriers and roleplaying requirements.

Status: The NADTC Proof of Concept (POC) was designed in Fall of 2014 and built in January 2015. The NADTC POC has since been renamed Virtual Aviation Distributed Environment and Research (VADER) to delineate between the Orlando POC and the final NADTCs delivered to Oceana and Pt. Loma in FY-17/18. VADER is an R&D asset, not a NADTC. VADER resides in the Interoperability, Design, Engineering and Application (IDEA) lab. VADER was utilized from April-June 2015 to integrate Strike and Maritime platforms for two separate technical demonstrations in June 2015 between six different sites. The technical capability was successfully demonstrated, leading to PMA 205 leadership requesting an actual exercise in September 2015 with Maritime trainers (H60R, H60S and P-3C) to demonstrate ability for crews to earn Readiness. Six training systems at four separate sites were tested and integrated from August 2015 – September 2015, leading to a successful Maritime exercise and Readiness earned for participating crews. VADER has now become the central hub for integrating and testing all new and upgraded Navy Aviation trainers, to include mission scenario testing. This allows for more robust requirements verification and validation, leading to more T&R opportunities for crews during FST-A and FST-J exercises. VADER will also continue to be utilized as an R&D asset for testing future NADTC improvements before they are implemented at the NADTC sites. Final NADTC Design is scheduled to be contracted and delivered to Oceana (East Coast) 2Q FY-17 and to TTGP (West Coast) 1Q FY-18.

Research Product:

- VADER built and integrated onto NCTE (March 2015)
- VADER Strike and Maritime trainer integration (April – June 2015)
- VADER Maritime (H60R and P-3C) and Strike (F/A-18 C/D and E-2D) technical demonstration for PMA 205 leadership. (June 2015)
- VADER Maritime Exercise. (H60R, H60S and P-3C) at 4 separate sites. Readiness earned by participating crews. (September 2015)
- VADER designated R&D verification and validation asset utilized for all new and upgraded Navy Aviation training systems. (September 2015)

NEUROPHYSIOLOGICAL MEASUREMENT AND ASSESSMENT

Start: Sep 13 End: Dec 14

Need: Advanced human performance measurement and assessment systems are needed to support ongoing and future capacity for in-house, state-of-the-art science and technology efforts requiring electroencephalogram (EEG) and physiological measuring technologies.

Objective: Procure state-of-the art measurement and assessment capabilities to support current and future science and technology objectives.

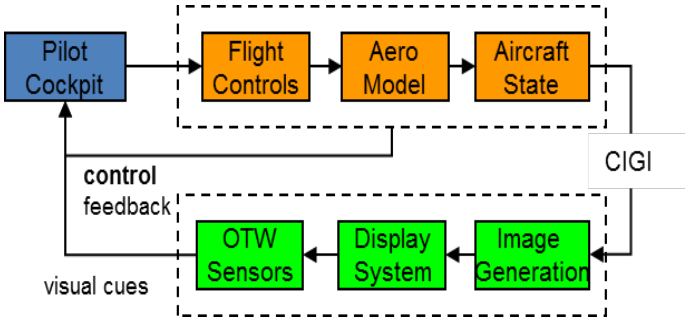
Benefits: With this investment, researchers at NAWCTSD now have a list of technologies at their disposal including two Electrical Geodesics flagship 128 channel EEG systems, two Seeing Machines Face Labs eye tracking systems, two Thought Technologies physiological measurement suites, three Advanced Brain Monitoring BeAlert X-24 EEG systems, and an X-10 EEG. These added in-house capabilities will further the ability to assess the human-system relationship and substantially increase participation in the fields of Augmented Cognition and Neuroergonomics. NAWCTSD's researchers will work to expand RDT&E in areas including teamwork assessment, personnel selection, and interface design through basic and applied physiological signal monitoring and interpretation. Most importantly, while new, the neurophysiological assessment capability has been designed to be flexible and grow to meet existing, emerging, and future needs as they arise and as both the technology and the needs of the Navy mature.

Status: The Neurophysiological capability was fully stood up by the close of calendar year 2014.

Research Products: New Neurophysiological measurement and assessment lab capability integration (Dec 14).

VISUAL SYSTEMS LAB

Start: Sep 14 End: Sep 15



Need: Capability to assess critical visual/aero training technologies to determine suitability to perform training in simulators vice aircraft. Need to reduce flight hours; increase use of "qualified" simulation; identification of critical training gaps; increase technology exploration; and reduce program risk through the development of traceable performance specifications.

Objective: Develop a reconfigurable simulation environment for the integration of visual & aero modeling technologies to assess fleet training requirement needs (e.g., carrier landings) and methods to define and achieve fidelity requirements in support of

- matching essential training objectives with the appropriate perceptual cues,
- optimizing visual and aero fidelity requirements (e.g., visuals, sensors, loaders, aero models, etc.) based on training objectives and tasks, and
- ensuring technology alignment with platform modernization.

