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RUNWAY ROUGHNESS CONSIDERATIONS

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Chris Olidis, P.Eng.

APPLIED RESEARCH ASSOCIATES, INC.

PRESENTATION OUTLINE

- A general overview of runway roughness
- Assessing roughness for new construction
- Assessing roughness of in service runways using the Boeing Bump Index
- Features that can influence roughness

WHY IS ROUGHNESS IMPORTANT

- Affects aircraft performance during take off and landing
- Dynamic forces from rough pavement can accelerate fatigue damage to aircraft components
- Dynamic loading reduces pavement life
- To a lesser extent, user complaints from pilots and passengers

NEW CONSTRUCTION

- Roughness is an indicator of construction quality
- Build a pavement smoother, it stays smoother longer
- Roughness for acceptance of new construction is typically measured with a straight edge

STRAIGHT EDGE ACCEPTANCE TESTING

- Transport Canada
  - The surface of a finished pavement shall be within 5 mm of the design grade, but not uniformly high or low and shall have no irregularities exceeding 5mm when checked with a 4.5 m straight edge placed in any direction.
- FAA
  - The finished surface of the final course of pavement shall not vary more than ¼ inch when evaluated with a 16 foot straightedge.

STRAIGHT EDGE

CALIFORNIA PROFILOGRAPH

- An FAA additional/optional acceptance test
  - The Contractor shall furnish a 25 foot wheel base California type profilograph and competent operator to measure pavement surface deviations.
  - The profile index will be determined in accordance with ASTM E 1274 using a 0.2-inch blanking band. Within each 1/10th mile subsection, all areas represented by high points having a deviation in excess of 0.4 inch in 25 feet or less shall be removed by the contractor using an approved equipment

CALIFORNIA PROFILOGRAPH

ACCEPTANCE OF NEW CONSTRUCTION

- From an operational perspective, aircraft are not affected by such small wavelength deviations
- Is acceptance based on straight edge or PI too conservative?
- Roughness is an indicator of construction quality
- Build a pavement smoother, it stays smoother longer

TYPES OF ROUGHNESS

- Discrete bumps create impact loading that can accelerate fatigue damage, as well as rattle equipment, crew, and passengers
- Repeated large wavelength bumps can induce harmonics and can accelerate fatigue damage to both the aircraft and the pavement
- Repeated short wavelength bumps can cause heat build up in struts/suspension

RIDE COMFORT INDEX

- Historical Transport Canada method was the ride comfort index (RCI)
- Subjective rating of ride quality by a panel of raters using passenger vehicle driving at 80 km/hr
- 0 (very poor) to 10 (very good)
- Pilot complaints expected when RCI < 5
- Aircraft suspension designed for landing not ride quality

RUNWAY PROFILE MEASUREMENT

- There are various equipment types to efficiently and objectively measure runway profiles
- Contact (walking inclinometer) profilers
  - DipStick, SurPRO, etc
- Non-contact (inertial) profilers
  - Lightweight and high speed laser

LIGHTWEIGHT AND HIGH SPEED PROFILERS

RUNWAY DATA

- ARA had a database of profile measurements from a number of runways
- The profile data was processed using the ProFAA software developed by FAA
- The Boeing Bump Index was the measure used for profile assessment

DATA COLLECTION

- Longitudinal profile measurements were completed with a ICC SurPRO 2000
- The equipment is portable and fully automated
- Includes 2 inclinometers, 1 optical distance encoder and a temperature sensor
- Meets World Bank Class 1 requirements for profiling devices

DATA COLLECTION PLAN

- Profile measurements were completed along the centreline, as well as 3.0 and 5.25 m offsets
- SurPRO was modified to include a laser target sensor to ensure operator maintains constant offset from centreline
- After initial warm up, the equipment inclinometers were calibrated by closed loop survey
- All data collected at speeds below 4 kph.

