Pavement Condition Index (PCI) Approach to Managing Heavy-Duty Pavements

Wellington International Airport Limited (WIAL)
and AECOM collaboration

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Background: WIAL and AECOM

AECOM is engaged by WIAL to provide a range of Engineering Services for airside and landside assets.

Includes a number of services supporting WIAL's airside pavement management:

- Airfield inspections and condition surveys
- Airside Pavement Maintenance Works Plan (APMW) - *FWP*
- Maintenance treatment selection
  - New surface treatments and technology
- Detailed pavement and surfacing design

Innovation and AM Improvement is a key focus for WIAL

We work collaboratively with the WIAL Infrastructure and AM teams to develop and implement innovations

- We leverage our experience with implementing technical and process innovations other aviation projects in NZ, Australia and internationally
- **The introduction of robust long-term asset life prediction methodologies to support APMW planning and improved pavement management is a key priority for WIAL**

The challenge for civilian airports

5-yearly maintenance and capital works funding negotiations

- Airside maintenance and capital works improvements are negotiated and agreed on a 5-yearly basis between the airport and the airlines.
- Having a reliable and robust airfield pavements AMP and comprehensive forward cost projections is an important financial cost planning tool for both the airport and the airlines (0-5 yrs & 5-10 yrs)

Safe and reliable operations

- Need to demonstrate that the surfacing condition is being maintained to the required condition and technical standards.
- Managing pavements/surfacing to support safe aircraft operations in the short/medium-term and longer-term (10-20 yrs and beyond).
- Minimising reactive works (timely interventions) and avoid costly service disruptions.

Implementing PCI methodology and related AM cost planning (PAVER software) alongside existing inspections and management tools has been able to demonstrate the surfacing/ pavement condition is being maintained and has supported improved planning, safety and cost efficiencies.

Pavement Condition Index (PCI) - Definition

Numerical rating of pavement based on type and severity of distresses

Ratings 0 (worst) to 100 (best)

Distress information is used to determine deduct values to calculate PCI

ASTM D5340-12 standard for airport pavement condition index surveys

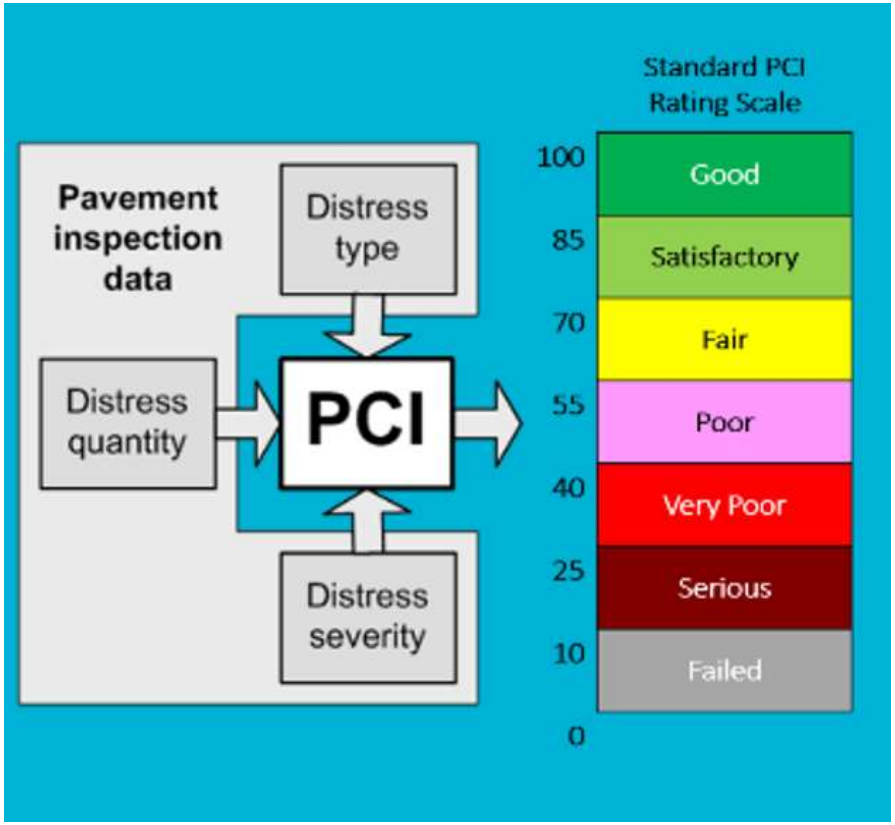
Can also use **ASTM D6433 standard** – Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys

PCI inspection history can help establish **rate of deterioration** and identify future major rehabilitation needs

Indicates structural integrity and **surface operational condition**

- *Does not measure structural capacity or direct measurement of skid resistance or roughness*

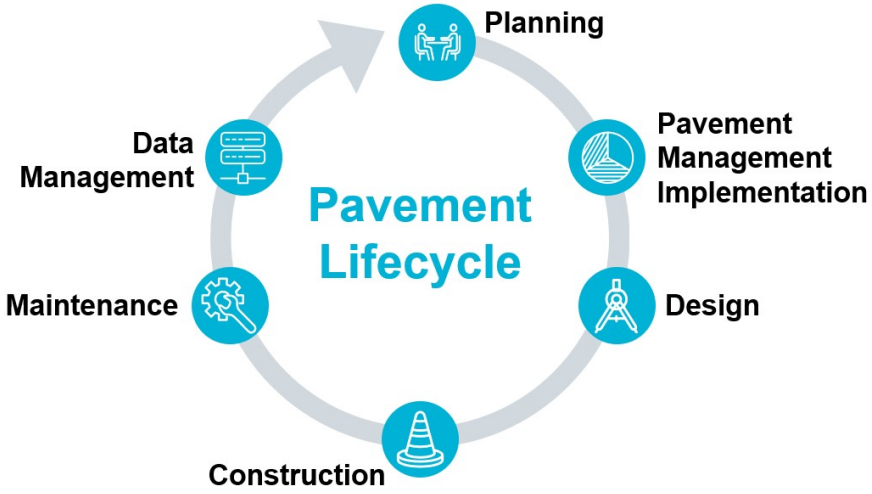
  e.g. Heavy Weight Deflectometer (HWD), Friction Testing



Pavement Management and PCI

Pavement Management System:

The purpose of this system is to provide a tool to assist asset owners with developing the most cost-effective and reliable preservation and rehabilitation alternatives for their pavements.

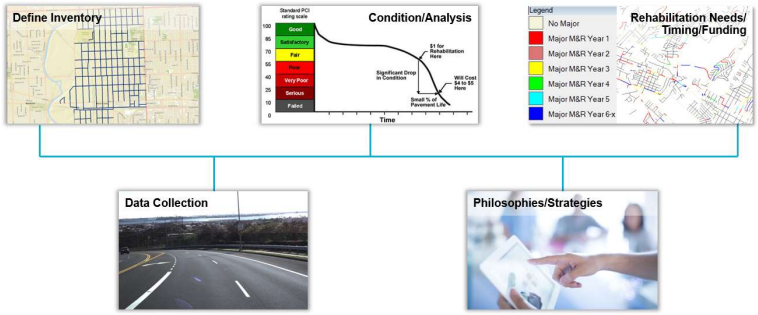


Pavement Condition Index (PCI):

A key input into the PMS and decision-making

Numerical indicator that measures the present condition of the pavement and provides an objective basis for determining maintenance & renewal needs.

Can be applied to any pavement asset; roading or airside pavements



Why use PCI over visual inspection planning methodologies?

Annual walk over visual inspection methodology has **significant limitations**:

- Does not enable accurate measurement or quantification of defects
- Cannot calculate condition deterioration rates/decline over time.
- Based solely on general visual observations on the day of inspection & limited to specific inspection areas (<100% coverage).

Assigned replacement cycles tend to be set conservatively, often replacement are scheduled prior to true need *(required to ensure surfacing's are being maintained in a "sound" condition);* Lacks the more accurate longer-term asset life prediction capabilities

This conservative approach results early replacement costs and has **limited scope for consideration of alternative earlier in life preservation** treatments aimed at extending service life.

