






COMPARISON OF DIFFERENT EVENNESS MEASUREMENTS
APPLICATION ON THE CASE OF A NEWLY CONSTRUCTED ROAD SECTION

SURF 2012

Authors:
Carl Van Geem (BRRC)
Bart Beaumesnil (BRRC)

Presented by:
Luc Goubert (BRRC)

Assessment of the evenness of a new road

When a new road is constructed in Belgium, the roughness must have an "acceptable level"…

Criteria (cf. standard tender specifications):

- "3m straightedge (TMS)": maximum values are prescribed
- "APL" measures "Evenness Coefficient (EC)": maximum average values per block of 100 m are prescribed

This case:

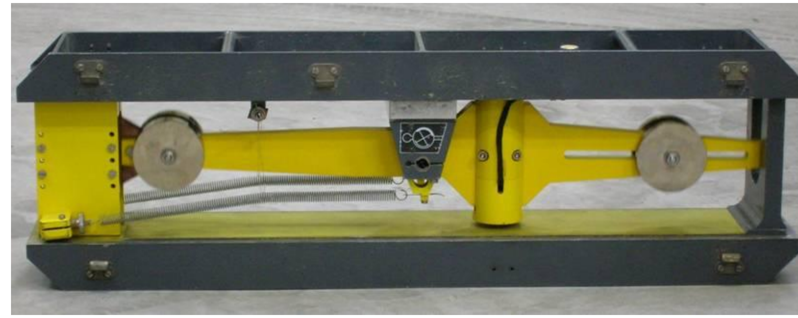
- Base course and road surface were renewed
- Sidewalk/bicycle path stayed in place
- Locally: introduction of traffic islands in the middle with a deviation of the road lanes as a consequence…

After the road works:

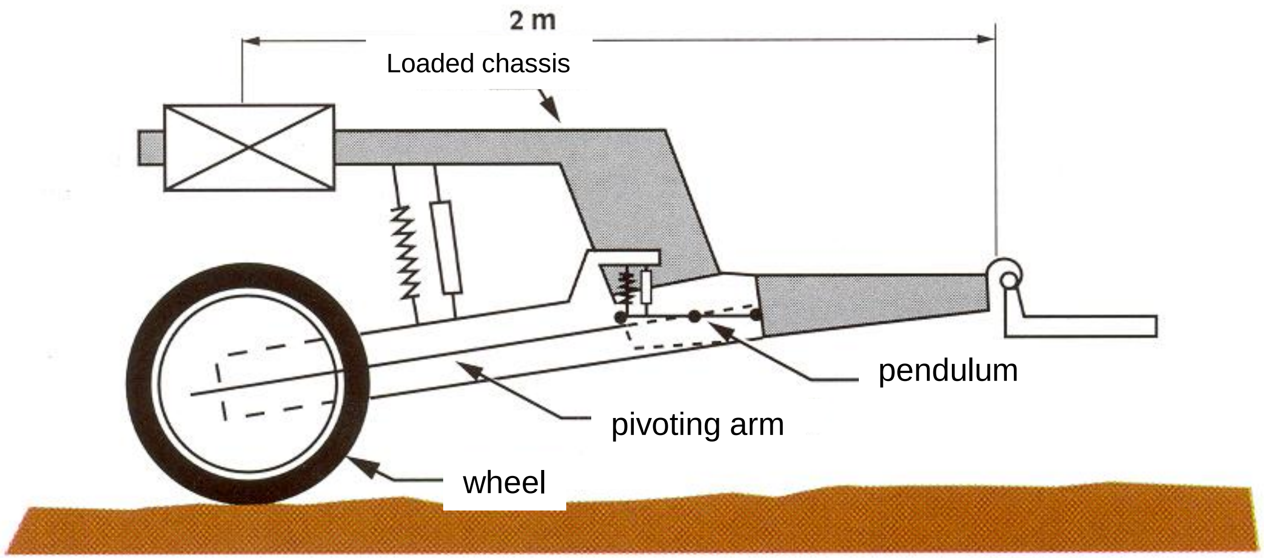
- Evenness didn't seem to comply, hence APL measurements were made.
- Comparison was made with TMS and level point measurements

