Communities of Interest (COI)
Tier-1 Taxonomy and Descriptions
March 7, 2016

1. Advanced Electronics

The advanced electronics technologies encompassed by the Advanced Electronics COI include those that provide for the processing of information; detection of chemical, biological, radiological and nuclear threats; radio frequency (RF) sensing, transmission, communication; electro-optical/infrared (EO/IR) sensing, transmission, and communication; motion detection including assured references; and the underlying enabling technologies, among others.

- **Electronics Integration**: packaging and reliability

  To create and explore new concepts, components and techniques for:

  - Planar and 3D integrated circuits
  - High power and dense packaging
  - Power electronics
  - Test

  To overcome these technical challenges:

  - Heterogeneous integration with intimate integration of digital control and reconfiguration
  - Device design, fabrication, reliability and robustness for high voltages and high currents
  - Inability to exploit advances in wide bandgap semiconductor technologies with advanced dielectric and magnetic materials
  - Computational electronics or modeling and simulation.

  To gain the following operational opportunities:

  - Operation in harsh environments with superior thermal management for military systems
  - Higher performance for size, weight and power constrained platforms
  - Higher power density and efficiency at high voltages

- **Electronic Materials**: synthesis and characterization

  To create and explore new materials:

  - With tailored responses: metamaterials, multi-ferroics, oxides and phase-change materials
  - For infrared focal plane arrays, quantum optics, mmW RF photonics
  - For novel low power, high-speed devices for heterogeneous integration with silicon
  - For leading edge trusted silicon integrated circuits

- For high-current, high-density cathodes

To overcome these technical challenges:

- Lack of high quality growth techniques and characterization methods
- Immature bottom-up and top-down assembly techniques for nanoelectronic materials
- Inability to model and simulate materials under operational conditions over time - Computational Electronics

To gain the following operational opportunities:

- Advanced sensing, electronic warfare, information technology, communication and imaging

- **EO/IR Components for sensing, transmission and communication**:

  To create and explore new concepts, components and techniques for:

  - Advanced sensors, sources, and optical components for the generation, transmission and detection of ultraviolet, visible and infrared radiation
  - RF and mmW photonic devices and circuits
  - Electro-optical quantum components for sensors, information and computation
  - Advanced focal plane arrays- sensors and read-out integrated circuits

  To overcome these technical challenges:

  - Inability to heterogeneously integrate disparate semiconductors - fabrication, reliability and robustness
  - Inability to model and simulate devices and circuits under operational conditions over time - Computational electronics
  - Inability to exploit advances in electronic materials

  To gain these operational opportunities:

  - Improved sensing and signal processing for ISR, tracking and targeting, electronic warfare, information technology and communication systems
  - Advanced infrared countermeasures
  - Directed energy

- **Microelectronics and Nanoelectronics**: mixed signal, digital processing and emerging architectures

  To create and explore new concepts, components and techniques for:

  - Beyond silicon and Moore's Law concepts for digital, high frequency and electro-optic devices
  - Quantum components for sensors, information and computation
  - Low-power, high-speed devices to heterogeneous integrate with silicon
  - Leading-edge, trusted silicon integrated circuits
  - Micro-electromechanical and micro-optoelectromechanical systems
  - More digital and cognitive apertures

- Extreme miniaturization - higher functionality per unit volume

To overcome these technical challenges:

- Limited availability of trusted, high-quality, affordable foundries and packaging houses
- Inability to model and simulate materials under operational conditions over time - Computational Electronics
- Inability to exploit advances in electronic materials and device models

To gain the following operational opportunities:

- Advanced sensing, electronic warfare, information technology and communication systems
- Improved device reliability and robustness

- **RF Components for sensing, transmission and communication**:

  To create and explore new concepts, components and techniques for:

  - Lightweight, miniature, efficient and affordable wide-bandwidth, high-linearity wide bandgap semiconductor devices / vacuum power electronics that cover frequencies from ~ 1 MHz to ~ 10 THz
  - Extremely low power devices for mixed signal integrated circuits
  - Advanced control components (filters, switches, etc.)
  - Advanced computational electromagnetic techniques and methods
  - Technologies that are reconfigurable and adaptive – both active and passive

  To overcome these technical challenges:

  - Limited technologies for reconfigurability
  - Limited ability to meet extreme military operational requirements
  - Shortfalls in efficiency, thermal management and performance
  - Limited design tools, models and designs for bandwidth, efficiency and linearity goals

  To gain these operational opportunities:

  - Next generation cognitive and adaptive sensors and countermeasures
  - Improved device reliability and robustness
  - Advanced electromagnetic sensor, communication, electronic warfare, imaging and directed energy (high power microwave) systems

2. Air Platforms

The Air Platforms COI serves as a standing forum within the DoD S&T Reliance 21 Program for developing consensus and identifying S&T issues related to air platforms, including fixed and rotary wing vehicles, aircraft propulsion, hypersonic systems, aircraft power and thermal management. The Air Platforms COI promotes cooperation and collaboration between DoD components leading the discovery, development, and

integration of innovative and affordable technologies for manned, unmanned, and optionally manned future air systems.

