Airfield Pavement Rehabilitation Planning

"Choosing the right fix"

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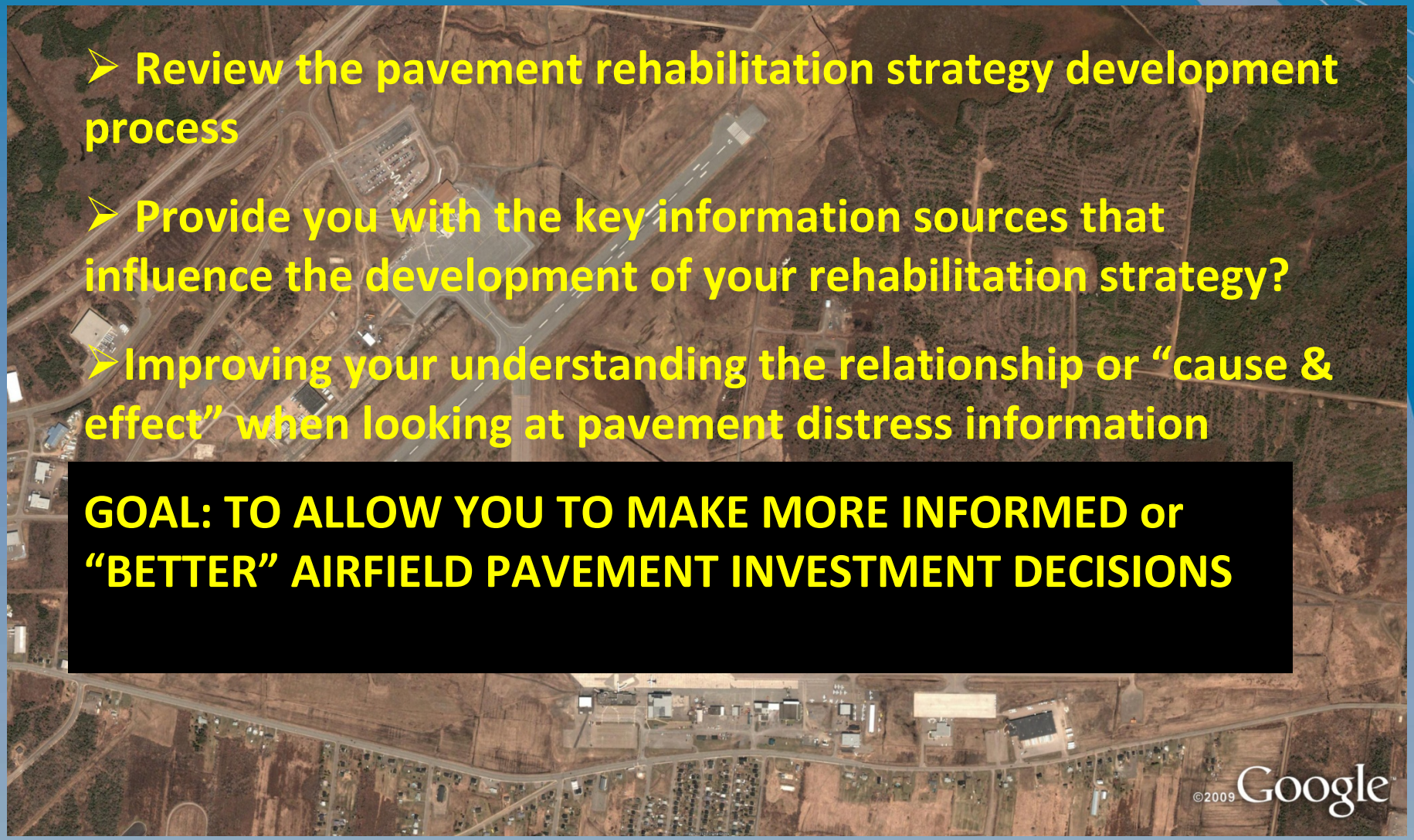
SWIFT
SUMMER WINTER
INTEGRATED FIELD TECHNOLOGIES

Presentation Objective



- Review the pavement rehabilitation strategy development process
- Provide you with the key information sources that influence the development of your rehabilitation strategy?
- Improving your understanding the relationship or "cause & effect" when looking at pavement distress information

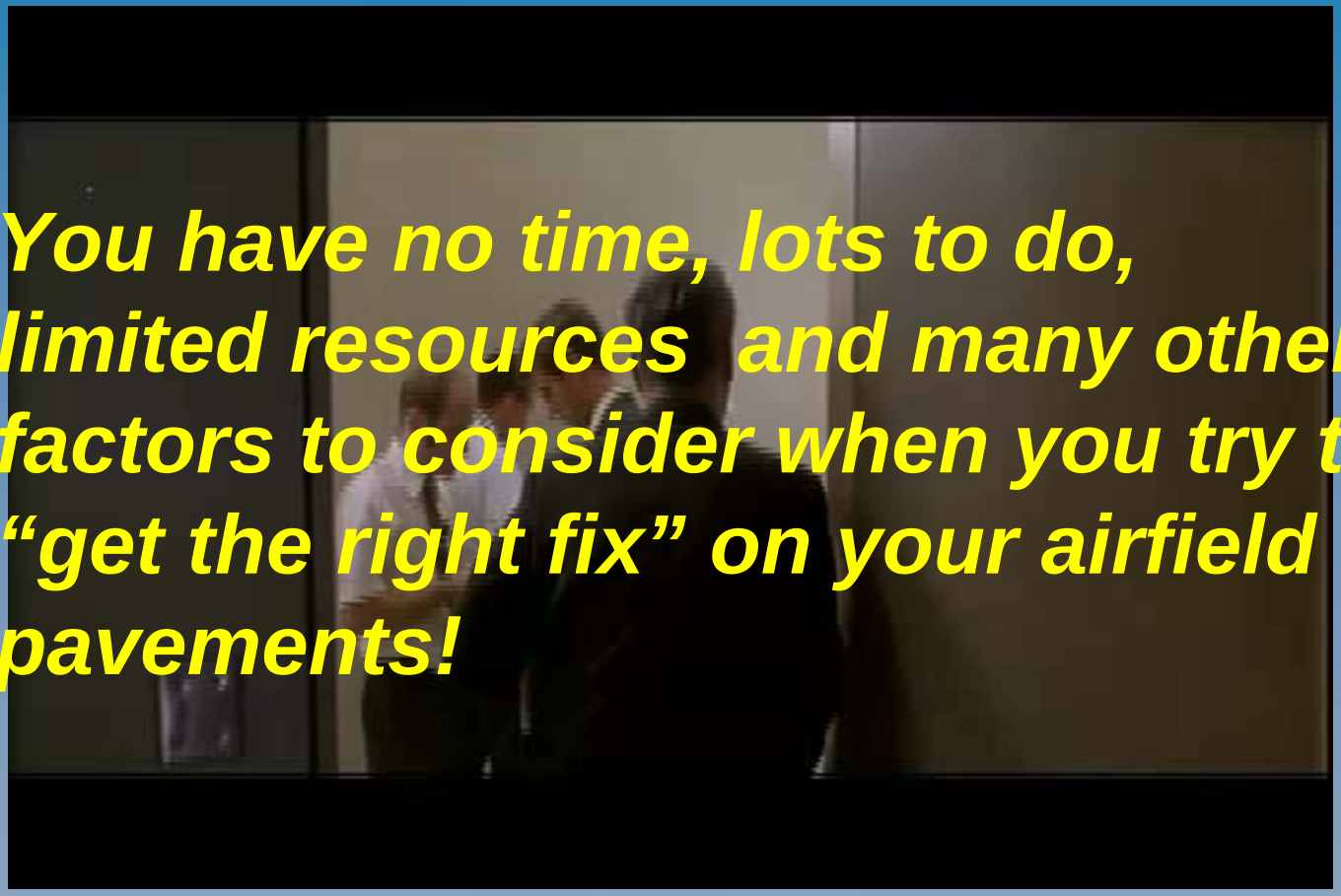
GOAL: TO ALLOW YOU TO MAKE MORE INFORMED or "BETTER" AIRFIELD PAVEMENT INVESTMENT DECISIONS

Making CORRECT pavement investment decisions is important (why?)

- **Airfield Pavement Assets comprise well over 50% of the total assets managed by your Management Team**
- **The cost of airfield deterioration is likely the most expensive "off the books" annual operations expense.**
- **Operational Impacts of airfield project implementation is a major consideration when planning projects.**
- **Many Canadian airports have airfield pavements that have surpassed their service life.**
- **Northern climatic influences and short construction season cause increased rates of deterioration**

The issue…strategy development is very challenging because

Because, like those Apollo 13 engineers…



You have no time, lots to do, limited resources and many other factors to consider when you try to "get the right fix" on your airfield pavements!

Presentation Overview

- Why Pavements Deteriorate (AC)
- What steps comprise a “sound” rehabilitation strategy development process
- Review of Pavement Deterioration Causal Factors
- Examine strategy versus distress type and causal factor
- Look at some examples
  - YYC – Charlottetown Airport
  - YQM – Moncton International Airport

What are the Causes of Deterioration?

