Transmission Dynamics®

SmartStep® Escalator Monitoring

OVERVIEW

Transmission Dynamics® has developed the Smart Step® in-service data logging system that monitors and automatically reports potentially damaging events from the escalator to the operator during routine operation.

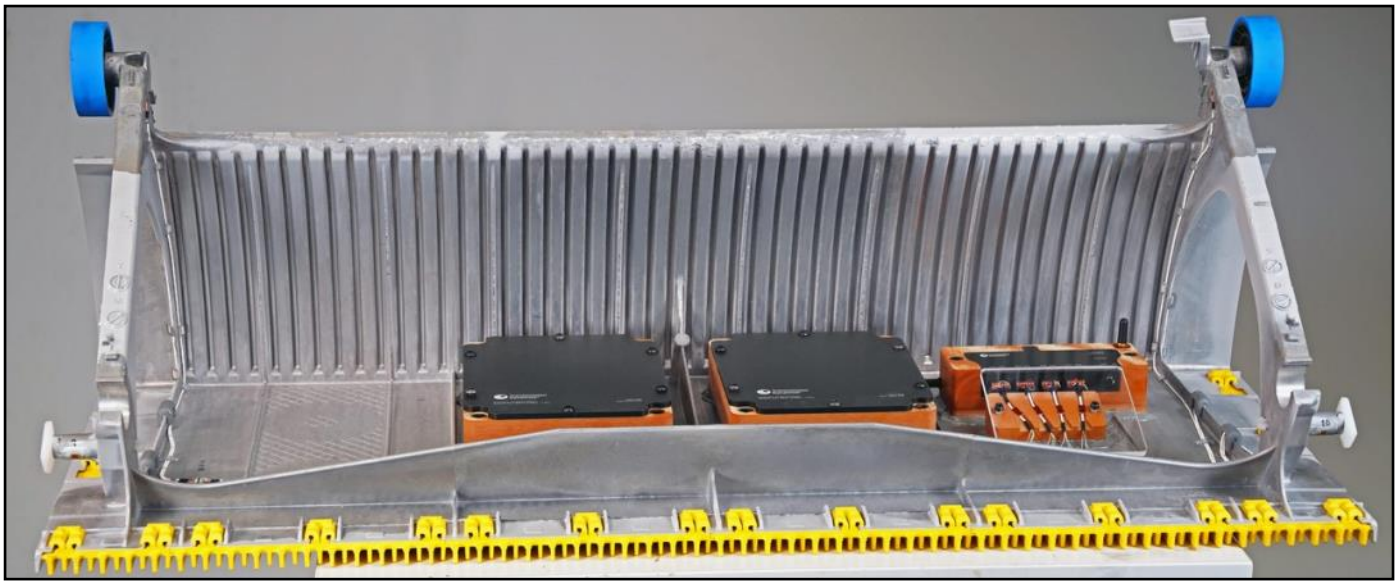
The system consists of a data logger equipped with wireless communication and battery pack, fitted to a standard escalator step. The device has sufficient battery power to provide at least one year of operation between battery changes, and operates autonomously, alerting the user in case of any instances of abnormal operation.

The Smart Step® monitors the operating parameters of the entire escalator, including stress levels, detecting most common abnormalities, such as for example:

- drive chain imbalance
- uneven chain wear
- excessive dynamic loads
- step misalignment
- stick-slip motion
- smoothness of operation
- upper and lower D section misalignment
- track issues and discontinuities

This powerful diagnostic and instrumentation system is successfully used to verify the effectiveness of maintenance ('before and after' maintenance data comparison), and is used as an important predictive maintenance tool. The system is used to accurately diagnose faults which helps maintenance and repair engineers to achieve high efficiency of the operations.

The advantage of continuous tracking and documentation of step skewing due to differential chain elongation allows decision makers to plan major refurbishment work such as replacing worn chains well ahead, before the chain reaches a critical state requiring urgent attention. This replaces the need for the implementation of additional systems to measure chain elongation which are difficult to implement and notoriously problematic.



