Machine Learning as an Operator Decision Aid on the Tactical Edge

Agile Decision Sciences, LLC
ASRC Federal

Customer-Focused.
Operationally Excellent.

ASRC FEDERAL

Our Corporate Structure

Arctic Slope Regional Corporation

- $2.5 billion in annual revenues
- 12,000 employees across the ASRC enterprise
- 13,000 Iñupiat shareholders
- Largest "Alaskan-owned and operated" company for 22 years

ASRC Federal

- ASRC Federal Holding Company formed in 2003 to manage multiple subsidiaries focused on winning federal government contracts.
- Headquartered in Beltsville, MD with employees in over 40 states across the U.S.
- Employ over 6,000 professionals with emphasis on technical excellence.

Capabilities

- Engineering
- Technical Services
- Information Technology
- Infrastructure Support
- Professional Services

Markets

- Intelligence
- Civil Space
- National Security Space
- Cyber
- Health IT

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ASRC FEDERAL

Introduction

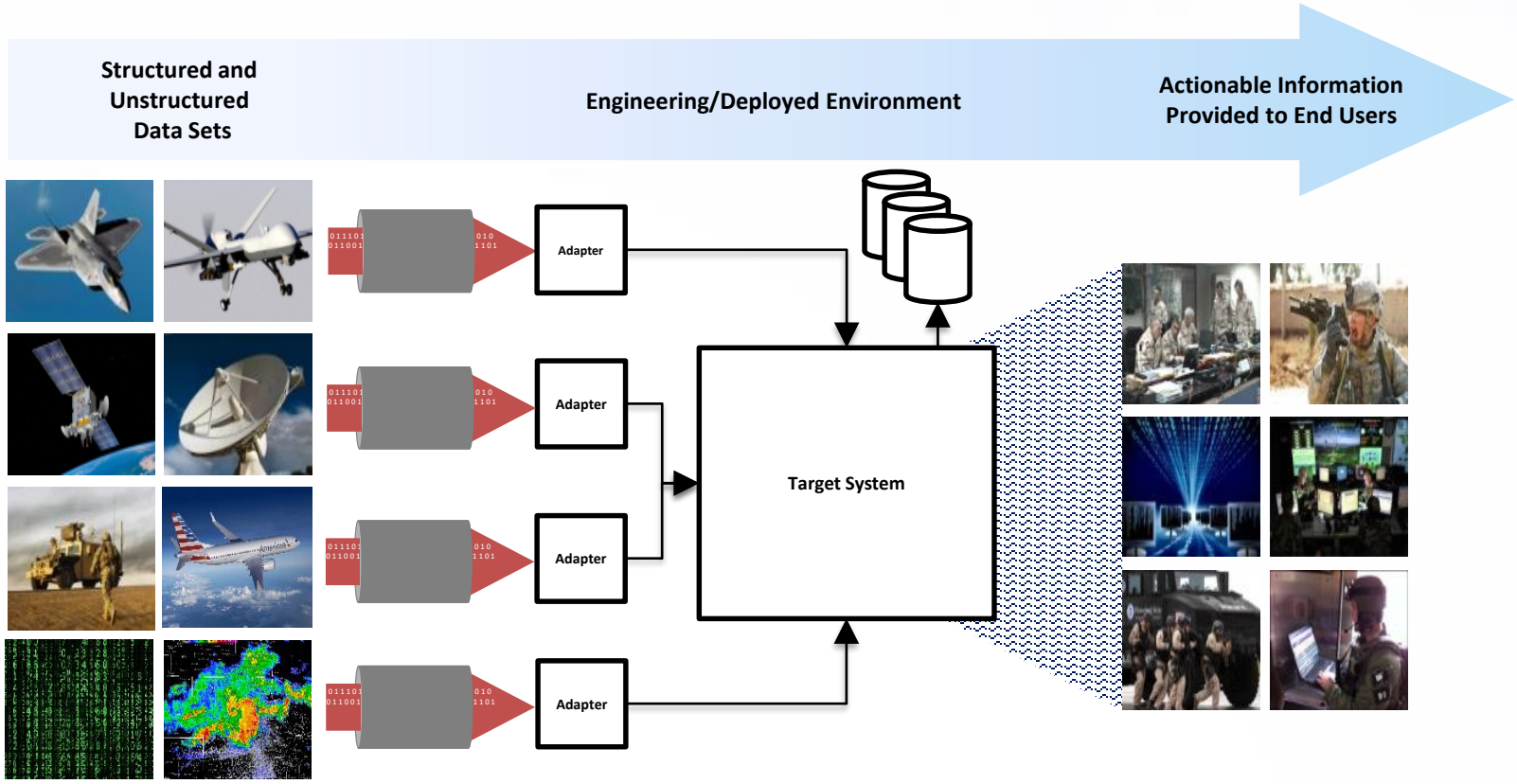
- The DoD deploys a wide range of systems, each having unique requirements and data-generation possibilities.
- The disparate nature of these systems and the platforms they operate within creates additional challenges with respect to collecting, processing, and making decisions on the data they generate.
- A data-agnostic analytics platform, built on a framework of core machine learning technologies, adds value to the tactical edge.

