SWIFT CONVENTION, CALGARY, SEPTEMBER 2010
FACTORS AFFECTING AIRCRAFT PERFORMANCE

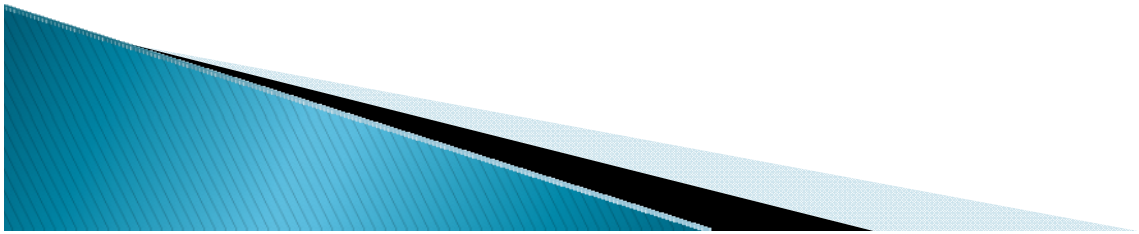
GORD DRYSDALE, PRESIDENT, CBR TECH

AIRFIELD OPERATOR'S GOAL

- Maximize the end user's benefit in a SAFE, ECONOMICAL and LEGAL manner
- SAFE (Compliance with Aircraft Certification Flight Manual)
- ECONOMICAL (Cost effective for both Airfield & Aircraft operators)
- LEGAL (Only consider if safe and economical)
  - AIRFIELD LICENSING AND EXEMPTIONS
  - DECLARE AVAILABLE FACILITIES
  - MINIMIZE LEGAL REDUCTIONS TO PERFORMANCE

LEVEL OF SAFETY (SINGLE-ENGINE TO AIRLINER)

- AIRLINE: Highest safety standards (2.5 accidents per million departures)
- 10 TO 19 PASSENGERS:
  - Scheduled – Comply with AIRLINE STANDARDS
  - On Demand (Charter) – comply with less than 10 passenger standards
- MULTI-ENGINE (Less than 10 passengers)
  - Limited engine failure and obstacle avoidance considerations
- SINGLE-ENGINE – Lowest safety standards
- ADVISE THE COMMUNITY OF POTENTIAL SAFETY STANDARDS POSSIBLE WITH AIRFIELD FACILITIES PROVIDED



REMOTE SITE CONSIDERATIONS

- Level of safety
- Runway facilities tailored to economical aircraft size
- 3,500-foot runway only accommodate single-engine and 35-passenger (Dash 8 100) aircraft
  - Twin Otter 300 may qualify
- B 1900 requires 4,500 to 5,000-foot gravel runway
- When paving is not economical
  - Gravel penalties apply

LARGE AIRCRAFT CERTIFICATION

- Airliner aircraft certification ensures engine-failure safety during all phases of flight:
- Aircraft weights are reduced on gravel surfaces to ensure safety speed can be attained on the runway length available
- Critical engine fail at safety speed
  - Accelerate-stop on runway (+ stopway)
  - And continue:
    - Attain 35-foot altitude at end of runway (+ clearway)
    - 1ST SEGMENT CLIMB (obstacles a major consideration)
    - 2ND SEGMENT CLIMB (obstacles a major consideration)
    - Clean-up phase
      - ENROUTE OBSTACLE CLIMB

GRAVEL RUNWAY CRITERIA

- Gravel surfaces increase rolling friction
  - Minimum firmness criteria is specified by Aircraft Certification
  - Canadian certification specifies Boeing's CBR Methodology
    - Testing included DC3, DC4, DC6, HS748, F27, Twin Commander, Convair, Herc, B727, B737 aircraft types
    - Over 40 years of flawless safety record for all of western world's heaviest commercial aircraft types certified on gravel surfaces that satisfied Boeing's specifications
    - Boeing's equipment can be carried as checked baggage on commercial airlines.

Boeing Methodology for Canadian Aircraft Certification

Gord

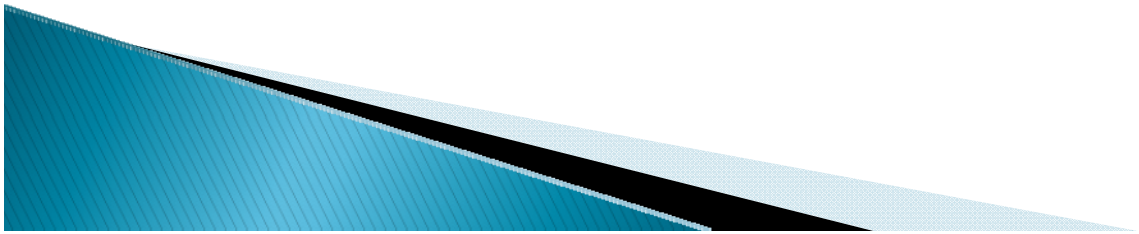
Further to our discussion today I am confirming that from an Aircraft Certification standpoint within Canada the only gravel runway strength measurement we now recognize is the Boeing Penetrometer method. All manufacturers to date have been asked to either provide connversions from whatever measurement method they have implemented or test on runways using the Boeing method.

Regards

…

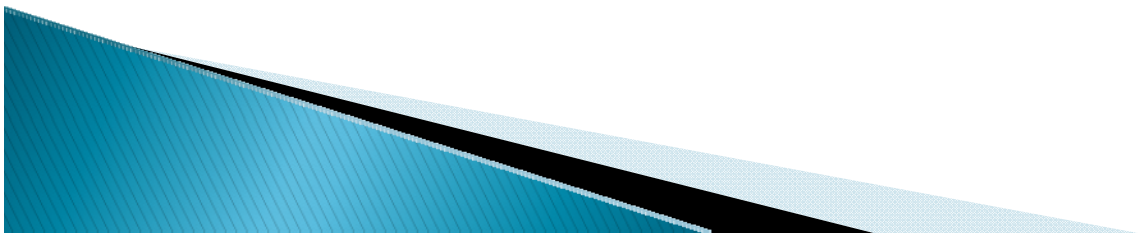
AIRCRAFT PERFORMANCE (MAXIMUM WEIGHTS)

- DETERMINED BY AIRFIELD FACILITIES
- RUNWAY CHARACTERISTRICS
  - LENGTH
  - SLOPE
  - LINE-UP ALLOWANCE
  - CLEARWAY
  - STOPWAY
- GRAVEL RUNWAY FIRMNESS
  - Minimum firmness criteria, expressed as a CBR Rating, is specified for gravel runway operations. Gravel surfaces are less firm, which will increase rolling friction. Inadequate firmness will result in aircraft power moving soils instead of accelerating the aircraft to safety speed in the available runway length.
- DEPARTURE OBSTACLES



