From the Founder&Managing Director
Haluk Karaoguz

Dear Sirs,

We are pleased to introduce to you Automated FOD Detection system “FOD” Foreign Object Debris

Prevent. Protect. Predictable. Proven

FOD is an electro-optic system to detect the FOD's and pavement anomalies on the runway surface of the airports.

FOD works real time and detects the smallest objects in any weather condition on the airport runway area. The images are captured with high resolution cameras located at the sides of the runway. FODs are identified with high accuracy using artificial intelligence techniques and instantly reported to the airport staff.

FOD is a solution that offers a high accuracy FOD detection performance with minimal false positives.

FOD is sensor independent and is powered by state-of-the-art artificial intelligence algorithms superior to human level performance.

Any material that should not be found on an airport taxiway, ramp, runway or airfield is classified as Foreign Object Debris (FOD) and must be removed to increase safety of operation and prevent aircraft damage.

Your passenger’s and flight’s safety is our main priority, that’s why we have produced FOD; A foreign object debris detection system that is used for tracking even the smallest objects in any weather condition in an airport. A-FOD provides comprehensive sets of surveillance and analysis tools in order to have a complete management of the runways.

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Registration No : 416173 ,Dated : 11/03/1999 , Mersis No: 0733010489100017

From the Founder&Managing Director
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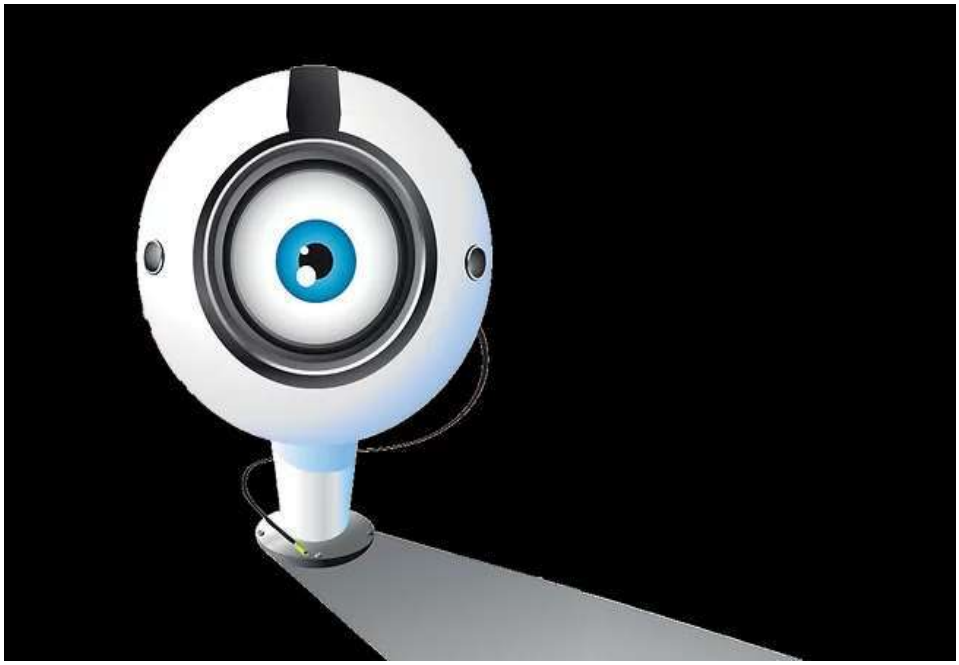

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Other undesired anomalies such as, snow, ice, pavement cracks, accumulation areas on the pavement and wildlife are also monitored through the electro-optic sensors directed at the runway.

Once a FOD is detected on the runway, it is precisely segmented by the system so that its location and size are determined.

The material type of the detected FOD (i.e. metallic, rubber, asphalt, nylon bag, and piece of paper) is also determined by the system.

The source of FOD (i.e. ground personnel, aircraft, wildlife, and pavement) is also estimated at this stage during the analysis

The long term changes in the runway are classified as a crack, irregularity on the center line, or an accumulation area (i.e. water ponding, snow accumulation etc.).

The width and length of the crack is calculated and reported.

The size of the accumulation area is calculated and reported.

The pavement classification process is completed without any interruption to normal FOD detection process.

Wildlife module detects the foreign object as bird, walking animal or soft animal. The density and the size computation gives more information to the airport staff for a proper risk estimation.

Snow or ice formation is also detected and the thickness is reported.

Snow – ice detection and depth measurement process is completed without any interruption to normal FOD detection process.

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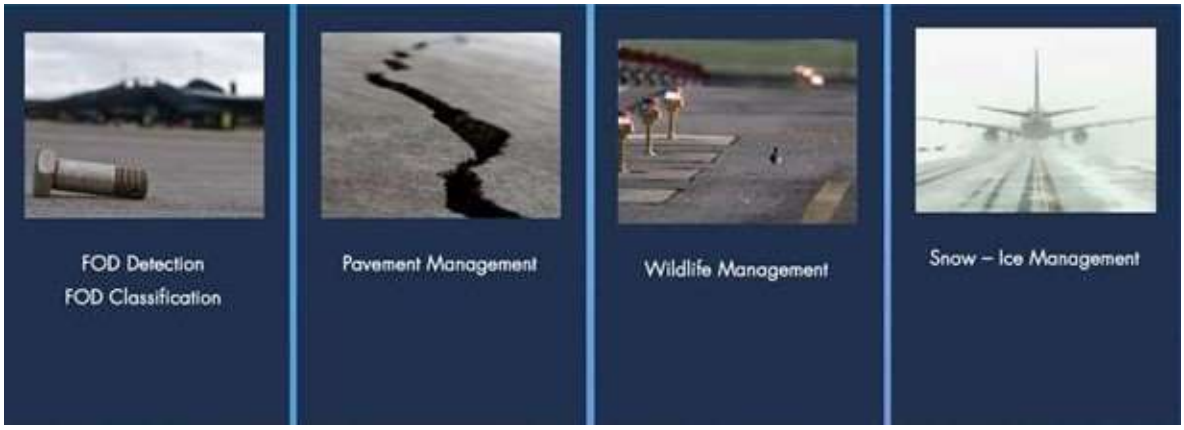

FEATURES

With its state-of-the art algorithms developed based on the cutting edge deep learning technologies, FOD;

• Easily, rapidly, and cheaply maintainable for many years.

• Robust to heavy rain conditions (no echo – no additional noise generating).

• Causes No FATAL Electromagnetic Interference Risk with the equipment of the airport and airplanes.

Scans all the areas of the runway 7/24

Analyses the collected data in real time without any interruption

By using advanced artificial intelligence, foreign objects are detected and an alarm is generated to warn the air traffic control center

With its simple interface, it enables the relevant airport staff to examine the foreign object remotely in detail using the provided location information,

When staff confirms the FOD removal, the object is visually located by a laser marker

The historical logs of the detections are saved in the database and statistical analyses are performed to create useful information about how the FODs are formed in the runway.

Creates a solid input for airport FOD management

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MODELS

FOD has two models differentiated by the installation locations and the number of sensors. Both are compatible with FAA and ICAO regulations.

FOD III-A is designed for runways up to Category III A operations

Less camera units

FOD III-B is designed for runways up to Category III B operations

More camera units

Please fee free for quotation and more information.Thank you for your cooperation.

Haluk Karaoguz

Founder&Managind Director

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FOREIGN OBJECT DAMAGE (FOD) TECHNOLOGY
AI FOR NEXT GENERATION AIRPORTS

- **Mission:**
  To improve runway & apron operational efficiency
  To reduce the number of runway & apron safety incidents.

- Dedicated team focused on the use of Image Processing, Deep Learning and Artificial Intelligence for FOD, operation tracking related Aviation Technologies.

- Experienced board and advisory team with digital programs delivery track record in USA and UK.

- **Patents:** Registered at U.S. Patent.

- **Products:** Apron, Runway FOD Detection, Operations Tracking.

