Case Study:
Automotive DC Motor Test

Alta Solutions
Innovative Signal Processing Solutions

Test Procedure

- Sixteen small DC motors (nine "reject" motors and seven production motors) were tested

- A magnetically mounted accelerometer was placed in the middle of the motor chassis in a radial direction

- A microphone was placed five inches above the motor on the existing test fixture

- Data was collected both in the clockwise and counter-clockwise direction. It was noted that one of the good motors had a slight audible "crunching" sound.
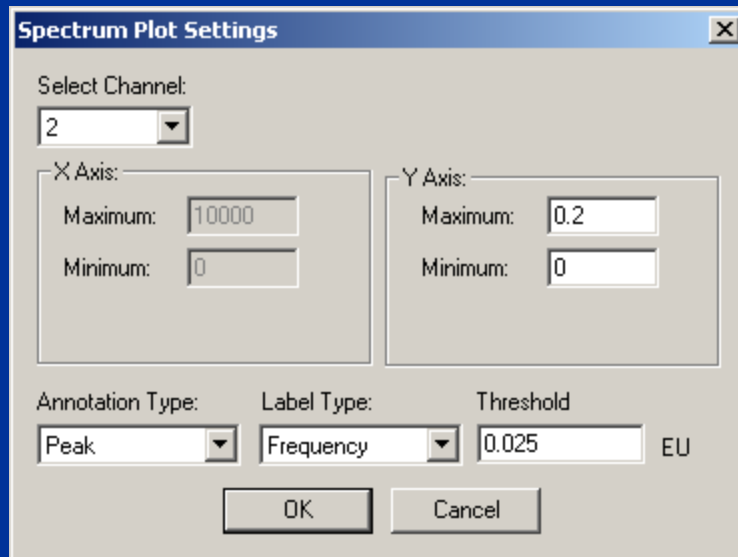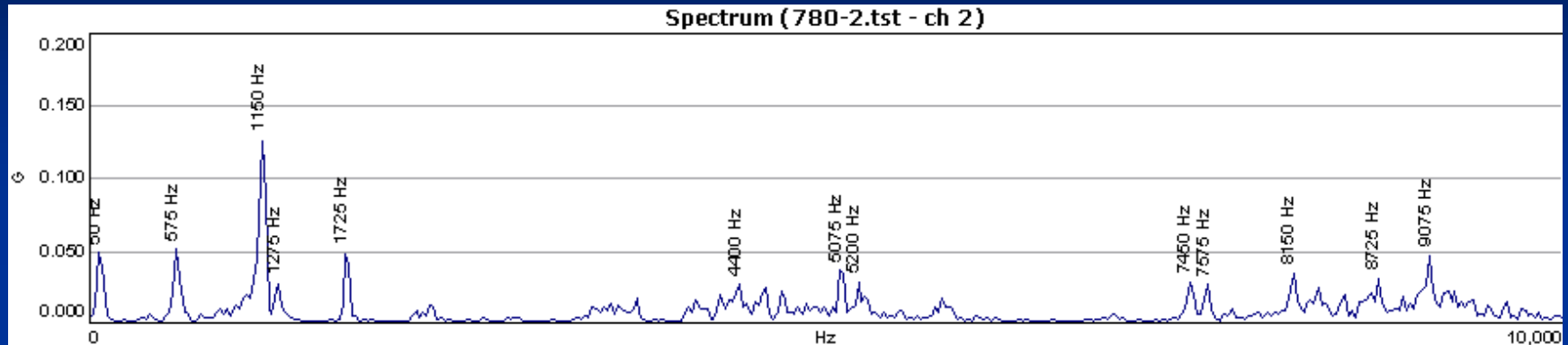
Initial Analysis

- This analysis is **not** meant to be exhaustive or complete
    - small sample population
    - exploratory measurement technique
    - lack of knowledge of the specific motor properties (armature, bearing, etc).

