On Low Speed Problem in Road Smoothness Profiling

Vadim Peretroukhine
Michael Nieminen

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Problem Description

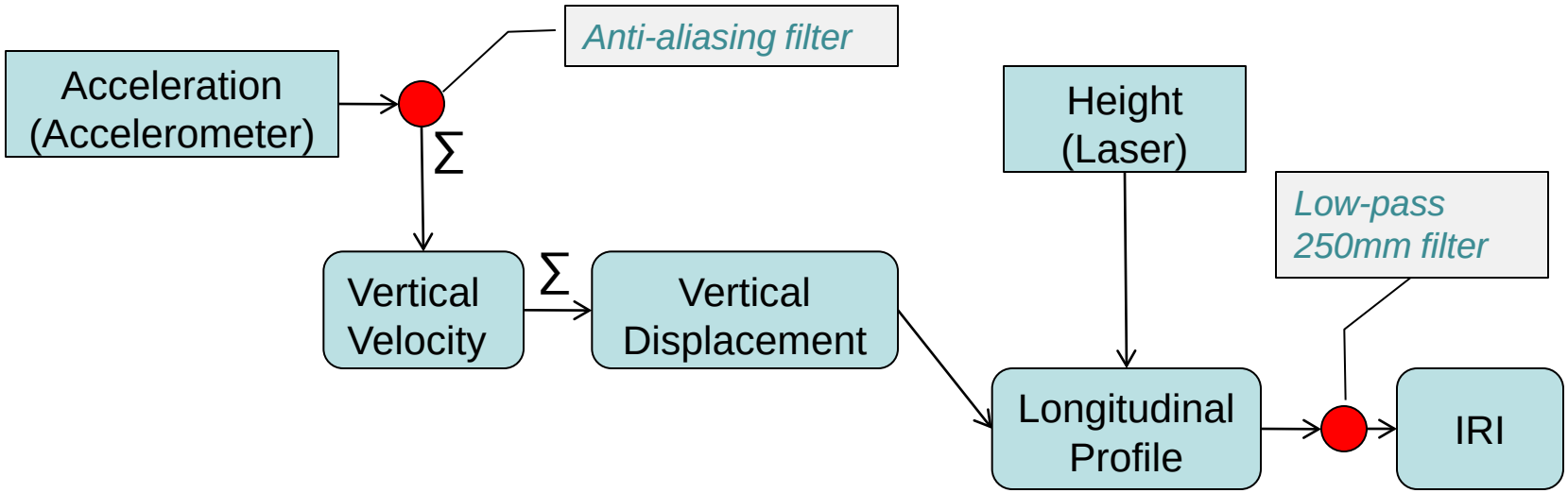
- Usually, the cruiser speed of inertial profiler is between 45 and 60 mph. Practically, from time to time during a collection session profilers have to reduce the speed due to the high traffic volume, traffic lights etc.

- When the speed gets lower, the longitudinal profile is more sensitive to the measurement from the accelerometer. The measurement of the elevation is proportional to the amplitude of the acceleration squared

- As a result, the calculated longitudinal profile and the IRI fail to meet the accuracy and repeatability criteria at lower speeds