- **Awards:**

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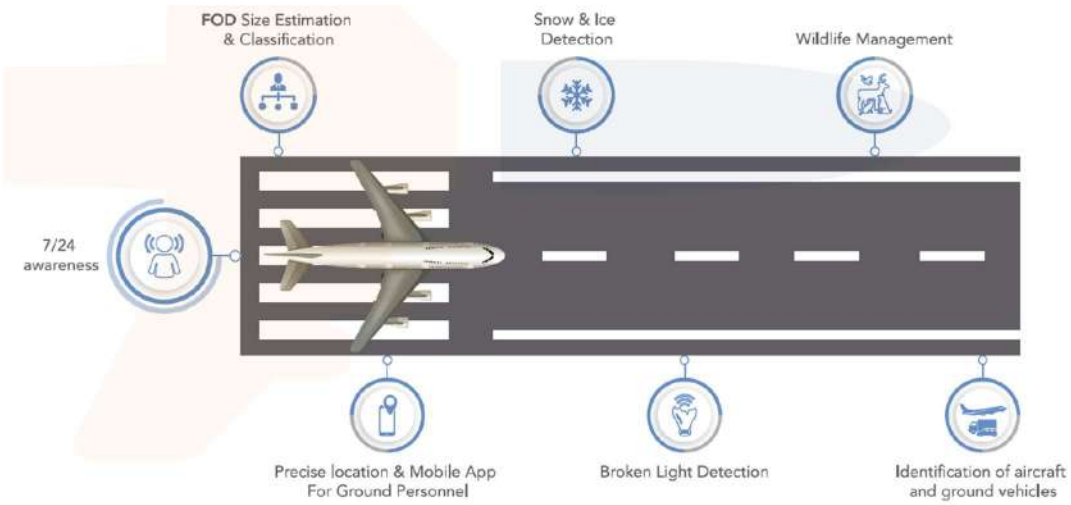
FOD AUTOMATED DETECTION WITH AI

- Unique computer vision and deep learning algorithms
- A superior performance with simple equipment:

  CAMERA + PTU + NIRILLUMINATOR + GPU



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WHAT MAKES FOD TECHNOLOGY SUPERIOR?

1) Increase runway / apron safety

- 7/24 high performance detection (The 1st & only in the world in the apron)
- NO or Less FOD incidents
- Instantaneous information for safety critical facts

2) Increase airport efficiency

- Less workload on airside operations
- Continuous and uninterrupted control over your primary assets
- Automation of other manual surface inspection operations
- Less downtime for FOD checks and other inspections
- Reduces maintenance costs (*at least 25%of engine overhauls caused by FOD)

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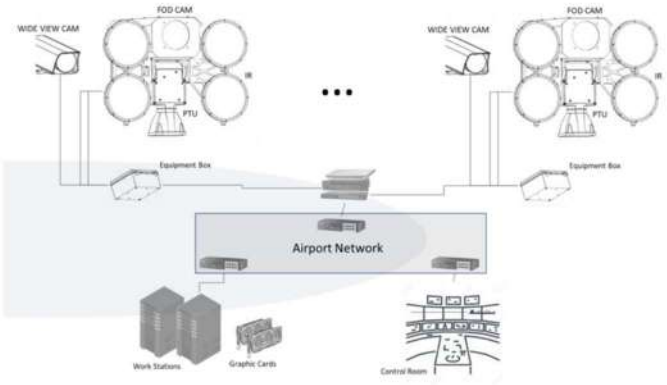
FOD TECHNOLOGY ARCHITECTURE

	FOD RUNWAY	FOD APRON
Operating temperature	+65 -20°C	
Operating humidity	%95 (Can be increased to %99)	
Detection in zero light	YES	
Works in local area network	YES	
Database Storage Capacity*	20 years (can be increased as req.)	
Image Storage Capacity*	2 years (can be increased as req.)	
Redundancy*	Supplied as req.	
User Interface	Web Based	
Mobile App	YES	
Interactive – Online learning	YES	
Compliant Standards	FAA AC 150/5220-24 & EUROCAE ED-235	
Scan Time	2 minutes daytime, 4 minutes nighttime	
Detection range	230m	90m
Min FOD Size	3x3x3cm	2x2x2cm
FODs Categorization	Metallic, Paper, Rubber, Bird, Others	
Automated Bird Scaring*	YES	N/A
Size Tolerance Mean Error	25%	20%
Location Tolerance	Real Coordinate ±1m & GPS ±5m	
Source of Fod Detection	YES	
Historical Analysis	Types of FODs, Source of FOD, FOD&Bird occurrence heat maps	
Additional Features*	A/C & Ground Vehicle Detection	Detection of not correctly located GSE Detection of all Ground Operations



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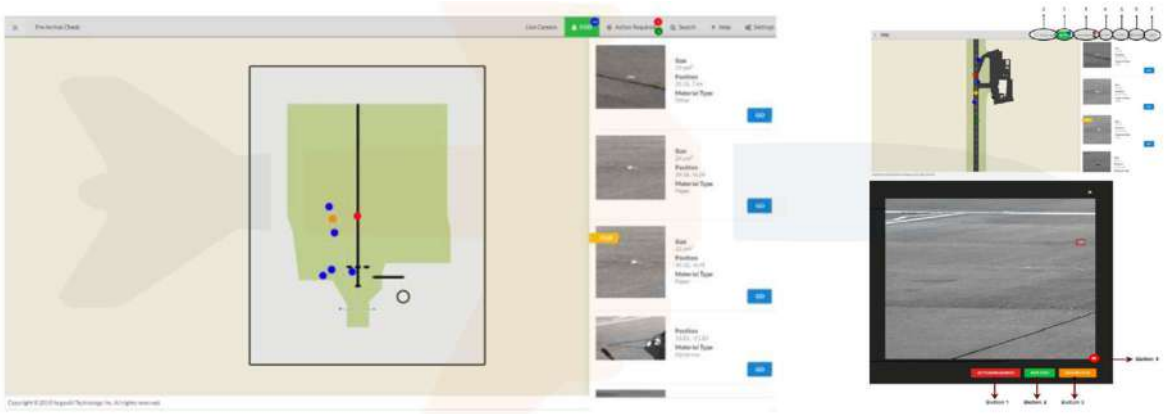
FOD TECHNOLOGY INTERFACE

Developed and optimized with accordingly:

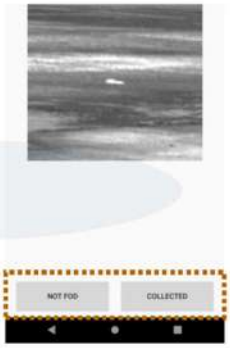


FOD TECHNOLOGY MOBILE APP INTERFACE

FOD Mobile App FOD Warning

Exact FOD Locations on runway

FOD Visual on FOD Mobile



Decision on removal for FOD

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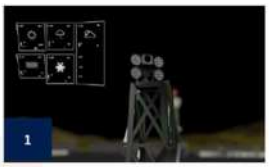
CASE FOR FOD TECHNOLOGY DURING RUNWAY



7/24 monitoring of the runway.

Real time detection, recognition and identification of any substance on the runway.

Real time visual and audio alerts via web based user interface

Zoomed live view along with the screening of the detected event. Action order creation for FOD removal via user interface.

The precise location of FOD is easily to be guided with FOD mobile app. Ground personnel immediately take action to collect when FOD notification is received.

RUNWAY FOD DETECTION INSTALLATION

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U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

Subject: Airport Foreign Object Debris (FOD) Detection Equipment	**Date:** 09/30/2009	**AC No:** 150/5220-24
	Initiated by: AAS-100	**Change:**

1. PURPOSE. This advisory circular (AC) provides information that airports can use to procure foreign object debris (FOD) detection equipment.

2. SCOPE. This AC contains minimum performance specifications for systems and equipment that detect foreign objects on airports. Four types of detection systems are discussed, including: stationary radar; stationary electro-optical; stationary hybrid radar and electro-optical; and mobile radar.

This AC is based on research conducted by the Federal Aviation Administration's (FAA's) Airport Technology Research and Development Program and Center of Excellence in Airport Technology (CEAT) to examine the performance of several new FOD detection technologies.

3. APPLICATION. The FAA recommends the guidance and specifications in this Advisory Circular for procuring airport FOD detection equipment. In general, use of this AC is not mandatory. However, it is mandatory for all FOD detection equipment acquired through the Airport Improvement Program (AIP) or the Passenger Facility Charge (PFC) Program. See Grant Assurance No. 34, *Policies, Standards, and Specifications*, and Assurance No.9, *Standards and Specifications*.