AIRFIELD SPECIFICATIONS

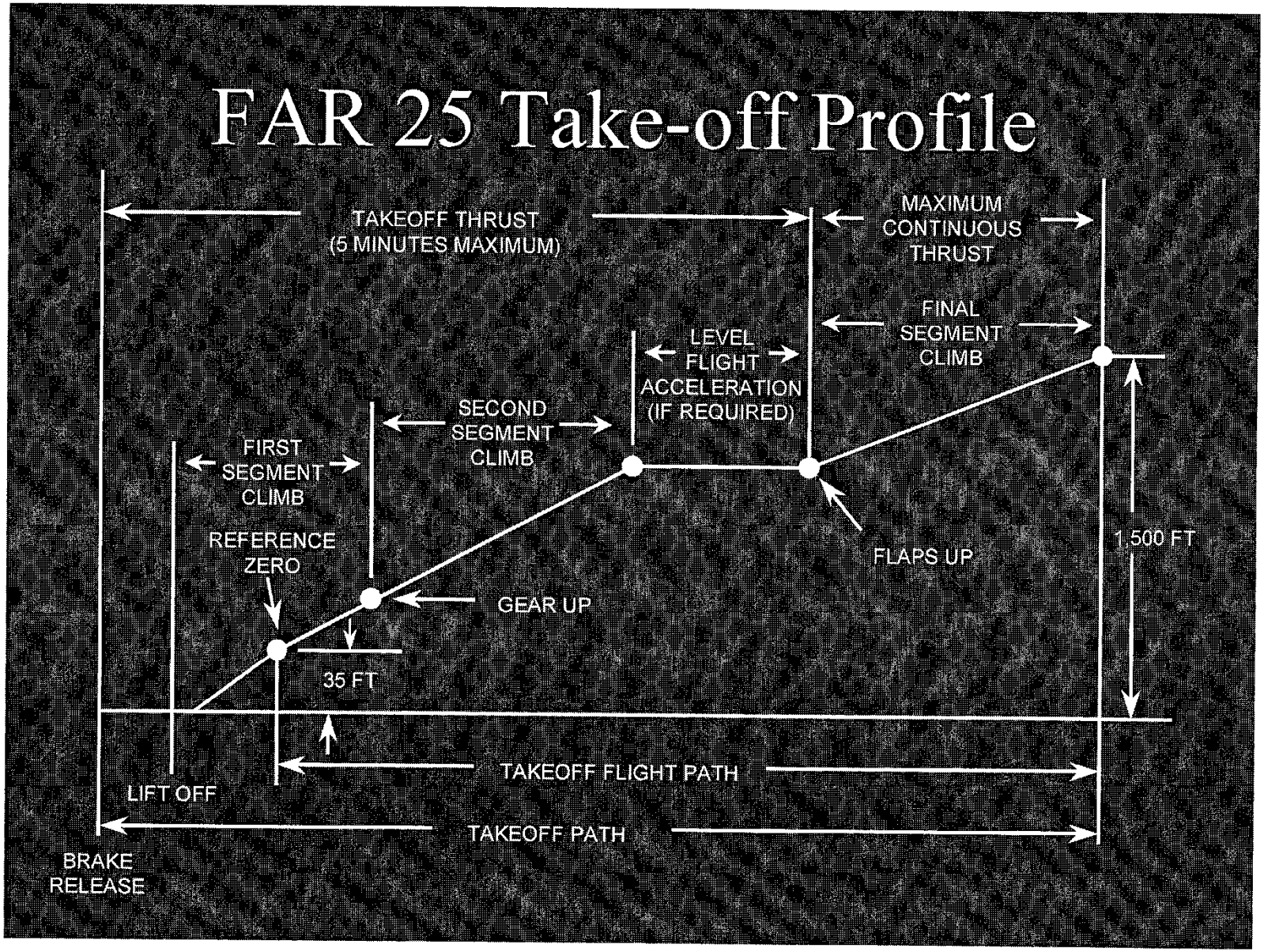
- AIRCRAFT PERFORMANCE DEPENDS ON:
- RUNWAY DATA:
  - Length (Clearways &/or Stopways)
  - Line-up criteria
  - Slope (net slope – end to end)
  - Surface firmness (rolling friction)
    - CBR, PCN, & PLR
- Departure obstacles:
  - Distance from runway end
  - Elevation above runway end



