



ISTA Field Data Workshop II

Practical Benefits and
Issues using Sampled
Vibration Data

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Pira International

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Introduction



Practical Benefits and Issues using Sampled Vibration Data

Vibration: the ups and the downs

The *journey* of data from bed of truck to packaged product on the vibration table



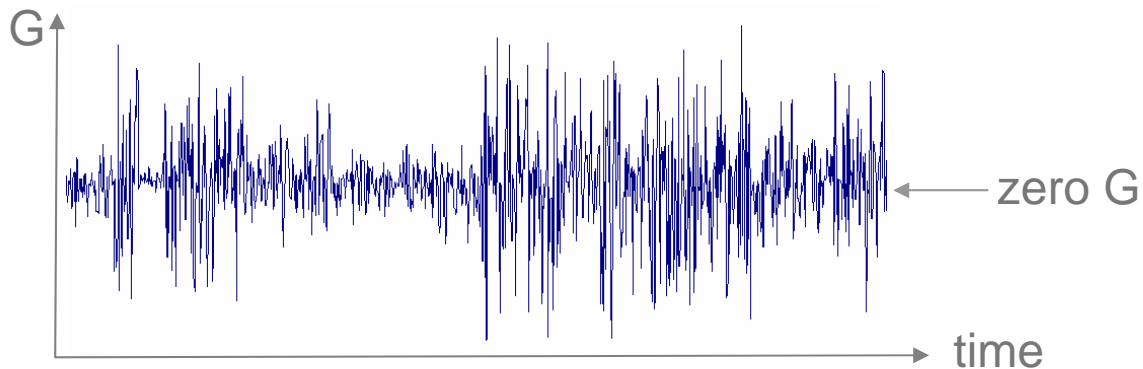
Vibration: the ups and the downs



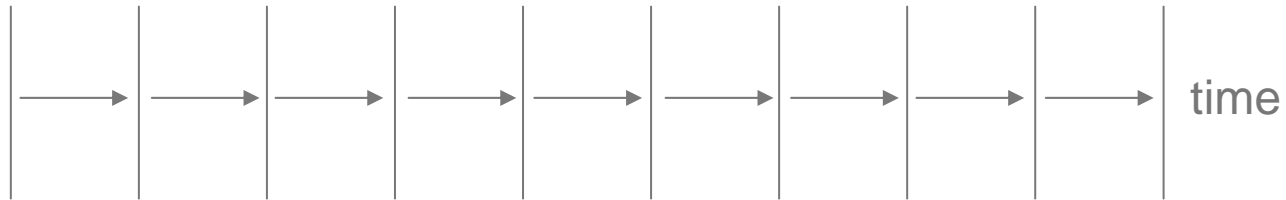
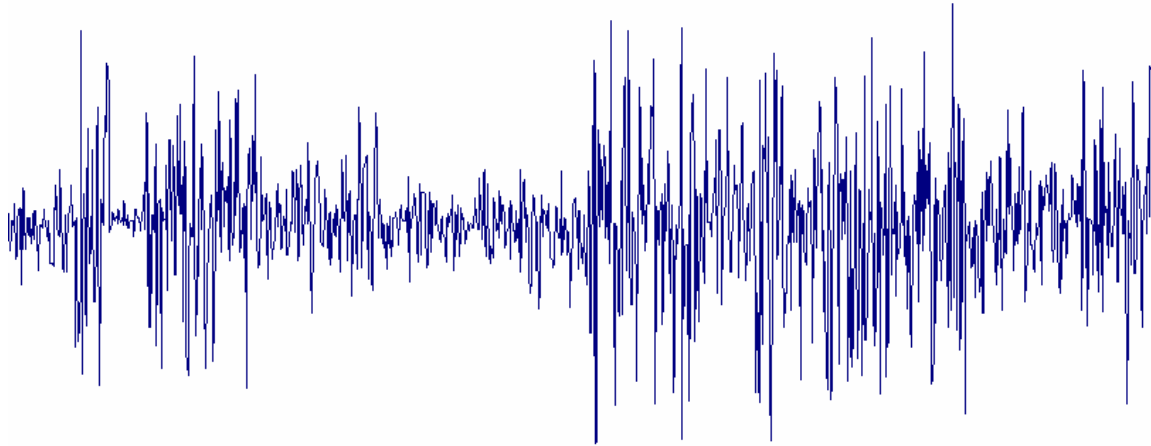
analogue



*digital
signal*



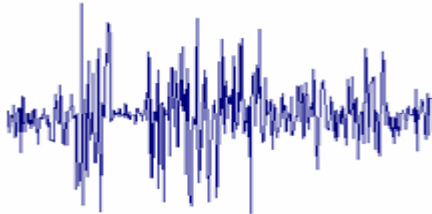
Digital signal



Split in to equal time segments and stored in the recorder memory

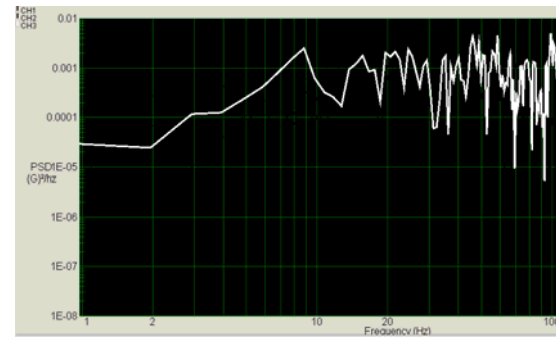
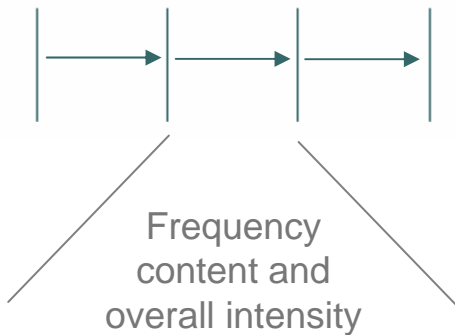


Start of analysis

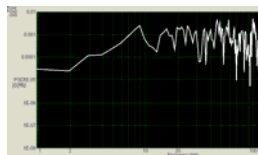
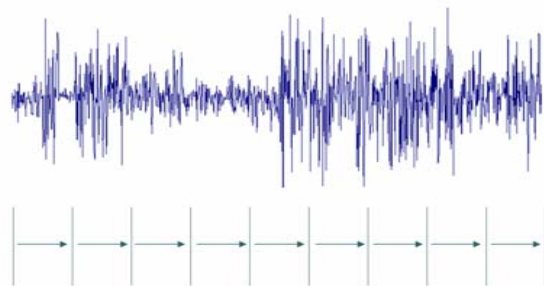


