Sensors and Processing CoI
March 20-22, 2018

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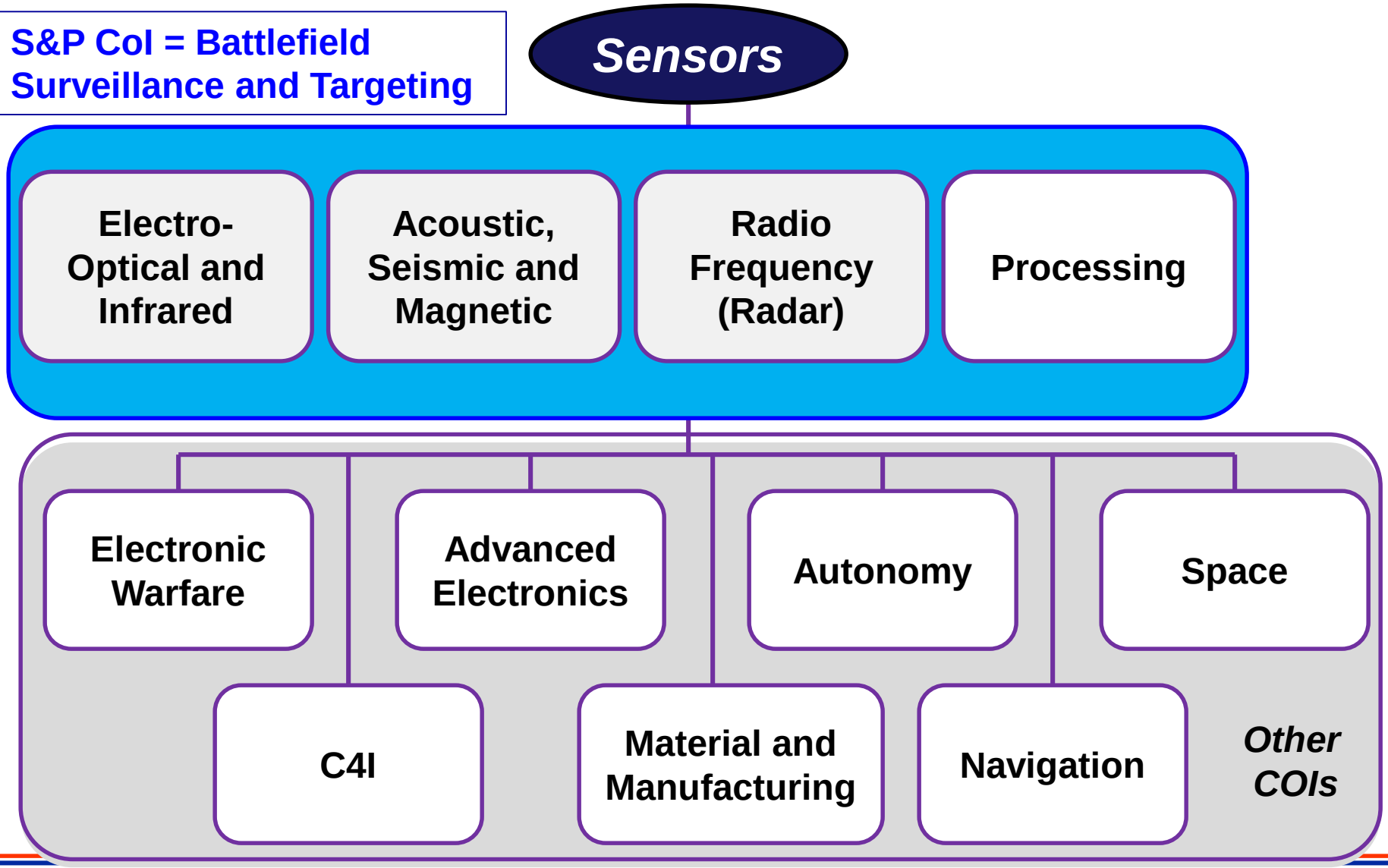
Sensors and Processing in the DoD

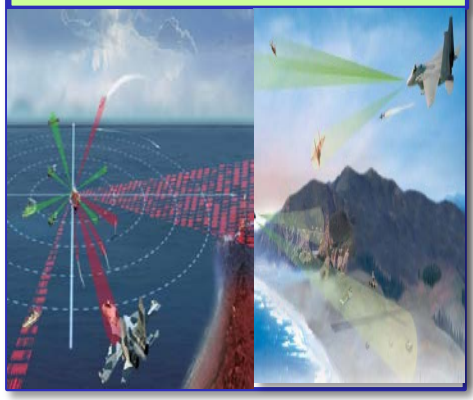
S&P CoI = Battlefield Surveillance and Targeting



