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ADVANCED REACTOR SAFEGUARDS

Security Systems of the Future for SMRs and Microreactors – FY22-25 AI Activities

Perimeter Intrusion Detection , Beyond the Fence, and Drone Detection, Using AI -- Deliberate Motion Analytics (DMA)

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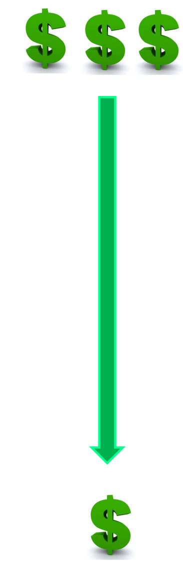
Motivation

Current Challenges:

- Nuclear Power generation faces increasing economic pressures
- Cost of physical security ranks high on plant operational costs
- US nuclear power plants are seeking new cost-effective physical security methods and technologies

Objective of AI Work
Deliberate Motion Analytics (DMA)

- Demonstrate a mathematically fused sensor system that can provide reliable detection and low nuisance alarm rates, multiple environments:
  - Two Fence Perimeter
  - Beyond the Fence
  - Drone Detection



Why Its Important for Advanced Reactors:

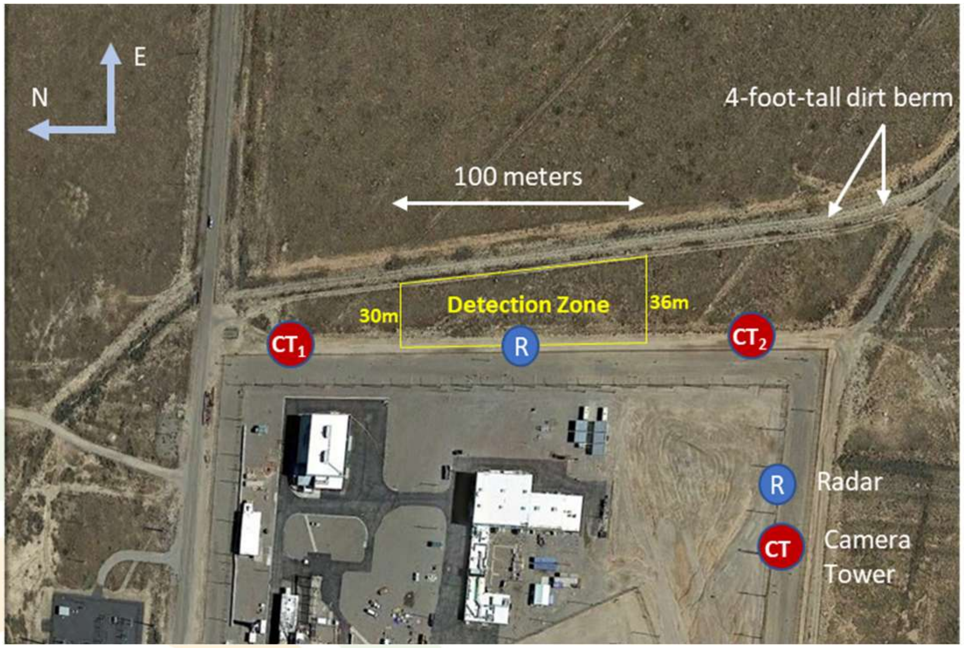
- Represents an enabling capability for new security solutions that will: reduce costs; reduce installation time, yet provide reliable detection

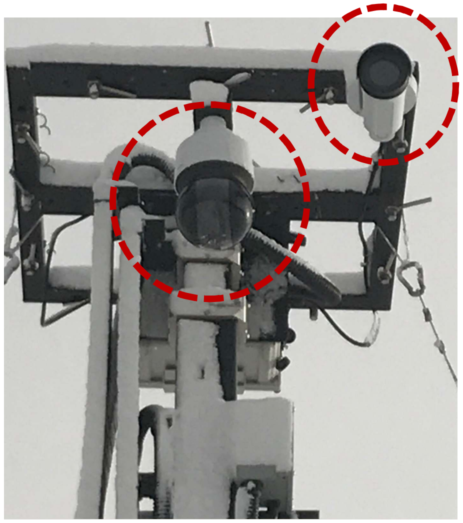
What is Deliberate Motion Analytics (DMA)

