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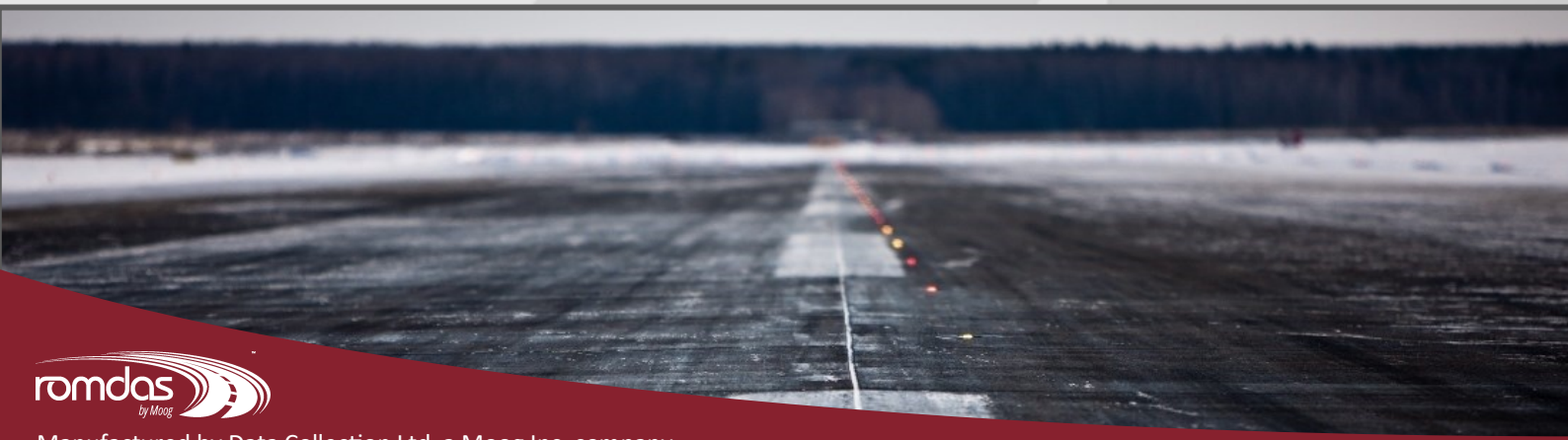
ROMD AS LCMS wit h LFO D

Combined Automatic FOD Detection and Pavement Analysis System



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ROMDAS System Overview

ROMDAS® (**RO**ad **M**easurement **D**ata **A**cquisition **S**ystem) is a comprehensive, cost effective and modular system for collecting asset and pavement information. Implemented in over 60 countries, it's flexible design allows for installation on locally sourced vehicles and meets widely accepted international standards.

Depending on your needs, a ROMDAS system can be easily customized with a variety of add-on modules to suit the specifications and budget of any project.