Taxonomy

Sensors and Processing Technology

RF *(non-EW)*



- **RF Sensors**

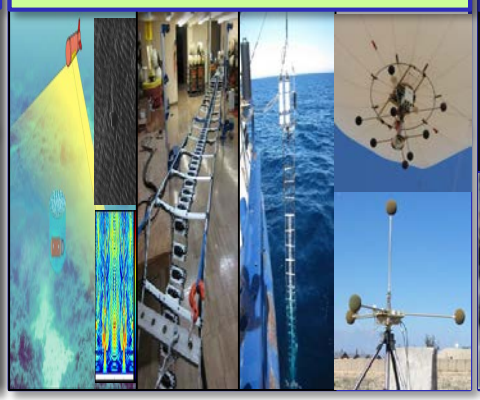
Active
- Monostatic Radar
- MIMO

Passive

Cooperative
- Multistatic Radar

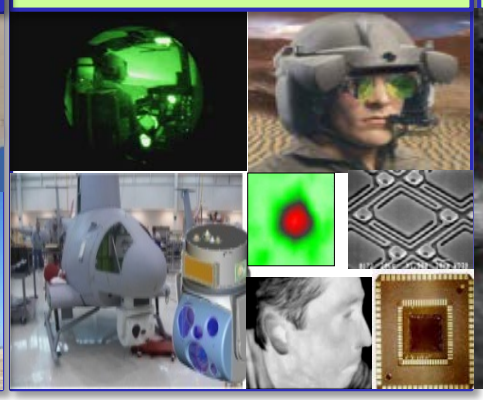
Non-Cooperative
- PCL
- SIGINT

Acoustic, Seismic, Magnetic



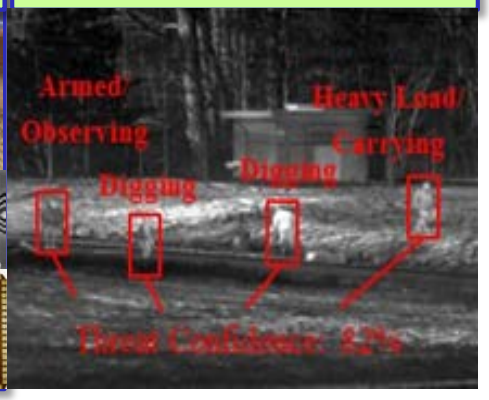
- **Acoustic**
  - Active
  - Passive
- **Seismic/Acceleration**
  - Ocean
  - Terrestrial
- **Magnetic/E-M Field**
  - Maritime
  - Terrestrial

Electro-Optics /Infrared



- **Imaging**
  - Active
  - Passive
- **Lasers**
  - High Power CW
  - Pulsed
- **Displays**
  - Direct View
  - Virtual

Sensor Processing



- **Sensor Processing**

Automatic or Aided DCRIF

Intelligent Targeting Tracking

Compression

Automatic Learning

Multi-Sensor Fusion/Full Spectrum Targeting and Visualization

What is a Community of Interest (CoI)?

- **Communities of Interest (CoI): A set of technical groups led by the science and technology (S&T) Executive Committee (ExCom).**
- **Scope of each CoI shown in the Reliance 21 document which is the overarching framework of the Department of Defense's (DoD) Science and Technology joint planning and coordination process.**
- **Sensors and Automatic Target Recognition sub-area active in Technology Assessment and Requirements Analysis (TARA) days**
- **CoIs were established in 2009.**
  - Covers 17 technical areas that span DoD
  - CoI structure distributes automated exploitation needs across multiple areas
  - Processing was originally included in the 2010 briefing to the ExCom
  - The 2016 ExCom endorsed re-establishment of Sensors and Processing CoI as the home for Processing. The 2016 Annual Sensors and Processing Meeting met to define roles and Taxonomy in April 2016.
  - During the 2016 Annual Meeting options were discussed on how to incorporate Processing back into the Sensors and Processing CoI.

Why should I care? / What's in it for me?