APL: the measuring device

2 APL trailers towed by a car



pendulum



APL principle

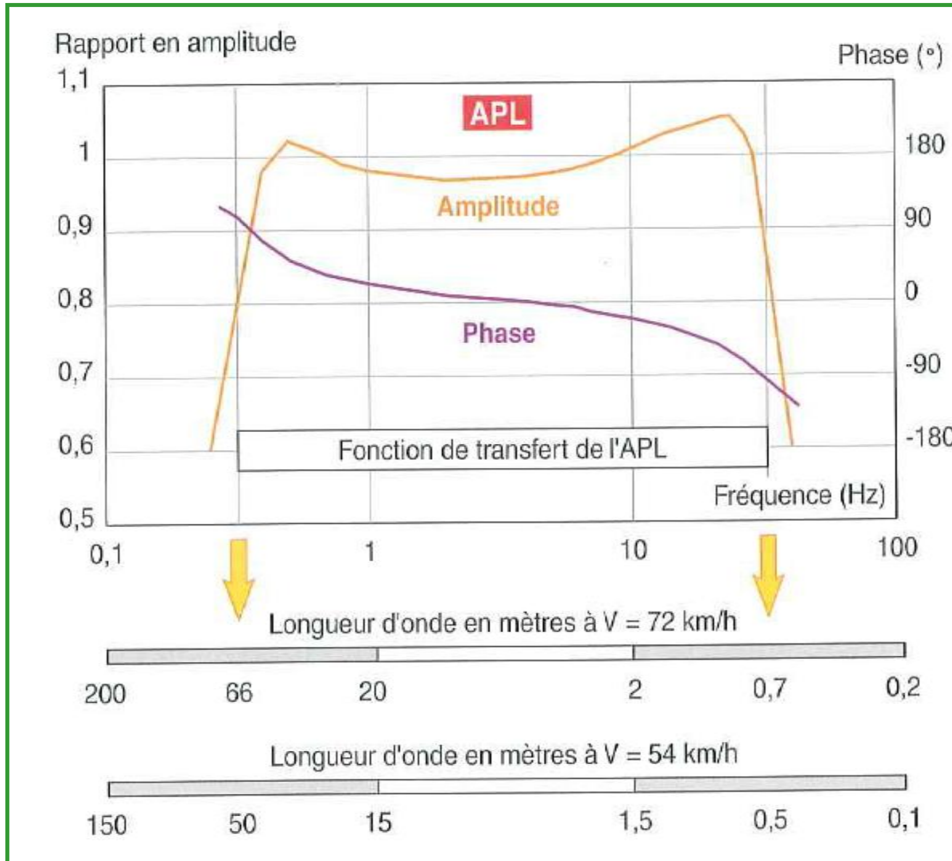
APL is a filter

- APL only "sees" frequencies in a certain window.
- The window shifts when driving at different speeds.
- Therefore, APL must measure at constant speed.

- Road = input signal
- APL reads output signal

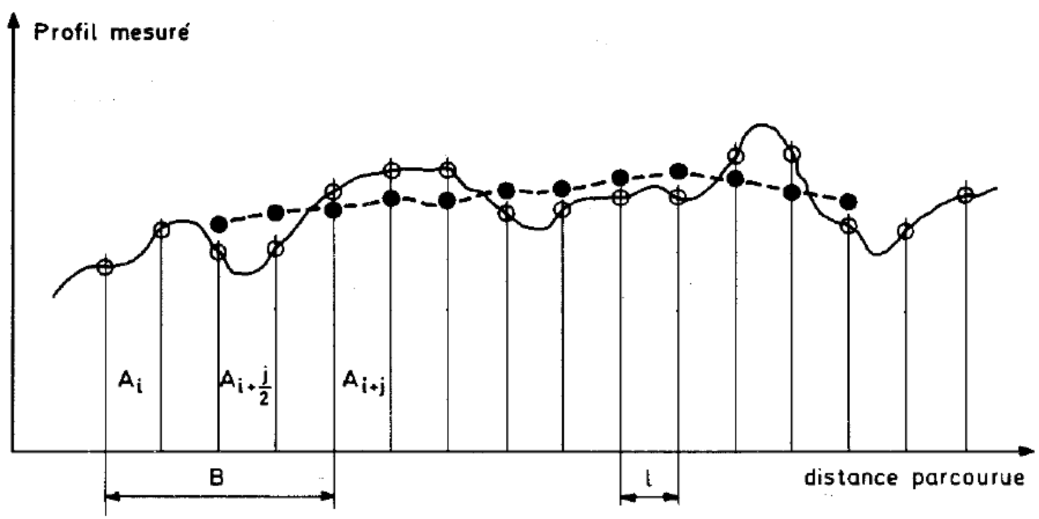
- Window is where
  input/output = 1

- Very short and very long wavelengths are filtered away…



The Family of Evenness Coefficients (EC_B)

