Assessment of integration method for displacement determination using field accelerometer and geophone data

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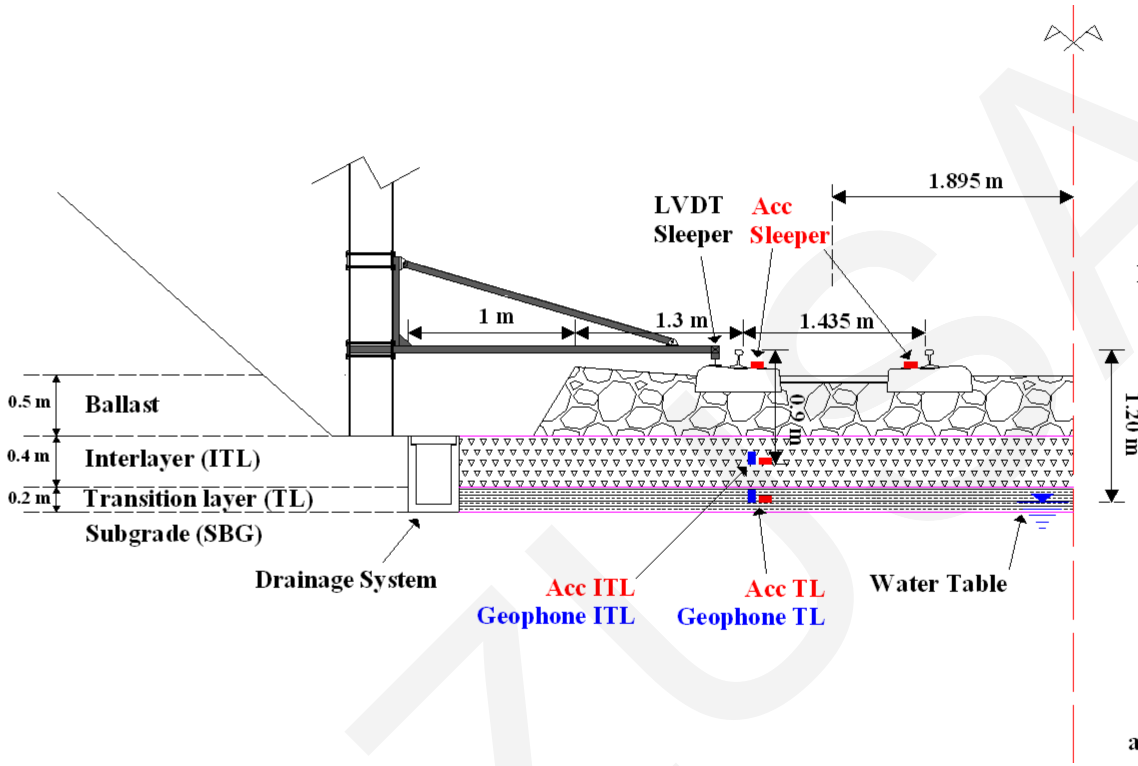
INTRODUCTION

- A conventional French railway track was instrumented with accelerometers and geophones at three depths: sleeper (surface), interlayer (ITL / z = -0.93 m), and transition layer (TL / z = -1.20 m). A LVDT was also used to monitor the displacement at the sleeper level.
- It is important to evaluate the mechanical behaviour of railway trackbeds by field monitoring in order to assess the track's response

QUESTIONS TO BE ADRESSED

- To define **how to filter and analyze the recorded accelerometer signals** at different depths of the platform
- To assess the method of **filtering and integrating** the accelerometer signal
- To estimate the **order of magnitude of the Interlayer's axial strain** at an experimental site