PROFILE INDICES

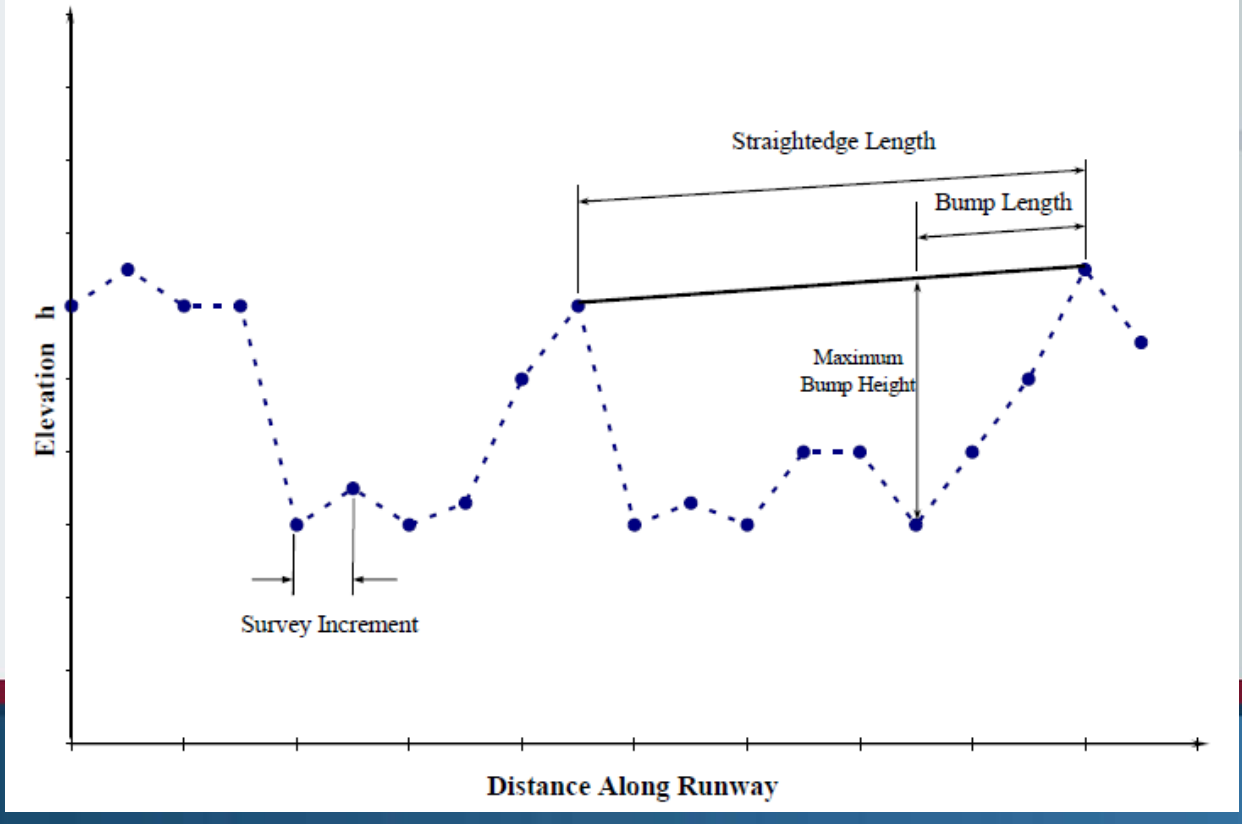
- ProFAA can simulate the following indices
  - Straight Edge
  - Profile Index (PI)
  - International Roughness Index (IRI)
  - RMS Bandpass
  - ***Boeing Bump***

BOEING BUMP METHOD

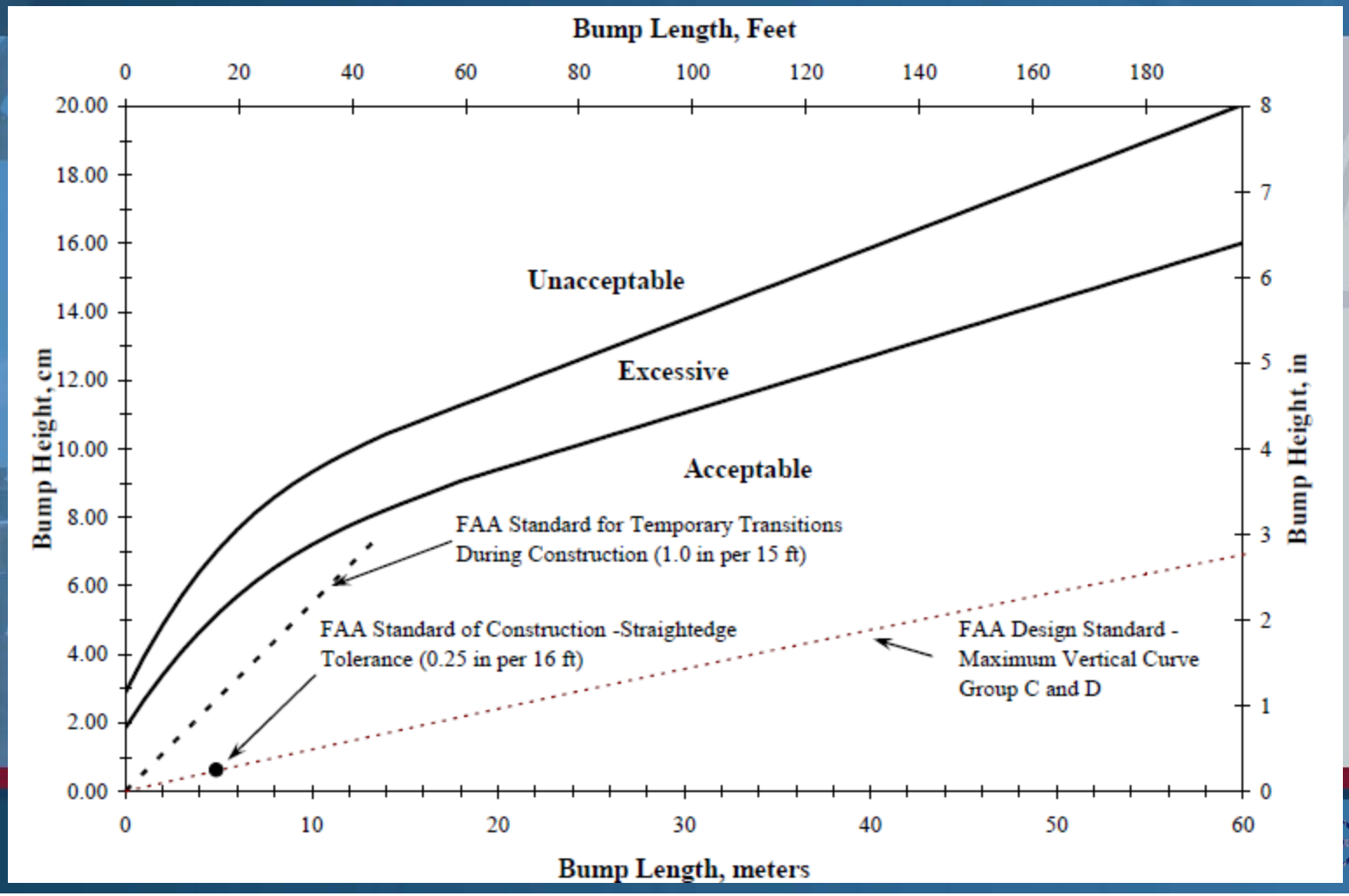
- D6-81746 *Runway Roughness Measurement, Quantification and Application – The Boeing Method*
- FAA AC 150/5380-9 *Guidelines and Procedures for Measuring Airfield Pavement Roughness*
- The method is user friendly
- Does not consider detailed analysis of aircraft response