Grms = sq root area under curve

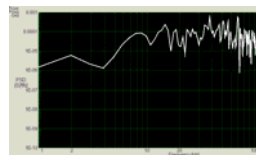
Grms: 0.23



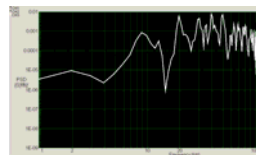
Series of PDS



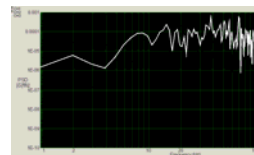
0.3 Grms



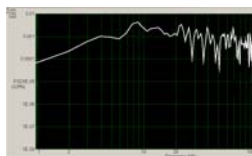
0.5 Grms



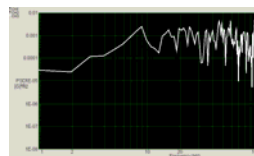
0.2 Grms



0.4 Grms



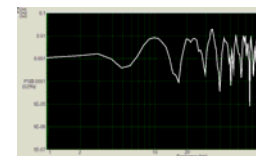
0.3 Grms



0.3 Grms



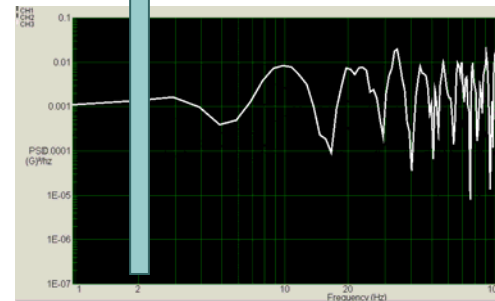
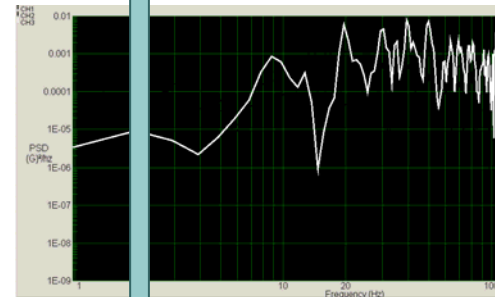
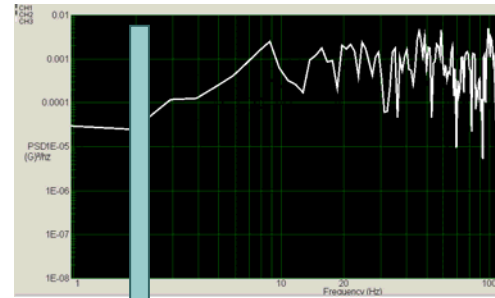
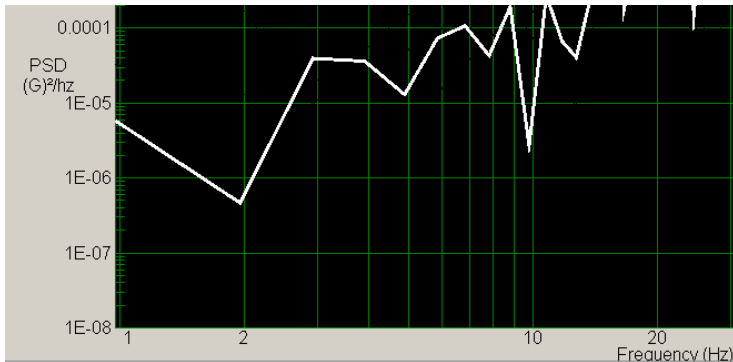
0.2 Grms



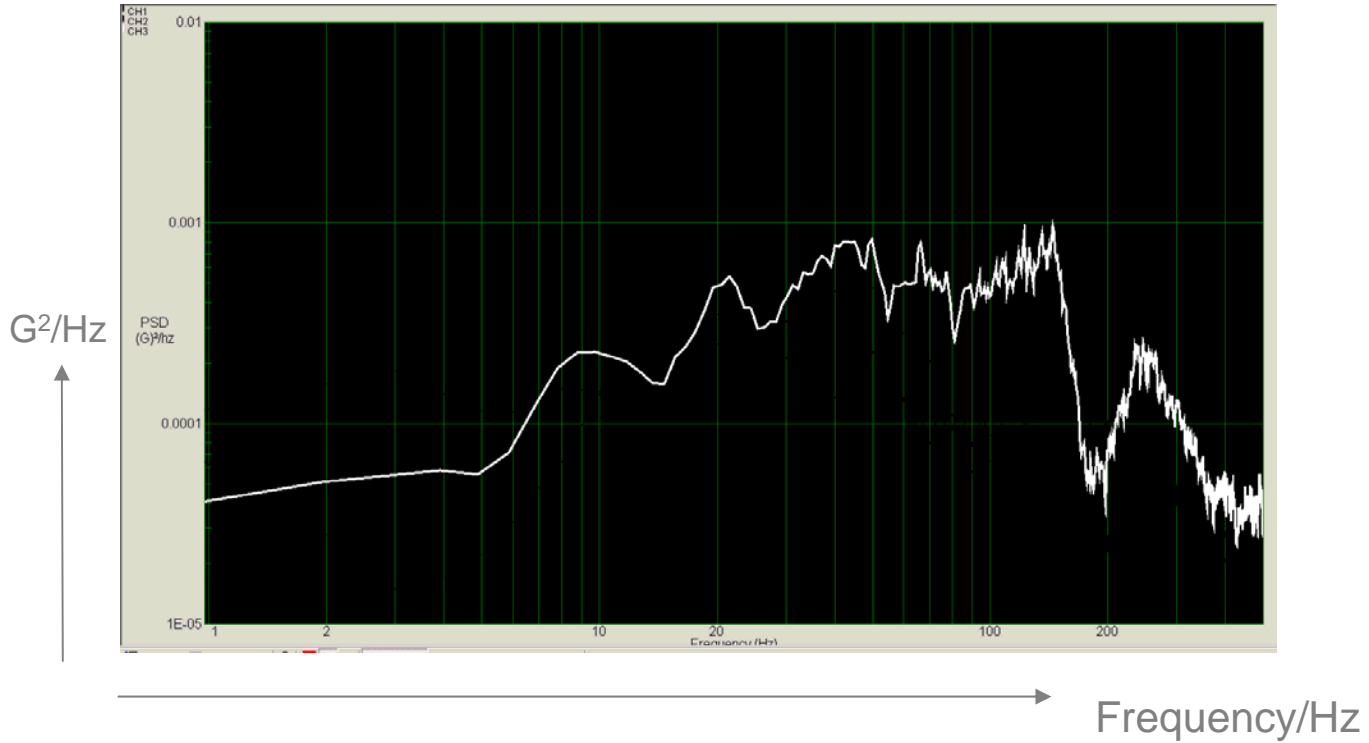
0.4 Grms

Overall PDS

- Maths generates overall spectrum (a representation of the journey)
- For each frequency bin the maths is averaging the intensity of vibration for that frequency across all the *selected* events
- Delivers an overall Grms