Big Data Overview

- "Big Data" refers to datasets whose scale and diversity require the use of new technologies to obtain insights that will aid users in making critical decisions.
- Defined with the 3-V's
  - Volume – extremely large quantities
  - Velocity – high rate of input and information processing
  - Variety – structured and unstructured types from numerous sources
- The volume, variety, and velocity of the data require a new type of analytics decision aid to manage the large amounts of data in a timely manner.
  - When combining big data with high-powered analytics, some of the results can include:
    - Real-time detection of threats to an environment
    - Determining root causes of failures, issues, and defects
    - Recalculating best-case scenarios from mod/sim events

Understanding the Complex Environments

High-level View



Data Sources:

- Ubiquitous sensors
- "Stovepiped" data providers
- Massive amounts of data
- Digital and analog signals
- Equipment

Processing:

- Data Fusion
- Data Correlation
- Data Processing
- Data Visualization
- Data Exploration

Dissemination:

- Cloud Architectures
- Command Centers
- Edge Delivery
- Design Teams

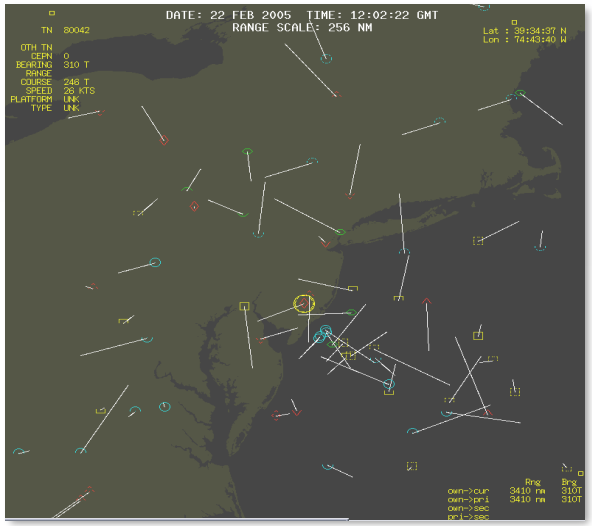
End Users:

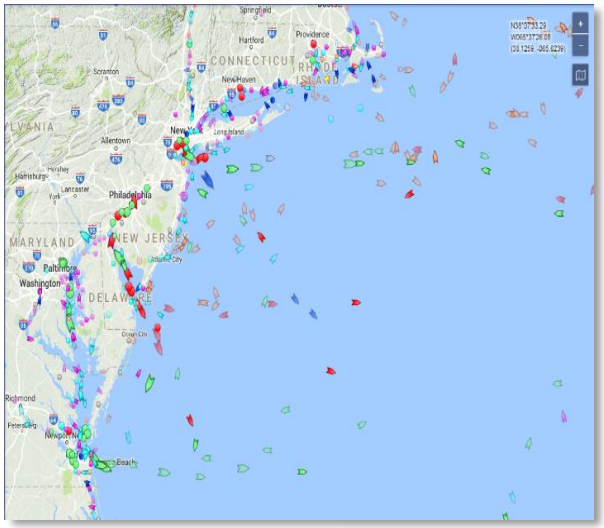
- First Responders
- Disaster Relief Workers
- Soldiers in the Field
- Operators
- Engineers