BOEING BUMP METHOD

- Measures the deviation from a virtual straightedge to the pavement surface



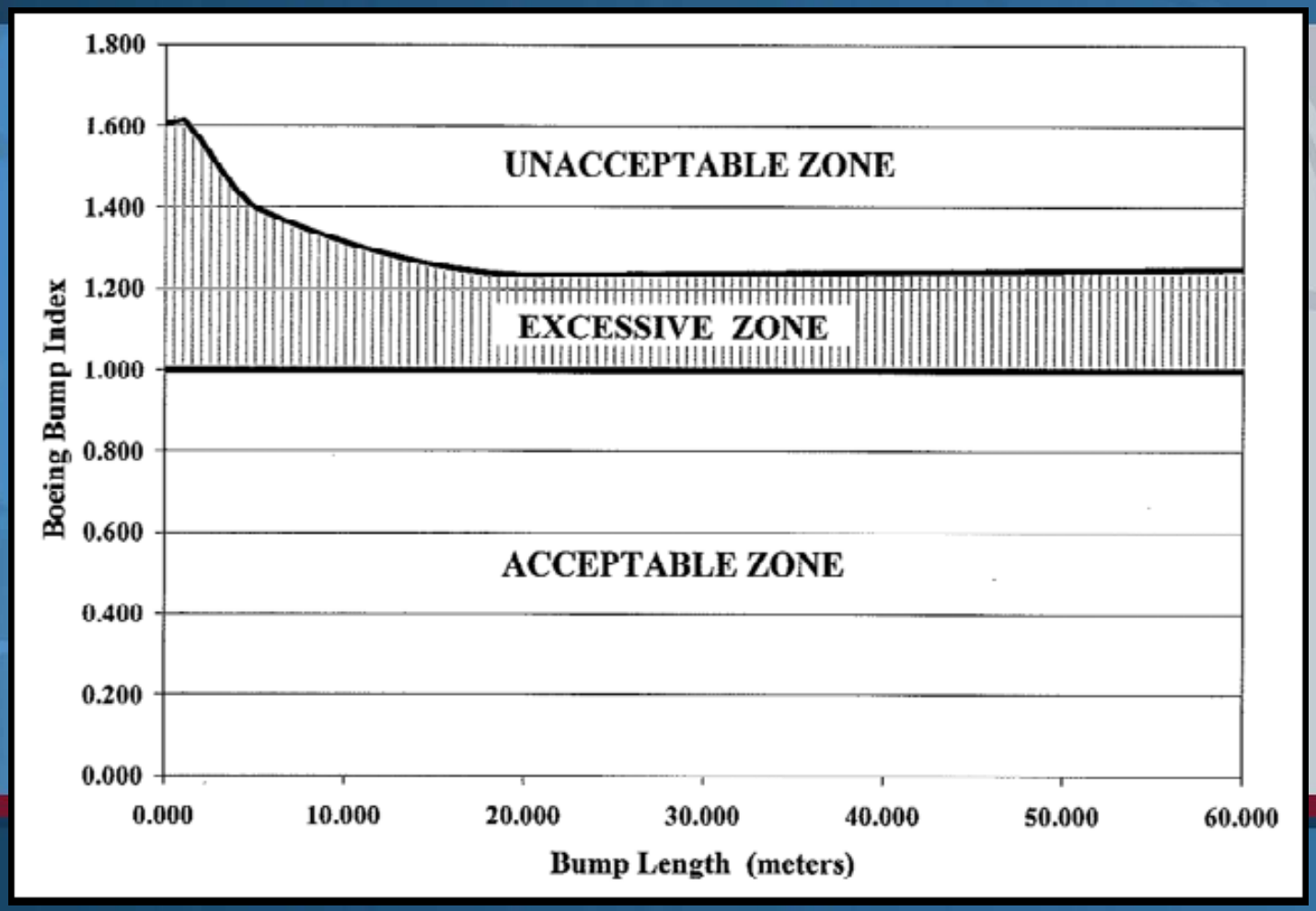
BOEING ROUGHNESS CRITERIA



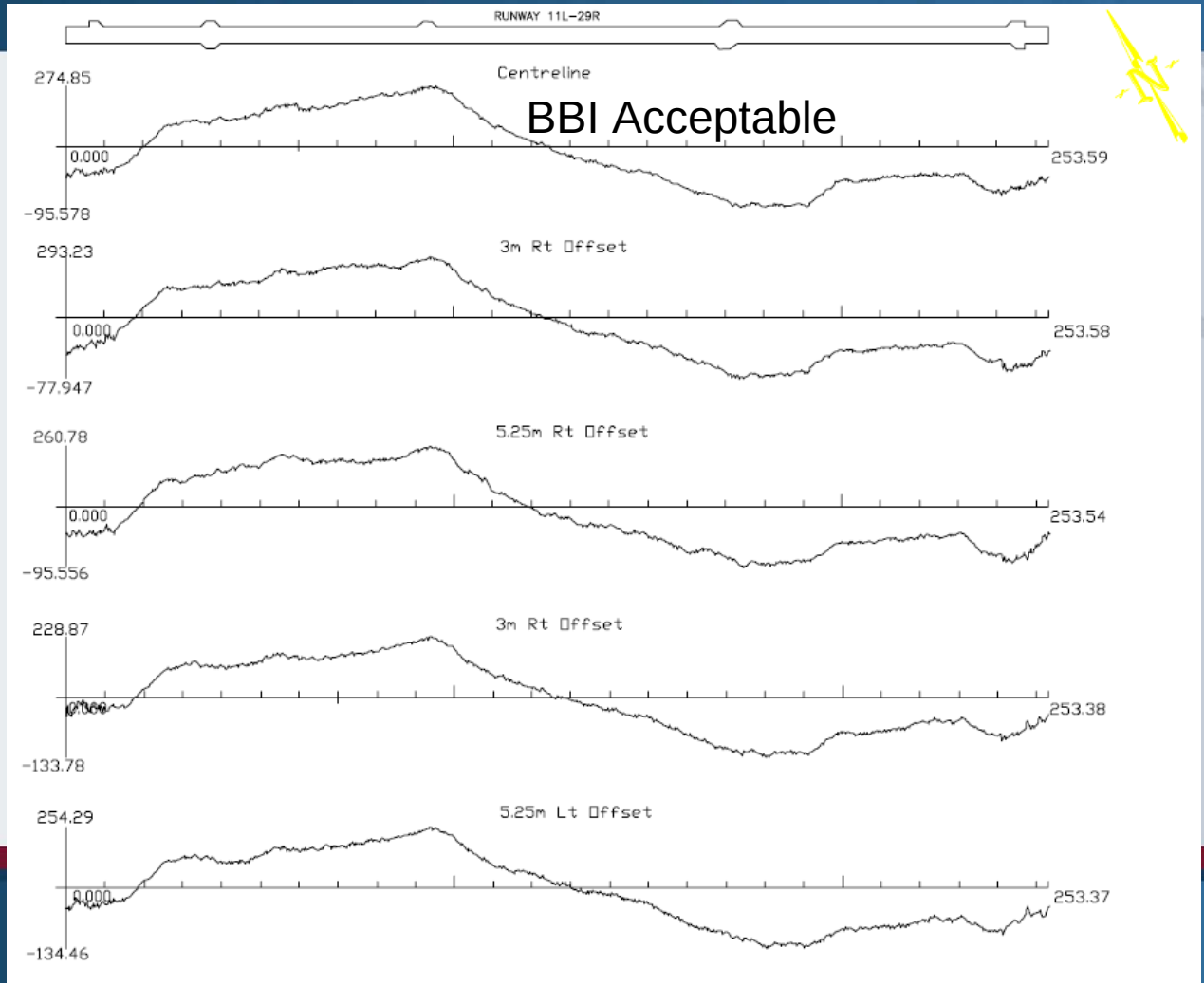
BOEING BUMP INDEX

- Considers a virtual straight edge bump length from 0.5 m to 120 m
- Boeing Bump Index (BBI) is determined by calculating a ratio of the measured bump height to the limit of acceptable bump height, for each straight edge length
  - BBI < 1 is considered acceptable
  - BBI > 1 is considered excessive or unacceptable