No quantitative measurement of defects over time; Difficult to review and compare varying maintenance strategies with any degree of accuracy.

Variability: Subjective visual only inspection process can vary between inspectors; what is deemed acceptable by one inspector maybe considered seriously degraded to another.

Only allows a rudimentary replacement asset management system to be established.

Why use PCI over visual inspection planning methodologies

Adoption of the **more rigorous PCI inspection** approach:

- Measures and rates a predefined range of surfacing defects & related severities
- Used to calculate a Pavement Condition Index (PCI)
- Allows a structured understanding of the types and severity of defects occurring
- Allows defects to be checked and tracked over time.

Inspectors are all trained on how to assess and rate defects in accordance with the PCI methodology to **remove subjective variance** between inspectors.

The PCI methodology requires **more rigorous inspection and defects recording** process - Data collection can be manually or digitally captured (PCI scanning).

- Digital scanning provides a comprehensive 100% digital data record which can then be onward referenced in later years via manual inspections.
- Digital crack maps and rutting location identification generated from scanning is extremely beneficial in gaining an in-depth appreciation of the airfields surfacing conditions.

PCI	Color	Scale
85 < PCI ≤ 100		Good
70 < PCI ≤ 85		Satisfactory
55 < PCI ≤ 70		Fair
40 < PCI ≤ 55		Poor
25 < PCI ≤ 40		Very Poor
10 < PCI ≤ 25		Serious
0 ≤ PCI ≤ 10		Failed

Legend

- Alligator Cracking
- Block Cracking
- Depression
- Longitudinal and Transverse Cracking
- Oil Spillage
- Patching
- Potholes
- Raveling
- Rutting
- Sealed Crack
- Swell
- Weathering

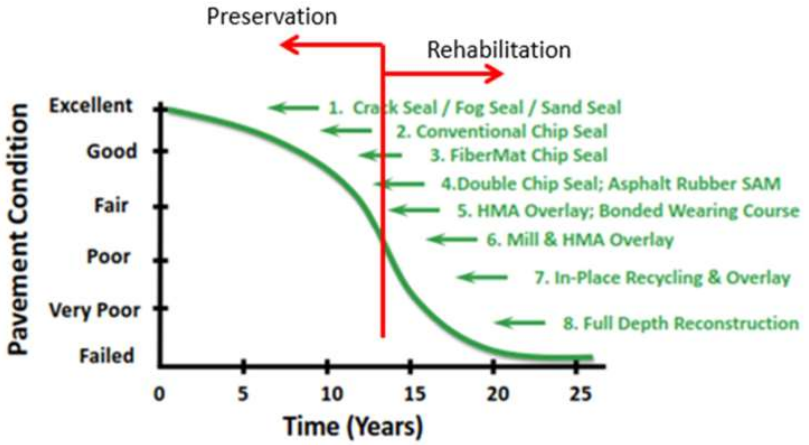
Recommend: PCI laser scanning on all airside roads, taxilanes, taxiways & runways + PCI visual inspections on the parking aprons.

Why use PCI over visual inspection planning methodologies

The PCI PAVER software is an industry standard pavement asset management tool that:

- **allows scenario options** for maintenance procedures to be assessed in order to optimise the maintenance strategies
- can **predict longer term service life** based the actual measurement of surfacing defects
- can be used in the development of **performance models** for each pavement area to **predict future condition** & assign future maintenance expenditure

The PAVER software can also complete complex budgetary analysis well beyond what can be achieved from simple planning spreadsheets.