4. COMMENTS OR SUGGESTIONS for improvements to this AC should be sent to:

Manager, Airport Engineering Division (AAS-100)
ATTN: FOD ENGINEER
Federal Aviation Administration
800 Independence Avenue SW
Washington DC 20591

Michael J. O'Donnell
Director of Airport Safety and Standards

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CHAPTER 1. TERMINOLOGY AND REFERENCES

1.1. DEFINITIONS.

a. Air Operations Area (AOA). All airport areas where aircraft can operate, either under their own power or while in tow. The AOA includes runways, taxiways, and apron areas.

b. Airport Apron. A surface in the AOA where aircraft park and are serviced (refueled, loaded with cargo, and/or boarded by passengers).

c. Airport Ramp. See Airport Apron.

d. Alert. The outcome of sensor use where a foreign object is detected and personnel are notified of the object's presence.

e. Continuous Surveillance. Uninterrupted surveillance by a sensor of a surface within a specific scan area.

f. Dry. A surface on the AOA that has no sign of moisture (for the purposes of this AC only).

g. Electro-Optical Detection System. A system containing a sensor that uses visual light wavelength as the primary means to detect objects.

h. False Alarm. An alert causing the airport operator to take action to remove a FOD object that does not exist.

i. Foreign Object Debris (FOD). Any object located in an inappropriate location in the airport environment that has the capacity to injure airport or airline personnel and damage aircraft.

j. Hazard. A condition, object or activity with the potential for causing damage, loss, or injury.

k. Hybrid Detection System. A system containing both electro-optical and radar sensors, having the ability to use data from both sensors as the primary means to detect objects.

l. Image Processing. Analysis of electro-optical sensor data using digital processing.

m. Manufacturer. The manufacturer, distributor, lessor, or supplier of automated FOD detection equipment. This includes any provider of a FOD removal program that incorporates automated FOD detection equipment.

n. Radar Detection System. A system containing a sensor that uses radio detection and ranging, which actively transmits and receives radio signals, as the primary means to detect objects.

o. Two-Year Storm. A statistical event (containing rainfall, wind speed, and/or surge properties) of given intensity and duration having a fifty percent (50%) chance of occurring in any one year. This does not imply that it will occur only every two (2) years or, having occurred, will not happen again for another two (2) years.

p. Wet. A surface on the AOA that displays signs of moisture (for the purposes of this AC only).

1.2. ACRONYMS AND TERMS.

AOA	Air Operations Area
FAA	Federal Aviation Administration
FOD	Foreign Object Debris or Foreign Object Damage
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association

1.3. APPLICABLE DOCUMENTS.

The following documents form part of this specification and are applicable to the extent specified.

a. FAA Advisory Circulars (ACs):

AC 150/5200-18	*Airport Safety Self-Inspection*
AC 150/5340-30	*Design and Installation Details for Airport Visual Aids*
AC 150/5345-46	*Specification for Runway and Taxiway Light Fixture*s

b. National Oceanographic and Atmospheric Administration (NOAA), National Climatic Data Center.

CLIM 20	*Climatology of the United States No. 20*

c. Sources:

(1) FAA ACs may be obtained from: U.S. Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Ave., Landover, MD 20785. Telephone: (301) 322-4961, FAX: (301) 386-5394, website: www.faa.gov (navigate to the Airports section, then to the Advisory Circular database)

(2) NOAA, Satellite and Information Service, National Climatic Data Center, Federal Building, 151 Patton Avenue, Asheville NC 28801-5001, Telephone: (828) 271-4800, FAX: (828) 271-4876, website: http://www.ncdc.noaa.gov/oa/mpp/

CHAPTER 2. INTRODUCTION

2.1. GENERAL.

The presence of FOD on airport runways, taxiways, aprons and ramps poses a significant threat to the safety of air travel. FOD has the potential to damage aircraft during critical phases of flight, which can lead to catastrophic loss of life and airframe, and increased maintenance and operating costs. FOD hazards can be reduced, however, by the use of FOD detection equipment.

2.2. FOD FUNDAMENTALS.

a. FOD Hazards. FOD can severely injure airport or airline personnel or damage equipment. Types of potential damage include: cutting aircraft tires; being ingested into engines; or becoming lodged in mechanisms affecting flight operations. Personnel injuries can occur when jet blast propels FOD through the airport environment at high velocities.

b. Sources of FOD. FOD comes from many sources, which complicates efforts to maintain safe aircraft movement areas. FOD can be generated from personnel, airport infrastructure (pavements, lights, and signs), the environment (wildlife, snow, ice) and the equipment operating on the airfield (aircraft, airport operations vehicles, maintenance equipment, fueling trucks, other aircraft servicing equipment, and construction equipment).

c. Types of FOD. The exact nature of FOD is also varied. FOD can be composed of any material and can be of any color and size. In a one year airport study (*Information Paper on French Study on Automatic FOD Detection Systems – Workshop EUROCONTROL*, 9-10 June 2008), over 60% of the FOD items were made of metal, followed by 18% of the items being made of rubber. Dark-colored items made up nearly 50% of the FOD collected. Common FOD dimensions can be 1 in. by 1 in. (3 cm by 3 cm) or smaller. Typical FOD includes the following:

- aircraft and engine fasteners (nuts, bolts, washers, safety wire, etc.);
- aircraft parts (fuel caps, landing gear fragments, oil sticks, metal sheets, trapdoors, and tire fragments);
- mechanics' tools;
- catering supplies;
- flight line items (nails, personnel badges, pens, pencils, luggage tags, soda cans, etc.);
- apron items (paper and plastic debris from catering and freight pallets, luggage parts, and debris from ramp equipment);
- runway and taxiway materials (concrete and asphalt chunks, rubber joint materials, and paint chips);
- construction debris (pieces of wood, stones, fasteners and miscellaneous metal objects);
- plastic and/or polyethylene materials;
- natural materials (plant fragments and wildlife); and
- contaminants from winter conditions (snow, ice).

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CHAPTER 3. FOD DETECTION EQUIPMENT

3.1. BACKGROUND.

a. Airport personnel and users currently serve as the primary "sensor" to detect FOD on airport surfaces. Recent technological developments have greatly expanded the capabilities of FOD detection through automation. Advanced technologies are now available for improved FOD detection, including capabilities for continuous detection on runways and other aircraft movement areas and mobile detection devices to supplement the capabilities of airport personnel.

b. The advanced technologies use different methods and sensors to perform the mission of detecting FOD. Commercially available technologies employ radar and/or electro-optical sensors to detect FOD items rapidly and provide operations staff with alerts to achieve higher levels of removal performance. A summary of the detection system categories and operational modes available from current technologies is shown in Table 1.

Table 1. Summary of FOD Detection Systems.

System	Detection Principles	Capability
Human / Visual	Fundamental baseline for the performance of FOD detection systems. Human observation provides detection and human judgment provides the hazard assessment capability to assure safety.	Supports regularly scheduled, periodic condition, and special inspections.*
Radar	Uses radio transmission data as the primary means to detect FOD on runways and AOA surfaces.	Fixed systems support continuous surveillance. Mobile systems supplement human/visual inspections.*
Electro-Optical	Uses video technology and image processing data as the primary means to detect FOD on runways and AOA surfaces.	Supports continuous surveillance.
Hybrid	Uses a combination of radar and electro-optical data as the primary means to detect FOD on runways and AOA surfaces.	Supports continuous surveillance.

* Per the inspection frequencies defined in AC 150/5200-18, Section 6.b.

c. System Characteristics.

(1) This AC does not limit the technology that airports may use for FOD detection. However, general characteristics of systems that are available (as of the writing of this AC) include:

(a) Stationary Radar. A radar detection system, able to detect a metallic cylindrical target measuring 1.2 in. (3.0 cm) high and 1.5 in. (3.8 cm) in diameter at ranges of up to 0.6 mile (1 km). Sensors are located 165 ft (50.0 m) or more from the runway center line. Generally, two or three sensors are required per runway, depending on airport requirements.

(b) Stationary Electro-Optical. An electro-optical detection system, able to detect a 0.80 in. (2.0 cm) object target at ranges of up to 985 ft (300. m) using only ambient lighting. Sensors are located 490 ft (150 m) or more from the runway center line. Generally, five to eight sensors are required per runway, depending on airport requirements.