INSTRUMENTED TRACK



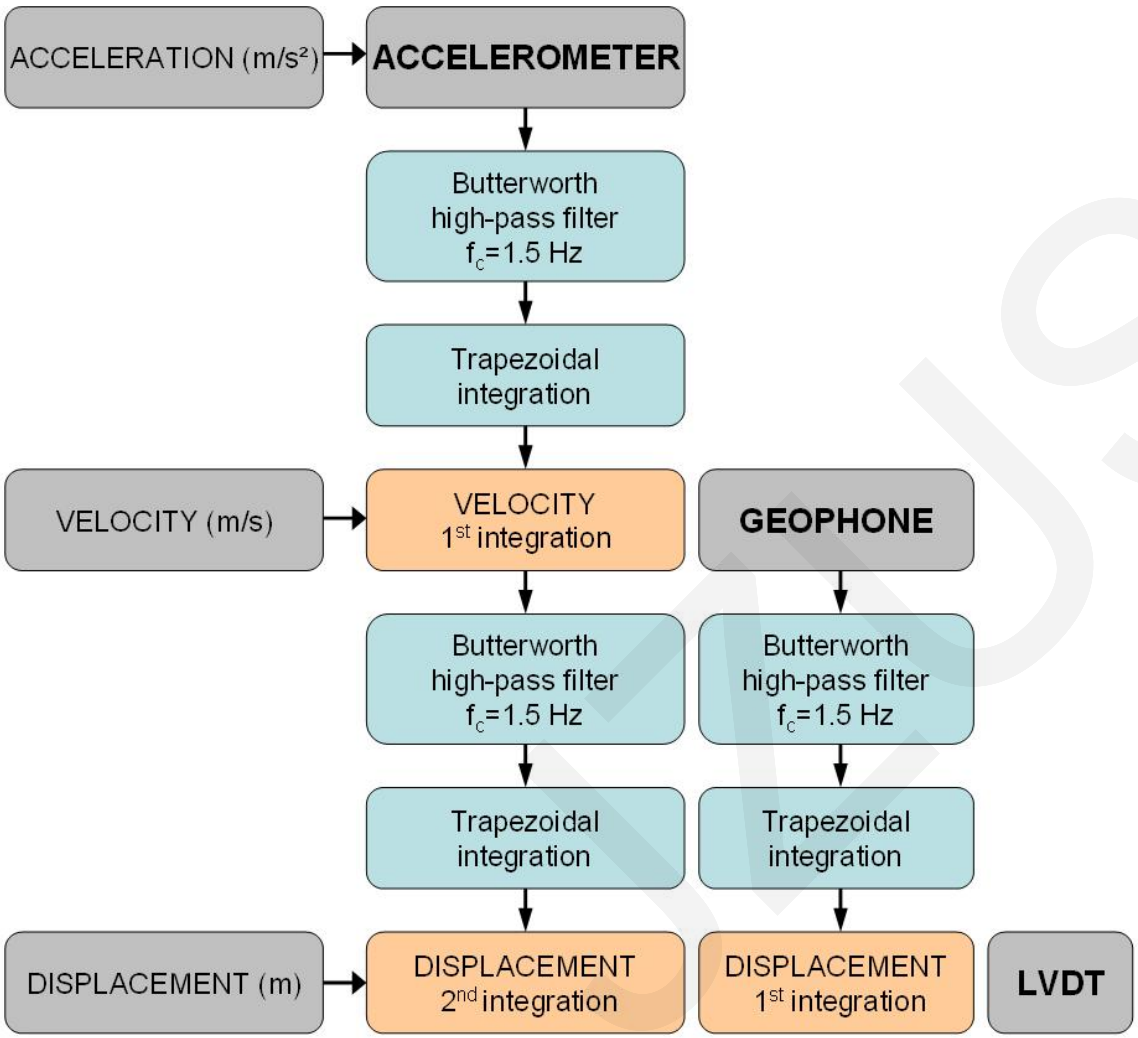
LVDT and accelerometer on sleeper

Installation of embeeded accelerometers and geophones

Instrumented track scheme

- **3 different depths and 3 different types of measurements: LVDT, Geophone and Accelerometer**