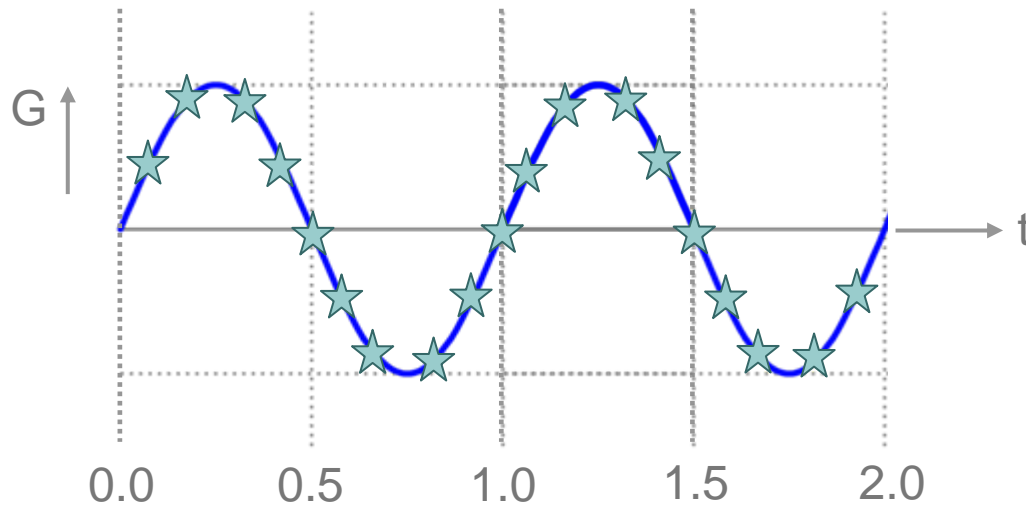
Overall PDS



Key set-up parameters



- Sampling rate



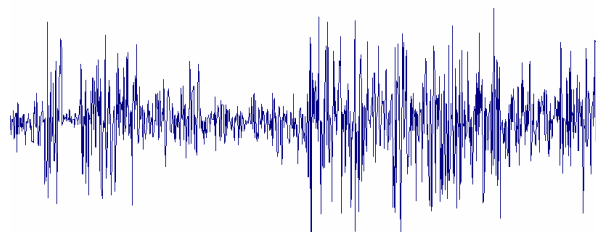
1 Hz signal

Sampling at 10 Hz

aliasing

Key set-up parameters

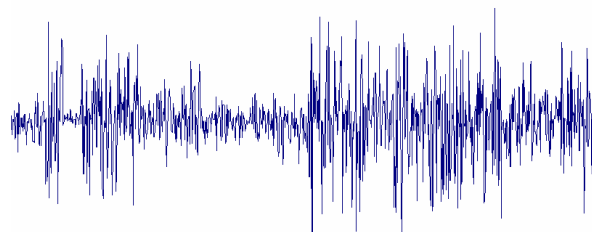
- Record time



If record period is too short,
analysis can't resolve low
frequency content

Record needs to be 1 second
long to resolve down to 1 Hz

Record needs to be 2 seconds
to resolve down to 0.5 Hz



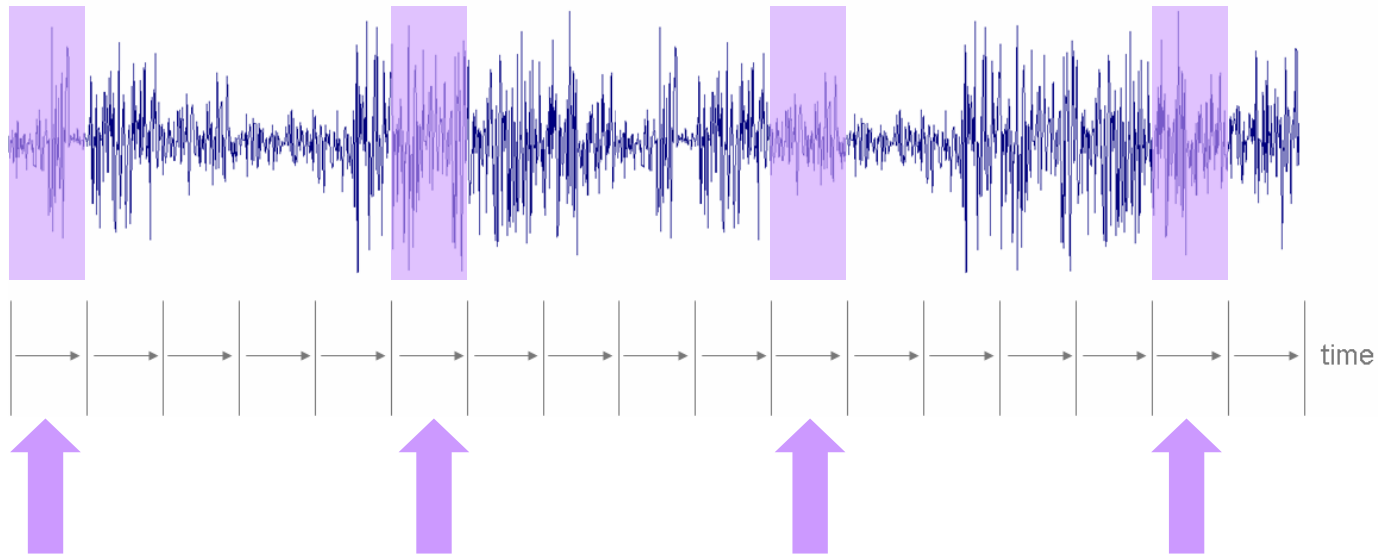
If record period is too long,
then higher energy vibration
is lost in averaging