- EC_B is a family of indices…
- Take signal read by APL (= “curve 1”),
- Choose basis B: compute sliding average where average is taken over a distance B (this makes a new curve: “curve 2”),
- Compute half of the area between “curve 1” and “curve 2” over a block with length E. This is EC_B reported on block E.
- See paper for choice of E and B, and corresponding speed.



$$\overline{A}_{i+\frac{j}{2}} = \frac{1}{j+1} \sum_{k=0}^{j} A_{i+k}$$

Theoretical estimate of TMS from APL

Assume road is measured by APL and the resulting “curve 1” is given by formula: $A \cdot \sin(2 \pi x / \lambda)$.

Then it can be shown by analytical computation that:
$EC_B = (100 \cdot A / \pi) \cdot (1 - (\lambda / \pi.B) \cdot \sin(\pi \cdot B / \lambda))$

(where “100” is a scale factor, and where block length E is chosen as a multiple of λ).

Maximal deformation under a beam of length B is equal to 2.A .

From this, the following table can be derived, estimating TMS from APL on sinus function:

$EC_{2,5m}$ in 1000mm²/hm	10	30	50	70	90	110	150	180
H (=2.A) in mm	0.63	1.89	3.14	4.40	5.66	6.91	9.42	11.31
H + 20% in mm	0.76	2.27	3.77	5.28	6.80	8.30	11.31	13.58

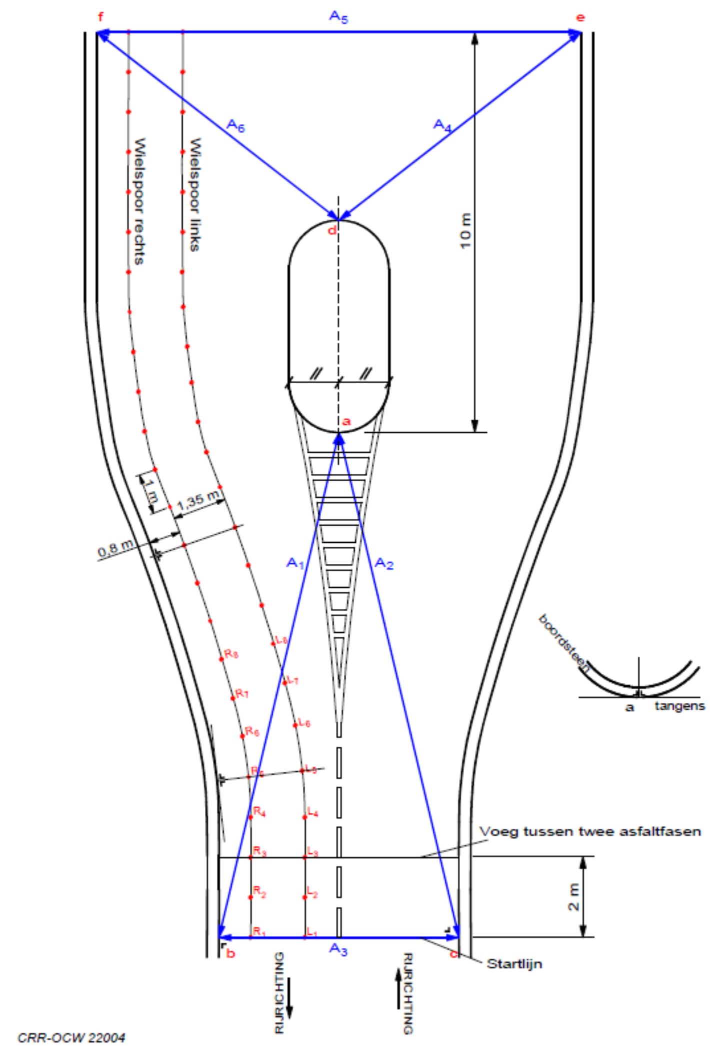
(see paper for more details).