(c) Stationary Hybrid. Uses both an electro-optical and radar sensor in a unit collocated with the runway edge lights. The system is able to detect a 0.8 in. (2 cm) target on the runway. Generally, sensors are located on every, or every other, edge light, depending on airport requirements.

(d) Mobile Radar. A radar detection system mounted on top of a vehicle that scans the surface in front of the vehicle when moving. The radar scans an area 600. ft by 600. ft (183 m by 183 m) to detect FOD items measuring 1.2 in (3.0 cm) high and 1.5 in (3.8 cm) in diameter. The system can operate at speeds of up to 30 mph (50 km/h), supplementing human/visual inspections.

d. System Selection.

(1) Major advances in FOD detection technologies provide airports with a wide range of pricing and performance options. An airport operator can identify any specific performance standards based on a number of factors to meet their unique needs and requirements. Some of the factors that may be considered are the:

(a) Number and type of aircraft operating,

(b) Number and size of surveillance areas (e.g., runways, taxiways, aprons, etc),

(c) Location of surveillance areas (and their distance from the sensor),

(d) Detection equipment precision/sensitivity (generally, an increase in detection precision/sensitivity will also increase the rate of false alarms),

(e) Detection equipment maintenance requirements,

(f) Airport climate (sensors generally operate most effectively under clear and dry conditions - heavy rainfall or snow can degrade sensor effectiveness), and

(g) Ability of personnel to respond to alerts and recover FOD from runway surfaces.

3.2. PERFORMANCE SPECIFICATIONS.

a. Basic Functions. FOD detection equipment must perform the following functions:

(1) Provide surveillance in the AOA as specified by the airport.

(2) Detect and locate single and multiple FOD items on the AOA.

(3) Provide an alert to the user when FOD has been detected.

(4) Operate in conjunction with, and not interfere with, airport and aircraft communication, navigation, and surveillance systems.

(5) Operate in conjunction with, and without interference from, normal airport and aircraft operations (e.g., aircraft and vehicle movements).

(6) Provide a data record of detected FOD, allowing for equipment calibration and maintenance, and for analysis of the FOD event.

b. Detection Performance.

(1) Object Detection. FOD detection systems must be able to detect the following objects (mobile systems must provide this performance at a minimum speed of 20 mph (30 km/h):

(a) An unpainted, metal cylinder, measuring 1.2 in (3.1 cm) high and 1.5 in (3.8 cm) in diameter,

(b) A white, grey, or black sphere, measuring 1.7 in (4.3 cm) in diameter (i.e., a standard size golf ball),

(c) 90 percent of the following group of objects when placed within a 100 ft by 100 ft (30 m by 30 m) square in the desired coverage area. One item from each category must be included in the group and each item must measure no larger than 4 in (10 cm) in any dimension unless otherwise specified:

- A "chunk" of asphalt or concrete,
- Any portion of a runway light fixture (in-pavement or edge light),
- An adjustable crescent wrench (up to 8 in. (20 cm) in length),
- A deep socket (at least 2 in. (5 cm) in length),
- A piece of rubber from an aircraft tire,
- A distorted metal strip (up to 8 in. (20 cm) in length),
- Fuel cap (aircraft or automotive),
- Lug nut,
- Hydraulic line (from aircraft or GSE, up to 8 in. (20 cm) in length)
- PVC pipe, white (2 in. (5 cm) in diameter), and

(d) Any two of the objects above, located no more than 10 ft (3 m) apart from each other, identified as separate objects.

(2) Location Accuracy. FOD detection systems must provide location information for a detected object that is within 16 ft (5.0 m) of the actual FOD object location. Note: This standard is based on the average accuracy of hand-held GPS devices, which most airport operators will use when retrieving detected FOD. Airport operators using non-visual detection systems, who require greater location accuracy, can procure optional components that enable the system to have visual detection capabilities.

(3) Inspection Frequency

(a) Continuous Detection Systems. These systems must provide continuous operation from fixed sensors to allow for the continuous inspection of runway surfaces during flight operations. The duration of flight operations is dependent on the airport and specified by the user.

(b) Mobile Detection Systems. These systems must provide a mobile operations capability to enhance mandated airport safety self-inspections (per AC 150/5200-18). The frequency of inspections is dependent on the airport and specified by the user.

(4) Detection Response Time. FOD detection systems must have the capability to provide rapid detection of a FOD occurrence in the area being scanned.

(a) For continuously operating FOD detection systems that are designed to provide between-movement alerts, the system must provide inspection of runway surfaces between aircraft movements.

(b) For other continuously operating FOD detection systems, the system must provide inspection updates as specified by the airport, generally within 4 minutes of a FOD occurrence.

(5) Surveillance Area. The airport operator will specify the desired surveillance (detection) area in the AOA requiring FOD detection. This area is generally based on the airport's FOD management plan. The primary area of coverage is the runway (certain portions of the runway may be specified by the airport operator if full coverage is not feasible). Other areas are of lesser importance, with a decreasing level of priority from other paved movement areas down to non-paved, non-movement areas. The manufacturer of a FOD detection system must notify the airport operator of any locations within the specified surveillance area where detection would not be possible.

(6) Performance in Weather. FOD detection systems must demonstrate the detection performance under both clear and inclement weather conditions. Under clear weather conditions, the pavement of the AOA is expected to be dry, while under inclement weather conditions the pavement will be wet with rain, snow, or mixed precipitation.

(a) Detect objects under rainfall or snow conditions (e.g. having a specific intensity, duration, and frequency) for a two-year category of storm in the local region (as specified in CLIM 20, *Climatology of the United States No. 20*). More stringent requirements may be specified by the user.

(b) FOD detection systems must have site-specific performance specifications that include:

(i) performance during clear weather conditions;

(ii) performance during inclement weather conditions; and

(iii) provide the user with the amount of time required for the system to recover after a rain or snow storm, that is, to return the performance capabilities of clear weather conditions after adverse weather conditions subside. In this case, the end of adverse weather conditions will be defined as when precipitation of rain or snow ends.

(c) Lighting conditions. All systems must demonstrate detection performance during daylight, nighttime, and dawn/dusk operations.

(7) Alerts and Alarms. FOD detection systems must be able to alert the system operator to the presence of FOD in scanned areas. The alert must provide airport management with enough information to assess the severity of the hazard in order to determine if immediate object removal is necessary.

(a) False alarms (an alert causing the airport operator to take action to remove a FOD object that does not exist) should be minimized and must not exceed:

(i) one per day as averaged over any 90 day period, for FOD detection systems with visual detection capabilities, or

(ii) three per day as averaged over any 90 day period, for FOD detection systems without visual detection capabilities. Note: Wildlife may move, or small items may be blown away, before airport operators using these detection systems have a chance to investigate FOD alerts.

c. System Output.

(1) Detection Data. All FOD detection systems must automatically provide a data record on detected FOD.

(a) Records must contains the following information at a minimum:

(i) Alert time and date, and

(ii) Location of FOD object.

(b) Additionally, capturing the following information is recommended, but not required:

(i) Description of FOD detected or retrieved (e.g. size, name, type, serial number, etc.)

(ii) Time and date of FOD retrieval

(iii) Time and date of disposition of alert

(iv) Name of personnel detecting / investigating FOD item

(v) An image of the FOD object retrieved (if available)

(vi) Chain of custody information

(2) Data Presentation. FOD detection data can be provided in a coordinate scheme, on maps of the airport, in an operator's console, or broadcast to mobile units. The selection of information options will be specified by the airport, consistent with airport systems operations.

(3) Data Management. Data collected in the FOD detection process should be digitally recorded. Data systems should have the capability to retain the data for at least two years after the detection event.

3.3. OTHER STANDARDS.

a. Design Standards.

(1) Total Life. FOD detection equipment must be designed to perform its intended function for its "total life" period when maintained according to the manufacturer's instructions. The "total life" for which the equipment is designed, assuming it is used and maintained in accordance with the manufacturer's recommendations, must be a minimum of 10 years. For mobile systems, a frequency of use of 365 cycles per year, is assumed.

