Procedures for FOD Detection
System Performance Assessments: Electro-Optical FOD Detection System
I will be talking today about an electro-optical (camera-based) FOD detection system that incorporates intelligent vision processing. The system is the IFerret™ FOD Detection System developed by Stratech Inc.
Stratech *iFerret* FOD Detection System

- Electro-optical w/ intelligent vision
- Tower-mounted sensors (200 m from runway)
- Single sensor scan coverage:
  - Up to 1000ft (300m) length of runway
  - Entire width of runway
- Installation consists of multiple sensors networked to a system control console
General Assessment Information

• Full system assessment completed at Changi International Airport, (SIN) Singapore.
  – Conducted May 2009

• Single sensor assessment at O’Hare International Airport, (ORD) Chicago, Illinois, USA.
  – testing began June 2009 and is ongoing
Installation at Changi Int’l, Singapore

• Installed on two major runways with 12 sensors on each 13,000 ft. runway.
• Each sensor provides 1000 ft (300m) of coverage and placed X ft from the edge of the runway.
• Focus on full system functionality and detection redundancy
Installation at O’Hare Int’l

• Installation of two sensors on a single tower covering two different surfaces:
  • Runway 27L (220 ft section, Full width)
  • Taxiway MM (170 ft section, Full width)
• Focus on single sensor functionality
Issues Associated with Electro-Optical Sensors

- Surface Characteristics
  - Contrast
- Object Characteristics
  - Shape
  - Surface (reflective or non-reflective)
- Illumination
  - Light angle
  - Shadowing
- Angle of View and Aspect
Weather Issues Associated with All Sensors

• Attenuates sensor capabilities
• Changes background conditions
• Adds targets, particularly snow
Color and Surface Condition

• Contrast between object and background will influence detection.

• Pavement variability – rubber residues and paint marking.

• An object variability.
  – Object surface condition (smooth or rough) and reflectivity influence contrast. (ex. Asphalt and concrete pieces, rubber).
  – Object shape and size, particularly height above runway surface influence detection and produce shadows.
Color and Surface Condition

- Assessment targets chosen to evaluate effects of all factors on detection.
- Standard calibration target includes a set of three identical items providing a color contrast gradient (white, grey and black).
- Performance and blind targets consist of representative and actual FOD items and include a range of colors, sizes, and reflectivity.
Item Location and Retrieval Methods

• Items must be accurately placed and quickly retrieved.
  – Item accounting critical

• Brightly colored and reflective paint increases visibility but will influence detection.

• Used neutral UV paints to identify item location and mark items for retrieval.
  – UV paint not highly visible under normal lighting.
  – Fluoresces brightly under UV light allowing for rapid location of position and retrieval of FOD items.
Aspect

• Visibility of an object from a fixed position varies based on the object’s shape, aspect, and orientation.

• Aspect – length vs. width and height
  ▪ Large aspect – longer and thinner
  ▪ Small aspect – more square (dimensions similar)
  ▪ Height important – taller objects more visible than flat objects

• Orientation to sensor changes object’s appearance based on aspect.
  ▪ Long items’ appearance varies greatly based on orientation
  ▪ Square items’ appearance remains relatively similar at different orientations.
Aspect

- Spheres and cylinders used for calibration targets.
- Round shapes present a uniform appearance regardless of orientation.
- Performance testing requires targets to be placed at several orientations to explore its affect on detection.
Illumination

- Light is necessary for vision-based sensors.
- Illumination and lighting angle is constantly changing in an outdoor environment.
- Vision-based systems must operate in all lighting conditions (day, night and twilight) to provide constant surveillance.
- 2 methods for detection in low light.
  - Active: sensor projects light onto surface, usually in a spectrum invisible to humans.
  - Passive: amplification of ambient light and intelligent vision processing
- Tests were conducted during dawn, day, dusk and night.
- Point and read solar meters are used to measure light intensity during every scan.
Weather

• FOD detection systems must contend with a wide range of weather conditions.