For the vast majority of
situations, 1 to 2 second
period is appropriate

Key set-up parameters



- Data capture mode

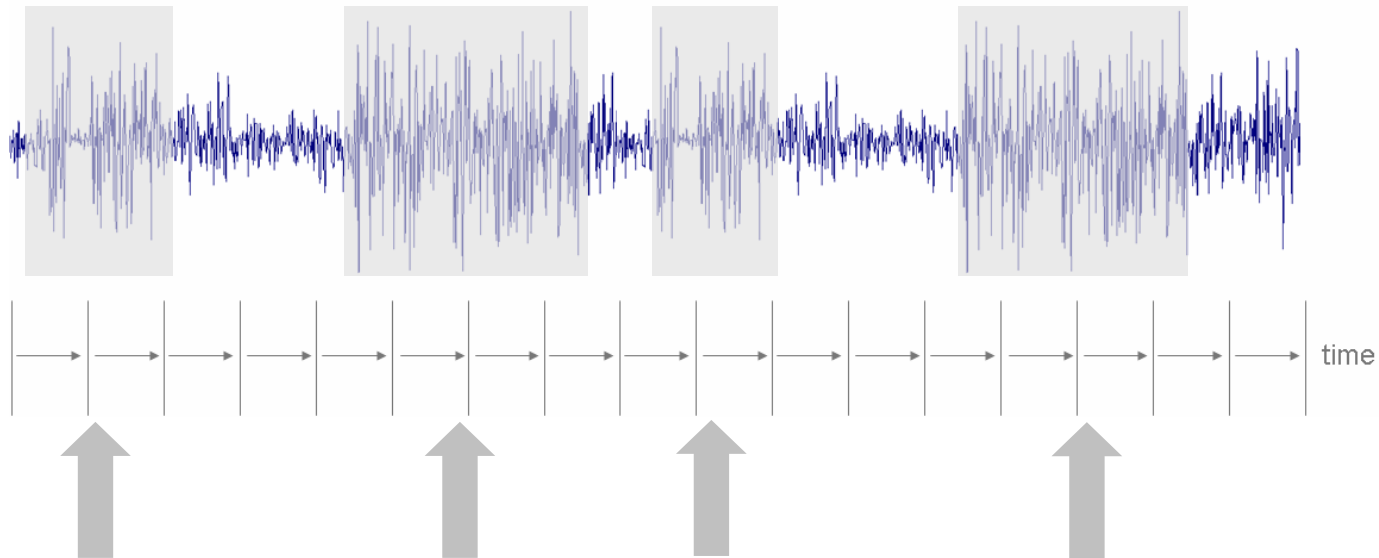


Capture on time basis

Key set-up parameters

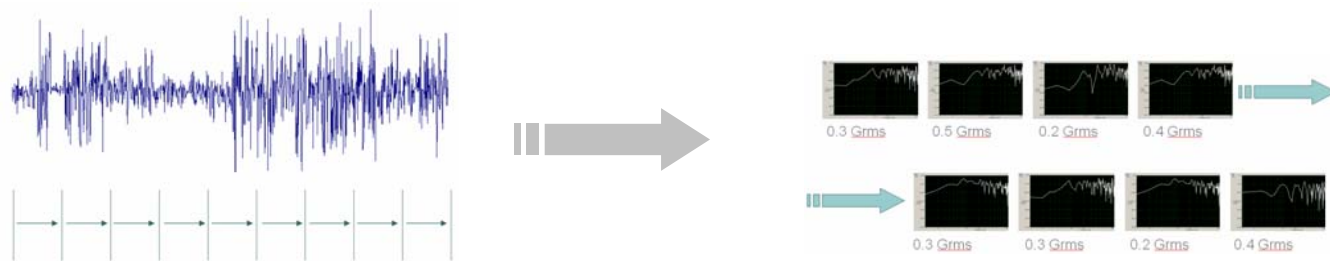


- Data capture mode

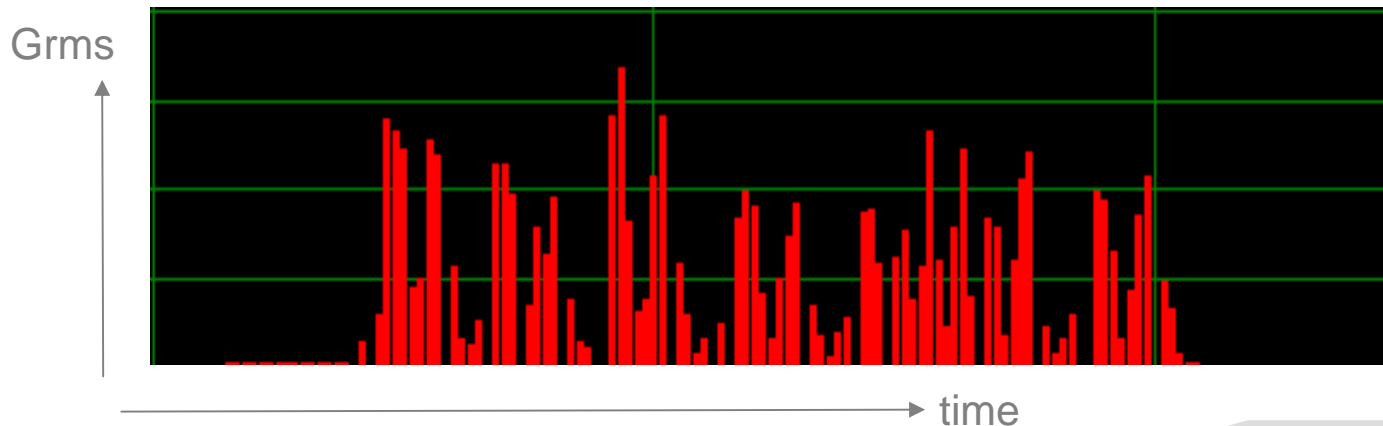


Capture on signal basis

Capture mode



As well as the frequency content, need to gather sufficient information to understand range and population of Grms levels

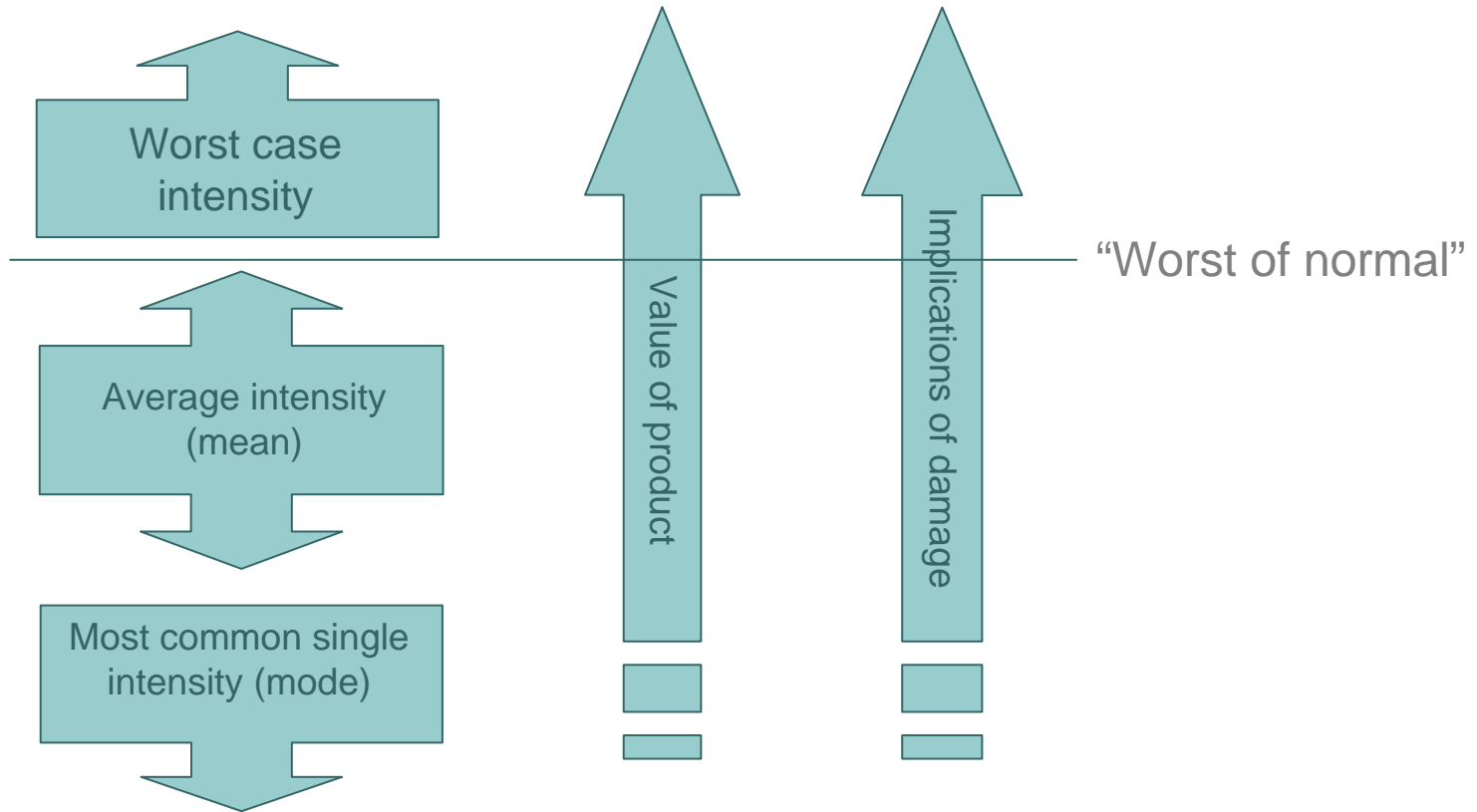


Data recorder set-up

Objective of test



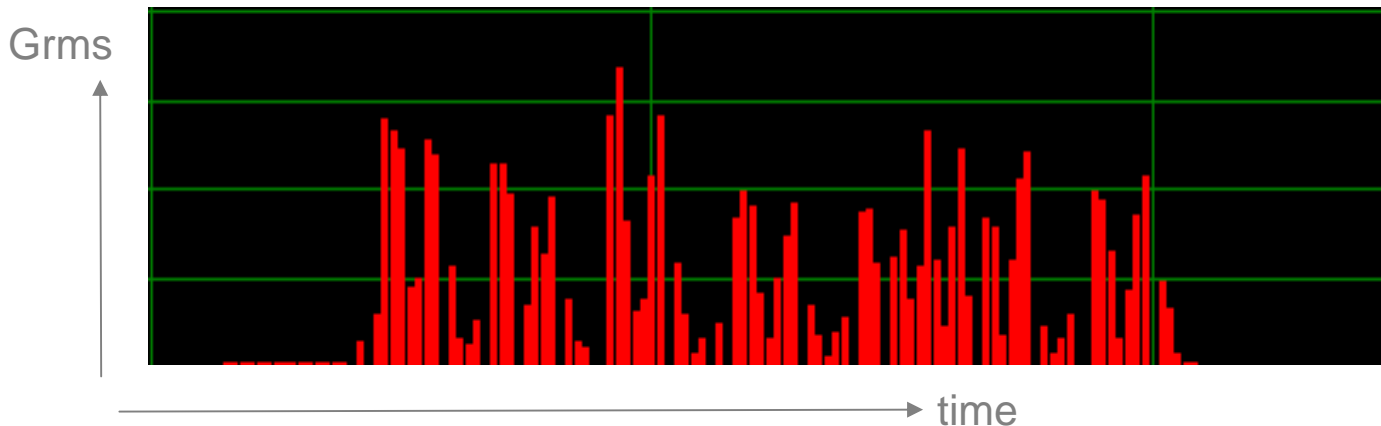
What are you trying to re-create on the vibration table in the lab?



