

AI for Defense and Intelligence

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Computer Vision

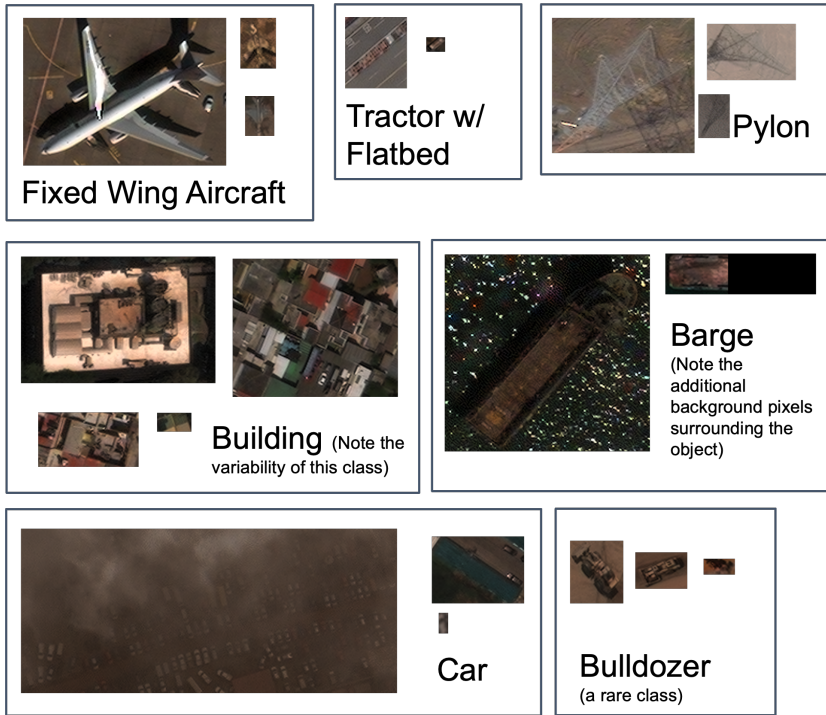


Figure 21. Examples of several object classes in the open source xView dataset.

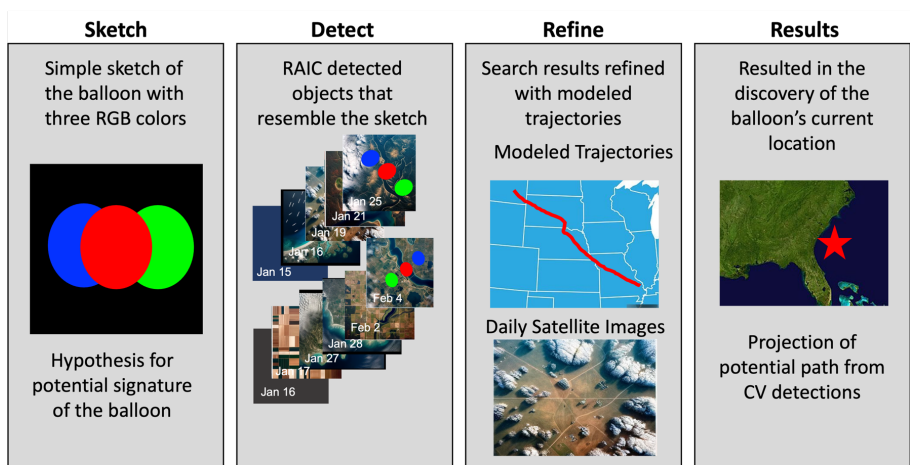


Figure 22. Application of SyntheAIC RAIC to find the Chinese Spy Balloon. Adapted from [14].