Deliberate Motion Analytics Is:

- A sensor algorithm that can fuse multiple sensor outputs to create a multi-physics sensor system, allowing explicit implementation of complementary sensors
- It uses deliberate motion to differentiate intruder alarms from nuisance alarm sources, including weather, moving fences, and foliage
- Incorporates a multi-layer nuisance alarm suppression strategy
- A Multi-Intelligence Fusion Algorithm – including Bayesian Techniques, Clustering, and Multi-Hypothesis Tracking,
- It decides when to "and" and when to "or" filtered alarm outputs from each sensor

Ex: 1 Beyond the Fence -- Environment





Ex: 1 Beyond the Fence -- Results

Detection Results

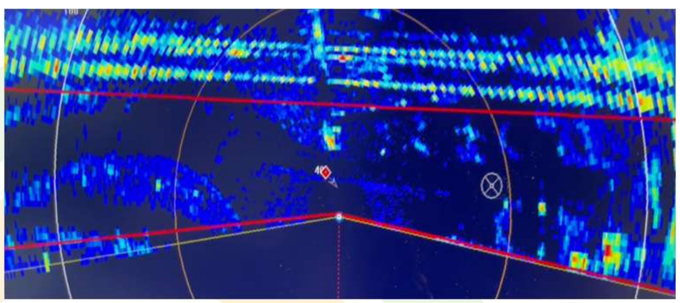
Exceeds DOE Perimeter Requirements

Threat	Total Attempts	Total Hits	Total Misses	P_S at 95% CL
Walker 1 ft/sec	35	35	0	92
Run At 10 ft/sec (+)	35	35	0	92
Hands and Knees Crawler	35	35	0	92
Belly Crawl	35	35	0	92

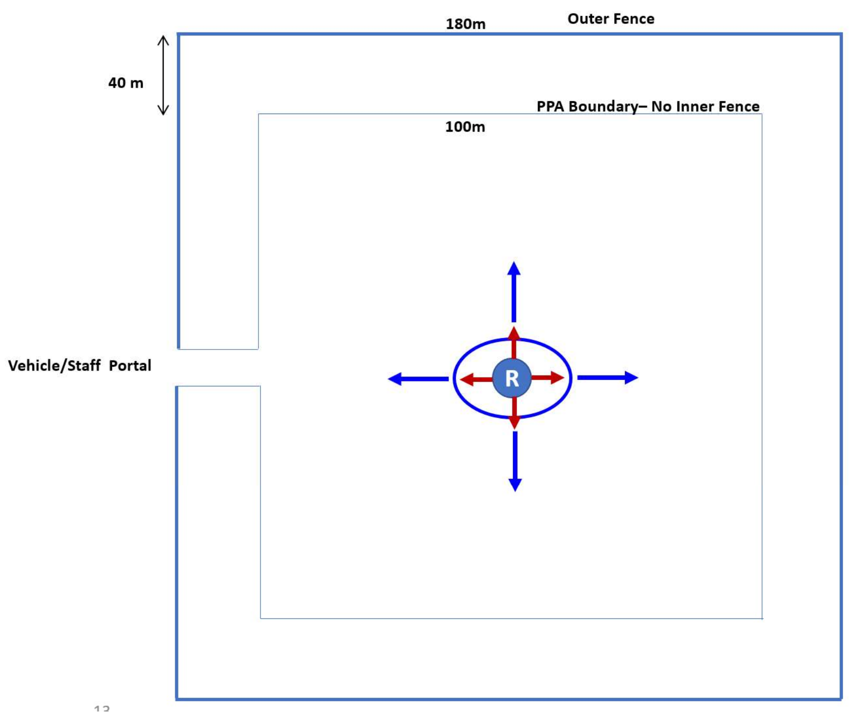
Nuisance Alarm Results

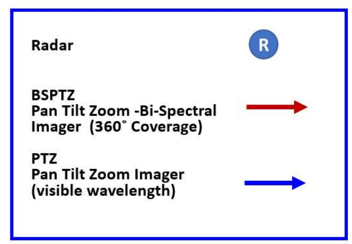
	Number of Nuisance Alarms	Weather	Wildlife	Average NAR Alarms/Day
Radar	15,388	14,618	770	13,190
Video Analytics	143,211	136,050	7,161	122,752
DMA	0	0	0	0