Understanding the Complex Environments

Front-end System View

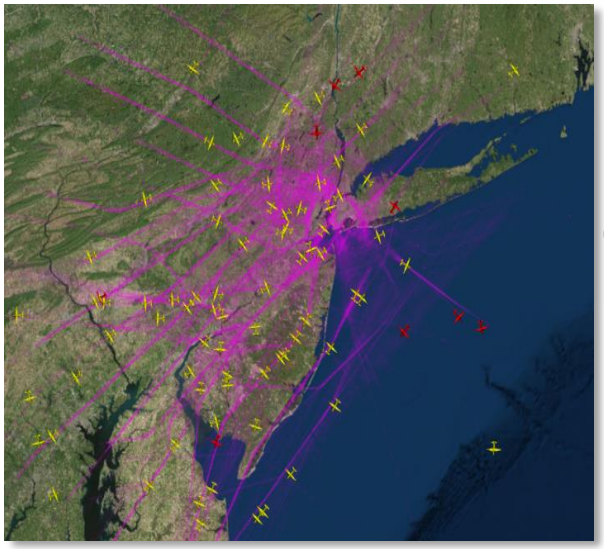
Navy





Coast Guard

Air Traffic Control

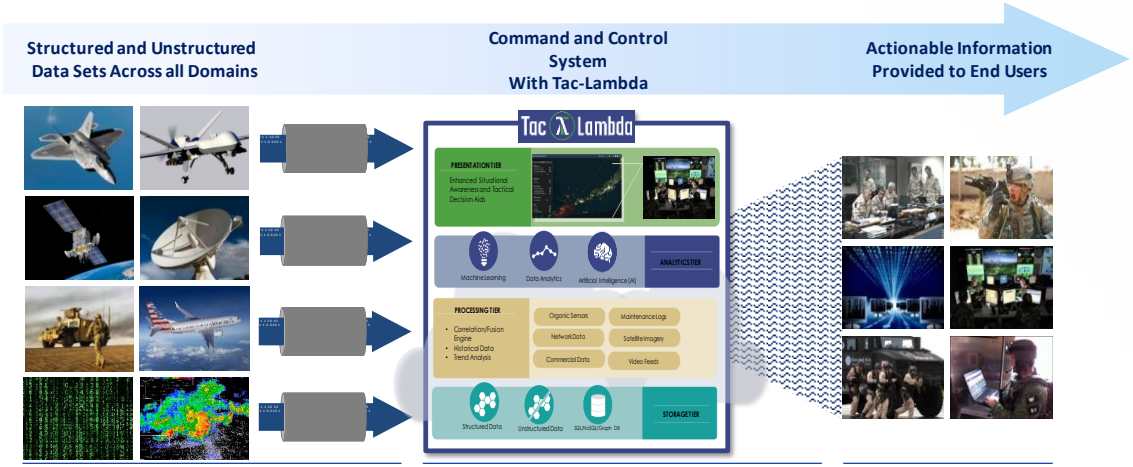


Commercial Air Traffic

Tac-Lambda Overview

The Software Center of Excellence division of ASRC has developed an AI/ML framework leveraging Agile Core Services (ACS-3)

- **Tactical Analytics**
  - Analytics on the Tactical Edge
  - Big Data ingestion and scalable analytics tailored to customer domains
  - Threads such as systems/sensor efficacy, condition-based maintenance, anomaly detection
  - Leveraging Agile Core Service
  - Ingress, egress, analytics, and monitoring components deployed as microservices



Current Data Sources:
- Ubiquitous sensors
- "Stovepiped" data providers
- Massive amounts of data
- Digital and analog signals
- Equipment
- Cyber

