The Effectiveness of Remote Lift Monitoring with Regards to Lift Reliability

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Abstract. A study was carried out to understand more about whether the lift industry can benefit from the internet of things (IoT); specifically, to understand whether connecting lifts electronically to the internet and then remotely monitoring various elements of the lift can reduce breakdowns, by enabling the service company to identify a maintenance programme that ensures better reliability. Ten lifts were selected that were alike in type, usage and condition to compare similar lifts and rule out any anomalies associated with this. The selected lifts were then fitted with a remote monitoring device (RMD) that connected directly to the lift control panel. Failure mode, effects and criticality analysis (FMECA) was the method used to quantify numerically the effects of lift breakdowns. The lifts were retrospectively analysed 160 days before a remote monitoring system was fitted and 160 days after. With the remote monitoring device fitted, supervisory engineers could influence engineers' decisions, and to interact with the client. The results were averaged over the 3 sets of data to give an average score. Overall there was a 63% reduction in the number of calls. The data showed that remote monitoring can offer many advantages to managing a lift system in terms of maintenance and reliability, specifically task-based maintenance.

1 INTRODUCTION

The subject of this paper was inspired by what the author perceived as the downward spiral in maintenance standards, due to reduced costs and maintenance frequency. It was felt that this reduction in maintenance frequency, has in turn led to a reduction in reliability, with an increased level of breakdowns and downtime.

A lift breakdown is a failure and a failure can be most often described as a shortfall between performance and standards [1]. There can be several reasons for failure, from misuse; in its various guises, wear and tear related factors, through to component failure which could be a result of poor maintenance or poor initial design. The duty or wear and tear issues may be considered a failure of maintenance, if sufficient action is not taken to ensure timely repair or replacement is not undertaken.

Lift reliability is an ongoing issue for the industry. Whilst comparable industries, for example, the motor trade have seen significant drops in the average number of breakdowns per annum over the last few decades, the lift industries' breakdown rate is thought to be some 3-5 breakdowns per year (Mitsubishi, 2016). There is a possibility that the breakdown rate was higher in the past, as for example, there has been technological advances with sealed for life bearings and more reliable control systems widely in use, together with a reduction in mechanical hardware, an expected fall in the number of breakdowns should be expected.

However, the lift industry has evolved over recent years and has taken advantage of the developing technologies as they have progressed. The control panel, for example, by using microprocessor based technology to replace previous relay logic, has in turn eliminated many of the failures previously encountered, with relay logic controllers, such as contact wear and contact failure along with dry solder joints found through interconnections. It is becoming more common to see in the lift industry the CANbus system being used, which reduces the amount of wiring and interconnections between component parts, therefore improving overall reliability within the control system.

So as far as the advances in technology are concerned the lift industry has also made considerable progress. So, the question is, why are lifts still breaking down on average 3-5 times a year? Part of the explanation for this, could be that much of the lift equipment in question is not the new equipment mentioned above and could instead be 30 or more years old, and along with a ‘one size fits all’ approach to maintenance, then the appropriate level of maintenance is not always given. This is exacerbated by a price war, where there’s a ‘drive to the bottom’ currently being experienced and the only way profits often can be maintained is by cutting the number of visits, or the labour used to service the lifts.

The above are somewhat interconnected in that the old stock when originally designed, for 12 monthly visits a year, was largely because the oils and the grease required topping up. If we were to take a 50-year-old Express-Evans lift, it had grease filled cartridges that required winding in monthly and the guides needed oiling every month. The contacts may have needed cleaning due to arcing, carbons and braids required replacing, air gaps needed adjusting, etc. The newer lifts require less maintenance; sealed bearings have negated the need for greasing points, electronics and “sealed” relays and contactors have negated the need to file carbons and contacts.