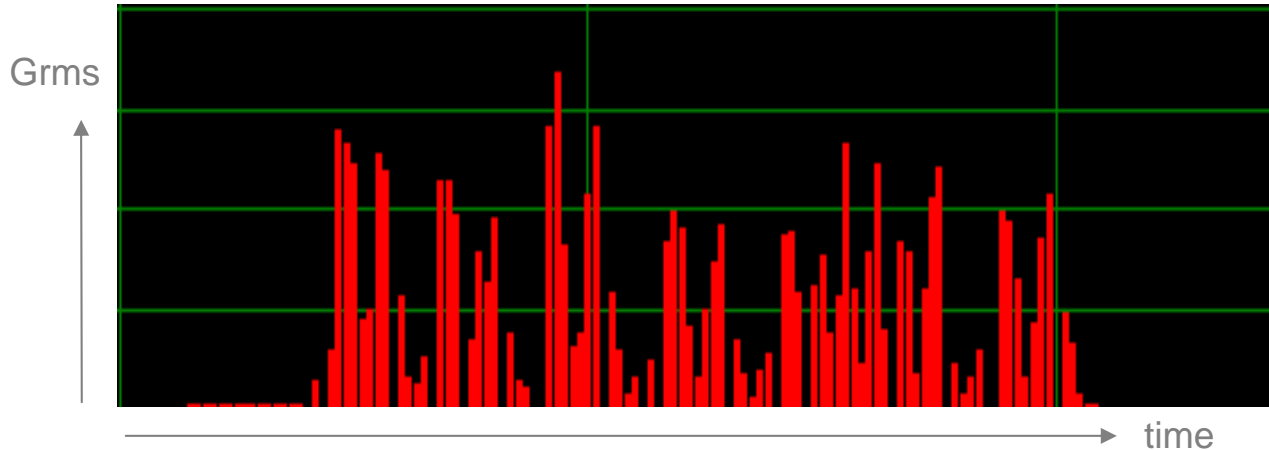
Capture mode



- Modern data recorders have large memory capacity
- For most journeys adequate memory to capture data representing the range of conditions using time triggered capture basis
- Personally: still like to capture a quantity of data on signal triggering (allows sense check of time triggered data)

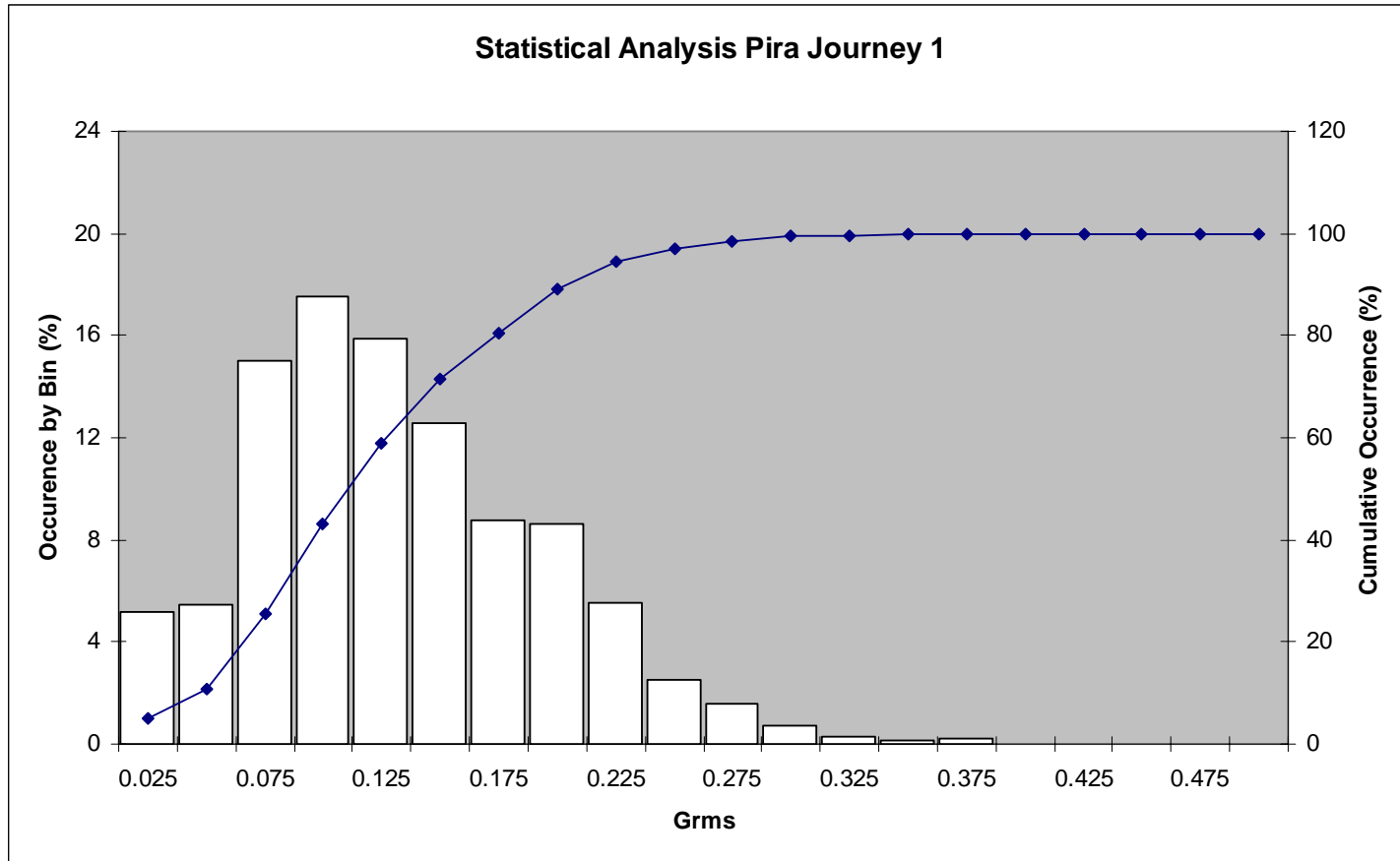


Grms throughout journey

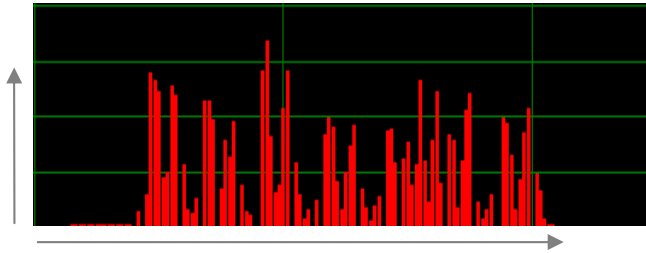


- Package testing research community...debate on how to manage the variability of Grms throughout the journey
 - If Grms is consistent, data is stationary
 - If Grms is highly variable, data is non-stationary