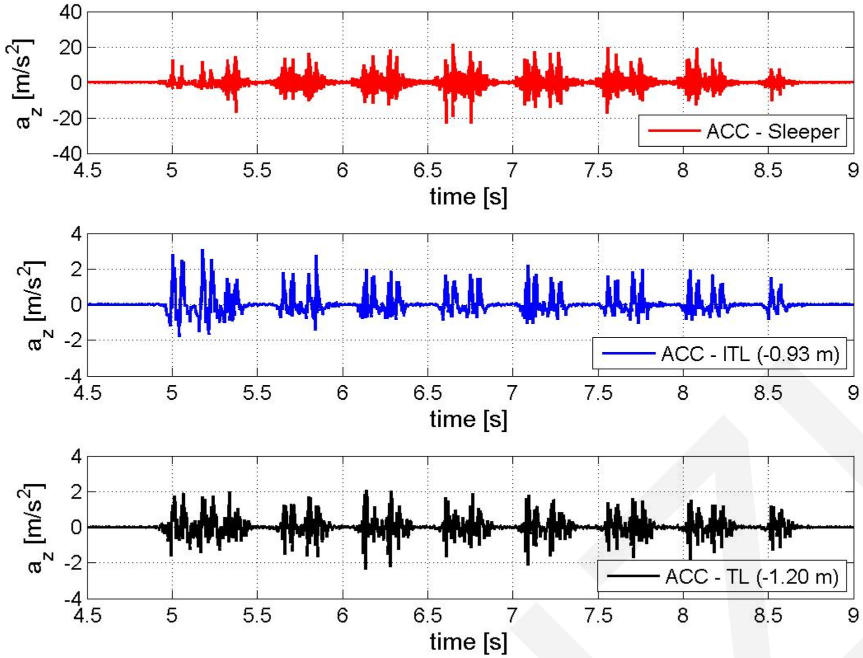
INTEGRATION PROCESS



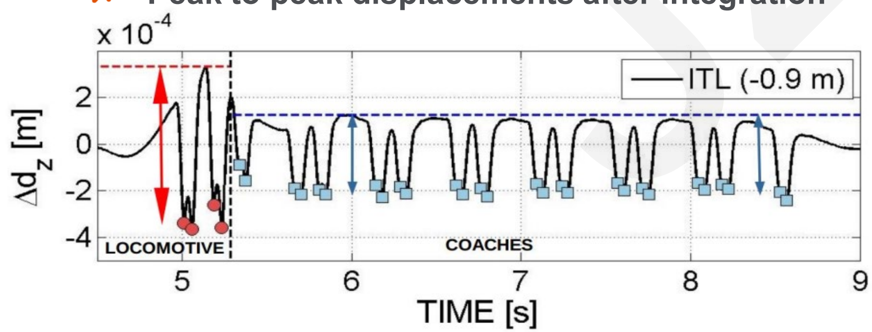
- **Depends on signal type: displacement, velocity or acceleration**
- **Very low frequencies are filtered in order to avoid baseline effects**
- **Filters are applied in both senses of the signal vector**
- **Butterworth filters are preferred because of the simplicity of their parameters and no distortion of near-filter frequencies**

ACCELEROMETERS IN RAILWAY MONITORING

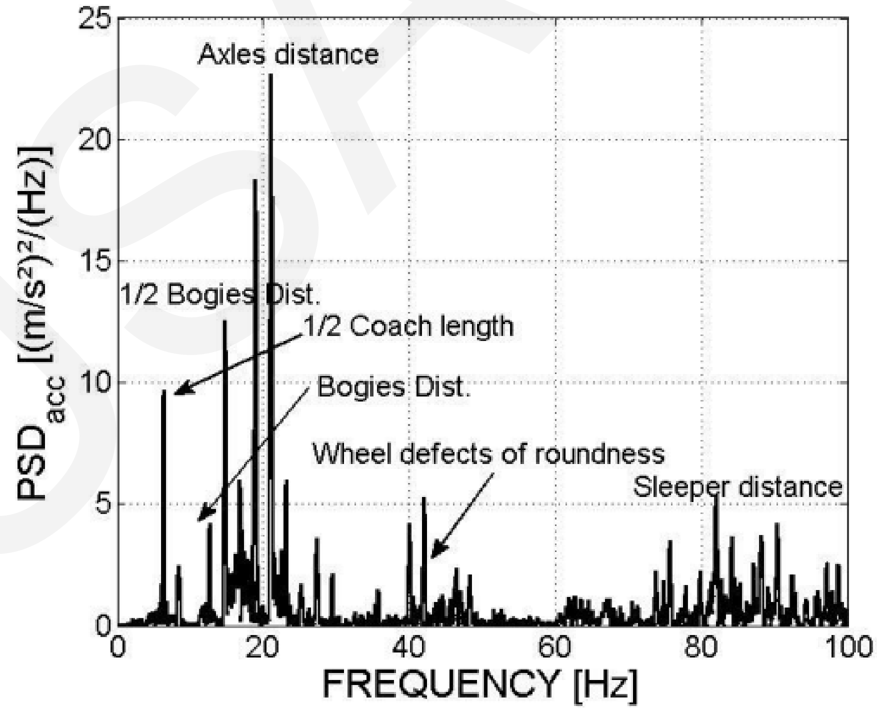
- **Acceleration at three depths in time domain**