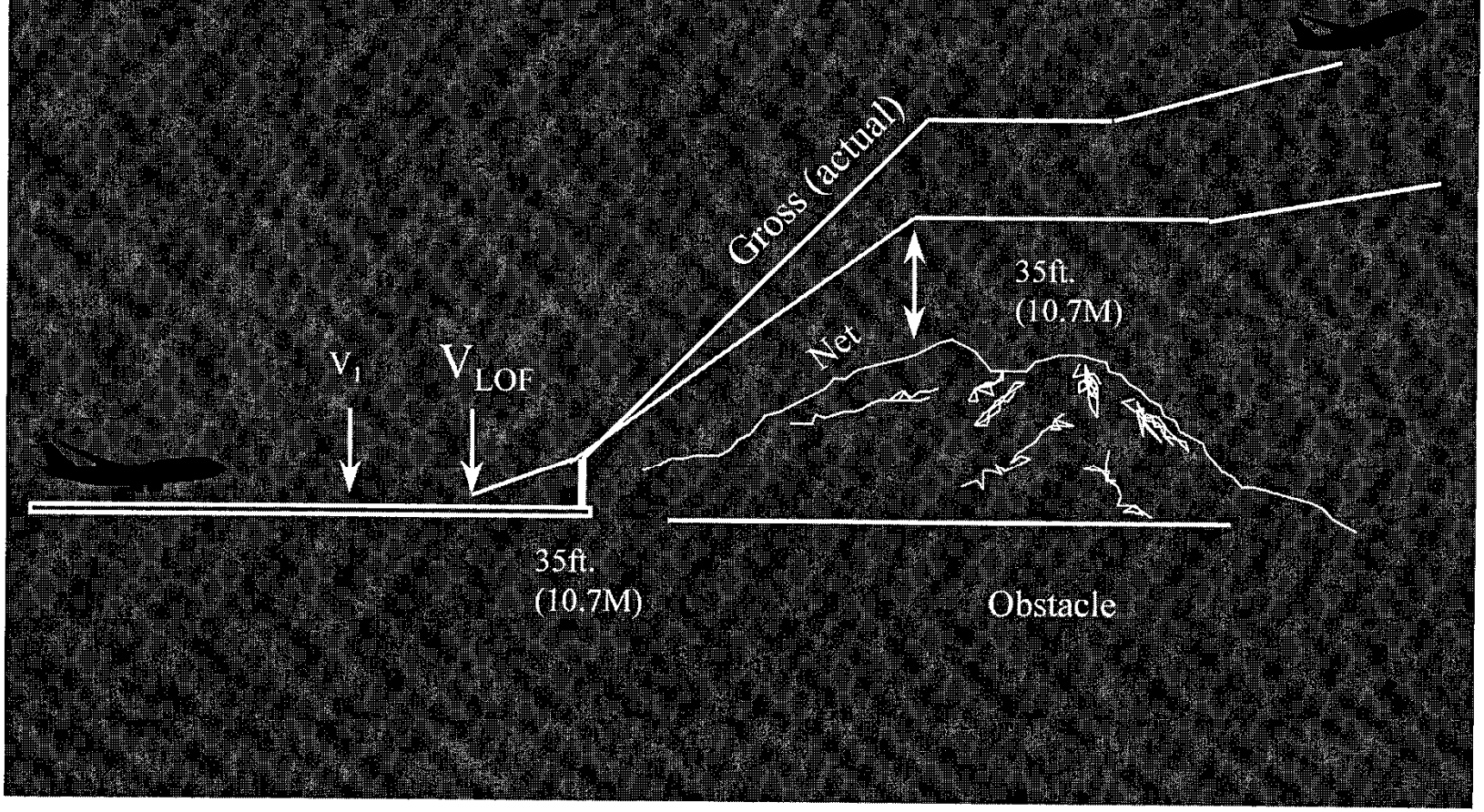
AIRFIELD CERTIFICATION

- Consult with end users prior to construction
- Airfield Licensing Code determines:
  - max runway length, width, etc.
  - Max scheduled aircraft capacity
- TP312 changes may improve situation
- Code 2 Airport
  - Runway length less than 1200 m (3933 feet max)
  - Up to 500-foot extension possible (4433-foot runway)
  - 20+ passenger scheduled flights not allowed
  - 20+ passenger charter flights acceptable
  - Pavement Load Rating &/or Pavement Classification Number may be required. PLR is Canadian & PCN is International

FAR 25 Take-off Profile



Net Flight Take Off Flight Path for Obstacle Clearance



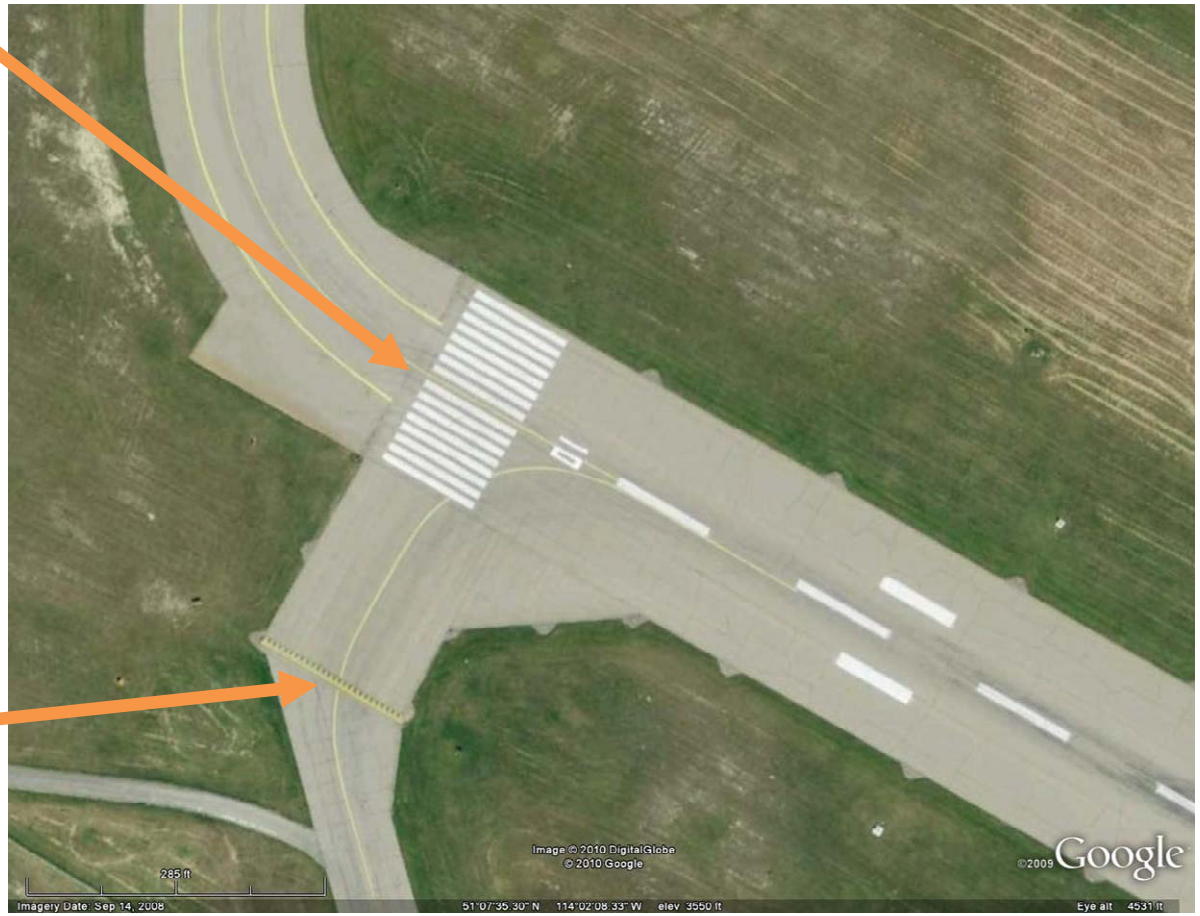
AIRCRAFT PERFORMANCE
50 feet over the far runway end?

SWIFT 2010 words of wisdom

- James Cherry SWIFT INTRO
  - Promote, co-operate, influence, & leadership
- If well designed and well constructed, the facilities will be efficient
- YYC runway 10 line-up
  - Cliff beck, YYC, & EBA Engineering designed facilities to maximize aircraft performance
    - Thousands of extra pounds for B767 200 ER
- Buttonville ITOA
- Accounting & airfield management must consult to maximize benefits

YYC RWY 10 LINE-UP ALLOWANCES

- No line-up Penalty
- 90-degree Turn penalty
- B737 approx 100 feet



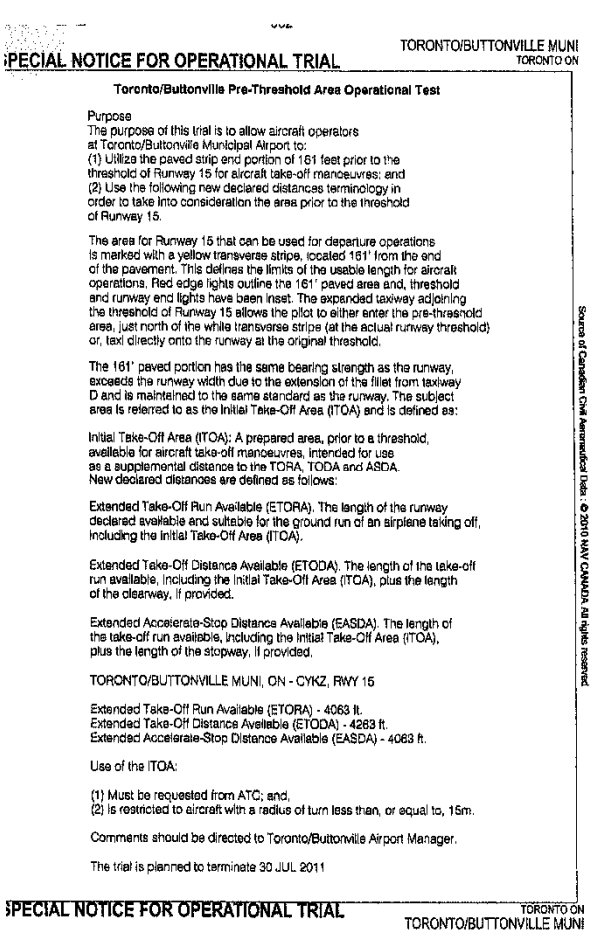
Buttonville's ITOA Safely Increases Performance

