Autonomous Target Acquisition (ATA) Tech Showcase

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Agenda

- Introduction to the Munitions Directorate

- Munitions Directorate Priority Areas

- Munitions ATA vs ISR/Fire Control ATR

- Synthetic Data Generation

- Domain Mismatch

- ATA for Collaborative Munitions

- Scene Context

- Weapon / ISR / Fire Control Integration

- Yavin ML Data Science Toolkit

- Random Thoughts

- Autonomy in Weapon Systems – DoDD 3000.09

MUNITIONS DIRECTORATE

- One of nine Technology Directorates comprising the Air Force Research Laboratory

- Location: Northwest Florida - Eglin Air Force Base

- Mission: Discover, develop, integrate, demonstrate, and transition conventional air-launched weapons technologies, enabling the Department of the Air Force to dominate across all domains.

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2023 Priority Areas for Munitions Directorate

RW 2.0 IMPLEMENTATION
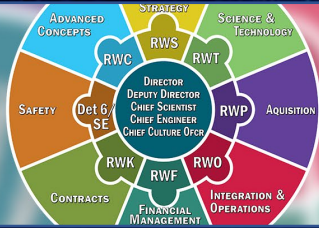
COUNTERAIR

DIGITAL MATERIEL MANAGEMENT

FOUNDATIONAL WEAPON S&T

NETWORKED, COLLABORATIVE, AUTONOMOUS (NCA) WEAPONS

AIRBASE DEFENSE

COUNTERMARITIME

S&T ENABLERS FOR NDO, SOF, AND SPACE

Munitions ATA vs ISR / Fire Control ATR

Typical Munitions Platform

Expendable

Relatively inexpensive

Cheap sensor(s)