It is observed that the client may seek a less expensive alternative to their present incumbent, because “we never have any problems with our elevators” so why do we pay so much [5]. So, they have paid a proactive maintenance company giving good preventive maintenance, only for the discerning lift company to be penalised by their own success. Indeed, it may even be found that by switching to a less expensive maintenance regime, for example less visits per annum, or a basic contract that involved only lubrication, and minor adjustments, that the building owner will not see a discernible difference in the first weeks or months, due to the previous regime, but it’s inevitable that less maintenance will result in more wear and potentially more breakdowns.

Further, it can be found that the clients with larger portfolios will often have a mix of lifts, with varying levels of maintenance needs. These variations can be due to different ages, types: for example, traction, hydraulic or chain driven, or usage rates may vary widely. The inclination can be, to look for a “one size fits all” solution. This is often driven by the need to introduce a level playing field for competing lift companies, which will in turn produce competitive comparable quotes. Whereas this will almost certainly successfully produce a range of quotes, enabling the client to choose the lowest, it will not necessarily produce the most effective maintenance regime for the lifts on offer. The drive for the cheapest price often results in 4 service visits a year, which may be suitable for new lifts but completely unsuitable for the older or heavily used type.

1.1 Maintenance Regimes

There are a variety of types of maintenance on offer from a range of service providers, and from they would normally fall under three general categories [2]:

1. **Oil and grease**, where the maintenance company will provide an operative to maintain lubrication levels, ensure that the pit, shaft, motor-room and car top are free from dirt and debris, and make any minor adjustments. All other attendances, such as breakdowns and parts are chargeable.
2. **Fully comprehensive**, as the oil and grease, but with the addition of providing breakdown cover that is included in the price.
3. **Premium comprehensive**, that would provide additional services such as condition monitoring, remote monitoring, and performance guarantees, where there is a penalty charged if the lift were to fail more than a pre-agreed number of times in a period.

A brief history of maintenance within the lift industry was given by Rory Smith at the 2016 Lift Symposium [4].

- **Reactive maintenance** - the initial task of the maintenance or service engineer was reactive, that is they would attend the site and repair the lift in the event of a failure and return the lift into service.
- **Preventive maintenance** - was the next logical step forward to reduce the number of breakdowns, for example by ensuring that the lubrication regime was maintained, and appropriate adjustments were made to the machinery, then the goal was to prevent the lift from breaking down, and to increase the overall service life of the lift.
- **Usage based maintenance -** evolved from the late 1990's, with the principle purpose to adjust the quantity and timing of maintenance visits so they were based on the number of journeys made, in much the same way as the number of miles driven in a car, where the oil is changed, or the number of miles driven before the cam belt is routinely changed, therefore the data is of use to the incumbent to enable a more bespoke maintenance regime.
- **Condition based maintenance** – Although this type of maintenance has been the cornerstone of efficient maintenance of technical equipment [3] in many industries for some years, it has been comparatively late coming to the lift industry. The concept of measurement and analytics of physical properties, and measuring magnitudes gives an objective view of the potential condition of the components under surveillance.
- **Task based maintenance** - the production of maintenance task lists based on the condition or the use of the lift.
- **Data driven maintenance** – is to combine all the maintenance regimes into one system.

1.2 Empirical Study

An empirical study was carried out to establish whether remote monitoring can affect the reliability of a lift. The aims of the study were:

1. To investigate the effective use of the data gained during remote monitoring of the lift.

2. To establish the effectiveness of a remote lift monitoring system on its reliability.

The group of lifts monitored, were a similar age, condition and type. That is, low rise, goods lifts with manually operated doors. The lifts were operated by the same retailer, although the usage varied. All lifts had been refurbished in the last 5 years and had the same modern microprocessor based lift control system, and encoder based signalling systems. The lifts were a combination of traction and hydraulic.

The aim of the study was to understand more about whether the lift industry can benefit from the internet of things (IoT); specifically, to understand whether connecting lifts electronically to the internet and then remotely monitoring various elements of the lift can reduce breakdowns, by enabling the service company to identify a maintenance programme that ensures better reliability.