- machine dynamics, NVH, failure analysis, fatigue/accelerated life testing
- specialised instrumentation, data acquisition and analysis
- rotating machinery design and troubleshooting: gearboxes, shafts, bearings, couplings, belts and chains

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OPERATION

During operation the Smart Step® continuously acquires data from a series of strain gauges mounted in critical locations around the step. The system is also equipped with tri-axial accelerometers and a 3-axis gyroscope designed to monitor smoothness of operation and provide additional information at the flip-over.

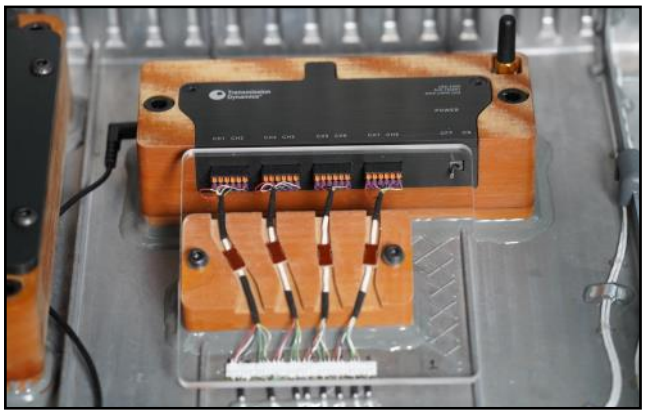

Figure 1

There are two modes of operation. In the routine predictive maintenance mode of operation a simple traffic-light system is implemented, allowing operators to quickly overview the status of many escalators simultaneously. Green lights represent normal operation, amber indicates a need for attention, and red indicates a requirement for urgent attention. In this mode of operation the system sends a regular update and provides basic reporting for quality assurance.

In the second mode of operation (alarm mode) the system can deploy instantaneous alarms by sending emails and text messages to a list of pre-defined, authorised recipients. This mode of operation is activated only in cases of a rapid deterioration of critical escalator parameters such as missing track section, significant high load level, etc.

The wireless link provides continuous, reliable communication between the Smart Step® and internet-enabled receiver, with no need to stop the escalator. Alternatively, maintenance engineers equipped with a wireless transceiver can interrogate the system locally.

DATA ANALYSIS

From the acquired time-domain data, it is possible to identify individual features attributable to various events. There are, for example, clear time-domain traces recorded by strain gauges which are attributable to passenger load and passenger behaviour. These features are present on the top-side travel and are used to collate information on the average load, excessive load, and abusive load, which form an important input allowing prediction of accumulated fatigue cycles. Figure 2 shows typical traces attributable to such behaviour.

In figure 2 a typical time-domain trace is presented for a full escalator cycle, starting with returnside travel followed by passenger side travel, after a midpoint flip over. From this figure (*) it can be seen that track features are easily identifiable as short duration spikes due to impact at the track joints. In a typical scenario these features are more pronounced at the returnside which usually receives less attention during refurbishment. Following track maintenance these features should be significantly reduced making these measurements powerful in maintenance verification, especially by reducing the fatigue cycles affecting the step band.

Built-in features also appear with every cycle of the escalator in figure 2. Monitoring these features is an important step in predicting the condition of the whole escalator system.

The escalator time domain data has a consistent pattern with repeating cycles. This allows for the easy identification of transient behaviours and the detection of long-term changes in the system. Escalators provide sufficiently unique operational data that each SmartStep® develops a “fingerprint” of each individual escalator, however these features are often overshadowed by major changes due to gradually or rapidly developing faults. This makes a strong case for deployment of one step per escalator to form a powerful asset monitoring and predictive maintenance solution for the entire infrastructure.