Highly SWAP constrained

Processor constrained

ATA Timeline: Order of seconds to minutes

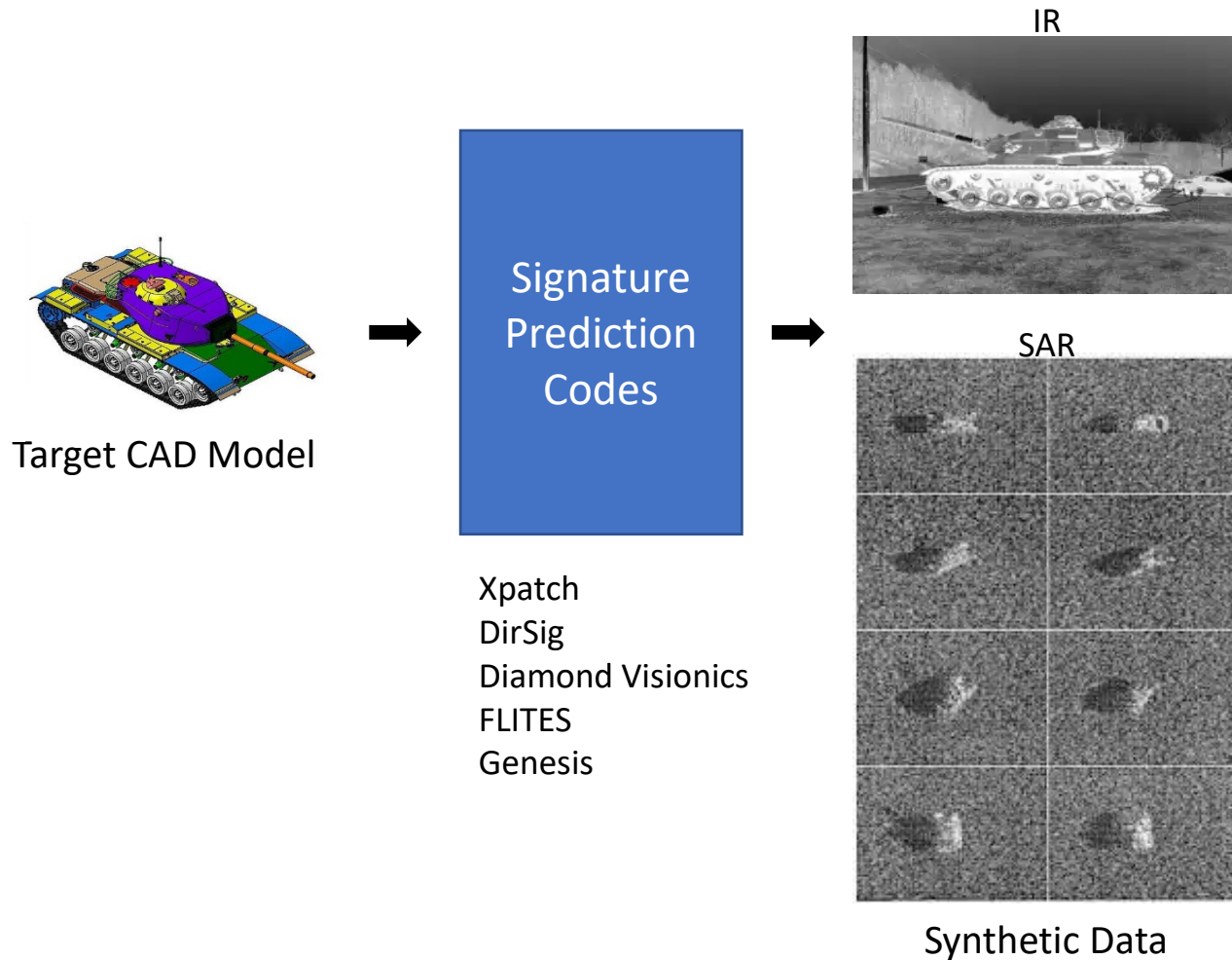**Typical Fire Control Platform**

Reusable

Relatively expensive

Exquisite sensors

Much less SWAP constrained

Much less processor constrained

ATR Timeline: Order of minutes +

Munitions ATA has unique requirements and challenges

Dealing w/ Data Scarcity – Synthetic Data Generation

Target CAD Model

→ **Signature Prediction Codes** →

Xpatch
DirSig
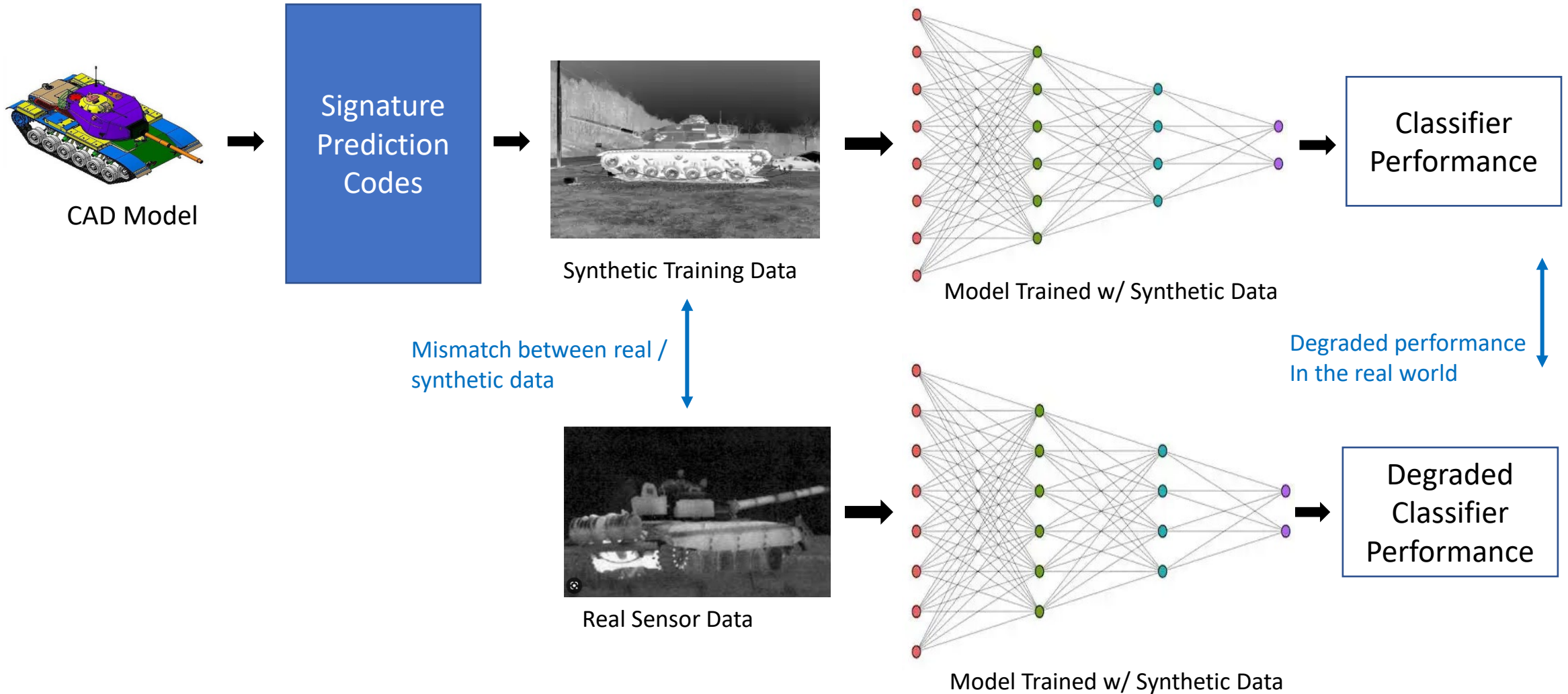Diamond Visionics
FLITES
Genesis