- **Peak to peak displacements after integration**

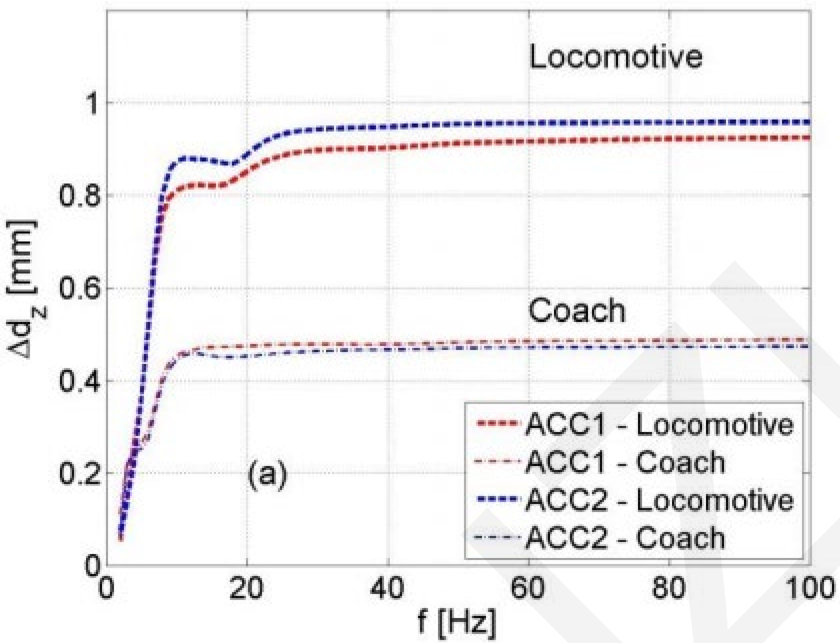


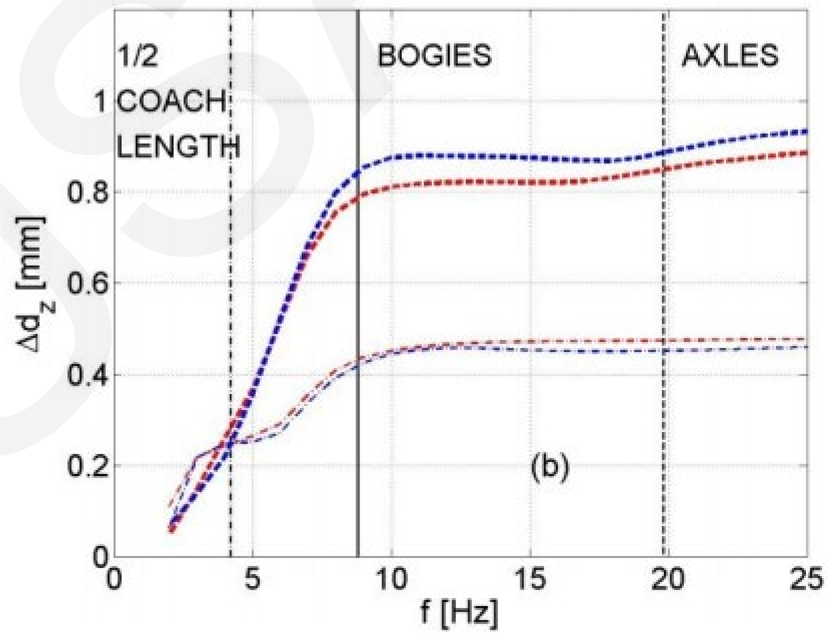
- **Scheme of acceleration in frequency domain**