(2) Environment. FOD detection equipment, including all associated outdoor mounted equipment, must be designed to withstand the following extreme climatic conditions and operate without damage or failure:

(a) Weather

(i) Ambient temperature range: -25 degrees F (-32 degrees C) to +123 degrees F (+52 degrees C) ambient outdoor air temperature. (may be modified by the purchaser if the device is to be used in extreme climates)

(ii) Relative Humidity: 5% to 90%. (may be modified by the purchaser if the device is to be used in extreme climates)

(iii) General Environment: Dust and airborne hydrocarbons resulting from jet fuel fumes.

(b) Components must be protected from mechanical, electrical, and corrosion damage causing impairment of operation due to rain, snow, ice, sand, grit, and deicing fluids.

(c) All electric motors, controls, and electrical wiring / equipment placed outdoors must be weatherproof in order to protect the equipment and connections from the elements.

(d) All non-moving structural components and materials must be individually and collectively designed and selected to serve the total life requirement under such conditions. Moving or working components, such as tires, motors, brakes, etc. are exempt from this provision.

(3) Power Supply. In the event of a power failure, the system must have the capability to automatically power-up and operate in the condition and settings that were available just prior to the power failure.

b. Construction Standards.

(1) General Requirements.

(a) All equipment and material must be new, undamaged, and of the best grade; decisions concerning quality, fitness of materials, or workmanship are determined by the purchaser.

(b) Where items exceed one in number, the manufacturer must provide products from the same component manufacturer with identical construction, model numbers, and appearance.

(c) Insofar as possible, products must be the standard and proven design of the manufacturer.

(d) The manufacturer must install electrical connections for power, controls, and devices in accordance with NEMA and NEC recommendations and requirements. Transmitting equipment must be installed and adjusted in accordance with manufacturer's published instructions and the requirements specified herein.

(2) Workmanship. The manufacturer must install all equipment, materials, specialties, etc., in accordance with the best engineering practice and standards for this type of work.

(3) Materials.

(a) Equipment exposed to the weather must be weatherproof type.

(b) All external components must be constructed and finished in a manner to inhibit corrosion based on the purchaser’s specific environment.

(c) All machined surfaces must be coated with a suitable rust preventative.

(4) Parts.

(a) Standard and Commercial Parts. Insofar as practicable, commercially available standard parts complying with commercial and/or military standards must be used throughout.

(b) Interchangeability and Replaceability.

(i) All parts having the same manufacturer's part number must be directly and completely interchangeable with each other with respect to installation and performance.

(ii) All components and assemblies incorporated in the equipment must be designed and manufactured to dimensional tolerances which permit future interchangeability and facilitate the replacement of parts.

(c) Spare / Replacement of Parts. The manufacturer must develop and provide to the purchaser a parts list, including associated replacement/repair costs.

(d) Substitutions. The purchaser must approve any material or equipment designated as an "or equal" product, but these items must be clearly distinguished and noted in the technical manuals as substitutions.

(5) Codes, Standards, Regulations, and References. The manufacturer must recognize and comply with all codes and standards applicable to the design and construction of this type of equipment which are generally accepted and used as good practice in the industry.

c. Installation and Acceptance Standards.

(1) Installation.

(a) Obstructions and other standards. FOD detection systems must conform to applicable airport obstruction criteria, marking and lighting, and equipment design and installation standards.

(i) For systems located near the runway within the runway safety area:

- Frangibility. Sensors must be mounted on a frangible coupling (reference AC 150/5345-46, *Specification for Runway and Taxiway Light Fixtures*)

- Height. The height of the sensors must be no more than 30 in (0.76 m), depending on the height of existing edge lights for the runway. (reference AC 150/5340-30, *Design and Installation Details for Airport Visual Aids*)

- Connector. The sensor must be connected through a connector that will disconnect upon sensor impact. (reference AC 150/5345-46)

- Wind. The sensors must withstand a wind loading of 300 mph (483 km/h). (reference AC 150/5345-46)

(b) Prior to installation, the manufacturer must obtain all site construction, environmental, and coordination requirements for installation of the detection system at the airport.

(c) Unless otherwise specified by the purchaser, installers of mechanical and electrical work must participate in any pre-installation meetings at the project site to review conditions of other related project work.

(d) The manufacturer must provide trained personnel at the time of delivery to place the device into operation.

(e) Equipment located outside of paved surfaces should be designed and built with ease of maintenance in mind.

(f) The mobile system must be installed on existing vehicle infrastructure, tested and ready for use within 5 days after delivery.

(2) Quality Assurance. The manufacturer must test all of the equipment installed under this specification and demonstrate its proper operation to the purchaser. The manufacturer must furnish all required labor, testing, instruments and devices required for the conduct of such tests.

(a) The manufacturer must install all electrical, instrumentation, and mechanical works to the satisfaction of the purchaser, with inspecting authorities having jurisdiction.

(b) The manufacturer must notify the purchaser in writing of any instances in the specifications that are in conflict with applicable codes. The manufacturer must perform all work in accordance with applicable laws, rules, or regulations.

(c) Deviations from the specifications required for conformance with the applicable codes and/or laws must be corrected immediately, but not until such deviations have been brought to the attention of the purchaser.

(d) For applicable codes and/or laws that govern the minimum design requirements: where this AC calls for materials, vents, sizes, design details, etc., in excess of the code requirements, the AC takes precedence.

(3) Inspection. The manufacturer will establish a formalized final inspection regimen to ensure each system is adjusted as designed, all systems are operating properly, and the finish in complete and undamaged. The user may choose to participate in the final inspection of designated systems.

(4) Testing. After the equipment has been installed and the various units have been inspected, adjusted/calibrated, and placed in correct operating condition, the equipment must be field tested in accordance with the purchaser's testing procedures and requirements. The field tests must demonstrate that the equipment functions are in compliance with the specifications over the entire range of operation. The manufacturer must report any unusual conditions and correct deficiencies of any of the units.

(a) Preliminary Qualification Tests. Preliminary qualification tests may be specified by the purchaser.

(b) Formal Qualification Tests. Formal qualification tests may be specified by the purchaser.

(5) Manuals and Publications. The following operation and maintenance manuals must accompany the delivered equipment. The quantity of items is specified by the purchaser. No special format is required.

(a) Operator's handbook.

(b) Illustrated parts breakdown and list.

(c) Preventive maintenance schedule.

d. Equipment Training and Maintenance Standards.

(1) Training.

(a) The manufacturer must provide trained personnel at the time of delivery to adequately train airport/airline staff in the operation and maintenance of the detection equipment.

(b) Training must include written operating instructions that depict the step by step operational use of the detection system. Written instructions must include, or be supplemented by, materials which can be used to train subsequent new operators.

(c) Training topics must include trouble shooting and problem solving, in the form of theory and hands-on training, for personnel designated by the purchaser.

(d) At least four hours of training for airport/airline personnel must be provided by the manufacturer. Training selected personnel as part of a "Train the Trainer" program will also satisfy this requirement.

(e) Upon the completion of training, the manufacturer must issue to each participant a certificate of competency.

(2) Maintenance.

(a) Preventive. The manufacturer must develop and provide to the purchaser written documentation on recommended preventive maintenance actions.

(b) Cleaning. The manufacturer must develop and provide to the purchaser written documentation on recommended cleaning procedures, including solvent types and tools.

(c) Inspection. The manufacturer must develop and provide to the purchaser written documentation on regularly scheduled maintenance inspection procedures. A focus on sensitive equipment and schedule timelines must be included in the documentation.

(d) Recalibration. The manufacturer must develop and provide to the purchaser a recalibration plan and recalibration procedures. Recalibration should ensure FOD management program performance specifications are maintained for the life of the sensor.

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U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

Subject: Airport Foreign Object Debris (FOD) Detection Equipment	**Date:** 09/30/2009	**AC No:** 150/5220-24
	Initiated by: AAS-100	**Change:**

1. PURPOSE. This advisory circular (AC) provides information that airports can use to procure foreign object debris (FOD) detection equipment.

2. SCOPE. This AC contains minimum performance specifications for systems and equipment that detect foreign objects on airports. Four types of detection systems are discussed, including: stationary radar; stationary electro-optical; stationary hybrid radar and electro-optical; and mobile radar.

