CLAIMS

1. A method of processing a data signal obtained from a sensor sensing a dynamic signal including signal components caused by vibro-acoustic energy generated by fluid flow at a location within an operational pipeline network, the method including:

periodically sampling the data signal at a predetermined time interval to obtain a set of sampled data segments (S) for a time period;

processing the data segments to determine power spectral density values for each data segment;

processing at least the determined power spectral density values for each data segment to extract one or more frequency domain features for each data segment;

performing an analysis to characterise changes in a value of at least one of the one or more extracted frequency domain features over the time period; and

detecting an indication of a structural anomaly event proximal the location depending on the characterisation;

wherein the structural anomaly event includes an occurrence and/or further development of a crack in the pipeline network.

2. The method of claim 1 wherein the operational pipeline network is a mains water distribution pipeline network including a network of cast iron pipes, and wherein detecting an indication of a structural anomaly event depending on the characterisation of changes in a value of at least one of the one or more extracted frequency domain features over the time period includes:

a. detecting an indication of an occurrence and/or further development of a circumferential crack in a cast iron pipe; or

b. detecting an indication of an occurrence and/or further development of a longitudinal crack in a cast iron pipe.

3. The method of claim 1 or 2 wherein the value of the at least one of the one or more extracted frequency domain features is a statistical value.

4. The method of claim 1 wherein each data segment has an associated duration, and wherein the duration of each data segment is less than about 60 seconds, or wherein the duration of each data segment is less than about 60 seconds, or wherein the duration of each data segment is less than about 30 seconds, or wherein the duration of each data segment is less than about 20 seconds, or wherein the duration of each data segment is less than about 15 seconds.

5. The method of any one of claims 1 to 4 wherein the dynamic signal is an acoustic signal and wherein each data segment is an uncompressed wave file.

6. The method of any one of claims 1 to 5 wherein the one or more frequency domain features includes at least one of:

a value of a median frequency;

a value of a mean frequency;

a value of a peak frequency;

a standard deviation of a power spectral density;

a kurtosis of a power spectral density;

a skewness of a power spectral density;

a spectral flatness;

a spectral centroid;

a spectral spread; and

a distribution of the power spectral density values.

7. The method of any one of claims 1 to 6 further including processing the data signal to extract one or more time domain features of the data signal and performing an analysis to characterise changes in at least one of the one or more extracted time domain features.

8. The method according to any one of claims 1 to 7 wherein performing an analysis to characterise changes in the value of the at least one of the one or more extracted frequency domain features includes:

comparing values of an instance of the at least one frequency domain feature with a reference value, or

recognising a trend or pattern associated with the at least one frequency domain feature over the time-period, or

identifying a predetermined behaviour and/or attribute of the at least one frequency domain feature, or

determining a rate of change of the at least one frequency domain feature over a time-period.

9. The method of claim 1, wherein processing the data segments to determine power spectral density values for each data segment includes:

framing each data segment as a sequence of data frames; and

processing a selection of the data frames for each data segment to determine separate respective sets of power spectral density values for each data segment.

10. The method of claim 9 wherein extracting one or more frequency-domain features for each data segment includes:

processing each separate set of power spectral density values to determine a respective first parameter value; and

processing a set of the determined first signal parameter values to determine the one or more frequency-domain features.

11. The method of claim 10 wherein the first signal parameter includes a median frequency of one or more the power spectral densities derived from or for the data signal.

12. The method of claim 11, wherein the median frequency is a normalised median frequency.

13. The method of claim 10 wherein the first signal parameter includes a root-mean-squared noise derived for or from the data signal.

14. The method of claim 10 wherein processing a selection of the data segments to determine a value of a first signal parameter for each data segment includes selecting, for processing, only data segments satisfying a processing condition.

15. The method of claim 10 wherein processing a set of determined first signal parameter values to identify an indicator value includes identifying the indicator value as a first signal parameter value which *n*% of the ordered set of first signal parameter values exceeds,

wherein *n%* is between about 50% and about 75%, or

wherein *n*% is between about 75% and about 90, or

wherein *n*% is about 90%.

16. The method of claim 1 further including:

detecting a change in a profile of the distribution of the power spectral density values for a current data segment of the set as an indicator of the structural anomaly event proximal the location, wherein the change is detected based on identifying a difference between the power spectral density values of the current data segment and the power spectral density values of one or more previous data segments of the set; or

detecting a characteristic of the power spectral density values for a current data segment of the set as indicating the structural anomaly event proximal the location, wherein the characteristic is detected using a neural network operable to receive a collection of power spectral density values for earlier data segments.

17. A system for processing a data signal obtained from a sensor sensing a dynamic signal including signal components caused by vibro-acoustic energy generated by fluid flow at a location within an operational pipeline network, the system including:

a memory;

a set of computer readable instructions stored in the memory;

a processor for executing the set of computer readable instructions to:

periodically sample the data signal at a predetermined time interval to obtain a set of sampled data segments (S) for a time period;

process the data segments to determine power spectral density values for each data segment;

process at least the determined power spectral density values for each data segment to extract one or more frequency domain features for each data segment;

perform an analysis to characterise changes in a value of at least one of the one or more extracted frequency domain features over the time period; and

detect an indication of a structural anomaly event proximal the location depending on the characterisation;

wherein the structural anomaly event includes an occurrence and/or further development of a crack in the pipeline network.

18. An apparatus for processing a data signal obtained from a sensor sensing a dynamic signal including signal components caused by vibro-acoustic energy generated by fluid flow at a location within an operational pipeline network, the apparatus including:

means for periodically sampling the data signal at a predetermined time interval to obtain a set of sampled data segments (S) for a time period;

means for processing the data segments to determine power spectral density values for each data segment;

means for processing at least the determined power spectral density values for each data segment to extract one or more frequency domain features for each data segment;

means for performing an analysis to characterise changes in a value of at least one of the one or more extracted frequency domain features over the time period; and

means for detecting an indication of a structural anomaly event proximal the location

depending on the characterisation;

wherein the structural anomaly event includes an occurrence and/or further development of a crack in the pipeline network.

19. A computer-readable storage device storing instructions that, when executed by a processor, cause the processor to perform operations comprising:

obtaining a data signal from a sensor sensing a dynamic signal including signal components caused by vibro-acoustic energy generated by to fluid flow at a location within an operational pipeline network:

processing the data signal to determine power spectral density values for one or more frequency bands of the data signal;

processing at least the determined power spectral density values to extract one or more frequency domain features;

performing an analysis to characterise the one or more extracted frequency domain features; and

detecting an indication of a structural anomaly event proximal the location depending on the characterisation;

wherein the structural anomaly event includes an occurrence and/or further development of a crack in the pipeline network.