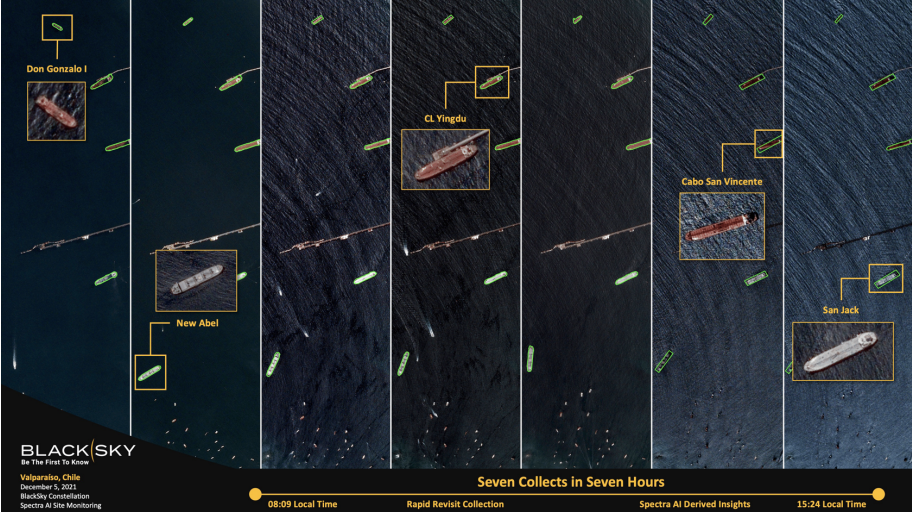


Figure 23. Blacksky Automated Vessel Detection near Valparaiso, Chile [15].
Used with Permission of Blacksky, Inc.



Figure 24. A 3D Model of a Military Tank Generated with a Text Prompt.
(MasterpieceX)

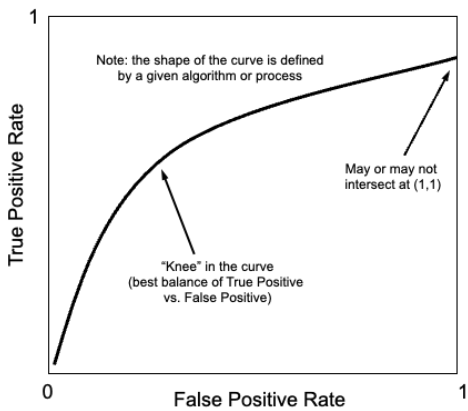
$$\text{Accuracy} = \frac{\text{True Positives} + \text{True Negatives}}{\text{True Positives} + \text{False Positives} + \text{True Negatives} + \text{False Negatives}}$$

$$\text{Precision} = \frac{\text{Correctly Classified Positives}}{\text{All Predicted Positives}} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}$$

$$\text{Recall} = \frac{\text{Correctly Classified Positives}}{\text{All Actual Positives}} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Negatives}}$$

$$\text{F1 Score} = \frac{2 \times (\text{Precision} \times \text{Recall})}{(\text{Precision} + \text{Recall})}$$

