# Improving automotive supply chain performance through maintenance strategy development

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## Abstract

The automotive supply chain is a unique set of linked businesses which are subject to constant pressure to be 'lean' and deliver products 'Just in Time' (JIT). Additionally, the continued partnership throughout the automotive supply chain is dependent on the business being able to react to an annual 'cost down' requirement. Lean production tools and techniques, in particular equipment maintenance, ensure this is a constant challenge. Research has established the requirement for a maintenance department to be considered as an equal partner to other manufacturing functions within the business. Failure to do so would lead to missed opportunities of improved production and cost based efficiencies. Yet if a business is surviving within the highly competitive manufacturing environment of automotive production, what is the motivation for change?

It is proposed the solution lies within the investigation and improvement of supply chain development. This will include the construction of a model which aligns the maintenance strategy across the supply chain as well as contributing towards the 'cost down' culture. Consequently, this requires a reappraisal of how equipment should be maintained and the how resources should be managed in this dynamic environment. Therefore there is a need to demonstrate the benefits of a new approach to maintenance within the automotive supply chain. This is necessary as the performance of a manufacturing business can be strongly linked to the effectiveness of its maintenance department, and its ability to deploy appropriate maintenance strategies.

This paper will present initial findings which have emerged from multiple case studies. The rich data reveals there continues to be a separation of the maintenance function from the production system utilised by the business. This separation varies between suppliers, but is damaging to the business and constrains the effectiveness of the maintenance department. Secondly, and perhaps a more pressing issue, there exists a distinct absence of any technical discussion or sharing of best practice between Tier 1 suppliers and their upstream supply chain. The lack of technical development with upstream partners increases the risk to supply chain failure. This may be demonstrated by an over reliance on buffer stock due to production stoppages, or quality issues with the supplied product. The proposed research explores this situation and considers the possibility of developing a model which provides a long term maintenance strategy, overcoming identified constraints to maintenance effectiveness. This aspect of maintenance research is unique, offering specific focus upon the automotive supply chain, the prevailing production system, maintenance strategy cost and unified maintenance development.

## *1. Introduction*

The automotive sector and its supply chain are a vital contributor to the economy of The North East of England. The manufacture of cars in Sunderland has generated over £7bn in sales and directly created over 26,000 jobs. A further 141,000 jobs have been created in local businesses. Despite this success, opportunities exist to improve operational efficiency within automotive companies and their supply chains, in terms of equipment maintenance and machine reliability.

The success of a business within the automotive supply chain is heavily dependent upon satisfying the customer standard for quality, cost and on time delivery. This may not be unique to a manufacturing environment but is extremely challenging within automotive manufacture (Doran, 2001) . The lean principles deployed within this arena ensure waste reduction is a primary concern. Contrary to what might be expected, automotive Tier 1 suppliers often carry significant levels of finished goods stock to service

the Original Equipment Manufacturer (OEM). This means that the absolute deployment of JIT strategies within automotive supply chains is somewhat of a misnomer. Carrying high levels of stock conflicts with the principles of JIT and Lean, which are normally considered the mantra of automotive companies (Monden, 2012). These actions may be explained if the consequences of customer dissatisfaction are considered. Failure to supply 'on time', in sequence and with the appropriate quality could lead to financial penalties or worse still, supplier switching (Thun et al., 2011) .From initial discussions with Tier 1 companies it would seem that some, if not most of the buffer stock was being used as an 'insurance' against machine breakdown.

Preliminary research included other observations of note. The approaches to maintenance within the supply chain were often fragmented and with little or no support from the OEM. This lack of support continued between downstream partners. At a strategic level, the whole supply chain would benefit from a cohesive and 'joined up' maintenance approach yet this could prove challenging, since companies can be reluctant to share information (Singh et al., 2005). Surely, by improving collaboration holistically across the supply chain, this would help facilitate the management of the infrastructure, thus enabling it to operate with improved efficiency.

Looking forward, this thought process suggests that supply chains need to work in new ways to plan, design and maintain infrastructure both at a national and local level. This will allow each business to maintain and have the ability to increase production levels to meet the demand of the automotive industry. Clearly, opportunities exist to improve performance both at a department, business and supply chain level. A new strategy development model, which may be used by Tier 1 and Tier 2 suppliers, would alleviate the symptoms of poor maintenance performance. These symptoms include increased buffer stock and an elevated risk to supply chain relationships. In the dynamic environment of automotive manufacture where quality, cost and on time delivery are essential, the need for all operational departments to maximize their effectiveness is crucial, if the business is to remain competitive (Slack et al, 2011).