- **Provide a forum for coordinating S&T strategies across DoD**
  - Interact with colleagues across DoD
  - Share new ideas, technical directions and technology opportunities
  - Jointly planning programs
  - Measure technical progress
  - Report on the general state of health for specific technology areas of interest across services.
- **Leverage other service's efforts/investment**
- **Participation in CoI-sponsored activities (Contractor IRAD engagement FY16, RRTO a Search for nontraditional technologies, September 26-27, 2017 at Fort Belvoir Officers' Club, Sensors and Processing, AE, and EW CoIs)**
- **ATRWG Annual Meeting, December 2017**
- **Sensor and Processing CoI annual meeting March 7-8, 2018**
- **ATRWG Annual Meeting, October 2018**

Why Does the DoD Need To Invest in Sensors and Processing S&T?

- **Long range surveillance & targeting largely a military requirement. State-of-the-art capabilities provide U.S. a strategic advantage.**
  - Most of the sensor technology in the COI Is military specific, requiring DOD investment to improve the state-of-the-art, meet new and more demanding requirements
- **Consumer applications mostly very low cost/low performance:**
  - Consumer: Focus on lowest cost and packaging (point solutions). Examples:
    - Back-up sensor (ultrasonic)
    - Driving camera (infrared)


DoD does not invest in CMOS day TV cameras

  - Military: Focus on highest performance at acceptable cost (10-1,000X consumer thresholds)
- **Some high performance commercial sensors are adaptations of military technology, where the commercial business case does not justify extensive commercial S&T investment**
  - Example: cooled Forward Looking Infrared (FLIR) cameras for scientific and law enforcement applications
- **Some commercial markets do not want to do business with DoD**
- **DoD S&T community needs to maintain awareness and invest in adaptations of non-military sensor technology where possible**
  - Examples: IR driving cameras (industry invested heavily in signal processing)

    Acoustics program focuses on processing of acoustic signals not hardware (microphones)
  - Perform “smart buyer” function for Users and Acquisition community

Why CoIs?

- **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.**
- **Provide a forum for coordinating S&T strategies across DoD**
  - Interact with colleagues across DoD
  - Share new ideas, technical directions and technology opportunities
  - Jointly planning programs
  - Measure technical progress
  - Report on the general state of health for specific technology areas of interest across services.
  - Mechanism to encourage multi-agency coordination and collaboration in cross-cutting technology focus areas with broad multiple-component investment.
- **Leverage other service's efforts/investment**
- **Participation in CoI-sponsored activities (Contractor IRAD engagement in FY16, and RRTO a Search for nontraditional technologies, Sept. 26-27, 2017)**
- **A "coalition of the willing" (100% voluntary).**

Common Warfighter Needs Met By Sensors COI

- Survivable Broad Area Persistent Surveillance
- Target Detection, Recognition & ID at Standoff Ranges
- Force/Platform/Sensor Protection
- Target Tracking
- Early Warning
- Battle Damage Assessment (BDA)
- Precision Strike
- Resilient Architectures

Difficult Targets that Challenge Today's Sensors Processing Capabilities

- Submarines
- Small UAVs
- Mines
- People
- Enemy Sensors
- Low trajectory munitions
- Camouflage
- Underground
- Under Foliage
- Cruise and Ballistic Missiles

Low Contrast, Small, Fleeting Targets Challenge the Limits of Sensor Resolution & Signal-to-Noise – Processing of Signals Key Part of Systems to Detect, ID and Track these Threats

- **All made more difficult with additional emphasis on near peer competitor**

Overview of Sensor COI and Accomplishments

Personnel changes:

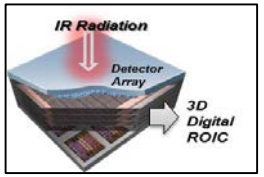
- No change of Chair, Steering Group, or RF, EO/IR, or ASM Sub-Group leads in the past year.

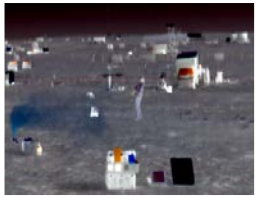
Sub-Group/Taxonomy changes:

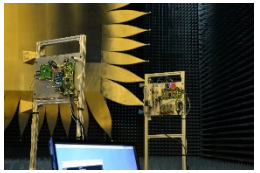
- Sensor Processing (SP) sub-group added, leads are Mr. D. Wiegmann and Ms. L. Graceffo.