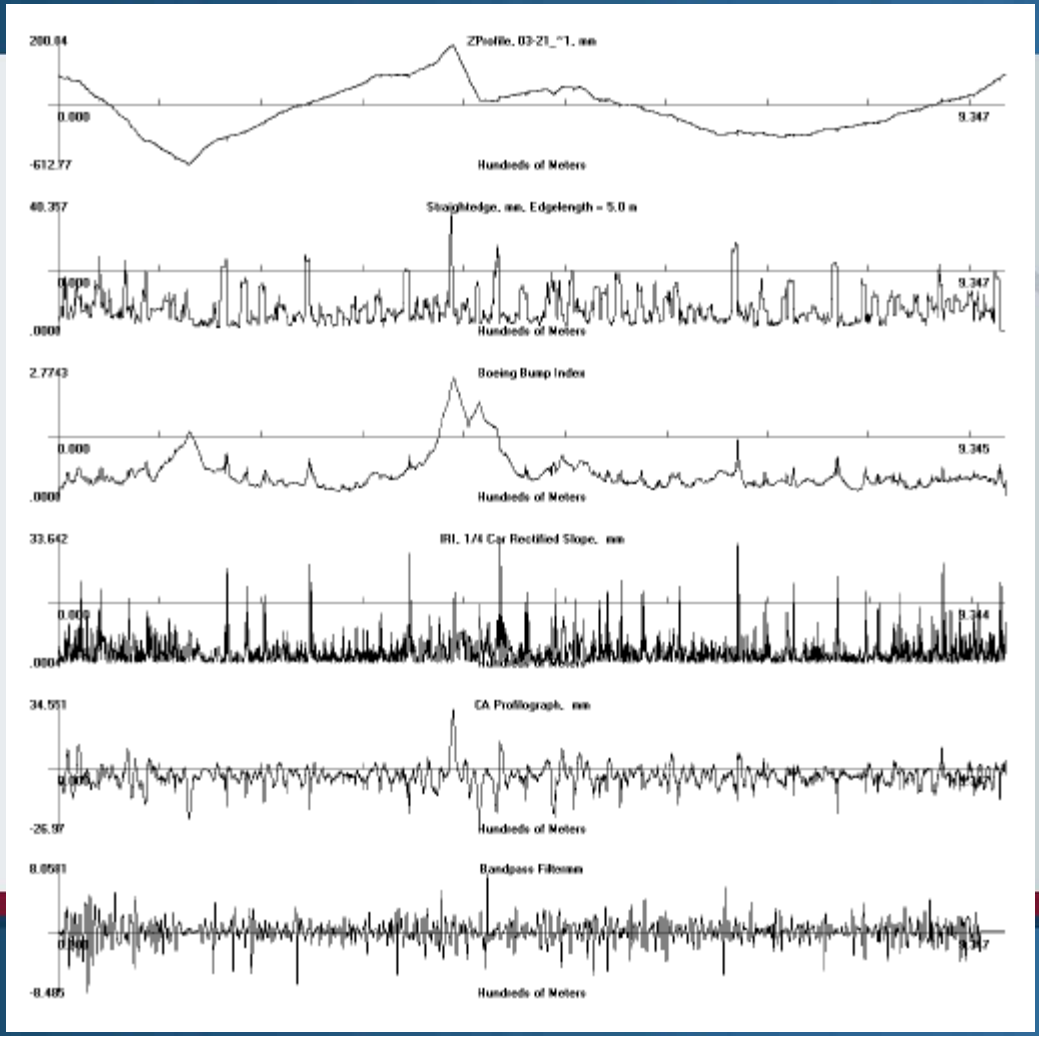
BBI CRITERIA



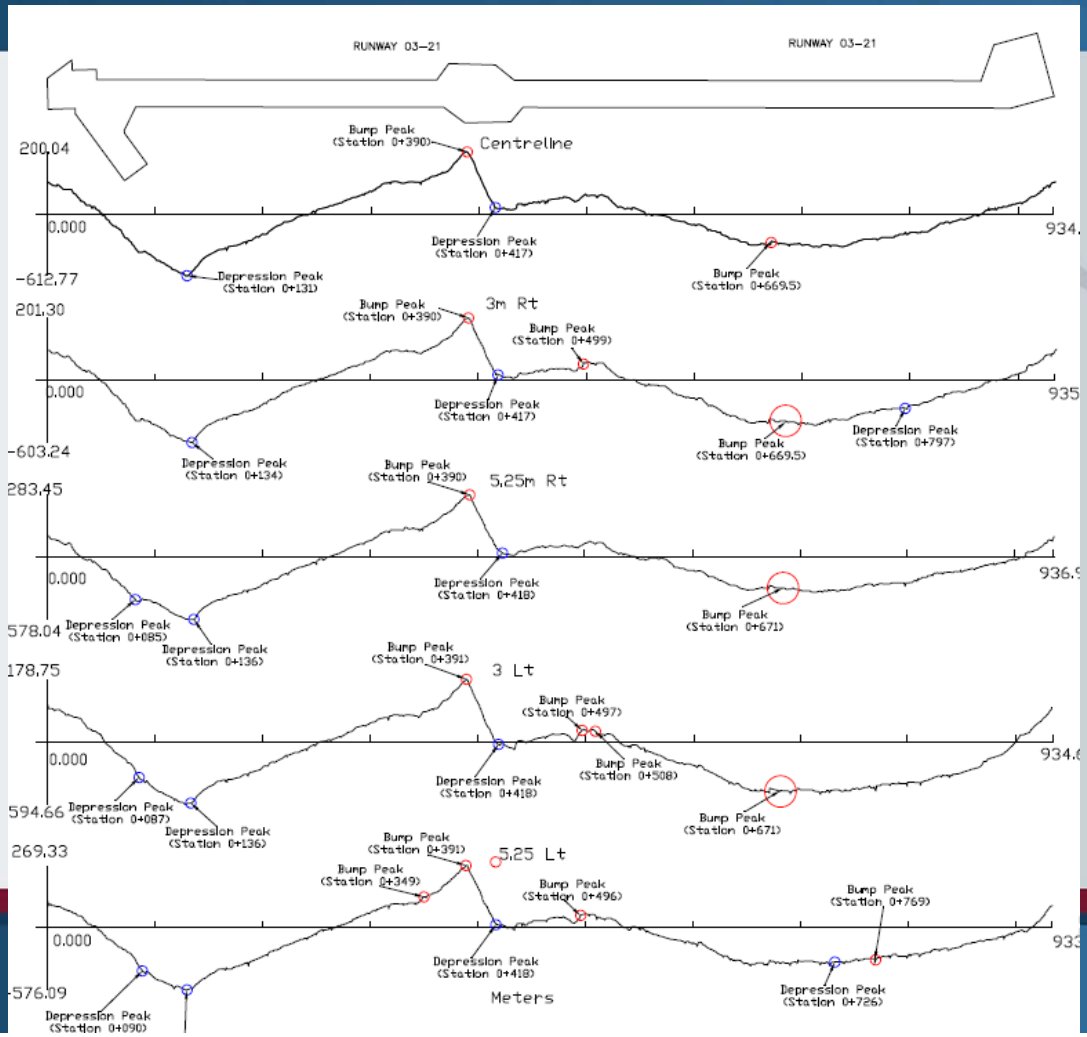
PRIMARY RUNWAY – SITE 1



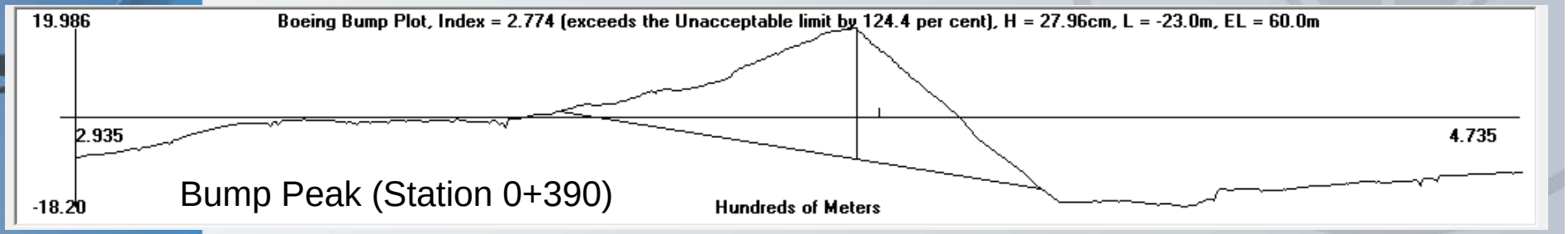
CROSSWIND RUNWAY – SITE 1



