

# Advanced Correlator-Navy (ACOR-N) Multi INT, Ship Track Data Fusion and Pattern of Life Processors

NAVSEA SBIR Topic N193-A01

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***The Mission:*** Detection, tracking, classification, and identification of threats of high interest at long range from the Battle Group



# *Jove Sciences, Inc. (JOVE)*

- **Unique expertise in multi sensor data fusion, cloud computing, acoustic signal processing, oceanography, ocean wave energy, and other high tech areas**
- **Advanced Correlator – Navy (ACOR-N)**
  - “Seed” started in 1998 from a Naval Postgraduate School project
  - ACOR-N currently has had three previous SBIR Phase II efforts for NAVWAR, ONR, and USAF
  - ACOR-N’s government patent rights can be applied to commercial projects
  - JOVE is transitioning ACOR-N to the NAVSEA Cooperative Engagement Capability (CEC) Program of Record



# The ACOR-N PoLP Team

The Advanced Correlator-Navy (ACOR-N) ship track multi-INT data fusion processor is TRL-8:

- Been demonstrated in five Trident Warrior Experiments – assessed as needed by Fleet outside POM process
- Tracking threat contacts in WESTPAC with COMPACFLT
- Detecting and **tracking ships worldwide in near real-time!**

The ACOR-N Pattern of Life Processor (PoLP) receives ACOR-N's output AIS tracks in near real-time, and uses Machine Learning algorithms to detect anomalous behavior

ACOR-N PoLP Engages Across the Fleet:

- C3F
- NAVWAR
- NIWC-PAC COR
- Minotaur
- PACOM
- COMPACFLT





# The Navy Challenge

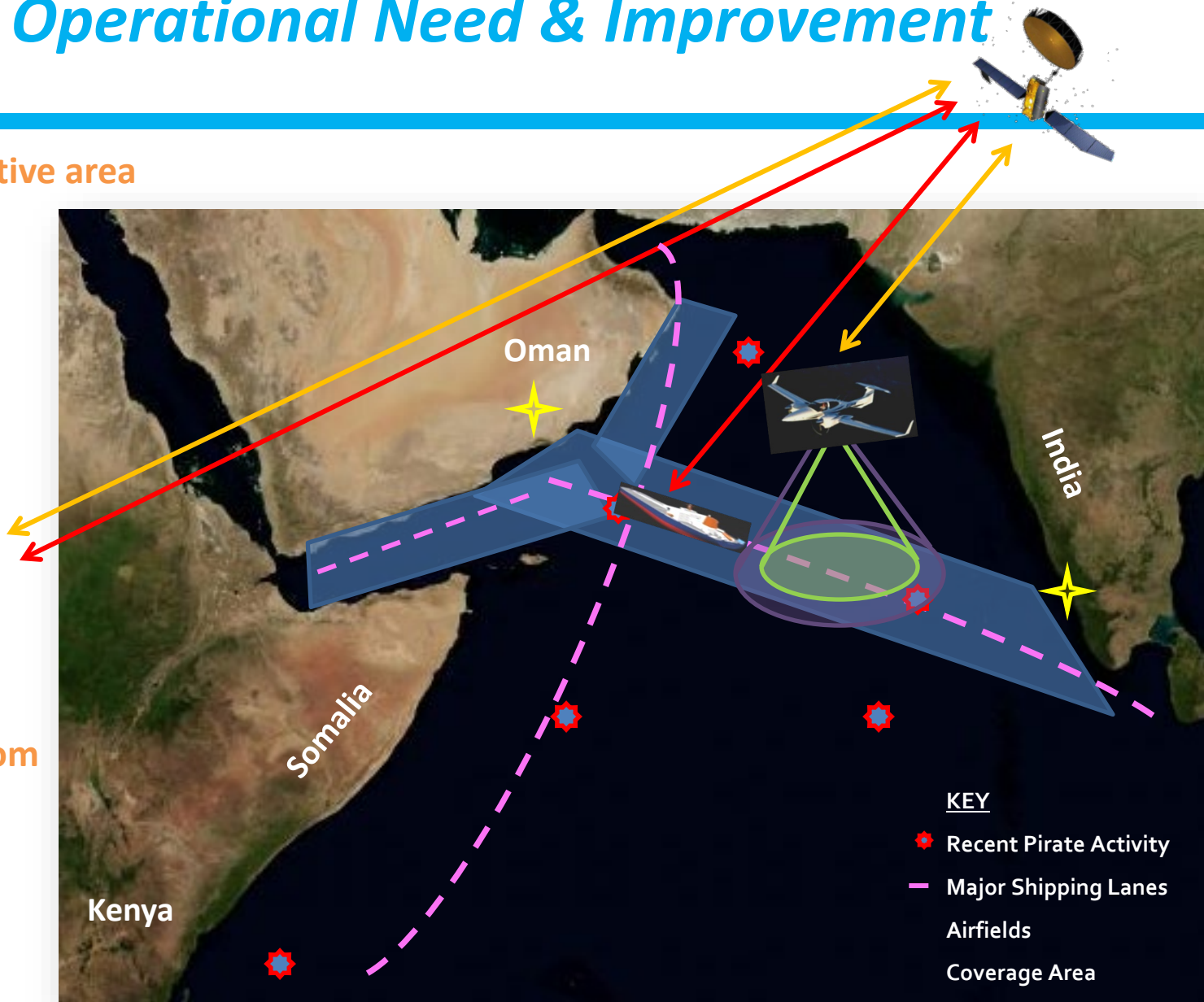
- Detect, track, classify, and identify adversary naval combatants that are hiding among commercial ships in dense shipping environments
- **Multi sensory data fusion is absolutely required – no single sensor is a silver bullet:**
  - **ACOR-N** has been demonstrated and assessed in five real-time Trident Warrior experiments, as well as coprocessing WESTPAC data with COMPACFLT to DT&C threats of interest in an experiment called ACOR-N Harvest 20120
  - The ACOR-N Pattern of Life Processor significantly enhances threat classification and identification
- **Expected transition targets**
  - Cooperative Engagement Capability Inc II
  - Minotaur/NAVAIR; IWS-5 ASW; DCGS-N
- **Expectations**
  - Phase III contract with CEC
  - Minotaur direct to Phase II contract