Quick Review of Collected Data
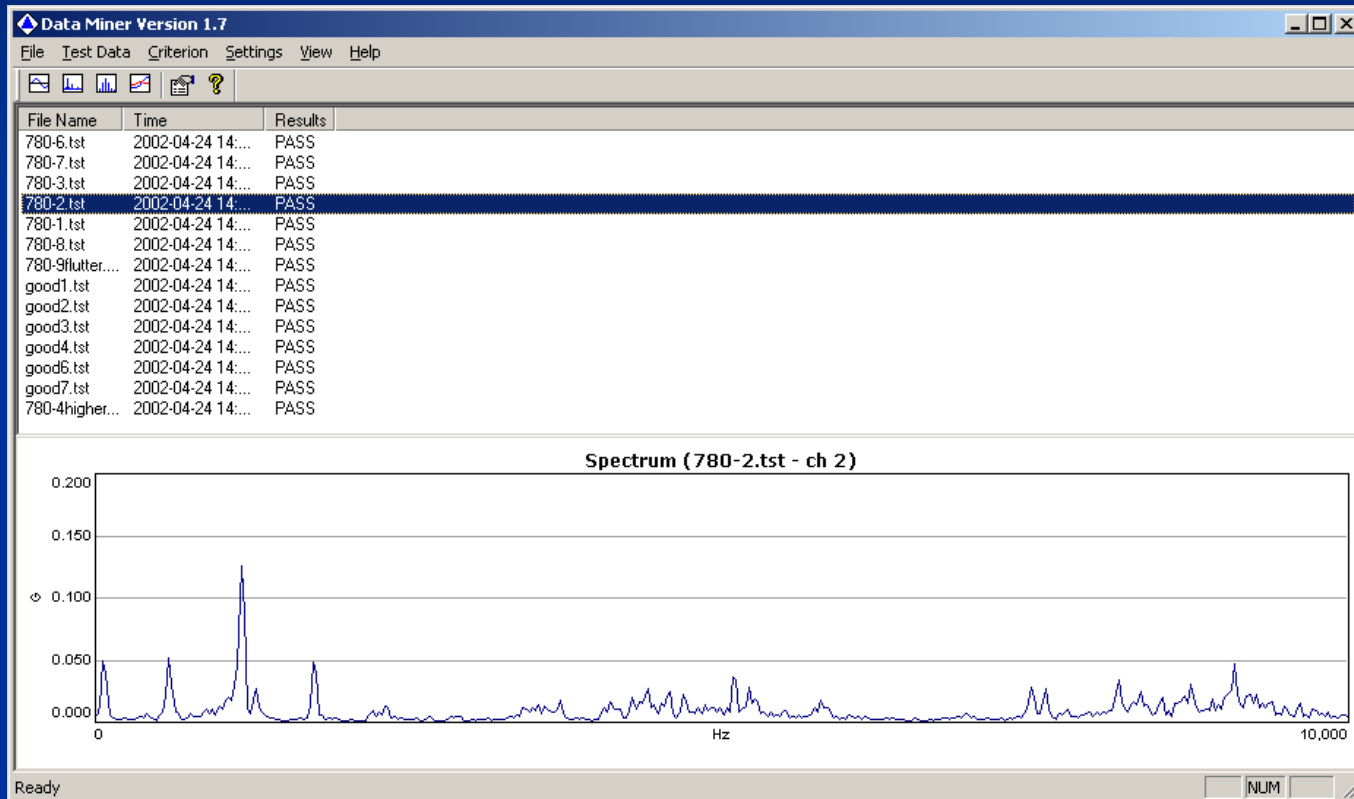
Peak Annotation

Allows annotation of spectral peaks by amplitude or frequency

Overall Amplitude

Overall	
Tag:	
OA	
Description:	
Overall	
Settings:	
Channel:	
2:	
Threshold:	Boolean is TRUE when:
1 Units	value > threshold
OK	Cancel

File Name	Results	OA (Pa)
780-6.tst	PASS	0.316443
780-7.tst	PASS	0.271043
780-3.tst	PASS	0.116114
780-2.tst	PASS	0.226654
780-1.tst	PASS	0.228064
780-8.tst	PASS	0.147554
780-9flutter.tst	PASS	0.199024
good1.tst	PASS	0.168927
good2.tst	PASS	0.153209
good3.tst	PASS	0.134711
good4.tst	PASS	0.215908
good6.tst	PASS	0.197043
good7.tst	PASS	0.155528
780-4higher.tst	PASS	0.517334

The simplest quantitative test is to determine the amount of vibration that each motor produces.