2 METHODOLOGY

The lifts were fitted with a device (RMD) that monitors the lift through the control panel. The control panel is a purpose designed system using a PIC based microcontroller to undertake the lift functions such as call processing, initiating motor control, (via a VVVF drive) stopping and levelling (via an encoder) and connects to the RMD serially via RS485.

Once appropriate data was received from the individual lifts, the data was acted on in the most appropriate way to reduce the frequency of breakdowns. By considering the reasons behind each failure then various techniques could be employed to prevent the same events from occurring again.

Various parameters were monitored including: -

- number of journeys,

- start failures,
- gate lock failure,
- car gate faults.
- gate locks tipped in both high speed and low speed,
- stuck pushes.
- out of door zone.
- number of door operations.
- lift position.

The method used for analysing the reasons for failure in more detail, was Failure, Modes, Effects and Critical Analysis (FMECA) [6]. FMECA includes a critical analysis, which is used to chart the probability of failure modes against the severity of their consequences. This enables the user to highlight the resulting failure modes with relatively high probability and severity of consequences. This further allows remedial effort to be directed where it will produce the greatest value. The FMECA process enabled a number to be put on the effect to customers of lift failures. These numbers were then compared using the same techniques before and after the remote monitoring system has been fitted to the lift. Therefore, if there is a reduction in the numbers it could be expressed in a meaningful number or percentage.

2.1 Recording Breakdowns

The methodology was to use the data from the RMDs from the sites previously identified (10 stores identified by geographical location: Bow, New Addington, East Acton, Formby, Kirkby, Newport Commercial, Eltham, Altrincham, Gloucester, Watford and Greenford), and evaluate whether reliability has improved, the time scale is 160 days before RMD was fitted and 160 days after RMD was fitted. The customer has its own system of recording reported faults named Compass. This is a central system that the stores use to communicate with their head office to record any maintenance issues, request subcontractor such as the lift provider attendance, monitor reactive and preventative maintenance visits and to log quotes and invoicing. The subcontractor's attending engineer will record their actions onto the Compass system once completed. This system is live and access to the data was readily available for analysis. Therefore, independent data from the Compass system was viewed for 160 days prior to RMD and then 160 days after and then examined to see if breakdowns have reduced in the second 160-day period.

Action was taken when a fault or breakdown occurred and if the breakdown was to reoccur then resources were used, for example: technician level involvement to quickly resolve the issue. This, in the first instance, was remotely administered.

2.2 Recording Usage and Adapting Maintenance Regime to Suit Usage

The lift usage varied between sites, and usage was measured from the busiest stores at approximately 100,000 journeys per year. It was found that these lifts often ran out of guide lubricant and were often reported as noisy, resulting in additional visits. Given that many of these lifts were more than 50 years old and required grease pot rotation and regular lubrication. The service regime was traditionally set at monthly intervals. It was therefore prudent to establish a regime such that if the lift experienced more than 10,000 trips per month then additional service visits will be implemented, i.e. after every 10,000 trips, and an alert set to inform the engineer supervisor.

A systematic record made by the RMD was regularly inspected to see if any events were frequently occurring, that may eventually impact on reliability. The following events were thought to be significant:

- Start failure
- Slow speed gate lock trip
- High speed gate lock trip
- System reset
- Stopped out of door zone
- Gate lock fault

3 DATA ANALYSIS

The retail stores observed within this study were averaging some 6 faults per lift per store over the range of 470 lifts in total.

With reference to Fig 1, the 10 sites are identified by their geographical location, and referred to this on the x-axis of the charts below. The blue columns represent the actual number of faults logged for all the sites with RMD installed during 2016. Only 7 sites had 6 months data prior to RMD installation, and 6 months data after RMD installation. For example, Bow had an RMD installed on 29th February 2016, so the calls 6 months prior to the installation were 31 (blue).