Grms throughout journey



Grms throughout journey

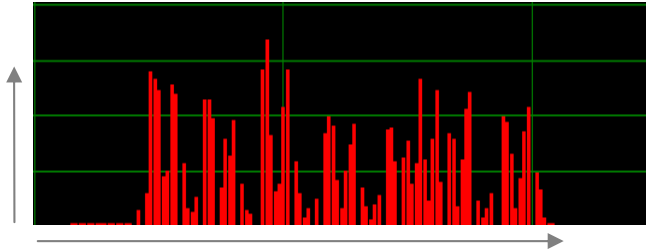


3 approaches

- 1) Take overall (average) Grms
 - as used in standards

- 2) Split level testing, which is normally mainly around the average
 - but specifically includes higher energy periods
 - to compensate for real life where there are short bursts of higher energy vibration

Grms throughout journey



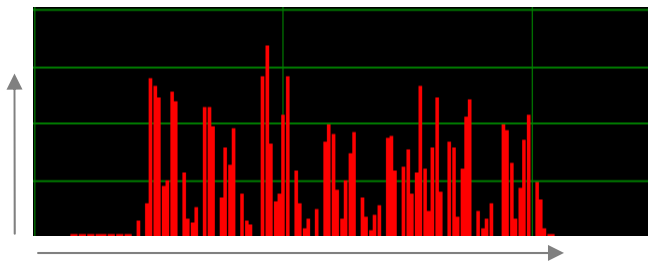
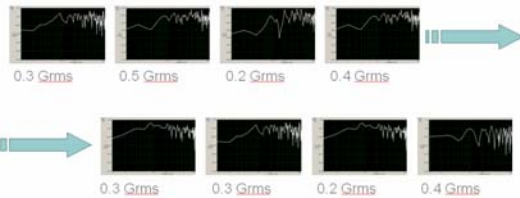
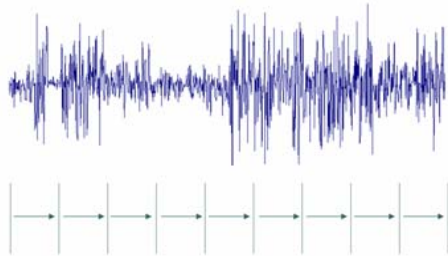
3) Large number of different test levels for the same PDS

- special controller that varies the overall level with time according to a distribution

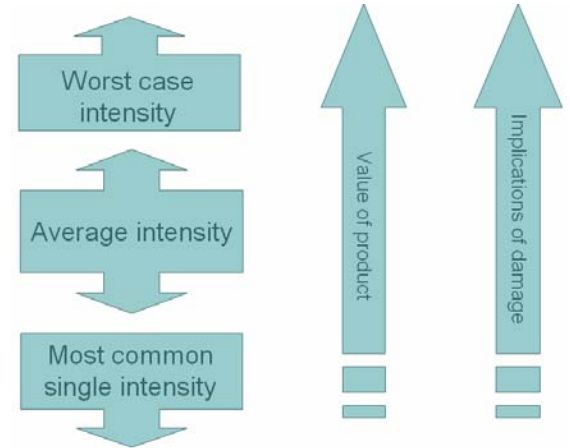
Complex, further research/debate required

- more real life performance vs lab data research needed
- *Pira's position is that there is merit in multi-level testing, but it comes with health warning not to over-accelerate the higher energy content*

Objective of test?



Relate capture mode and managing range of Grms levels *to objective of test*



Analysis

Overall PDS



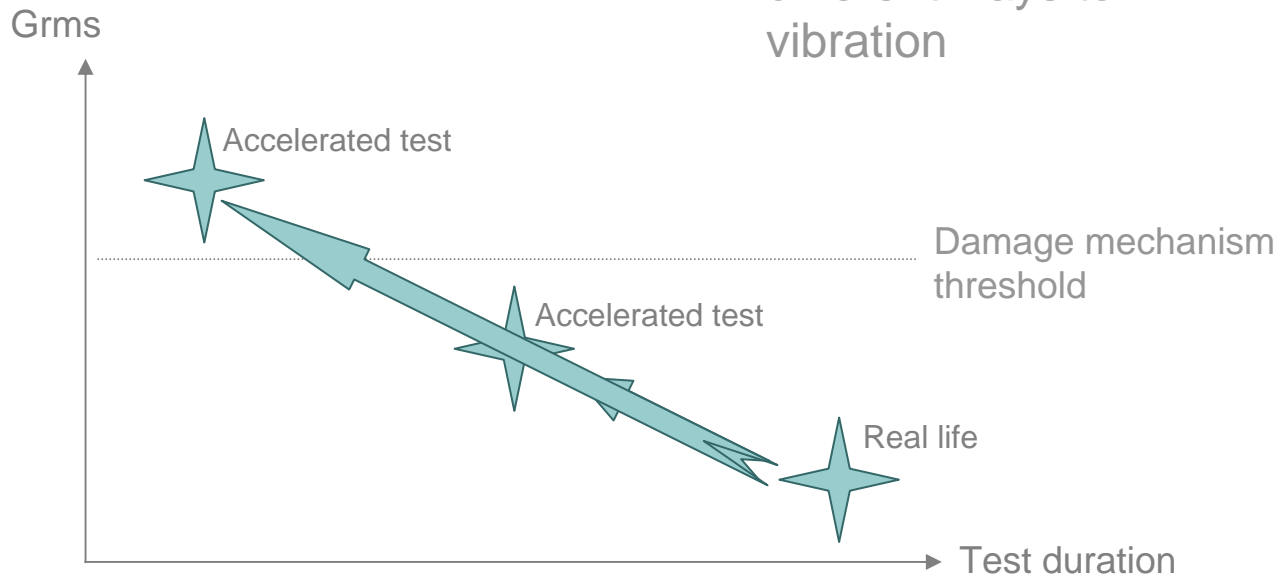
- Now have spectrum representing frequency content of journey and intensity (average or some distribution of intensity)
- Assuming that zero level data or near zero level data has been removed
 - Either programme the spectrum in to vibration controller
 - play test for duration equivalent to real life
 - Or undertake time compression to shorten the test (commonly Miner-Palmgren maths is used)

$$\frac{T_{\text{real}}}{T_{\text{test}}} = \left(\frac{\text{Grms}_{\text{test}}}{\text{Grms}_{\text{real}}} \right)^k$$