The overall amplitude (OA) test criterion reduces the total vibration energy into a single number.

OA Analysis

Filename	Preliminary Diagnosis	OA
780-1.tst	Slight 28.125 Hz "Flutter"	**0.2281**
780-2.tst	High Peak (1150Hz), Slight Impact (57 Hz)	**0.2266**
780-3.tst	No apparent defect	0.1161
780-4higher.tst	High Overall	**0.5173**
780-6.tst	Medium Impact (57 Hz)	**0.4475**
780-7.tst	Medium Impact (57 Hz)	**0.3164**
780-8.tst	Slight Impact (57 Hz)	0.1475
780-9flutter.tst	Medium 28.125 Hz "Flutter"	**0.1990**
Average (excludes good4.tst)		0.1618

- The other two parts have similar overall values to the good parts, because overall is calculated over a period of time

- Therefore, transient defects as ticks, and rubs could be easily masked.
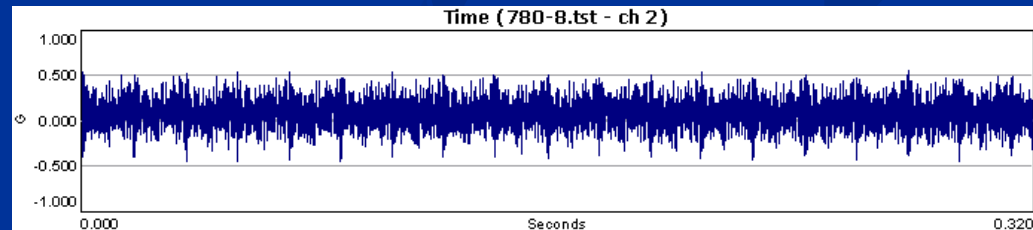
Impact (Tick) Defect

Impacts Present
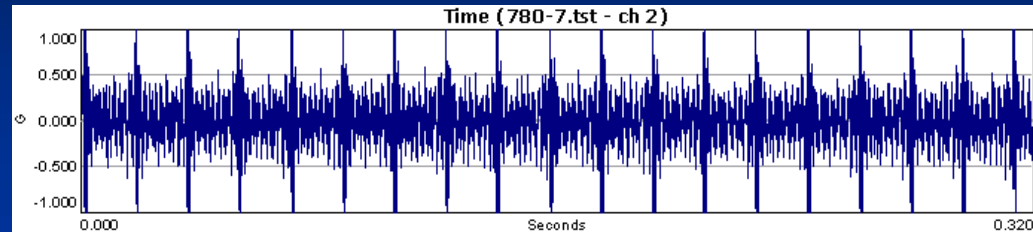
Impacts Present
with other noise
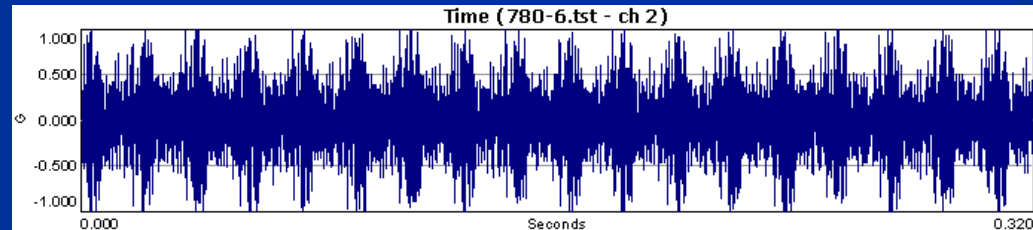
Slight Impacts
Present