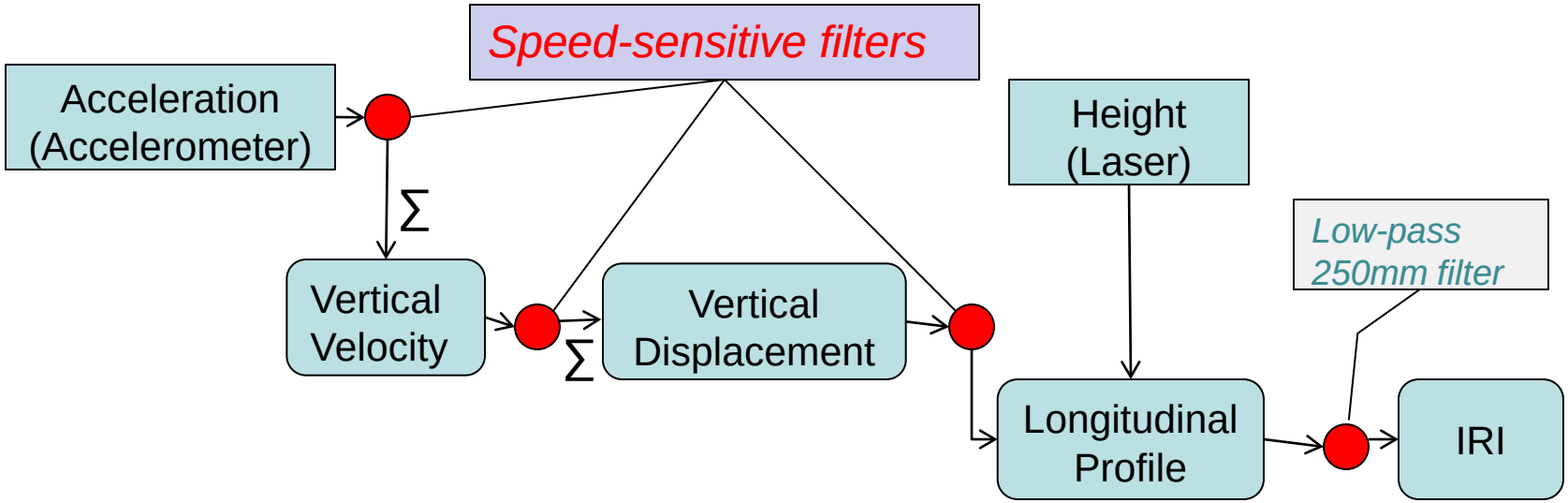
Standard Pipeline

- The principal components of inertial profilers are height sensors, accelerometers, and a distance measuring system
- The typical data pipeline is shown below. The difference between the measurements of the accelerometer (integrated twice) and height sensor is the longitudinal road profile that is the input for calculation of the International Roughness Index (IRI)



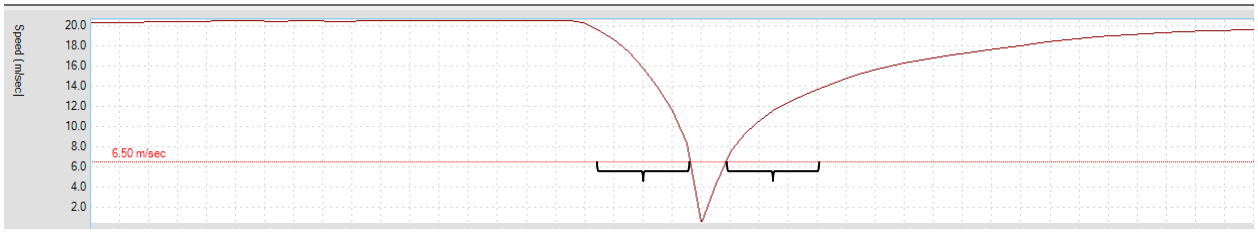
Enhanced Pipeline

- The pipeline is enhanced with speed-sensitive filters that smoothen the accelerometer influence at low-speed zones and remove parasitic frequencies specific for certain low speed intervals
- Resulting longitudinal profile is much closer to the road profile collected at the cruiser speed only



Benefits for Network Collection

- Current practice
  - Exclude from section averages the IRI collected in low speed (<12.5 mph) zones