The Environment (Temperature & Water)

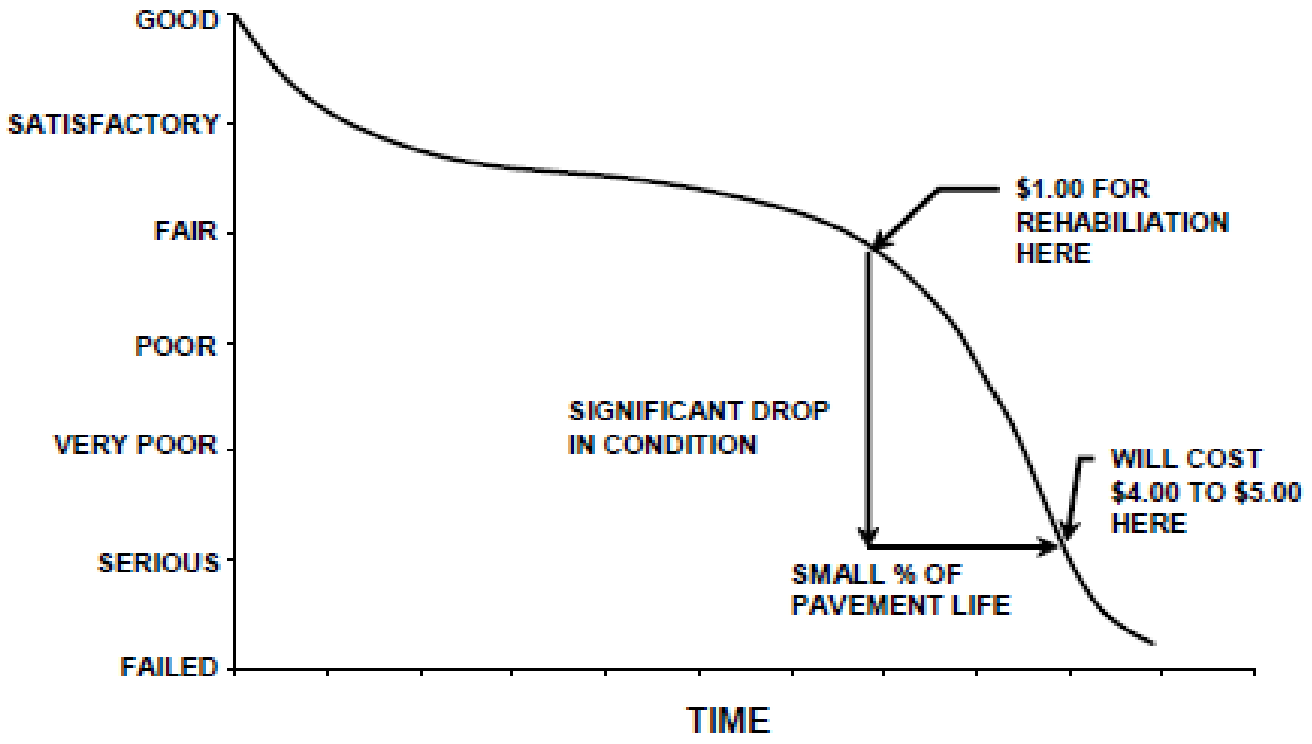
Simple?

Structural Loading (Weight & Frequency)

Not Really…


Sub-Grade Soils
Pavement Structure
Landings Takeoffs
Aircraft Fleet
Pavement Deterioration
Drainage
Materials
Construction Quality
Freeze Thaws
Cross Section

Many Factors result in the shape of the deterioration curve!



Key is the right fix, at the right time!

The Challenge

- Getting a good understanding of the "complete" pavement condition,

and

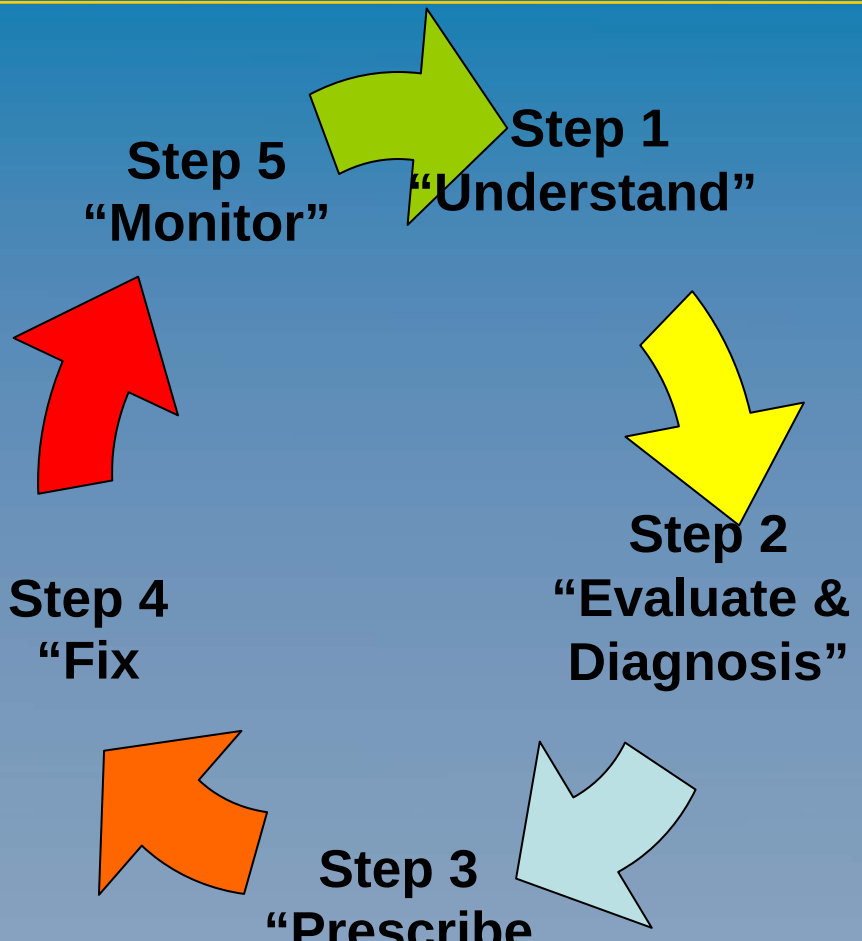
- knowing the primary and secondary causes of the deterioration exhibited.

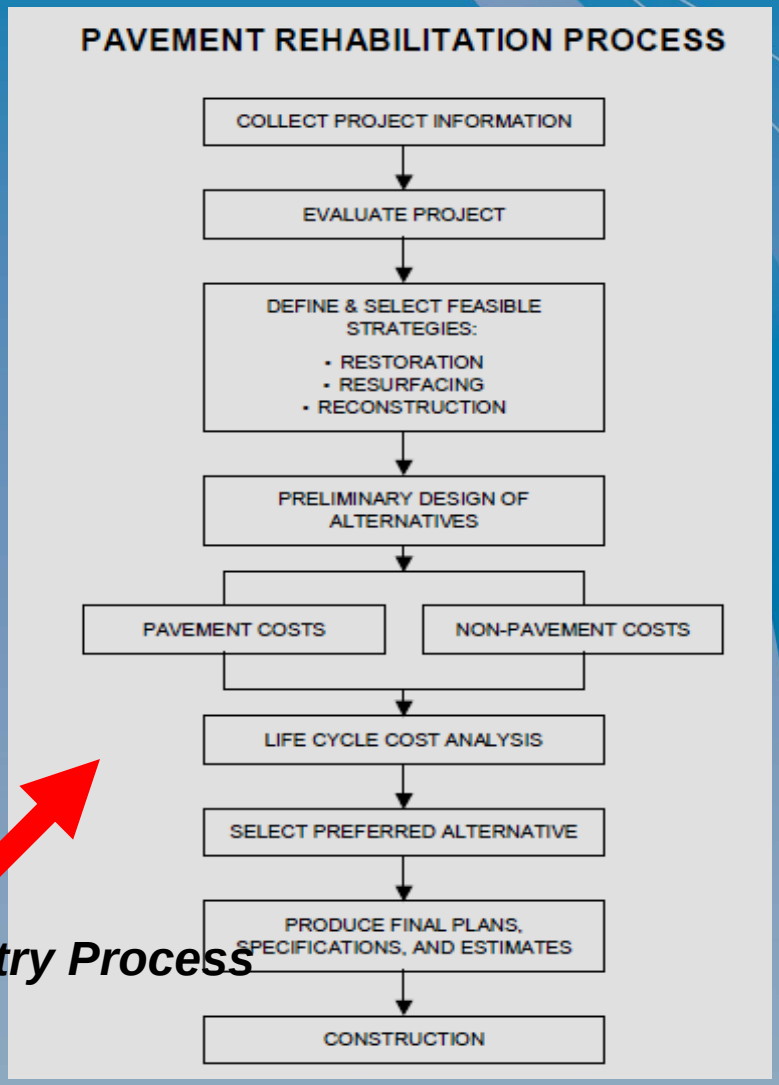
So, you can

- pick the best fix for YOUR situation!

How do you do it?

The Strategy Development Process

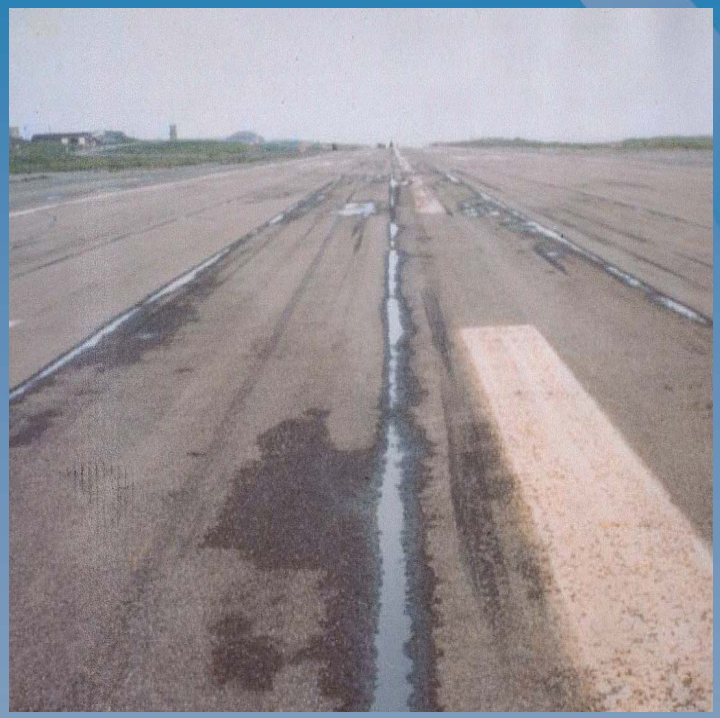




Industry Process

Step 1: Understand your Pavement's Condition

- Past Construction History
- Pavement Condition Surveys
- Detailed Pavement Assessments
  - Functional
  - Structural