Computer Vision



Chapter 7 Generative AI

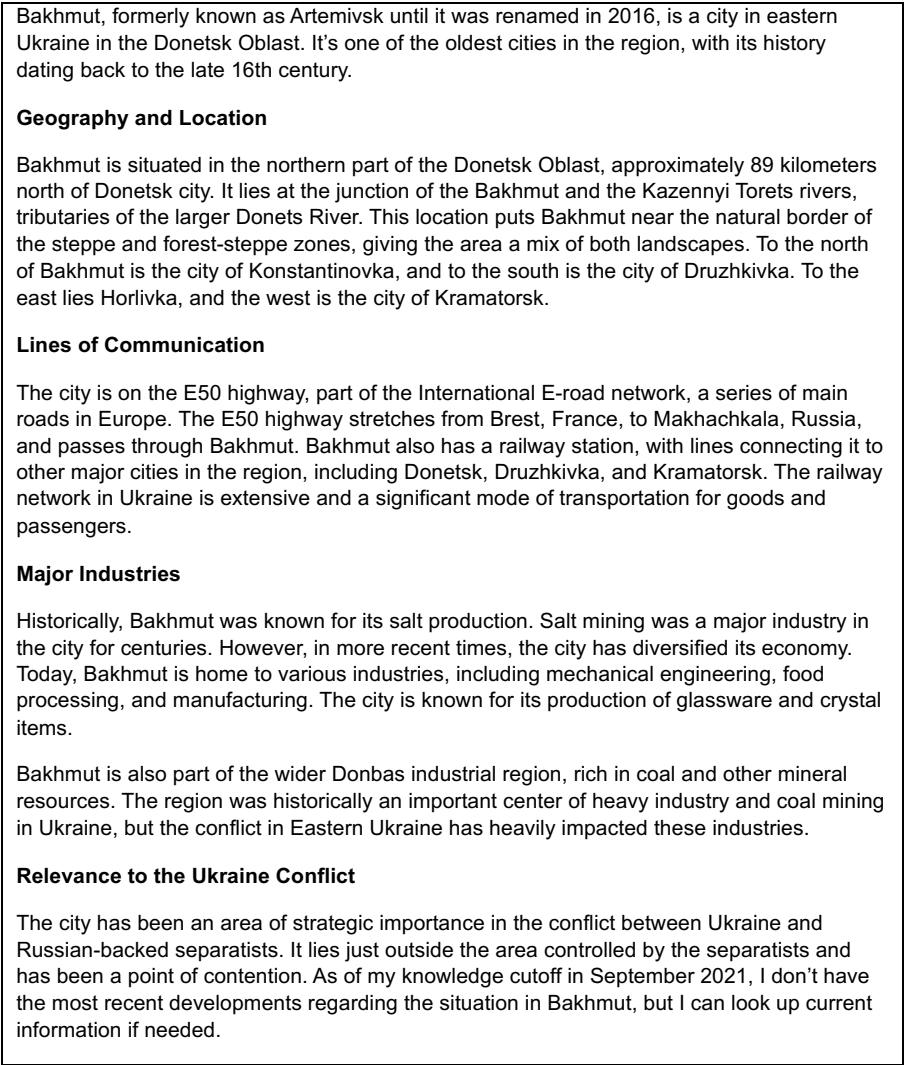


Figure 25. Example of a ChatGPT-generated backgrounder on the Ukrainian city of Bakhmut.



Figure 26. Midjourney-generated photorealistic scene for military training.



Figure 27. Midjourney-generated synthetic imagery.



Figure 28. Midjourney example of synthetic imagery simulating medium altitude drone footage.



Figure 29. Midjourney-generated images of the Final Scenes in a Hallmark Movie.

```

from geopy.distance import geodesic
import itertools

co_travelers = []

# Iterate over all unique pairs of vessels
for (mmsi1, vessel1), (mmsi2, vessel2) in itertools.combinations(data.groupby('mmsi'), 2):

    # Compare each record of vessel1 with each record of vessel2
    for idx1, record1 in vessel1.iterrows():
        for idx2, record2 in vessel2.iterrows():
            time_diff = abs(pd.to_datetime(record1['timestamp']) -
                             pd.to_datetime(record2['timestamp']))
            distance = geodesic((record1['latitude'], record1['longitude']),
                                (record2['latitude'], record2['longitude'])).kilometers

            # Check if both time and distance thresholds are met
            if time_diff.total_seconds() <= time_threshold * 3600 and
               distance <= distance_threshold:
                co_travelers.append({
                    'mmsi1': mmsi1,
                    'mmsi2': mmsi2,
                    'timestamp1': record1['timestamp'],
                    'location1': (record1['latitude'], record1['longitude']),
                    'timestamp2': record2['timestamp'],
                    'location2': (record2['latitude'], record2['longitude'])
                })

return pd.DataFrame(co_travelers)

```

Imports Packages

Code Explanation

Math Calculations

Indenting

Figure 30. Example of GPT-generated Python Script to Find Co-Travelers.



You

Review vessels.csv and identify a pair of vessels that conduct a transshipment event. Only include events that occur more than 10km from any landmass. Include events between a fishing vessel and any other type of vessel. Tell me how many times the pair performed an activity together and the total duration of their activities. Make a table that summarizes six transshipment events for a selected pair of vessels.



ChatGPT

Here is a table highlighting six transshipment events involving the vessels with Maritime Mobile Service Identity (MMSI) 258139000 and 576195000. The table includes details such as start time, end time, duration, median speed, and location (latitude and longitude):

Start Time (UTC)	End Time (UTC)	Duration (Hours)	Median Speed (Knots)	Mean Latitude	Mean Longitude
2015-05-20 04:10	2015-05-21 06:20	26.17	0.041	-62.76	-61.16
2015-05-01 03:40	2015-05-01 12:00	8.33	0.432	-64.37	-61.82
2017-05-13 10:40	2017-05-14 05:30	18.83	0.046	-62.48	-59.72
2017-05-31 11:30	2017-05-31 14:50	3.33	1.368	-63.71	-60.38
2017-06-11 01:00	2017-06-13 08:20	55.33	1.701	-63.30	-62.09
2015-03-24 14:30	2015-03-26 16:20	49.83	0.033	-62.48	-59.72

This table provides a snapshot of the transshipment activities, showcasing the duration and speed of these events along with their geographic coordinates. The participating vessels and their associated metadata are as follows:

Vessel 1:

- MMSI: 258139000
- Flag: Norway (NOR)
- International Maritime Organization (IMO) Number: 9160358
- Name: ANTARCTICSEA
- Type: Trawler

Vessel 2:

- MMSI: 576195000
- Flag: Vanuatu (VUT)
- International Maritime Organization (IMO) Number: 8226739
- Name: LAMANCHE
- Type: Specialized Reefer

These two vessels have performed transshipment activities together 22 times, with a total duration of approximately 581.33 hours.