The paper is 'positional' and sets out the context and preliminary findings of the research. Whereby, Section 2 is a Literature Review, Section 3 Methodology, Section 4 consists of Initial Findings, Section 5 discusses a New direction and Section 6 concludes the paper.

## *2. Literature review*

### 2.1 *Introduction*

The purpose of this section is to present an examination of the current literature on engineering maintenance, strategy and supply chain management, predominantly within the automotive sector. In addition, the review will conclude with a summary which will identify a gap in current scholarly activity.

### 2.2 *Maintenance approaches*

Maintenance is an essential feature of an effective manufacturing business. Moreover, the impact a maintenance function can have upon the efficiency of the production department is substantial and well recognised (Kumar et al., 2013). A well-considered maintenance strategy forms the cornerstone of a maintenance department. Maintenance strategy development has been researched extensively over previous years and the emergence of strategies that are synonymous with particular industries is not new. Maintenance engineering represents an area of great opportunity to reduce cost, improve productivity and increase profitability for manufacturing companies throughout the world. There are examples of best practice that may be known as World Class Maintenance which are hugely beneficial to the business (Baglee and Jantunen, 2014). In addition, the management of the infrastructure of maintenance within modern industry has become an increasingly important and complex activity. Techniques including Reliability Centered Maintenance (RCM) was developed to be used as a tool within the aviation industry (Kelly, 2000). Furthermore, Total Productive Maintenance (TPM) was developed for use within the automotive industry in the late 20th century (Waeyenbergh and Pintelon, 2002). Research and historical developments aside, initial findings have revealed that there are still fundamental maintenance performance issues within the automotive manufacturing industry.

Maintenance management, including the generation of any operational strategy by the appropriate leadership team, must be linked to the business objectives (Hill & Hill 2009). The efficiency of this process directly affects how well the strategy is deployed (Crespo Márquez et al., 2009). Where extensive research exists identifying the need to integrate a maintenance department with the business, there is often a disjoint between what has been researched to what is seen to be practiced. Previously it had

been recognised within the literature that maintenance was seen as a necessary evil and a fixed overhead (Pintelon, Pinjala & Vereecke 2005; Albert H.C. Tsang, 1998). Yet recent research has recognised the importance of the maintenance function to the business as a whole, which includes its ability to offer a competitive advantage (Muchiri and Pintelon, 2008, Muchiri et al., 2010). The maintenance strategy within a business, its maturity and efficiency can provide an insight into its stature within the business. The traditional conflicts between the production department and the maintenance function may have receded, but the expectation by the business that maintenance can offer a competitive advantage is not the case. As recognised by (Al-Turki, 2011), the lack of integration with business goals can prove problematic.

### 2.3 *Maintenance Strategy development*

The academic discipline of maintenance strategy development within the automotive supply chain has failed to emerge as a subject in its own right, largely remaining an adjunct of manufacturing maintenance management. The explicit consideration of a maintenance strategy within the context of the automotive supply chain, provides an opportunity to contribute towards maintenance research. Without an effective strategy which supports planning and scheduling, maintenance operations will continue to operate in a model which is reactive, inefficient and expensive. Therefore, the potential for the maintenance function to offer a competitive advantage to the business increases with the development and implementation of a functional strategy (Raouf et al., 2006). The strategy should consider a full range of decision elements that are related to both structure and infrastructure. This is recognized and explored by (Pinjala et al., 2006). The temptation is for senior managers within a fast paced manufacturing industry such as the automotive supply chain to become reactive and not explore the full potential of an operational function, such as maintenance (Hill & Hill, 2009). It can be argued that the increase in equipment complexity and the constant pace of technological innovations may force Tier 1 and Tier 2 suppliers to look to each other to solve their maintenance and manufacturing issues, as a weak link in the chain could have a damaging effect on the performance of the supply chain.