Benefits: Reduce flight hours and increase use of "qualified" simulation; identify critical training gaps, and provide high risk concept verification; support visual/aero technology exploration and risk management; and mitigate acquisition strategy risk and improve performance specifications.

Status: The Contractor AVT Simulation, delivered enhancement upgrades to the Naval Air Warfare Center Training Systems Division (NAWCTSD) visual/aero assessment system with a modernized, integrated visual/aero testing suite that supports continued research for aerial refueling training. Under a Real Image Aerial Refueling Prototype and Small Business Innovation Research (SBIR) Phase III contract AVT delivered four new high resolution projectors with flexible mounting structures and an auto-alignment system to an existing 200 x 60 degree display screen. Also added was a new four channel MetaVR image generator with a full North American terrain database and the air refueling database models. The models include the Navy F-18 "Buddy Tanker", the USAF KC-135 Tanker with its' challenging Boom Drouge Attachment (BDA), and various wingman aircraft.

AVT integrated these visual system components with the air refueling simulation computers and software developed in the previously awarded Navy SBIR Phase II contract for Air Refueling. The combined visual/simulation system was then integrated with an existing Navy F-18 cockpit hands on throttle and stick (HOTAS) controls and cockpit. This modernized aerial refueling simulation capability will allow continued Navy research of real image displays and air refueling visual and aero modeling techniques and capabilities.

Research Products: Successful installation of reconfigurable projector mounting structure, LED projectors, video switch, and new auto alignment system.

OTHER NAVY, DOD AND JOINT PROJECTS/PROGRAMS

SQUAD OVERMATCH – TACTICAL COMBAT CASUALTY CARE

Start: Aug 15 End: Dec 16

Need: Tactical Combat Casualty Care (TC3) is, by definition, team decision making under stress. It requires interdependent squad members, performing their role-based critical tasks, to make decisions that achieve a set of common goals under extreme stress.

Objective: The objective of SOvM-TC3 is to develop a capability affording Army 68W Combat Medics, Navy Corpsmen, Army/Navy/Marine Corps Combat Life Savers, and TC3 first-responders the opportunity to practice simulation-based Care Under Fire and Tactical Field Care skills in a squad-based, integrated training immersive environment.

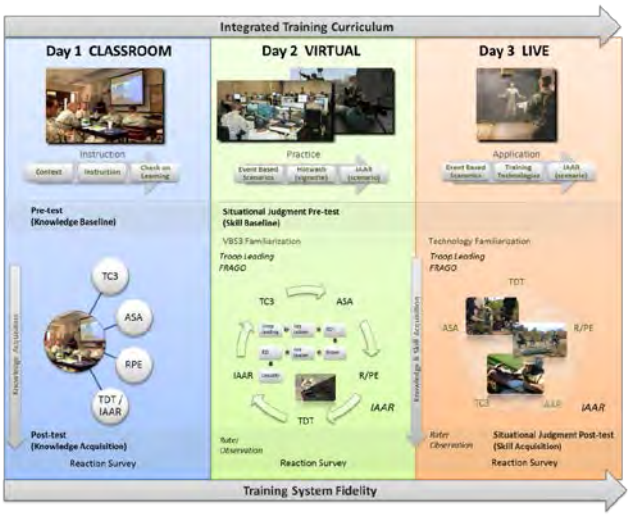


Figure: SOvM-TC3 Integrated Curriculum contents and organization.

Benefits: SOvM-TC3 is teaching integrated combat skills. More than building knowledge, this effort is about developing skills through application to increase mission capability. Squads get a chance to put all these skills to use in tactical scenarios, to give them hands-on experience at where, when, and how to apply the targeted skills to make themselves more tactically effective units.

The Collective TC3 training course developed within this project spans three days and includes Classroom, Virtual and Live training. TC3 providers and squad leadership receive instruction on and have opportunities to practice and apply teaming skills, medical and tactical decision making skills, and stress response skills in a series of increasingly complex and challenging virtual and live environment mission scenarios following a contiguous storyline.

Status: A joint research team including the Naval Air Warfare Center Training Systems Division (NAWCTSD), Army Research Laboratory Simulation and Training Technology Center (ARL STTC), Walter Reed Army Institute of Research (WRAIR), the Fort Benning Maneuver Center of Excellence (MCoE), and Marine Corps Systems Command Program Manager for Training Systems (PM TRASYS), in an effort helmed by the Army Program Office for Simulation, Training and Instrumentation (PEO-STRI), is conducting this study evaluating an integrated curriculum and technology enhancements in gaming and live environments to improve TC3 effectiveness for Army and Marine Corps Infantry squads through integrated training. This effort is funded by the Office of the Secretary of Defense's Defense Health Office Joint Program Committee – 1.