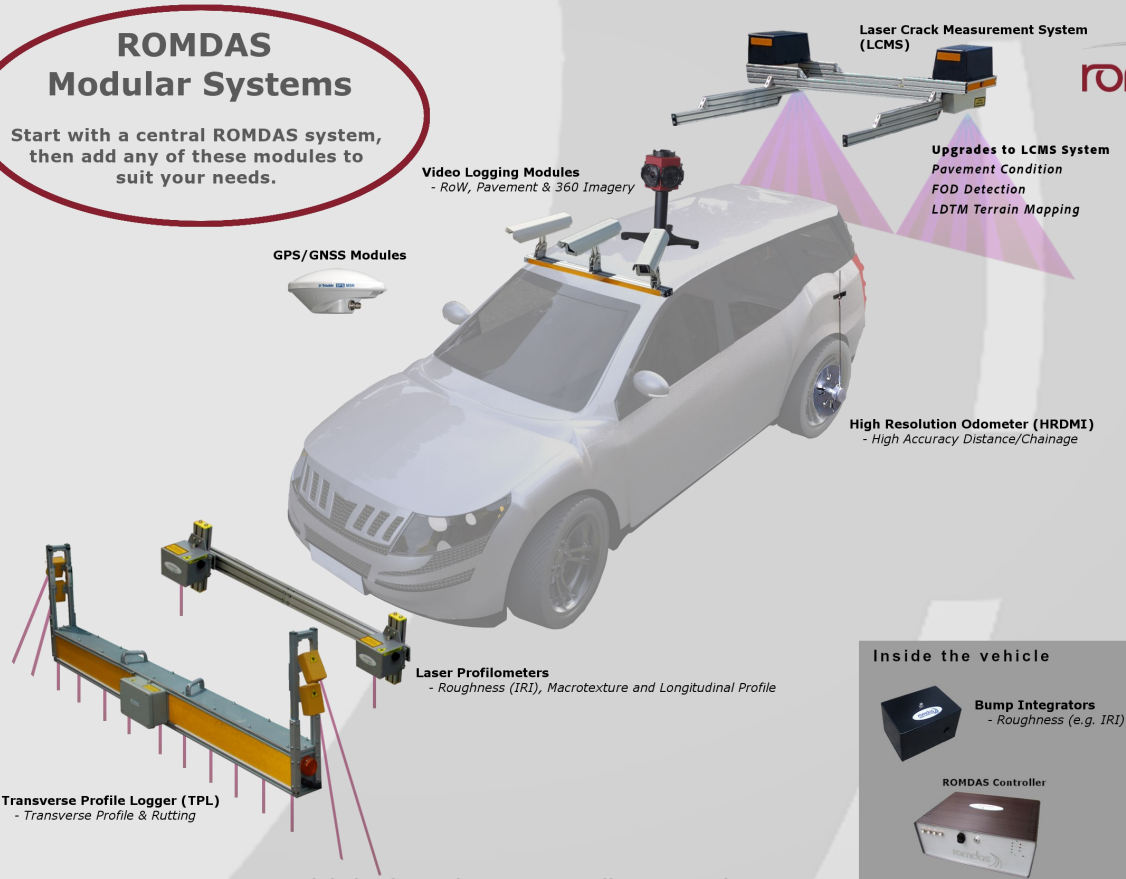
Whether a private consultant, government department or research institution, ROMDAS offers great reliability, flexibility and ease of use for anyone who needs to quickly and accurately collect asset data.

ROMDAS CAN BE USED FOR...

- ✓ High-speed network level or project specific road surveying
- ✓ Road roughness surveys
- ✓ Transverse profile/rutting surveys,
- ✓ Macro-texture (MPD)
- ✓ Visual condition, environment or event rating
- ✓ Automatic crack and surface defect inspections
- ✓ Location referencing (spatial GPS/GNSS data or linear LRP data)
- ✓ GIS mapping of condition data and road alignment
- ✓ Video logging surveys (right of way, 360 and pavement view)
- ✓ Mobile mapping of roadside assets & inventory
- ✓ Road geometry surveying
- ✓ Travel time and congestion surveys

ROMDAS Modular Systems

Start with a central ROMDAS system, then add any of these modules to suit your needs.



Software Solutions

ROMDAS Data Acquisition
In Vehicle

DataView
Office Post-Processing

Mobile Mapping
Office Post-Processing

Inside the vehicle

Bump Integrators
- Roughness (e.g. IRI)

Event Rating Keyboards

ROMDAS Controller

Survey Computers

For Global Sales and Support, email sms@romdas.com

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ROMDAS LCMS with LFOD

Key Features & Benefits

LCMS with LFOD

- ⇒ Automatic FOD detection,
- ⇒ Collect a variety of key pavement analysis data.
- ⇒ Cost-effective and flexible compared to stationary ground based systems,
- ⇒ Safe and efficient for all airfield areas,
- ⇒ Operate in day or night conditions,
- ⇒ Operating speed 0-100km/h,
- ⇒ 5m scan width,
- ⇒ Installed on locally available vehicles for easy vehicle maintenance,
- ⇒ Data reference to GPS location,
- ⇒ Generic file formats for easy export of FOD and pavement data to 3rd party GIS mapping or Pavement Management System (PMS).

Accurate, Flexible & Reliable FOD Management and Pavement Analysis

Overview

As air travel and freight continues to expand and airports become busier and more congested, the need for automated systems to ensure safe tarmacs are becoming increasingly important. The ROMDAS LCMS with LFOD is aimed at addressing this exact need.