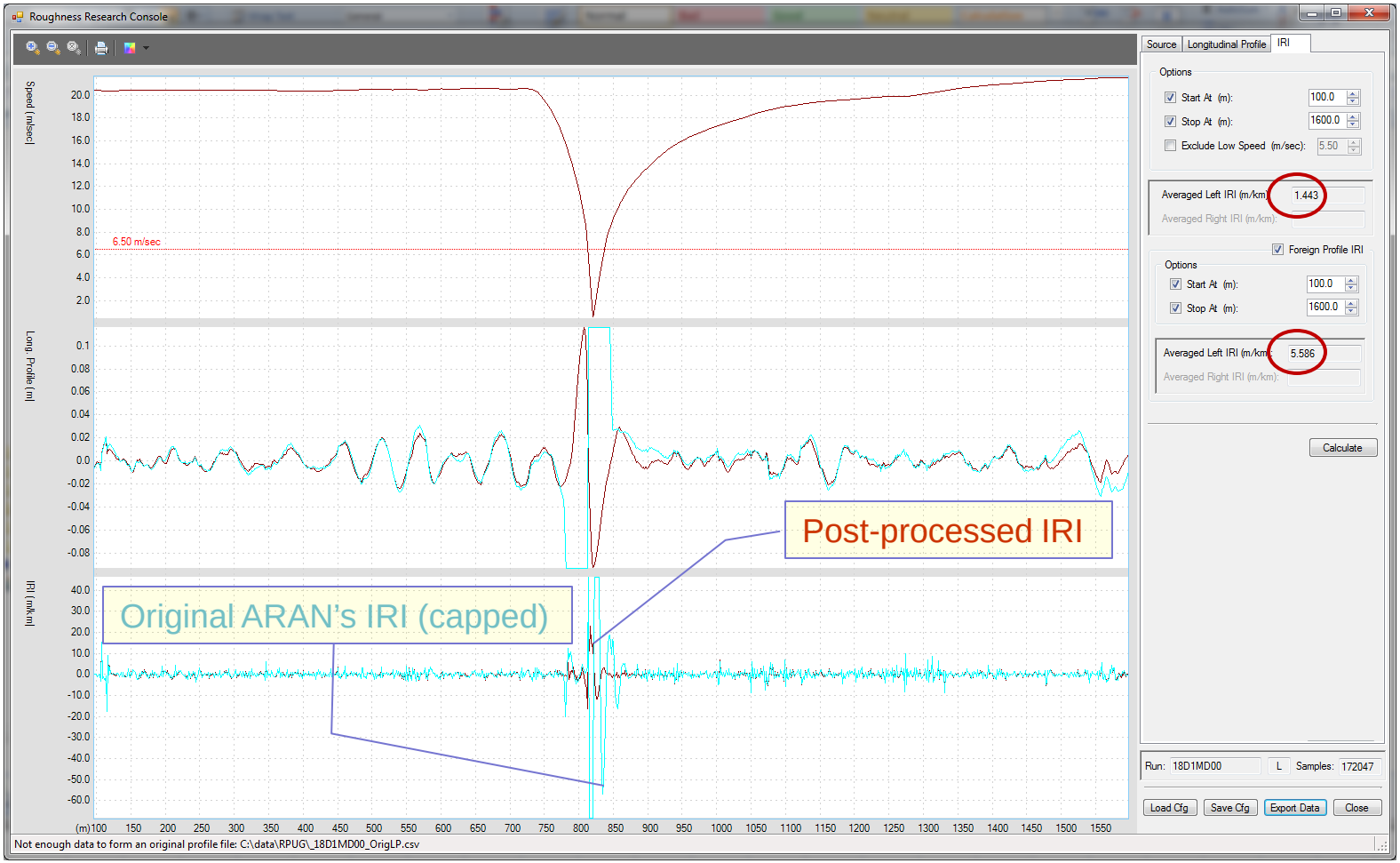
- Benefits of improved filters
  - Minimize invalidation zone
  - Greater coverage of valid IRI

Sample Output 1

- Collection vehicle performed a full stop during a section, resulting in a spike in the longitudinal profile and, consequentially, in a large IRI value
- Post-processing reduced the magnitude of the spike quite dramatically