28 hour NAR collection period



Ex: 2 Simulating a Small Modular Reactor -- Environment

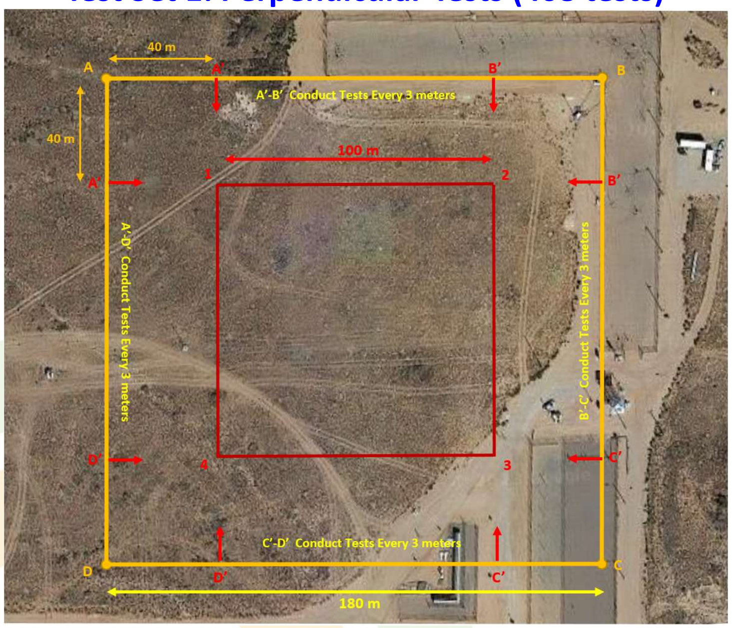




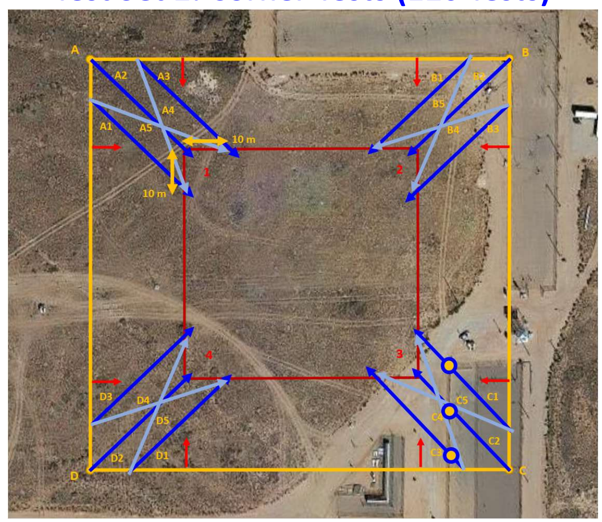
Ex: 2 Simulating a Small Modular Reactor --Environment

Over 576 Tests Conducted

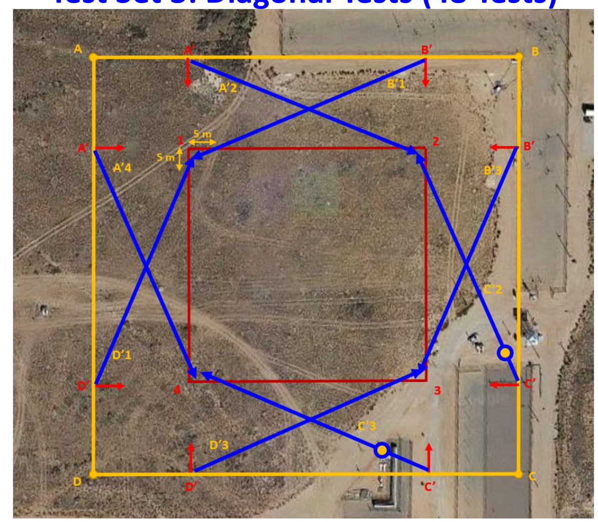
Test Set 1: Perpendicular Tests (408 tests)



