Evaluation of Opportunities for Connected Aircraft Data to Identify Pavement Roughness at Airports

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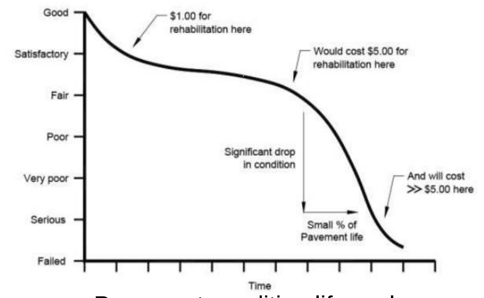
Introduction

Airports are an essential component of the nation’s transportation system and regularly compete for federal, state and local funding. Quantitative performance measures are critical for objective asset management programs that prioritize maintenance and capital investments . Performance measures typically include usage reports and traditional inspection based asset rating systems

However, the cost of collecting asset management data using traditional inspection techniques can be challenging and many transportation modes have begun to examine crowdsourced data to supplement traditional inspection techniques.

Doan, Ramakrishan, and Halevy define crowdsourcing as a process that “enlists a crowd of humans to help solve a problem defined by the system owners” (1).



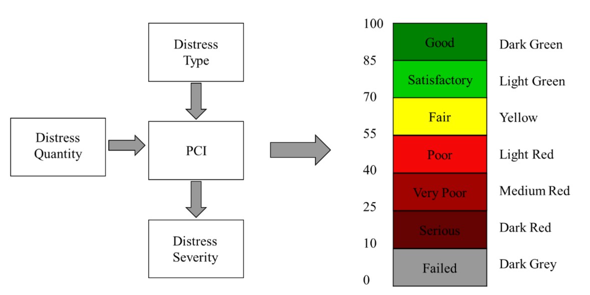
Pavement condition life cycle

This paper examines the feasibility of using existing airframe accelerometers on a Cirrus SR20 to collect airfield pavement condition data.

Literature Review

Airports have particularly rigorous construction and surface monitoring requirements to ensure safe operation of aircraft. Airfield pavement roughness standards are in large part driven by concern for aircraft loss of directional control (2). Another concern is fatigue on aircraft components (increase stress and wear) and other factors which may impair the operation of the aircraft (cockpit vibrations, excessive g-forces) (3).

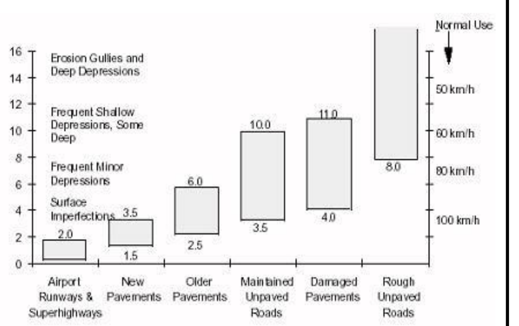
Pavements need to be managed, not just maintained. The Federal Aviation Administration (FAA) has released many Advisory Circulars (AC) outlining standards for the construction, monitoring, maintenance and inspection of airfield pavements (2, 3, 4–6).



Standard PCI rating Scale

ASTM D5340, Standard Methods for Airport Pavement Condition Index (PCI), “provides a measure of the present condition of the pavement based on the observed distresses on the surface of the pavement which also indicates the structural integrity and surface operational condition” (7).

IRI is a profile based metric established by a study conducted by the World Bank (8) to measure the roughness of the pavement. The IRI defines the characteristic of the road surface along the longitudinal profiles of the travelled wheel track using high speed vans equipped with lasers and accelerometers.



Standard IRI Scale

References

1. Doan A, Ramakrishnan R, Halevy AY. Crowdsourcing systems on the World-Wide Web *Communications of the ACM*, Vol. 54, No.4, 2011, pp.86.

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3. Federal Aviation Administration. *AC 150/5380-9, Guidelines and Procedures for Measuring Airfield Pavement Roughness* http://www.airporttech.tc.faa.gov/Portals/0/Documents/airport_pavement/150_5380_9.pdf Accessed Jul. 15, 2016.