- **Aircraft Propulsion, Power and Thermal**: This subarea encompasses propulsion, electrical power and thermal management technologies for primary and secondary power systems of military aircraft, including integration of these subsystems. Traditionally organized under the Versatile Affordable Advanced Turbine Engines (VAATE) and Energy Optimized Aircraft (EOA) initiatives, multiple technologies in this subarea have wider applicability and are leveraged by the Energy and Power COI, especially those associated with power, thermal management and alternative concept propulsion (e.g., non-turbine, battery-powered, fuel cells, hybrids, etc.). Technologies include: Turbofan/jet – Large; Turbofan/jet – Small; Alternative Concept Propulsion; Turboshaft / prop; Expendable Turbines; Integrated Aircraft Architectures and Controls; Power Generation; Thermal Management; Power Management and Distribution; Energy Storage; and Actuation.
- **Fixed Wing Vehicles**: This subarea covers the investigation, development, analysis, integration, and demonstration of advanced fixed wing vehicle technologies that improve the performance, supportability, and capability of existing and future air vehicles in the subsonic and supersonic speed regimes. This includes: Manned and Unmanned Systems; Advanced Structures Technologies; Flight Control; Vehicle Configurations; Fabrication Processes; Propulsion Integration; Weapons Integration; Multi-disciplinary Design & Analysis; High Fidelity Computational Analysis; and Sustainment Technologies to Reduce Life Cycle Costs & Increase Readiness.
- **High-Speed/Hypersonics**: This subarea develops, matures, integrates, and transitions aerospace vehicle technologies for atmospheric hypersonic flight. Relevant end-user applications include hypersonic cruise missiles and glide weapons for strike; air platforms for strike, ISR, and transport; and space launch systems. Applicable technology areas include: Propulsion; Aeromechanics; Materials & Structure; Guidance, Navigation & Control (GN&C); Power & Thermal Management; and Thermal Protection Systems.
- **Rotary Wing Vehicles**: This subarea supports both the current and future fleet with a portfolio that is balanced according to Warfighter gaps and priorities. Overarching capabilities to be enabled include extending areas of operations - flying faster and farther while carrying more, full spectrum operations in complex environments, demonstration of autonomy, and advanced low- and zero-maintenance concepts. The technical areas include: Rotors & Aeromechanics; Vehicle Management & Control; Structures; Power Systems & Drives; Operations & Sustainment; Human Systems Interface; Avionics & Networking; Autonomy & Teaming; Survivability; Concept Design & Assessment; Sea Based Aviation; Propulsion; and Flight Control.

3. Autonomy

The Autonomy COI will closely examine the DoD's S&T investments in the enabling of autonomous systems, to include the strategic assessment of the challenges, gaps, and opportunities to the development and advancement of autonomous systems, and identification of potential investments to advance or initiate critical enabling technology development.

- **Human/Autonomous System Interaction and Collaboration (HASIC)**: The keys to maximizing the human-agent interaction are: instilling confidence and trust among the team members; understanding of each member's tasks, intentions, capabilities, and progress; and ensuring effective and timely communication. All of which must be provided within a flexible architecture for autonomy; facilitating different levels of authority, control, and collaboration.
- **Machine Perception, Reasoning and Intelligence (MPRI)**: Perception, reasoning, and intelligence allows for entities to have existence, intent, relationships, and understanding in the battle space relative to a mission.
- **Scalable Teaming of Autonomous Systems (STAS)**: Collaborative teaming is a fundamental paradigm shift for future autonomous systems. Such teams are envisioned to be heterogeneous in size, mobility, power, and capability.
- **Test, Evaluation, Validation, and Verification (TEVV)**: The creation of developmental and operational T&E techniques that focus on the unique challenges of autonomy, including state-space explosion, unpredictable environments, emergent behavior, and human-machine communication.

4. Biomedical (ASBREM)

The purpose of the Armed Services Biomedical Research Evaluation and Management (ASBREM) COI is to: 1) Sustain and improve the program's responsiveness to medical readiness and warfighting needs; 2) Eliminate unwarranted duplication of effort within the program; 3) Promote program efficiency, stability and productivity by optimizing infrastructure, capabilities, coordination and information exchange among the Services and Defense Agencies; and 4) Provide a forum and mechanism to address program and management issues and organizational roles among the Services and Defense Agencies

- **Biomedical Informatics / Health Information Systems & Technology (BI/HIST)**: Research is focused on coordinating emerging military medical simulation and health information technologies/informatics research across all stakeholder communities and transferring research solutions and knowledge to meet DoD goals. Major categories of medical simulation and training research include: Combat Casualty Training, Medical Readiness Training, Health Focused Education, and Tools for Medical Education. Health informatics categories of research include:

Theater/Operation Medicine, Health Services and Population Health, Health Operations Resourcing and Enterprise Infrastructure Management.

- **Military Infectious Diseases (MID)**: The Research Program plans, coordinates and oversees a S&T infectious diseases research and development program leading to fielding of effective, improved means of protection and treatment to maintain maximal global operational capability with minimal morbidity and mortality. The program employs a requirements-driven process to protect the warfighter against naturally occurring, known, predictable, endemic diseases threats.
- **Military Operational Medicine (MOM)**: Research is focused on developing effective medical countermeasures against operational stressors and preventing physical and psychological injuries during training and operations in order to maximize health, performance and fitness of Service Members. Major categories of research include Psychological Health and Resilience, Injury Prevention and Reduction, Environmental Health and Protection, and Physiological Health and Performance.
- **Combat Casualty Care (CCC)**: The CCC Program seeks to optimize survival and recovery in service members injured in combat by planning, programing, budgeting and overseeing the execution of the full range of CCC Research across the spectrum of care from POI through en-route, and facilities. Areas of focus include those focused on medical issues such as Traumatic Brain Injury (TBI) and Hemorrhage Control, Resuscitation and Blood Products, as well as portfolios addressing care delivered in specific field medical environments such as Enroute Care and Forward Surgical and Critical Care. Medical photonics is a significant enabler, crosscutting the other portfolios.
- **Medical Radiological Defense (MRD)**: The Radiation Health Effects Research Program JTCG-7 mission is to provide leadership and coordination with DoD, U.S. Government, and civilian research and development working in relevant areas and report these efforts. JTCG-7 contributes to JPC-7 efforts for planning and research oversight, development, test, and evaluation (RDT&E) activities of discovery and development of materiel and knowledge that reduce medical capability gaps relevant to radiation health effects, enhance military readiness in a radiation environment, and to enhance medical capabilities against radiation exposure. The principal focus today is research and development of medical countermeasures to prevent or treat the effects of Acute Radiation Syndrome (ARS). Comment: Radioactive materials are widely distributed in governments and civilian organizations worldwide for industry and medicine; are used in large quantities in power generation; are in nuclear weapons in numerous countries; and can be used potentially in improvised nuclear devices (IND). Radiation and nuclear risks represent a threat to U.S. forces, to U.S. facilities, and harm to American and international individuals and governments.
- **Clinical and Rehabilitative Medicine (CRM)**: The Research Program focuses on developing knowledge and materiel products to reconstruct, rehabilitate, and