One of the biggest potential threats and hardest to effectively detect are small Foreign Objects and Debris (FODs). While FODs can be as simple as loose aggregate, fixings or tools, they have the potential to damage aircraft, causing huge financial loss and put passengers and staff at risk.

Mounted on a vehicle the LFOD system utilizes advanced 3D laser scanning technology and sub-meter GPS to automatically detect, alert and archive FODs over an entire airfield.

Unique to FOD detection systems the ROMDAS LFOD also collects a wide variety of pavement condition data used in the effective management of airfield. This further increases the value and applicability of the system for small or medium airports, which may normally struggle to justify the expense of fixed FOD detection systems.

The ROMDAS LCMS with LFOD is aimed at being a versatile and cost-effective tool for FOD and pavement management systems.

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ROMDAS LCMS with LFOD

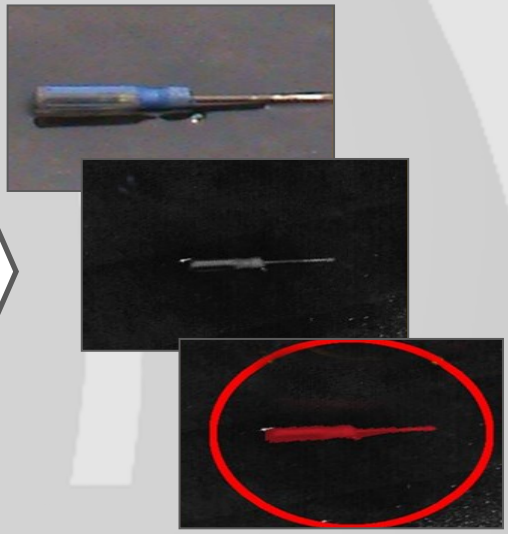
Operational Principle

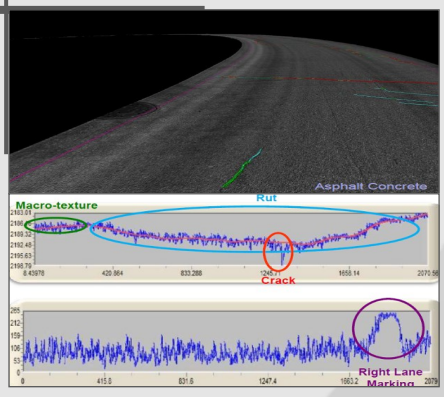
1) Data Acquisition

Two 3D Scanning Lasers record extremely high-accuracy transverse profilers (+4,000 points per profile). Profiles consist of range coordinates and light intensity data for each point. A high sampling rate (28,000 profiles per second) means the system creates almost millimeter resolution 3 D profiles of the surface. Additional sensors such as GPS, Odometer and IMUs sync with the lasers for referencing profiles with location and orientation.

2) Real-Time FOD Detection

FOD detection algorithms run in real-time during inspections and results to immediately trigger the in-vehicle alarm if a FOD is detected. The live map interface allows the operator to easily find and retrieve potential FOD. All FODs are logged and exported post-survey for use in identifying hot-stops and developing FOD management policies.





3) Post-Processing—Pavement Analysis

Algorithms analyze the raw profiles to identify trends which corelate to common pavement defects like cracking, potholes, macrotexture, rutting and more.

Processed data can then be imported into commonly used GIS or Pavement Management Systems (PMS) for archiving, deterioration modeling and maintenance planning.

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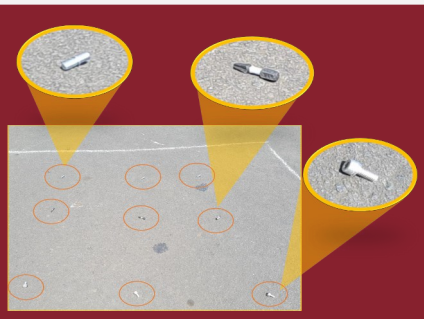
ROMDAS LCMS with LFOD