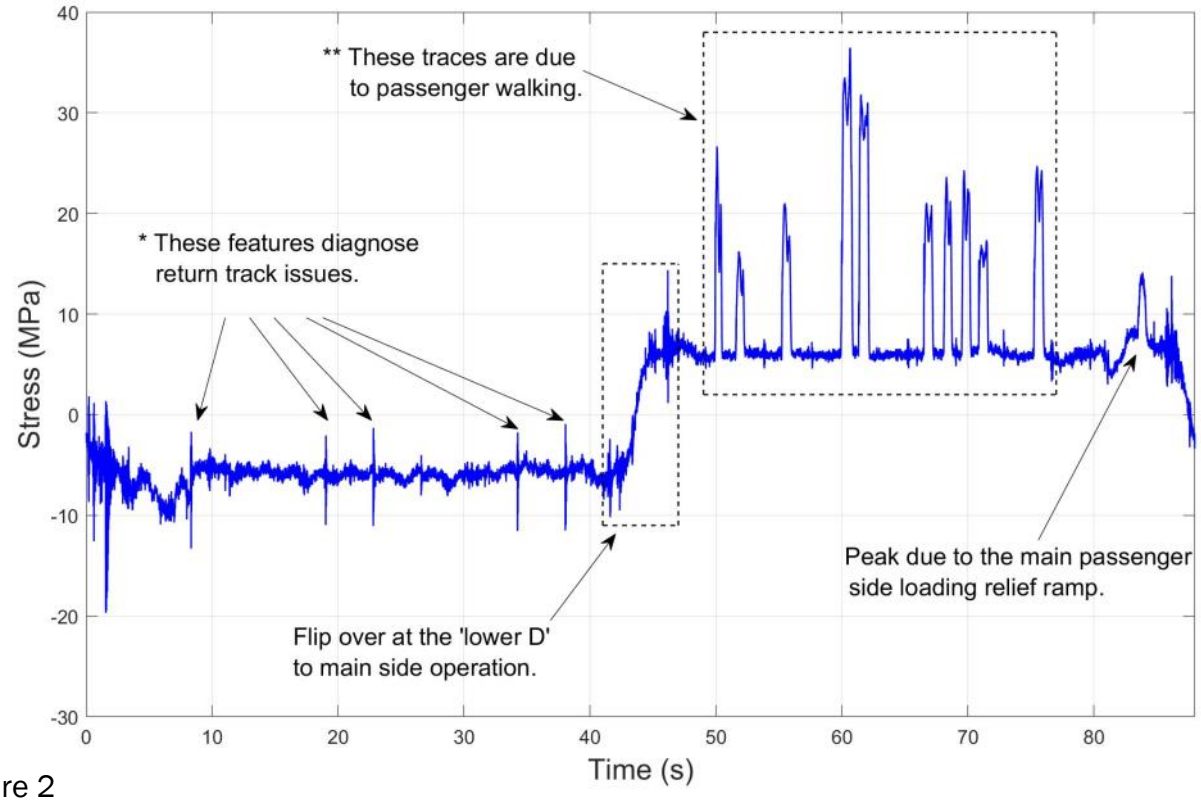

Figure 2

In addition to acting as a fundamental condition monitoring and predicative maintenance tool, SmartStep® allows collection of additional data related to passenger behaviour and statistics. It is these statistics which are presently occupying the centre of attention when analysing big data and the use of future pattern recognition and artificial intelligence.

Using pattern recognition techniques, key features of the data can be extracted, regardless of human-perceived significance. These signals are analysed using both engineering insight and data techniques.

Long-term observation of passenger behaviour can be use to predict loading across the whole escalator. Understanding this global loading is key for predicting the impact on escalator health.

Data provided by the SmartStep® provides a significant amount of information about each passenger. Specifically, it is possible to detect running passengers, passengers with varying walking styles, weight of the passengers, etc (**).

COMPANY PROFILE

Transmission Dynamics® have developed a comprehensive range of advanced instrumentation, allowing measurement of strain, temperature and acceleration in demanding industrial applications.

We provide a range of our own telemetry instrumentation products, which are used by blue-chip technology clients across the globe.

For Smart Step®, New Civil Engineer Techfest award for Technology Driving Whole Life Performance.