# Operational Need & Improvement

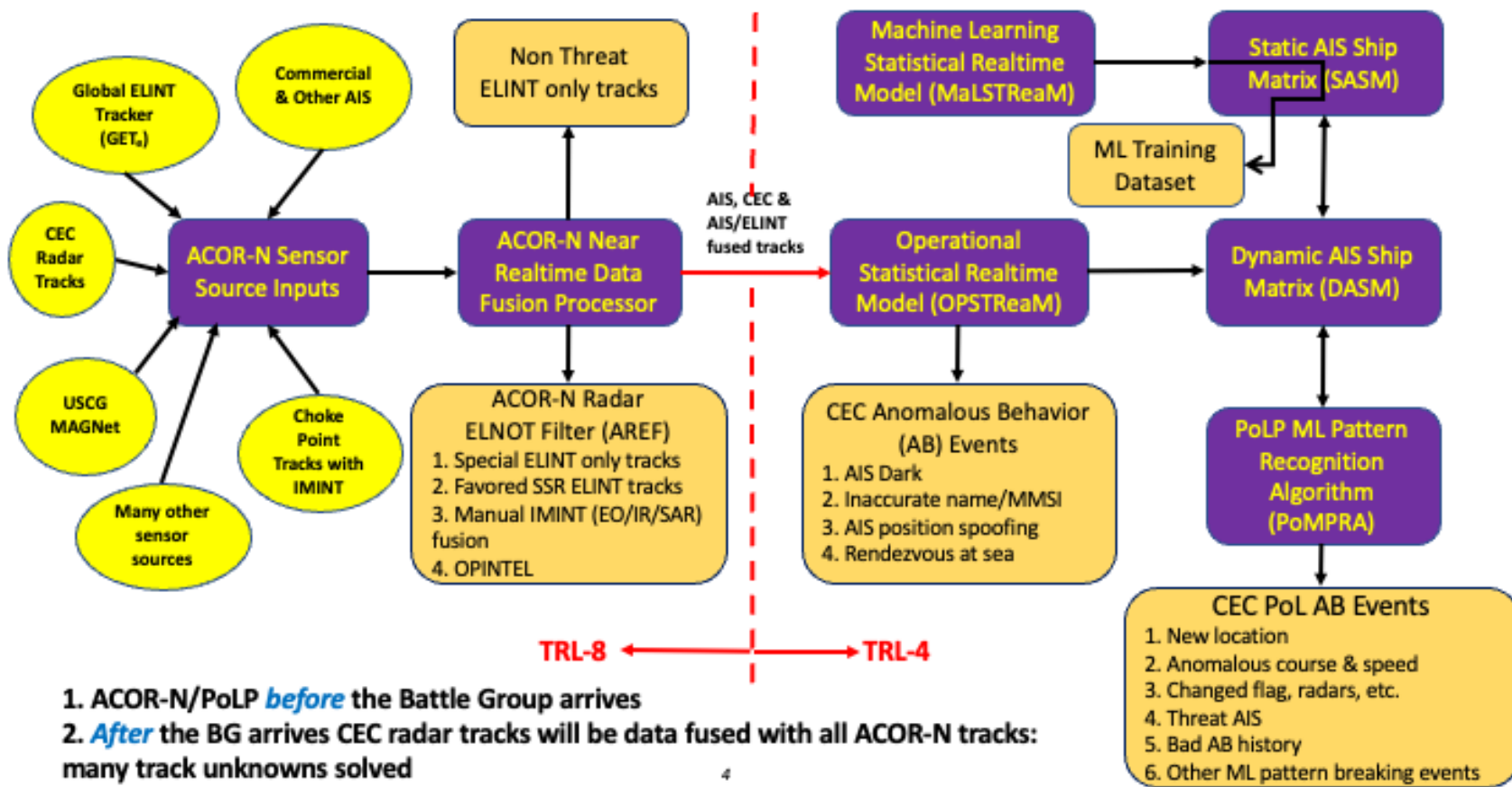
Notional illustrative area





# The Solution