provide definitive care for injured Service members (SM). The ultimate goal is to return the SM to duty and restore their quality of life. Primary research focus areas include Neuro-musculoskeletal Injury (prosthetics, assistive devices and rehabilitation and reintegration strategies), Pain (battlefield, acute and chronic), Regenerative Medicine, and Sensory Systems (Vision, Hearing and Balance).

- **Medical Chem-Bio Defense (MCBD)**: The Chemical and Biological Defense Program plans, coordinates, and oversees research, development, testing, and evaluation of vaccines, therapeutics, and diagnostics against chemical and biological threats of security concern and novel and emerging infectious disease threats. The program employs a requirements-driven process to protect the warfighter against these threats to maintain maximal global operational capability with minimal morbidity and mortality.

5. Command, Control, Communications, Computers & Intelligence (C^4I)

The C4I COI will coordinate the DoD C4I S&T portfolio investment and review DoD organizations' strategic plans to support C4I related S&T investments in the context of overall DoD strategic priorities and goals. The C4I COI will establish priorities and guidance, monitor current and planned investments in S&T including but not limited to Networks, Command & Control (C2), and Data to Decision efforts. The COI will identify gaps, establish and maintain a set of S&T roadmaps to guide DoD research program investments, perform portfolio assessments, and provide future resource recommendations to leadership. The C4I COI will also establish mechanisms to encourage coordination between researchers to facilitate information exchange, and promote collaboration.

- **Advanced Computing/Software Development**: The study, design and development of software, hardware and systems engineering of C4I relevant computing and software resources.
- **Human Computer Interfaces (HCI) for Decision Making**: Studying and improving human computer interfaces, digital information presentation and collaboration between Commanders, intelligence analysts and their decision and intelligence tools.
- **Information Collection/Management**: Employing information systems to collect, process, store, display, disseminate and protect data, information and knowledge products in support of decision-making.
- **Synthesis/Analytics/Decision Tools**: The assessment, reasoning, fusion, and analysis of data as well as the development of planning tools and decision aids for the Commander and intelligence analysts.
- **Networks and Communications**: The study, design and development of advanced robust and resilient networks and communications (hardware/ software) systems and technologies.

6. Counter Improvised Explosive Devices (C-IED)

The purpose of the Counter-IED COI is to encourage multi-agency coordination and collaboration in crosscutting science and technology focus areas that have particular benefit addressing the proliferating and enduring challenge presented by IEDs. The COI concentrates on fostering the bonds between the Joint Improvised-Threat Defeat Agency (JIDA) and the DoD S&T Enterprise by improving the visibility of operational needs and technology gaps, and identifying alignment of S&T capabilities, experts, facilities, and programs/projects with these gaps.

- **Identify Threat Networks that Employ or Facilitate IEDs**: Detection & predictive analysis of threat networks and their functions through the analysis of intelligence, network activities, exploitation, and signatures.
- **Detect IEDs and/or IED Components**: Detection of IEDs in every operational environment (mounted, dismounted, in water, or from the air) as rapidly as possible and at distances beyond the serious injury zone of each device. Various types of sensors, as well as the capabilities of humans and animals, may be used to detect any of the common components of an IED: main charge, initiator, switch, container, or power source.
- **Prevent and/or Neutralize IEDs**: Neutralization can include: pre-detonation, render safe, and disposal of the IED or the disruption of the detonation command signals. Where neutralization is impossible or impractical, methods such as disabling the trigger mechanism or preventing emplacement of the device are effective alternatives.
- **Mitigate IED Effects**: Maximize the survivability of personnel, facilities and equipment by mitigating the blast and fragmentation effects of IEDs.
- **Distribute IED-related Data across the COI**: Synchronization of intelligence and operational forces by sharing appropriate all-source information and intelligence up and down the chain of command from the strategic to the tactical level, across Federal Department and Agencies and with our allies and partner nations. IED related data includes, but is not limited to, significant event reports, post blast analysis, forensic and biometric data, trends analysis, C-IED capability assessments, crime pattern analysis, network analysis, intelligence products and reports and new innovative analytic techniques.
- **Train C-IED Capabilities**: Employing relevant and effective C-IED tactics, techniques and procedures by rapidly developing, defining, and implementing materiel C-IED training tools, including standards, and integrating into appropriate Service, Joint, and DoD concepts, policy and doctrine.

