ICAO Seventh Meeting of Aerodromes Operations and Planning Sub-Group (3-6 July 2023)

CHANGI airport group

iFerret™: An Effective FOD Detection System for Enhancing Runway Safety

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Keeping runways hazard-free is critical to drive down risk to aircraft operation, especially with growing traffic intensity

15

fatal accidents per year

- Most accidents occur during take-off or landing phases within and around the runway compound

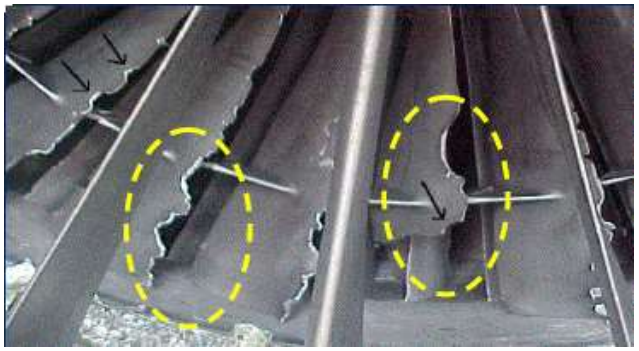
Source: EASA; Airbus

US$13B

Losses per year

- Bird strikes and FOD cost the aviation sector US$13 billion/year, which should be avoided

Source: EASA



12%

of total aircraft incidents

- 12% of 2019's aircraft incidents occurred from operational damage (e.g. damage in-flight due to foreign object ingestion)

Source: ICAO

Current regulatory requirements prescribe outcomes but not means of compliance

ICAO Annex 14 Vol.1, Standard 10.2.1

"*The surfaces of all movement areas including pavements (runways, taxiways and aprons) and adjacent areas shall be inspected and their conditions monitored regularly as part of an aerodrome preventive and corrective maintenance programme with the objective of avoiding and eliminating any foreign object debris (FOD) that might cause damage to aircraft or impair the operation of aircraft systems.*"

FAA 139.305 (a)(4)

"*…mud, dirt, sand, loose aggregate, debris, foreign objects, rubber deposits, and other contaminants must be removed promptly and as completely as practicable.*"

Singapore Changi Airport's initiative and journey to automate runway FOD detection

2006

INITIATION OF IDEA AND RESEARCH & DEVELOPMENT

Partnered local technology vendor and sought government innovation funding to develop 24-by-7, all-weather automatic runway FOD surveillance system using smart cameras

2008 - 2010

INSTALLATION OF iFERRET SYSTEMS ON CHANGI AIRPORT RUNWAYS 1 & 2

Operationalised original iFerret system with Standard Definition cameras after extensive testing, including on-site involvement by FAA-consultant and assessor, Prof Edwin Herricks

2015 - 2017

UPGRADING OF iFERRET SYSTEM

Switched iFerret to use full High Definition cameras for better image resolution and real-time FOD threat assessment (e.g. Hard or soft objects)

2017 - 2019

TECHNOLOGY REVIEW

Studied the employment of other runway FOD detection technologies, for example, millimetre wave radar, point-cloud laser, thermal imaging, etc.

2019

TAKING OVER OWNERSHIP OF iFERRET INTELLECTUAL PROPERTY RIGHTS/TRADEMARK AND IN-SOURCING OF MAINTENANCE FUNCTIONS

Acquired all intellectual property and source codes rights of iFerret system from technology vendor including filing of patents and trademarks
CAG also in-sourced expertise to operate and maintain the system in-use

2020 - 2022

DEVELOPMENT OF ENHANCED iFERRET SYSTEM ON NEW RUNWAY 3 AT CHANGI AIRPORT

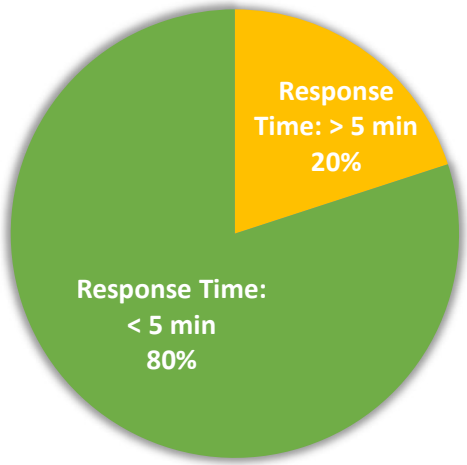
Working with new partner to enhance detection algorithms to minimise false alarm and incorporate other system improvements
(e.g. FOD classification and hot-spot identification)