IR

SAR

Synthetic Data

Issues

Availability / accuracy of target CAD models
Material properties in band of interest
Dealing w/ denied targets / unavailable targets
Verification & validation of signatures
High level of expertise required to use tools
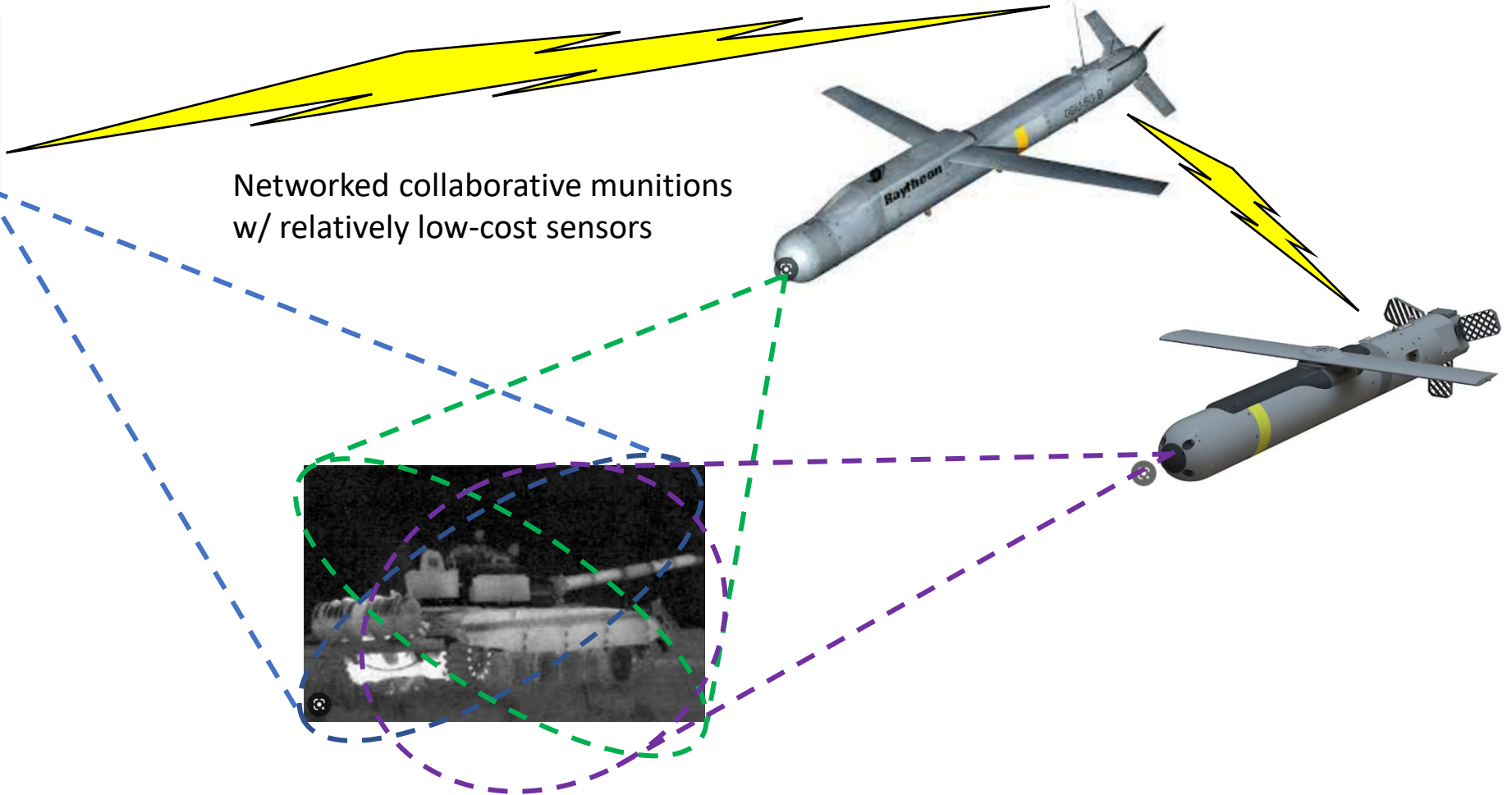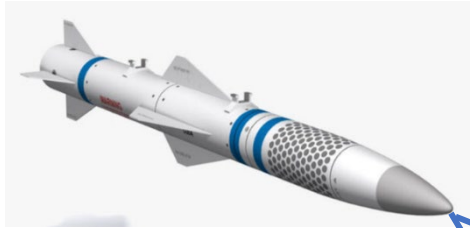Frequency band (X, Ku, Ka, etc) effects ?