LFOD Inspection Workflow

1) Detection



2) Real Time Alerts

3) Recovery

Immediate

LFOD Vehicle

Scheduled

Targeted Maintenance

4) Archive & Analysis

Export

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ROMDAS LCMS with LFOD

Key Features & Benefits

FOD Management

- ⇒ Detect FOD as small as a few millimeters,
- ⇒ Cost-effective and flexible compared to stationary ground based systems,
- ⇒ Real-time alerts in vehicle and remotely via Cloud software for appropriate decision making and efficient removal,
- ⇒ User configurable alerts and severities based on size or volume,
- ⇒ Operate in day or night conditions,
- ⇒ Operating speed 0-100km/h,
- ⇒ Accurate GPS tagging of FODs,
- ⇒ Automatic syncing with Cloud database,
- ⇒ GIS mapping compatible data,
- ⇒ Covers all recommended FAA FOD inspection areas; runways, taxiways, aprons, aircraft servicing operations, air cargo operations, construction, aircraft maintenance activities (FAA AC: 150-5210 -24)

FOD costs the industry around USD$13 billion per year

Runway Safety: FOD, Birds, and the Case for Automated Scanning, Insight SRI, 2010

FOD Management

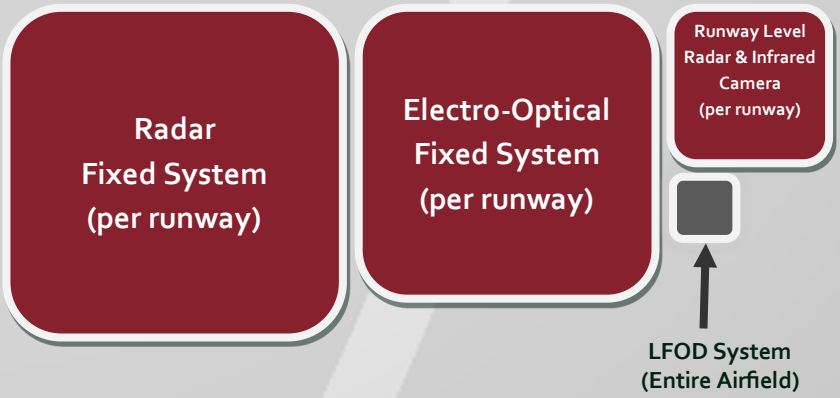
FOD management is not just about detection. LFOD combines high detection capabilities with the ability to easily record where, when and what FODs were recovered. GIS maps of each survey are automatically generated and used to identify possible hotspots, with the aim of improving FOD management and prevention.

FAA Guidelines For Automatic FOD Detection

The ROMDAS LCMS with LFOD complies with the following guidelines in the FAA's performance specifications for airport FOD detection equipment (AC No. 150/5220-24-2009);

- System outputs (detection data, data presentation, data management)
- Basic functions,
- Detection performance,
- Inspection frequency (Mobile),
- Detection response time,
- Surveillance area,
- Alerts and alarms,

Graphical Price Comparison



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ROMDAS LCMS with LFOD

Key Features & Benefits

LFOD vs. Visual Inspections

- ⇒ Improved safety to staff,
- ⇒ Improved accuracy and reliability of results,
- ⇒ Easily detect small FODs,
- ⇒ Automatic FOD size, location, height, severity and image recorded,
- ⇒ Improved speed of operation,
- ⇒ Inspection quality unaffected by night time conditions,
- ⇒ Automatic FOD data transmission and archiving,
- ⇒ Automatic GPS referencing of FODs.
- ⇒ Detect multiple FODs simultaneously,

Visual inspections detect no more than 3%-4% of debris present on a runway

Runway Safety: FOD, Birds, and the Case for Automated Scanning, Insight SRI, 2010

Inspection Principles

A mobile system like the ROMDAS LCMS with LFOD is capable of inspecting any paved airfield area. This mobility allows an LFOD system to be deployed using a variety of methods and seamlessly integrate with existing airfield operations.

Taxiways & Aprons

Routine inspections of the taxiway and aprons can be performed at any time without interfering with aircraft operations.

Runway Inspections

Best practice for runway inspections depends heavily on the volume of runway traffic and operating hours. A site-specific inspection schedule is easily developed by utilizing one, or a combination, of the following inspection techniques. In many cases, airports can use the same procedure as their existing visual inspections, but with the added advantage of automatic and reliable detection.

Rapid 'Wheel Path' Inspection

In 2000 a small piece of metal located near the center of the runway punctured a tire and caused the fatal Concorde crash. This tragedy highlights how crucial the aircraft's 'wheel path' is in a FOD management system.