Application to the case of a new road section

- Communal road, connecting two local community centers.
- Speed limit 50km/h.
- APL at constant speed of 21.6km/h.
  - Window of APL will mainly measure short wavelengths!
- EC_B:
  - B = 2.5m (short wavelength evaluation),
  - E = 10, 25 or 100m.

Campaign of TMS and level point measurements

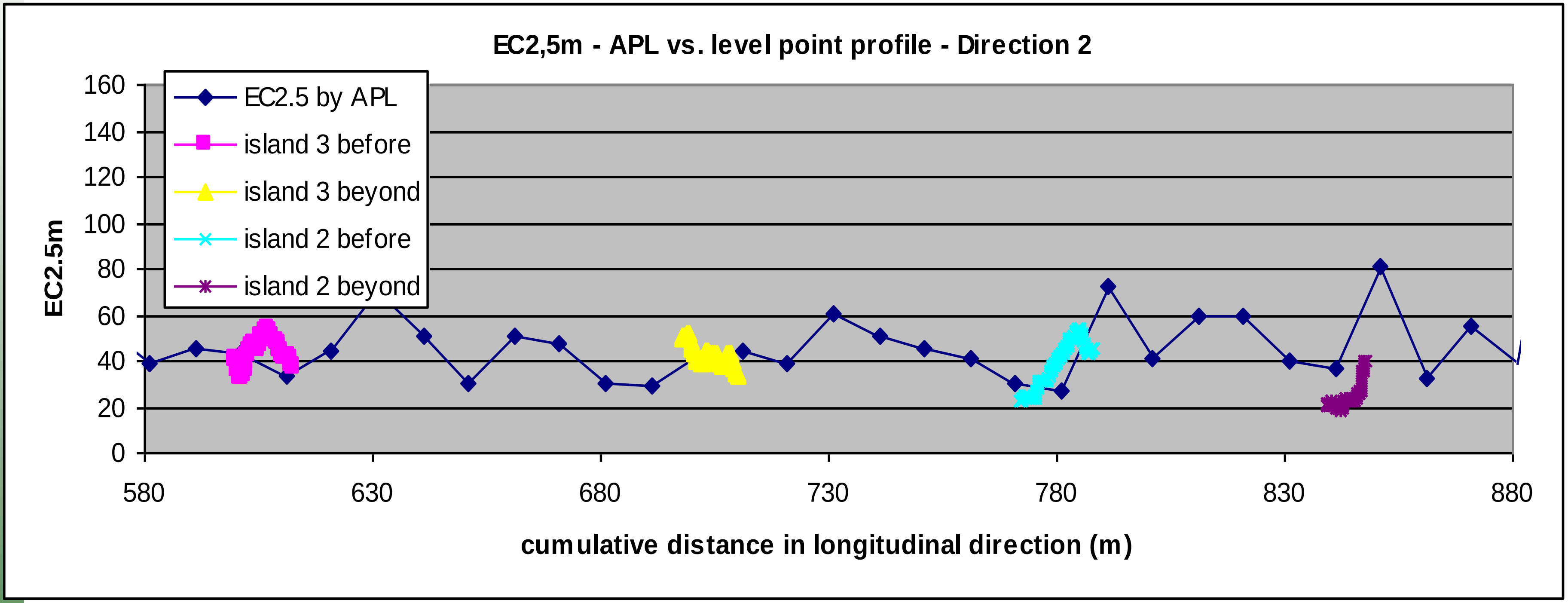
- Near the beginning and the end of traffic islands, wheel tracks were drawn on the road (where APL must have passed).
- In the wheel tracks, TMS and level point measurements were repeated every 1 meter
- TMS: deviation under a beam of 3m long.
- Level point measures: height variations with respect to one particular fixed point nearby.