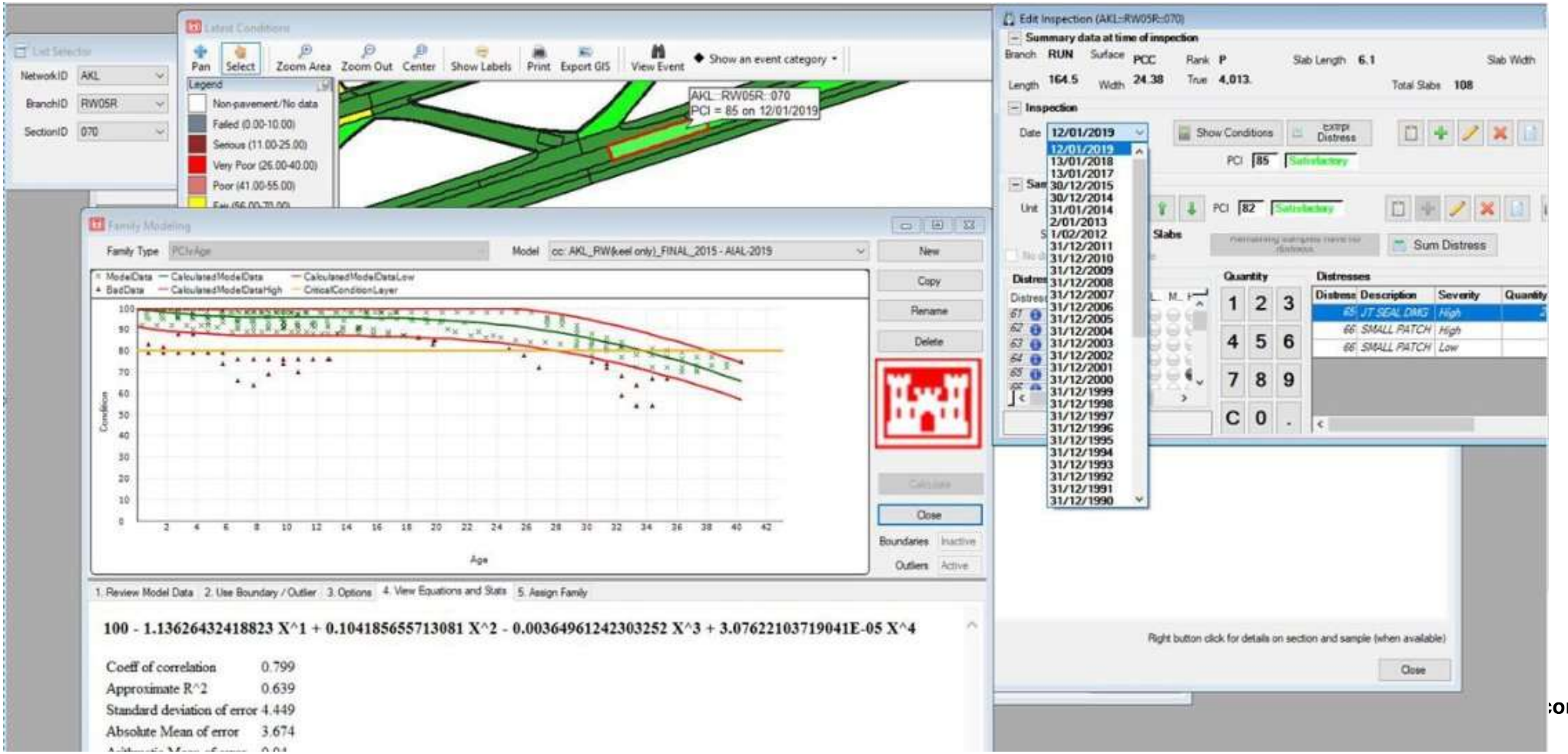
Relative timing of the various preventative maintenance items is a function of the surfacing condition and whether it is in preservation or rehabilitation mode.

AECOM has developed a range of maintenance treatments developed over multiple programmes for all aspects of annual surface maintenance, preservation, and renewals; These can be built into the PCI base models.

PCI does require the establishment of an airfield pavement assets GIS database and a more rigorous inspection process

PAVER – Condition prediction and future maintenance

PAVER's deterioration and financial cost models are able to advise on network level maintenance budgets and when funding is limited prioritise works and advise on maintenance 'backlog' issues.
Varying annual maintenance budgets can be assessed.