Time acceleration



In reality, different products respond in different ways to vibration



Time acceleration

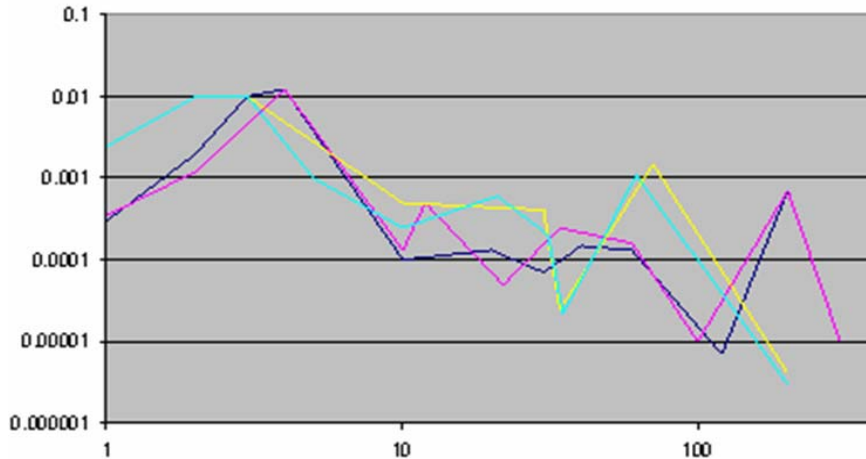


Time acceleration

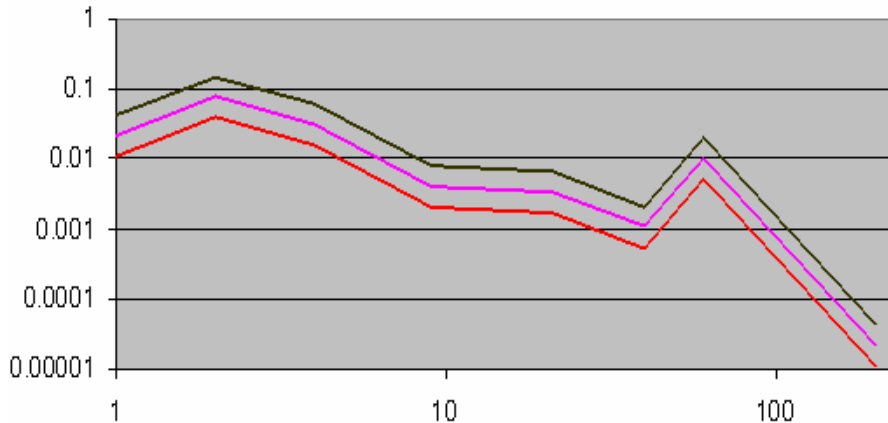


In the field

Time acceleration



Mean PDS for 4 rough road journeys sections, Africa



Accelerated PDS

Mode: 0.51 Grms

80 percentile: 0.72 Grms

95 percentile: 1.00 Grms

Isolated high energy events



Mixed loads: roll cages

Retailer parts of supply chain

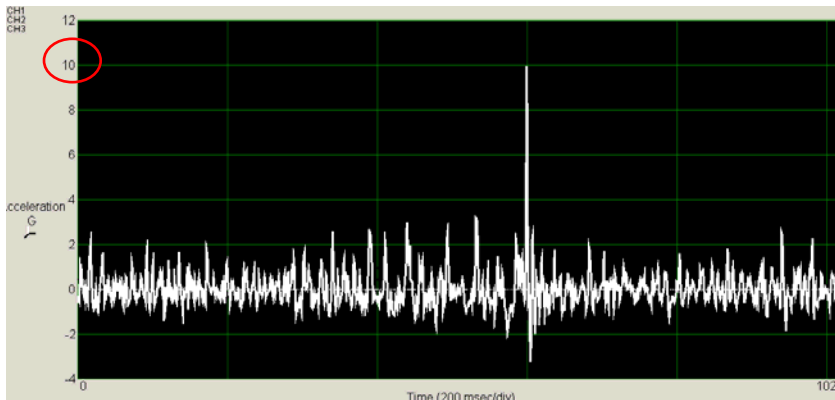
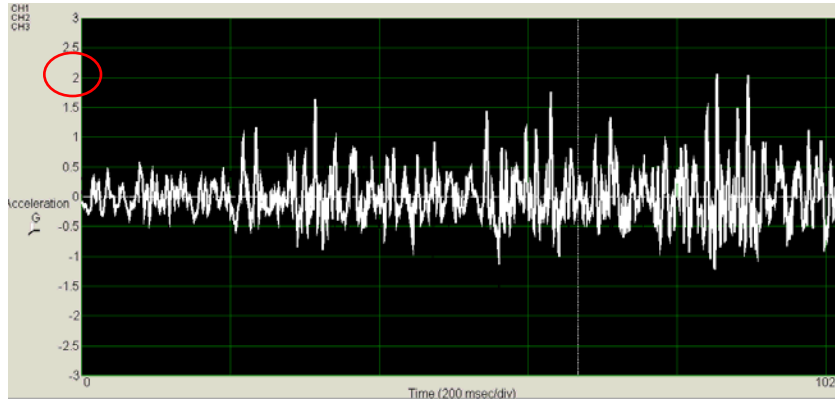
Recording vibration over rough surface (concrete floor behind store areas)