Five of the motors (780-2, 780-6, 780-7, 780-8, and good4) have
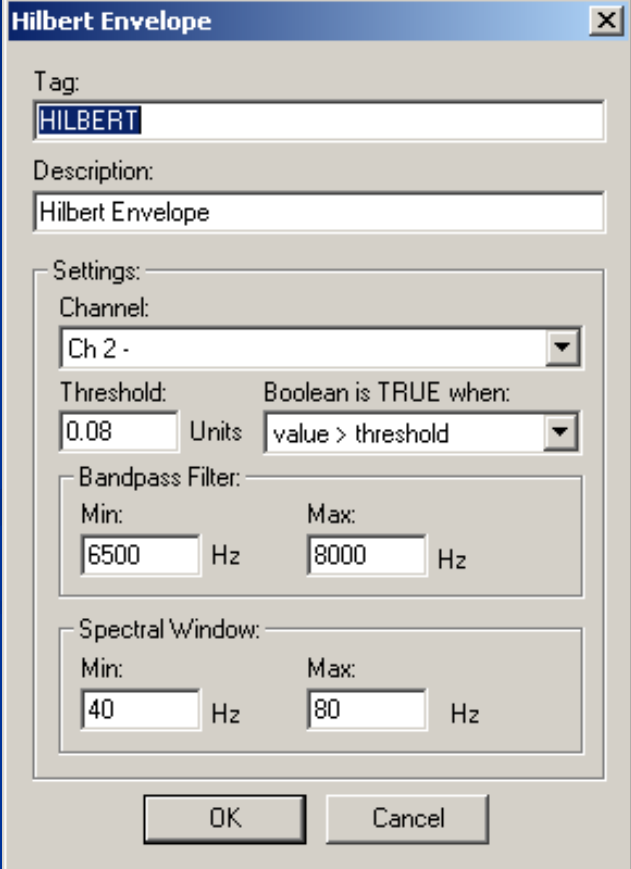impacts that occurs every 0.174 seconds (57 Hz period)

Hilbert Transform

- The impacts excited the resonance frequencies of the motor casing

- Select filter range of a region excited by the impacts

- Take a look at the filtered time record and enveloped
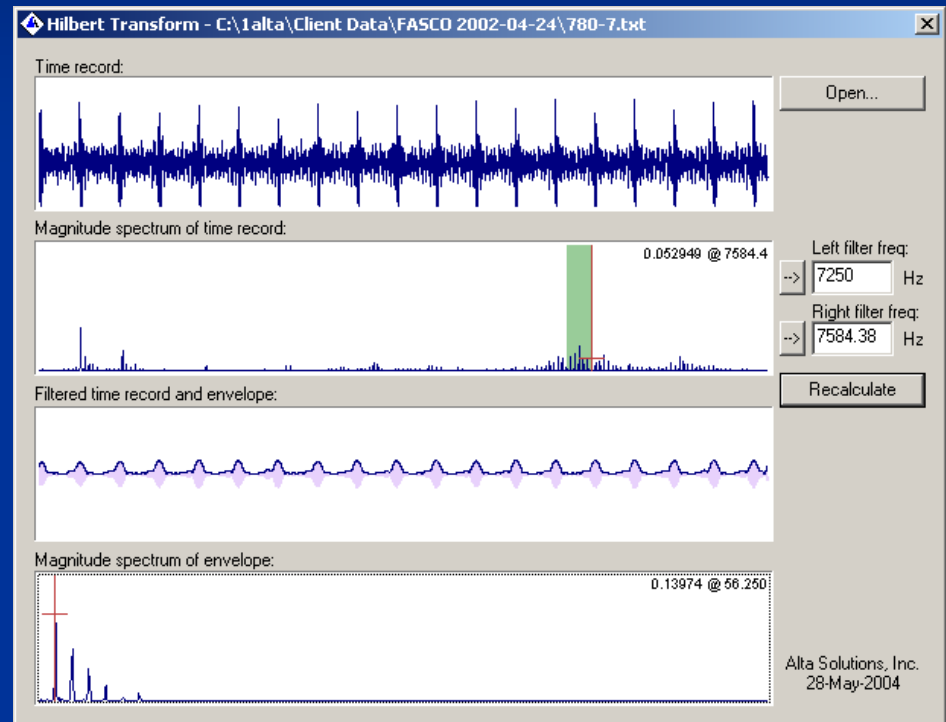
Setting Up a Hilbert Envelope

- **Configure Hilbert test criterion**
  - Channel
  - Threshold
  - Bandpass Filter
  - Spectrum Window

Impact (Tick) Defect

Filename	Preliminary Diagnosis	H1
780-4higher.tst	High Overall	0.0746
780-6.tst	Medium Impact (57 Hz)	0.1039
780-7.tst	Medium Impact (57 Hz)	0.1359
780-8.tst	Slight Impact (57 Hz)	0.0284
Average of Good motors		0.0102

Hilbert Transform provides 2.8x to 13x difference in good and bad motors

Need to do further analysis to determine the root cause of this "ticking" or rubbing.