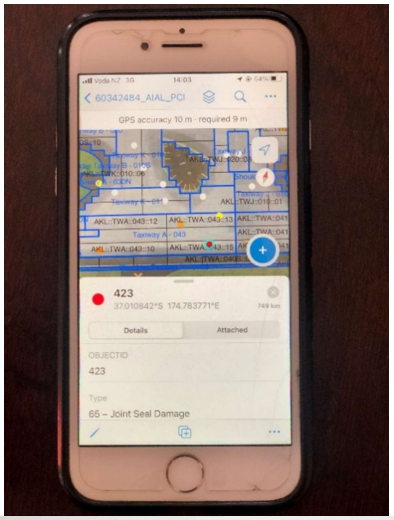


Our experience: PCI Centre of Excellence

AECOM has a **US based centre of excellence established for PCI** surveys in the Chicago Illinois office.

- This entire office is dedicated to airfield pavement AM and inspection programmes across North America.
- This team is actively servicing around 100 plus facilities inspections and maintenance works planning programs per annum.
- We actively use the AECOM Chicago team to setup our local NZ airport clients master GIS pavement and inspection plans
- They also provide Quality Assurance checking of all our PCI programs in this region.

There is a high level of technology exchange between the two regions in the development of airfield laser scanning methodologies and the more recent development of portable handheld inspection and reporting software apps.



Our experience: PCI system history

The PCI system has been running for over 25 years in the US and used in over 800 civilian airport and all US Military airfields

This inspection methodology is required under the US Federal system in order to be eligible for Federal funding for surface maintenance and renewals in the USA.

PCI system has been adopted at airports worldwide.

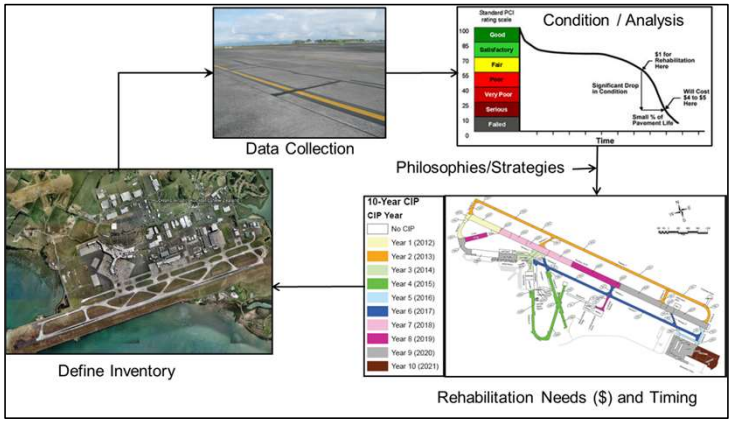
AECOM introduced the PCI methodology in NZ to:

- Auckland in 2012 - Converted 20 plus years of manual inspection records to establish a comprehensive rate of decline databases for that facility.
- Christchurch - Implemented the system in 2013/14 & fully up and running in 2015.
  - The system has generated a dramatic shift in airfield surfacing asset management;
  - based on our US experience we were able to establish very accurate and proven rates of decline models specific to Christchurch that allows a high level of confidence in predicted future airside surface condition models.
- Wellington in 2023

How do you use the PCI outputs

AECOM's approach to airfield AM is to work alongside our clients to gain an in-depth understanding of the airports pavement assets and identify as early as possible where the potential problem areas are located.

Desktop review of past inspection reports & past maintenance to get an understanding of 'hotspots'



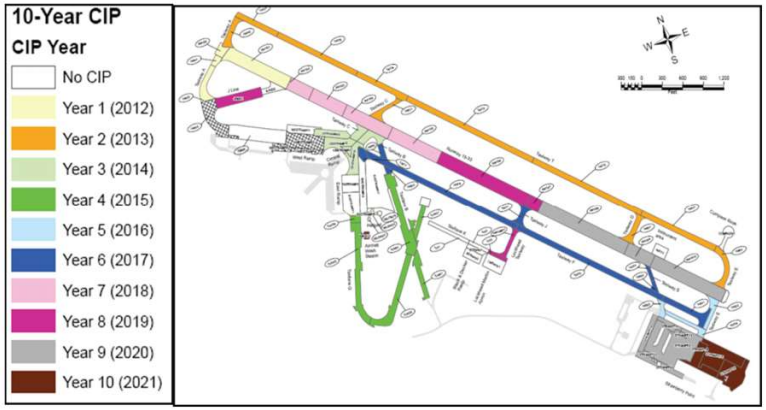
Evaluate the data collected by the PCI inspection (digital and/or manual).