- ORIGINAL
  - TORA – 3902'
  - TODA – 4102'
  - ASDA – 3902'

- ADDING 161' ITOA (Initial Take-off Area)

- EXTENDED
  - ETORA – 4063'
  - ETODA – 4263'
  - EASDA – 4063'

BUTTONVILLE RESA CREDIT



TORONTO/BUTTONVILLE MUNI
TORONTO ON

SPECIAL NOTICE FOR OPERATIONAL TRIAL

Toronto/Buttonville Pre-Threshold Area Operational Test

Purpose
The purpose of this trial is to allow aircraft operators at Toronto/Buttonville Municipal Airport to:
(1) Utilize the paved strip end portion of 161 feet prior to the threshold of Runway 15 for aircraft take-off manoeuvres; and
(2) Use the following new declared distances terminology in order to take into consideration the area prior to the threshold of Runway 15.

The area for Runway 15 that can be used for departure operations is marked with a yellow transverse stripe, located 161' from the end of the pavement. This defines the limits of the usable length for aircraft operations. Red edge lights outline the 161' paved area and, threshold and runway end lights have been inset. The expanded taxiway adjoining the threshold of Runway 15 allows the pilot to either enter the pre-threshold area, just north of the white transverse stripe (at the actual runway threshold) or, taxi directly onto the runway at the original threshold.

The 161' paved portion has the same bearing strength as the runway, exceeds the runway width due to the extension of the fillet from taxiway D and is maintained to the same standard as the runway. The subject area is referred to as the Initial Take-Off Area (ITOA) and is defined as:

Initial Take-Off Area (ITOA): A prepared area, prior to a threshold, available for aircraft take-off manoeuvres, intended for use as a supplemental distance to the TORA, TODA and ASDA.
New declared distances are defined as follows:

Extended Take-Off Run Available (ETORA). The length of the runway declared available and suitable for the ground run of an airplane taking off, including the Initial Take-Off Area (ITOA).

Extended Take-Off Distance Available (ETODA). The length of the take-off run available, including the Initial Take-Off Area (ITOA), plus the length of the clearway, if provided.

Extended Accelerate-Stop Distance Available (EASDA). The length of the take-off run available, including the Initial Take-Off Area (ITOA), plus the length of the stopway, if provided.

TORONTO/BUTTONVILLE MUNI, ON - CYKZ, RWY 15

Extended Take-Off Run Available (ETORA) - 4063 ft.
Extended Take-Off Distance Available (ETODA) - 4263 ft.
Extended Accelerate-Stop Distance Available (EASDA) - 4063 ft.

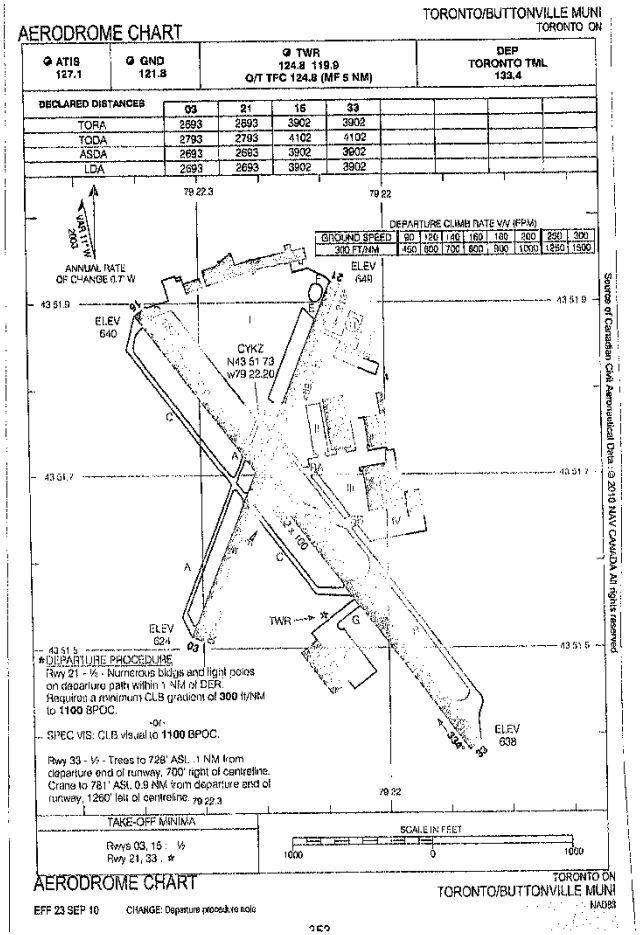
Use of the ITOA:

(1) Must be requested from ATC; and,
(2) Is restricted to aircraft with a radius of turn less than, or equal to, 15m.

Comments should be directed to Toronto/Buttonville Airport Manager.

The trial is planned to terminate 30 JUL 2011

SPECIAL NOTICE FOR OPERATIONAL TRIAL
TORONTO ON
TORONTO/BUTTONVILLE MUNI



AERODROME CHART
TORONTO/BUTTONVILLE MUNI
TORONTO ON

ATIS 127.1	GND 121.8	TWR 124.8 119.9 O/T TFC 124.8 (MF 5 NM)	DEP TORONTO TML 133.4

DECLARED DISTANCES	03	21	15	33
TORA	2693	2693	3902	3902
TODA	2793	2793	4102	4102
ASDA	2693	2693	3902	3902
LDA	2693	2693	3902	3902

DEPARTURE CLIMB RATE V/V (FPM)

GROUND SPEED	90	120	140	160	180	200	250	300
300 FT/NM	450	600	700	800	900	1000	1250	1500

79 22.3 79 22
ANNUAL RATE OF CHANGE 0.7° W
ELEV 648
ELEV 640
CYKZ
N43 51 73
W79 22.20
3 x 100
ELEV 624
TWR
ELEV 638
43 51.9
43 51.7
43 51.5
79 22.3 79 22

*DEPARTURE PROCEDURE
Rwy 21 - ½ - Numerous bldgs and light poles on departure path within 1 NM of DER. Requires a minimum CLB gradient of **300** ft/NM to **1100** BPOC.
-or-
SPEC VIS: CLB visual to **1100** BPOC.