Improving operational efficiency, minimising runway closure time and optimising runway capacity

FOD CLEARANCE TIMES AT CHANGI AIRPORT

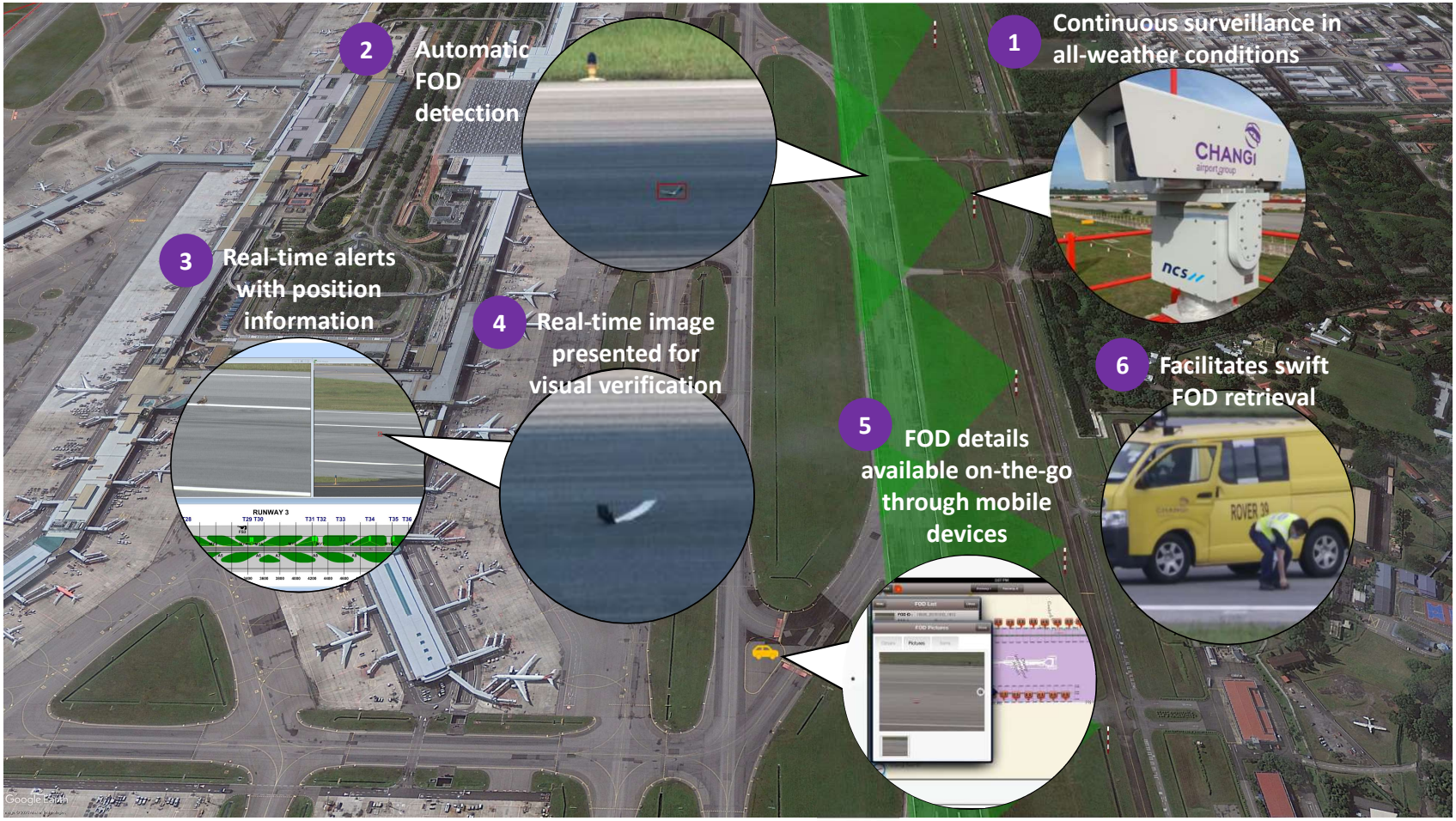
Pre-iFerret

With iFerret and associated enhancement of FOD response procedure



- Our statistics show that having fully-automated and continuous surveillance, as provided by iFerret, enables 7 times more FOD to be detected in real time, vis-a-vis 4 times-a-day physical runway inspections
- iFerret also offers significant reduction in FOD response time by pin-pointing the exact location of the object with real-time image to assist the respondent to clear the FOD expeditiously
- Automated classification function can also assist operators in making informed decisions about the threat level of the FOD

iFerret™ system overview