If a maintenance department is to be considered effective and contribute towards the key operational drivers of the business, then there are 'key' decision areas when forming a strategy. According to Pinjala et al (2006) they are 10 decision elements that should be considered when proposing and developing an effective maintenance strategy. They are listed in Table 1, and aligned as being either being infrastructure or structural in their nature. The decisions taken in these areas will have a significant impact on the ability of the maintenance department to support and contribute towards the goals and objectives of the business.

| **Decision element** | |
|---|---|
| Maintenance capacity | Structure |
| Maintenance facilities | |
| Maintenance technology | |
| Vertical integration | |
| | |
| Maintenance organisation | Infrastructure |
| Maintenance policy and concepts | |
| Maintenance planning and control systems | |
| Human resources | |
| Maintenance modifications | |
| Maintenance performance measurement and reward systems | |

*Table 1 Maintenance Decision Elements*

### 2.4 *Supply chain management*

The crucial nature of the relationship a Tier 1 manufacturer has with its supply chain is magnified due to the lean production system adopted. Whilst (Thun et al., 2011) noted lean management and production can lead to efficient supply networks, it may also expose weaknesses within the supply chain. These weaknesses can be alleviated through supply chain development and value transfer. A manufacturer can gain a competitive advantage if key performance activities are optimised and configured within its supply chain (Porter, 1980). Research has led to an elementary classification of the relationship a manufacturer may have with its suppliers. Hill & Hill (2009) classify the possible relationships as beginning with 'Trawling the markets', progressing to 'Ongoing relationships' leading to 'Partnerships' and finally 'Strategic alliances'. Within the context of the automotive supply chain an expectation would be of a partnership, where long term contracts are established between suppliers and information is readily shared. Initial interviews reveal that relations are more closely aligned with trawling the market or ongoing relationships. The possibilities are simplified by Singh et al., (2005), who describe the relationship as being relational or contractual. A relational affiliation is noted as promoting a close working association, sharing

information and best practice. Conversely, a contractual relationship is more formal and could be described as combative. The importance of the supply chain within automotive manufacturing would suggest the clear need for a relational association. Yet Singh et al., (2005) continues that the very nature of a lean production system can dictate that a relationship within a supply chain may be defined by cost down requirements, as opposed to targeting improved manufacturing efficiency.

This consistent cost down culture may encourage a contractual relationship, hindering supply chain development. A lack of communication at this level would inhibit the opportunity to improve technical functions such as maintenance. The benefits of sharing technical information throughout the supply chain as well as 'strategic partnering' can reduce the influence of problematic areas and improve business efficiency (Hill and Hill 2009). As noted by (Kumar et al., 2013) a refined and efficient maintenance function can have a dramatic effect upon the performance of a business.

### 2.5 *Conclusion*

The initial review of the current literature supports the conclusion that whilst best practice is recognised in the development and deployment of maintenance strategies, there exists a lack of research into maintenance strategies specific to the supply chain within the automotive industry. The literature also highlights the potential for missed opportunities with regards to developing a maintenance strategy which considers multiple decision elements and hence becomes specific as opposed to generic. This offers the opportunity to develop a maintenance strategy which would be both effective and unifying across the supply chain.

The literature has highlighted the danger of maintenance strategies being allowed to 'self-evolve' based upon the lack of any real strategic direction or goal. Therefore, it is important to be aware that any new framework for multiple companies i.e. within a supply chain, must, collectively take into consideration the organisation of the maintenance function and the way maintenance tasks are structured. This requires a focused maintenance strategy which supports the selection of maintenance tasks and the design of the infrastructure that supports maintenance. Finally, the literature has shown that success of any initiative depends upon several companies, each carrying out its own role effectively as part of a larger, overall supply chain.

## *3. Methodology*

This section begins with a description of the methodology, together with a justification for the design. The section concludes with a more detailed look at the type of data collected, the methods of that collection process and how it has been analysed.

### 3.1 *Aim*

The aim of this research is to develop a model which provides the most effective maintenance strategy for Tier 1 and Tier 2 of the automotive supply chain. The strategy will accommodate the constraints and demands which, when combined, are singular to the automotive industry. This paper is part of a wider body of research which is focusing upon maintenance management within the automotive supply chain.

### 3.2 *Case studies and selection criteria*

A series of case studies is proposed as being the primary and most effective way of answering the research questions. The 'context' is a crucial aspect of the design consideration for the methodology. The context is essential and highly relevant, as confirmed by Gray (2009) and De Witt and Meyer (2010). As part of this investigation, the researcher is looking to study the phenomenon of maintenance and the context of the manufacturing environment in which it is occurring. Each individual case or manufacturer could expect to differ in the following areas:

- The product which is manufactured and its contributing processes
- The OEM which is supplied
- Magnitude of the workforce, both technical and operational
- Geographical location
- Management structure
- Business development history.