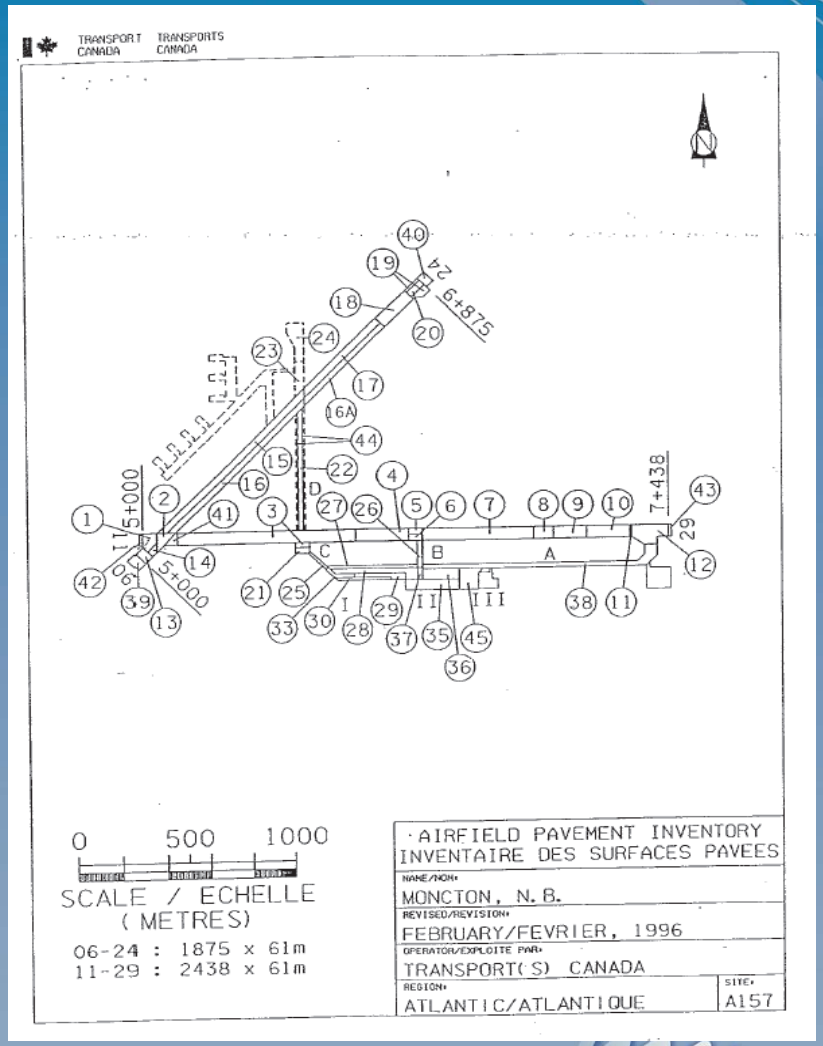
Step 1: Understand Pavement Condition

➢ Past Construction History

Page: 1 — TRANSPORT CANADA - AIRFIELD PAVEMENT CONSTRUCTION HISTORY — Printed: 24/05/1996

Airport: MONCTON (NAS) — Region: ATLANTIC — Revised: 26/02/1996

FACILITY DIMENSIONS					CONSTRUCTION HISTORY						PAVEMENT STRENGTH	
Pavement Facility	Plan Code	Chainage (m)	Width (m)	Area (m² x 1000)	Layer Thickness (cm) PCC	AC	B	SB	Contract Number	Year Built	Strength Code	Code PLR Field PLR
RUNWAY 06-24	13	5000 5061	61	3.72		8.9 17.8 10.2 -5.0 5.0	30.5	38.1	58450 QH-1309 QH-2959 * QH-2959 *	1958 1961 1975 1988 1988	S75t142	11 9
Note: * 45 m of centerline milled 5.0 cm deep and replaced.												
RUNWAY 06-24	14	5061 5122	15.2R	0.93		8.9 10.2 -5.0 5.0	30.5	38.1	58450 QH-1309 QH-2959 * QH-2959 *	1957 1975 1988 1988	S53t107	9 9
Note: * 5.0 cm cold milled and replaced. Outside 8.0 m edge not refurbished - 1975 vintage.												
RUNWAY 06-24	15	5168 6140	45.7L	44.42		5.1 8.9 10.2 -5.0 5.0	15.2 10.2 30.5		30881 31929 58450 QH-855 QH-2959 * QH-2959 *	1939 1940 1957 1970 1988 1988	S51t104	9 9
Note: * 38 m cold milled and replaced. Outer 8.0 m edge not refurbished - 1970 vintage.												
RUNWAY 06-24	16	5168 6140	15.2R	14.77		8.9 10.2 -5.0 5.0	30.5	38.1	58450 QH-855 QH-2959 * QH-2959 *	1957 1970 1988 1988	S53t107	9 9
Note: * 7.2 m cold milled and replaced. Outer 8.0 m edge not refurbished - 1970 vintage.												
RUNWAY 06-24	16A	6140 6595	15.2R	6.92		8.9 10.2 -5.0 5.0	30.5	38.1	58450 QH-855 QH-2959 * QH-2959 *	1957 1970 1988 1988	S53t107	9 9
Note: * 7.2 m cold milled and replaced. Outer 8.0 m edge not refurbished - 1970 vintage.												
RUNWAY 06-24	17	6140 6595	45.7L	20.79		5.1 8.9 10.2 -5.0 5.0	10.2 30.5	25.4	33668 58450 QH-855 QH-2959 * QH-2959 *	1942 1957 1970 1988 1988	S51t115	9 9
Note: * 38 m cold milled and replaced. Outer 8.0 m edge not refurbished - 1970 vintage.												



Step 1: Understand Pavement Condition

- Pavement Condition Survey as ERD-121 TC Airport Pavement Structural Condition Surveys
  - Longitudinal And Transverse Cracks
  - Alligator Cracks, Map Cracking
  - Block Cracking
  - Raveling, Rutting
  - Bleedings, Distortion
  - Edge Cracking, Tearing

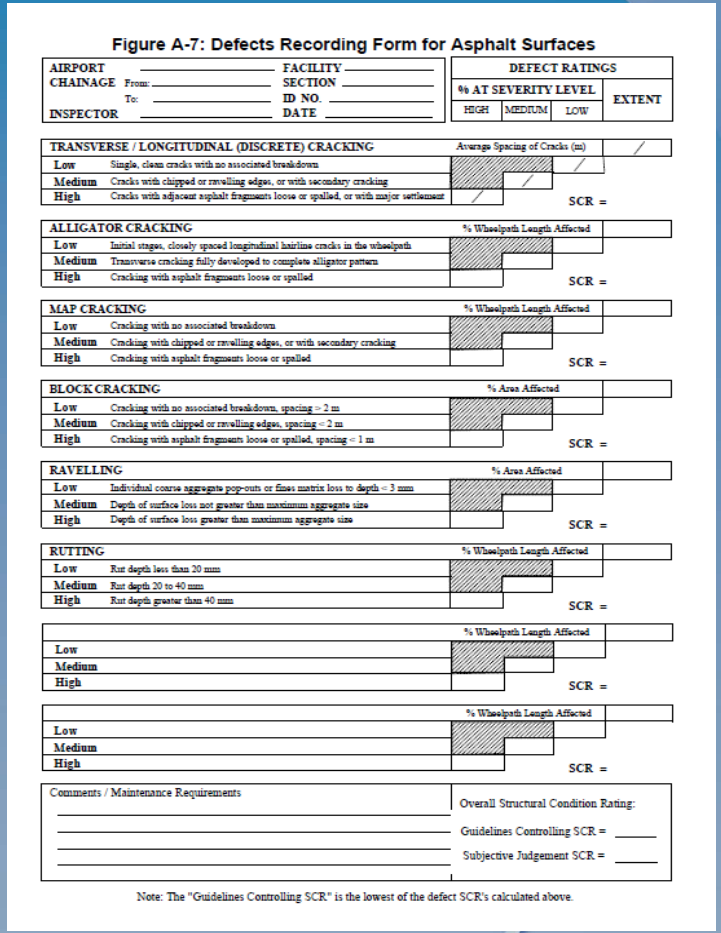


Figure A-7: Defects Recording Form for Asphalt Surfaces

AIRPORT		FACILITY	
CHAINAGE	From:	SECTION	
	To:	ID NO.	
INSPECTOR		DATE	

DEFECT RATINGS			
% AT SEVERITY LEVEL			EXTENT
HIGH	MEDIUM	LOW	

TRANSVERSE / LONGITUDINAL (DISCRETE) CRACKING		Average Spacing of Cracks (m)			
Low	Single, clean cracks with no associated breakdown				
Medium	Cracks with chipped or ravelling edges, or with secondary cracking				
High	Cracks with adjacent asphalt fragments loose or spalled, or with major settlement				SCR =

ALLIGATOR CRACKING		% Wheelpath Length Affected			
Low	Initial stages, closely spaced longitudinal hairline cracks in the wheelpath				
Medium	Transverse cracking fully developed to complete alligator pattern				
High	Cracking with asphalt fragments loose or spalled				SCR =

MAP CRACKING		% Wheelpath Length Affected			
Low	Cracking with no associated breakdown				
Medium	Cracking with chipped or ravelling edges, or with secondary cracking				
High	Cracking with asphalt fragments loose or spalled				SCR =

BLOCK CRACKING		% Area Affected			
Low	Cracking with no associated breakdown, spacing > 2 m				
Medium	Cracking with chipped or ravelling edges, spacing < 2 m				
High	Cracking with asphalt fragments loose or spalled, spacing < 1 m				SCR =

RAVELLING		% Area Affected			
Low	Individual coarse aggregate pop-outs or fines matrix loss to depth < 3 mm				
Medium	Depth of surface loss not greater than maximum aggregate size				
High	Depth of surface loss greater than maximum aggregate size				SCR =

RUTTING		% Wheelpath Length Affected			
Low	Rut depth less than 20 mm				
Medium	Rut depth 20 to 40 mm				
High	Rut depth greater than 40 mm				SCR =

	% Wheelpath Length Affected			
Low				
Medium				
High				SCR =

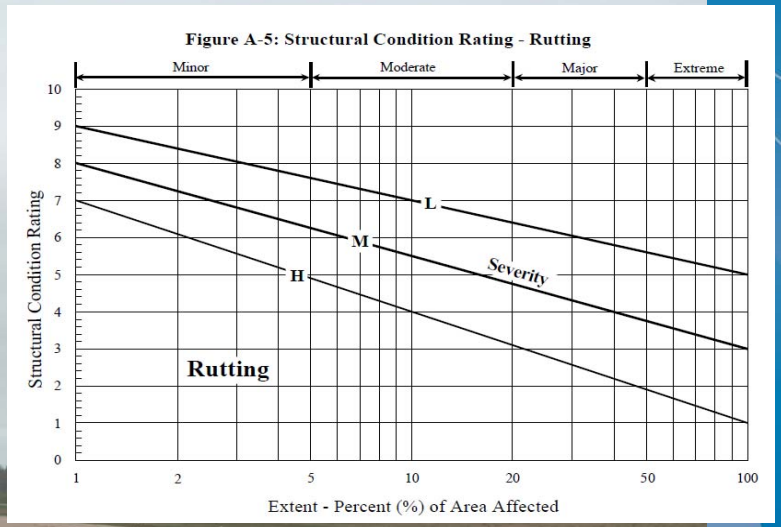
	% Wheelpath Length Affected			
Low				
Medium				
High				SCR =

Comments / Maintenance Requirements	Overall Structural Condition Rating:
	Guidelines Controlling SCR = _____
	Subjective Judgement SCR = _____

Note: The "Guidelines Controlling SCR" is the lowest of the defect SCR's calculated above.