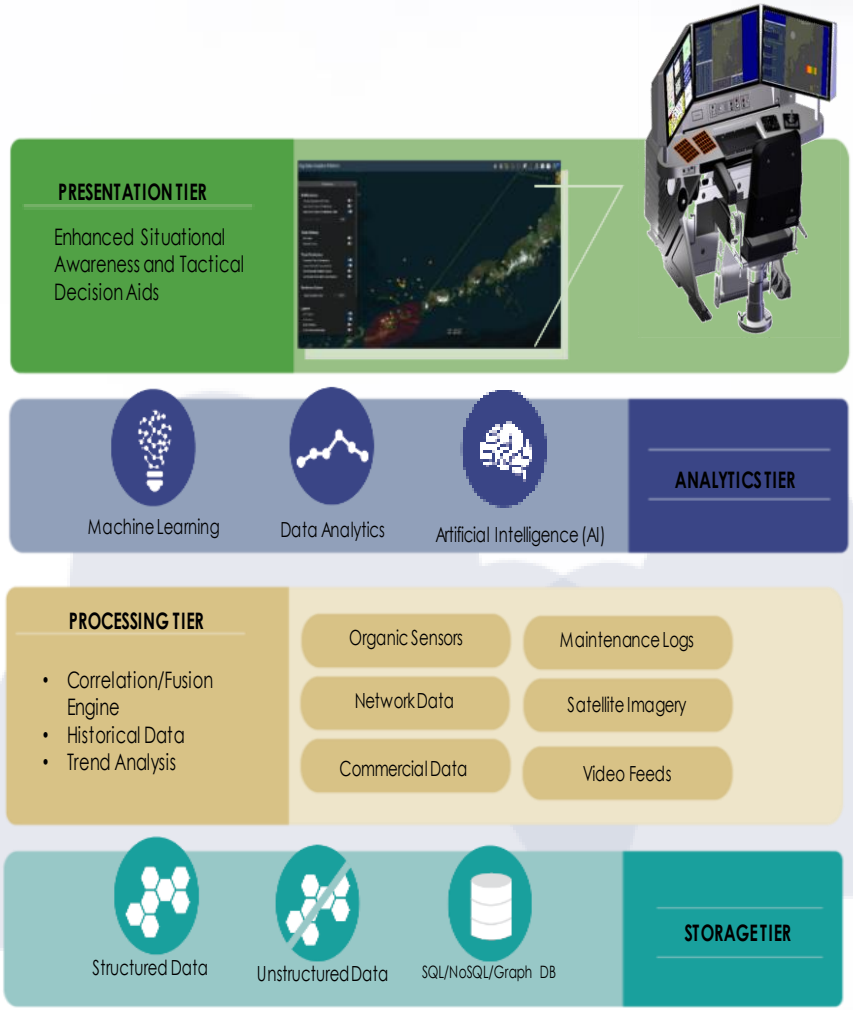
Processing:
- Data Fusion
- Data Correlation
- Data Processing
- Machine Learning

Dissemination:
- Cloud Architectures
- Command Centers
- Edge Delivery

End Users:
- Soldiers in the Field
- Joint/Allied Partners
- Disaster Relief Operations
- First Responders

Applicable Use Cases

- Performance Health Monitoring
- Condition-Based Maintenance (CBM)
- Cyber
- ***Hostile Intent – Flight Anomaly Detection***
- ***Edge-based Computer Vision***
- ***Tac-Lambda Miniaturization (UAV)***
- Operator Workload Reduction
- Track History
- Interceptibility/CPA
- Engageability/Sensor-To-Shooter
- Object Recognition with Augmentation and Synthetic Data Generation
- ***Data Analytics Workbench***