Rwy 33 - ½ - Trees to 728' ASL, 1 NM from departure end of runway, 700' right of centreline. Crane to 781' ASL 0.9 NM from departure end of runway, 1260' left of centreline.

TAKE-OFF MINIMA
Rwys 03, 15 . . ½
Rwy 21, 33 . . *

SCALE IN FEET
1000 0 1000

AERODROME CHART
TORONTO ON
TORONTO/BUTTONVILLE MUNI
EFF 23 SEP 10 CHANGE: Departure procedure note
NA(B)

Source of Canadian Civil Aeronautical Data: © 2010 NAV CANADA. All rights reserved.

Old Crow, YT

- No water transport
- Only surface access is a winter road constructed approximately every 7 years
- Air transport is a necessity, not a privilege
- DC3's landed on sandbars until mid-1970's
- 5,000-foot runway constructed to accommodate future aircraft requirements

Old Crow: Google Earth Aerial

Above: Northeast to northeast

Above: Southwest to southwest

Performance reductions at YOC

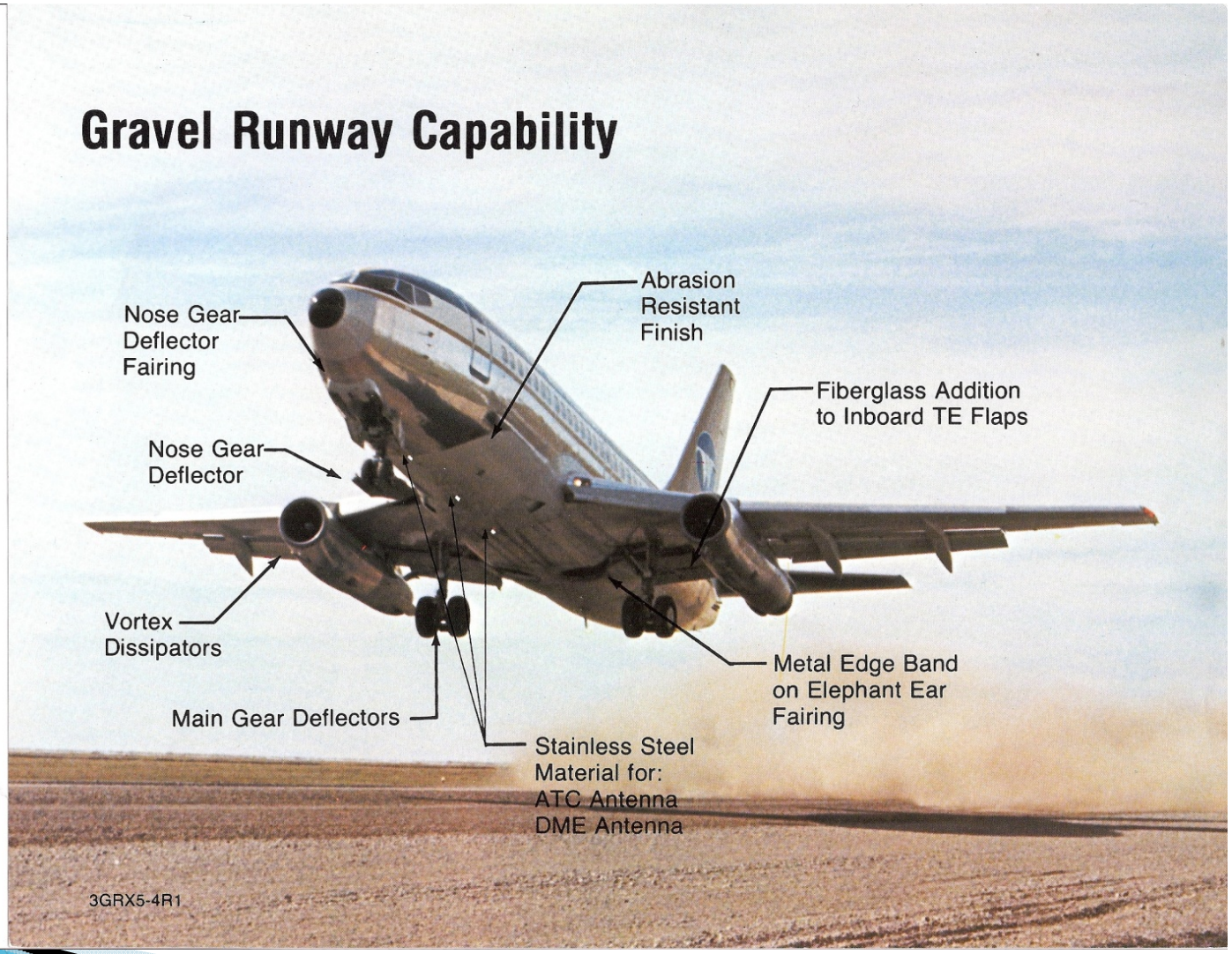
- Roadway crosses both thresholds
- Game fence inside both roadways
- RESA at both ends
- Displaced threshold due to roadway & fence
- B 737 line-up penalty
- 5000-foot runway length reductions:

	Take-off	Landing
RESA	400’	400’
Roads & fences	100’	100’
Line-up penalty	100’	N/A
Displaced threshold	N/A	200’
Total Reductions	600’	700’
Runway Available	4400’	4300’