Step 1: Understand Pavement Condition

- All distresses colleted and combined "Distress Signature"
- SCR – Structural Condition Rating assigned based on the lowest value of rating for an individual distress.



My CONCERNS!

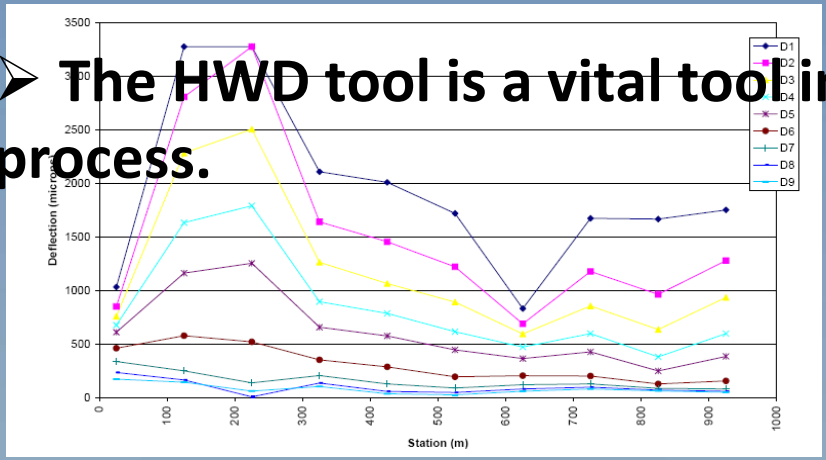
Does SCR provide enough detail to develop a rehabilitation strategy?

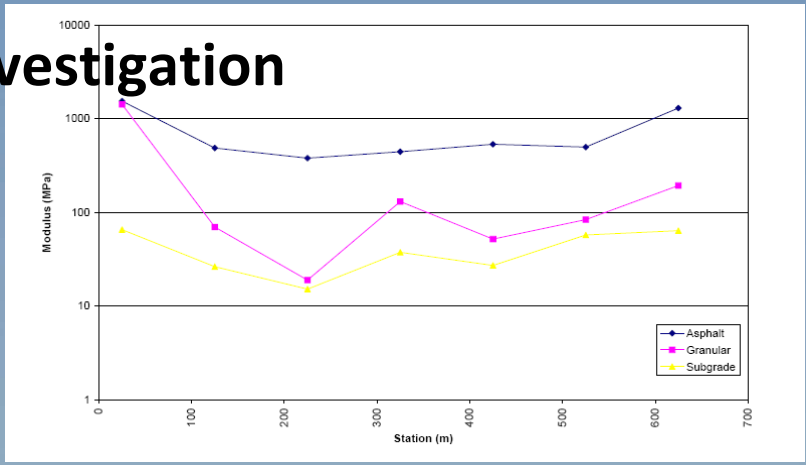
With your SCR, do you clearly understand the deterioration causal factors?

What project level investigation should be initiated?

Good Pavement Engineers…
"Know what they don't know"!

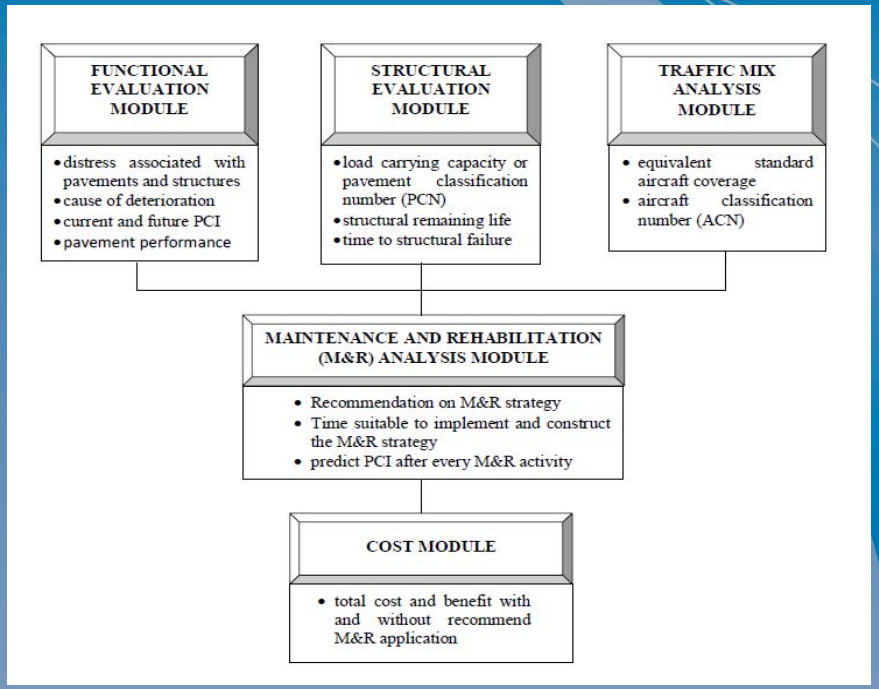
- **Surface condition indexes provide a good "overall" measure for network level planning**
- **The distress signature (or individual scores. when compared) provide a valuable understanding of the causal factors.**
- **It is very difficult to confirm need for structural investment with out detailed pavement evaluation**
- **The HWD tool is a vital tool in the investigation process.**





Step 2: Diagnosis of the Problem

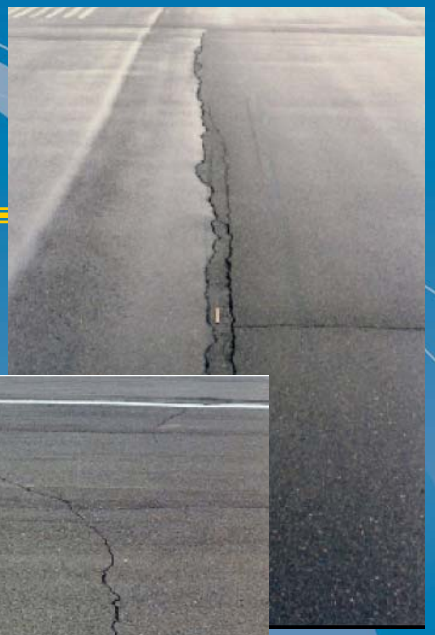
- Successful pavement rehabilitation strategies must go beyond the "surface view" from pavement distress ratings
- Expert System for pavement strategy development
- The strategy must address the causal factors and not just the symptoms..



BUT…What are the causal factors? Environment, Materials, Construction, Sub-soils, Drainage, Loadings

Diagnosis: Cracking

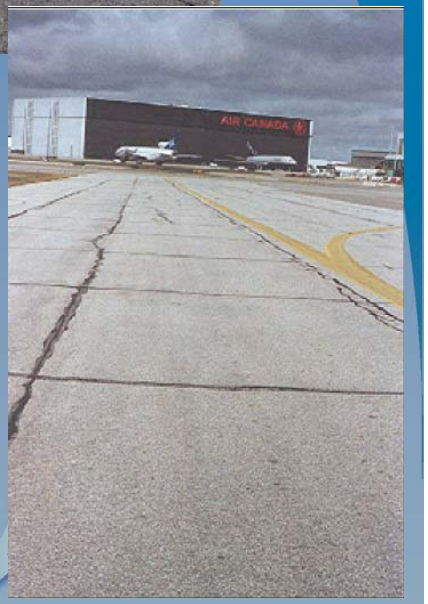
Longitudinal, Transverse and Edge Cracks



Description: **Longitudinal and transverse cracks are generally isolated failures that run along joints or transverse across the pavement structure.**

Causal Factors:

- ✓**Temperature & Drainage**
- ✓**Mix Composition**
- ✓**Reflection of underlying layers**
- ✓**Poor Construction**
- ✓**Weak shoulder support**



Experience: ***The majority of longitudinal cracks are thermal/age failures on poorly constructed joints and are construction related. Transverse cracks are generally thermal & moisture related, reflective, or a result of poor mix design.***

Diagnosis Structural Issues;

Alligator Cracks, Map Cracking & Block Cracking

Description: **Alligator cracks, map cracks and block cracking are generally located in areas of load transfer. Alligator cracks are specifically base related, while map and block cracks tend to be a progressive failure of other cracking types.**

Causal Factors:

- ✓**Loads vs. pavement structure**
- ✓**Drainage**
- ✓**Poor maintenance of isolated cracks**
- ✓**Poor Construction**

Experience: ***The majority of alligator type cracks are due to failure of the pavement structure to withstand the loads imposed on it. This weakness may be a result of a number of factors but typically it is base material related.***

Diagnosis: Surface Defects
Raveling

Description: **Aggregate loss and general disintegration of the asphalt surface.**

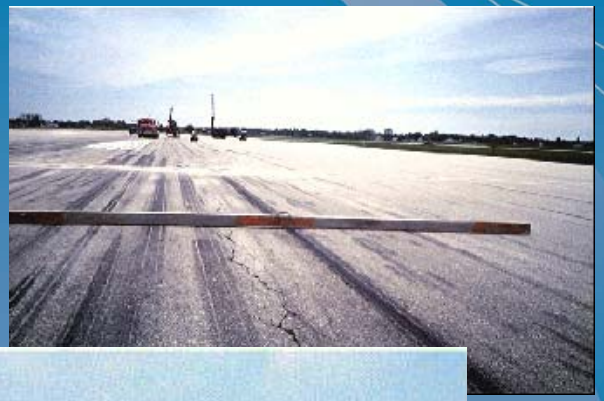
Causal Factors:

- ✓**Temperature (Freeze Thaw)**
- ✓**Poor Mix Composition (Low AC)**
- ✓**Poor Construction (Compaction)**
- ✓**Poor Construction (Temperature)**
- ✓**Poor Construction (Materials handling)**
- ✓**Age & Oxidation**

Experience: ***The majority of raveling failures are related to aged surface and/or poor construction quality. Late season asphalting or low compaction results due to poor workmanship (timing, temperature, segregation) during placement.***

Diagnosis: Surface Deformation
Rutting, Shoving & Distortion

Description: **Rutting and Shoving are "deformation" type failures. They are characterized by wheel path (high load area) failure. Many times this is base failure but in others it is AC mat movement. Shoving occurs in areas of excessive lateral movement or braking.**



Causal Factors:

- ✓**Temperature (high load – hot day)**
- ✓**Mix Composition**
- ✓**Poor Construction (compaction)**
- ✓**Poor Construction (layer bond)**
- ✓**Structure failure (Soon!)**

Experience: ***The majority of rutting and shoving is due to failure of the structure and AC mat. In some cases alligator cracking follows fast, but in others, the initial deformation forces problems of surface drainage and ride comfort.***

Diagnosis: Surface Defects
Bleeding

Description: **Bleeding is characterized as areas with liquid asphalt permeating to the surface of the mat. The mat will have a tacky or "wet" look as the excess asphalt coats the area. Typically found in wheel track areas.**

Causal Factors:

- ✓**Temperature**
- ✓**Mix Composition (AC Content)**
- ✓**Tack Coat from underlying areas**
- ✓**High traffic loads**

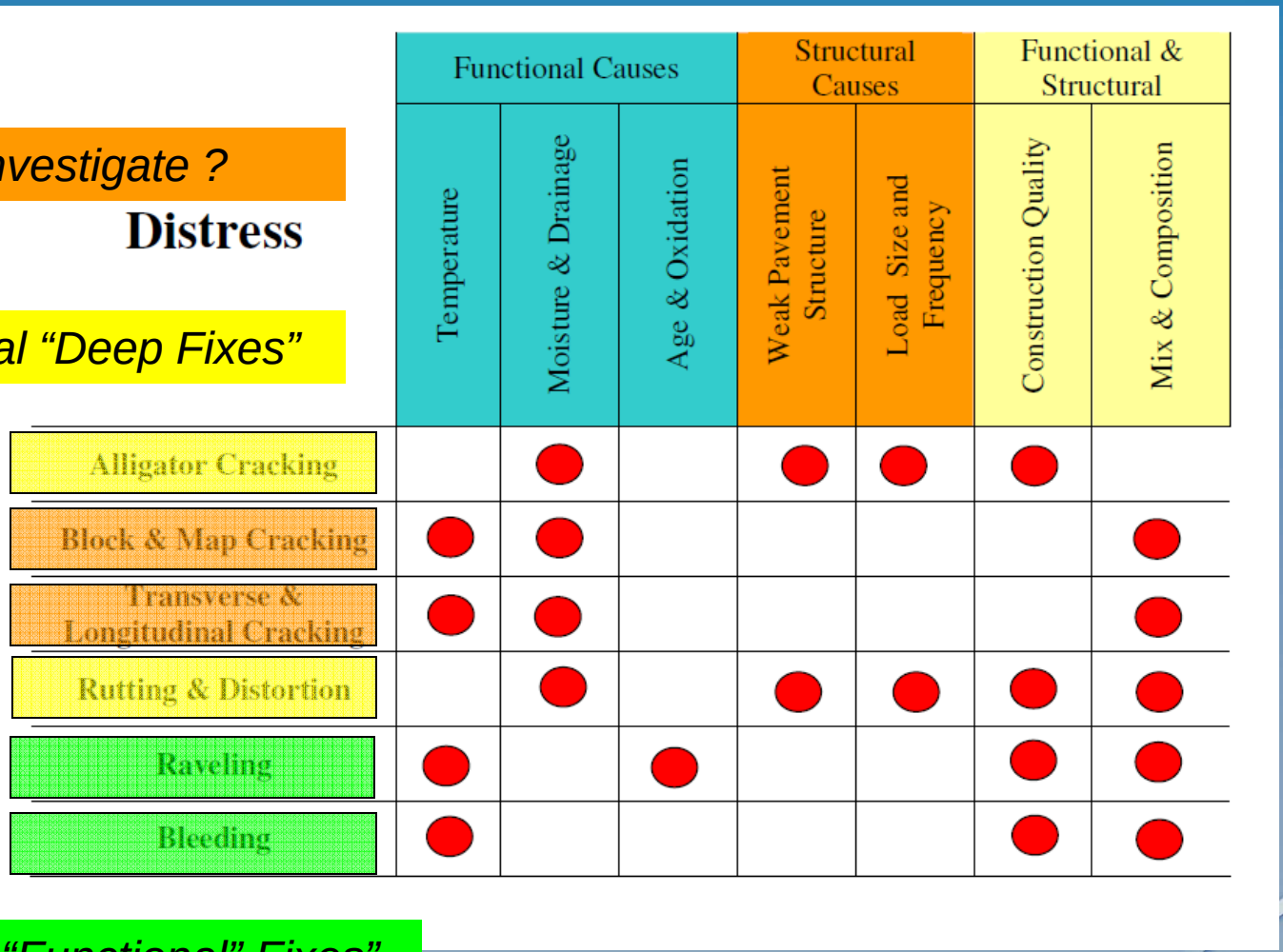
Experience: ***The majority of bleeding occurs in areas with poor mix composition. Excess asphalt under repeated wheel loadings makes its way to the surface causing functional and operational problems.***

Step 2: The Diagnosis: Understand your causal factors?

? Investigate ?

Structural "Deep Fixes"

Surface "Functional" Fixes"



Distress	Functional Causes: Temperature	Functional Causes: Moisture & Drainage	Functional Causes: Age & Oxidation	Structural Causes: Weak Pavement Structure	Structural Causes: Load Size and Frequency	Functional & Structural: Construction Quality	Functional & Structural: Mix & Composition
Alligator Cracking		●		●	●	●	
Block & Map Cracking	●	●					●
Transverse & Longitudinal Cracking	●	●					●
Rutting & Distortion		●		●	●	●	●
Raveling	●		●			●	●
Bleeding	●					●	●

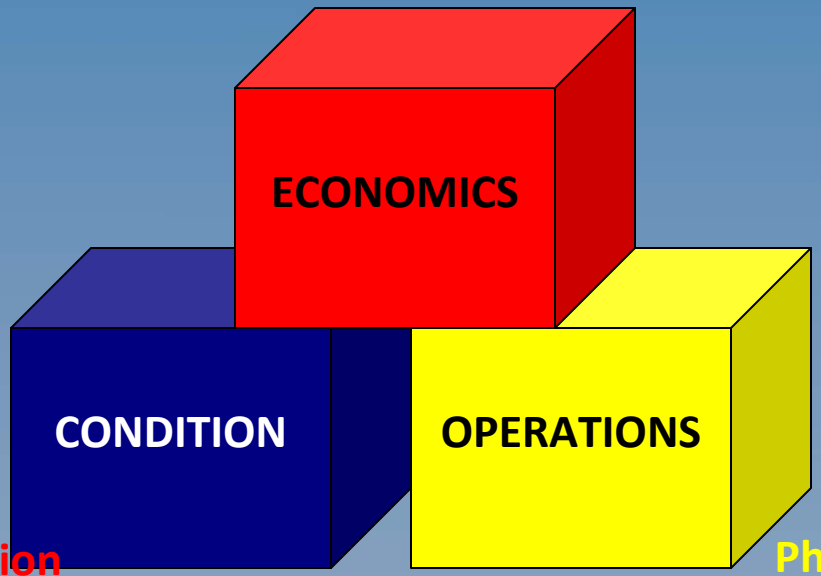
Step 3: Narrow down your alternatives

Distress	Surface Repairs				Partial Rehabilitations		Full Depth Reconstructions	
	Overlay	Partial Mill and Overlay	Centerline Mill & Repairs	Deep Crack Repairs	Full Asphalt Replacements	Asphalt Recycling or Pulverization & Reworking	Full Depth Reconstruction	Full Depth Pulverization and Reconstruction
Alligator Cracking				●			●	●
Block & Map Cracking		●	●	●	●	●		
Transverse & Longitudinal Cracking	●	●	●	●				
Rutting & Distortion		●	●		●	●	●	●
Raveling		●	●		●			
Bleeding		●	●		●			

Step 3: Develop or "Prescribe" your Fix

Consideration of all the influences is critical to the selection of the FINAL rehabilitation strategy

Economic Factors
Cost of Fix vs. Budget
Life Cycle Costs
Costs of partial or interim fixes

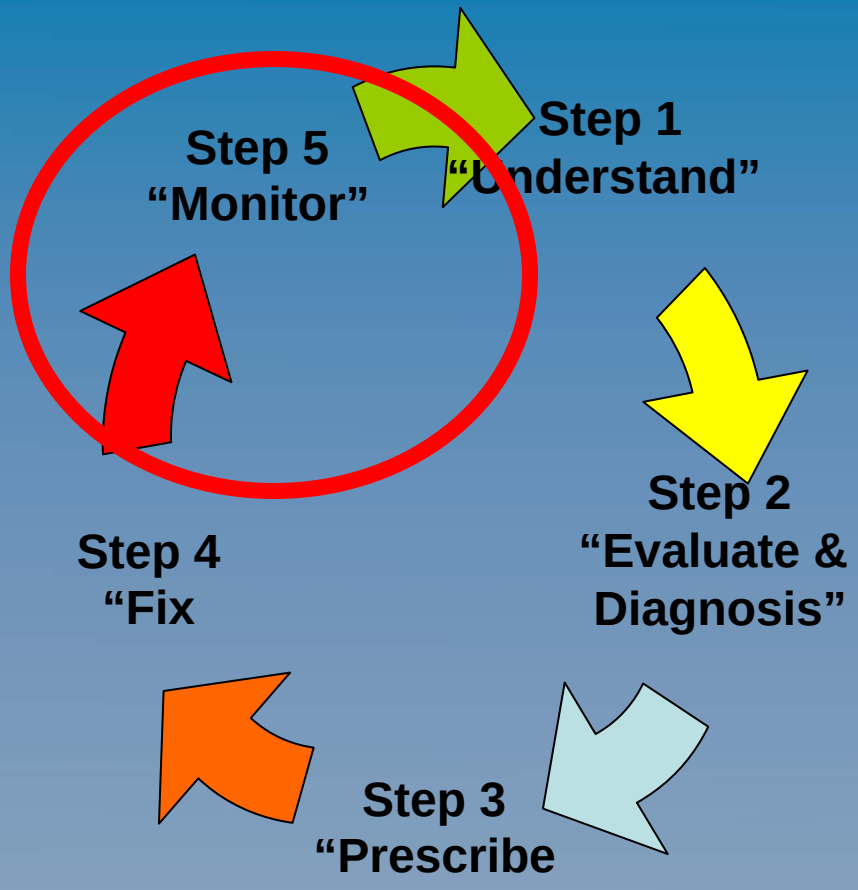


Pavement Condition
Distress Types
Distress Severity
Causal Factor
Potential Strategies