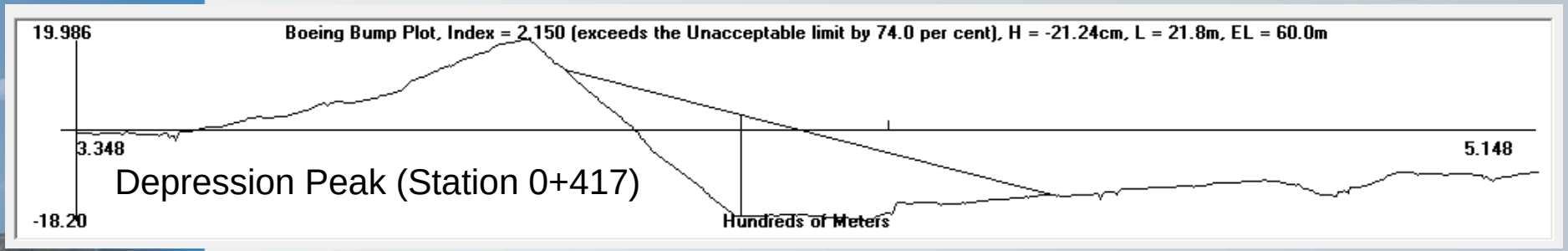
CROSSWIND RUNWAY – SITE 1



BBI ANALYSIS – SITE 1

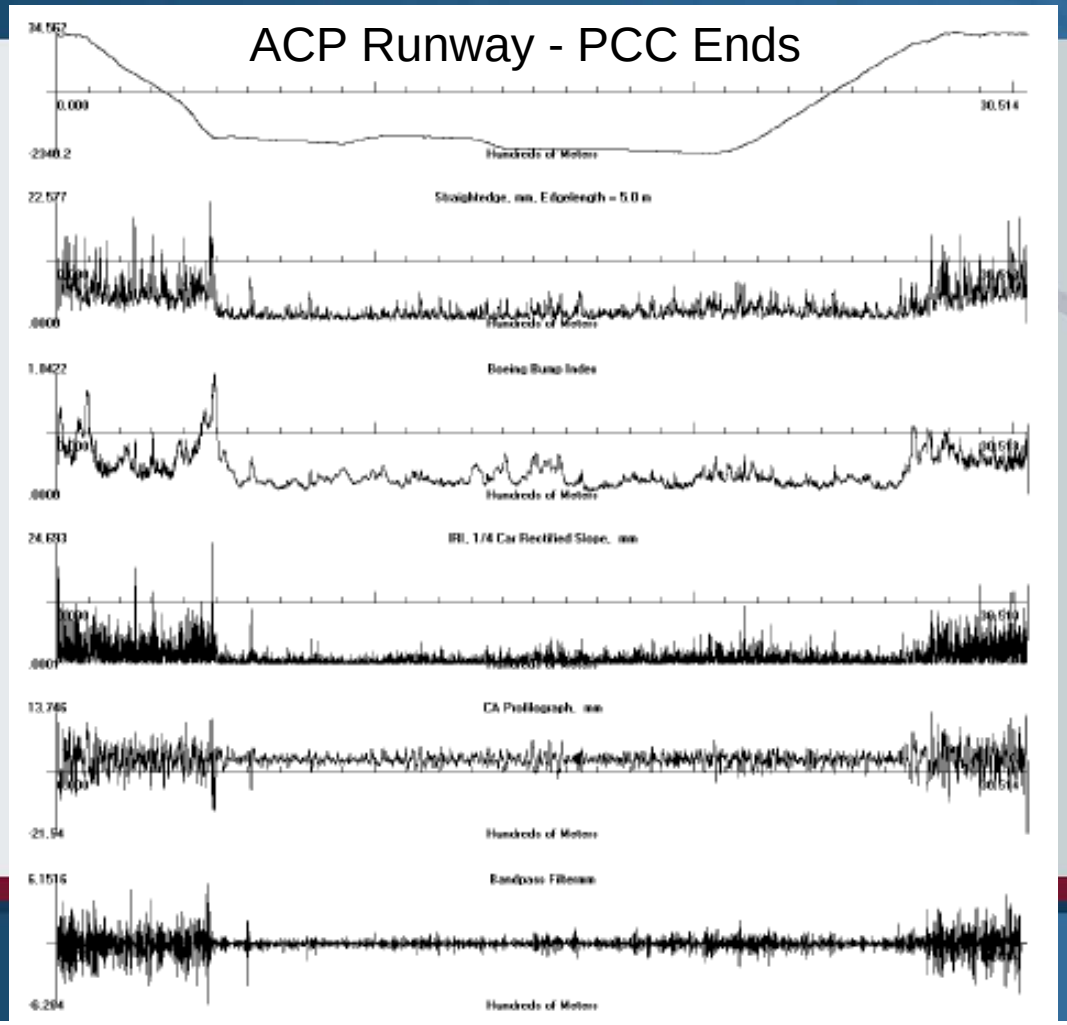


Bump Peak (Station 0+390)