Three Tier 1 suppliers were engaged to participate as well as three direct suppliers to those businesses. They would be termed Tier 2 suppliers and are upstream in the supply chain. A differing set of criteria was required for the selection of participants at Tier 1 as opposed to a Tier 2 supplier. The Tier 1 supplier who initially promoted the cause for concern, leading to this investigation was included. Selection of the other Tier 1 suppliers was based upon the following criteria:

- A variation in product manufactured for the OEM.
- A variation in the OEM which was supplied.
- Exclusion of small to medium sized enterprises (SME's).

The criteria will increase the range of data collection which is possible, as well as exposing different aspects of the automotive manufacturing landscape. The manufacture of different products strongly suggests that different processes and technologies will be involved, thereby widening the focus for any particular maintenance strategy (Renna, 2012) . The variation in the OEM that is supplied again increases the range and type of external pressure, which may be imposed upon the Tier 1 supplier. Finally, the exclusion of SME's from consideration for Tier 1 suppliers sharpens the focus for the key issues affecting maintenance strategy development. In the first instance the research does not cross over into pervious areas of literature and scholarly work. Secondly, a small to medium sized enterprise by definition has less than 250 employees and a turnover, which would suggest the reduced ability to contribute towards engineering resources. This strategic selection of case studies based upon the criteria discussed, allows the study to investigate the research question in an effective manner (de Vaus, 2001).

Each Tier 1 supplier has a different range of products, leading to the production technology at each supplier being discrete. Supplier 1 is an international company, and employs approximately 1200 people across three manufacturing sites within the North East of England. Each individual site produces a separate product, but all supply one common OEM. Collectively, Supplier 1 produces injection moulded, foam and sheet metal based parts. Supplier 2 is also an international company, and has two sites within the North East. Each of these sites manufacture similar products to the other, for a group of OEM's. One site employs approximately 1000 people and predominantly manufactures the vehicle chassis and sub frame. The second site is smaller, employing approximately 200 people and manufactures a range of pressed parts utilised within the vehicle chassis. The third participant is also based in the North East and employs 500 people. The main product for manufacture is differing aspects of vehicle trim, which involves injection moulding and paint processes. This participant also supplies various OEM's.

There are two main areas of focus for the selection of Tier 2 suppliers. Firstly, their own product requires manufacture and hence involves a production process. This process would require some form of maintenance or it would, at some point, be prone to breakdown and failure (Renna, 2012) . Secondly, that the product manufactured had to be a 'made to order' component which forms part of an overall assembly process. This allowed a continuation of the prevailing production constraints throughout the supply chain.

### 3.3 *Data Collection*

The primary nature of the data from the case study participants is qualitative and collected from interviewing selected personnel from each business. The selection of personnel to be interviewed across all case study participants has, where possible, been consistent. Selection has been centred upon employees who play an active role in maintenance development and deployment. This allows rich data to be gathered from staff who have both a direct or indirect role within engineering maintenance. The range includes those who have the responsibility of developing maintenance strategies, personnel who are required to manage the strategy and finally, employees who have an active role in deploying the strategy. The job roles include senior managers through to production operators. This cross section of employees, with varying technical and academic backgrounds will provide the opportunity to link feedback and attitudes, to staff experience.

The data collection consists of several stages. Preliminary interviews at Tier 1 are complete, and semi structured interviews are nearing completion within the Tier 1 case study group. The questions asked within the interview are sourced from the literature review as well as the being refined from work carried out through the preliminary interviews. Following this, the responses are coded to identify constraints to maintenance effectiveness, which emerge from the interview. The constraints are then categorised against the maintenance strategy decision elements described within Table 1 of the literature review. Consistent themes emerging from the rich data will lead to a concentrated set of decision elements. These decision elements will provide focus for the automotive manufacturing industry, on the key issues which require attention for maintenance strategy development.