Histrogram(HILBERT)

X: -0.0257 Units, Y: 0.00 % (mean: 0.0345, std. dev: 0.0441, max: 0.1286, min: 0.0029)
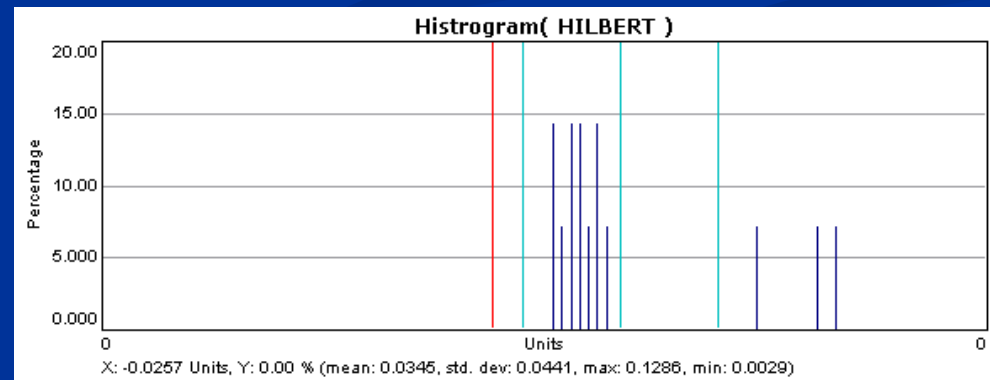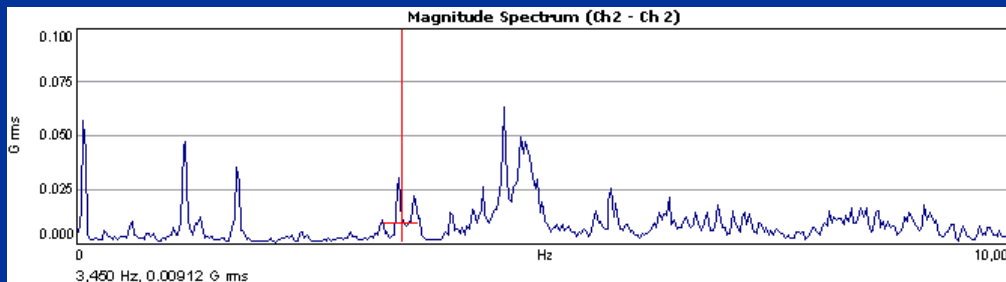
Flutter Defect
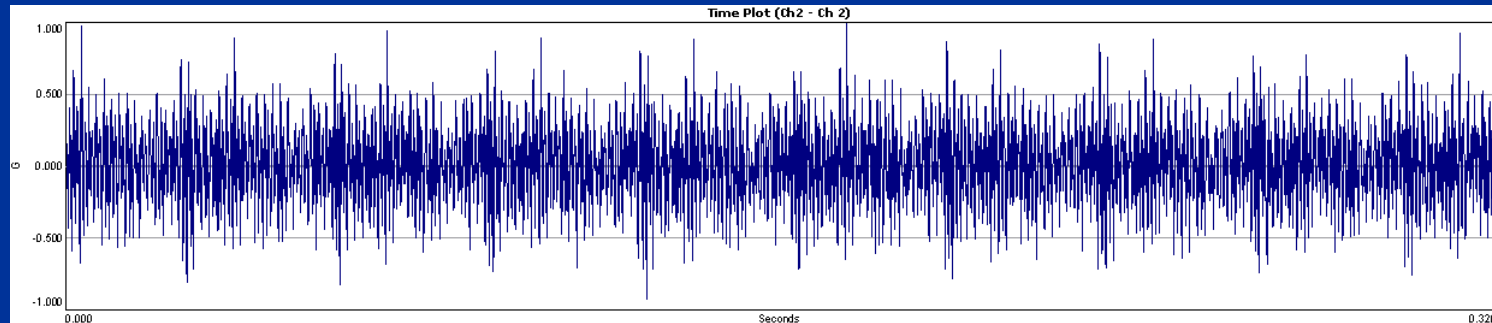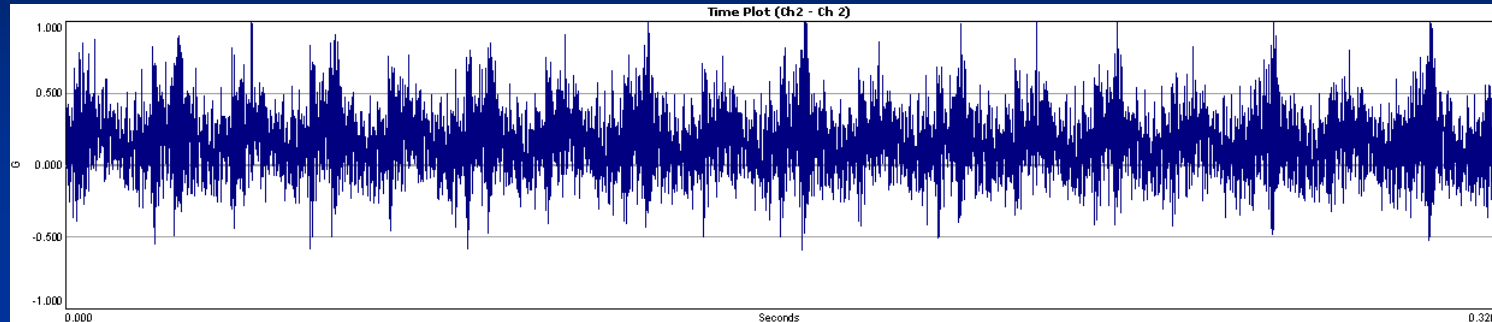
Two of the motors (780-1, and 780-9) show an impact that occurs every 0.174 seconds (28.125 Hz period)