7. Counter Weapons of Mass Destruction (C-WMD)

The mission of the Counter-WMD COI is to promote cooperation, collaboration, and communication among the Components leading to the discovery, development, and integration of innovative and affordable technologies that enhance DoD capabilities in C-WMD. It also provides a forum to advocate for new ideas, technical directions, technology opportunities, C-WMD S&T strategies. The C-WMD COI also serves as a mechanism for DoD to facilitate improved interagency communication, coordination, and research and development as envisioned in the National Strategy for Combating WMD.

- **Understand the Environment, Threats, and Vulnerabilities**: It is essential for DoD to have as clear an understanding of the environment as possible. This requires creating and maintaining situational awareness of the location, quantity, and vulnerability of global materials and stockpiles and of the intentions and capabilities of actors of concern. This includes adversaries' proliferation pathways, development activities, supporting networks, decision making, and doctrine.
- **Control, Defeat, Disable and/or Dispose of WMD Threats**: DoD must possess the capabilities to conduct activities to control, defeat, disable, and/or dispose of specific WMD threats. Control activities require the ability to isolate, intercept, divert, seize, and secure WMD and related capabilities. Defeat WMD activities target the entire spectrum of an adversary's pathway from development through employment of WMD with the aim of delaying, disrupting, destroying, or otherwise complicating specific nodes, links, and supporting networks prior to an adversary's acquisition of WMD.
- **Safeguard the Force and Manage Consequences**: The ability to respond to a CBRN incident in order to mitigate hazards and the effects of use such that military personnel and other mission-critical personnel can sustain effective operations and enable support for U.S. civil authorities and foreign civil authorities as authorized. DoD must be prepared in the event that adversaries use WMD in the homeland, against allies or partners, or against deployed U.S. forces. In these scenarios, it will be essential to recover casualties rapidly, decontaminate personnel and equipment, and establish a protective posture while continually monitoring the force.

8. Cyber

The purpose of the Cyber COI is to promote cooperation and collaboration between DoD components leading the discovery, development, and integration of innovative and affordable technologies to dominate cyberspace through integrated defensive and offensive operations across blue, red, and gray cyber systems as well as across the global cyberspace commons.

- **Assuring Effective Missions**: Assess & control the cyber situation in mission context.

- **Agile Operations**: Escape harm by dynamically reshaping cyber systems as conditions/goals change.
- **Resilient Infrastructure**: Withstand cyber attacks, while sustaining or recovering critical functions.
- **Trust Foundations**: Establish known degree of assurance that devices, networks, and cyber-dependent functions perform as expected, despite attack or error.

9. Electronic Warfare (EW)

- The mission of the Electronic Warfare (EW) COI is to develop a cross-cutting S&T investment strategy with resulting leap-ahead capabilities involving the use of Electro-Magnetic (EM) and directed energy to control the EM Spectrum or to attack the enemy while protecting our own EM systems against interference.
- **Cognitive/Adaptive Capabilities**: Effectively outpace adversary decision and technical options.
- **Distributed/Coordinated/Net-Enabled Systems**: Spatially and temporally diverse awareness, action and response.
- **Preemptive/Proactive Effects**: Prevent or disrupt the adversary's ability to engage our forces.
- **Broadband/Multispectral Components and Systems**: EO/IR/RF receivers and transmitters with wideband and extended spectral coverage.
- **Modular/Open/Reconfigurable Architectures**: Software defined; unrestricted waveforms; standard interfaces.
- **Advanced Electronic Protection Techniques and Technology**: Allow unfettered ops in the dense EM spectrum environment.

10. Energy and Power (E&P) Technologies

The E&P Technologies COI purpose is to provide technologies to enable intelligent power & energy management to enhance operational effectiveness.

- **Electromechanical Conversion**: Increase the power density, efficiency, and robustness of motors, generators, and actuators while also reducing their life cycle costs.
- **Energy Storage**: Improve electrical and electrochemical energy storage devices to decrease device size, weight, and cost as well as increase their capabilities in extreme temperatures and operating conditions.

- **Power Control and Distribution**: Develop tactical, deployable power systems using conventional fuels, alternative fuels, and energy harvested from renewable/ambient sources.
- **Power Generation/Energy Conversion**: Enable smart energy networks for platforms, forward operating bases, and facilities using modeling and simulation tools as well as new, greater capability and efficiency components.
- **Thermal Transport and Control**: Efficiently manage heat and enable higher power density systems through advanced thermal science and technology: advanced components, system modeling, and adaptive or hybrid-cycle technologies.

11. Engineered Resilient Systems (ERS)

Future military success depends on the ability to develop and sustain weapons and materiel systems that are effectively responsive to increasingly complex and dynamic missions, while meeting current and anticipated threat scenarios and budget constraints. Requirements for these systems parallel DoD dynamic missions and have become more complex, requiring systems-of-systems to meet competing requirements with the constraint of leaning-down and reducing risks throughout the life-cycle of the system. Program managers and acquisition officials have to manage and mitigate these risks through the development and procurement of more resilient systems. The Engineered Resilient Systems (ERS) community of interest strategically inserts key S&T investments within the acquisition process to better inform decisions that are made "efficiently, effectively, and quickly." ERS products provide engineering, warfighting, and the acquisition decision-makers with an advanced capability to evaluate a multi-dimensional tradespace with full and consistent information throughout the life-cycle of the systems.