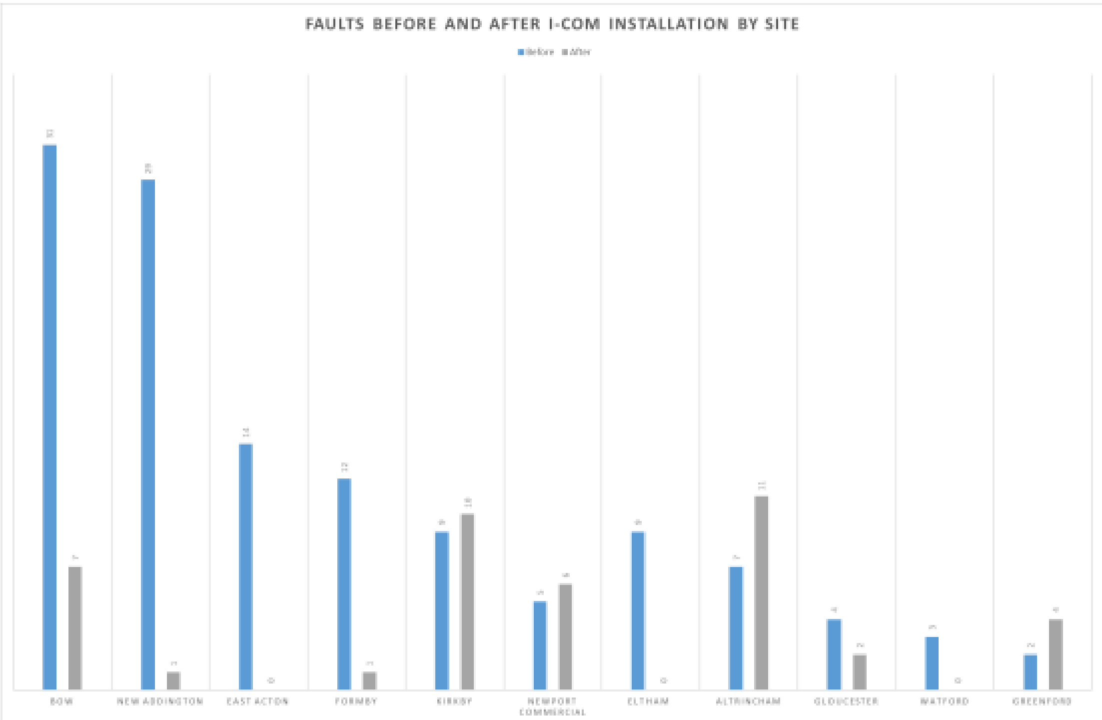

Figure 1 Faults Before and After RMD Installation by Site

Overall there was a 63% reduction in the number of calls. Where there was a high number of annual journeys undertaken by any of the lifts, the maintenance regime was increased to every 8000-10,000 journeys, in some cases effectively doubling the maintenance visits. The maintenance was also more targeted focussing more on the issues registered on RMD. There was more interaction with the staff as engineers were alerted to remotely (email) of faults, resulting in the staff understanding the co-relation between how they use the lift and the frequency of breakdowns.

Generally, faults other than housekeeping reduced. The housekeeping faults increased due to more detection from RMD, this was generally generated from the "start failures". Several start failures were expected as the operators did not always close the doors properly. It was deemed that anything more than 10 failures daily would prompt a phone call to the store, or if persistently requiring a visit from the engineer. The visit may have entailed instructing staff, to keep the tracks clear, or minor adjustment to the lock mechanism. The ROA were also significantly reduced, in effect there should not have been any ROAs as it can be seen if the lift is in service prior to dispatching an engineer, however, the communication between the team monitoring the lifts and the operations teams taking the breakdown calls was not always 100% resulting in engineers being dispatched.