Develop an overarching airside pavement repair programme using the PAVER software system (including for 5, 10 and 20-year maintenance horizons)

Calculate rough order cost expenditure profiles for the relevant maintenance strategies.

Work area plans are produced and updated annually.

Update the maintenance plan database in parallel to the developing the airfield pavement PCI asset plan.



PCI implementation: About Laser Scanning

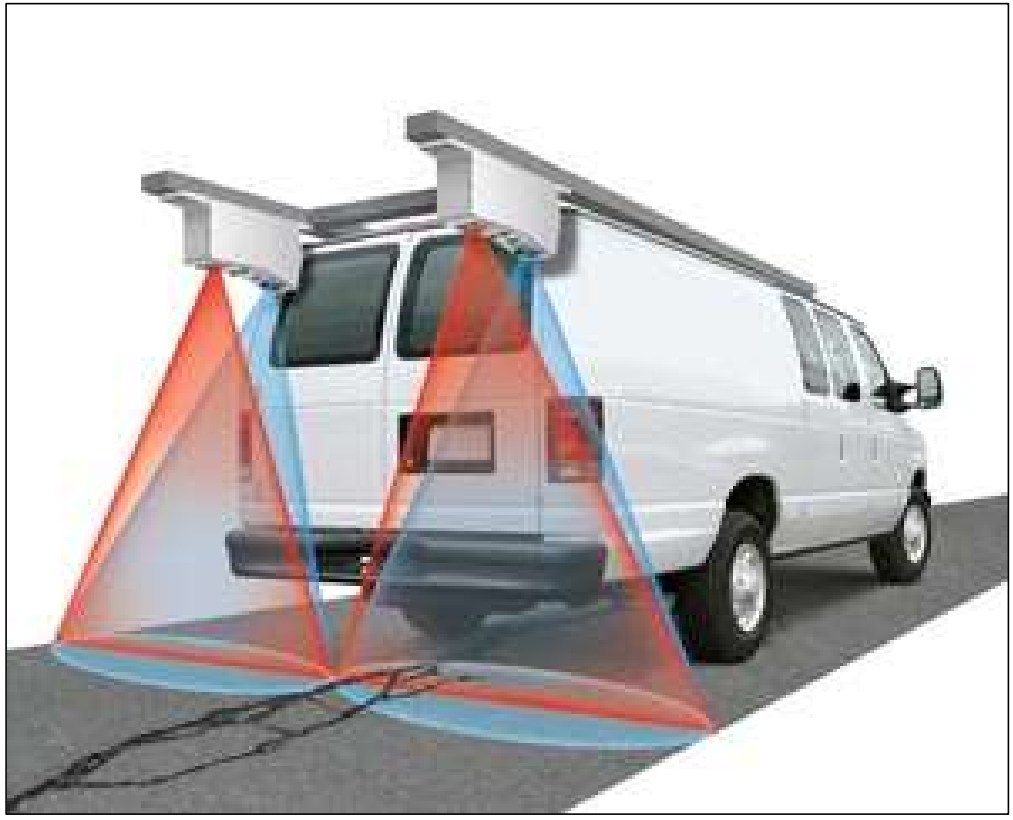
Profiling devices Dynatest Road Surface Profiler Mark 4 (RSPIV) and Laser Crack Measurement System (LCMS) are used to offer high speed visual surveys output as a Pavement Condition Index (PCI) map of airports throughout New Zealand

The RSPIV and LCMS provide visual and roughness surveys with minimal disruption, day or night at speeds up to 100km/hr.