This AC is based on research conducted by the Federal Aviation Administration's (FAA's) Airport Technology Research and Development Program and Center of Excellence in Airport Technology (CEAT) to examine the performance of several new FOD detection technologies.

3. APPLICATION. The FAA recommends the guidance and specifications in this Advisory Circular for procuring airport FOD detection equipment. In general, use of this AC is not mandatory. However, it is mandatory for all FOD detection equipment acquired through the Airport Improvement Program (AIP) or the Passenger Facility Charge (PFC) Program. See Grant Assurance No. 34, *Policies, Standards, and Specifications*, and Assurance No.9, *Standards and Specifications*.

4. COMMENTS OR SUGGESTIONS for improvements to this AC should be sent to:

Manager, Airport Engineering Division (AAS-100)
ATTN: FOD ENGINEER
Federal Aviation Administration
800 Independence Avenue SW
Washington DC 20591

Michael J. O'Donnell
Director of Airport Safety and Standards

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CHAPTER 1. TERMINOLOGY AND REFERENCES

1.1. DEFINITIONS.

a. Air Operations Area (AOA). All airport areas where aircraft can operate, either under their own power or while in tow. The AOA includes runways, taxiways, and apron areas.

b. Airport Apron. A surface in the AOA where aircraft park and are serviced (refueled, loaded with cargo, and/or boarded by passengers).

c. Airport Ramp. See Airport Apron.

d. Alert. The outcome of sensor use where a foreign object is detected and personnel are notified of the object's presence.

e. Continuous Surveillance. Uninterrupted surveillance by a sensor of a surface within a specific scan area.

f. Dry. A surface on the AOA that has no sign of moisture (for the purposes of this AC only).

g. Electro-Optical Detection System. A system containing a sensor that uses visual light wavelength as the primary means to detect objects.

h. False Alarm. An alert causing the airport operator to take action to remove a FOD object that does not exist.

i. Foreign Object Debris (FOD). Any object located in an inappropriate location in the airport environment that has the capacity to injure airport or airline personnel and damage aircraft.

j. Hazard. A condition, object or activity with the potential for causing damage, loss, or injury.

k. Hybrid Detection System. A system containing both electro-optical and radar sensors, having the ability to use data from both sensors as the primary means to detect objects.

l. Image Processing. Analysis of electro-optical sensor data using digital processing.

m. Manufacturer. The manufacturer, distributor, lessor, or supplier of automated FOD detection equipment. This includes any provider of a FOD removal program that incorporates automated FOD detection equipment.

n. Radar Detection System. A system containing a sensor that uses radio detection and ranging, which actively transmits and receives radio signals, as the primary means to detect objects.

o. Two-Year Storm. A statistical event (containing rainfall, wind speed, and/or surge properties) of given intensity and duration having a fifty percent (50%) chance of occurring in any one year. This does not imply that it will occur only every two (2) years or, having occurred, will not happen again for another two (2) years.

p. Wet. A surface on the AOA that displays signs of moisture (for the purposes of this AC only).

1.2. ACRONYMS AND TERMS.

AOA	Air Operations Area
FAA	Federal Aviation Administration
FOD	Foreign Object Debris or Foreign Object Damage
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association

1.3. APPLICABLE DOCUMENTS.

The following documents form part of this specification and are applicable to the extent specified.

a. FAA Advisory Circulars (ACs):

AC 150/5200-18	*Airport Safety Self-Inspection*
AC 150/5340-30	*Design and Installation Details for Airport Visual Aids*
AC 150/5345-46	*Specification for Runway and Taxiway Light Fixture*s

b. National Oceanographic and Atmospheric Administration (NOAA), National Climatic Data Center.

CLIM 20	*Climatology of the United States No. 20*

c. Sources:

(1) FAA ACs may be obtained from: U.S. Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Ave., Landover, MD 20785. Telephone: (301) 322-4961, FAX: (301) 386-5394, website: www.faa.gov (navigate to the Airports section, then to the Advisory Circular database)

(2) NOAA, Satellite and Information Service, National Climatic Data Center, Federal Building, 151 Patton Avenue, Asheville NC 28801-5001, Telephone: (828) 271-4800, FAX: (828) 271-4876, website: http://www.ncdc.noaa.gov/oa/mpp/

CHAPTER 2. INTRODUCTION

2.1. GENERAL.

The presence of FOD on airport runways, taxiways, aprons and ramps poses a significant threat to the safety of air travel. FOD has the potential to damage aircraft during critical phases of flight, which can lead to catastrophic loss of life and airframe, and increased maintenance and operating costs. FOD hazards can be reduced, however, by the use of FOD detection equipment.

2.2. FOD FUNDAMENTALS.

a. FOD Hazards. FOD can severely injure airport or airline personnel or damage equipment. Types of potential damage include: cutting aircraft tires; being ingested into engines; or becoming lodged in mechanisms affecting flight operations. Personnel injuries can occur when jet blast propels FOD through the airport environment at high velocities.

b. Sources of FOD. FOD comes from many sources, which complicates efforts to maintain safe aircraft movement areas. FOD can be generated from personnel, airport infrastructure (pavements, lights, and signs), the environment (wildlife, snow, ice) and the equipment operating on the airfield (aircraft, airport operations vehicles, maintenance equipment, fueling trucks, other aircraft servicing equipment, and construction equipment).

c. Types of FOD. The exact nature of FOD is also varied. FOD can be composed of any material and can be of any color and size. In a one year airport study (*Information Paper on French Study on Automatic FOD Detection Systems – Workshop EUROCONTROL*, 9-10 June 2008), over 60% of the FOD items were made of metal, followed by 18% of the items being made of rubber. Dark-colored items made up nearly 50% of the FOD collected. Common FOD dimensions can be 1 in. by 1 in. (3 cm by 3 cm) or smaller. Typical FOD includes the following:

- aircraft and engine fasteners (nuts, bolts, washers, safety wire, etc.);
- aircraft parts (fuel caps, landing gear fragments, oil sticks, metal sheets, trapdoors, and tire fragments);
- mechanics' tools;
- catering supplies;
- flight line items (nails, personnel badges, pens, pencils, luggage tags, soda cans, etc.);
- apron items (paper and plastic debris from catering and freight pallets, luggage parts, and debris from ramp equipment);
- runway and taxiway materials (concrete and asphalt chunks, rubber joint materials, and paint chips);
- construction debris (pieces of wood, stones, fasteners and miscellaneous metal objects);
- plastic and/or polyethylene materials;
- natural materials (plant fragments and wildlife); and
- contaminants from winter conditions (snow, ice).

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CHAPTER 3. FOD DETECTION EQUIPMENT

3.1. BACKGROUND.

a. Airport personnel and users currently serve as the primary "sensor" to detect FOD on airport surfaces. Recent technological developments have greatly expanded the capabilities of FOD detection through automation. Advanced technologies are now available for improved FOD detection, including capabilities for continuous detection on runways and other aircraft movement areas and mobile detection devices to supplement the capabilities of airport personnel.

b. The advanced technologies use different methods and sensors to perform the mission of detecting FOD. Commercially available technologies employ radar and/or electro-optical sensors to detect FOD items rapidly and provide operations staff with alerts to achieve higher levels of removal performance. A summary of the detection system categories and operational modes available from current technologies is shown in Table 1.

Table 1. Summary of FOD Detection Systems.

System	Detection Principles	Capability
Human / Visual	Fundamental baseline for the performance of FOD detection systems. Human observation provides detection and human judgment provides the hazard assessment capability to assure safety.	Supports regularly scheduled, periodic condition, and special inspections.*
Radar	Uses radio transmission data as the primary means to detect FOD on runways and AOA surfaces.	Fixed systems support continuous surveillance. Mobile systems supplement human/visual inspections.*
Electro-Optical	Uses video technology and image processing data as the primary means to detect FOD on runways and AOA surfaces.	Supports continuous surveillance.
Hybrid	Uses a combination of radar and electro-optical data as the primary means to detect FOD on runways and AOA surfaces.	Supports continuous surveillance.

* Per the inspection frequencies defined in AC 150/5200-18, Section 6.b.

c. System Characteristics.