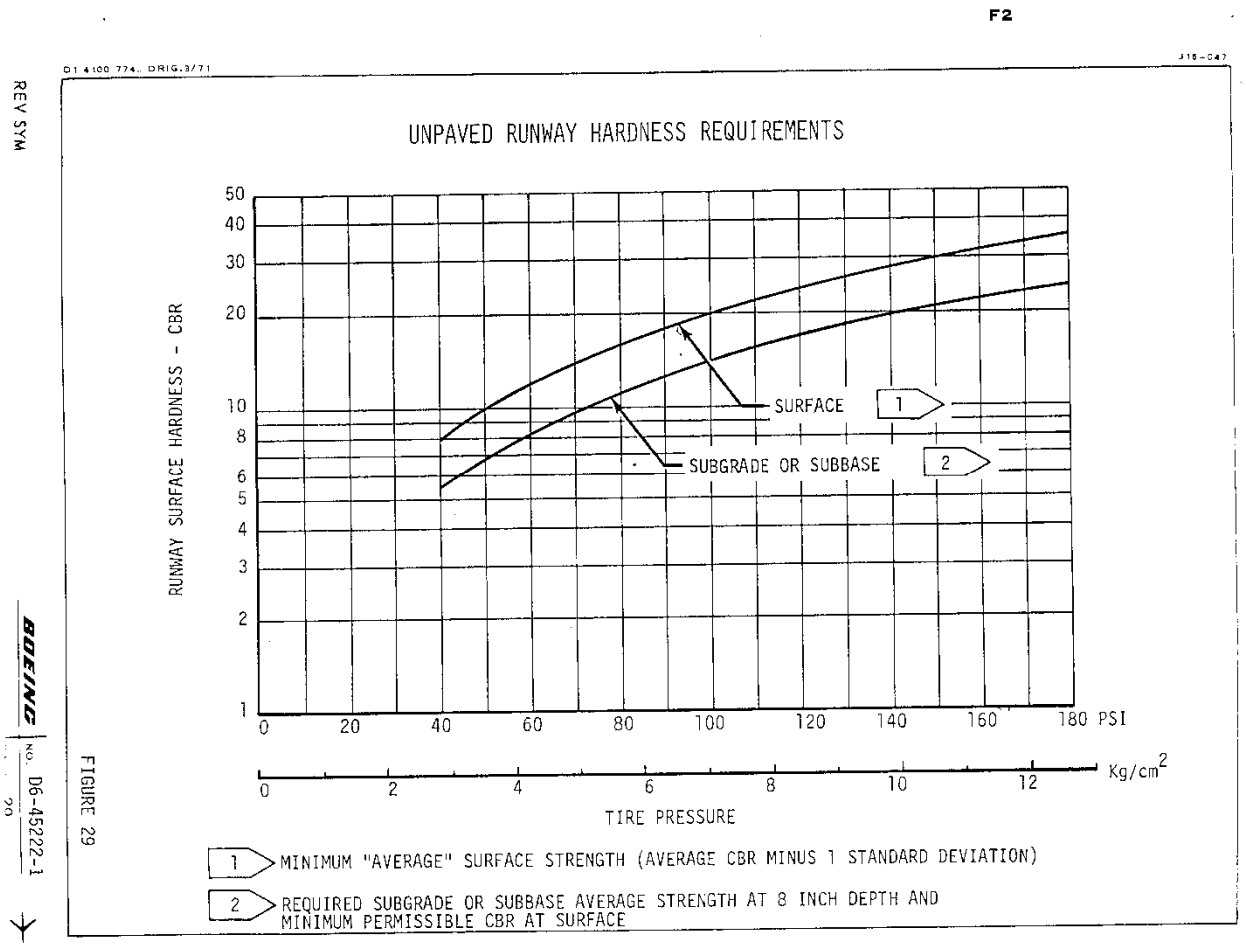
Boeing 737 Gravel Certification

B727 GRAVEL LANDING

B737 GRAVEL EQUIPMENT



BOEING ENGINEERING



F-28 Landing

NEGATIVE TRANSVERSE SLOPE

POOR CROWN & POOR DRAINAGE

RUNWAY MAINTENANCE

- Erosion
  - Wheel path erosion
  - Jet-pipe and prop erosion (B737 has 400 mph velocity at 3-foot height)
  - Compaction with irrigation after heavy aircraft arrival
  - Granular, deficient in fine surface
  - Standing water prohibited
- Side Drainage
  - Runway failure
  - Frost heaves
  - 6-7% for 200 feet ideal
- Transverse slope
  - Reduced firmness
  - 2.5% ideal
- Retention of Fines
  - Grade in, not out

3 worst enemies of surface firmness: Water, Drainage, and Moisture

Longitudinal wheel paths and poor crown

- 

Autumn – Under Construction

Winter – raised thresholds &edges

Spring – mile-long bath-tub

Following Summer – runway failure

RUNWAY MAINTENANCE

- Side Drainage
  - Runway failure
  - Frost heaves
  - 6-7% for 200 feet ideal
- Transverse slope
  - Reduced firmness
  - 2.5% ideal

Moisture is worst determent to consistent firmness

No strength outside geo-matting

No PLR & Sub-base Inadequate

CBR OKAY, BUT RUNWAY FAILURE

- Very poor side drainage
- Immediately after spring thaw
- Preceding freeze-up was wet (soils were saturated)
- Side drainage for weight bearing
- Crown for surface firmness

DRAINAGE

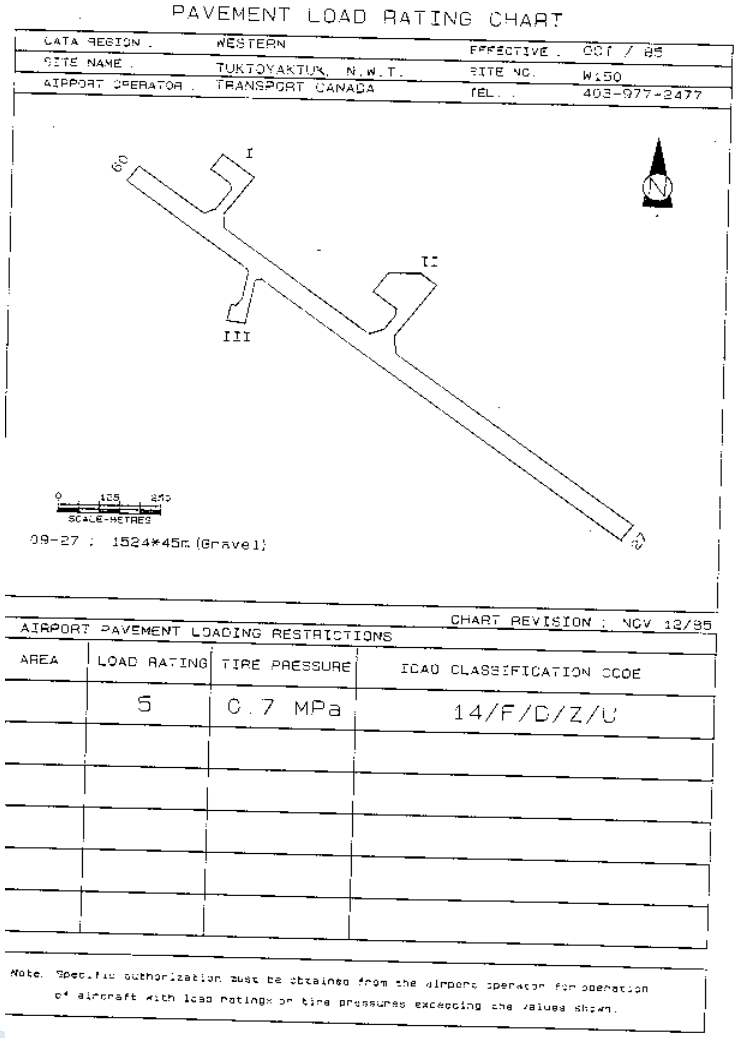
SUBSURFACE FAILURE

GRAVEL RUNWAY FAILING

Same runway failed

- 

PLR 5 (B737 needs PLR 9)
TP 0.7MPa (B737 needs 1.0MPa)



PAVEMENT LOAD RATING CHART

DATA REGION :	WESTERN	EFFECTIVE :	OCT / 85
SITE NAME :	TUKTOYAKTUK, N.W.T.	SITE NO.	W150
AIRPORT OPERATOR :	TRANSPORT CANADA	TEL. :	403-977-2477

09-27 : 1524*45m (Gravel)

CHART REVISION : NOV 12/85

AIRPORT PAVEMENT LOADING RESTRICTIONS

AREA	LOAD RATING	TIRE PRESSURE	ICAO CLASSIFICATION CODE
	5	0.7 MPa	14/F/D/Z/U

Note. Specific authorization must be obtained from the airport operator for operation of aircraft with load ratings or tire pressures exceeding the values shown.