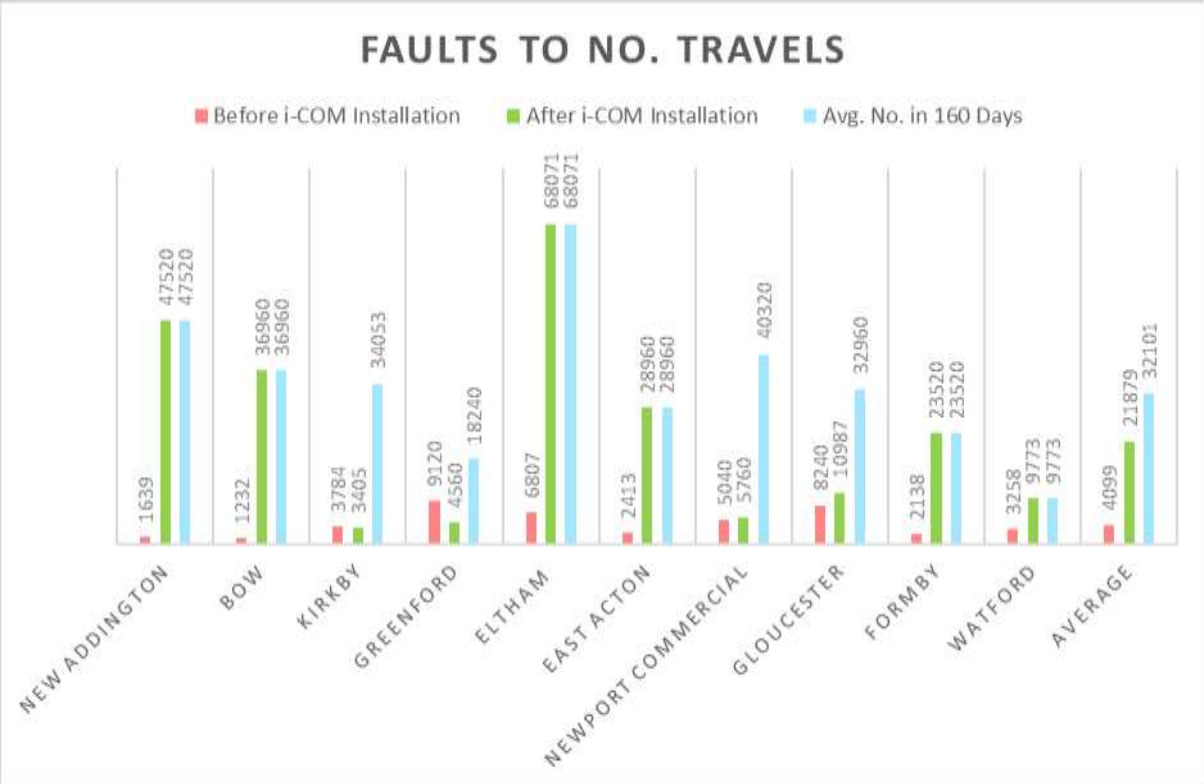

Figure 2 Graph to Show Number of Faults to Journeys

4 CONCLUSION

The data clearly shows that remote monitoring of lift installations will facilitate more effective observations, a faster route to fault detection and better maintenance scheduling of the lift by enabling more observations to take place more frequently. This is due to the observational element being transformed to a desktop exercise. The number of journeys per fault also increased, along with a reduction in breakdowns. There are several explanations for the results, including:

- Better and more targeted maintenance
- Faster fault identification
- Faster fault resolution.
- Eliminating false reporting of breakdowns
- Improved communication with lift user (educating correct lift usage).

Since the end of the study, the development of the RMD and lift maintenance regimes associated with this has continued and with the

- FMECA system automated and used to generate a score,
- If the score was over a pre-set number (100) the issues well examined by a technician and a task list compiled to remedy the issues
- The task list was undertaken by a field service engineer
- The FMECA was observed, and if it was reducing in the coming days then the result of the task list was positive
- If it continued then the engineer was ordered to return to site to carry out the tasks a second time, or a supervisor was ordered to attend alongside the engineer
- The reduction in breakdowns has continued at a similar rate
- Concludes that RM will help to ensure appropriate levels of maintenance is carried out.
- RM combined with task driven maintenance will help identify areas where maintenance should be carried out.

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BIOGRAPHICAL DETAILS

Charles Salter is the owner and Managing Director of ACE Lifts. He has an MSc in Lift Engineering and has been in the lift industry for around 40 years.