Hilbert Envelope for Flutter

- Configure Hilbert test criterion
    - Channel
    - Threshold
    - Bandpass Filter
    - Spectrum Window

Flutter Defect

Filename	Preliminary Diagnosis	H2	Multiple
780-1.tst	Slight 28.125 Hz "Flutter"	0.0512	11.6
780-9flutter.tst	Medium 28.125 Hz "Flutter"	0.0510	11.6
Average (excludes good4.tst)		0.0044	1
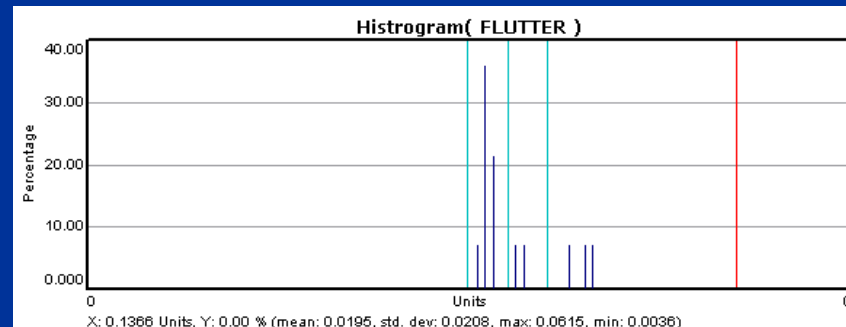
The envelope value H2 is a measure of the "flutter" defect. The ratio for the good parts to the "flutter" parts was more than 11 to 1.

With knowledge of the mechanical properties of these motors, we could then determine what defect is the cause (bearing damage, brush noise, etc).

Conclusion

- The preliminary data collection and analysis shows that several defects can be identified

- The system even identified a defect (impact type) in one of the seven tested good motors, which was heard during the data collection.