Each day of the 3 day curriculum includes the integration of various training media to support individual and collective TC3 response: Classroom including PowerPoint, interactive discussion, scenario diagnostic exercises, and hands on part task medical simulators; Virtual involving tactical and medical scenarios – Virtual Battlespace 3 (VBS3) has been augmented with TC3Sim, a game based TC3 trainer; and Live environments incorporating a wide variety of training media ranging from simulated artillery and IED blasts to interactive wall avatars interacting as opposing forces capable of inflicting and receiving casualties, as role-players, key leaders, and tactical questioning targets, and as casualties capable of incorporation into triage and TC3 scenario management. Warfighters and role-players in the live environment are also equipped with MILES gear augmented with electronic casualty display devices enabling TC3 responders to identify, prioritize and succeed or fail to provide appropriate treatment according to realistic timelines and prognoses. Role players were equipped with moulage and simulated injuries to increase realism. Data collection was conducted at Fort Benning at the McKenna MOUT and Clarke Simulation Centre in October and November 2015.

Follow-on work in FY16 will involve a training effectiveness evaluation incorporating Army and Marine Corps infantry squads augmented with 68W Medics and Hospital Corpsmen, respectively, in a quasi-experimental design intended to help quantify the benefit of the SOvM-TC3 integrated training approach.

Research Products:

- Program Outbrief, 4 Nov 2015.
- NAWCTSD & USMC Training and Education Command (TECOM) Colloquium (19 Nov 2015).
- Technical Report for year 1 in development (Dec 2015).

SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM) EDUCATIONAL OUTREACH

NAWCTSD STEM PROGRAM

STEM COORDINATORS: Bob Seltzer and Dani McNeely

NAWCTSD supports Department of Defense (DoD) and Navy Science, Technology, Engineering and Mathematics (STEM) goals and priorities. Through Command and ONR funding support, the Program addresses the challenge to educate, train, recruit and retain personnel in STEM critical skill shortfall disciplines for National Security and Defense needs. The Navy's STEM Program, is built around five priorities:

1. **Inspire** the next generation of scientists and engineers (S&Es)
2. **Engage** students and build their STEM confidence and skills through hands-on learning activities that incorporate naval-relevant content
3. **Educate** students to be well prepared for employment in STEM careers that support the Navy and Marine Corps
4. **Employ**, retain and develop Naval STEM professionals, and
5. **Collaborate** across the Naval STEM enterprise, and with best practices organizations to maximize benefits to the Department.

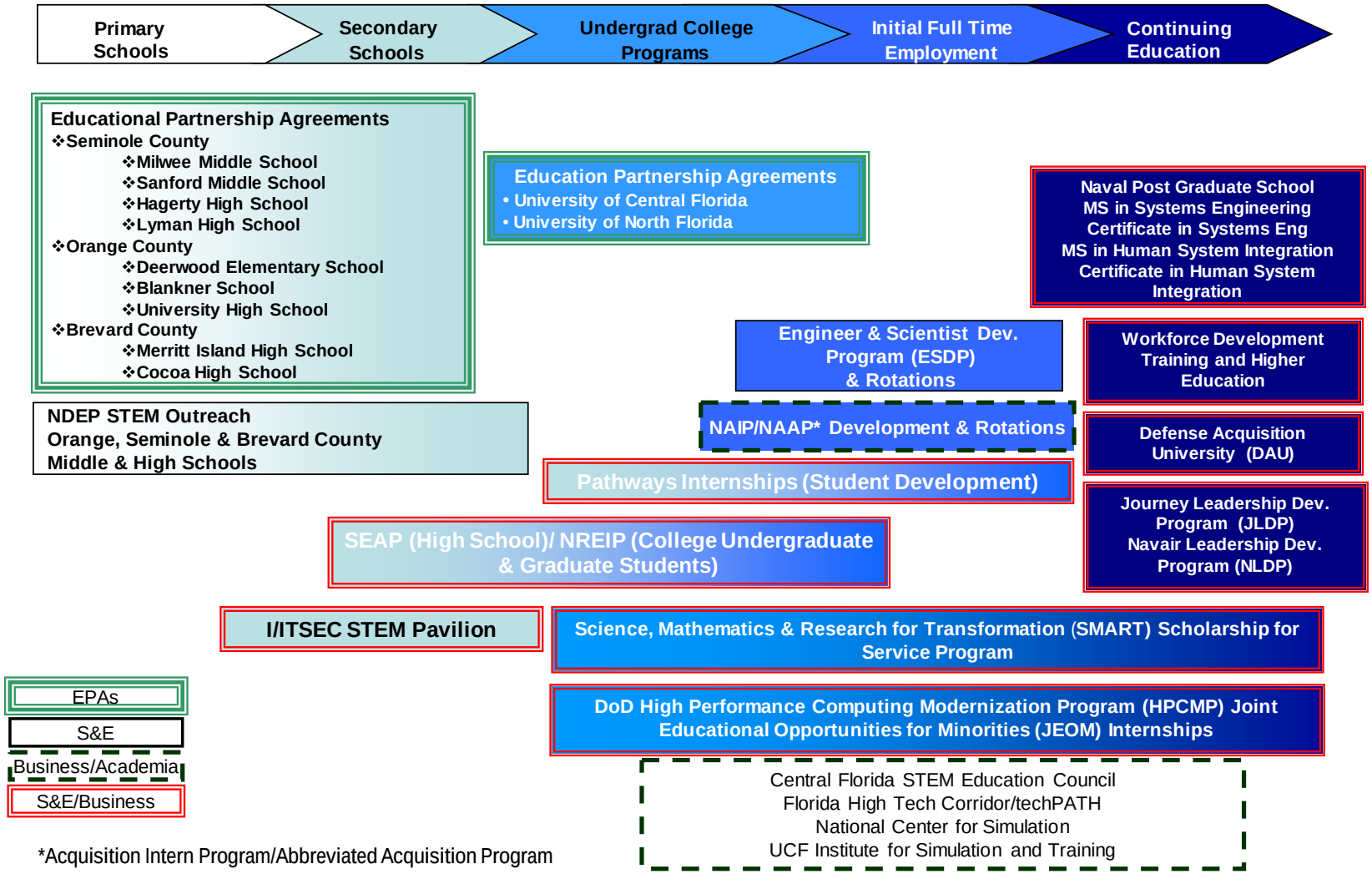
NAWCTSD'S implementation of the National Defense Education Program/ONR-supported STEM initiatives commenced in late 2009, however, NAWCTSD has had a 25-year partnership with the Blankner School (K-8) in Orange County, where NAWCTSD has provided mentors, laboratory tours, job-shadow opportunities and awards/incentives for students. NAWCTSD has also had strong relationships with the University of Central Florida (UCF), providing internship opportunities for UCF students.