• Weather can influence sensor performance:
  – Changes light conditions
  – Changes background and contrast
  – Changes visibility distance
  – Creates FOD.

• Year long assessment plan included opportunistic testing in different weather conditions.
Weather

• Cloud cover important in illumination and lighting.
  – Clear and completely overcast days present relatively uniform illumination.
  – Scattered clouds can create rapid fluctuations in the light intensity and create variable shadows.
  – Clouds reflect ambient light. A cloudy night at an airport is a very bright environment.
• Recorded solar intensity with a handheld solar meter.
• Archived sun angle and sun azimuth data.
Weather

• Falling precipitation attenuates sensor capabilities.
• Rain and snow changes the detection background.
  – Wet pavement darker than dry pavement.
  – Drying pavement a patchwork of light and dark areas.
  – Blowing and accumulating snow coats surface.
  – Snow removal operations
• Standing water can be detected as FOD. Nearby objects can be reflected by wet surface.
• Clumps of snow will be detected as FOD.
• Collected weather data using a portable weather station and from local sources.
Sensor Installations

• Changi International Airport, Singapore
  – Complete runway installation with 12 sensors for 13,000 ft runway.
  – Each sensor survey approximately 1000 ft of surface.
  – Assessment of the system and sensor redundancy

• Chicago O’Hare International Airport
  – Limited installation - two sensors single tower
  – Portions of Runway 27R and Taxiway MM covered each by a single sensor.
The Performance Assessment

• Calibration – Standard Targets
  – Confirm sensor operation
  – Basic information on sensor reliability and robustness

• Performance Testing – Variety of Targets
  – Determine system performance for different items at defined distances and orientations to the sensor
  – Evaluates system’s capabilities of detecting representative FOD items.
  – Provides data set on detections, item characteristics and conditions.

• Blind Testing
  – Assess system detection of randomly placed objects simulating an operational environment.
  – Uses representative and actual FOD items.
  – Challenges system to detect a diverse and unpredictable set of items.
Basic Procedure

- System must scan the surface to establish a background image. This is referred to as a ‘clear scan’.
- After the clear scan, targets are placed.
- A scan is initiated for detections. Records made of the time of the scan, light intensity and other conditions.
- With completed scan targets are retrieved and logged.
- Another clear scan is then initiated to prepare for next placement of targets.
Calibration

- Standard targets placed at known positions.
  - 1.5” (3.7cm) diameter golf balls
  - 1.5” (3.8cm) diameter x 1.25” (3.1cm) high cylinders.
  - Each set of targets contains a white, grey and black item
Calibration

- Sixteen target sets placed in an array throughout the entire detection area.
- Individual targets placed in a line, spaced .5 ft apart.
- 3 rows of spheres
  - System specific targets
- 1 row of cylinders
  - CEAT assessment targets
System Calibration-Standard Target Array

- Conducted on full system installation at Changi Int’l Airport.
- Focus on system redundancy; testing for detections from sensor overlap.
- Calibration targets placed in rows between two sensor ranges.
Performance Testing

• Five identical items are placed at one time at the same orientation.
• Items placed in a row spanning the entire detection area.
  – Two rows of items placed with one on each side of the center line.
  – Each row is placed halfway between the center line and edge line.
• Each item set is placed at two different orientations: parallel to the center line, and perpendicular to the center line.
• Standard targets also used at known locations in all performance testing.
Calibration Positions on Runway 27L at ORD

0 10 20 40 Meters

Performance Item
Blind Testing

- Thirty randomly selected FOD items placed ten at a time randomly throughout the testing area.
  - Targets are selected from a collection of over 100 different items.
- Target placements are determined by random positioning in a grid.
  - Positions within the grid are nonexclusive and several targets may be placed in a single area.
- Targets placed at a random orientation.
- Location of targets recorded with a handheld GPS.
Blind Testing Grid on Runway 27L at ORD
Pete, for conclusions, why not include the table that provides a listing of the testing that has been performed, eg. Number of runway and taxiway tests.
ASMP