The Smart Step® is now deployed in critical transport systems in the UK, reducing the incidence of escalator downtime and streamlining underground maintenance regimes.

"The Smart Step has been extensively used to monitor escalator performance over the past few years, and has helped to identify multiple problems which were swiftly rectified."

Tube Lines

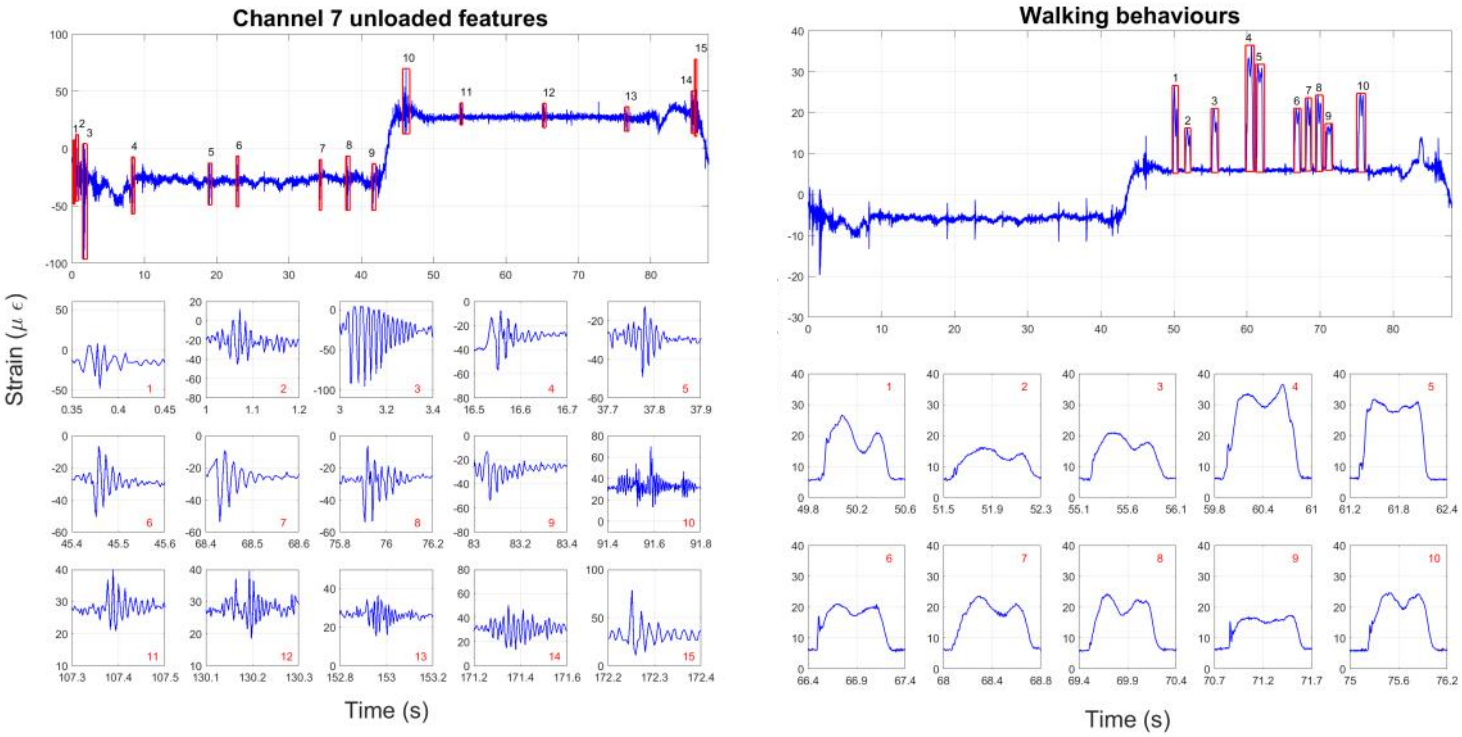

Figure 3—typical examples of automated feature extraction built in data processing algorithms.