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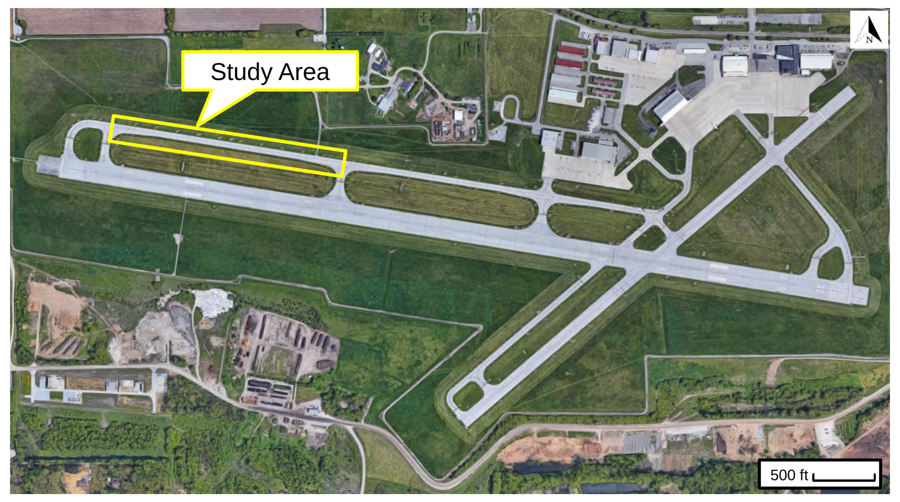
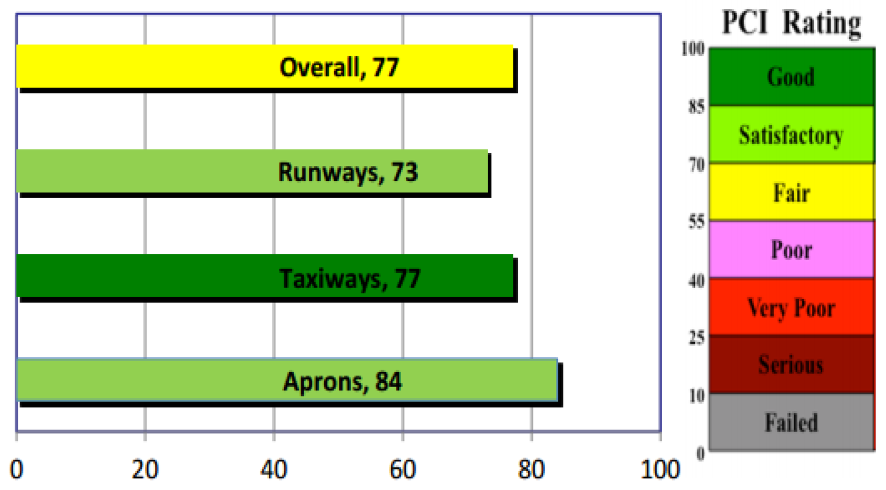
7. American Society for Testing and Materials. D5340-12, Standard Test Method for Airport Pavement Condition Index Surveys *Reproduction*, No.December, 2012, pp.1–54.

8 . Sayers MW, Gillespie TD, Paterson WD 0. *Guidelines for Conducting and Calibrating Road Roughness Measurements* https://deepblue.lib.umich.edu/bitstream/handle/2027.42/3133/72764.pdf?sequence=2 Accessed Jul. 15, 2016.