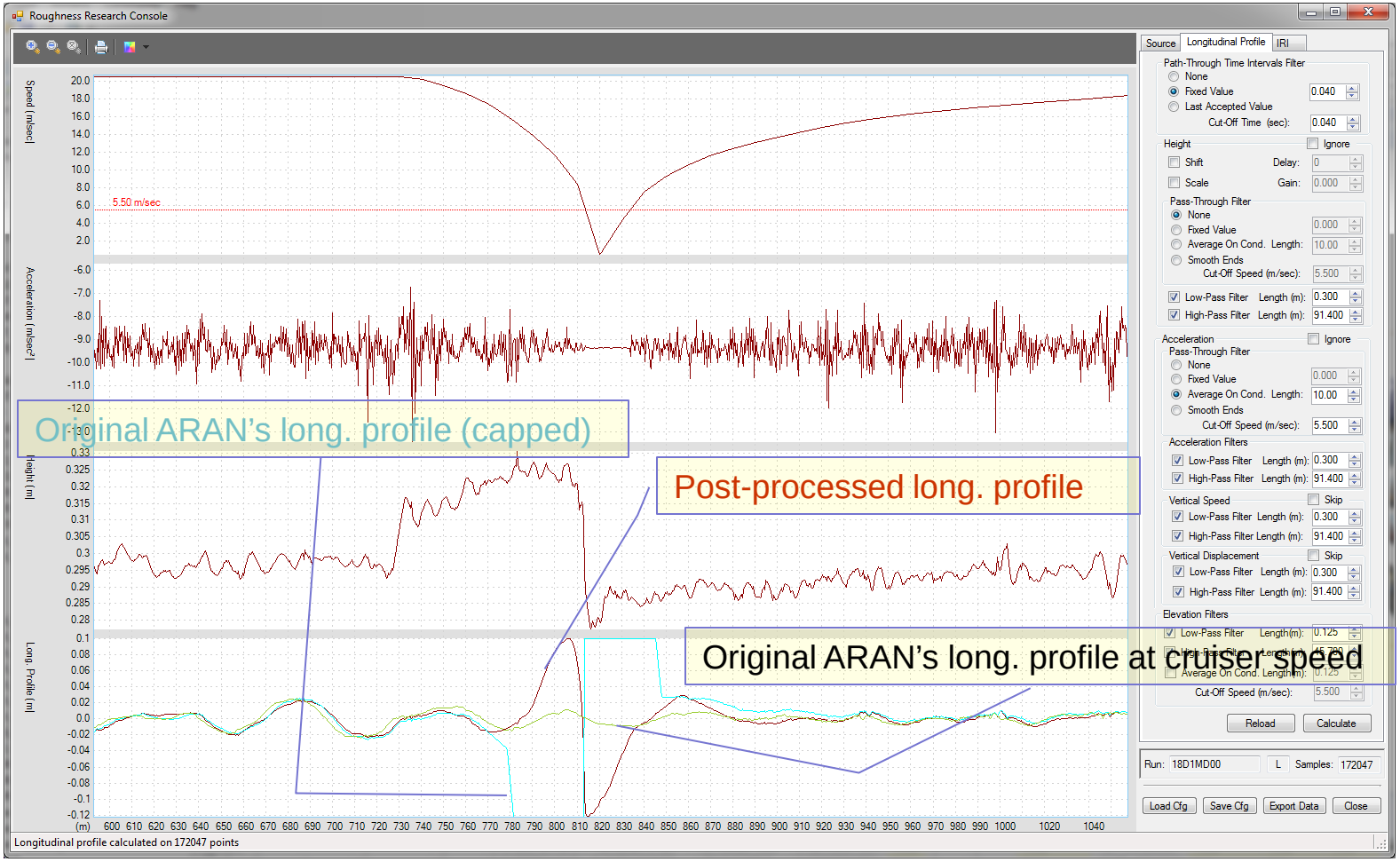
Sample Output 2

- Spike in instantaneous IRI is also reduced
- Average IRI for the section dropped from 354 in/mile to 91 in/mile (actual is 86 in/mile)



Sample Output 3

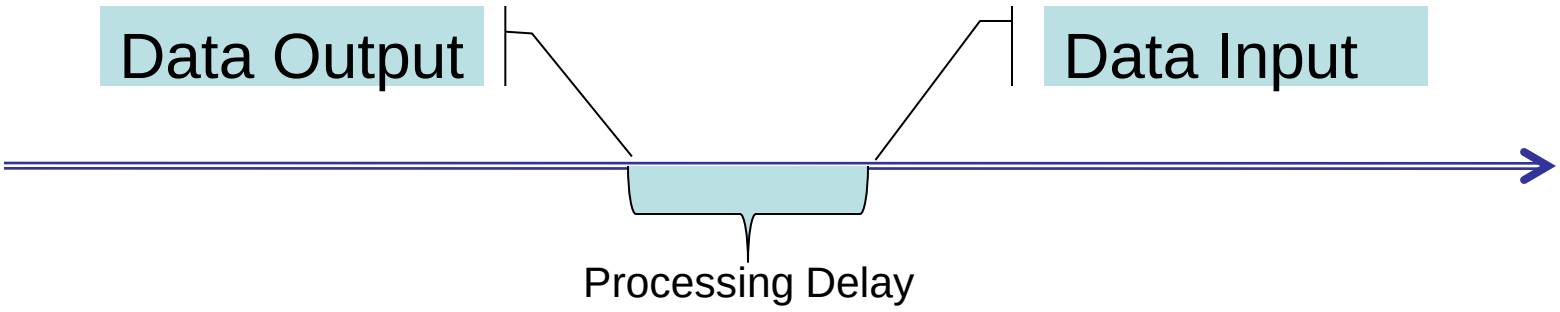
• Compared with the profile collected at cruiser speed, we still can see some disturbance but at much smaller magnitude than for the original one



Non-Casual Filters

- Our speed-dependent filters are non-casual
- The longitudinal profile and the IRI indexes can be calculated as

1. A post-processing activity based on the collected raw data.
2. A pseudo real-time procedure with the delay that is approximately equal to the sum of the base lengths of all used filters in the enhanced pipeline.



Future Directions

- Continue to work on improving the repeatability of the profiles calculated with a new technique for the collection sessions with low speed zones.
- Apply the same technique to different accelerator models in order to understand how the set of the speed-sensitive filters must be tuned for specific hardware
- Define and use typical patterns, such as the measured height volatility during the sudden deceleration of the truck, for improving the correlation of the calculated profile with the profile collected at the cruiser speed
- Incorporate data from other sensors during low speed zones to improve calculation of inertial reference

Why Care?

- IRI is part of the standard HPMS reporting
  - Small sample sections
  - Difficult to get accurate data on some sections
  - Improving low speed roughness can help
- Enable a consistent standard measure (IRI) to be used in both urban and rural environments
- Longitudinal profile and IRI are widespread measurements
  - High accuracy and robustness has common benefit
  - Low cost measurement also helps developing nations measure and manage infrastructure investments

Questions?

Thank You