Figure 31. Application of Advanced Data Analysis to Discover Activities.

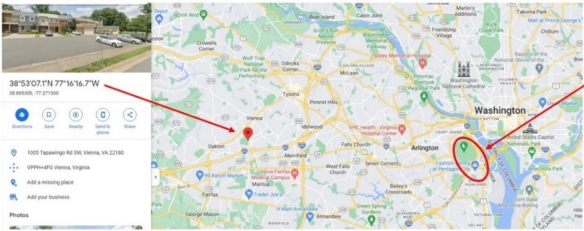
AI Large Language Models (LLMs) – Are designed to string words together

Human: In what country is 38.8853, -77.2713 located?

ChatGPT: The coordinates 38.8853, -77.2713 correspond to a location in the United States. Specifically, **these coordinates point to an area in Arlington, Virginia**, near the Pentagon and the Arlington National Cemetery. Arlington is a county located in the Commonwealth of Virginia, which is part of the United States.

Human: How did you determine that 38.8853, -77.2713 point to an area in Arlington VA?

ChatGPT: I apologize for any confusion caused. I made an error in my previous response. The coordinates 38.8853, -77.2713 do not specifically correspond to Arlington, Virginia. I apologize for the incorrect information. To accurately determine the specific location corresponding to those coordinates, additional information or context is needed. **The coordinates alone are not sufficient to identify a precise place** without further details or nearby landmarks.



“Near the Pentagon and
Arlington National Cemetery”

Large Language Models cannot
accurately answer geospatial
questions because they do not
“understand” coordinates

Approved for Public Release NGA-U-2023-02064

Figure 32. NGA Example of Using LLMs to Answer Geospatial Queries [16].

Chapter 8 Optimization

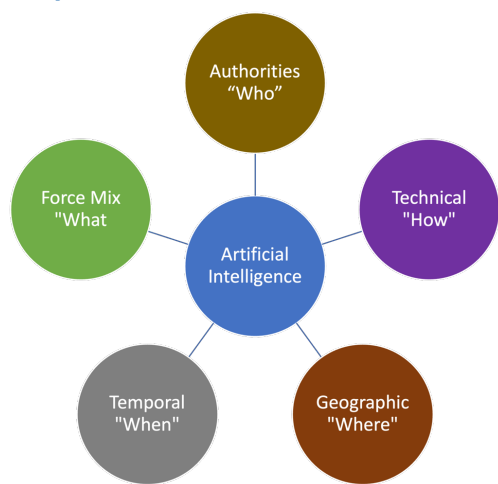


Figure 33. Influence of AI on Joint All Domain Command and Control [17].



Figure 34. DARPA 2005 Grand Challenge Winner, “Stanley” [18].

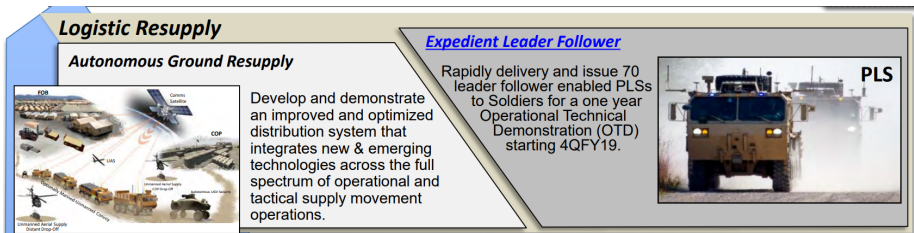


Figure 35. Autonomous Ground Resupply Program Overview [19].