Today, NAWCTSD is committed to energizing STEM education in area schools by partnering scientists and engineers with teachers in classrooms to facilitate inquiry and design through project-based learning. NAWCTSD provides training opportunities for professional development of science and math teachers, provides mentors for robotics, STEM clubs, summer interns and at risk students, provides tours of NAWCTSD laboratories and demonstrations of modeling and simulation technologies for students and educators, and supports science fairs, teach-ins, science/technology field trips and summer camps. To enhance STEM education in the Central Florida area, NAWCTSD has partnered with Orange, Seminole, and Brevard County Public Schools, the University of Central Florida, the National Center for Simulation Education and Workforce Development Committee, members of the Central Florida STEM Education Council (CFSEC) and the Florida High Tech Corridor Council's techPATH.

NAWCTSD provides high school and college undergraduate and graduate level summer internship opportunities to include the following programs: Science and Engineering Apprenticeship Program (SEAP), Naval Research Enterprise Internship Program (NREIP), and Joint Educational Opportunities for Minorities (JEOM). Numerous development opportunities are provided for the NAWCTSD workforce such as Naval Post Graduate School courses for degrees/certifications, Defense Acquisition University (DAU) courses and certifications, NAVAIR leadership development programs (JLDP, NLDP) and Science, Mathematics & Research for Transformation (SMART) Scholarship for Service Program.

The following figure illustrates the NAWCTSD STEM Program Continuum.

NAWCTSD STEM Continuum



*Acquisition Intern Program/Abbreviated Acquisition Program

TEACHERS AND SCIENTIST & ENGINEER (S&E) PARTNERSHIPS

- ***SeaPerch***

NAWCTSD has coordinated training of NAWCTSD S&Es with teachers and trainers from Seminole and Orange County Public Schools, the Girl Scouts, Boys and Girls Clubs of Central Florida, the Orlando Science Center (OSC), and the YMCA. As a result of this training, SeaPerch clubs have been formed in Seminole County Public Schools, the OSC continues to offer SeaPerch summer camp sessions, the Army PEO STRI continues to use SeaPerch in its summer intern program, and the YMCA uses the SeaPerch activity in it's after school programs.

- ***STEM Clubs***

In FY15, NAWCTSD S&Es assisted teachers with robotics programs in middle schools and high schools in Orange, Seminole and Brevard counties. S&Es also organized and ran a Math Club at Deerwood Elementary School in Orange County and tutored students in the Norfolk, Virginia area.

- ***Oak Ridge High School Aviation/Aerospace Magnet Program***

NAWCTSD has been an active partner in the development and roll-out of the new Oak Ridge High School Aviation/Aerospace Magnet Program. NAWCTSD has provided five aerospace engineer mentors and provides lab tours and material funding.