- ERS addresses the DoD need for acquiring more affordable and mission-resilient warfighting systems
- ERS implements an integrated suite of modern computational engineering tools, models, simulations, and tradespace assessment and visualization tools within a framework aligned with acquisition and operational business processes
- ERS integrated toolsets will operate within a framework that supports data-driven decision-making and provide advanced knowledge management, including data retention and lessons-learned, in a multi-community, innovative, and collaboration environment
- ERS will significantly improve the use of understanding of advanced computational technologies for all aspects of the acquisition process, with specific emphasis on requirements generation, alternative analysis, prototyping, and lifecycle management

The foundation for the ERS program consists of the following key areas for investment:

- **Tradespace Analysis:** This sub-area capabilities are focused on enabling deeper consideration of system design alternatives, while keeping the design options open as long as possible to address resiliency to changing conditions and constraints. The tradespace analysis capabilities support highly complex decision-making across the lifecycle by communicating to multiple perspectives across the system hierarchy, while considering fiscal and environmental constraints. The tradespace analysis tools analyze the complex resources, costs, and technical considerations in system requirements for ships, aircrafts, ground vehicles, etc., and design alternatives.
- **Collaborative Analysis and Decision-making:** The goal of ERS is to become a DoD-wide framework that provides a standardized approach to analyzing new systems or adapting existing systems to changing mission requirements. ERS will accomplish this by developing and integrating a suite of products that will provide a magnitude of improvements to the existing acquisition process. This sub-area will develop approaches for knowledge sharing, management, and representation to support complex distributed engagements between scientists and engineers working on feasibility assessment of conceptual designs; integrated product teams representing all functional disciplines; program managers to broaden the tradespace beyond performance; test and evaluation teams to support the planning and execution of T&E by focusing on key designs to validate developmental and operational testing; program executive officers to focus on delivery, cost, and risk integration; and industry to refine designs, approaches to knowledge sharing, management, and representation to support cross-cutting decision processes
- **Conceptual, Computational, and World-Wide Environmental Representation:** This sub-area is focused on identifying, evaluating, and assimilating new and existing modeling and simulation tools for evaluating the performance of proposed materiel solutions in a wide range of environmental conditions. This sub-area will make use of high-fidelity modeling capabilities that exist across the DoD to model future systems early in the acquisition process. Models and simulations require a wide range of environmental data to assess the impact of the environment on future weapons systems. This sub-area will identify gaps in the existing datasets and invest in environmental models to fill those gaps as needed, specifically including: physics-based representations of systems; manufacturability and producibility analysis; mission context representations; and systems of systems representations
- **Integrating Architecture and Capability Demonstrations:** One of the primary ERS goals is to develop an architectural framework that enables the integration of disparate systems and systems-of-systems for the purpose of performing analyses throughout the systems life-cycle. The framework will maintain a level of openness while accommodating pertinent data, analysis tools, collaboration, and multiple tool types. This sub-area will identify DoD platforms that can benefit from the ERS approach, as well as create an active user community to transfer lessons learned that will benefit future ERS development efforts.

ERS will identify, evaluate, and select from relevant models what is needed to create robust, integrated, computational prototyping environments to be used by the Services and OSD.

- **Computational Research Engineering Acquisition Tools and Environment (CREATE):**

In addition, ERS strategically leverages and greatly augments the tool development efforts and processes of the Computational Research Engineering Acquisition Tools and Environment (CREATE) component of the DoD High Performance Computing Modernization Program. CREATE tools are focused on innovative software development and capability transition for the acquisition and engineering communities.

The CREATE's software development efforts and their capability objectives that are integral to the ERS Program are as follows:

- Helios: facilitates full rotorcraft (all types, manned and unmanned) high-fidelity simulation
- Kestrel: performs computational fluid dynamic, structures, kinematics, and kinetics as well as other analyses
- Capstone: provides a comprehensive and integrated set of geometry, meshing, and associative attribution software capabilities.
- NavyFoam: provides the ship design engineer with the capability to rigorously analyze alternative hull form designs
- IHDE (Integrated Hydrodynamics Design Environment): provides the prediction of the hydrodynamic performance of a ship design
- RSDE (Rapid Ship Design Environment): provides a high-end toolset that integrates ship design generation tools with physics-based analysis
- NESM (Navy Enhanced Sierra Mechanics): predicts ship structural response and damage due to loading for stand-off and close-in air, surface, and underwater explosions
- SENTRi (computational electromagnetics): provides finite element / boundary integral code for radiation and scattering analysis
- CREATE-GV: provides a suite of software for analyzing ground vehicles

12. Ground and Sea Platforms (G&SP)

The G&SP COI provides a forum for discussion of topics associated with a broad range of platform technologies for both ground and sea systems. The portfolio examines concepts in modularity, survivability and mobility as the primary emphasis areas. In addition examination of required S&T for cost effective maintenance and sustainment of platforms is pursued in the portfolio.

- **Maintainability/Sustainability**: Science and Technology that reduces life cycle cost, reduces logistics burden, increases reliability, and provides timely support of ground and sea platforms. Areas of research include structural health monitoring, sustainment analysis tools, networked sustainment command and control, and high reliability structures and components.
- **Modularity**: Science and Technology that standardizes and designs interfaces, subsystems, and components that allow functional elements to be used across or within platforms. Areas of research include flexible designs for multi-mission adaptability, interoperable components and payloads, and platform infrastructure.
- **Mobility**: Science and Technology focused on improving the mobility / maneuverability of ground and sea platform systems over all operational environments. Areas of research include sea stability during intense maneuvering, land stability in aggressive terrain, high efficiency powertrain components, fuel economy, technologies enabling increased power generation, and amphibious maneuvering.
- **Survivability**: Science and technology that provides protection to ground and sea platforms and their occupants while maintaining and enhancing ability to accomplish mission through development, evaluation, integration, maturation and testing of technologies integrated into the platforms. Areas of research include platform centric approaches to threat defeat including active protection (hard and soft kill), ballistic protection, and hazard protection to include blast, shock, and fragmentation hazards and directed energy weapons.
- **Unmanned Ground and Sea Vehicles**: Science and technology for maturation and integration of optionally manned competencies into ground and sea platforms to enhance force structure operational capabilities. Areas of research include conversion technologies for manned/unmanned operation and advanced unmanned vehicle development and integration concepts.