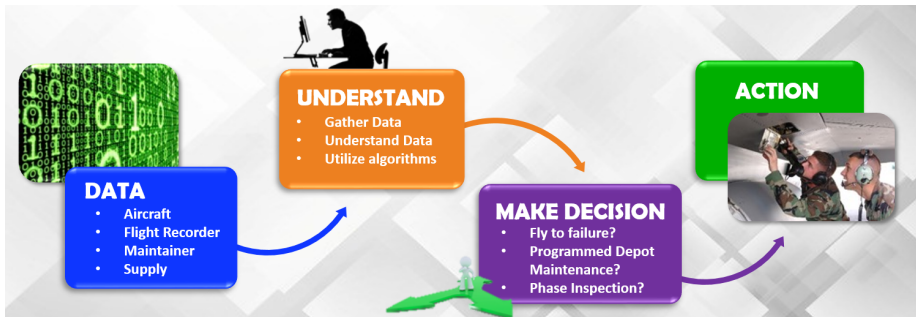


Figure 36. Overview of Condition-Based Maintenance+ (CBM+) [20, 21].

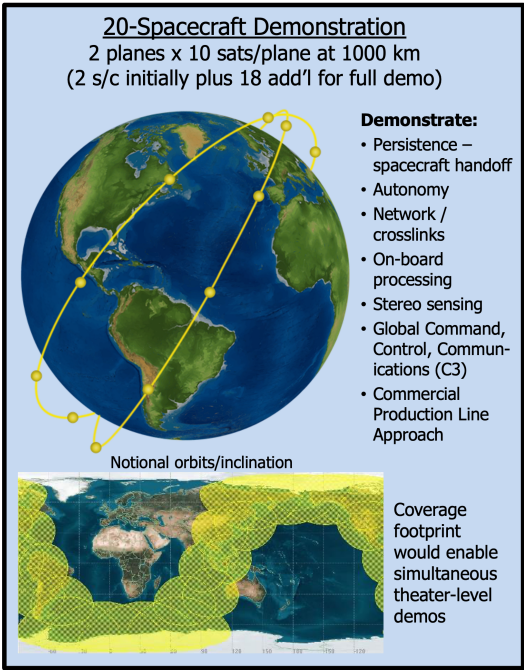


Figure 37. Concept of Operations for DARPA’s Blackjack Proliferated LEO Program [22].

Wordle

S	L	A	T	E
A	B	H	O	R
B	A	C	O	N

Chapter 9 Agent-Based Modeling

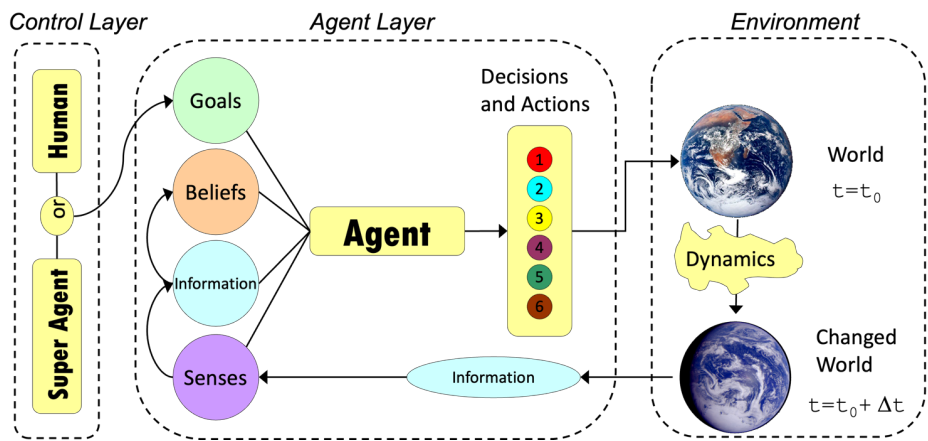


Figure 38. Overview of Agent-Based Modeling [2].

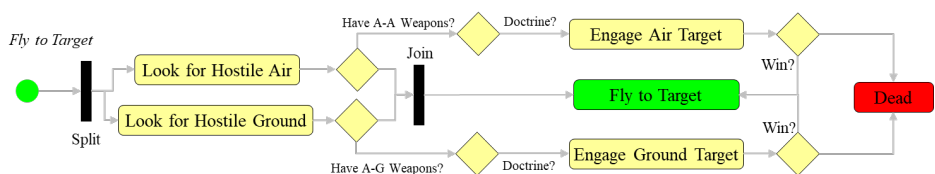


Figure 39. Example of a SysML Sequence Diagram for Agent Rules [2].