Aegis Critical Experiment

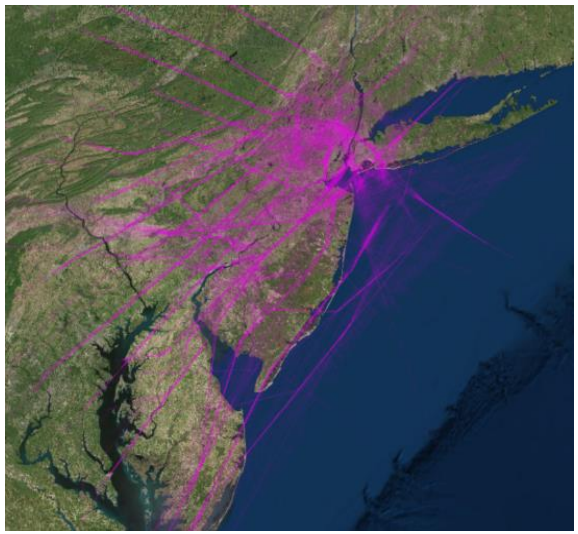
Flight Anomaly Detection

- **Current Issues:**
  - The current system lacks a full set of tools/aids to help operators determine suspicious behavior or hostile intent
  - With a large amount of flights displayed, it is nearly impossible for a human to determine changes in track attributes to identify flights of interest
- **Intended Goals:**
  - Develop a set of decision aids that enables tactical operators to take actions much quicker
  - Provide the ability to automatically identify anomalous air flights in near real-time, reduce operator workload, and reduce time to detect a potential threat
  - Deliver an end-to-end solution that is scalable and extensible for future work and manages the amount of data generated

Aegis Critical Experiment

Applying Machine Learning

- To develop an algorithm capable of discerning the difference between normal and abnormal flight patterns, a model was established from a significant amount of real flight data
- Historical commercial flight data was purchased from FlightAware in order to provide the largest data set available
  - 1 month's worth of local data provided, well over 1 million flight records
- For anomaly detection, a decision-tree model was generated based on positional and kinematic data attributes



Heatmap generated from training data

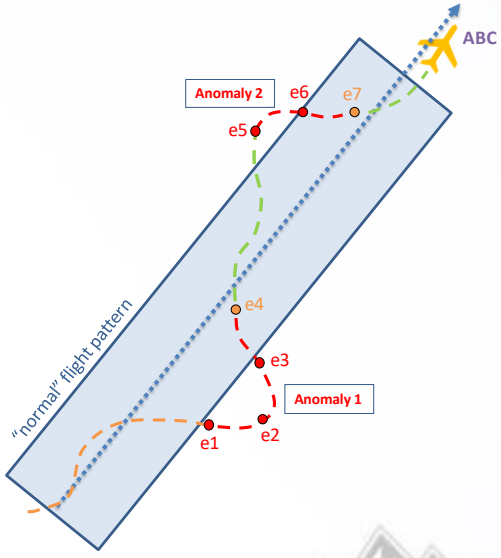
Aegis Critical Experiment

Applying Machine Learning

- While the Government understands the importance of artificial intelligence (AI) and machine learning (ML), there are "trust" issues

"The system has to tell us what it's thinking, that's where the trust gets built. That's how we start to use and understand them."

- In addition to detecting if an aircraft is an anomaly, the rationale behind the decision must also be provided
  - Anomaly detection from an ML model is either a "Yes" or "No" answer
  - The rationale method was used to determine how far off of the norm each of the flight attributes was
  - *Result showed if a flight was traveling too high or low, too fast or slow, or if it was off course*