Test Set 2: Corner Tests (120 Tests)



Test Set 3: Diagonal Tests (48 Tests)



Ex: 2 Simulating a Small Modular Reactor -- Results

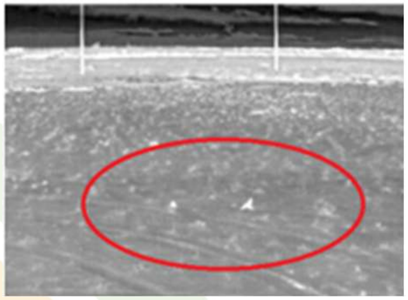
Detection Results

	Number of Attempts	Number of Detections	Number of Misses
Walker	192	192	0
Runner	192	188	4
Belly Crawl*	192	192	0
Total	576	572	4

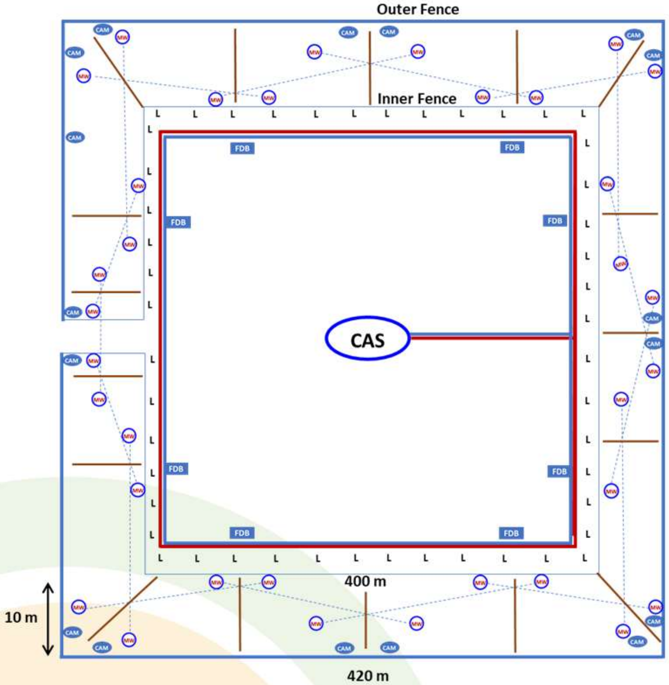
Exceeds DOE Perimeter Requirements

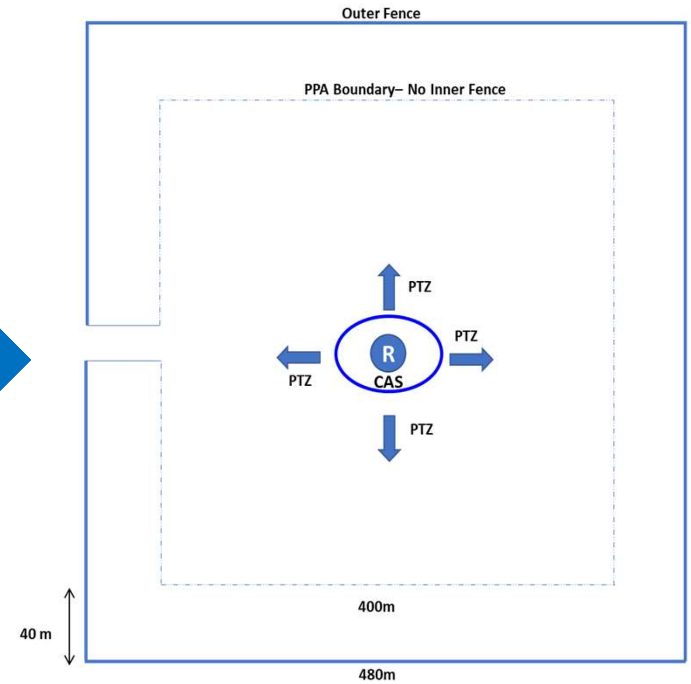
Nuisance Alarm Results

	Duration of NAR Collection (days)	Nuisance Alarms From Wildlife	Nuisance Alarms From Weather	Nuisance Alarms From Other	Total Nuisance Alarms	Average NAR Per Day
Radar	87.8	did not tabulate	did not tabulate	did not tabulate	12942308	147407
DMA	87.8	81	0	2	83	0.9