The 'wheel path' inspection is aimed at focusing the accuracy and reliability of the LFOD during the busiest times to the most critical area. Large airports with high traffic can deploy an LFOD vehicle to inspect the 'wheel path' with little to no disruption to operations.

During 'wheel path' inspection the operator can also perform a traditional visual inspection of the less critical runway edges to detect any high severity FODs during peak-times.

Off Peak or Night-Time Full Inspection

These inspections are aimed at 100% coverage of a runway when air traffic is low to ensure every mm of the runway is scanned at least once a day. Because the system doesn't require any external light it can therefore operate 100% effectively at night and take advantage of lower traffic volumes or nightly runway closures.

The Driver Assist GPS helps guide operators at night to guarantee efficiency and that no areas are missed.

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Key Features & Benefits

Unmatched Accuracy

Detection Technology	FOD Sensitivity
ROMDAS LFOD	>5 mm day or nighttime
Fixed or mobile radar	>25mm
Electro-optical	>40mm daytime
Runway level radar & camera hybrid	>25mm daytime >50mm nighttime

Unaffected by Material Type

Systems relying on radar or cameras can struggle to detect certain materials and/or objects with low contrast to the pavement. The LFOD system does not have this shortfall and is extremely reliable at detecting objects regardless of material type or colour.

Detection with LFOD

Staggering Inspection Runs

A single runway end-to-end run with the LFOD system takes less than 5min. This means if multiple runs are required as part of a wheel-path or full inspection then they can be staggered around takeoff and landings to avoid interference with flight operations.

Reduce Inspection Times with Multiple Vehicles

Due to it's cost-effective nature several vehicles can be setup for significantly less than traditional fixed systems, vehicles can work simultaneously or assigned to specific areas .Therefore if reducing inspection time is critical, this can be achieved while still at a very competitive price.

High Speed Means High Productivity

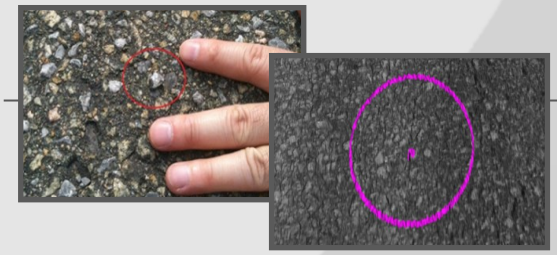
The high operating speed (up to 100km/h) means inspections are performed as quickly as possible. A focused wheel-path scan will take less than 15min with a single vehicle or a full runway scan covering every inch of pavement will take around 30min with a single vehicle or less than 15min with multiple vehicles.

Alternative Deployment: Supplementing Fixed Systems

The ROMDAS LCMS with LFOD system is an excellent option to enhance a FOD management system already using fixed FOD detection equipment.

Take advantage of the benefits from both systems by utilizing fixed FOD detection sensor on runways and mobile LFOD systems for flexible use on taxiways, aprons, construction sites and performing detailed scans for very small FODs during off-peak or night-time inspections.

	Single LFOD	Multiple LFODs
Wheel path inspection	<15min	5-10min
Full runway inspection	Approx. 30-40min	Approx. 15-20min
Scan width	6m	6m (per vehicle)
Time required per run	<5min	<5min



Loose aggregate, normally invisible to other systems, detected by LFOD at speed

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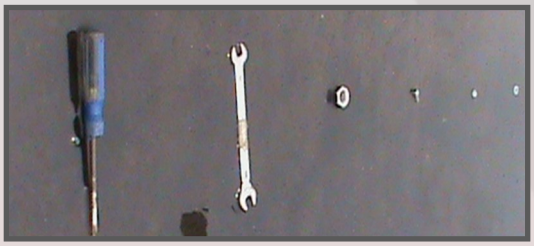
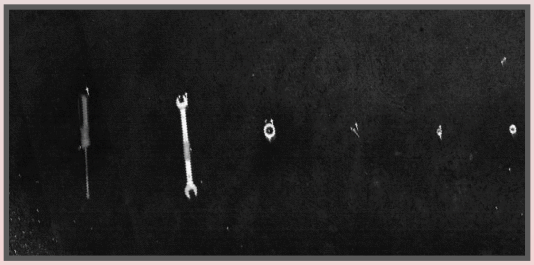
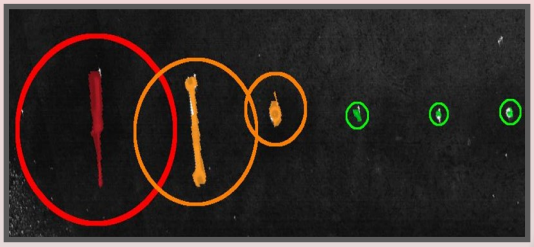
Performance in Wet Conditions