Comparison APL/TMS/level points

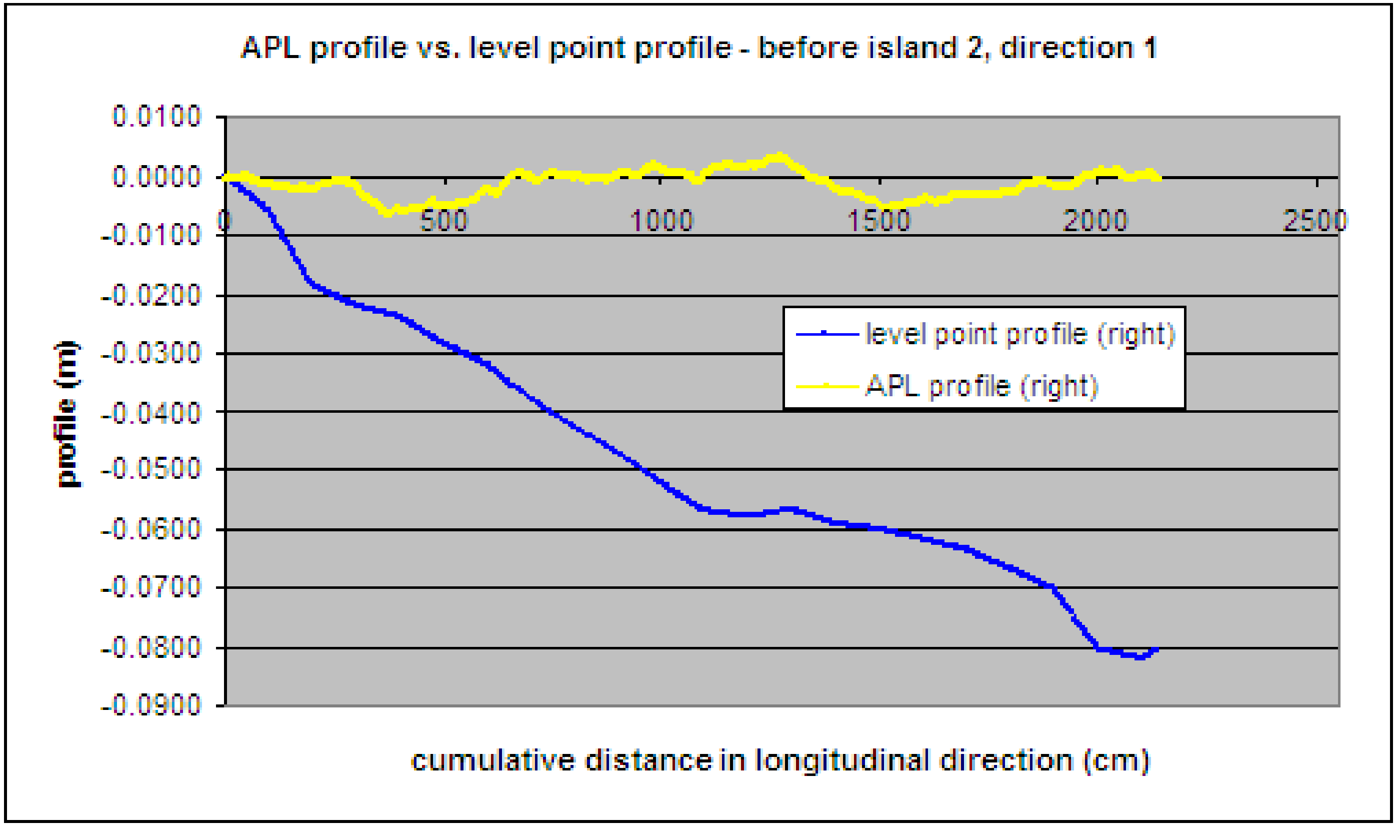
- APL theoretical estimates of TMS: very high values; unrealistic at first sight…
- … but TMS measurements: in some spots >10mm!
- Comparison APL and TMS measurements point by point (see table in paper):
  - similarities and tendencies could be observed
  - but 1-to-1 relationship is impossible due to the very different nature of the measurement techniques
- Therefore we tried to see correspondences between the APL profile and the level point profile. These overlapped rather well…

Comparison APL profile and (local) level point profile



Remark: APL and level point profiles are different in nature

- Level point profile is the real road surface profile.
- APL signal is filtered and is hence <u>not</u> a real road surface profile: long wavelengths are ignored.
- This is clearly illustrated by this local comparison:

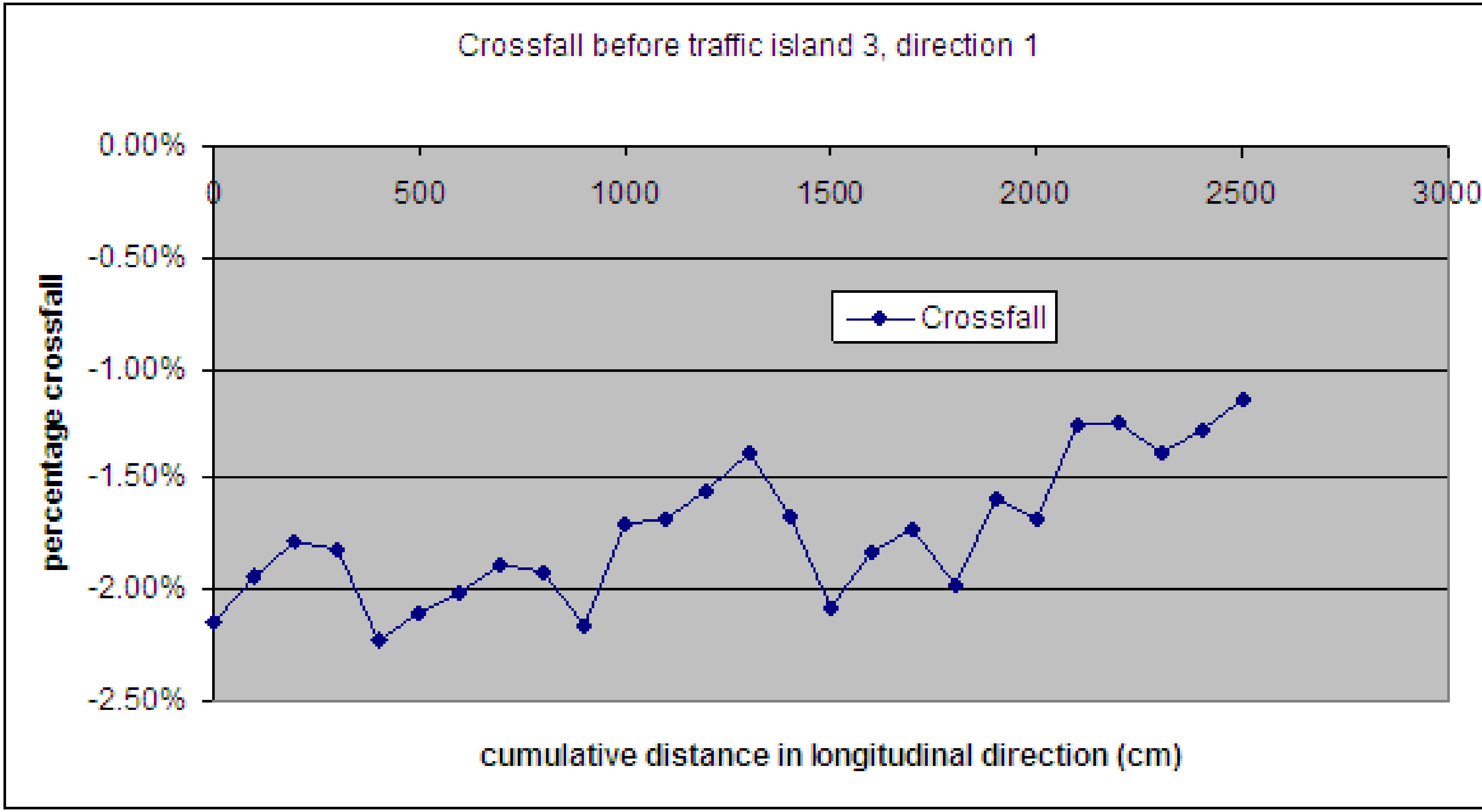


Remark: influence of « cross fall » on APL measurements

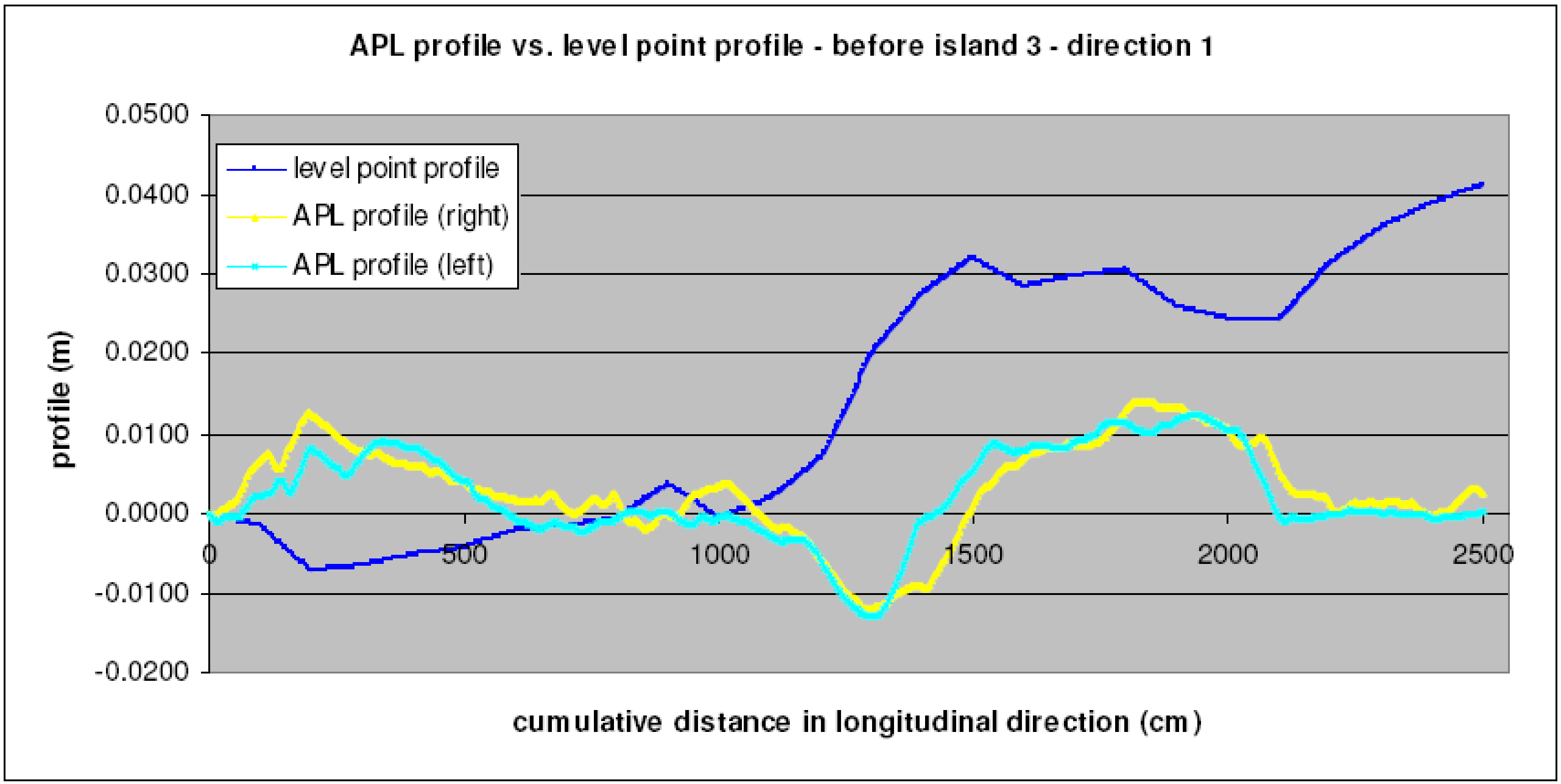
- Attachment between towing car and APL is made for limiting the influence of vertical movements of the car on the measurements.
- During calibration, this potential influence is measured, up to a certain vertical movement: movements of up to +/- 50mm with frequency of 1Hz do not influence the APL by construction, and verified during calibration.
- However, on very bumpy roads, the vertical movement can be more important than what is generated in “laboratory conditions” during calibration…

Influence of cross fall on APL results

Lot of variation of the cross fall:



Noticeable influence on APL



Conclusions for the case

- APL and TMS measurements both showed that evenness was not acceptable.
- APL and TMS measurements, although different in nature, gave comparable results.
- From comparison with level point measurements it was observed that in the very rare cases where APL seemed to overestimate unevenness, there were important variations in cross fall

General conclusions

- APL and TMS give good indication of the evenness characteristic.
- Obviously, APL is a method allowing a rapid measurement on a long distance whereas TMS is a local and extremely precise but slow (punctual) measurement technique.
- Theoretical estimate of height under TMS is good enough in order to make a rapid assessment.
- APL results can be influenced by significant, non monotonous variations of cross fall over a short distance, when this makes the towing car move – but then the unevenness in transverse direction is too important for being acceptable.








Thank you for your attention!

Authors:
Carl Van Geem c.vangeem@brrc.be
Bart Beaumesnil b.beaumesnil@brrc.be