Accomplishments:

- Digital ROIC design and fabrication to enhance dynamic range and on chip processing for multifunction applications.
- Large format/high performance LWIR HSI FPAs for detection of difficult concealed targets and material ID for tactical and intelligence applications.
- Low Cost Flexible Radar (LCFR) indoor range demonstration of a software defined synthetic aperture radar (SAR) mode in real time on an FPGA.
- Beginning to deploy ships with modern passive sonar
- Real time demonstration of air to ground sensor to analyst actionable intelligence determination.







State of Technology: Focus Areas

RF	EO/IR
• Autonomous multifunction RF, multi-platform sensor resource management, simultaneous mode scheduling, maximum use of diversities, simultaneous transmit and receive (STAR) apertures • Affordable ISR Initiative; C-SWaP of high dynamic range, wideband receivers, affordable AESA • Small Loitering ISR Munition (SLIM): software-defined radar/comms, low cost phased arrays, reduced processor-load algorithms	• Affordable, large format IR sensors (reduced pitch, alternative substrates, alternative material systems, sensitive across multiple atmospheric windows) • High performance sensors for difficult target detection, tracking, and ID (cross domain, multi-function, multi/hyperspectral). • High Performance Digital Readout Integrated Circuits (well capacity/gain) • High efficiency, multi-function, multi-band lasers
ASM	**Processing**
• Modern passive sonar to maintain acoustic superiority • High duty cycle active sonar • Deep water acoustic sensors that exploit low noise environments. • Long range synthetic aperture sonars (SAS) that discriminate targets	• RF and EO/IR target ID, cross-cueing and sensor fusion • Machine Learning and Artificial Intelligence algorithms for real time target detection, classification, recognition, identification, tracking, etc. • Target recognition for bistatic – monostatic radar • Autonomy focus that automates the battlefield with advanced algorithms, augmented reality, autonomous vehicles (air and ground) and asymmetric vision

State of Technology: Investments

What gaps have the CoI identified as a risk areas needing further investment?

- Cross-service, Multi-static Radar Systems have the potential to increase system performance, Survivability, and affordability.
  - Leveraging multiple assets to improve radar related asks such as (search, detect, track, etc.) is accomplished y using correlation gain to reduce measurement error.
  - Additional resources could be used to establish a cross-service multi-function radar experimental environment. An ARAP proposal is being submitted.
- Artificial Intelligence/Machine Learning are key DoD technologies. Commercial activities will continue to develop AI/ML approaches, but military specific applications and military data sets to feed those applications need future investment.

Where Is One Service Leveraging Investments From Another Service Or OSD Activity To Make An Investment?

- DROICS: Army and Air Force leveraging DARPA investments and collaborating on DROIC enabled image and signal processing.
- LWIR HSI FPAS**:** Army and Air Force leveraging each other's investment in Phenomenology, Component Development (FPAS), and Concept Exploration. Army and Air Force collaborated (with NATO Partners) on the Strongbow HSI phenomenology collection in Canada.
- Tri-services leveraging high speed optical interconnect seedling funded by USD(R&E) and being executed at the AIM Photonics National Manufacturing Institute.
- Army Leveraging Navy And Air Force III-V FPA Based Sub-system/System Developments (CESARS And JSF EODAS).

Future Direction

Initiatives or best practices to accelerate R&D process

- Sept. 26-27 2017, the Sensor & Processing CoI, in conjunction with the Advanced Electronics and Electronic Warfare CoIs hosted a Rapid Reaction Technology Office (RRTO) Solutions meeting at Fort Belvoir. The purpose of the event was to help Tri-Service S&T representatives identify non-traditional technology innovations to support emerging operational needs.

Cross-CoI, Industry, Academia Opportunities for Collaboration

- Military Sensing Symposium:
  - Parallel MSS on Battlefield Survivability and Discrimination (BSD); Passive; Detectors; Materials: March 19-23, 2018, Gaithersburg, MD
  - Tri-Service Radar Conference, June 25-29, 2018, Monterey, CA
  - Joint (National, BAMS, NSSDF, ATAC), Oct. 23-25 2018, Gaithersburg, MD
  - Active/EO- IRCM Conference, Los Angeles, CA, May 14-16 2019 Tentative
- Annual Sensors and Processing CoI coordination meeting: March 7-8 2018, Fort Belvoir, VA.
- ATRWG Conference, October 2018, Fort Belvoir, VA (Tentative)