13. Human Systems

The Human Systems COI provides a framework for Service, Agency, and DoD Executives, Scientists, Engineers, and Human Systems Integration Practitioners to share information, ideas, and best practices; identify opportunities; measure progress; jointly plan and coordinate programs across Department of Defense (DoD), and report on the state of the health of Human Systems and related science and technology.

- **Personalized Assessment, Education, and Training**: Research and development in personnel assessment will produce integrated measures and adaptive testing for more precise assessment of individual potential, yielding improved personnel selection and assignment. While work in education and training will produce competency-based systems for full spectrum, rapidly updated, adaptive training that will accelerate learning. Together these capabilities will enhance warfighter

readiness and retention while decreasing costs for skills acquisition and maintenance.

- **Protection, Sustainment, and Warfighter Performance**: Research and development in this area will produce better understanding of the critical environmental stressors and the human factors yielding individual performance differences in operational environments in order to mitigate their effects. This includes designing systems that support and exploit individual differences, and developing operationally relevant metrics to monitor and assess performance.
- **Human Aspects of Operations in Military Environments**: Research and development in this area will yield capabilities that exploit knowledge of combatant and non-combatant beliefs, attitudes, and norms that motivate threat behaviors. These capabilities will improve sociocultural situation awareness, enable more accurate forecasts of human behavior, and consequently yield more robust courses of action.
- **System Interfaces & Cognitive Processes**: Research and development in this area will produce human-technology interfaces that enhance warfighters' ability to focus on their primary mission. These cognitively engineered interfaces will be intuitive to use, will learn with experience, and support mixed-initiative communication.

14. Materials & Manufacturing Processes (M&MP)

The purpose of the M&MP COI is to provide National leadership in developing technology-based options for advanced materials and processes for the Department of Defense. The COI delivers technology products as well as the scientific and engineering expertise needed to maintain and enhance U.S. Defense capability. The COI achieves these objectives through direct integration and coordination of eight (8) key technology activities and by continuing collaboration with the best expertise available in related activities across the broader materials and manufacturing fields, whether domestic or international. The cross-DoD technology teams currently making up the COI include SMEs in the materials and manufacturing processes for the following Structures and Protection; Propulsion and Extreme Environments; Sensors, Electronics, and Photonics; Power and Energy; Readiness; Individual Warfighter; Civil Engineering; and Corrosion.

- **Materials/Processes For Survivability & Life Extension** is comprised of all materials and processes that enable mission operations. This contains M&MP Technical Area Teams (TATs) for: Structures and Protection; Propulsion and Extreme Environments; Sensors, Electronics and Photonics; Power and Energy; the Individual Warfighter; Corrosion; and Readiness.
- **Manufacturing Technology For Affordability** contains the materials, processing and fabrication techniques to significantly change the manufacturing cost curve. This includes but is not limited to processing and fabrication of electronics, composites and metals, as well as emerging capabilities developed within the advanced

manufacturing enterprise. This is coordinated via the Joint Defense Manufacturing Technology Panel (JDMTP) and efforts are integrated into M&MP TATs' roadmaps for Materials/Processes for Survivability & Life Extension

- **Environmental Quality** reflects the DoD activities conducted with the framework of the DoD-DoE-EPA Strategic Environmental Research and Development Program (SERDP). This includes research and development in five program areas: energy and water; environmental restoration; munitions response; resource conservation and climate change; and weapons systems and platforms.
- **Civil Engineering** supports all aspects of technology necessary for force protection, force projection, and sustainment, including logistics planning, amphibious assault and rapid port enhancement, base and in-theater infrastructure, and force protection on the battlefield and at installations and bases with an emphasis on expedient protection systems. Projects are reported in the M&MP TAT, Materials and Processes for Civil Engineering.

15. Sensors

The Sensors COI provides a forum for sharing new ideas, technical directions and technology opportunities, jointly planning programs, measuring technical progress, and exchanging advances in sensors and surveillance technology.

- **Radio Frequency (RF) (non-EW)**: RF is a rate of oscillation in the range of around 3 kHz to 300 GHz, which corresponds to the frequency of radio waves, and the alternating currents which carry radio signals. RF usually refers to electrical rather than mechanical oscillations. The determination of the object's position, velocity and other characteristics, or the obtaining of information relating to these parameters by the transmission of radio waves and reception of their return is sometimes referred to as radiodetermination. For example, radar operates by generating pulses of radio frequency energy and transmitting these pulses via a directional antenna. When a pulse impinges on an object in its path, a small portion of the energy is reflected back to the antenna. The radar is in the receive mode in between the transmitted pulses, and receives the reflected pulse if it is strong enough. The radar indicates the range to the object as a function of the elapsed time of the pulse traveling to the object and returning. The radar indicates the direction of the object by the direction of the antenna at the time the reflected pulse was received. The "radar equation" mathematically describes the process and may be used to determine maximum range as a function of the pulse width (PW) and the pulse repetition rate (PRR). In most cases, narrow pulses with a high PRR are used for short-range, high-resolution systems, while wide PW's with a low PRR may be used for long-range search. In general, a higher gain (larger aperture) antenna will give better angular resolution, and a narrower pulse width will give better range resolution. The key to modern radar systems is the digital computer and its data processing capability which can extract a vast amount of information from the raw radar signals and present this

information in a variety of graphic and alphanumeric ways on displays as well as feeding it direct to weapon systems. It also enables the systems to carry out many more tasks such as target tracking and identification. In addition, modern signal processors provide adaptive operation by matching the waveform to the environment in which the radar is operating.