(1) This AC does not limit the technology that airports may use for FOD detection. However, general characteristics of systems that are available (as of the writing of this AC) include:

(a) Stationary Radar. A radar detection system, able to detect a metallic cylindrical target measuring 1.2 in. (3.0 cm) high and 1.5 in. (3.8 cm) in diameter at ranges of up to 0.6 mile (1 km). Sensors are located 165 ft (50.0 m) or more from the runway center line. Generally, two or three sensors are required per runway, depending on airport requirements.

(b) Stationary Electro-Optical. An electro-optical detection system, able to detect a 0.80 in. (2.0 cm) object target at ranges of up to 985 ft (300. m) using only ambient lighting. Sensors are located 490 ft (150 m) or more from the runway center line. Generally, five to eight sensors are required per runway, depending on airport requirements.

(c) Stationary Hybrid. Uses both an electro-optical and radar sensor in a unit collocated with the runway edge lights. The system is able to detect a 0.8 in. (2 cm) target on the runway. Generally, sensors are located on every, or every other, edge light, depending on airport requirements.

(d) Mobile Radar. A radar detection system mounted on top of a vehicle that scans the surface in front of the vehicle when moving. The radar scans an area 600. ft by 600. ft (183 m by 183 m) to detect FOD items measuring 1.2 in (3.0 cm) high and 1.5 in (3.8 cm) in diameter. The system can operate at speeds of up to 30 mph (50 km/h), supplementing human/visual inspections.

d. System Selection.

(1) Major advances in FOD detection technologies provide airports with a wide range of pricing and performance options. An airport operator can identify any specific performance standards based on a number of factors to meet their unique needs and requirements. Some of the factors that may be considered are the:

(a) Number and type of aircraft operating,

(b) Number and size of surveillance areas (e.g., runways, taxiways, aprons, etc),

(c) Location of surveillance areas (and their distance from the sensor),

(d) Detection equipment precision/sensitivity (generally, an increase in detection precision/sensitivity will also increase the rate of false alarms),

(e) Detection equipment maintenance requirements,

(f) Airport climate (sensors generally operate most effectively under clear and dry conditions - heavy rainfall or snow can degrade sensor effectiveness), and

(g) Ability of personnel to respond to alerts and recover FOD from runway surfaces.

3.2. PERFORMANCE SPECIFICATIONS.

a. Basic Functions. FOD detection equipment must perform the following functions:

(1) Provide surveillance in the AOA as specified by the airport.

(2) Detect and locate single and multiple FOD items on the AOA.

(3) Provide an alert to the user when FOD has been detected.

(4) Operate in conjunction with, and not interfere with, airport and aircraft communication, navigation, and surveillance systems.

(5) Operate in conjunction with, and without interference from, normal airport and aircraft operations (e.g., aircraft and vehicle movements).

(6) Provide a data record of detected FOD, allowing for equipment calibration and maintenance, and for analysis of the FOD event.

b. Detection Performance.

(1) Object Detection. FOD detection systems must be able to detect the following objects (mobile systems must provide this performance at a minimum speed of 20 mph (30 km/h):

(a) An unpainted, metal cylinder, measuring 1.2 in (3.1 cm) high and 1.5 in (3.8 cm) in diameter,

(b) A white, grey, or black sphere, measuring 1.7 in (4.3 cm) in diameter (i.e., a standard size golf ball),

(c) 90 percent of the following group of objects when placed within a 100 ft by 100 ft (30 m by 30 m) square in the desired coverage area. One item from each category must be included in the group and each item must measure no larger than 4 in (10 cm) in any dimension unless otherwise specified:

- A "chunk" of asphalt or concrete,
- Any portion of a runway light fixture (in-pavement or edge light),
- An adjustable crescent wrench (up to 8 in. (20 cm) in length),
- A deep socket (at least 2 in. (5 cm) in length),
- A piece of rubber from an aircraft tire,
- A distorted metal strip (up to 8 in. (20 cm) in length),
- Fuel cap (aircraft or automotive),
- Lug nut,
- Hydraulic line (from aircraft or GSE, up to 8 in. (20 cm) in length)
- PVC pipe, white (2 in. (5 cm) in diameter), and

(d) Any two of the objects above, located no more than 10 ft (3 m) apart from each other, identified as separate objects.

(2) Location Accuracy. FOD detection systems must provide location information for a detected object that is within 16 ft (5.0 m) of the actual FOD object location. Note: This standard is based on the average accuracy of hand-held GPS devices, which most airport operators will use when retrieving detected FOD. Airport operators using non-visual detection systems, who require greater location accuracy, can procure optional components that enable the system to have visual detection capabilities.

(3) Inspection Frequency

(a) Continuous Detection Systems. These systems must provide continuous operation from fixed sensors to allow for the continuous inspection of runway surfaces during flight operations. The duration of flight operations is dependent on the airport and specified by the user.

(b) Mobile Detection Systems. These systems must provide a mobile operations capability to enhance mandated airport safety self-inspections (per AC 150/5200-18). The frequency of inspections is dependent on the airport and specified by the user.

(4) Detection Response Time. FOD detection systems must have the capability to provide rapid detection of a FOD occurrence in the area being scanned.

(a) For continuously operating FOD detection systems that are designed to provide between-movement alerts, the system must provide inspection of runway surfaces between aircraft movements.

(b) For other continuously operating FOD detection systems, the system must provide inspection updates as specified by the airport, generally within 4 minutes of a FOD occurrence.

(5) Surveillance Area. The airport operator will specify the desired surveillance (detection) area in the AOA requiring FOD detection. This area is generally based on the airport's FOD management plan. The primary area of coverage is the runway (certain portions of the runway may be specified by the airport operator if full coverage is not feasible). Other areas are of lesser importance, with a decreasing level of priority from other paved movement areas down to non-paved, non-movement areas. The manufacturer of a FOD detection system must notify the airport operator of any locations within the specified surveillance area where detection would not be possible.

(6) Performance in Weather. FOD detection systems must demonstrate the detection performance under both clear and inclement weather conditions. Under clear weather conditions, the pavement of the AOA is expected to be dry, while under inclement weather conditions the pavement will be wet with rain, snow, or mixed precipitation.

(a) Detect objects under rainfall or snow conditions (e.g. having a specific intensity, duration, and frequency) for a two-year category of storm in the local region (as specified in CLIM 20, *Climatology of the United States No. 20*). More stringent requirements may be specified by the user.

(b) FOD detection systems must have site-specific performance specifications that include:

(i) performance during clear weather conditions;

(ii) performance during inclement weather conditions; and

(iii) provide the user with the amount of time required for the system to recover after a rain or snow storm, that is, to return the performance capabilities of clear weather conditions after adverse weather conditions subside. In this case, the end of adverse weather conditions will be defined as when precipitation of rain or snow ends.

(c) Lighting conditions. All systems must demonstrate detection performance during daylight, nighttime, and dawn/dusk operations.

(7) Alerts and Alarms. FOD detection systems must be able to alert the system operator to the presence of FOD in scanned areas. The alert must provide airport management with enough information to assess the severity of the hazard in order to determine if immediate object removal is necessary.

(a) False alarms (an alert causing the airport operator to take action to remove a FOD object that does not exist) should be minimized and must not exceed:

(i) one per day as averaged over any 90 day period, for FOD detection systems with visual detection capabilities, or

(ii) three per day as averaged over any 90 day period, for FOD detection systems without visual detection capabilities. Note: Wildlife may move, or small items may be blown away, before airport operators using these detection systems have a chance to investigate FOD alerts.

c. System Output.

(1) Detection Data. All FOD detection systems must automatically provide a data record on detected FOD.

(a) Records must contains the following information at a minimum:

(i) Alert time and date, and

(ii) Location of FOD object.

(b) Additionally, capturing the following information is recommended, but not required:

(i) Description of FOD detected or retrieved (e.g. size, name, type, serial number, etc.)

(ii) Time and date of FOD retrieval

(iii) Time and date of disposition of alert

(iv) Name of personnel detecting / investigating FOD item

(v) An image of the FOD object retrieved (if available)

(vi) Chain of custody information

(2) Data Presentation. FOD detection data can be provided in a coordinate scheme, on maps of the airport, in an operator's console, or broadcast to mobile units. The selection of information options will be specified by the airport, consistent with airport systems operations.