Operational Factors
Scope of Project
Timing of the Work
Phasing and Programming
Airport Masterplan

Step 4: Perform the Work

Step 5: Monitor your System



- Track the performance of the repair
- Monitor the deterioration of your system
- Track the system investment
- Invest in pavement management if possible

Summary: Keys to Effective Rehabilitation Strategy Development (Picking the right fix)

1. **Good pavement history (construction, investment, performance, condition curve)**
2. **Understand that distresses are not the key problem, they are a symptom.**
3. **Document the pavement failure causal factors to allow adjustment of QC Programs, Specifications or typical designs.**
4. **Build your tool kit of solutions. (resources, specifications)**
5. **Spend wisely to respect the pavement life cycle and the other investment influences**

Case Studies for:

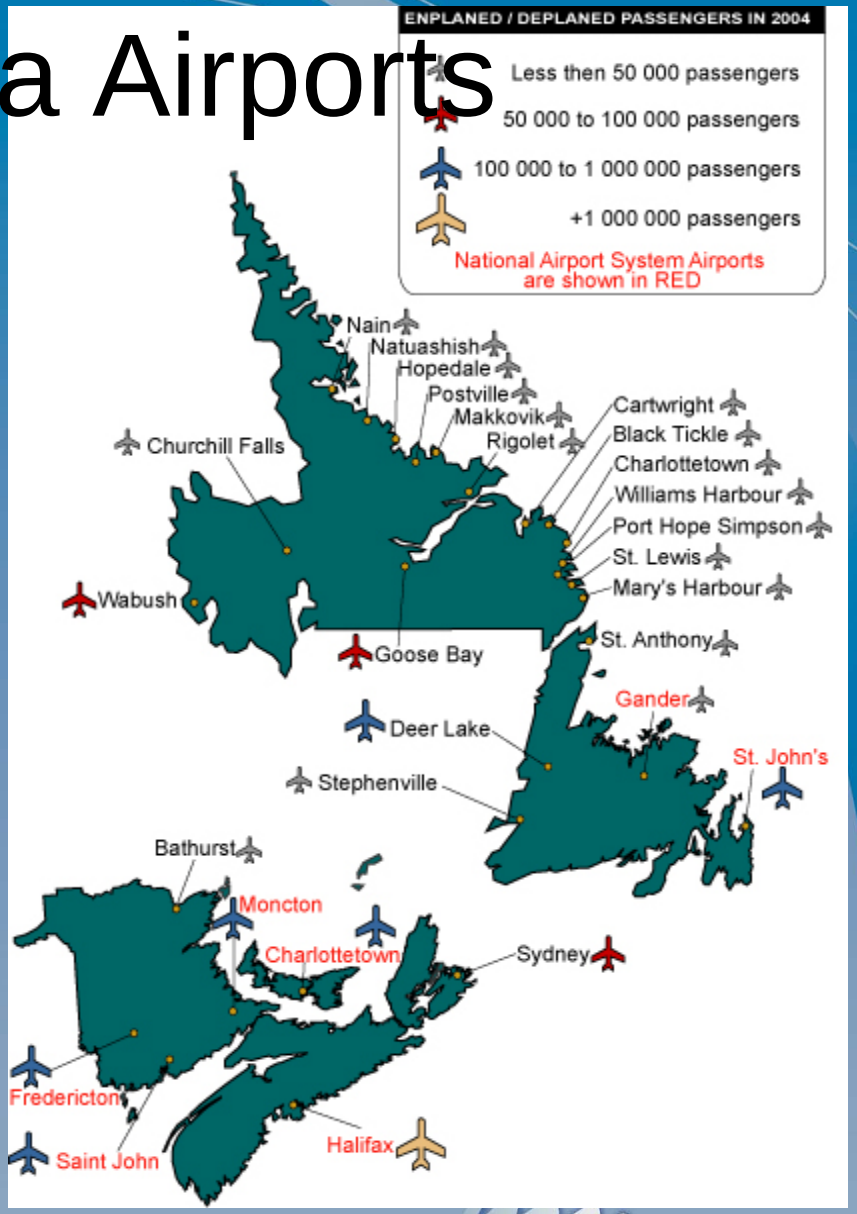
Effective Pavement Rehabilitation Strategy Development

- **Greater Moncton International Airport YQM**
  - **2010 Airfield Rehabilitation Program**
- **Charlottetown Airport YYC**
  - **2011 Runway 10-28 Rehabilitation**

Atlantic Canada Airports

Key Airports (Approx #'s)

- Halifax 5M
- St. John's 1.25M
- Moncton .65M
- Charlottetown .23M
- St. John .150M
- Fredericton, Sydney, Gander, Goose Bay, Deer lake <.15M



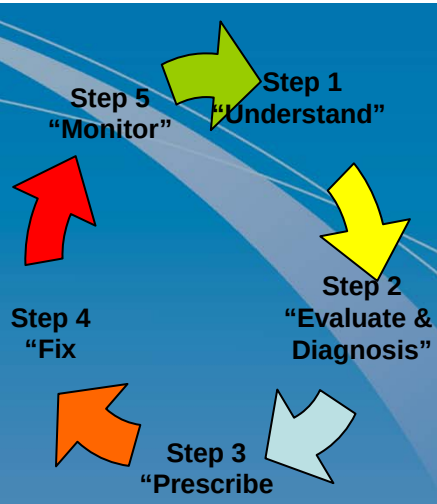
Charlottetown Airport

- YYC is located in Charlottetown PEI
- only airport on the Island with passenger service.
- The CAA took operation of the airport 10years ago.
- Apron 1 expansion
- overlay assignments on 03-21

- Recent Master planning has identified airfield rehabilitation as a priority for the airport.

- Hatch Mott MacDonald contracted to plan, design and manage the construction phase services for the 10-28 rehabilitation project.

Developing the Plan



- Runway 10-28 is the cross wind runway at YYC.
- 1524m x 60m (5000' x 200') Code 3E ?
- Past study stated $7M mill & overlay Runway
- 10-28 edge lighting is in fair to poor condition
- The length of 5,000' not adequate to accommodate commercial operations
- Used by lighter and smaller general aviation aircraft.
- Airport concerned about investment

Rehabilitation Strategy Development
Charlottetown Airport

- **Operational Costs an issue Winter and Summer**
- **Runway 03-21 accommodated 80% of all runway operations**
- **Runway 10-28 (20% of all traffic) but mainly GA activities.**
- **Surface Distress Assessment (ERD-121)**
  - **The section west of Runway 03-21**
    - **low to medium severity transverse and longitudinal cracking**
    - **low to medium severity block cracking over 25 % of the surface**
    - **low severity ravel over 100% of the surface**
    - **asphalt patching completed in 1998 on longitudinal mat joint cracks**
    - **SCR = 4.5**
  - **The section east of Runway 03-21**
    - **Increased surface distress, with low to high severity transverse and longitudinal cracking**
    - **Low to medium severity block cracking over 75% of the surface**
    - **Low to high ravel over 100% of the surface**
    - **Minor vegetation growth in cracks, some pop-outs, ponding water on the asphalt along the edges of the runway**
    - **SCR = 4.0**

Rehabilitation Strategy Development
Charlottetown Airport

- **Runway 10-28 has excellent crown and experiences no drainage concerns.**
- **The edge drain system was recently sampled by video and revealed a system in excellent condition.**
- **The surface exhibits extensive longitudinal cracking along paving joints. These longitudinal cracks have an average width of 10mm.**

Rehabilitation Strategy Development
Charlottetown Airport

- **The transverse cracks are more pronounced on the north end of the runway and average 9 meter spacing with a coverage of 50% north of runway 03-21 and 25% coverage on the south end.**
- **The transverse cracks are severe and the average width is 15mm. Over 50% of the major cracking and transverse cracking occurs in the centre 30m width of the runway.**

Major Transverse Cracking!!