MENTORING AND INTERNSHIPS

- ***Teach-ins***

American Education Week, held in November of each year, is a national celebration of public education. NAWCTSD S&Es participated in this event by taking part in Teach-Ins at area schools. The S&Es spoke about their careers in STEM fields, NAWCTSD and the Navy in general. The response from the schools and students are overwhelmingly positive and our S&Es continue to return year after year.

- ***Blankner School Mentoring and Job Shadow Day***

Throughout the year, several NAWCTSD employees mentor at risk students of Blankner K-8 School. Mentors spend at least one hour per week assisting students at the school. In addition, at the end of the year, 8th grade students are provided with a Job Shadowing opportunity. This year, approximately 25 students shadowed NAWCTSD employees, had lunch with job shadow partners and attended 1-2 modeling and simulation demonstrations.

- ***FIRST Robotics Teams***

In the school year 2014-2015, NAWCTSD S&Es continued to mentor FIRST Robotics Competition (FRC) teams at Merritt Island and Cocoa High Schools, FIRST Tech Challenge (FTC) teams at University and Hagerty High Schools and FIRST Lego League (FLL) teams at Sanford and Milwee Middle Schools. During the FIRST season, S&Es met with teams at least once a week and they attended competitions with teams. Additionally, a NAWCTSD engineer mentors the University of Central Florida (UCF) Robotics Club. NAWCTSD S&Es continue to support area robotics teams.

- ***Summer Interns***

Every summer, NAWCTSD scientists and engineers (S&Es) mentor high school and college undergraduate/graduate students through the Office of Naval Research (ONR) internship programs, Science and Engineering Apprenticeship Program (SEAP) and Naval Research Enterprise Internship Program (NREIP), and the DoD High Performance Computing Modernization Program's Joint Educational Opportunities for Minorities (JEOM) internship program. SEAP places academically talented high school students with interest and ability in science and mathematics as apprentices in Department of the Navy laboratories for eight weeks during the summer. NREIP is a ten-week intern program designed to provide opportunities for undergraduate and graduate students to participate in research, under the guidance of an appropriate research mentor, at a participating Navy laboratory. Students from the local area high schools, the University of Central Florida and other universities were mentored by NAWCTSD S&Es this past summer.

COMMUNITY/SPECIAL STEM EVENTS

- ***Science Olympiads***

Science Olympiad competitions are like academic track meets. Each year, a portion of the events are rotated to reflect the ever-changing nature of genetics, earth science, chemistry, anatomy, physics, geology, mechanical engineering and technology. By combining events from all disciplines, Science Olympiad encourages a wide cross-section of students to get involved. Emphasis is placed on active, hands-on group participation. Through Science Olympiad, students, teachers, parents, principals and business leaders bond together and work toward a shared goal.

The culmination of more than 280 regional and state tournaments is the Science Olympiad National Tournament, held at a different university every year. This rotating system gives kids a chance to visit new parts of the country, to tour colleges they might consider for their undergraduate studies, and provides a memorable experience to last a lifetime.

In 2015, NAWCTSD S&Es assisted with several events at the Florida State Science Olympiad and the Elementary Science Olympiad both held at the University of Central Florida. S&Es have also supported Science Olympiads in previous years.

- ***Summer Camps***

In the Summer of 2015, NAWCTSD hosted several summer camp groups. One of these groups was the ZORA! STEM middle school camp which was hosted in partnership with the National Center for Simulation and UCF's Institute for Simulation and Training. In addition, one FRC team – 12 Volt Bolt and a UCF Camp Connect group toured NAWCTSD. Approximately 62 students were treated to demonstrations of simulators and discussions involving engineering, science and aviation careers.

- ***Scientist For A Day***

For the 2015 Bring Your Kid(s) To Work Day, NAWCTSD hosted a Scientist For A Day event. Kids and parents alike experienced various lab stations where they learned science hands on. Stations included lessons like the science behind batteries where the kids learned how make a coin battery, and how opposites repel each other while making a colorful keepsake of their experiment. Another station taught them about surface tension by making a paper clip float. A favorite station by all in attendance was the one where you made your own catapult and learned about how the Navy uses catapults. The future scientists/engineers were delightfully able to launch their marshmallows farther than some of our engineers'.