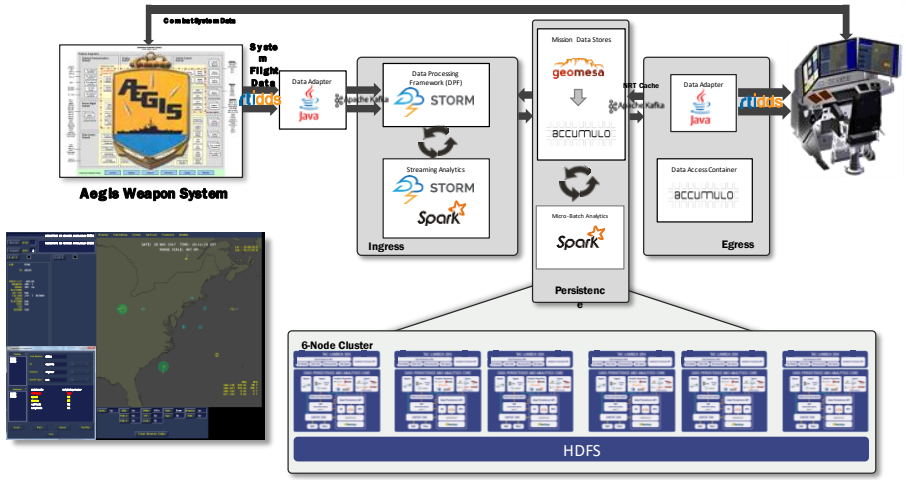


Aegis Critical Experiment

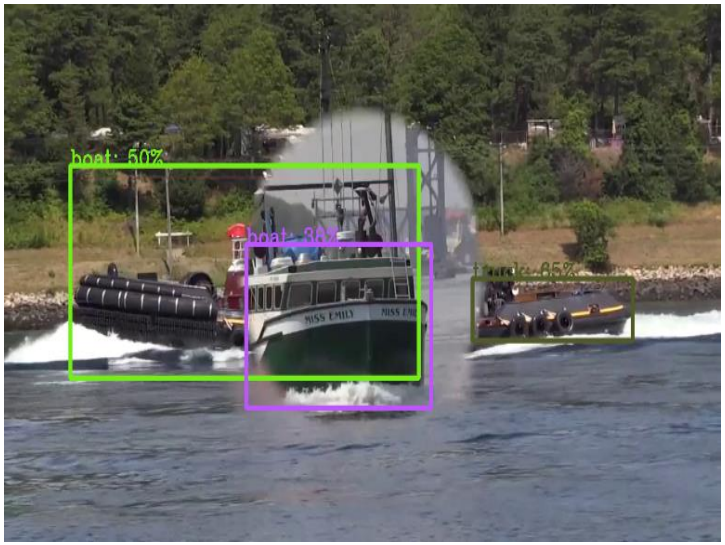
Integrating the Solution

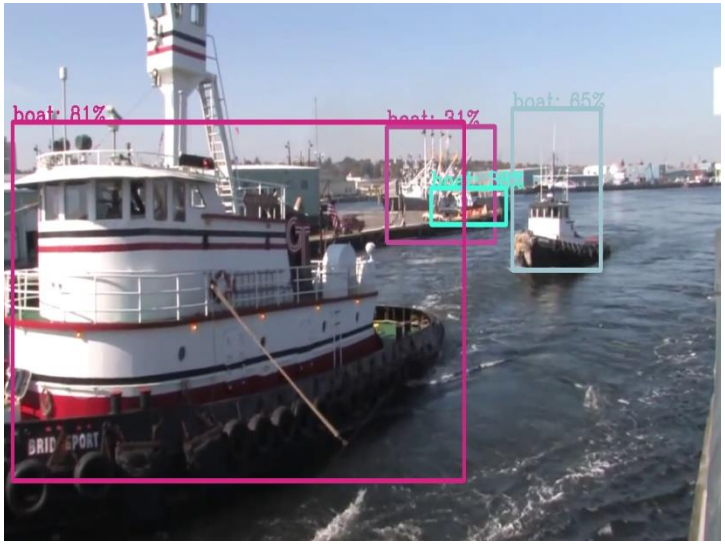
Aegis AI/ML Critical Experiment

- Implemented an AI decision aid for flight anomaly detection
- Created data adaptors to convert existing messages to Kafka for real-time streaming
- Created new Operator Window to organize/prioritize events
- **Solution integration in 2 weeks from inception to delivery**
- **Working to deploy to the Virtual Pilot Ship by Spring 2020**