Performance specifications

Superior image quality

Full HD coloured images (2 megapixels) even under low-light condition

Detection time

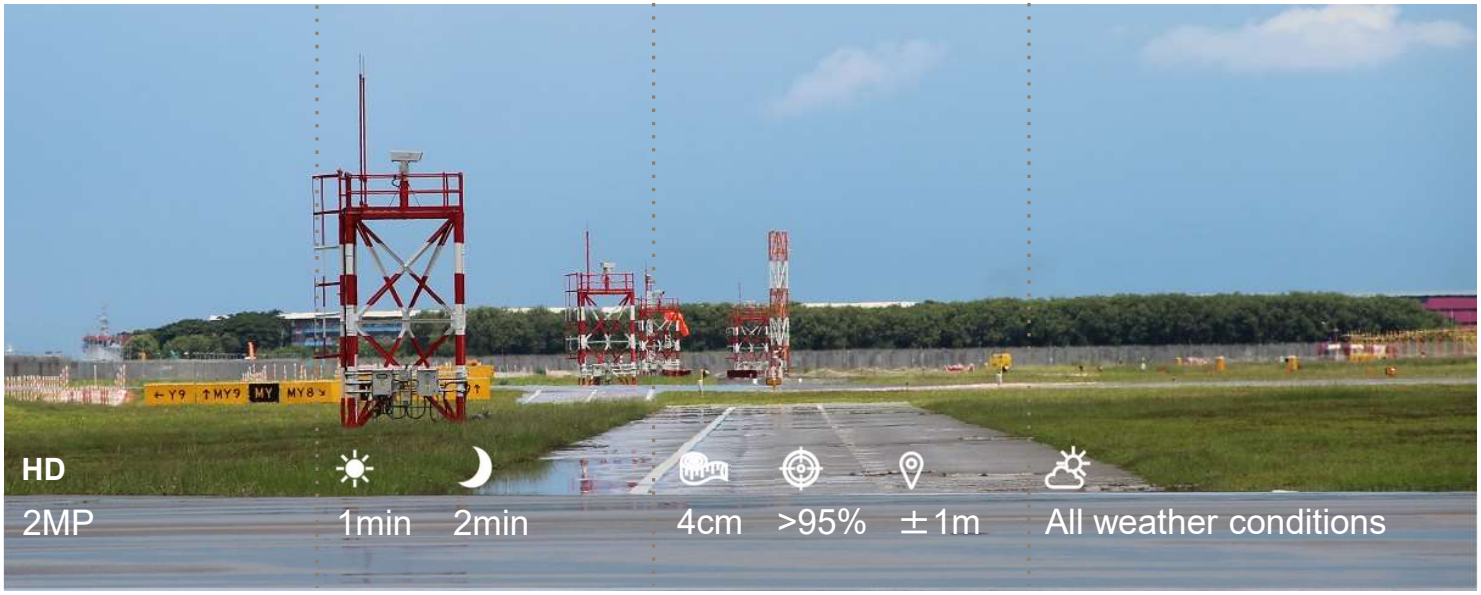
1 minute cycle-time for FOD detection in the day and 2 minutes at night

Detection capability

Detect objects as small as 4 cm with >95% success rate and at +/-1m position accuracy

Operating conditions

Able to perform satisfactorily in both day and night, under all weather conditions – sun, rain, mist, fog and snow, meeting FAA Advisory Circular 150/5220-24



Night view through human eyes

Same night view with iFerret

Key strengths

1. Non-intrusive with ease of installation

iFerret is a passive system that does not interfere with aviation systems or pose health hazards. Licensing and approval of radar frequency is not required.