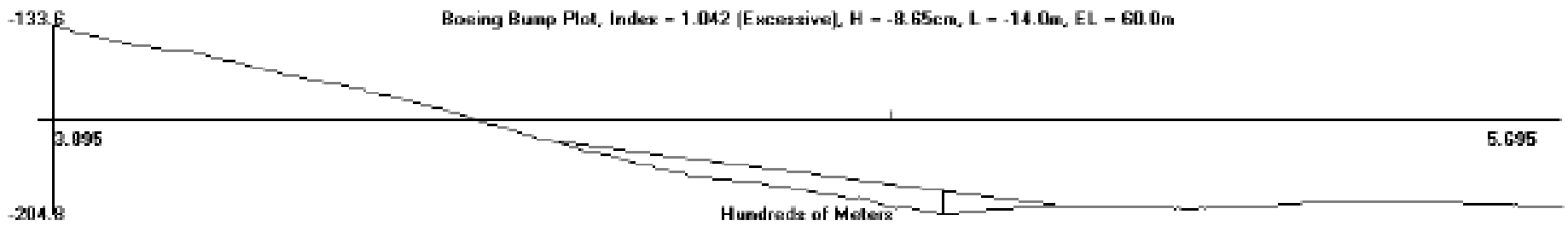
Depression Peak (Station 0+417)

RUNWAY ANALYSIS – SITE 2



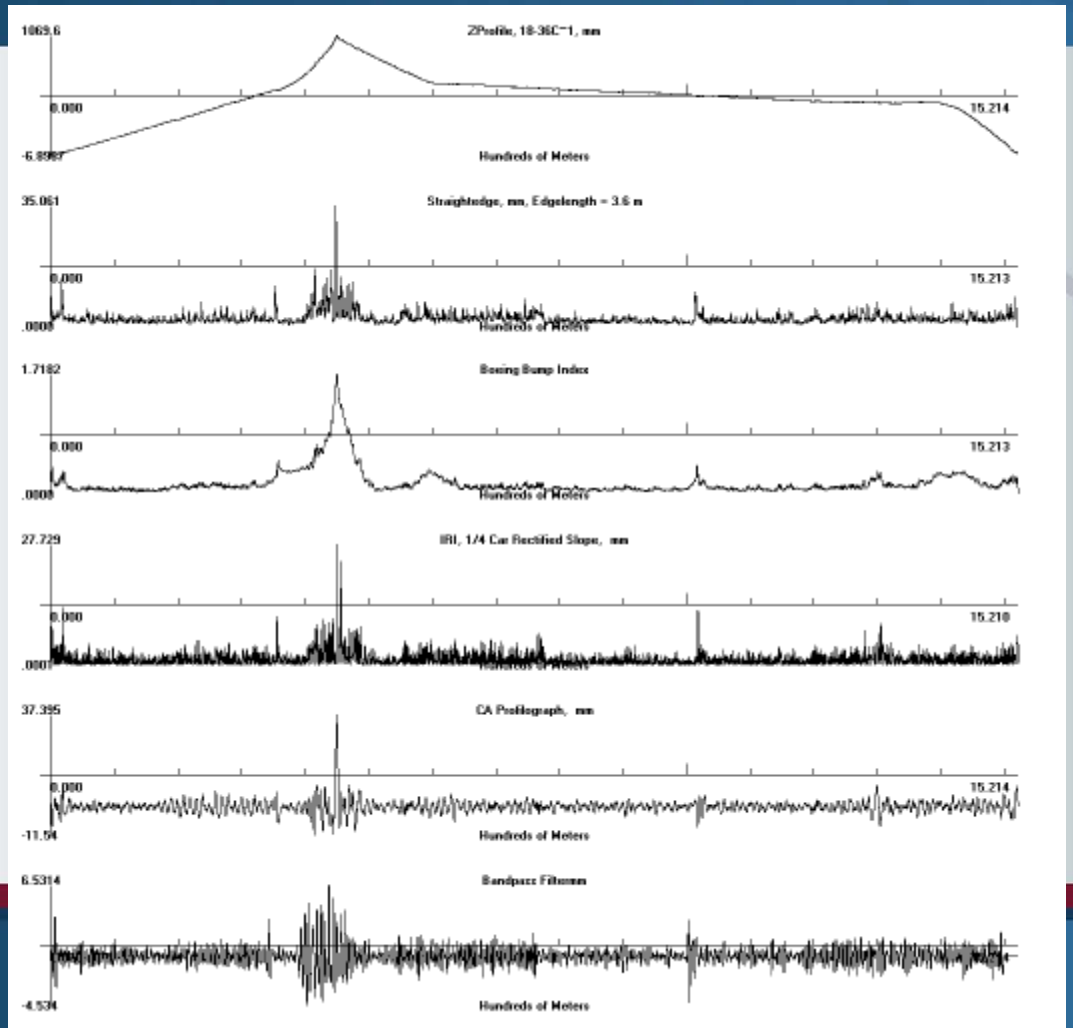
RUNWAY ANALYSIS – SITE 2

Depression Peak (Station 0+496)

