U.S. Navy FOD Program

A Risk-Based Operational Approach

Mr. Jonathan Sides | Swift Conference | 25-28 September 2023

MISSION

The FOD mitigation portfolio increases enterprise aircraft readiness and decreases fundamental costs by rapidly developing and fielding innovative processes and technologies to improve decision making and reduce operational risk for the warfighter

FOD Goals

75% Reduction in engine removals due to FOD

Zero Loss of Aircraft

100% Automated FOD mitigation solutions to relieve maintainer workload

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Engine FOD Is a $150 Million a year cost for the United States Navy and United States Marine Corps

Cost is growing with the introduction of the F-35 Joint Strike Fighter (JSF)

Engine FOD is a $2 Billion+ a year cost for the civil aviation community.

This cost is assumed by the airlines and breaks down to approximately $67 per movement (touch + go landing/takeoff)

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PHASE 1:

Augment Existing Engine FOD Mitigation Efforts

"Brute-force" methods

Process Review

Enhanced data collection & visualization

FOD Support Equipment & Personnel

PHASE 2:

FOD Data Generation

Inform "Risk-Based" Operations
Efforts in-progress through research

Airfield FOD Detection Radar Towers

Aircraft Engine Inlet Debris Monitoring System (IDMS)

Machine Learning & Analytic Development

Pavement Degradation Analytics

PHASE 3:

Informed, Autonomous FOD Remediation

Solutions achievable to mitigate Engine FOD in the future

Joint Military & Civil Policy Based Solutions

Airfield Solutions

Autonomous Solutions

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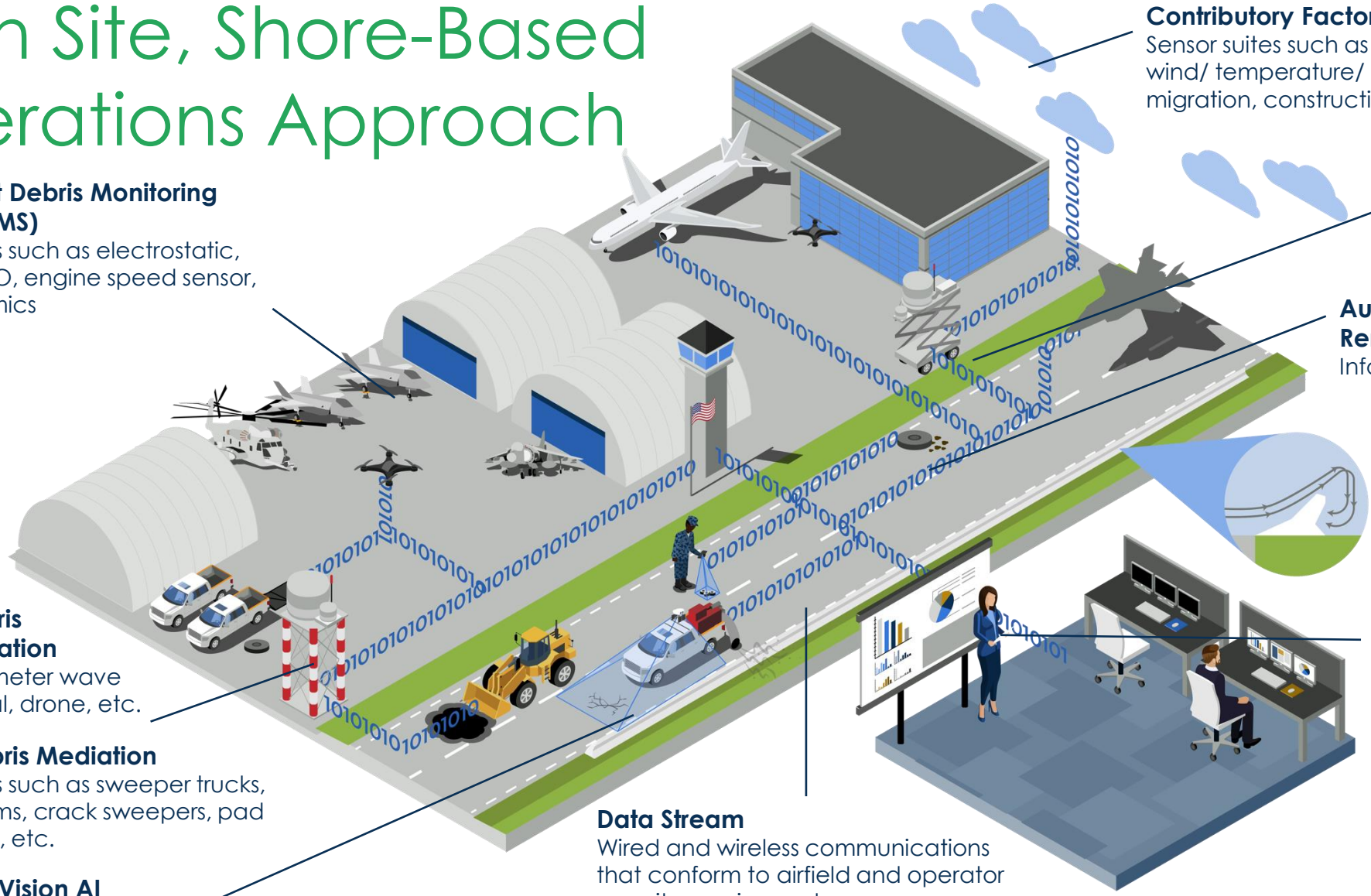
Main Site, Shore-Based Operations Approach