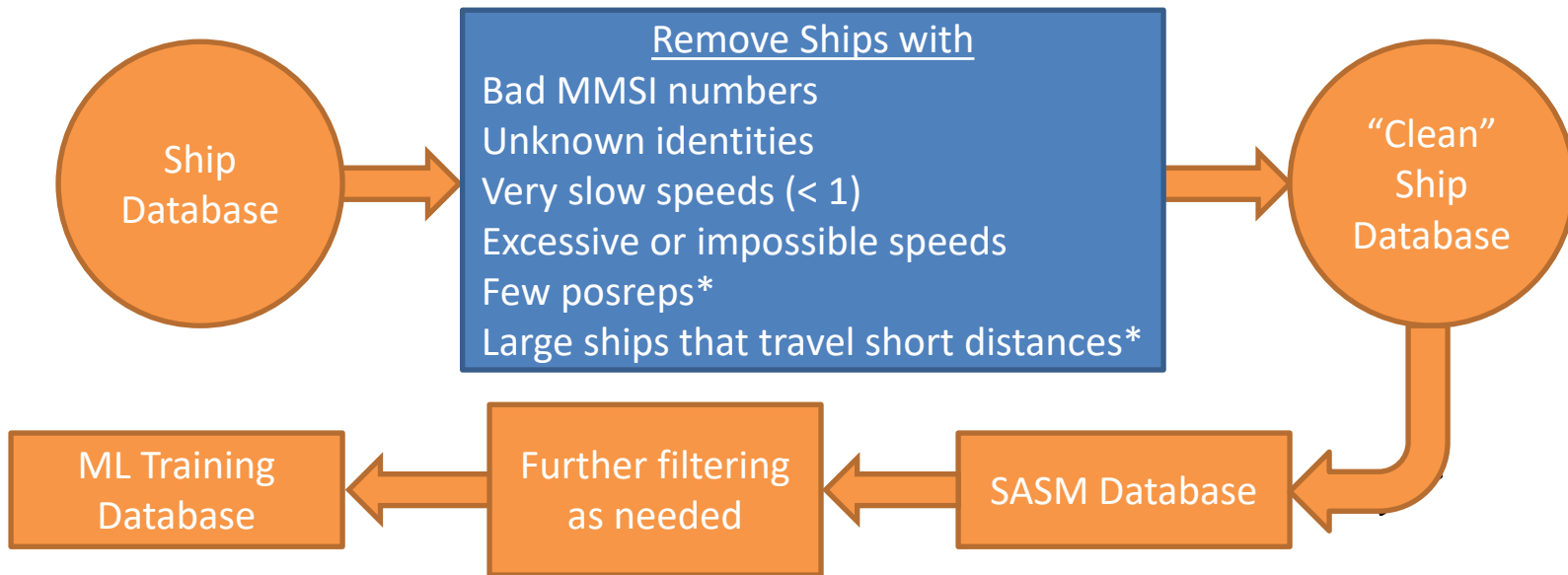
## Advanced Correlator – Navy (ACOR-N) Connectivity to Pattern of Life Processor (PoLP)