RESPONSE REPEATABILITY

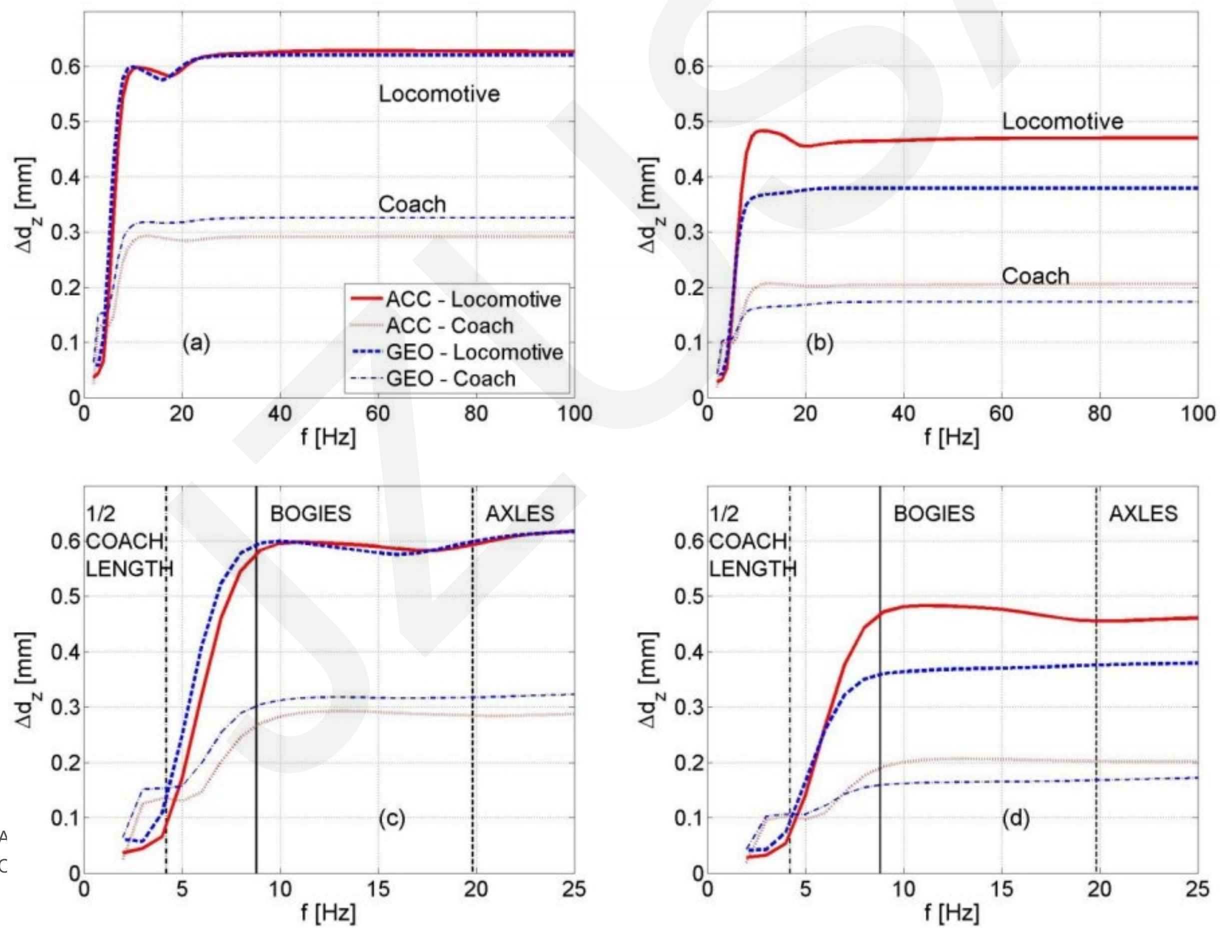
- **Comparison in frequency domain, of peak-to-peak displacement, between accelerometers on same sleeper (at surface) in order to test repeatability**