Aircraft Inlet Debris Monitoring Systems (IDMS)
Technologies such as electrostatic, laser, RFMIMO, engine speed sensor, blade dynamics

Airfield Debris Characterization
Such as millimeter wave radar, optical, drone, etc.

Manual Debris Mediation
Technologies such as sweeper trucks, blower systems, crack sweepers, pad eye cleaners, etc.

Vision AI
Enables real-time pavement inspection and Operational Condition Index (OCI) trending capability



Contributory Factors
Sensor suites such as aircraft telemetry, wind/ temperature/ humidity data, bird migration, construction, etc.

Analytics and Edge Computing

Automated Debris Remediation
Informed by Analytics

FOD Barriers
Frangible runway edge barriers

FOD Risk Coordinator
Empowered with machine learning and analytic tools to manage airfield FOD risks manually or autonomously

Data Stream
Wired and wireless communications that conform to airfield and operator security requirements

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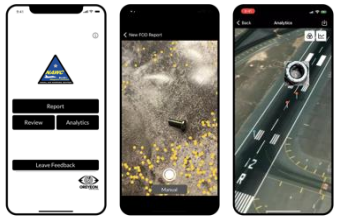
FOD System Development Work

MCAS Yuma and NAS Lemoore are the primary RDT&E sites for FOD System of Systems

- MOOG Radar Towers
- Oreyeon FOD App
- ADSB Vehicle Tracking (Virtower)
- Dedicated FOD Officers
- Brute Force Equipment
- Airvrix FOD Barriers
- Vision AI for Pavement Management
- Acoustic Vehicle Tracking
- Expeditionary FOD Tower at MCAS Miramar

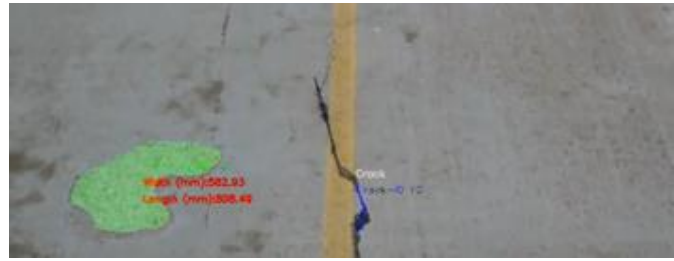


Oreyeon FOD App

Xsight

MOOG Radar Towers (Fixed & Mobile)