EO/IR Technical Challenges

- Affordable, large format IR sensors (reduced pitch, alternative substrates, alternative material systems, sensitive across multiple atmospheric windows)
- High performance sensors (multi-band, extended cutoff, low noise, reduced pitch, higher operating temps)
- High Performance Readout Integrated Circuits (well capacity/gain)
- Day/night, color, HD low light cameras and novel low noise pixels enabling HD color imaging
- High efficiency multi-band lasers and sources
- Multi-function lasers
- 3D imaging and processing
- Light-weight, low volume optics and image formation strategies
- Atmospheric Mitigation & Image Formation Algorithms

RF Technical Challenges

- **Long Stand-Off** - Power-aperture, low slant angle, resolution, clutter, obscuration, slow asset repositioning, simultaneous field of view, multi-static radar
- **Persistent Stand-In** - Tx: Novel waveforms and adaptive use of contested sensing spectrum Rx: Passive Multi-Mode (PMM) radar, MIMO, distributed radar processing
- **Open System Arch** - Maximum interoperability, autonomous multifunction RF, multi-platform sensor resource management, simultaneous mode scheduling, maximum use of diversities, simultaneous transmit and receive (STAR) apertures
- **Advanced Components** - High dynamic range, wideband receivers, affordable AESA components for SWAP-constrained payloads (low prime power, high performance), improved power added efficiency, element level-DREX
- **Expendable RF** - Small Loitering ISR Munition (SLIM): software-defined radar/comms, low cost phased arrays, reduced processor-load algorithms
- **Concurrent EP** - Radar/Electronic Protection, operate in spectrally crowded environments

ASM Technical Challenges

Ocean Acoustics

- High performance two dimensional passive arrays that exploit az/el variations in the noise field
- Small low power sonar and acoustic interceptors that detect acoustic threats
- Deep water acoustic sensors that exploit low noise environments
- Long range synthetic aperture sonars (SAS) that discriminate targets

Air Acoustics

- Detection of low SNR targets for ASW passive sonar systems
- Robust signal classification in complex environments and after extended propagation ranges
- Technologies to replace larger arrays with small-aperture microphone arrays or particle velocity sensors

Seismic

- Ground conditions are unknown and asymmetric due to geology variability
- Significant clutter near urban areas
- Shallow seismic susceptible to airborne acoustics
- Timely access to data from ocean bottom seismometers in tactically and strategically relevant environments

Magnetics

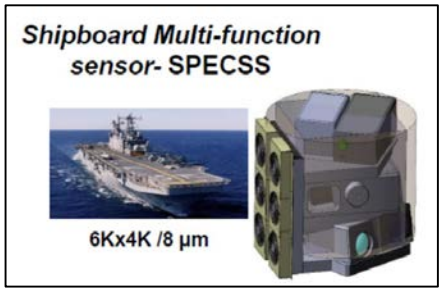
- Low SWAP-C magnetometers
- Magnetometers on unmanned platforms
- Low cost magnetometers for wide area coverage

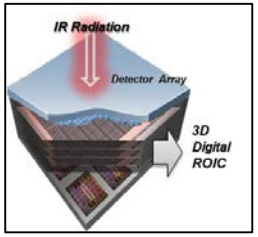
Processing Technical Challenges

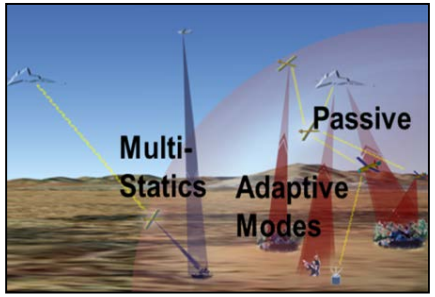
- Complex Urban Environments
- High Confidence and False Alarms
- Multimodal and Multi-looks
- Training Costs