(3) Data Management. Data collected in the FOD detection process should be digitally recorded. Data systems should have the capability to retain the data for at least two years after the detection event.

3.3. OTHER STANDARDS.

a. Design Standards.

(1) Total Life. FOD detection equipment must be designed to perform its intended function for its "total life" period when maintained according to the manufacturer's instructions. The "total life" for which the equipment is designed, assuming it is used and maintained in accordance with the manufacturer's recommendations, must be a minimum of 10 years. For mobile systems, a frequency of use of 365 cycles per year, is assumed.

(2) Environment. FOD detection equipment, including all associated outdoor mounted equipment, must be designed to withstand the following extreme climatic conditions and operate without damage or failure:

(a) Weather

(i) Ambient temperature range: -25 degrees F (-32 degrees C) to +123 degrees F (+52 degrees C) ambient outdoor air temperature. (may be modified by the purchaser if the device is to be used in extreme climates)

(ii) Relative Humidity: 5% to 90%. (may be modified by the purchaser if the device is to be used in extreme climates)

(iii) General Environment: Dust and airborne hydrocarbons resulting from jet fuel fumes.

(b) Components must be protected from mechanical, electrical, and corrosion damage causing impairment of operation due to rain, snow, ice, sand, grit, and deicing fluids.

(c) All electric motors, controls, and electrical wiring / equipment placed outdoors must be weatherproof in order to protect the equipment and connections from the elements.

(d) All non-moving structural components and materials must be individually and collectively designed and selected to serve the total life requirement under such conditions. Moving or working components, such as tires, motors, brakes, etc. are exempt from this provision.

(3) Power Supply. In the event of a power failure, the system must have the capability to automatically power-up and operate in the condition and settings that were available just prior to the power failure.

b. Construction Standards.

(1) General Requirements.

(a) All equipment and material must be new, undamaged, and of the best grade; decisions concerning quality, fitness of materials, or workmanship are determined by the purchaser.

(b) Where items exceed one in number, the manufacturer must provide products from the same component manufacturer with identical construction, model numbers, and appearance.

(c) Insofar as possible, products must be the standard and proven design of the manufacturer.

(d) The manufacturer must install electrical connections for power, controls, and devices in accordance with NEMA and NEC recommendations and requirements. Transmitting equipment must be installed and adjusted in accordance with manufacturer's published instructions and the requirements specified herein.

(2) Workmanship. The manufacturer must install all equipment, materials, specialties, etc., in accordance with the best engineering practice and standards for this type of work.

(3) Materials.

(a) Equipment exposed to the weather must be weatherproof type.

(b) All external components must be constructed and finished in a manner to inhibit corrosion based on the purchaser’s specific environment.

(c) All machined surfaces must be coated with a suitable rust preventative.

(4) Parts.

(a) Standard and Commercial Parts. Insofar as practicable, commercially available standard parts complying with commercial and/or military standards must be used throughout.

(b) Interchangeability and Replaceability.

(i) All parts having the same manufacturer's part number must be directly and completely interchangeable with each other with respect to installation and performance.

(ii) All components and assemblies incorporated in the equipment must be designed and manufactured to dimensional tolerances which permit future interchangeability and facilitate the replacement of parts.

(c) Spare / Replacement of Parts. The manufacturer must develop and provide to the purchaser a parts list, including associated replacement/repair costs.

(d) Substitutions. The purchaser must approve any material or equipment designated as an "or equal" product, but these items must be clearly distinguished and noted in the technical manuals as substitutions.

(5) Codes, Standards, Regulations, and References. The manufacturer must recognize and comply with all codes and standards applicable to the design and construction of this type of equipment which are generally accepted and used as good practice in the industry.

c. Installation and Acceptance Standards.

(1) Installation.

(a) Obstructions and other standards. FOD detection systems must conform to applicable airport obstruction criteria, marking and lighting, and equipment design and installation standards.

(i) For systems located near the runway within the runway safety area:

- Frangibility. Sensors must be mounted on a frangible coupling (reference AC 150/5345-46, *Specification for Runway and Taxiway Light Fixtures*)

- Height. The height of the sensors must be no more than 30 in (0.76 m), depending on the height of existing edge lights for the runway. (reference AC 150/5340-30, *Design and Installation Details for Airport Visual Aids*)

- Connector. The sensor must be connected through a connector that will disconnect upon sensor impact. (reference AC 150/5345-46)

- Wind. The sensors must withstand a wind loading of 300 mph (483 km/h). (reference AC 150/5345-46)

(b) Prior to installation, the manufacturer must obtain all site construction, environmental, and coordination requirements for installation of the detection system at the airport.

(c) Unless otherwise specified by the purchaser, installers of mechanical and electrical work must participate in any pre-installation meetings at the project site to review conditions of other related project work.

(d) The manufacturer must provide trained personnel at the time of delivery to place the device into operation.

(e) Equipment located outside of paved surfaces should be designed and built with ease of maintenance in mind.

(f) The mobile system must be installed on existing vehicle infrastructure, tested and ready for use within 5 days after delivery.

(2) Quality Assurance. The manufacturer must test all of the equipment installed under this specification and demonstrate its proper operation to the purchaser. The manufacturer must furnish all required labor, testing, instruments and devices required for the conduct of such tests.

(a) The manufacturer must install all electrical, instrumentation, and mechanical works to the satisfaction of the purchaser, with inspecting authorities having jurisdiction.

(b) The manufacturer must notify the purchaser in writing of any instances in the specifications that are in conflict with applicable codes. The manufacturer must perform all work in accordance with applicable laws, rules, or regulations.

(c) Deviations from the specifications required for conformance with the applicable codes and/or laws must be corrected immediately, but not until such deviations have been brought to the attention of the purchaser.

(d) For applicable codes and/or laws that govern the minimum design requirements: where this AC calls for materials, vents, sizes, design details, etc., in excess of the code requirements, the AC takes precedence.

(3) Inspection. The manufacturer will establish a formalized final inspection regimen to ensure each system is adjusted as designed, all systems are operating properly, and the finish in complete and undamaged. The user may choose to participate in the final inspection of designated systems.

(4) Testing. After the equipment has been installed and the various units have been inspected, adjusted/calibrated, and placed in correct operating condition, the equipment must be field tested in accordance with the purchaser's testing procedures and requirements. The field tests must demonstrate that the equipment functions are in compliance with the specifications over the entire range of operation. The manufacturer must report any unusual conditions and correct deficiencies of any of the units.

(a) Preliminary Qualification Tests. Preliminary qualification tests may be specified by the purchaser.

(b) Formal Qualification Tests. Formal qualification tests may be specified by the purchaser.

(5) Manuals and Publications. The following operation and maintenance manuals must accompany the delivered equipment. The quantity of items is specified by the purchaser. No special format is required.

(a) Operator's handbook.

(b) Illustrated parts breakdown and list.

(c) Preventive maintenance schedule.

d. Equipment Training and Maintenance Standards.

(1) Training.

(a) The manufacturer must provide trained personnel at the time of delivery to adequately train airport/airline staff in the operation and maintenance of the detection equipment.

(b) Training must include written operating instructions that depict the step by step operational use of the detection system. Written instructions must include, or be supplemented by, materials which can be used to train subsequent new operators.

(c) Training topics must include trouble shooting and problem solving, in the form of theory and hands-on training, for personnel designated by the purchaser.

(d) At least four hours of training for airport/airline personnel must be provided by the manufacturer. Training selected personnel as part of a "Train the Trainer" program will also satisfy this requirement.

(e) Upon the completion of training, the manufacturer must issue to each participant a certificate of competency.

(2) Maintenance.

(a) Preventive. The manufacturer must develop and provide to the purchaser written documentation on recommended preventive maintenance actions.

(b) Cleaning. The manufacturer must develop and provide to the purchaser written documentation on recommended cleaning procedures, including solvent types and tools.

(c) Inspection. The manufacturer must develop and provide to the purchaser written documentation on regularly scheduled maintenance inspection procedures. A focus on sensitive equipment and schedule timelines must be included in the documentation.

(d) Recalibration. The manufacturer must develop and provide to the purchaser a recalibration plan and recalibration procedures. Recalibration should ensure FOD management program performance specifications are maintained for the life of the sensor.

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