## *4. Initial Findings*

There were several key areas raised from the literature review regarding the development of an effective maintenance strategy. These included

the need for senior management to be involved with the development of the maintenance strategy and the importance of a specific, targeted maintenance programme. Additionally, specific strategies prove most effective when relevant maintenance decision elements are taken into account during the formulation of the maintenance strategy. According to literature, this improved the likelihood for a business to be both efficient and successful. The initial findings from this research help clarify this perspective. This involved research across three automotive Tier 1 suppliers which identified the key points constraining the deployment of effective maintenance strategies. The information shown in Table 2 was produced by transcribing and analyzing the interviews.

| Constraints | Supplier 1 | Supplier 2 | Supplier 3 |
|---|---|---|---|
| Training | ✔ | - | ✔ |
| Skills | ✔ | - | ✔ |
| Staff Resources | ✔ | - | ✔ |
| Equipment and spares | ✔ | - | ✔ |
| Production System | ✔ | ✔ | ✔ |
| Maintenance shift system | ✔ | - | ✔ |
| OEM | ✔ | ✔ | ✔ |
| Supply chain partner | ✔ | ✔ | ✔ |
| Audit requirements | ✔ | ✔ | ✔ |
| Parent Company | ✔ | ✔ | ✔ |
| Senior Management | ✔ | ✔ | ✔ |
| Organisational Culture | ✔ | ✔ | ✔ |
| KPI's | ✔ | - | ✔ |
| Budget | ✔ | - | ✔ |

*Table 2 Identified constraints across each case study participant.*

Table 2 provides an effective snapshot of the status of the suppliers involved in the research. Along the left hand column of the table is a list of the constraints/influences on the development and execution of a successful maintenance strategy. 'Production system' refers to the relationship between the OEM and the Supplier e.g. JIT, synchronous supply (Doran, 2001) or modular supply (Doran, 2004).

If Table 2 is more closely considered, it can be seen that Supplier 1 and Supplier 3 have the same constraint profile but differ from Supplier 2 in quite a few areas. Clearly, opportunities exist to cascade the knowledge gained from Supplier 2 and share this with the other organisations, but further investigation is required. Considering the agreement between suppliers, seven key constraints were noted.

### 4.1 *Production System*

Firstly, it was clear from the interviews that the 'Production system' imposed significant demands on Tier 1 suppliers. As a result, this generated considerable internal tension and stress. The requirement of the OEM for suppliers to deliver in sequence and on time, with high levels of quality was a constant challenge. As a result, traditional conflicts over manufacturing priorities were amplified between production and maintenance. This can be exemplified by production needing to run the equipment, whilst maintenance needed access the equipment to maintain and repair. The failure to release operational capacity meant that planned maintenance was often postponed in preference to production needs. Over time, the frequent disruption to maintenance policy must seriously limit the effectiveness of any conventional maintenance strategy. This forces a rethink on what might be appropriate in this dynamic and challenging environment.

### 4.2 *Senior management*

The engagement of the senior management with the maintenance department was seen as an issue for suppliers. The involvement and support of the senior management team with the maintenance department varied dramatically across the companies. In the cases of Supplier 1 and 2, they indicated a progressive attitude towards the maintenance function by senior management, an attitude which recognised the shortcomings of the department but also the potential benefits it offered to the business. However, Supplier 3, indicated a traditional attitude toward the maintenance function, Here, they were seen as a cost centre, an overhead, a 'necessary evil'.

Interview feedback alluded to the long-term development of the maintenance function by senior management being superficial or even absent. Rather than working with maintenance to agree holistic and coherent strategies, more emphasis was being placed on lagging performance indicators such as Overall Equipment Effectiveness (OEE) and industry audits such as TS 16949. This emphasised the static monitoring of day-today operations, with

little emphasis on improvement activity. There was clear evidence that senior maintenance engineers were more often directly involved in reactive and remedial maintenance and that the notion that such a responsive policy was appropriate, seemed to prevail. There appeared to be little pressure or direction from senior management for maintenance to change, or develop any long-term goals for the department.

### 4.3 *Organisational Culture*

The importance and management of culture within an organization is crucial to the success of any business strategy (de Wit et al., 2010). In terms of maintenance strategy and culture, Kelly (2000) emphasized the need for a 'holistic' approach to strategy coupled with a positive and progressive attitude towards maintenance. When the interviews were held, a number of cultural issues and inter-departmental disputes were raised. Interviewees expressed a frustration over the negative attitude of fellow staff toward maintenance. This was not restricted to the shop floor but also was evident amongst senior management. Moreover, colleagues were more focused on their own agenda rather than considering and supporting the maintenance group.