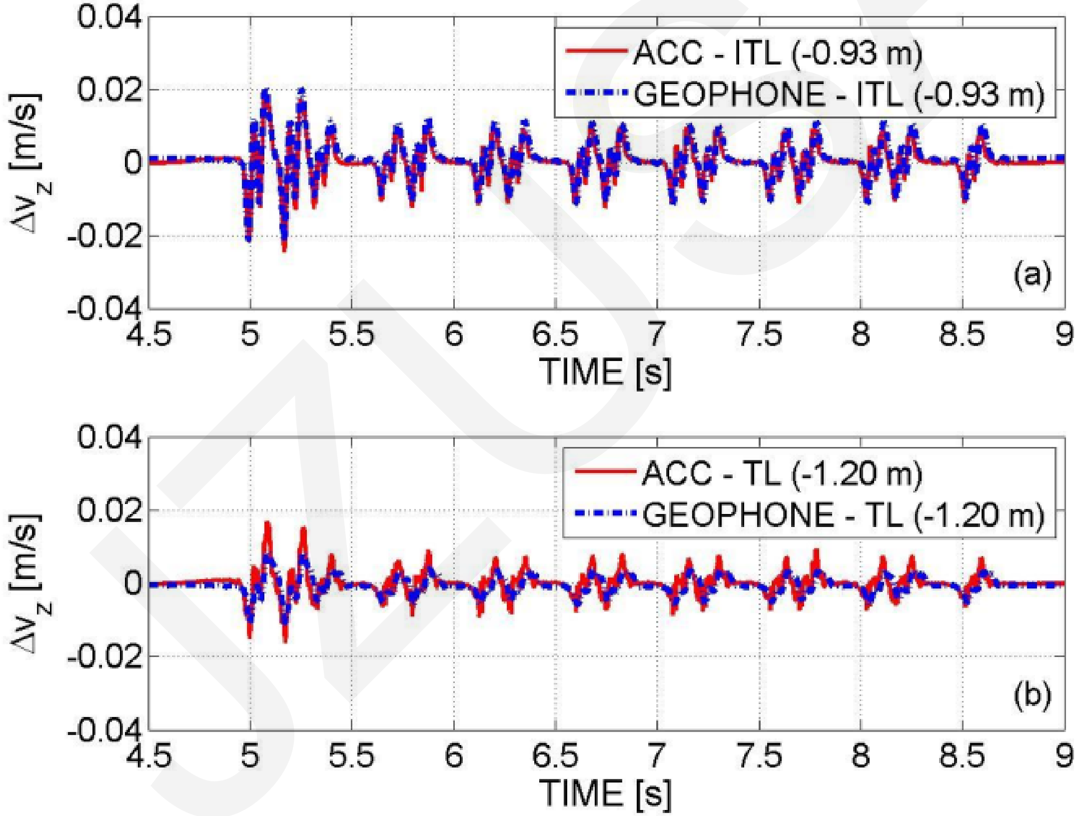
SENSOR COMPARISON

- The response of different sensors is equivalent after integration. Below: comparison between integrated accelerometer and geophone, installed at same depth. More than 92% of total displacement amplitude is developed by the first 25 Hz at all analyzed depths



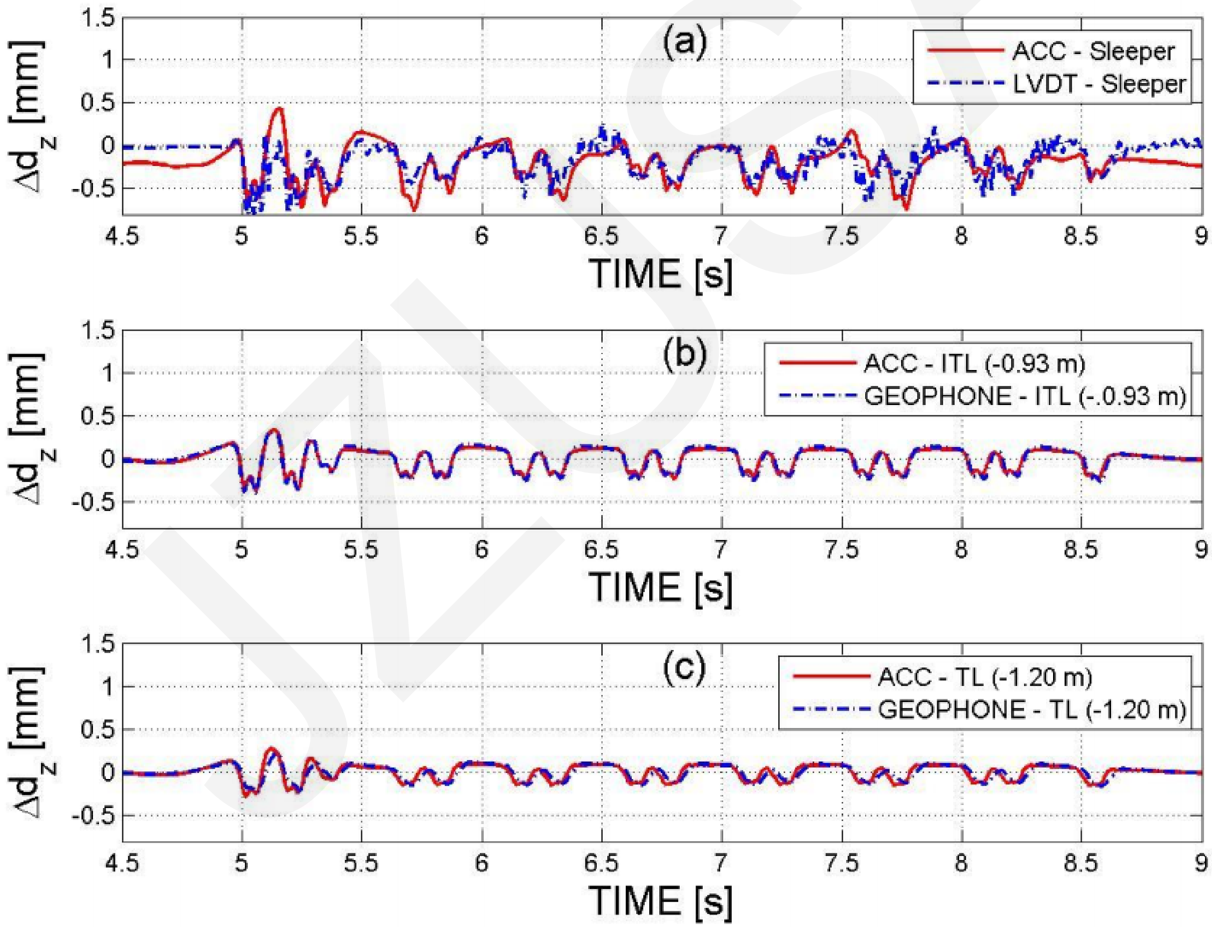
SENSOR COMPARISON

- The response of different sensors is equivalent after integration even in time domain. Velocities from geophone and integrated accelerometer.