Summary of Findings

- **The runway is severely oxidized and has moderate ravelling with a 90 to 100% coverage.**
- **FOD is not present and much of the polished aggregate is due to sweeping as opposed to continuous loss.**
- **The 1997 Transport Canada condition assessment "mirrors" the 2009 assessment.**
- **It is suspect that the ravelling of 100% of the surface occurred in the first 10 years of the runway.**
- **Overall, the runway has deteriorated from thermal loading (environmental).**
- **It shows no signs of distortion, rutting, or any structural failure, except at the intersection of the two runways.**
- **The runway is in good structural shape, but the severity of the cracks is such that a standard overlay will not last. It is expected that if a standard overlay were attempted, reflective cracking would occur, in the first 3 years.**
- **Cracks are very severe and load transfer and base strength reduction impacts of water unknown.**

Need for In-depth Testing

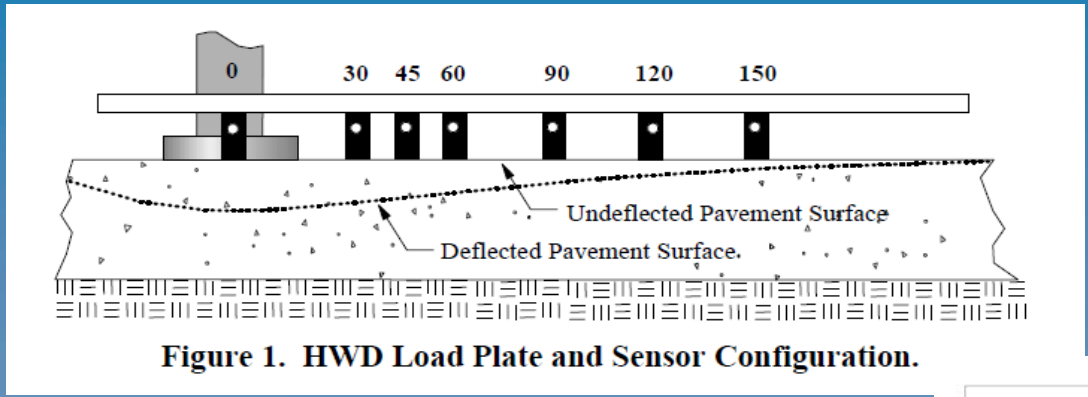
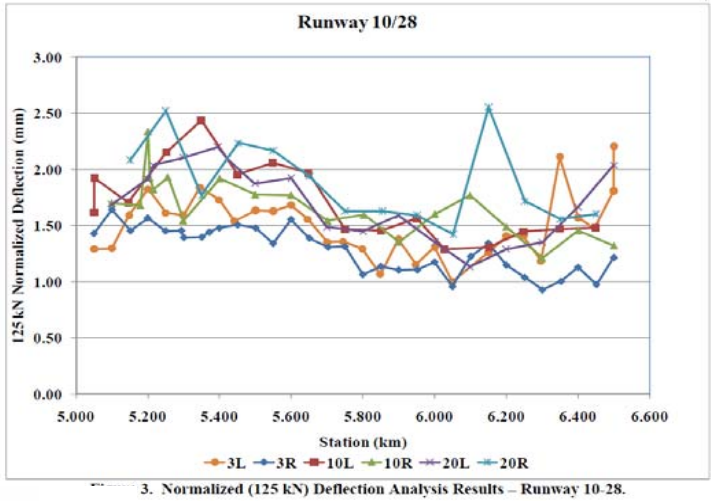


Figure 1. HWD Load Plate and Sensor Configuration.



3. Normalized (125 kN) Deflection Analysis Results – Runway 10-28.

APPLIED RESEARCH ASSOCIATES, INC.

Rehabilitation Plan Developed

- **Confirmed structural strength**
- **Weak load transition across the system**
- **All surface repairs, age and functional**
- **The strategy will involve;**
  - **Reduction of runway width and focus on the centre**
  - **Mill 30-50mm (to be determined) to a 45 meter width**
  - **Mill all deep cracks 300mm wide and pad with AC**
  - **Remove 30m width total 100 mm depth of AC (15 meters each side of centreline)**
  - **Pave 70mm of AC in the centre 30m strip**
  - **Pave 30-50 mm AC overlay 45 meters wide the entire length of runway.**
  - **Replace edge lights**
  - **Total Cost $5.5M (savings of $1.5M)**

Other Program Findings

- **HDW Tests done for whole airfield (economies)**
- **Confirmed long term role of 10-28**
- **1524m x 45 (5000’ x 150’) as a Code 3C**
- **Examination of potential to extend to 1829m x 45m (6000’ x 150’) as a 4D for Commercial traffic and more balanced usage of the airfield**

Project 2: Greater Moncton Airport

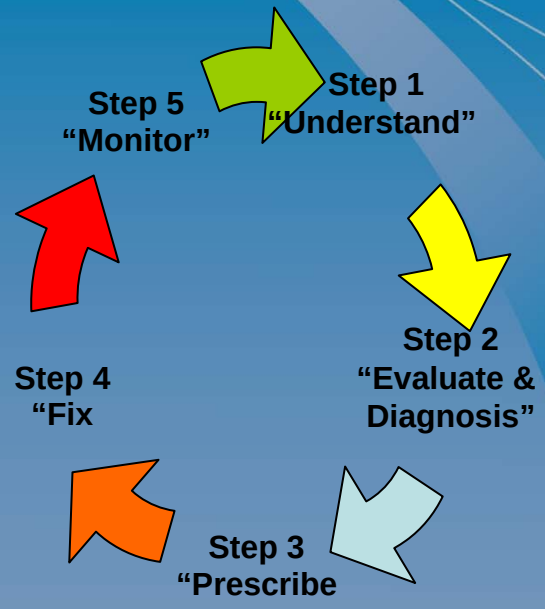
- YQM is located in southeastern New Brunswick.
- GMIAA took operation of the airport over 10years ago.
- Expansionary projects and 06-24 were addressed in that period.

- Extensive backlog of paving projects “on the books” and Board identified these as priorities in 2010-2012 program.
- Hatch Mott MacDonald contracted to plan, design and manage the construction phase services of the $20M program.

Greater Moncton International Airport

Overall Paving Program 2010-2012

Rehabilitation Strategy Development
Greater Moncton International Airport

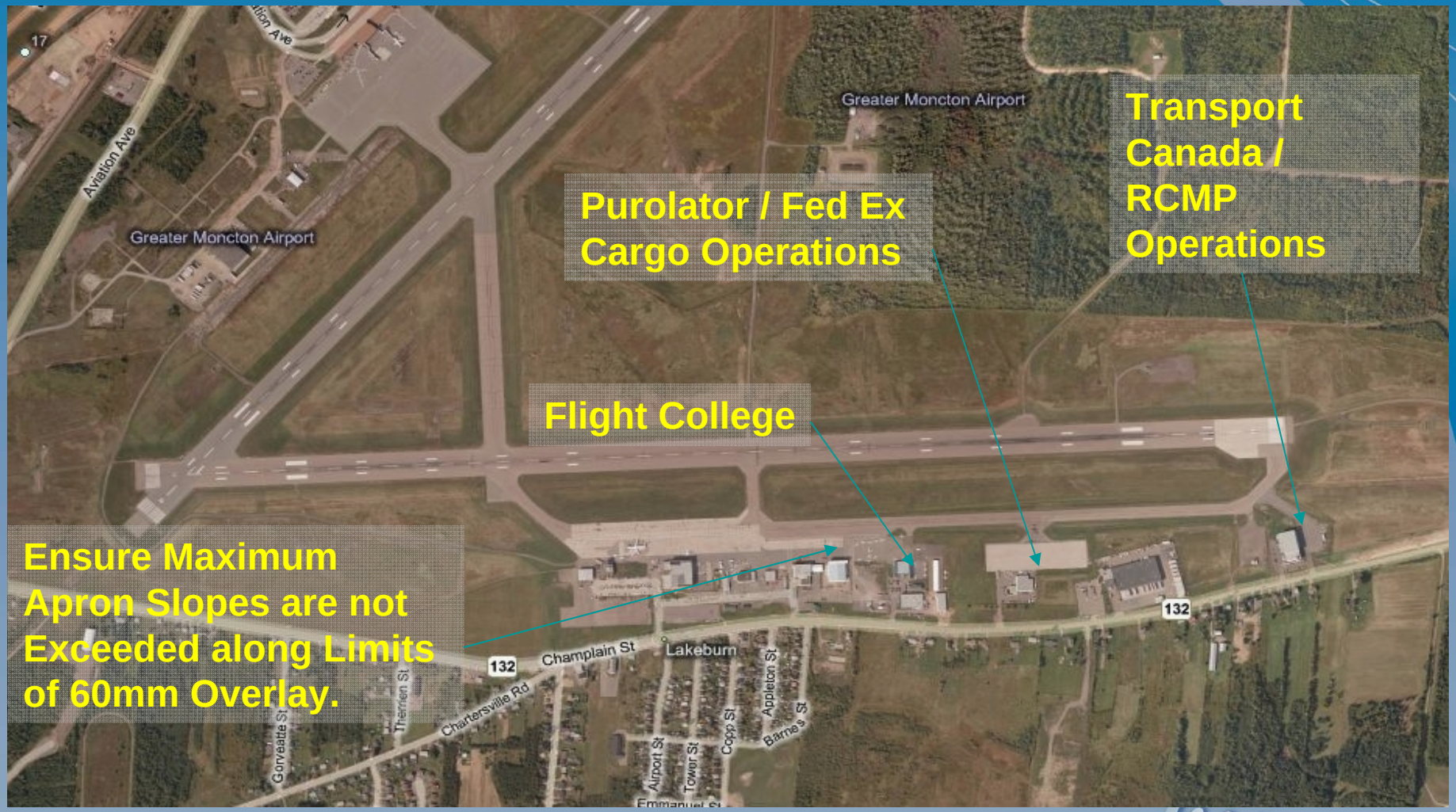


- Research of Past work
- Interview with Operations
- Field Investigation
- Geotechnical Program
- HWD Program
- Interview with Stakeholders

Key Challenges

- Limited Data on drainage systems
- Apron 1 and Taxi A black topped during life.
- Apron 1 having low PCN

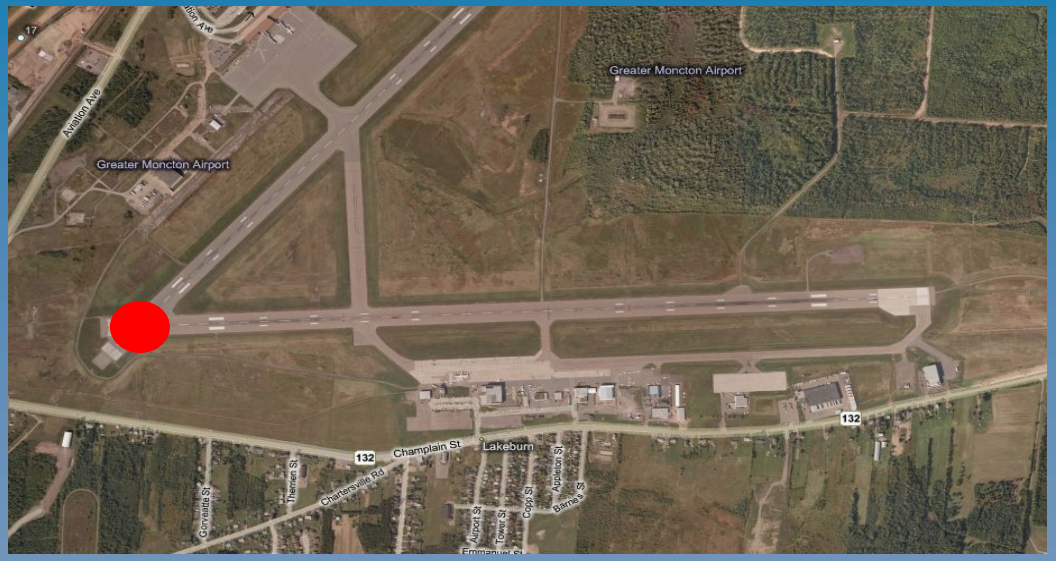
- Taxi A showing signs of map cracking and borderline alligator cracking
- Deep asphalts due to many overlays
- Six (6) intersections
- FedEx, Purolator, Transport Canada, Prince Edward Air, MFC all impacted