Data Collection



Google Maps Image of KLAF Showing the Study Area



KLAF PCI Rating

Examples of Transverse Joints from C2 to C3 on Taxiway C at KLAF

Sensors

Rail Mount – Side View

Rail Mount – Front View

Mounting Configuration in Cessna 172

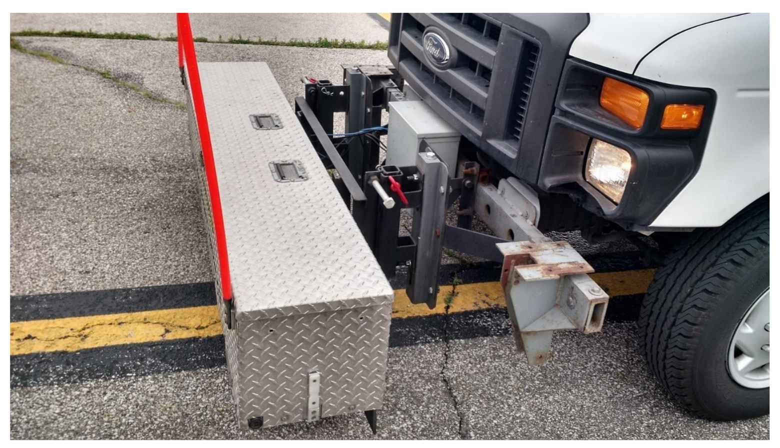
A 3 –Axis Accelerometer

Garmin G1000 Avionics Package

Cirrus SR20

B G1000

C Inertial Profiler Van for measuring IRI



Acknowledgements

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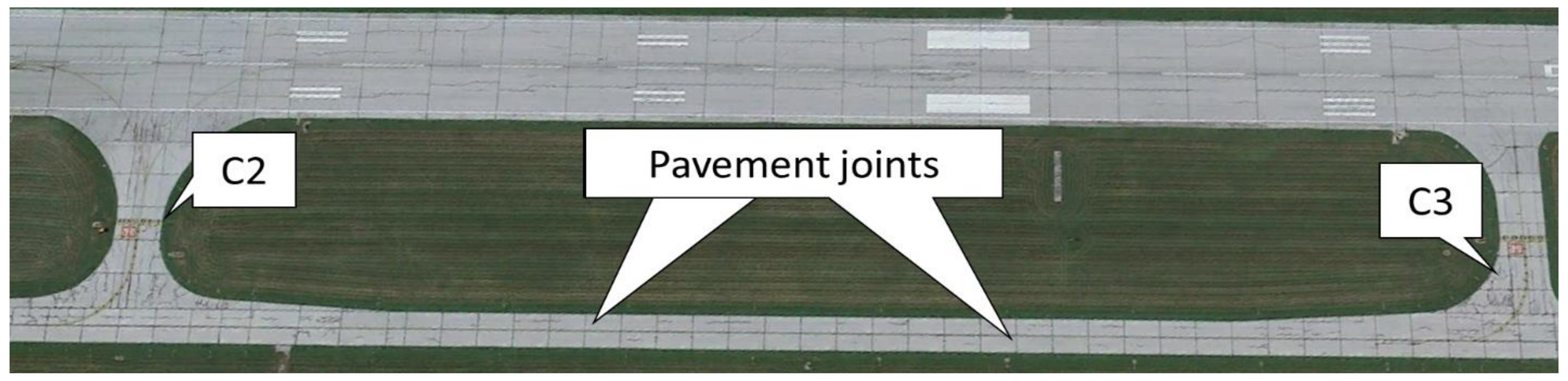
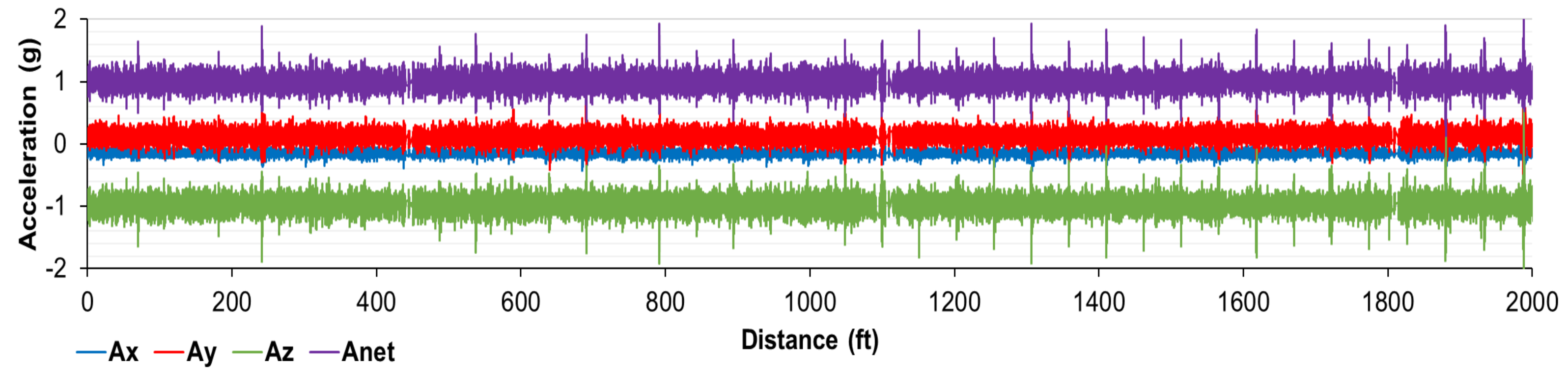
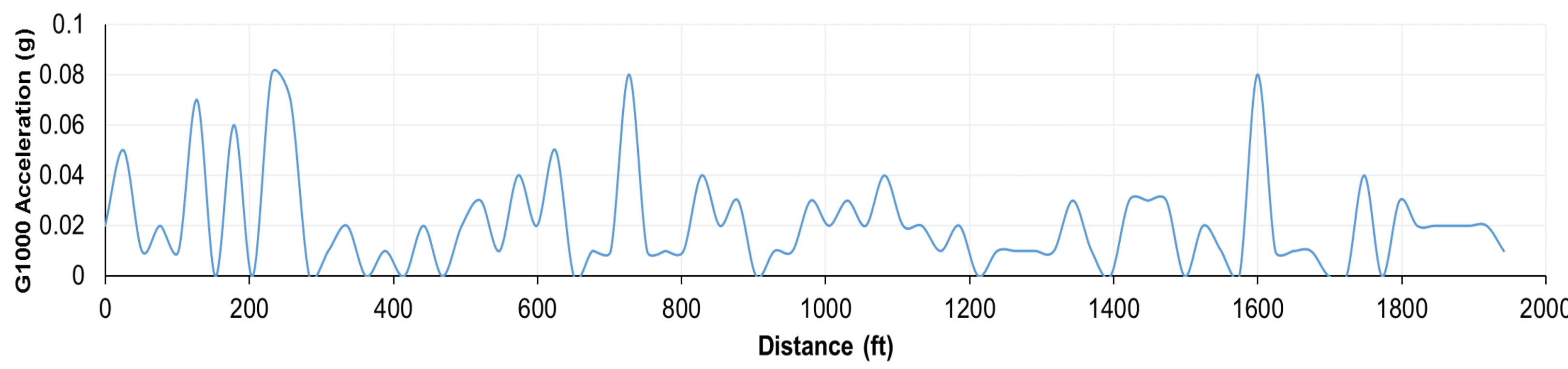
Results