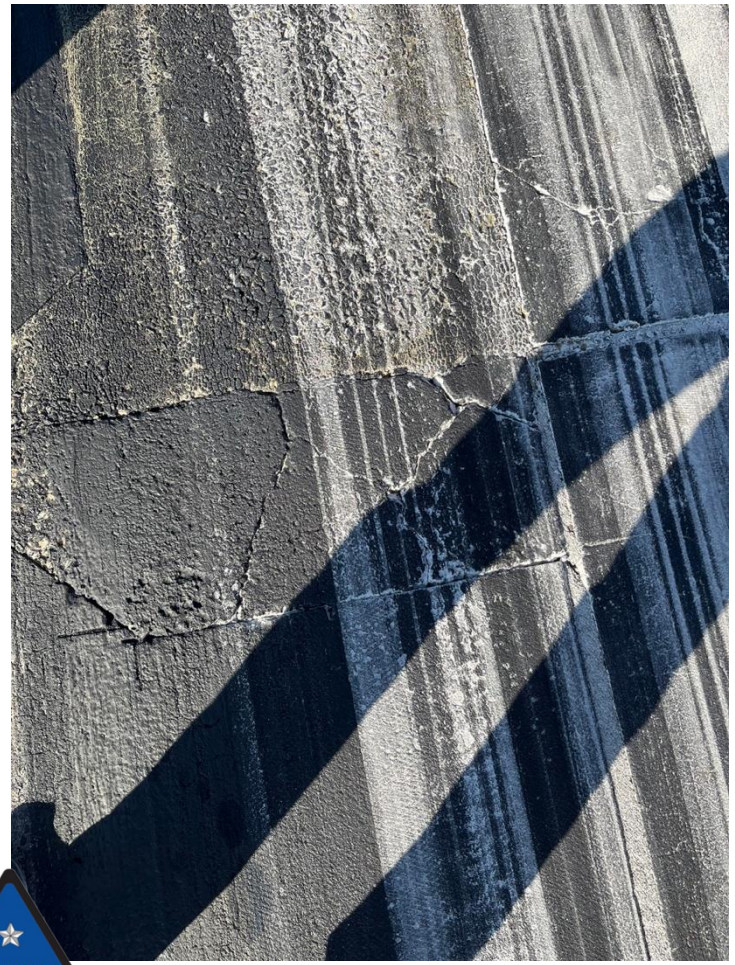
Airvrix FOD Barrier

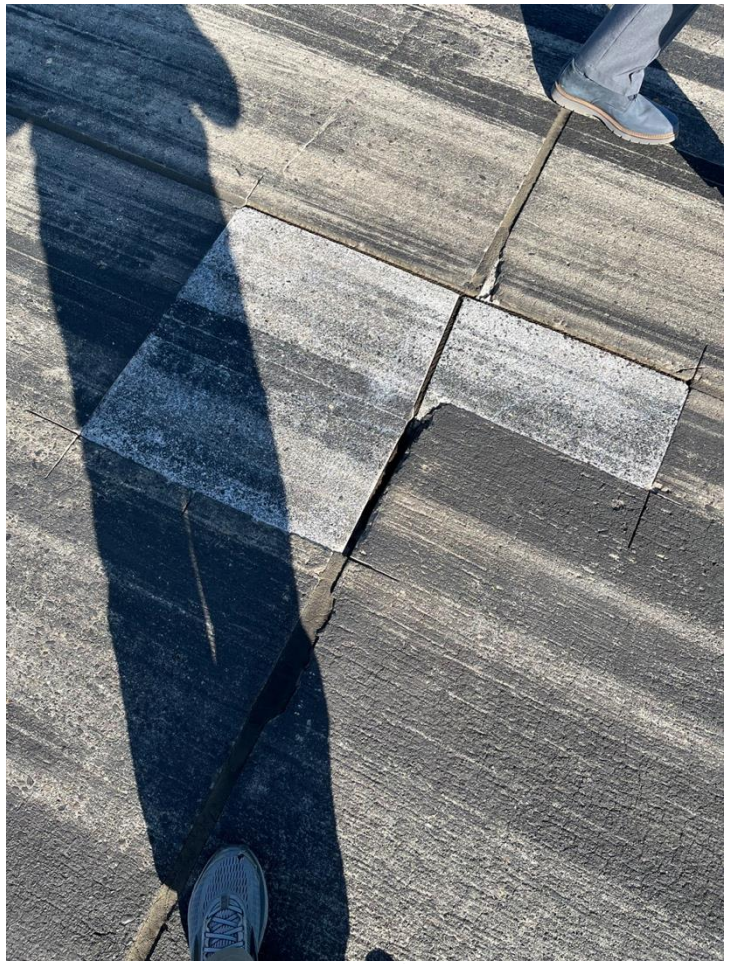


Oreyeon Vision AI

Centerline Patch Blowout

US Military Airfield 17 November 2022



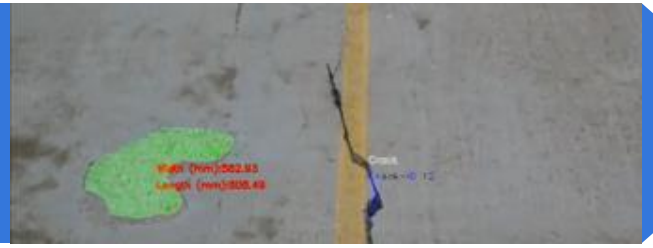


Pavement Condition Vision AI:

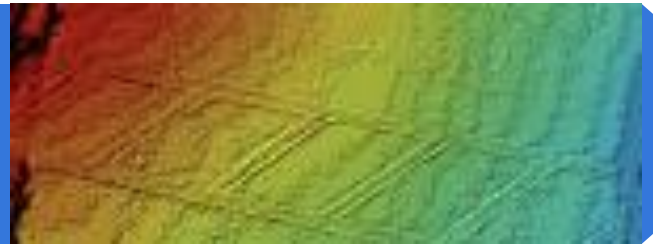
Ground-based imaging coupled with AI-based detection for flaw identification

Versatile Ground-Based High Resolution Imaging

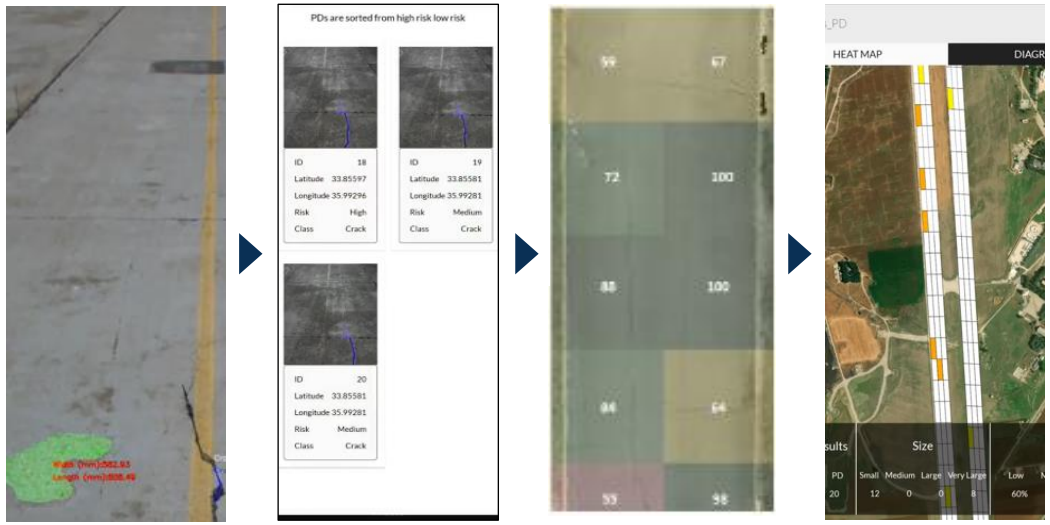
AI-Based Flaw Detection & Characterization



High Resolution 2D Orthomosaics and Full 3D Reconstruction



AI-Based Flaw Detection and Automatic Operational Condition Index (OCI)



AI Distress Detection | Auto Tiling | OCI Estimation | Heat Map

$3B per year is required to sustain USN/USMC airfield pavement

Source: Jacobs Engineering for Tri-Service Pavements Meeting 07 March 2019

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Why OCI?

New methods are required to pair available funding with critical airfield requirements

- Airfield recapitalization estimated at $6 Billion per year across the U.S. Department of Defense (DoD)
- PCI is the basis of airfield funding requirements
- Airfield degradation is more rapid than predicted by PCI
    - Aging pavement
    - Different aircraft (thrust, wheel loading, operations)
    - Federated repair solutions
    - Varying quality control (patches and recapitalization)
- Supports FAA 40 Year Pavement Life Initiative
- Optimizes repairs within available budget constraints

Extract more life from pavement assets

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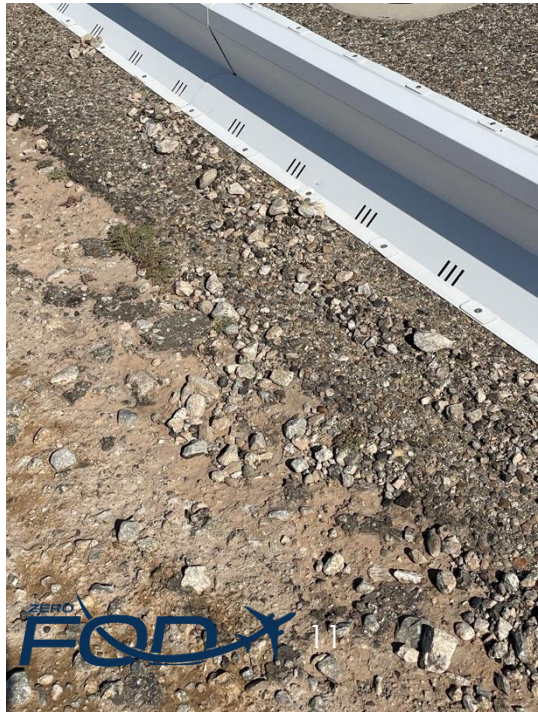
FOD HEAT MAP: TARSIER RADAR

MCAS Yuma Sunday, 2 May 2021

FOD Barrier

Integrated System Test

- Installation is beginning at MCAS Yuma for test and evaluation
  - Utilizing Oreyeon Vision AI and MOOG Radar to quantify benefit
- Barriers compliment the FOD blower
- Does not cause harm to an aircraft if it is run over



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Joint FOD Program

Evolving Working Groups

HQMC (AVN) OPNAV N98 CNIC I & L

MCIC CNAF NAVAIR PEO(JSF)

Department of Navy (DoN) FOD Working Group requires cross-command involvement to develop, acquire, and scale FOD solutions

Diverse membership is required to transition FOD solutions to the Civil Aviation community.

US Air Force FAA

Example Industry Partners…

MOOG Southwest Alaska

Delta TechOps SEA

Foreign and Domestic Regulatory Agencies, Commercial Airlines, Airports, DoD, Maintenance Repair and Operations (MRO), Aviation Insurance, Adjacent Working Groups

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Integrate Civil Aviation Community

- Understand the civil aviation business case
  - Quantify FOD rates by carrier and location
  - Measure the cost of a FOD event and determine who pays the bill
- Brings common solutions to civil and military aviation communities
- Improve civil aviation readiness
- Interaction between airlines, airports, and regulatory organizations
- Jointly develop and implement FOD solutions

Leverage existing industry meetings and forums to transition FOD solutions

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