FODs semi-submerged in pool of water



Raw LFOD Image



Processed LFOD Image

Real-Time Alerts with LFOD

In-Vehicle Alerts

The system operator receives a visual and audio alert when a FOD is detected. This gives the operator the option to stop and recover the FOD immediately. This approach is commonly used when inspecting aprons and taxiways where timeframes are not as restrictive as runway inspections. It is also a very cost-effective method as the whole detection, recovery and archiving process is efficiently handled by a single operator.

User-defined Severity Rating

LFOD's severity rating is determined by the object's dimensions. The tolerance between low, medium and high severity is easily configurable by users .

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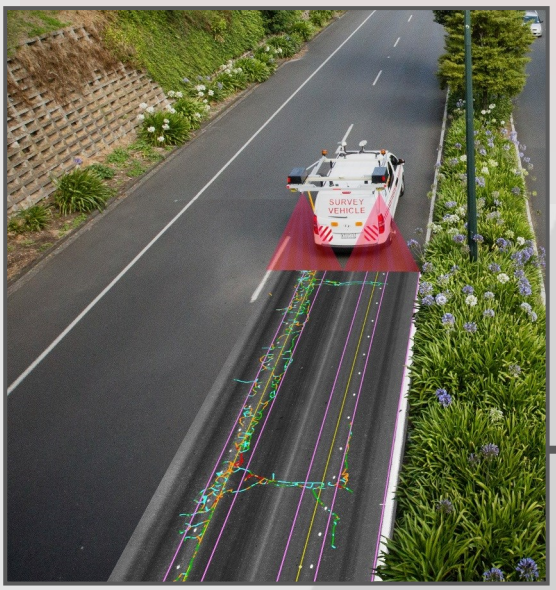
Key Features & Benefits

Pavement Analysis

- ⇒ Collect a wide variety of pavement condition data,
- ⇒ Reprocess using different parameters without resurveying,
- ⇒ Generic file formats for easy importing into GIS or Pavement Management Systems (PMS),
- ⇒ Real-time status display. Giving operators immediate feedback on correct operation of system,
- ⇒ Measures full 5 m width profiles ,
- ⇒ Operation in day or night time conditions,
- ⇒ Data referenced to GPS and distance,
- ⇒ Survey speeds up to 100 km/h.



Pavement Analysis Data

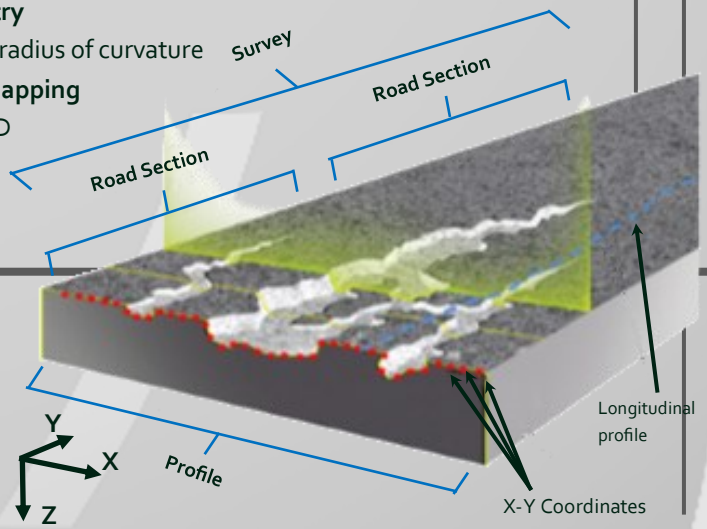
In addition to daily FOD inspections the LFOD offers the full range of pavement data offered by the base LCMS system. One of the most advanced technologies for collecting pavement data, LFOD can provide a detailed understanding of the surface condition and facilitate better decisions around maintenance and budgeting. With the system station on-site performing daily FOD inspections it becomes viable to perform more frequent and economical condition surveys.