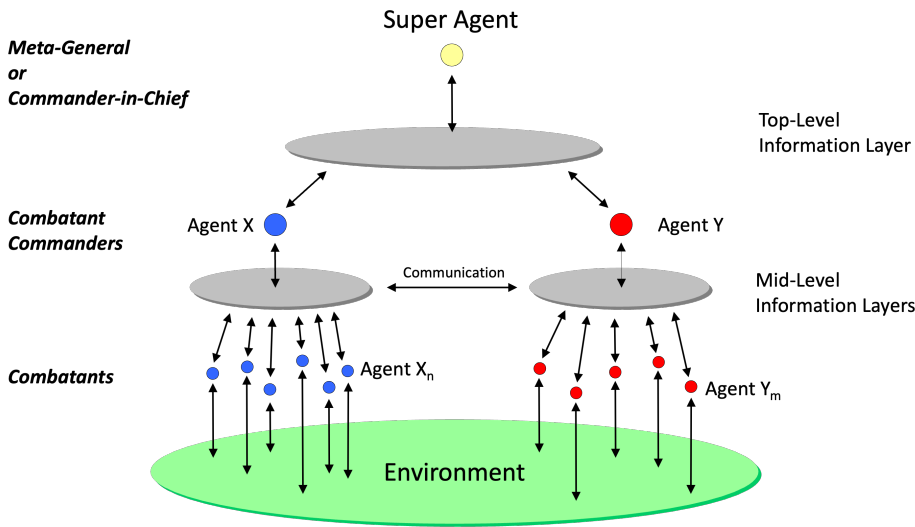
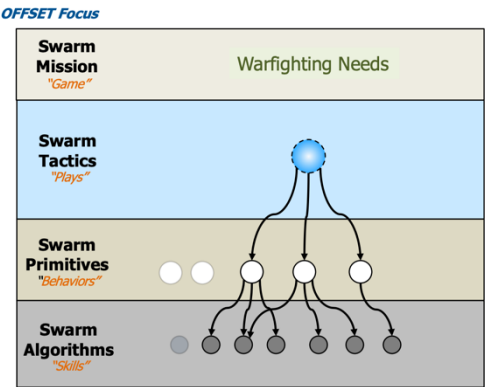


Figure 40. Overview of Multi-agent Systems [2].



Agent-Based Modeling

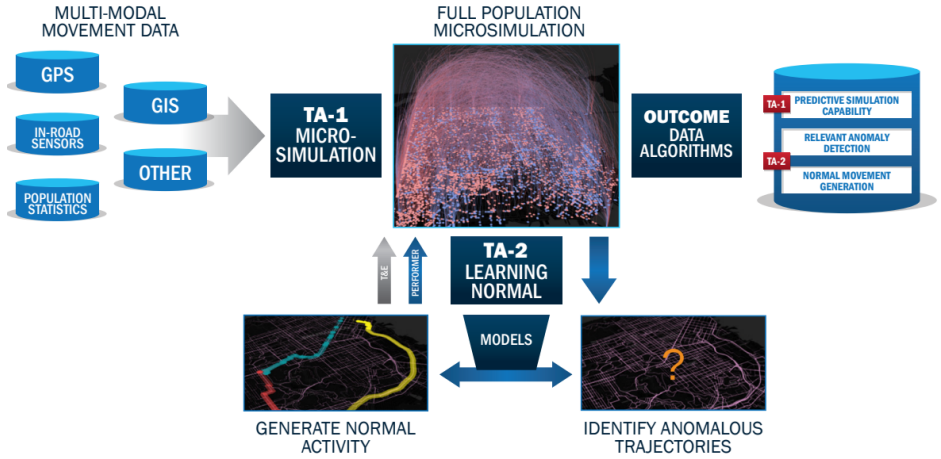


Figure 41. HAYSTAC Program Concept for Microsimulation and Trajectory Analytics [23].

Chapter 10 Defense Applications of AI



Third Offset Strategy Overview

Five initial vectors rejuvenate our Operational Battle Network in order to deter, fight, and win at the operational-level of war

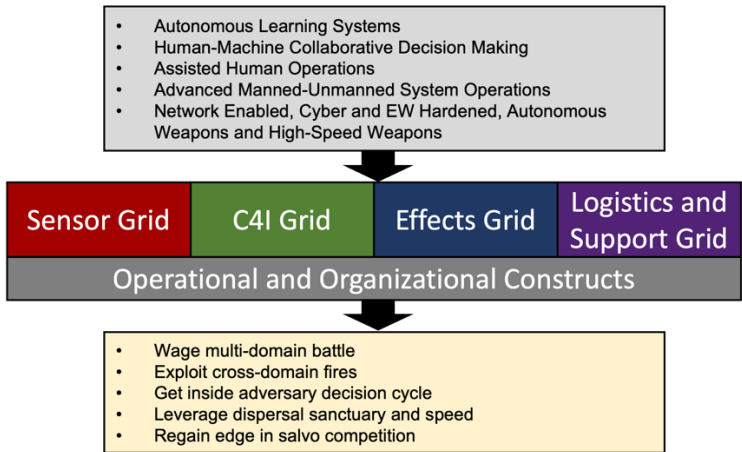


Figure 42. Third Offset Strategy. Adapted from [24].