Roughness is reported as The Boeing Bump Index (BBI) for airport surveys.

The digitized data collected is stored in the cloud, providing Engineers the ability to easily and quickly review and compare previous visual surveys with current pavement condition.

PCI implementation: Laser Defect Scanning



AECOM introduced 100% coverage laser scanning to the region to provide a digital record of the surfacing defects and to further automate the PCI condition survey.

AECOM ANZ carried out the first laser scanning project at Brisbane airport on the main runway in 2012 to determine the extent of surface cracking occurring.

AECOM USA has implemented digital scanning at selected US airfields since 2014.

AECOM with support from Dynatest completed the first airside laser scanning at Christchurch airport in 2017.

We have subsequently implemented 100% digital scanning at Melbourne Airport (2018) and Sydney Airport (2019).

AECOM is the only consultant actively implementing 100% digital scanning of runway and taxiways to provide a digital record of surfacing defects in ANZ.

Why use Laser Scanning for defect identification?

Thorough and quantitative - Picks up small defects that can be missed during visual inspections and quantifies exactly (eliminates human error).

Efficient - completed in a few night shifts vs. more shifts and resources on site depending on scale of the airport.

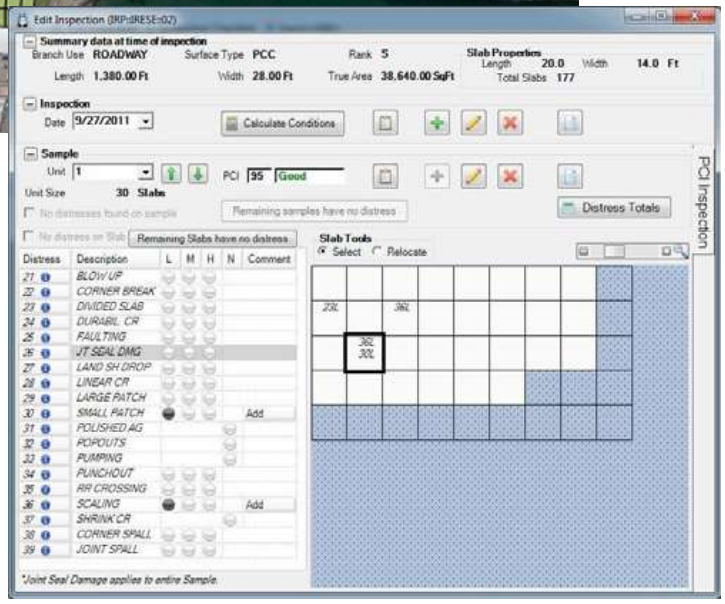
- 3 x 12hr days of multiple engineers on site typically for WIAL inspections

Deterioration Trending: Carried out annually for first 3 years to develop baseline trends and then 2-3 yearly.

- Becomes an effective tool for future 5-, 10- and 20-year maintenance planning.

Simple input, comprehensive output.

PCI implementation - PAVER software set-up for survey



PAVER software is used to analyse the PCI survey data

PAVER sections and sample unit setup is required prior to PCI scanning being undertaken

- The **same grid** is used for laser scanned data and manually collected data.

The **universal grid provides a centralised map** that can be used as a frame of reference and to store all relevant pavement data.

- For WIAL the sample units of the map are now used across designs and projects to improve data management, communication and consistency.

Input provided to GeoSolve for laser scanning

WIAL Airside Pavements		
Name	Area (m^2)	Length (m)
RWY 16/34	114,667	2,090
TWY A	70,896	1,904
Stub A1	2,927	79
Stub A2	2,309	53
Stub A3	1,173	51
Stub A4	1,144	50
Stub A5	1,332	52
Stub A6	1,245	53
Stub A7	1,262	55
Stub A8	1,243	51
Stub A9	3,051	112
Stub A10	2,250	69
Stub A11	2,947	82
TWY B	24,270	631
Stub B5	3,997	131
Stub B6	2,578	60
Stub B7	1,930	39
Stub B8	1,696	30
Stub B9	1,461	26
Stub B10	3,201	147
TXL P	9,040	180
TXL C	5,962	182
TXL R	1,587	54
TXL S	1,272	52
TXL T	721	51
TXL U	980	50
TXL Q	4,036	94
Stub M4	1,783	74
Stub M5	2,052	74
Romeo Apron TXL	3,950	88
Western Apron	33,801	470
SUM	**310,763**	**7,134**