Benefits from gaming / video industries – but not in most desired electromagnetic band

Synthetic / Real Domain Mismatch

CAD Model

Signature Prediction Codes

Synthetic Training Data

Model Trained w/ Synthetic Data

Classifier Performance

Mismatch between real / synthetic data

Real Sensor Data

Model Trained w/ Synthetic Data

Degraded Classifier Performance

Degraded performance In the real world

Domain mismatch is a significant problem for DoD

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ATA for Collaborative Munitions

Networked collaborative munitions w/ relatively low-cost sensors

Homogeneous or heterogeneous munitions and sensors

Decentralized control

Constrained network capacity

Sensor fusion from collaborative munitions likely to improve confidence in target ID
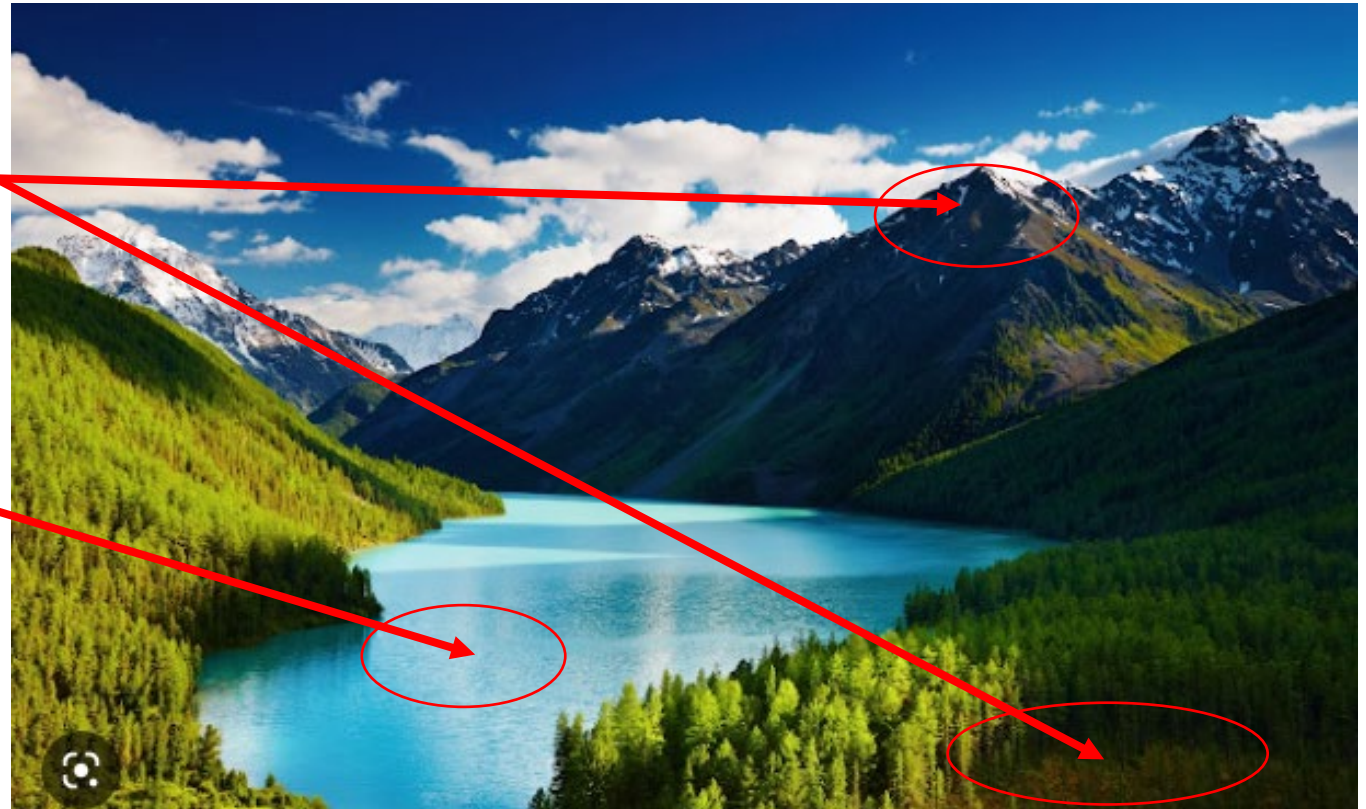
Weapon / Fire Control / ISR Integration
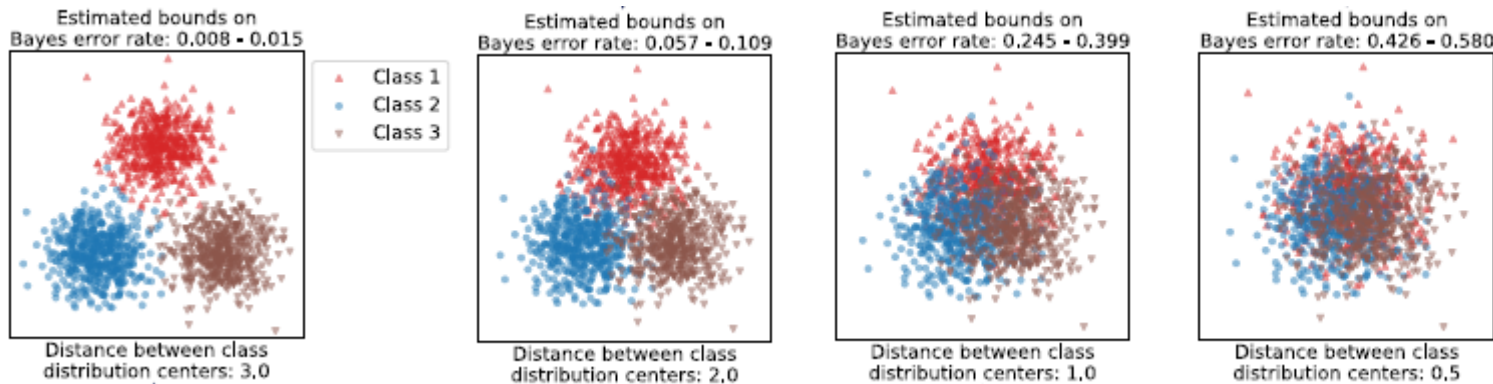
Concepts that more closely integrate _weapon ATA_, _fire control ATR_, and/or _ISR ATR_ subsystems to provide greater overall kill effectiveness, shorter overall kill timelines, lower overall costs, reduced operator burden, and or greater system autonomy.