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APPENDIX A

NAWCTSD Orlando R&T Focus Area Project Crosswalk

4 R&T Focus Areas:

1) Human Performance Modeling & Assessment
2) Human Systems Design and Decision Support
3) Virtual Environments & Training Technologies
4) Dist., Live, Virtual & Constructive Synthetic Training

KEY: ✓✓ = Primary Focus
✓ = Secondary Focus

TITLE	NAE STOs			4.6 R&T Focus Area			
	NWP STO-1 Training & Education.	NWP STO-2 Human Systems. Design & Decision Support	ID STO-1 Command & Control	HP Model & Assessment	Human Systems, Design & Decision Support	Virtual Environments & Training Technologies	Dist. LVC Synthetic Training
SCIENCE & TECHNOLOGY							
Discovery and Invention Research							
Basic Electricity and Electronics Tutorial Learning Environment – Human Computers and Speech (BEETLE HSC)	✓✓			✓✓		✓	
Tutoring Effectively: An Assessment of Common Heuristics (TEACH)	✓✓			✓✓		✓	
Human Systems Integration Progress & Risk Specification Tool (HPRST)	✓✓	✓			✓✓	✓	
In-House Laboratory Independent Research Projects							
Measuring Intuition and its Relationship to Somatic Markers and Individual Differences	✓✓			✓✓			
Impact of Low-Cost Haptic Feedback on User Performance and Workload	✓✓				✓		

TITLE	NAE STOs			4.6 R&T Focus Area			
	NWP STO-1 Training & Education.	NWP STO-2 Human Systems. Design & Decision Support	ID STO-1 Command & Control	HP Model & Assessment	Human Systems, Design & Decision Support	Virtual Environments & Training Technologies	Dist. LVC Synthetic Training
Independent Applied Research Projects							
Tailoring Instruction to the Individual: Investigating the Utility of Trainee Aptitudes for Use in Adaptive Training	✓✓			✓✓		✓	
Advanced Technology Development							
Carrier Qualification Training Reduction via Advanced Piloting Systems (CQTRAPS)	✓✓	✓		✓	✓✓	✓	
Modular Advanced Technologies Marksmanship Proficiency	✓✓	✓		✓		✓✓	✓
Capable Manpower Future Naval Capability Research							
Adaptive Training for Combat Information Center Teams	✓✓		✓	✓✓		✓✓	
Adaptive Training for Submarine Piloting and Navigation	✓✓			✓✓		✓✓	
Distributed, Adaptive, and Modular entities for Unmanned Aerial Systems (DyAdeM)	✓	✓✓		✓✓		✓	✓
Live, Virtual, and Constructive (LVC) Training	✓✓	✓		✓		✓	✓✓

TITLE	NAE STOs			4.6 R&T Focus Area			
	NWP STO-1 Training & Education.	NWP STO-2 Human Systems. Design & Decision Support	ID STO-1 Command & Control	HP Model & Assessment	Human Systems, Design & Decision Support	Virtual Environments & Training Technologies	Dist. LVC Synthetic Training
Naval Innovative Science and Engineering							
Basic and Applied Research							
Developing Warfighter Training Guidance for Cue Recognition of Trustworthiness in Culturally-Complex Environments	✓✓			✓✓	✓		
Improving Team Problem-Solving and Decision-Making using Communication Protocols	✓	✓✓		✓✓		✓	
Investigating Low-cost Untethered Virtual Reality Technologies And The Role of Affordances On Training Effectiveness In An Immersive Environment	✓✓	✓			✓✓	✓	
3D Interactive Aircraft Carrier Operations Planning Tool Prototype	✓✓	✓			✓✓	✓	
Information Presentation Modality: A Phased Solution	✓✓	✓			✓✓	✓	
Next Generation of Aviation Selection: Unmanned Aerial Systems	✓✓	✓	✓	✓✓		✓	
Optimizing Performance of Trainees for UAS Manpower, Interface & Selection (OPTUMIS)	✓✓	✓	✓	✓✓		✓	
The Efficacy of Feedback Parameters in Adaptive Training Systems	✓✓			✓✓		✓	

TITLE	NAE STOs			4.6 R&T Focus Area			
	NWP STO-1 Training & Education.	NWP STO-2 Human Systems. Design & Decision Support	ID STO-1 Command & Control	HP Model & Assessment	Human Systems, Design & Decision Support	Virtual Environments & Training Technologies	Dist. LVC Synthetic Training
Usability Survey Enabling Research and Assessment for Intuitive Designs (USER AID)		✓✓		✓✓		✓	
Virtual Environment Motion Fidelity Model	✓	✓✓			✓	✓✓	
Examining the effects of game features on learning in scenario-based training	✓✓	✓				✓✓	
Workforce Development: Strategic Growth							
A Brave New "Virtual" World: The Use of Virtual World Applications for Military Training	✓✓					✓✓	✓
Reverse Engineering Capability of 3-Dimensional Physical Objects	✓	✓✓			✓	✓✓	
Human Performance Model Validation Process	✓✓			✓		✓✓	
NAWCTSD Knowledge & Laboratory Expertise Advancement Regarding the Application of Cutting Edge Embedded Signal Processing Designs to Military Training and Simulation	✓✓	✓				✓	✓✓
Deploying 3D Game Engine Training Content on a Web Based Learning Management System	✓	✓✓			✓	✓✓	
Fusing High Dimensional Data Sources (FHDDS)	✓✓					✓✓	