Isolated high energy events



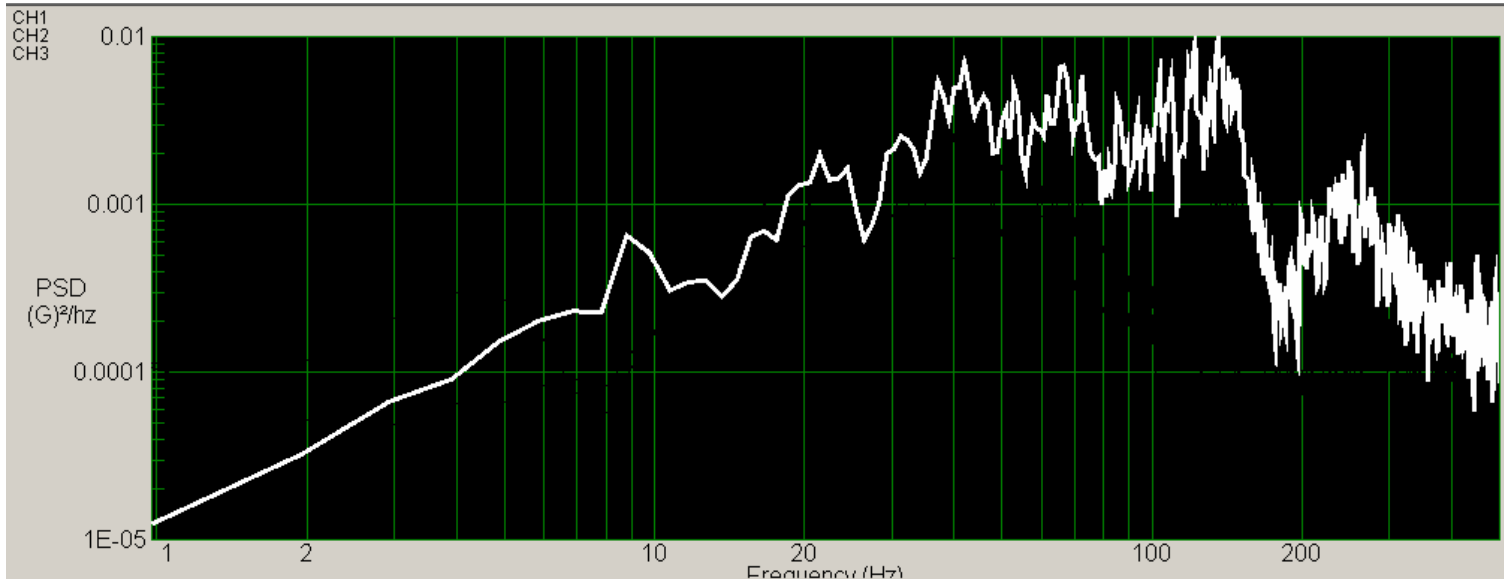
Isolated high energy events



Frequency range



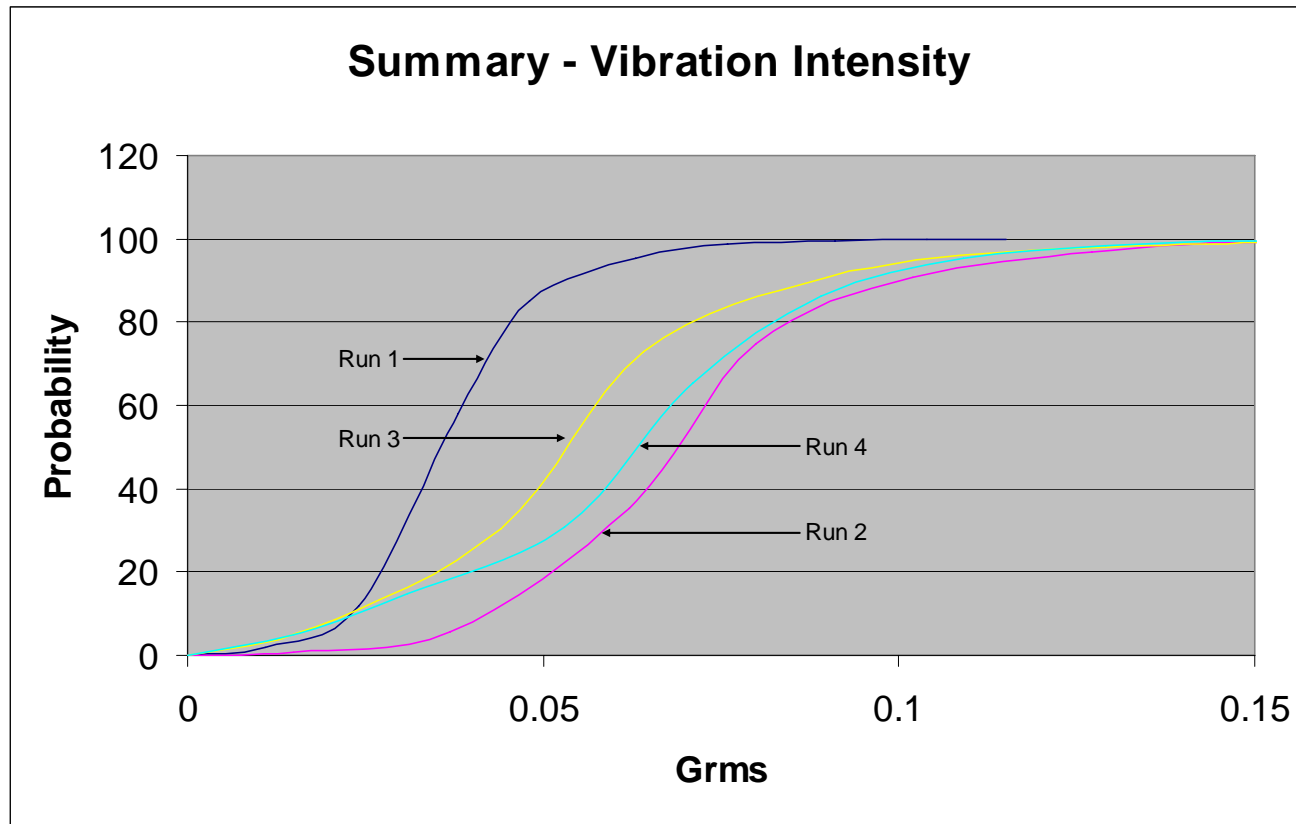
Roll cage vibration over rough surface



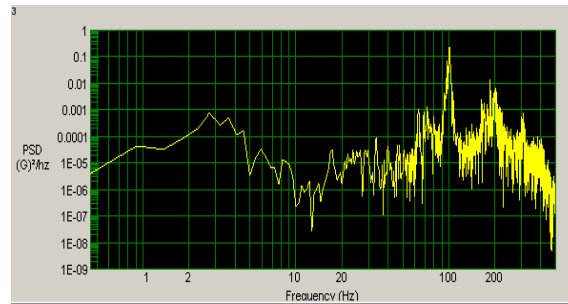
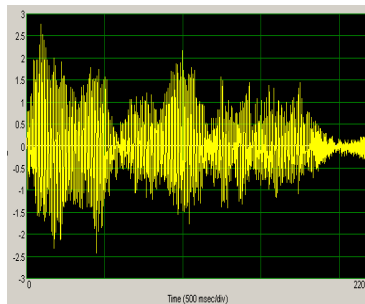
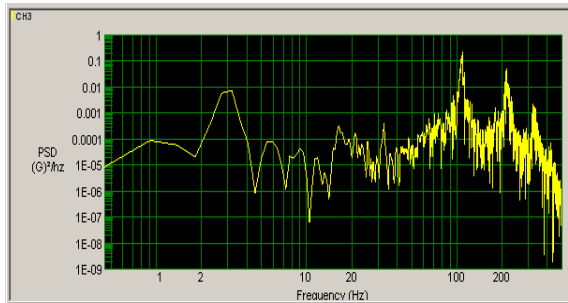
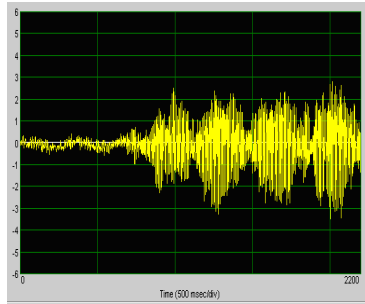
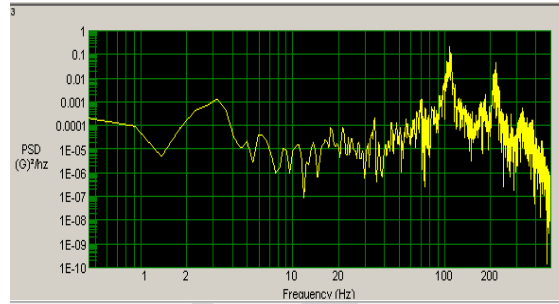
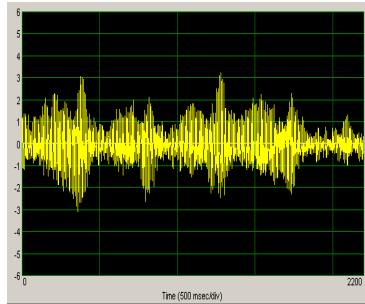
Circa 0.29 Grms (1 to 200 Hz)

0.78 Grms (1 to 500 Hz)

Number of journeys



Position of recorder



Chassis effects?

Peaks at higher frequencies
increasing Grms



It works!

- There are many variables and issues to consider
- There are assumptions and imperfections along the way
- But with careful consideration and experience, in many many cases a good correlation with field performance is achieved

Test	Grms	Duration	Result
D4169 level II	0.52	1 hour	Significant creasing and leakage (not observed in real life)
Based on SRETS/CEN proposal	0.24	40 minutes	Creasing and leakage (not observed in real life)
	0.33	20 minutes	
<i>D4169 level III</i>	<i>0.37</i>	<i>1 hour</i>	<i>Higher test level than tests undertaken based on SRETS/CEN proposal</i>
Based on published data from relevant region	0.10	96 minutes	Fair correlation with field observation
	0.15	24 minutes	
Pira measured data and test development	0.05	45 minutes	Good correlation with field observation
	0.07	10 minutes	
	0.18	5 minutes	

PhD



- New techniques in vibration testing and analysis to optimise packaging performance
- Pira and University of Bath
- Real time vibration data as alternative to simulated vibration



Thank you

Questions?

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