DISPLACEMENT AMPLITUDE COMPARISON

- **Time domain displacement signal, measured or calculated after integration, from different sensors are also equivalent at (a) Sleeper, (b) Interlayer and (c) Transition Layer**



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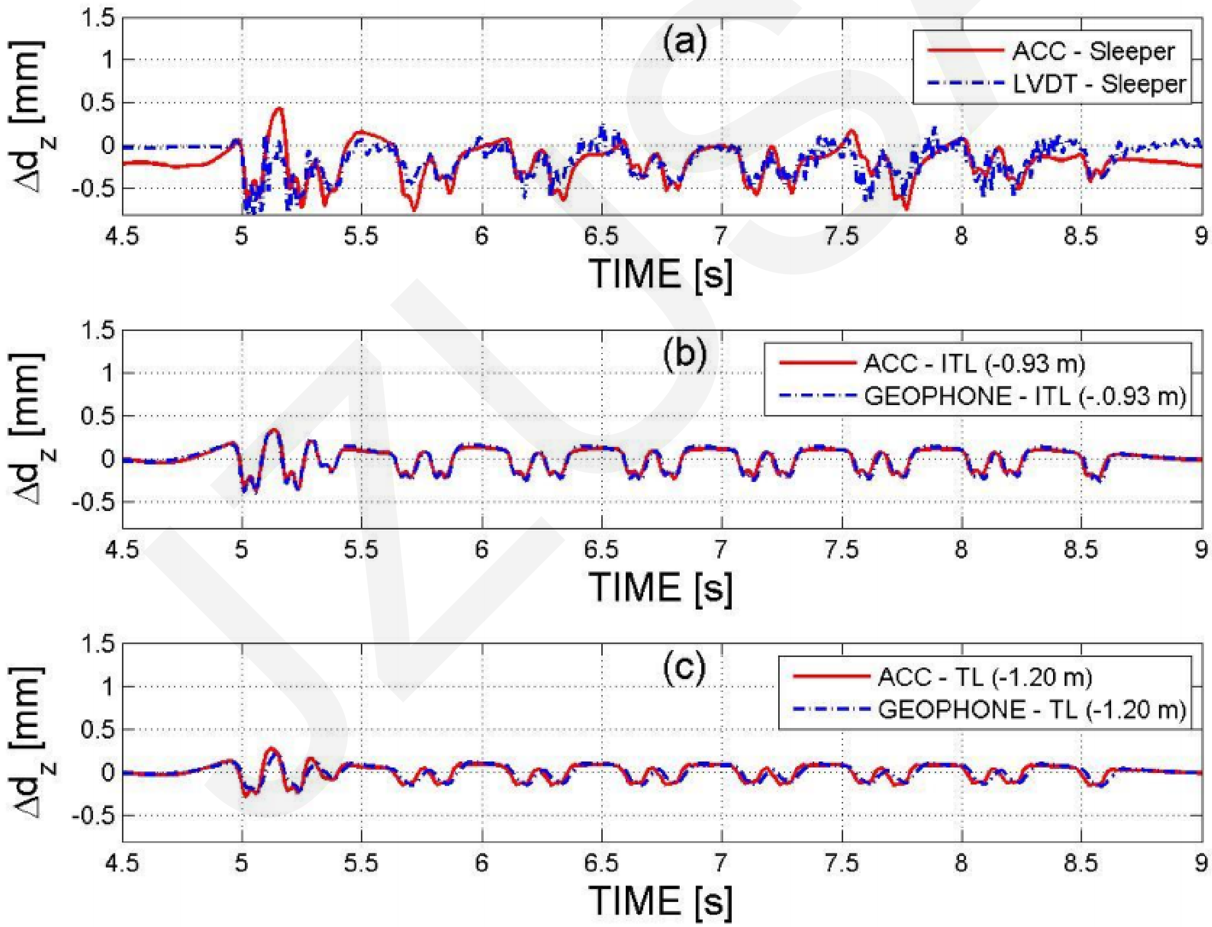
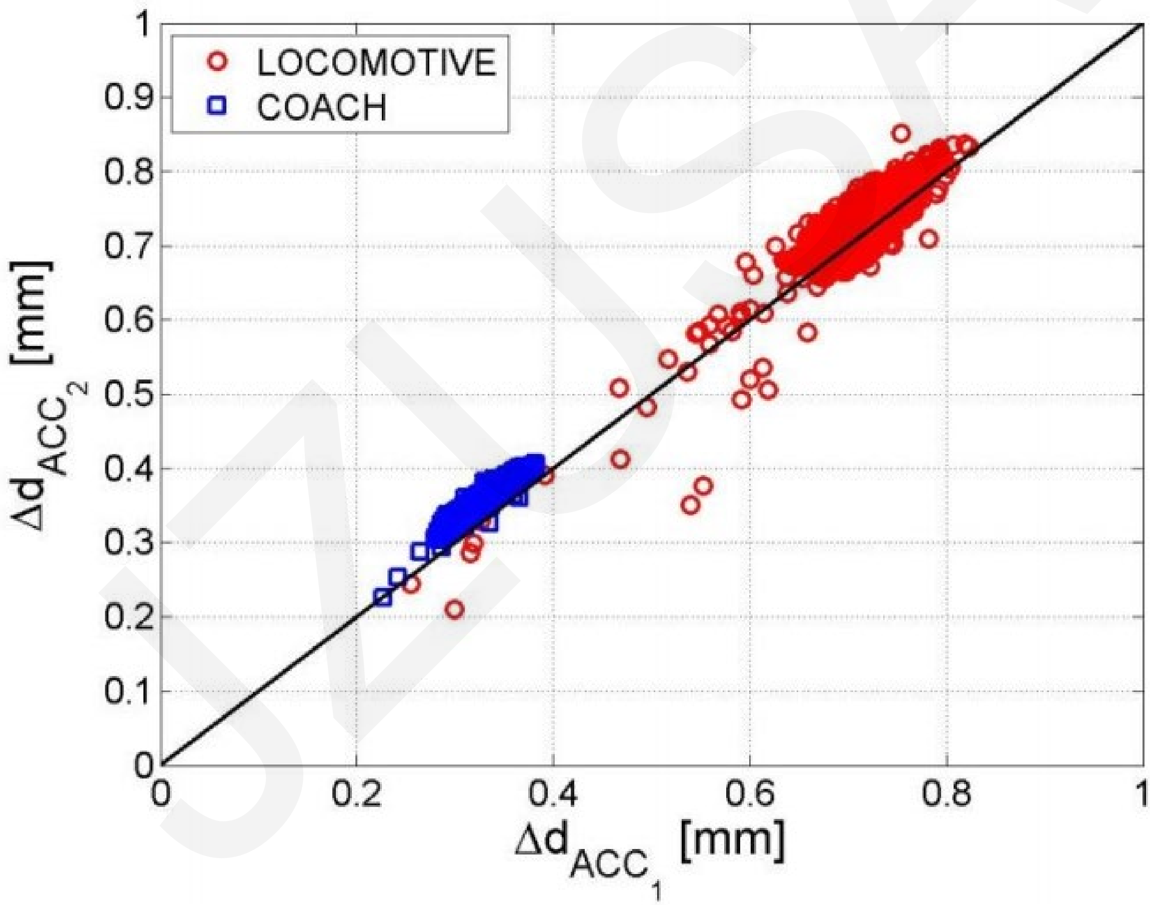


DISPLACEMENT AMPLITUDE COMPARISON

- A good repeatability of displacement amplitude is also obtained from different sensors under same loading



CONCLUSIONS

- An appropriate filtering is needed to process the signal from accelerometers or geophones in order to obtain displacements
- The **acceleration** amplitude in time domain is strongly dependent on the **high frequencies** signal
- The particle's **velocity** amplitude in time domain is dependent on the **low & mid frequencies** signal
- The particle's **displacement** is very dependent on the **low frequencies** signal. Frequencies under 25 Hz cause more than 92% of total displacement amplitude
- In order to **avoid the baseline effect** we have to filter the very low frequencies excitation from the signal (almost in piezoelectric accelerometers)
- The accelerometers data can be used **to satisfactorily estimate the strains** of a soil layer by integrating both accelerometers at different depths and virtually translating one accelerometer in parallel direction to train passage