TITLE	NAE STOs			4.6 R&T Focus Area			
	NWP STO-1 Training & Education.	NWP STO-2 Human Systems. Design & Decision Support	ID STO-1 Command & Control	HP Model & Assessment	Human Systems, Design & Decision Support	Virtual Environments & Training Technologies	Dist. LVC Synthetic Training
Transition							
Human Performance Based Simulation Certification Criteria Test and Evaluation Job Aid – Requirements Tracing Tool (RETT)	✓✓	✓			✓	✓✓	
Basic Electronics and Electricity Learning Environment (Beetle) II Transition	✓✓	✓		✓	✓✓		
System Evaluation for Training and Test Tool (SETT)	✓✓	✓		✓	✓✓		
Augmented Training for Experiential Learning For Landing Signal Officers	✓✓	✓		✓	✓✓		
TRANSITION RESEARCH							
Intelligent Tutoring and Authoring Delivery System (ITADS)	✓✓			✓		✓✓	
Air Warfare Training Development (AWTD) Program							
Performance Measurement (PM) Engine	✓✓			✓✓			✓
Post Mission Assessment for Tactical Training & Trend Analysis (PMATT-TA)	✓✓	✓		✓✓		✓	✓

TITLE	NAE STOs			4.6 R&T Focus Area			
	NWP STO-1 Training & Education.	NWP STO-2 Human Systems. Design & Decision Support	ID STO-1 Command & Control	HP Model & Assessment	Human Systems, Design & Decision Support	Virtual Environments & Training Technologies	Dist. LVC Synthetic Training
SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM & SMALL BUSINESS TECHNOLOGY TRANSITION RESEARCH (STTR)							
SBIR Phase I Projects							
Methods for Actionable Measures of Absolute Cognitive Workload [N16A-T002]	✓✓	✓		✓	✓✓		
Immersive Parachute Descent Procedure, Malfunction and Decision-Making Training System [N161-007]	✓✓	✓		✓	✓✓		
Crew Role-player Enabled by Automated Technology Enhancements (CREATE) [N142-090]	✓✓	✓		✓	✓✓		
Effective Measures of training display system performance [N142-104]	✓	✓✓			✓✓	✓	
SBIR Phase II Projects							
Distributed Synthetic Environment correlation assessment [N141-006]	✓✓					✓✓	✓
Mask-on Hypoxia Training Device [132-093]	✓✓					✓✓	
Common Unmanned Vehicle Control Procedures Trainer	✓	✓✓		✓	✓	✓✓	
Decoupled Rendering Channels to Reduce Logistical Support Spares Requirements of Large Scale Training Centers [N131-018]	✓✓				✓	✓✓	

TITLE	NAE STOs			4.6 R&T Focus Area			
	NWP STO-1 Training & Education.	NWP STO-2 Human Systems. Design & Decision Support	ID STO-1 Command & Control	HP Model & Assessment	Human Systems, Design & Decision Support	Virtual Environments & Training Technologies	Dist. LVC Synthetic Training
Geospecific Displacement Maps for Real Time, Stereoscopic Training Simulation (N102-116)	✓✓	✓	✓			✓✓	✓
Hyper-Elevation Modeling of Terrain, Topography & Urban Environments (N091-026)	✓✓					✓✓	
Innovative Collimated Displays (N121-041)	✓✓	✓				✓✓	
New and Improved Radio Frequency (RF) Modeling for Correlated Environment Communication System Simulators with Sensor Simulators [N121-011]	✓✓	✓	✓			✓✓	✓
Reconfigurable Aerial Refueling Trainer [N102-124]	✓✓					✓✓	
Small Projector Array Display System	✓✓					✓✓	
STTR Phase II Projects							
Automated Human and System Performance Assessment in Operational Environments [N11A-T001]	✓✓			✓✓		✓	✓
TECHNOLOGY TRANSFER							
Scenario Planning and Effects Control System (SPECS) and After-Action Review Technology	✓✓			✓		✓✓	

TITLE	NAE STOs			4.6 R&T Focus Area			
	NWP STO-1 Training & Education.	NWP STO-2 Human Systems. Design & Decision Support	ID STO-1 Command & Control	HP Model & Assessment	Human Systems, Design & Decision Support	Virtual Environments & Training Technologies	Dist. LVC Synthetic Training
CAPITAL IMPROVEMENT PROGRAM							
Distributed Training Network Guard (DTNG)	✓✓		✓			✓	✓✓
Interoperability Tool	✓✓	✓	✓		✓	✓	✓✓
Navy Aviation Distributed Training Center – Proof of Concept	✓✓					✓	✓✓
Neurophysiological Measurement and Assessment	✓	✓✓		✓	✓	✓✓	
Visual Systems Lab	✓✓	✓		✓	✓	✓✓	
OTHER NAVY, DOD AND JOINT PROJECTS/PROGRAMS							
Squad Overmatch – Tactical Combat Casualty Care	✓✓			✓		✓✓	✓