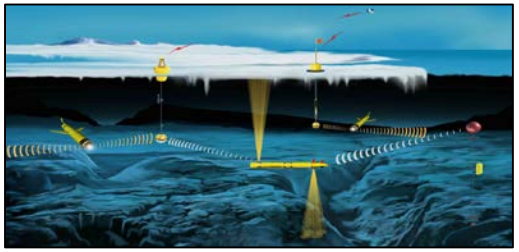
Cross Service Collaboration Efforts

- **Electro Optical / Infrared**
  - Degraded Visual Environments (DVE) – Fusing RF and EO multispectral technology by collaboration
  - Digital Readout Integrated Circuits (DROICs) – Developing real-time multi-function processing capabilities of DROICs. Applications include IR search and track, threat detection, 360 SA and pilotage/DVE
  - III-V Focal Plane Arrays (FPAs) – Tri-Services collaboration on development of an affordable large format FPA at higher operating temperatures (HOT)
- **Radio Frequency**
  - Target Detection in Concealed Environments (Foliage and Ground Penetration); combining RF and Ladar yielding significant ID capability
  - Multi-Mission/Multi-Function (M2/MF) RF Sensing HW/SW for improved capability and survivability against advanced jammers and IADS
  - Multi-Intelligence Sensor Processing, Exploitation and Processing (Multi-Int PED) for detect, track, and ID of mobile targets and enhanced intel capabilities through national to tactical tipping and exploitation.
  - Anti-Access/Area-Denial (A2/AD)Common Open Standards
- **Acoustic, Seismic, and Magnetic**
  - UUV based acoustic sensing efforts





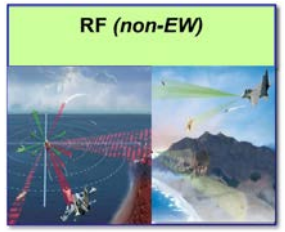


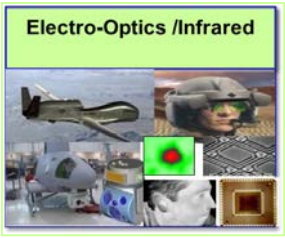


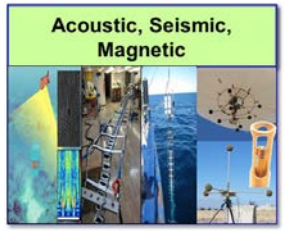
Overview of Sensor COI Portfolio Changes

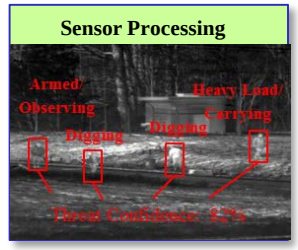
Roadmap Trends for Sensors and Processing (No changes to service's technology strategies)

- (EO/IR) Digital Read-Out Integrated Circuits becoming ROIC of choice and are being integrated into production offerings fielded systems with new capabilities
- (EO/IR) Investments in III-V Focal Plane Array technology have resulted in transitions to fielded systems (JSF EODAS)
- (EO/IR) Emphasis on affordability and cost reduction aligned to the vision of expendable sensors (HSI and image-forming sensors)
- (RF) Cross-service Focus to Affordable ISR (5-7 Focus) [FY17 AF lead Phase 0 trade study included multi-domain (air, land, surface, sub-surface] ISR Collection scenarios and analysis of alternatives assessment for multi-function C-SWAP constrained ISR concept platformS
- (ASM) Major investments in submarine sonars are driving efforts to optimally exploit an expanded sensor base.
- (SP) Synthetic and Hybrid Training data being matured to try and leverage commercial advances in Deep/Machine Learning for ATR
- (SP) Significant Investments in Machine Learning and Artificial Intelligence to develop automation superiority. Office of Director of National Intelligence (ODNI) is investing significant funds in Machine Learning and Artificial Intelligence (Project Maven) with spin-off to the DoD AI Community in CY2018.









Take Aways

- **Sensors and Exploitation Processing CoI is functioning as an effective Reliance 21 vehicle with good cross service collaboration in components and processing.**
- **The portfolio continues to be solid, particularly given the current fiscal environment.**
- **Good collection of CoI collaboration opportunities were executed in CY 17 with more planned for CY 18.**
- **Addition of Processing sub-group will assist in identifying cross service collaboration opportunities as well as leveraging of emerging thrusts from academia and non-traditionals in the sensor processing technology space.**
- **Continued resourcing of Applied Research for the Advancement of S&T Priorities (ARAP), and Seedling opportunities is an effective tool to stimulate additional tri-service collaboration.**

Conclusion

- **The Sensor COI will continue to act as OSD's principal Reliance tool for technical and programmatic de-confliction and coordination of efforts under the purview of the Sensors CoI.**

- **The CoI stands ready to work with industry to share gaps, technical challenges, and technical directions (subject to the limitations of the FAR, disclosure policy, and other DoD directives).**

- **The CoI membership will also seek to identify key Contractor IRAD efforts and leverage to the maximum extent possible across the department.**

Qs and As

QUESTIONS