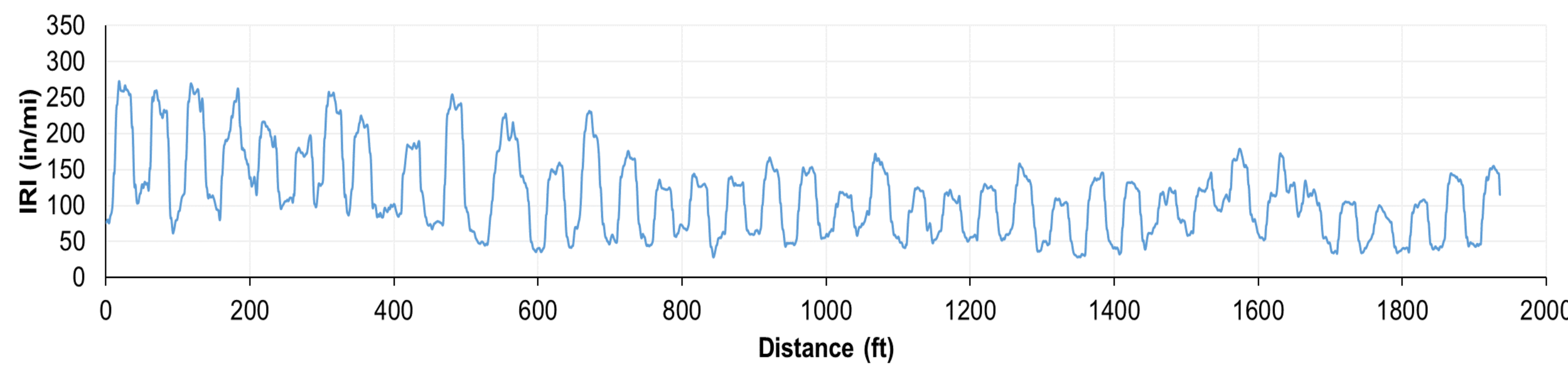
C2 to C3 Section of Taxiway C at KLAF



A Accelerometer data from USB Accelerometer



B Normal Acceleration Data from G1000



C IRI from Inertial Profiler

FINDINGS

This study presents the potential use of acceleration data from airframe mounted accelerometers and on-board avionic systems to provide an estimate of pavement roughness as a low-cost tool to support of an airfield pavement management program. IRI data was obtained from an inertial profiler van, 3-axis 400 Hz accelerometer data was obtained using a Cessna 152 and 1-axis, 1Hz acceleration data was obtained from a factory installed accelerometer from a G1000 on a Cirrus SR20. Both aircraft recorded data while traveling at approximately 15 knots and the instrumented van was traveling at 20 miles per hour (the minimum recommended speed for IRI data collection).

The results suggest airframe mounted accelerometers can be used to collect crowdsourced pavements condition, expanding the applicability of previous research that demonstrates the validity of using acceleration data to estimate IRI. In practice, 1-axis accelerometer data, such as that collected from the G1000 may be sufficient, but it would be desirable that the data is recorded at a higher sampling frequency than the 1 Hz used. A 100 Hz recording frequency would be ideal, but 10Hz would likely be sufficient.