Increases in weapon network communications and resultant standards will provide increased opportunities for integration of systems

AFRL/RW YavinML Data Science Toolkit

- Python data science package focused on military sensing problem domain
- <u>Supplements</u> open source packages for statistical analysis and ML
  - Graph methods
  - Method specific Henze-Penrose divergence estimators
  - Minimum spanning tree node degree function
  - Angular margin statistic function
  - . . .

YavinML Users:

Contact us if interested in becoming a user

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Random Thoughts

- One-shot / Few-Shot Learning being investigated

- Generally want to avoid the business of chasing infinitesimal performance improvements (Is 89.7% vs 89.5% statistically significant)

- Understanding the 'Why' of ML/AI has value

DoDD 3000.09 – Autonomy in Weapon Systems

DoD DIRECTIVE 3000.09

AUTONOMY IN WEAPON SYSTEMS

<u>25 January 2023</u> revision to original 2012 document
Available at https://www.esd.whs.mil/DD/ (Search for DoDD 3000.09)

This directive applies to the design, development, acquisition, testing, fielding and employment of autonomous and semi-autonomous weapon systems, including guided munitions that are capable of automated target selection.

- Establishes policy
- Provides definitions of autonomous / semi-autonomous weapons ←—————— Much of Munitions ATA falls under semi-autonomous weapons (lock-on-after-launch homing munitions)
- Assigns responsibilities
- Establishes Autonomous Weapon Systems Working Group

- Definitions:
  - Autonomous weapon system – a weapon system that, once activated, can select and engage targets without further intervention by an operator.
  - Semi-autonomous weapon system – a weapon system that, once activated, is intended to only engage individual targets or specific target groups that have been selected by an operator – includes lock-on-after launch homing munitions

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Questions?

Thank You!