The feedback indicated that operational staff often held 'traditional' attitudes and were resistant to engaging in new ideas, such as autonomous maintenance. This rigid adherence to historical working practices was clearly limiting maintenance resources and constraining potential development and change. In two of the companies, senior managers were deliberately minimising the 'interference' of operators as a matter of policy, in effect de-skilling them. This was an example how maintenance and production strategies can diverge locally when there is no strategic coherence or agreement. As underlined by Berges et al., (2013), *"the prevailing attitudes of senior managers, technical staff and production operators has a dramatic effect upon the effectiveness of the maintenance department".*

### 4.4 *Maintenance Performance Measurement (MPM)*

The establishment of an MPM strategy incorporating key performance indicators (KPI) can create an advantage to the business and provide value to its customers (Kumar et al., 2013). However, initial findings of the Tier 1 suppliers polled indicated that targeted KPI's for maintenance were limited. The focus of the businesses was directed towards OEE of the individual plant. Following this, participants indicated any measurement was predominantly financial, and may include percentage completion of preventative maintenance activities. It was evident that the Parent companies had a major influence on KPI's and drove most of the performance indicators used in the plants. Understandably, there was major emphasis on adhering to budget. Kumar et al (2013), warned that although a focus on financial performance may prove beneficial internally within a department, it may have little benefit to other functions, such as manufacturing. Summarising, all suppliers viewed their performance indicators as a constraint and clearly there was need to address this. Potentially, the development of a cohesive MPM strategy may be the way forward to close the gap in practice of the operational strategy development.

### 4.5 *Supply chain*

Given the context, it was expected that Supply chain development would be an integral part of the respondent's business strategy but this was found to be lacking. The need to share information and best practice, especially amongst maintenance professionals, has to be vital to the health and efficiency of any supply chain. However, feedback suggested there was little or no information being shared between Tier 1, Tier 2 suppliers or OEM's. Yet Thun et al. (2011) and Porter (1980) indicate it as a necessity to encourage best practice and mitigate risk. However, rather than using this approach, suppliers had built buffer stocks to ensure consistency of supply. Worse still, this practice was systemic within each plant. Buffer stock was stored at critical production points, to give 'breathing space' just in case there were machine failures. The location and quantity of safety stock often having been identified and agreed with the OEM. This was in response to a history of breakdowns and production line stoppages. Typically according to Thun et al. (2011) , operating with over-capacity and safety stock is more the hallmark of a SME within an automotive supply chain environment, yet here was an example of reactive practice being employed by large, international companies. A key contributor to this, was ineffective maintenance programmes leading to unreliable manufacturing processes. This continued inefficiency across the supply chain due to ineffective maintenance practice provides urgency for this research, offering the opportunity for maintenance strategy improvement across the supply chain.

### 4.6 ***Budget &Finance***

The constant demand on efficiency within the automotive supply chain, has led to a sharp focus on cost management. The annual 'cost down' requirement from the OEM (6% per annum in one instance), has led to a significant impact on maintenance resources with Supplier 1 and Supplier 3. Naturally, failure to achieve such a key business objective would place the relationship at risk and could result in the OEM switching suppliers. As a result, Supplier 1 experienced substantial conflict with the finance department. The continued tightening fiscal policy of the business, created a damaging procurement strategy, which did not support the optimum use of maintenance resources. Procurement of spare parts for machine and process maintenance was often driven by cost, as opposed to performance and component uniformity. This led to a high degree of the budget capacity for maintenance being contained within the stores department. This provides a good example of a reactive strategy to a cost down objective, limiting the potential of operational functions such as maintenance. Supplier 2 offered a different perspective. 'Cost Down' did not have the impact upon maintenance management that was in evidence with Supplier 1 and 3. A deeper understanding was in evidence with the senior mangement team of the financial requirements and procurement needs of the department. What emerges is that efficient financial performance is crucial if each Supplier is to be competitive within this manufacturing environment, yet it appears it does not always have to be to the detriment of resource intensive function such as maintenance.

### 4.7 ***Training, Skills and Staff***

The importance of sufficient skilled personnel is fundamental to the ability of an operational function, such as maintenance, to perform effectively over a long period (Samson, 1991). A review of Table 2 indicates Supplier 1 and 3 confirm issues with Training, Skills, and Staff, yet Supplier 2 does not. Further exploration of the initial findings from Supplier 2 indicated this is explained by the significant length of service demonstrated by personnel within the maintenance department. Additionally, