ZERO FOD

Foreign Object Damage Reduction

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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)

PHASE 1:

Augment Existing Engine FOD Mitigation Efforts

"Brute-force" methods

Process Review

Enhanced data collection and 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

PHASE 3:

Informed, Autonomous FOD Remediation

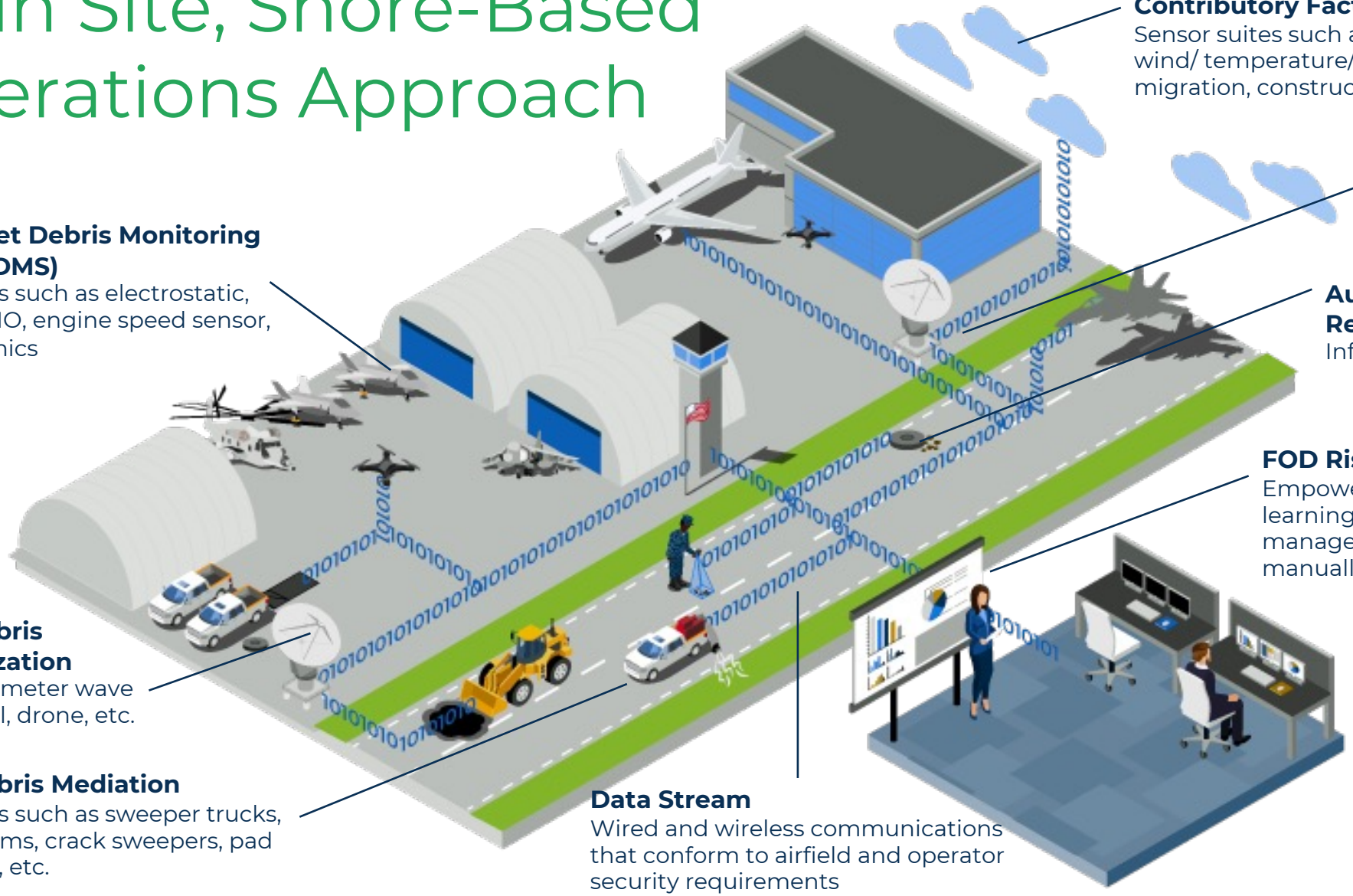
Solutions achievable to mitigate Engine FOD in the future

Policy-Based Solutions

Airfield Solutions

Autonomous Solutions

Main Site, Shore-Based Operations Approach



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

Analytics and Edge Computing

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

Automated Debris Remediation
Informed by Analytics

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

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.

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

FOD Solutions

FOD HEAT MAP: TARSIER RADAR

MCAS Yuma Sunday, 2 May 2021

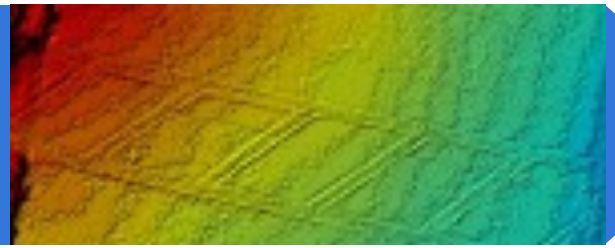
Pavement Condition Vision AI:

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

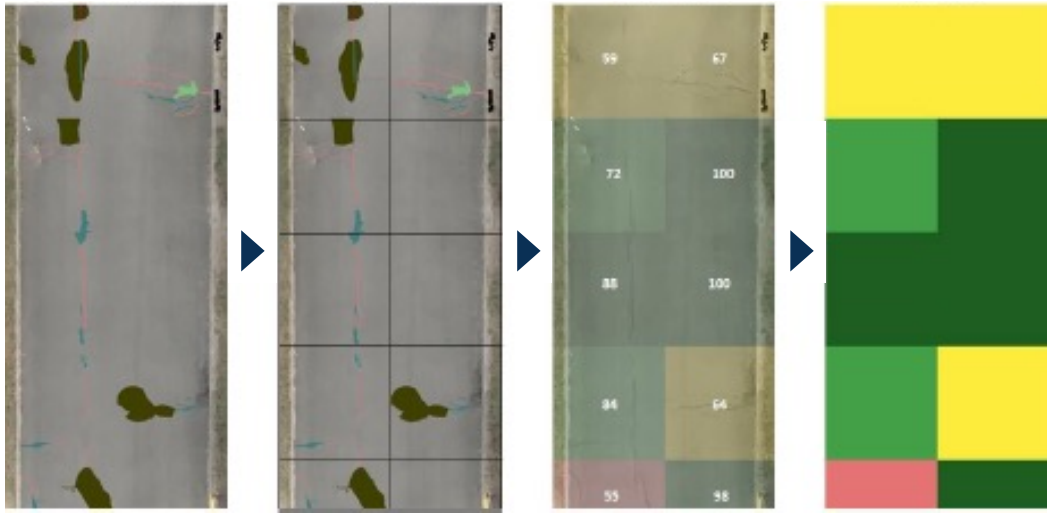
Versatile Ground-Based Imaging

High Resolution Imagery

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

Implementation

PHASE 1:

Demonstrate U.S. Navy FOD Reduction Solution

”Brute-force” Methods

FOD Data Generation

Informed Autonomous FOD Remediation

PHASE 2:

Establish Governance

DoD FOD Working Group

Civil Aviation FOD Working Group

Establish Joint Sponsors

PHASE 3:

Acquisition and Scalability

Aircraft Solutions

Airfield Solutions

Policy Generation

Integration with civil aviation is critical to the success of the FOD program

FOD Exposure

- Military aircraft operate at civil airfields and civil aircraft operate at military airfields
- Proven and consistent FOD mitigation procedures must be universally implemented to reduce military FOD rates

Rapid Development

- Scalable solutions incentivize industry to innovate and deploy
- FOD predictive modeling is improved with additional sites

Policy Generation

- Policy for autonomous operation does not exist and will rely on the FAA for guidance and collaboration
- A joint program office will generate policy and procedures for the civil and military aviation communities

Sustainment

- Military-specific solutions are not sustainable
- Industry supported commercial off the shelf (COTS) reduces cost and improves availability and readiness

Establish Civil Aviation Community FOD Working Group

- 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
- Establish Civil Aviation Working Group Charter

Leverage existing industry meetings to establish charter and membership for Joint Aviation Community FOD Working Group