SPRING-AUTUMN VARIATIONS

TYPICAL SUBGRADE BEARING STRENGTHS FOR SUBGRADE SOIL CLASSIFICATION GROUPS

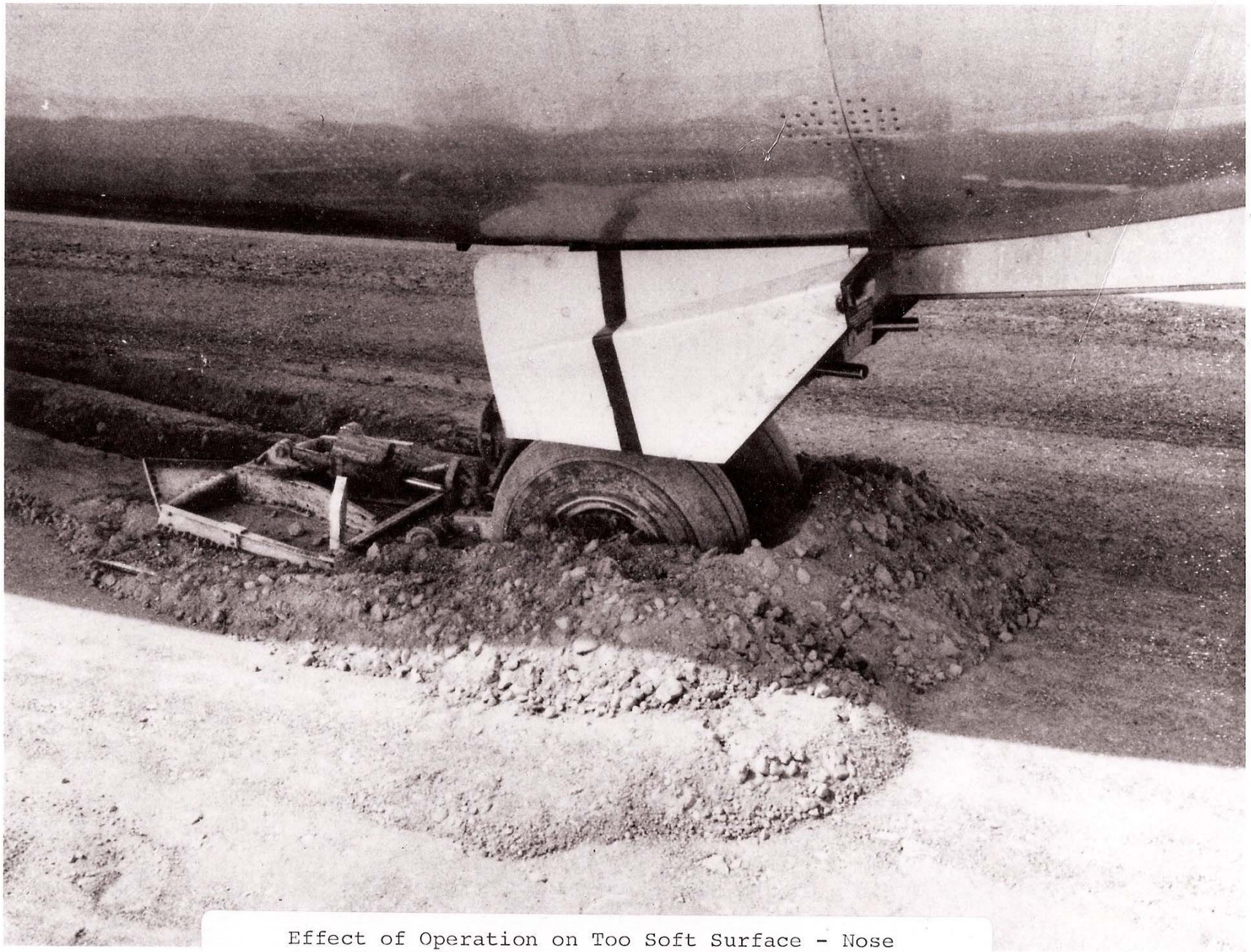
Subgrade Soil Type (Unified Soil Classification)	Usual Spring Reduction (%)	SUBGRADE BEARING STRENGTH (kN) (762-mm ϕ, 12.5-mm Δ, 10 app.)		
		Fall Range	Design Value	
			Fall	Spring
GW - Well graded gravel	0	290-400	290	290
GP - Poorly graded gravel	10	180-335	220	200
GM - Gravel with silty fines	25	135-335	180	135
GC - Gravel with clay fines	25	110-245	145	110
SW - Well graded sand	10	135-335	180	160
SP - Poorly graded sand	20	110-200	135	110
SM - Sand with silty fines	45	95-190	120	65
SC - Sand with clay fines	25	65-155	85	65
ML - Silt with low liquid limit	50	90-180	110	55
CL - Clay with low liquid limit	25	65-135	85	65
MH - Silt with high liquid limit	50	25-90	40	20
CH - Clay with high liquid limit	45	25-90	50	30

FIGURE 19

Subgrade Spring Reduction Factors Based on Soil Composition

Ref. 15; Transport Canada Document; AK-68-31-000

Gravel Runway Strength Critical for Nose Gear in Turns - Note that Support at Main Gear is Still Adequate



Effect of Operation on Too Soft Surface - Nose Gear Causes Plowing in Turns at Low Speed

PWA IN ARCTIC GRAVEL RUNWAY (Never a problem)