PCI and PAVER outputs

Pavement Condition Index Plan

Main deliverable is a colour coded traffic light condition plan

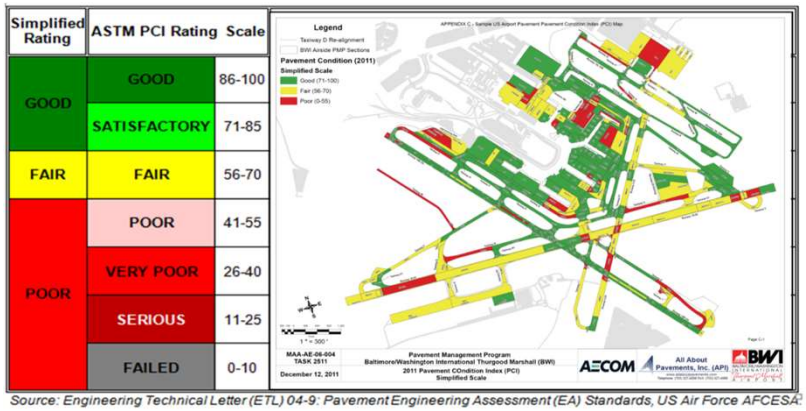
- Summarises the observed conditions across defined pavement areas
- Pavements are generally subdivided by construction history and last date of resurfacing
- This allows non-technical persons to get a feel for the airfield's pavement condition at a single glance.

The PCI index is calculated for each pavement area

GIS layer provides PCI index and defect types

Runways, taxiways & apron areas are subdivided:

- To allow focused treatments and sub-area renewals to be programmed in more detail.
- To allow better differentiation of the best treatments suited to each pavement type (i.e., flexible vs rigid).
- surface conditions are more accurately reported rather than an average of both types over a larger area



Source: Engineering Technical Letter (ETL) 04-9: Pavement Engineering Assessment (EA) Standards, US Air Force AFCESA

Runways and taxiways are subdivided into central and outer quarters plus shoulder.

Apron areas are subdivided into hard-standing (concrete) and asphaltic areas

Benefits of adopting PCI and AM procedures

Objective and rational basis for determining **M&R needs and priorities**

- Monitoring of the PCI is used to establish the rate of pavement deterioration, which permits early identification of M&R needs
- Provides feedback on pavement performance for validation or improvement of current pavement design and maintenance procedures

Advanced asset information collection and management: Moving to reliable and accurate data collection on condition (e.g. combining manual field surveys and laser scanning)

- Industry standard condition assessment methodology suites to each asset class (e.g. PCI type approach) and
- GIS based inventory to more advanced Digital Engineering (BIM enabled).

Ability to **predict future condition** from defects deterioration master curves developed for each airport asset.

Benefits of adopting PCI and AM procedures

Allows a **whole-of-life assessment** of the pavement assets to be undertaken and significantly streamlines the maintenance works programming and **reduces reactive works**.

- Maximise reliable service life from the airside pavements at the lowest overall cost over an extended timeframe.

Allows asset owners to **plan for renewals and related works with confidence** that:

- the asset has not been degraded through poor maintenance, and
- that surfacing is not replaced earlier than truly required.

Paver AM tools also allow us to demonstrate and **provide direct cost comparison between various maintenance strategies**:

- to confirm that annual cost budgets are sufficient and
- are not resulting in an unseen backlog of deferred maintenance costs that result in future unplanned financial “shocks”.

There are some initial set-up and baseline survey costs associated with establishing the PCI approach and processes;

Once established, the benefits continue long-term and enable wider innovations and improvements.

Thank you.

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