# MaLSTReaM Filters

- MaLSTReaM designed to create a clean truth statistical ship database for Machine Learning



- \*filter for ship statistics based on size of the water body, e.g., if statistics for a ship in an ocean is wanted, short transits not included



# Current Status

- ACOR-N data fusion processor is TRL-8
- PoLP is TRL-4 and can be developed rapidly using classified ACOR-N SIGINT
- IMINT tracks fused with AIS tracks. Anomalous Behavior (AB) detected with ML alg
- Goal is to extend the PoLP and MLK to characterize threats of interest
- Future Milestones, Schedule, and Potential Funding
  - Real-time JAVA code is being developed for **AREF** and **GET<sub>e</sub>** : 4 months Phase II
  - ACOR-N can then be transitioned into CEC under a Phase III SBIR: 18 months
  - PoLP will be developed in Phase III and with Minotaur Phase II funding: 18 months
  - The Statistical Real-time Model (**STReaM**) has two modules: Machine Learning STReaM (**MaLSTReaM**) to produce training data for ML Alg and Operations STReaM (**OPSTReaM**) to detect AB for the operator in near real-time; 16 months
  - The Static AIS Matrix (**SASM**) has one row for every AIS ship and over 100 columns with characteristics of each AIS ship: SASM has 500+ rows and increasing
  - The Dynamic AIS Matrix (**DASM**) data bases all OPSTReaM track history and course/speed statistics. CEC/BG can **build PoL data base worldwide!**
- ACOR-N is an ideal fit to CEC data fusing ACOR-N non-organic NOS and UAS sensor sources with CEC's organic radar sensor sources
  - PoLP to integrate ONI ORCA and other static PoL data bases as it transitions to CEC
- ACOR-N with AREF and GET<sub>e</sub> was developed and tested over two decades, and PoLP would not be possible w/o ACOR-N's performance





# Key Features / Advantages / Benefits

- **Currently CEC Inc II inputs only radar tracks organic to the Battle Group, but NAVSEA's number one technical objective is to "detect and track threats at range"**
- **ACOR-N solves this problem by detecting and data fusing NOS and UAS SIGINT and IMINT sensor sources with AIS tracks**
  - GET<sub>e</sub> detects ELINT tracks of high interest, while AREF filters out all non-relevant commercial AIS and ELINT tracks for PoLP processing
  - ACOR-N data fuses CEC organic radar tracks with ACOR-N non-organic tracks
- **DoD producers PoL information in static databases (ONI's ORCA)**
- **ACOR-N significantly enhances the PoL procedure by dynamically updating the AIS PoL database in the real-time ACOR-N tracks**
  - MaLSTReaM processes AIS training data for PoLP's Machine Learning (ML) Anomalous Behavior (AB) algorithm
  - OPSTReaM stores AIS track PosReps in DASM, and computes AIS course and speed fourth order statistics "On the Fly"
  - STReaM outputs tracks that go AIS Dark, that report inaccurate ship names/MMSI #s, that spoof their positions (non geofeasible speeds), or that rendezvous at sea
  - The PoLP ML algorithm then assesses AB as a function of ship type, season, ocean location (defined shape files), etc.



# Comparison of ACOR-N Capabilities

C4ISR Function vs. C4ISR Product	ACOR-N	Minotaur	S2A	ISAT	FADE/MIST	DCGS-N
Data Correlation	✓	✓	✓	✓	✓	✓
Data Fusion (Level 2+)	✓	✓	✓	✗	✗	✓
Multi-Int Fusion	✓	✓	✓	✗	✗	✓
ACOR-N Radar ELNOT Filter (AREF)	✓	✗	✗	✗	✗	✗
Global Elint Tracker- Enhanced (GET <sub>e</sub> )	✓	✗	✗	✗	✗	✗
Best Fit Algorithm (BFA) to Resolve Ambiguity of Tracks	✓	✗	✗	✗	✗	✗
ACOR-N SIGINT/IMINT Fusion (ASIF)	✓	✗	✗	✗	✗	✗
Jove Lynx SAR Tracker (JoLT)	✓	✗	✗	✗	✗	✗
ACOR-N PoL Processor: Static AIS Ship Matrix (SASM) and Dynamic AIS Ship Matrix (DASM)	✓	✗	✗	✗	✗	✗
Statistical Track Real-time Model (STReaM) for ML PoL Processor	✓	✗	✗	✗	✗	✗