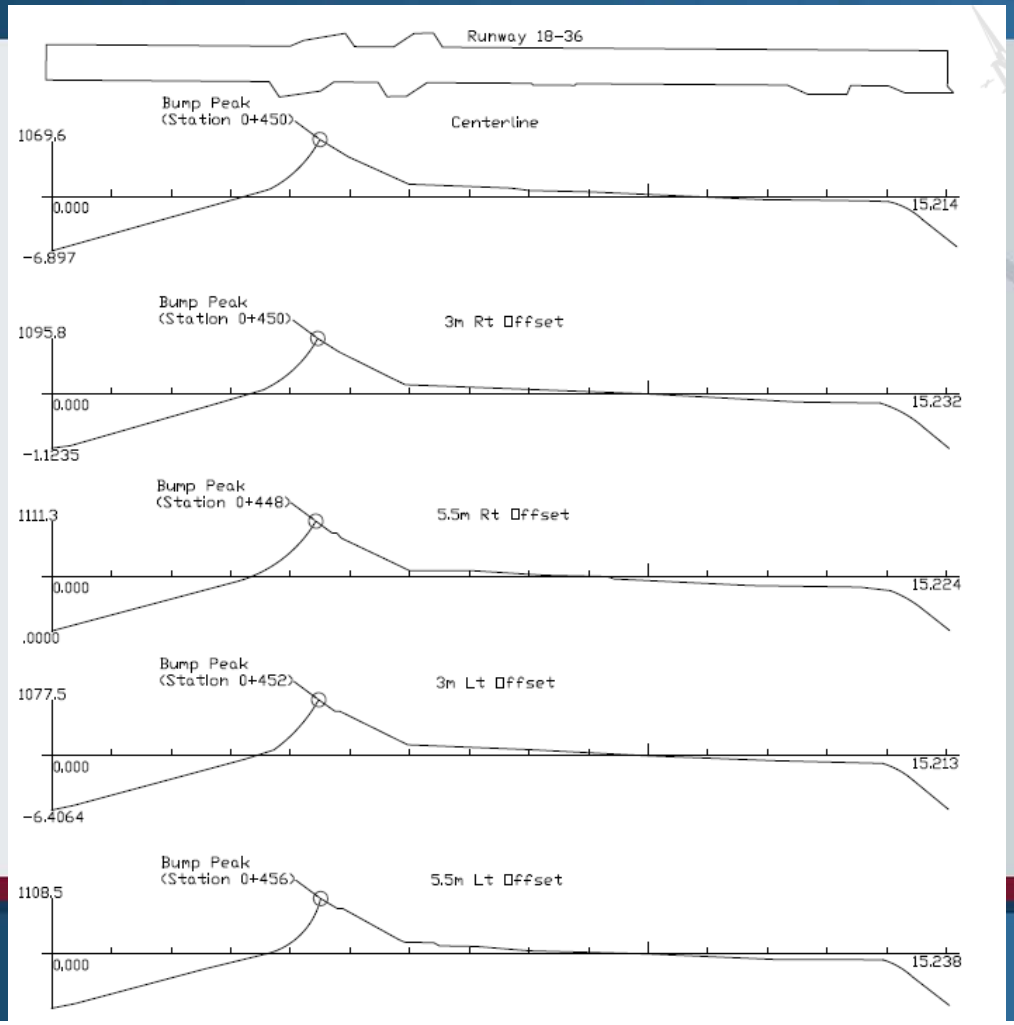


Excessive – Station 0+494 to 0+497

RUNWAY ANALYSIS – SITE 3



RUNWAY ANALYSIS – SITE 3



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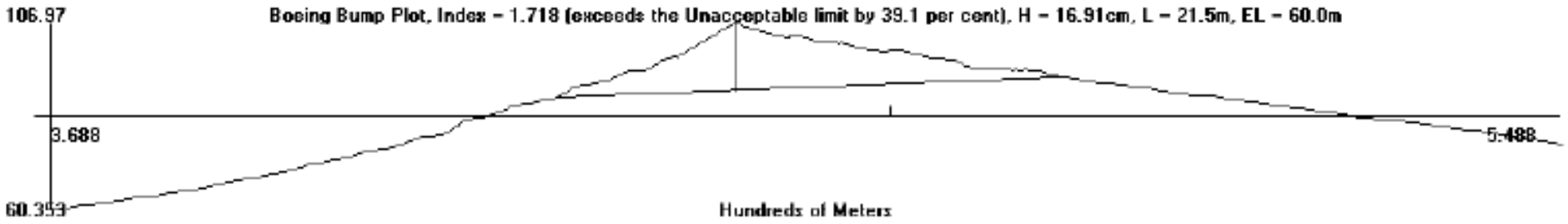

RUNWAY ROUGHNESS CONSIDERATIONS

- Runway intersections can be challenging to ensure a smooth pavement and maintain drainage
- Seasonal freeze thaw and permafrost degradation
- Post construction related settlement of embankment and underground services
- Pavement deterioration

COMMON CAUSES OF ROUGHNESS

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QUESTIONS
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