Ex: 2 Significance of SMR Results

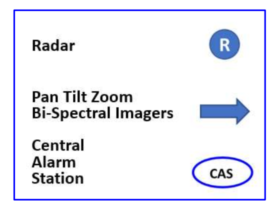




- PPA Boundary 400 m sides
- No Sectors
- No FDBs (Field Distribution Boxes)
- No Lights/Light Poles
- No Trenching for Power or Comms
- 8 Foot Security Fence
- Outer Fence, 1920m (6340 ft)
- 40 meter clear zone

Caveat Regarding "No Lights"

- No Lights on perimeter needed for intrusion detection
- Lights on/around the CAS
- Safety and Response Force may require lights



Estimating Reduced Cost
40% less than Traditional Design

Ex: 3 Drone Detection -- Environment

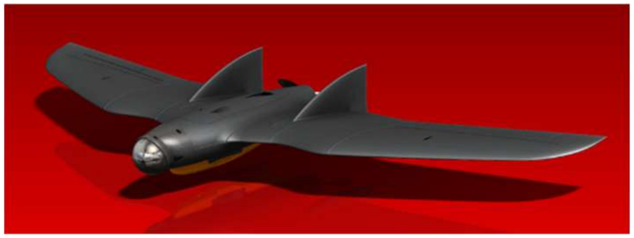
Objective: Demonstrate performance improvements of COTS drone detection, using DMA

Drones Included In Test Series

Table 3. Tested UAS platform characteristics.

UAS Platform	Manufacturer	Origin Country	Propulsion	Size[1]	Radio	Construction	Payload	Max Speed
Mavic 3 Pro	DJI	China	Quadcopter	13 inches	O3 Transmission System	Plastic	2 lb	40 mph
X500 V2	Holybro	U.S.	Quadcopter	20 inches	ExpressLRS (RC and Telemetry)	Carbon Fiber	3 lb	25 mph
Alta-X	FreeFly	U.S.	Quadcopter	46 inches	RFD-900 (Telemetry and RC)	Carbon Fiber	35 lb	70 mph
RV Jet	Range Video	U.S.	Fixed Wing	78 inches	ExpressLRS (RC) and RFD-900 (Telemetry)	Foam	1 lb	90 mph

[1]Size indicates the largest single dimension for any identified platform. For quadcopters, this is the wheelbase measurement and for the RV Jet, this is the wingspan.



Ex: 3 Drone Detection -- Results

Objective: Demonstrate performance improvements of COTS drone detection, using DMA

95 flights conducted

Detection Results			Sensor	Nuisance Alarm Results		
Individual Sensor Detection Rate (%)	Sensor Fused with D-Fend Detection Rate (%)	% Improvement With DMA Sensor Fusion		Individual Sensor Nuisance Alarms/Day	Sensor Fused with D-Fend Nuisances Alarms/Day	Reduction in Nuisance Alarms/Day
23	42	83	Magos Radar	60	2	58
54	67	24	EchoGuard Radar	509	4	505
80	88	10	EchoShield Radar	33	2	31
25	25	0	D-Fend Passive RF	0	0	0

Improved Detection Rate -- 10% to 83%

Reduction in Nuisance Alarms/Day -- 31 to 505

Next Steps

Current Activities in Progress

Vulnerability Assessment of DMA – to be complete June 2026

Regulatory Acceptance from NRC, DOE, DOW, … Topical Report on Regulatory Analysis for DMA as Commercial Nuclear Power Plants, Steven Horowitz, SNL

Commercialization of DMA – to be completed Sept 2028

Related Supporting Activities – New Technologies Being Developed

Secure Reliable Wireless Communications
Goal- Attempt to Jam Wireless Comms, Demonstrate no data lost

Beam Power to Sensors
Yr 1 Goal – 10-30 Watts, sensor location 100-300 meters away
Yr 3 Goal – 50-70 Watts, sensor location 300-500 meters away

The building blocks for a Totally Wireless Intrusion Detection System
Rapid Deployment and Huge Reduction in Security Costs, – 50% to 75%?