Pavement Condition Outputs

- ♦ Cracking (Longitudinal, transverse, alligator, multiple, sealed cracks),
- ♦ Rut depth, width & cross-sectional area across 5m scan,
- ♦ Macro-texture (MPD, MTD) across whole lane width in 5 AASHTO band,
- ♦ Concrete joint (faulting, spalling, sealant condition,
- ♦ Potholes & Delamination,
- ♦ Edge drop-off and curb detection,
- ♦ Pavement type detection,
- ♦ Pavement marking detection,
- ♦ Raveling,
- ♦ Bleeding,
- ♦ Shoving,
- ♦ Water pooling,
- ♦ Sewer and storm –drain,
- ♦ Geotagged Pavement images (.JPEG).

Optional upgrades

- ♦ **Longitudinal profile/Roughness**
  IRI and BBI in both wheel paths
- ♦ **Surface Geometry**
  slope, cross-fall, radius of curvature
- ♦ **LDTM Terrain Mapping**
  .LAS files for CAD



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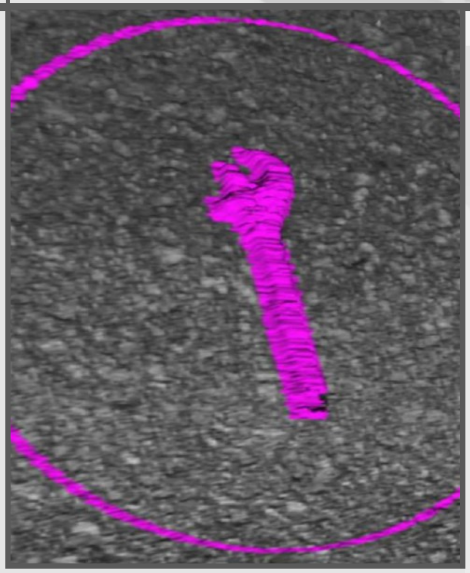

Advantages Over Fixed Systems

- ⇒ Unbeatable value with significantly lower purchase, setup and maintenance costs,
- ⇒ Some fixed systems are limited when detecting certain materials or colours, where LFOD easily detects FODs of any material and colour,
- ⇒ Detect FODs as small as 2mm, including loose aggregate which can be used to create a targeted program for routine runway sweeping,
- ⇒ Extremely cost-effective and flexible for covering aprons and taxiways where most FODs originate,
- ⇒ Output high accuracy pavement data,
- ⇒ Rapid and flexible deployment of mobile LFOD with no airside construction required,

Specifications

Detection type	Automatic Detection Using Mobile Scanning Lasers
Operating speed	0-100 km/h
Operating hours	Day and night (unaffected by ambient light)
Transverse field of view	5m wide scan
GPS positional accuracy	<10cm GPS accuracy (when connected to RTX signal)
Detection size	Down to 5mm
Detection time	Real-time in vehicle
IP rating	LCMS/LFOD Sensors and external connectors IP 67
FOD data outputs	**Direct from LFOD:** Vehicle ID, FOD ID, operator ID, speed, FOD description, GPS location, detection time, recovery time, FOD size, area, image, severity, environmental conditions.
Sampling rate	28,000 profiles/second
Depth resolution	0.5mm
Transverse profile resolution	1—1.5 mm (depending on mounting height)
Standards	**FOD Detection:** Complies with FAA AC No. 150/5220-24-2009 performance specifications - Basic functions, detection performance, inspection frequency (mobile), detection response time, surveillance area, alerts and alarms, system outputs (detection data, data presentation). **Pavement Analysis:** Cracking and potholes (AASHTO PP67), Macro-Texture (ASTM E965, ASTM E1845), Rutting (ASTM E1703, AASHTO PP69), Pavement Images (AASHTO PP68), Roughness/Longitudinal Profile (ASTM E950), Pavement Marking Reflectivity (ISO 7637-2, ISO 11452-2,ISO 11452-4, ISO 10605),

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