APPENDIX B

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NAWCTSD LABS

LAB	MISSION
Weapons Launch Console Team Trainer (WLCTT) Lab	Provide Life Cycle Support for the Integrated Undersea Surveillance System (IUSS) TL-29 and ICP synthetic acoustic analysis training. Develop, test and aid in the life cycle support and new development of the WLCTT fielded trainers.
Submarine Piloting & Navigation (SPAN) Lab	Develop Submarine Piloting & Navigation training system prototypes for NAVSEA, and provide smart buyer awareness for future submarine training system acquisition.
Virtual Environment for Submarine Shiphandling (VESUB)	Develop VESUB training system prototypes for NAVSEA and provide smart buyer awareness for future submarine training system acquisition.
Concept Development & Integration Lab (CDIL)	Research and prototype development of interoperable live, virtual and constructive training devices and technologies, and provide smart buyer awareness to training system acquisition programs.
Virtual Technology Development Operations Center (VTDOC)	Provide technology development and operations center for distributed simulation and training exercises.
Technology Integration Facility (TIF) (AKA Dome Room)	Provide Visual Systems analysis, system integration and Command demonstrations.
Training & Usability in Simulation-based Tools (TRUST) Lab	Conduct science & technology research & development, & acquisition activities through analysis, design, development, test, usability evaluation & transition of state-of-the-art products that enhance the training & operational capabilities of the nation's warfighters
Human Systems Integration S&T Lab (HSIL)	Conduct research, development and application of HSI tools, techniques, and technologies to Navy systems engineering and acquisition.
Anti-Submarine Warfare Center of Excellence (ACE) Lab	Develop Anti-Submarine Warfare Training Prototypes for the warfighter.
Trident Training System (TTS) Lab	Provide primary simulation and training support to the Trident Ballistic Missile Submarine force. Also provide simulation and training support for other UNDERSEA assets.
Live, Virtual & Constructive Modeling & Simulation (LVCMS) Lab	Integration Research and Development for development of ASW Training Systems.
Improving Multicultural Performance, Adaptability, & Competence in Teams (IMPACT) Lab	Investigation of interpersonal trust and the development of knowledge, skills, and abilities to accelerate Warfighter effectiveness when operating in multicultural environment.

NAWCTSD LABS (Cont'd)

LAB	MISSION
Acoustic Training & Simulation Lab (ATaS)	Provide current sensor and acoustic data used in modeling and simulation across Navy Anti-Submarine Warfare training devices.
Interoperability, Engineering & Application (IDEA) Lab	Provide simulation interoperability tools and technical expertise in support of joint, live, virtual, constructive programs and related research, development, and acquisition efforts.
Intelligent Virtual Environments for Naval Training (InVENT) Lab	Conduct applied research into techniques for incorporating pedagogical intelligence into virtual training environments. The lab is staffed by an interdisciplinary team that includes software developers, research psychologists, instructional system designers, systems engineers and other training acquisition professionals.
Multipurpose Reconfigurable Training System (MRTS)	Develop and deliver trainers that simulate the operation and maintenance of the Common Submarine Radio Room (CSRR) and the Submarine Communications Support System (SCSS) for SSBN, SSGN, Virginia, SSN-688, and SEAWOLF submarines. Develop and deliver operator and maintenance trainers for other submarine systems, including AN/BLQ-10.
Simulation & Training Research to Improve Knowledge & Effectiveness (STRIKE) Lab	Provide cognitive and behavioral research for improving training and human performance. Investigate and advance the use of technologies for support in embedded, distributed, and distance learning applications.
Submarine Research Application Team (SubRAT)	Develop networked simulations and instructor scenario-scripting and control capabilities. Primary development efforts focus on navigation, piloting and contact management training, and our secondary development efforts focus on the development of shipboard virtual tours to primarily support familiarization and expedited crew qualification.
Visual Systems Lab	Support visual database development efforts, Visual R&D projects, NPSI development, provide smart buyer awareness for future visual system acquisitions.
Weapons Simulation & Integration Lab (WSIL)	Provide in-house, rapid response research and development of software and hardware technology in the areas of interactive systems, operational system integration with virtual environments, simulated equipment and control interfaces, intelligent agents, and instructor support technologies.
Rapid Prototype Design & Fabrication Team	Provide in-house, rapid response electronics and mechanical design, development, and rapid prototype fabrication capabilities to support NAWCTSD science and technology, acquisition and life cycle efforts.