Figure 43. Overview of the U.S. Army’s Project Linchpin [25].

Unclassified
SPACE SYSTEMS COMMAND

➤ Opportunities – How could AI/ML help?

- Intelligent tasking management for multi-satellite tracking
- Algorithms for Multi-orbit 3D track fusion - Defense, Inter-agency, Commercial, Allies
- Automated Target Recognition for detecting evolving characteristics in cluttered scenes
- On-board edge-processing to optimize downlinked data
- End user visualization/notifications - Need to solve the challenge of limited operators
- Decision-ready operational planning products to Combatant Commands
- Predictive weather analysis - tackle “big data” problem



EMERGING CHALLENGE

Proliferated Architectures + More Capable Sensors + Complex Targets/Scenes

Unclassified

Figure 44. Space Systems Command Challenges to Applying AI/ML [26].

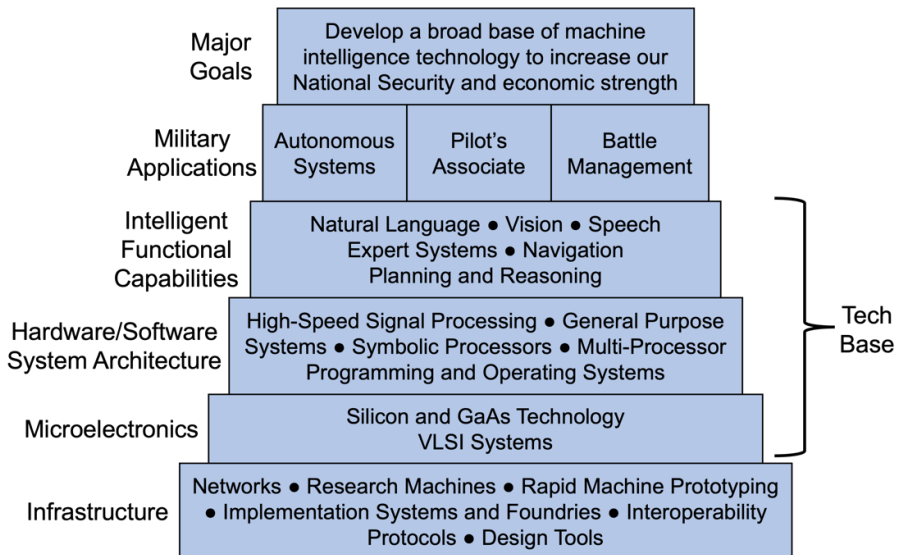


Figure 45. SCI Program Structure and Goals. Adapted from [27].

Table 8. Key DARPA AI Programs, 1960-Present [28].

Program Name	Year	Performers	Scope and Expected Outcomes
Project MAC	1963	MIT, Bell Labs, General Electric	To create a large-scale time-sharing system for computer research, advancing AI and computer science.
Speech Understanding Research (SUR)	1971	Carnegie Mellon University, MIT, SRI, BBN, IBM	To develop a computer system capable of understanding continuous human speech, making advancements in natural language processing.
Strategic Computing Initiative (SCI)	1983	Various incl. Texas Instruments, Martin Marietta, Thinking Machines	To develop advanced AI and computer systems for strategic defense, including autonomous vehicles and intelligent battle management.
High-Performance Knowledge Bases (HPKB)	1997	Stanford, MIT, SAIC, George Mason University, CMU, Northwestern, etc.	To develop large-scale, high-performance knowledge bases and reasoning systems to support diverse military applications.
Personalized Assistant that Learns (PAL)	2003	SRI, Carnegie Mellon University, Stanford University, University of Southern California	To create an intelligent software assistant that learns from its user, improving its performance and utility over time.
Cognitive Technology Threat Warning System (CT2WS)	2008	HRL Laboratories, Advanced Brain Monitoring, University of California San Diego	To develop a cognitive system that reads a user's brainwave patterns to rapidly detect and identify threats in real-time, helping soldiers make faster decisions.
Big Mechanism	2014	SRI, MITRE, Leidos, Harvard, University of Chicago, University of Arizona, etc.	To extract causal models from large amounts of scientific literature, advancing machine understanding capabilities especially for the description of complex systems.
Explainable Artificial Intelligence (XAI)	2016	UC Berkeley, CMU, Charles River Analytics, Rutgers, PARC, SRI, etc.	To develop AI systems that can explain their reasoning, making AI more understandable and trustworthy for human users.
Artificial Intelligence Exploration (AIE)	2018	Various universities, research institutions, and private corporations	To foster rapid innovation and groundbreaking AI research, enabling rapid exploration of new AI concepts and applications.
Guaranteeing AI Robustness against Deception (GARD)	2020	Two Six Technologies, IBM, MITRE, University of Chicago, Google	To develop AI systems that can detect and defend against adversarial attacks, improving the security and robustness of AI. (See gardproject.org)