- **Acoustic, Seismic and Magnetic**: The grouping of Acoustic and Seismic is natural, as there is an overlap at low frequencies (~20-200 Hz) where there is sensitivity in both types of sensors. Acoustic sensors are typically pressure based and seismic sensors are typically accelerometers. Magnetic and EM might have been more naturally grouped with electro-optics, as there is a continuum on that spectrum, however, inclusion with acoustics makes sense from an application perspective, as acoustics and magnetics are primary sensing modalities for submarine and buried object detection.
- **Electro-Optical/Infrared (EO/IR)**: EO/IR systems includes active and passive. The wavelength region for optical radiation spans from approximately 100 nanometers (nm) to 1000 micrometers (um). The optical radiation spectrum can be broken up into three basic regions: ultraviolet (UV) from 100nm – 400 nm; visible from 400 nm – 760 nm; and IR from 760 nm – 1000 um. These regions are dependent on the reflection of the target by sunlight or moonlight or the target's own emission of radiation. Radiation energy coming from the target and background is primarily reflective in the visible through short wave IR changing to a mixture of reflective and emissive in mid-wave IR. Long wave IR imaging relies on thermal emission of radiation from targets and background. Additionally, EO/IR photons travel through a medium, the atmosphere, which can refract, absorb, or scatter them. What has changed dramatically is the method and speed of processing the imagery, the amount of information that can be obtained, and the way that the information is displayed to the operator.

** Sensor Processing is an element of all areas*

16. Space

The goal of the Space COI is to: 1) Facilitate collaboration and leveraging of complementary investments of the space S&T efforts performed by the DoD, Intelligence Community, the National Aeronautics and Space Administration (NASA), the Department of Energy (DoE), the National Oceanic and Atmospheric Administration (NOAA), the commercial space industry and, as appropriate, Allied and friendly nations in support of the intent of the nation's Space interests; and 2) Identify gaps, establish and maintain a set of S&T roadmaps to guide Space Community research program investments, perform portfolio assessments, and provide future resource recommendations to leadership.

- **Satellite Communications (SATCOM)**: Provide seamless, end-to-end, space-based communications that are integrated and interoperable.
- **Missile Warning, Missile Defense, Kill Assessment and Attack Assessment**: Provide timely and unambiguous detection of ballistic missile launches and nuclear detonations from space.
- **Positioning, Navigation and Timing (PNT)**: Provide the ability for generating and using signals to enable determination of precise location, movement and time.
- **Intelligence, Surveillance and Reconnaissance (ISR)**: Provide Space-based systems for Space Situational Awareness (SSA), Geospatial Intelligence (GEOINT) and Signals Intelligence (SIGINT); includes National Technical Means, Commercial/Foreign Family of Systems, and small, rapid-response opportunities.
- **Space Control (SC) and Space Situational Awareness (SSA)**: Provide freedom of action in space to ensure: resilience to threats, ability to perform in a degraded environment, and ability to deny an adversary's use of space against our forces in conflict.
- **Space Access (SA)**: Provide delivery, maneuvering, and recovery of payloads to and from space in a responsive, reliable, flexible manner, ensuring assured access to space in peace, crisis, and through the spectrum of conflict.
- **Space and Terrestrial Environmental Monitoring (EM)**: Provide remote sensing and monitoring of the operational space environment and Earth weathercasting.
- **Command and Control (C2); and Satellite Operations (SATOPS)**: Provide the ability to operate over space forces and resources to monitor, assess, plan, and execute space operations at all echelons of command.
- **Space Enablers**: Development of pervasive technologies that facilitates the technical ability to perform successfully in the Space Arena.
- **Space Resilience**: Provide the ability to support the functions necessary for mission success in spite of hostile action or adverse conditions.

17. Weapons Technologies

The Weapons Technologies COI serves as the mechanism for the Components to understand technical capabilities and roadmap / integrate S&T efforts to address operational challenges, mitigate foreign threats, affordably-extend weapons performance, and develop leap-ahead offsets. Technology development thrusts (subareas) involve *guidance navigation & control (GN&C) and data links, ordnance*, *propulsion*, *undersea weapons*, *high energy lasers (HEL), radio frequency weapons (RFW), and non-lethal weapons (NLW)*. Advances in technology thrust areas are integrated, prototyped, and demonstrated in the *Guided Weapon Demonstrators (GWD)* subarea. The applications for the technologies in this COI are air, naval, ground,

offensive, defensive, tactical, theater, or strategic weapons including missiles (conventional and hypersonic), bombs, rockets, artillery, mortars, torpedoes, mines, guns, launchers, and projectiles.