Modification of runway infrastructure and closure of runway are not required for installation and maintenance.

2. Low maintenance complexity

Electro-optics sensor units are installed away from the runway restricted zone, making iFerret easy to maintain, anytime.

Runway can remain opened during maintenance, and the low number of hardware units reduces maintenance intensity.

3. Superior performance

iFerret cameras are capable of providing full HD coloured images in both daytime and low-light conditions.

Camera technology also allows for expanded functions, such as wildlife detection and recording, airfield monitoring and surveillance.

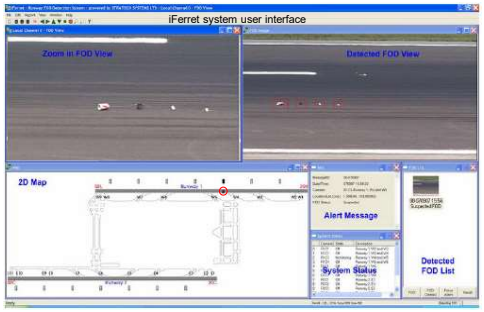
Desirable features of a runway FOD detection system

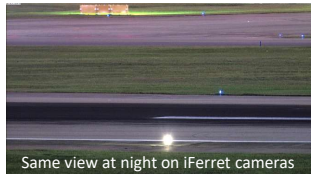
- **ACCURATE, FAST AND RELIABLE DETECTION AND REPORTING IN REAL TIME**
  Crucial not to miss any real FOD hazards under all weather conditions, ability to minimise false alarms, have short scanning/detection time with ability to immediately alert related stakeholders, and has redundancy built into the system design to prevent loss of system availability

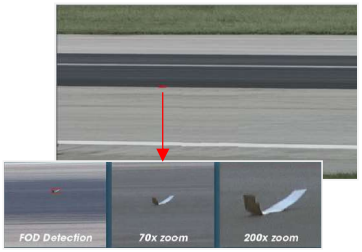
- **ABILITY TO ALLOW USER TO ZOOM IN ON SUSPECTED FOD AND ASSESS NATURE OF THREAT**
  A high-resolution camera system built-on quick-response and low-light sensing technology supplemented with with high zoom lenses is key to allow the duty personnel to confirm the presence of FOD and to ascertain its nature of threat to aircraft operation so that appropriate evasive action can be taken swiftly, only when necessary

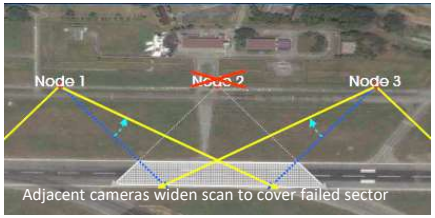
- **FRIENDLINESS IN INSTALLATION AND MAINTENANCE**
  Technology used should not disturb aircraft navigation and surveillance systems, with the option for the system to be set up outside the graded runway strip on frangible mountings out of safety concern, which would also facilitate life-cycle access for calibration, servicing and repair without affecting runway use

- **RECORDING AND PLAYBACK**
  While FOD detection is the primary mission, continuous data collected by the system can also be used to enhance management of wildlife around the runway, monitoring of pavement conditions, maintenance activities and aircraft incident investigation









In conclusion

- Fully-automated runway FOD detection is a matured technology.
- In light of fast growing air traffic, the risk of FOD left behind on runways, which are more intensively used, would increase correspondingly.
- The use of iFerret could help airports around the world avoid a catastrophic event due to unavoidable gaps in manual/physical inspection.

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