Greater Moncton Airport
Transport Canada / RCMP Operations
Purolator / Fed Ex Cargo Operations
Flight College
Ensure Maximum Apron Slopes are not Exceeded along Limits of 60mm Overlay.
Aviation Ave
Greater Moncton Airport
132
Champlain St
Lakeburn
Chartersville Rd
Goryeatte St
Therrien St
Airport St
Tower St
Coppi St
Appleton St
Barnes St
Emmanuel St

Need for Deeper Investigation

- **Visual Distress Survey of all Pavement Surfaces showing some surface defects.**
- **Deep asphalt, black top, poor drainage and some potential early structural defects identified.**
- **Need for Boreholes, Dynamic Cone Penetrometer**
- **Heavy Weight Deflectometer (HWD)**

Runway Intersection



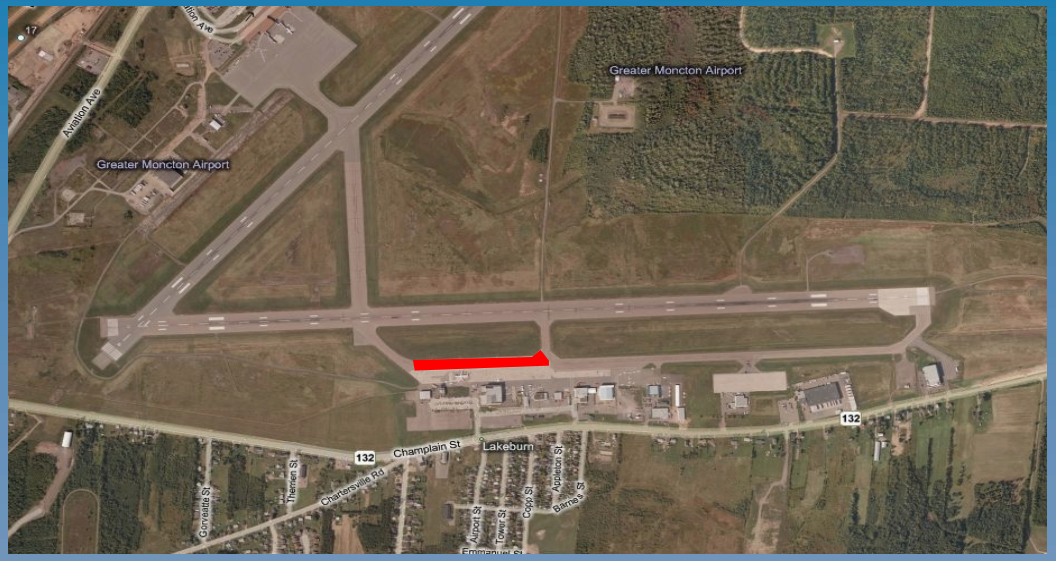
Intersection Runway 06-24 / 11-29

- **Exhibiting Numerous Surface Distresses**
- **Elastic Modulus of Asphalt is Low**
- **Structural Integrity was found to be acceptable using the HWD.**
- **Most Cracking is Not Associated with structural Failure.**

REHABILITATION OPTIONS:

Remove Existing Asphalt Full Depth and Repave in Order to Address the Soft Asphalt.

Apron 1 - Rehabilitation



Apron I

- 42 Year old Concrete Apron
- Already Undergone Extensive Repairs
- 75% of the Concrete Panels require Continual Maintenance.
- Structurally Sound

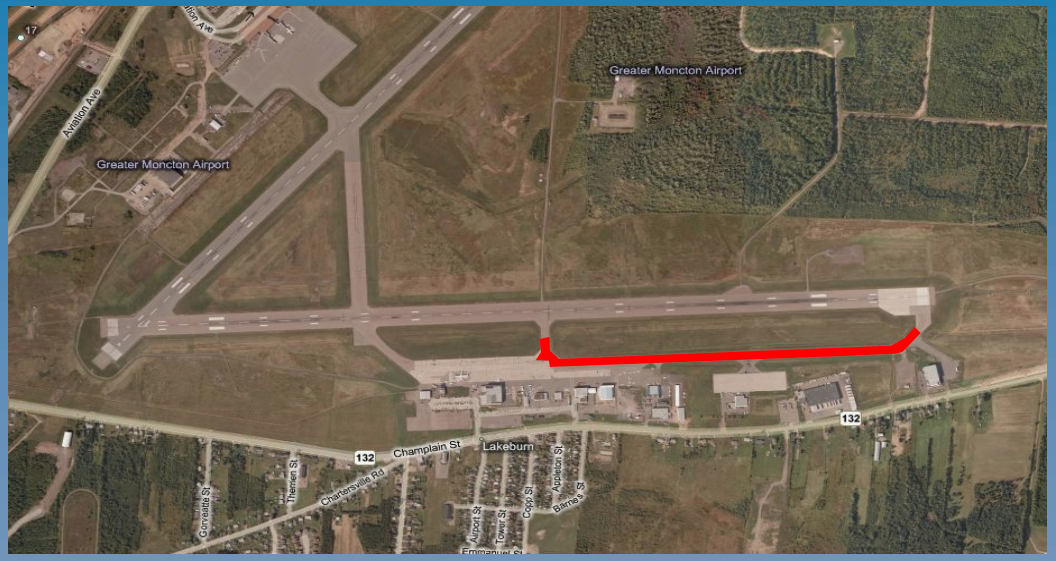
Several Options were Explored:

- Remove Top 50mm and place New Asphalt Surface.
- Remove Top 50mm, Place Crack Relief Layer, Place New Asphalt Surface.
- Rubblize Existing Concrete and Place New Asphalt Surface
- Remove Concrete and Place New Flexible Pavement Structure.

REHABILITATION OPTION:

Remove Existing Concrete and Place a New Asphalt Pavement Structure.

Taxi A



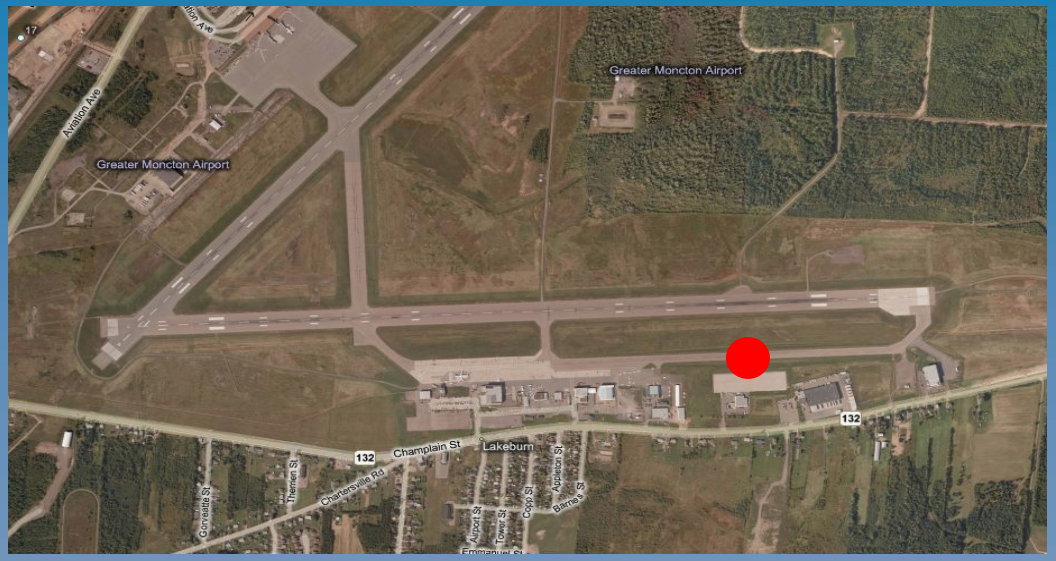
Taxi Alpha

- Last Resurfaced in 1991
- Significant Cracking in Wheelpaths
- Some Isolated Alligator Cracking
- Performed Well to Date
- HWD Analysis Indicates that the Pavement Requires Strengthening.

REHABILITATION OPTION:

1. Where Alligator Cracking is Present, Remove the 65mm of Asphalt and Repave.
2. Tack Coat and Place 60mm Asphalt Overlay over the Entire Surface.

Apron 5 Entrance



Apron V Entrance

- **Constructed in 1996**
- **Significant portion has been repaired since then.**
- **Moderate Alligator Cracking**
- **Some cracking at Construction Joints**
- **Distresses are indicative of Ongoing Structural Failure.**

REHABILITATION OPTION:

Reconstruction of the entire Pavement Structure.

Final Program

Total Cost for 2010 Construction Program $4.4M

Phase 5

- Full Reconstruction of Apron V Entrance
- Replace Edge Drains
- Reinstate Lighting
- Estimated Cost $0.4M

Project Success!

- Detailed pavement rehab planning process and good tender documents and strategy resulted in tenders at 15% below budget
- Contractor delivered the planned 16 wks of work in 7 weeks!
- Aggressive schedule and 24 hours of operation for;
  - 11-29 & 06-24 intersection
  - Cargo Apron
- No delays, excellent quality and well developed pavement strategy

A Final Note

- *Pavement rehabilitation strategy development involves a comprehensive process.*
- *Project investments are typically large and therefore the "right fix" is critical*
- *Surface distresses are symptoms, not the problems.*
- *Understand the problems!*
- *Know when you don't know!*
- *Great pavement rehabilitation programs address the fundamental causal factors and respect the operational and economic influences at the airport.*


Hatch Mott
MacDonald
Thank - You