Edge-Based Computer Vision

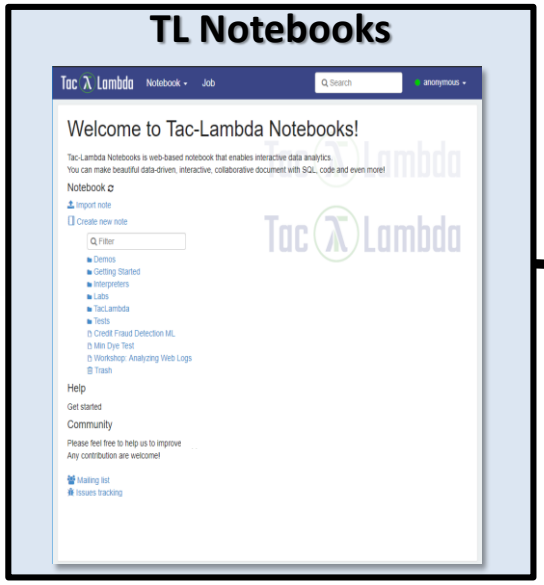




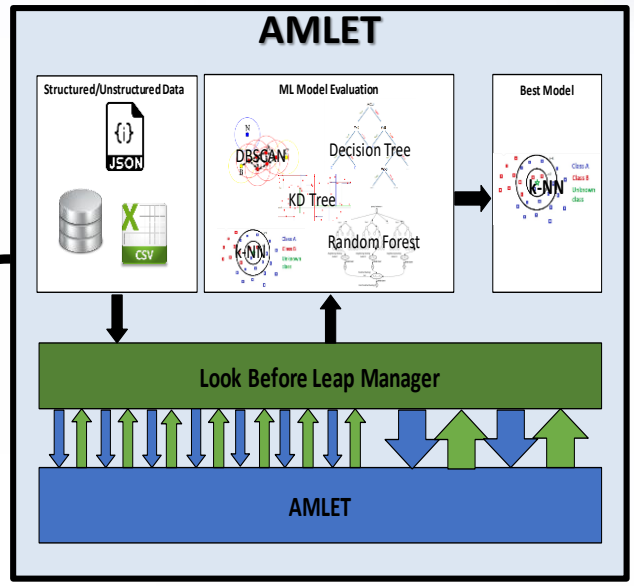
- Real Time
- Complex Images and Scenes
- Multi-Object Discrimination
- Variable Resolution Sources
- Parametric Tagging

2019 ACUASI Summer Mission

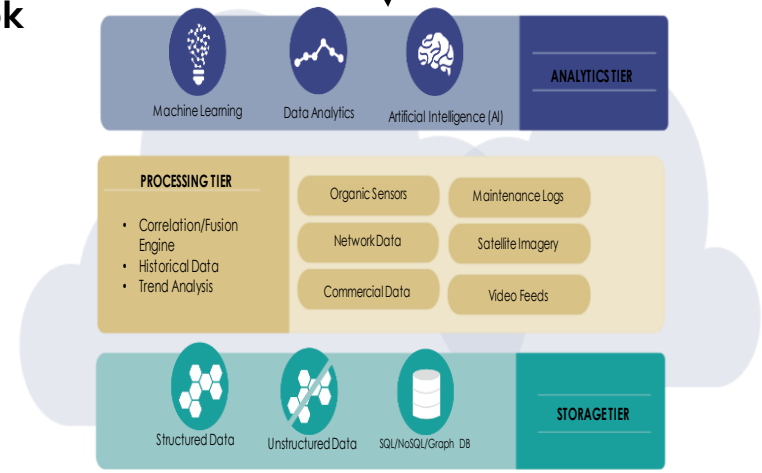
TL Data Analytics Workbench



Static and Real-time Data Analysis on a Deployed Tac-Lambda Cluster



Web-based notebook that enables data-driven, interactive data analytics to be developed on and deployed directly to the Tac-Lambda cluster



Adaptive Machine Learning Engine Toolset, *AMLET*, is a program to easily and efficiently create and test machine models. With its concurrent design, multiple models can be trained or tested in parallel

Wrap-Up

- Framework applies to Tactical and Non-Tactical use cases
- Standardizes the infrastructure platform for Big Data Analytics
- Leverages Agile Core Services (ACS) components being adopted by US Navy
- Value-add software layer to integrate with ACS for data Ingest, Analysis, and Egress
- Demand signal for Big Data technology in multiple areas across DoD

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