## *Transition to the Fleet*

- **Transition of ACOR-N to CEC Inc II has started**
  - Submitted proposal to Project Overmatch (PO) to coprocess and analyze ACOR-N WESTPAC data with C3F
  - Based on excellent Phase II results to date, NAVSEA/IWS-6 may award a Phase III contract to transition ACOR-N
  - The Raytheon CEC Test Facility (RCTF) in Saint Petersburg FL will be used to test and evaluate CEC organic radar data fusion with ACOR-N NOS sensor sources
- **NAVAIR/Minotaur is processing a JOVE extended Phase II to transition ACOR-N into Minotaur**
  - Minotaur Phase II is scheduled for Nov/Dec. 2021 funding
  - Minotaur will be enhanced with addition of automated data fusion, GET, and AREF
- **Other Programs of Record benefiting from ACOR-N are PMS-485 ASW acoustic, non-acoustic data fusion; Distributed Common Ground System – Navy (DCGS-N); Aegis and SSDS Combat Systems; and many others**



# Market Analysis

- **Commercial uses and opportunities**
  - **Illegal Fishing** is a multi billion-dollar industry, and ACOR-N is needed to detect, track, and classify illegal fishing vessels over large ocean areas for ~ 20 countries that have high impact (Thailand, Micronesia, United States, etc.)
    - ACOR-N participated in Sea Dragon II sponsored by PACOM JIOC in 2014 for illegal fishing in Micronesia, and ACOR-N easily detected vessels fishing in EEZ
    - Micronesia had a Cessna 339 for interdiction and EEZ area was much too vast for effective interdiction. Communication networks were also poor
  - **Anti-Pirating** has a critical need for ACOR-N data fusion
    - ACOR-N data fusion of active sensor sources, such as UAS SAR or airborne radars, with ACOR-N's passive sensor sources, such as AIS, IMINT, etc., is the optimum way to detect and track "EMCON Silent" or dark Pirate ships
    - Interdiction is efficient if a "Combined Task Force 161"-like capability is available as it is in the Western Indian Ocean
  - **Illegal drug and weapon contraband movement** requires ACOR-N detection, tracking and classification capability
    - Self Powered semi submersibles (SPSS) and Self Powered Fully Submersibles (SSFS or submarines) are very challenging threats
    - Weapons contraband carriers need to be tracked "port to port"



# Transition/Partnership Pitch

- **NAVSEA IWS-6 is fully supportive of a Phase III transition of ACOR-N if funding is available**
  - JOVE is reaching out to Project Overmatch (PO), Navy TENCAP, and other potential DoD sponsors to provide matching funds to IWS-6 for the Phase III contract
  - ACOR-N/C3F/Raytheon CEC Test Facility will provide value added results that ACOR-N fills existing capability gaps to enhance Phase III award probability
  - C3F/ACOR-N/CEC coprocessing and analysis will be presented to the high-level Broadcast Operations Information Group (BOIG) under PACOM sponsorship (2<sup>nd</sup> visit)
- **NAVAIR/Minotaur ACOR-N transition is well underway**
- **DCGS-N transition has NAVWAR and NIWC PAC as strong ACOR-N advocates. DCGS-N supports the technology once training impact can be demonstrated.**
- **IWS-5/PMS-485 has been briefed on ACOR-N non-acoustic/acoustic data fusion for the ASW mission – a high priority need**
  - ACOR-N is connected to the Air Force Unmanned Aerial System (UAS) MQ-9 Reaper, and NAVAIR's P-8/Triton UAS, NAVAIR's Minotaur, and USCG's UAS assets are natural markets for ACOR-N technology
  - Data fusion of acoustic and non acoustic sensor sources have not yet been addressed by DoD, and are exceptionally good ACOR-N customers (NAVSEA IWS-5, ONI, CUS, etc.)



## Conclusion

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- **Booth location**
  - Leave placeholder – will be assigned at later date

**Conclusion: The Fleet needs CEC/ACOR-N data fusion to detect, track, classify, and identify threats of high interest NOW**