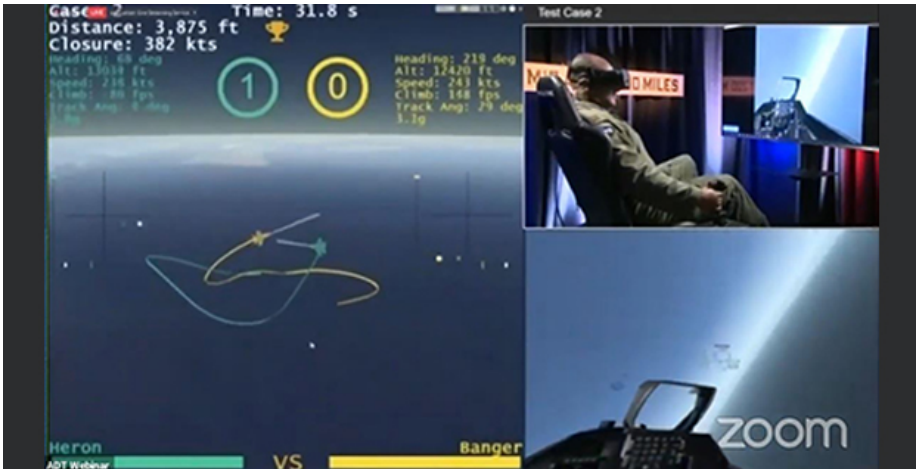
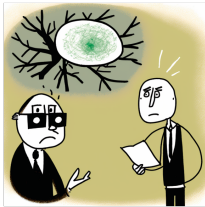


Figure 46. AlphaDogFight Trials Final Event [29].

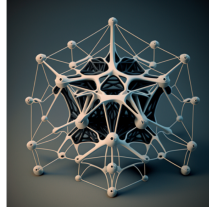
First Wave *Describe*



Handcrafted Knowledge

- Sets of rules to represent knowledge in well-defined domains
- Enables reasoning over narrowly defined problems
- No learning capability and poor handling of uncertainty
- The structure of the knowledge is defined by humans. The specifics are explored by the machine

Second Wave *Categorize*



Statistical Learning

- Statistical models for specific problem domains trained on big data
- Nuanced classification and prediction capabilities
- No contextual capability and minimal reasoning ability
- Requires extensive labeled training data
- Explosion of research into artificial neural networks

Third Wave *Explain*



Contextual Adaptation


- Systems construct contextual explanatory models for classes of real world phenomena
- Features models to explain and drive decision making
- Improves perception, learning, abstracting, and reasoning
- Better capable of expanding to domains for which models were not explicitly trained

Figure 47. Key Features of DARPA's Three Waves of AI. Adapted from [30].




Figure 48. Example of a DARPA Image-Description Capability [31].

AI NEXT CAMPAIGN




AI Exploration

DARPA investments in research that lead to prototype development resulting in new, game-changing AI technologies for U.S. national Security. Researchers will work to establish the feasibility of new AI concepts within 18 months of award.



Ongoing AI Programs

Larger and longer term DARPA technology efforts in A.I. that range from basic research to advanced technology development and are aimed at creating powerful new capabilities for the DoD



AI Colloquium

DARPA hosted event in March 2019 bringing together the DoD research community and stakeholders to learn more about DARPA's current and emerging AI programs, and discover how the technologies in development could apply to diverse missions.

Figure 49. DARPA’s AI Next Campaign [30].

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