CV580 OFF RUNWAY

CV580 OFF RUNWAY

POOR RUNWAY MATERIAL GOOD MAINTENANCE

Longitudinal Wheel Path Erosion

CBR too low and surface is deficient in fines

Reduced CBRs

TRANSVERSE SLOPE

Poor crown

Negative crown

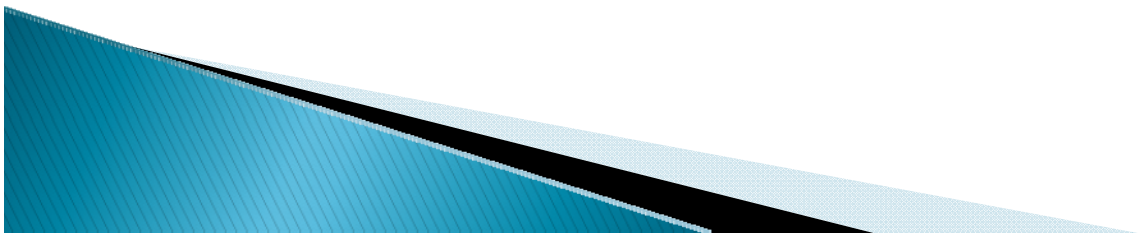
Obstacles

Obstacles

KING AIR ON HOT PAVEMENT

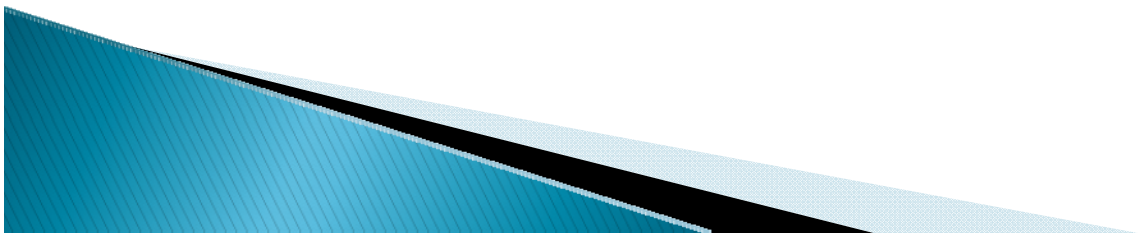
Exceptional Pilot

- *One day a long, long, long time ago, there was this pilot who, surprisingly, was not an arrogant "know-it-all"…*
- *But it was just one pilot…*
- *And it was a long, long. long time ago…*
- *And it was just for that one day…*



DATA AVAILABLE

- VISUAL AIDS
  - WINDSOCK
    - LEFT SIDE OF BOTH THRESHOLDS
- Net Runway Slope presented in a clear format



WHY WIND DATA IS IMPORTANT

- Brakes convert kinetic energy (K) or momentum into heat
- Landing groundspeed is velocity
- K = Mass X Velocity squared
  - @ 120 knots, energy factor is 120 X 120 = 14,400 units
  - @ 20 knot headwind, velocity is 100 knots and energy factor is 100 X 100 = 10,000 units
  - @ 20 knot tailwind, velocity is 140 knots and energy factor is 140 X 140 = 19,600 units
- Going from 20 knot headwind to 20 knot tailwind increased energy factor by 96%
- That extra 96% energy may be the point where brakes heat and lose effectiveness

F 28 landing at CFA7

Think Air France at Toronto

DETERMINING NET SLOPE

CANADA AIR PILOT AERODROME CHART

Net Slope = (Threshold to threshold elevation difference) / (Runway Length)

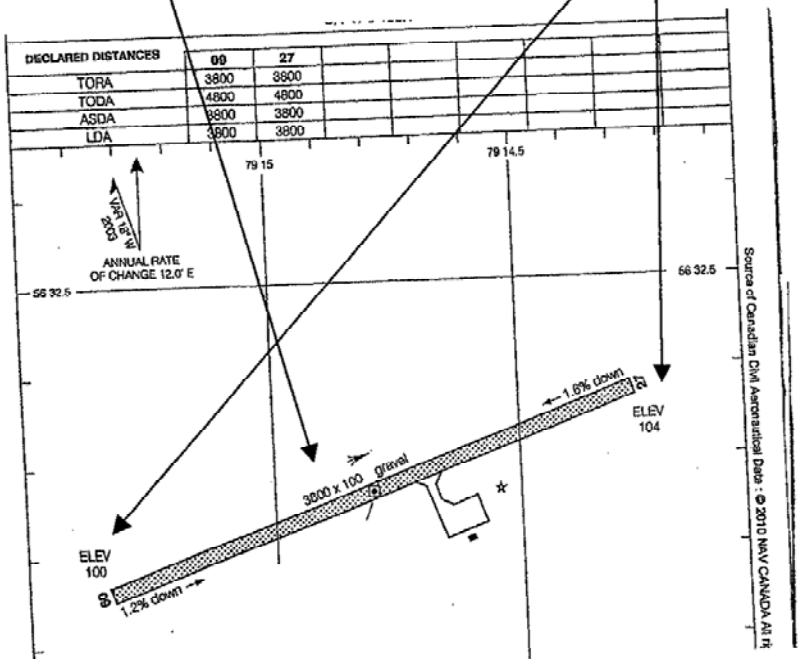
= (104 – 100) / 3800

= 4 / 3800

= 0.1%

(Runway Length)

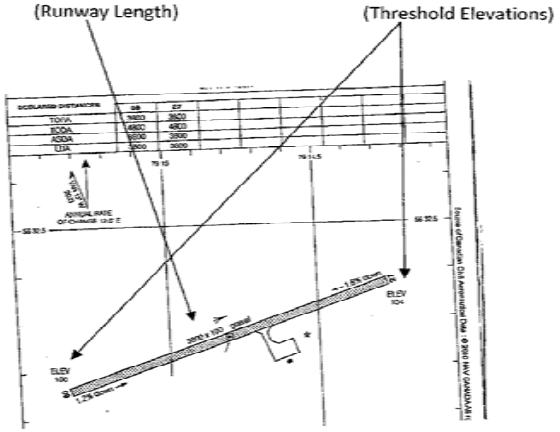
(Threshold Elevations)



AIRLINES REQUIRE NET SLOPE (not TP 312 airfield licensing data)

CANADA AIR PILOT AERODROME CHART

Net Slope = (Threshold to threshold elevation difference) / (Runway Length)
= (104 – 100) / 3800
= 4 / 3800
= 0.1%



RWY DATA	Rwy 09/27 3800x100 gravel Rwy 09 down 0.9% & rwy 27 down 1.2%
RCR	CARS ltd hrs O/T Council 867-266-8874

ABOVEORIGINAL CFS ENTRY **BELOW: AMENDED CFS ENTRY**

RWY DATA	Rwy 09/27 3800x100 gravel Rwy 27 down 1.6% first 1200' and up 1.2% last 1800'
RCR	CARS ltd hrs O/T Council 867-266-8874
LIGHTING	

WHAT SLOPE DATA WILL THE DISPATCHER USE?

AIRLINES ARE AN AIRFIELD'S END USER

"END USER" REQUIREMENTS TO PROVIDE AIR TRANSPORTATION THAT IS:

- Safety is ensured by aircraft certification criteria to maximize aircraft performance
- Economical facilities consider all factors that can maximize aircraft performance in a cost-effective manner
- Legal compliance can include waivers (exemptions) to existing airfield licensing criteria

Instrument Approach Regulatory Review

- New criteria requires threshold positions to have less than 1 foot displacement from prior positions
- Recommend establishing a NRCan Post-Processed-Position (PPP) survey control point first
  - Then verify existing threshold positions
- Threshold lights are 5-feet outside runway ends
- A land-surveyor surveyed a 5000 foot runway to be 5010 feet
  - The Instrument approaches were cancelled

CBR TECHNOLOGY INC.

ANY QUESTIONS?

Call us any time. We are here to help:

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Mike Boyle mike@cbrtech.ca 403-874-7538

cbrtech@shaw.ca