- **Guidance, Navigation & Control (GN&C) and Data Links**: This subarea includes weapon position, navigation, and timing (PNT), networked precision (data links and seekers), and high-speed guidance (maneuver algorithms and radomes). It encompasses software and hardware components that enable a weapon to know precise time, its position and attitude, the ability to predict and shape its trajectory, and the ability to communicate with networked assets for the purpose of exchanging data on the state of the weapon as well as the state of the intended target. The navigation function is performed by algorithms that take inputs from sensors (e.g., inertial measurement units (IMU) / devices and GPS receivers), and processes those inputs to produce the position, velocity, acceleration, etc. of the host platform. The platform's guidance algorithms utilize inputs from sensors/seekers and the navigation system to effect modifications to the platform's trajectory to put it on the desired path to the intended destination/target. The control system takes the desired trajectory modifications from the guidance system and translates them into actuation commands that generate forces and moments through the use of aerodynamic surfaces, thrust/reaction controllers etc. Data links provide the platform with the ability to communicate with other networked assets for the purposes of exchanging information about its state and targets.
- **Ordnance**: This subarea coordinates all S&T pertaining to explosives, reactive energetic materials, warhead casing materials and explosively accelerated damage mechanisms, penetrating warheads, the fuzing mechanisms of initiation, safe and arm mechanisms, and the integration of these components for what is coined an 'ordnance package'. The subarea also includes innovative concepts that maximize system capabilities and employment of these ordnance concepts in novel methods to achieve military objectives.
- **Propulsion**: This subarea includes propulsion S&T for guns, tactical missiles (rocket and air breathing), strategic missiles, missile defense boosters, and divert and attitude control systems (DACS) These applications operate over short range to extremely long range with additional operational requirements (e.g., impetus, energy management (pintle/pulse motors), temperature (sometimes coupled with acoustic input), DOT hazard classification and insensitive munitions). The solid rocket motor solutions for these applications develop advanced high specific impulse propellants (minimum signature, reduced signature and high performance (smokey)), propellant to insulation bondlines and liners, lightweight structures (case, insulation, nozzles) and attitude control thrusters. Air-breathing scramjet propulsion for weapons applications develops scramjet ignition and combustion technology with high efficiency fuels and lightweight structures. Strategic system 4th stage/post boost vehicles and missile defense kill vehicles using liquid rocket thruster

technologies rely on the Space COI community for developing and advancing this technology.

- **Undersea Weapons**: An undersea weapon is any device or system that provides "hard kill" or "mission kill" against a naval platform (principally a ship or submarine) or another weapon and delivers this capability within, or substantially through, the ocean sub-surface. This includes, but is not limited to, torpedoes, torpedo decoys and jammers, anti-torpedo torpedoes and underwater projectiles.
- **High Energy Lasers (HEL)**: This subarea coordinates all S&T pertaining to high-power, high-efficiency laser sources, including power sub-systems, thermal management, beam directors, beam propagation, and laser effects. Focus areas include laser sources (development of pulsed and continuous-wave laser sources to include solid state (slab) technology, fiber lasers and combining technology, and gas laser sources) and advanced beam control (development of lightweight beam directors, high-throughput beam directors, conformal arrays, atmospheric compensation and adaptive optics).
- **Radio Frequency Weapons (RFW)**: This subarea coordinates all S&T pertaining to high power RF systems, including pulsed power sources, micro-/millimeter wave sources, and antennas (conventional, flat, conformal). Focus areas include pulsed power sources (development of high-peak power waveforms with short peak rise times and high energy per pulse, high pulse repetition rates, and optimized frequencies), high power micro-/millimeter-wave sources (development of conventional and solid-state compact, electrically efficient sources), and antennas (development of conventional, flat, and conformal arrays for use with next generation HPM/RF systems and improve gain/directivity of antennas to increase range, and reduce size, weight, and power (SWAP)).
- **Non-Lethal Weapons (NLW)**: This subarea coordinates all S&T pertaining to both kinetic (rubber bullets, etc.) and directed energy (lasers and high power RF systems) technologies used for non-lethal weapons applications. Applications include counter-personnel (development of smaller, lighter, and lower cost Active Denial Technology (ADT) 95 GHz millimeter wave sources to demonstrate "repel effects" and developing antenna gimbal for solid-state ADT demonstrator), counter-materiel (maturing and demonstrating directed energy technologies capable of stopping vehicles and vessels at operationally-relevant standoff distances, researching and assessing the feasibility of directed energy technologies for other counter-materiel missions, and improving the size, weight, and performance of component and subsystem technologies), and human effects (characterizing ADT bio-effects trade space (effects vs. risk vs. system requirements) and non-lethal human effects modeling and simulation capability development).
- **Integrated Weapon Demonstrators (IWD)**: This subarea integrates, prototypes, and demonstrates key technologies developed in *guidance navigation & control (GN&C) and data links, ordnance*, *propulsion*, *undersea weapons*, *high energy lasers (HEL),*

radio frequency weapons (RFW), and/or *non-lethal weapons (NLW)* subareas. The GWD subarea proves the effectiveness and advancement of technology / integration to a TRL-6 level through weapon flight or live-fire demonstrations.

18. Non-COI

- **Ocean Battlespace Environments**: Focuses on ocean models and forecasts, ocean sensors and data, and small-scale oceanography.
- **Lower Atmosphere Battlespace Environments**: Focuses on theater weather modeling and prediction, battlefield laser propagation modeling, remote sensing applications, and weather simulation and visualization.
- **Terrestrial Battlespace Environments**: Research on the characterization and modeling of the physical phenomena, processes, interaction, and effects associated with terrain and its surface and subsurface features at scales of interest to ground forces.
- **Modeling and Simulation Technology**: Since this area borrows technical products from other technology areas, and the tools produced through advancing M&S Technology provide underlying capabilities in other technology areas, three areas have been defined to bound this technology area:
  - Frameworks for Interoperability: Work in this area established the architectural design, standards, and security approach to enhance interoperability of simulations across a broad range of DoD simulations and live C4ISR systems.
  - Simulation Information Technology: This area focuses on the technologies and standards necessary to develop, publish, discover, retrieve, and use data needed to develop scenarios, execute simulations, and pass data seamlessly between simulations and other systems.
  - Representation Technology: Work in this area seeks to provide the foundation for authoritative representations of physical environments, human and organizational behavior, decision-making, and effects of weapon systems.
- **Sustainment**
- **Classified**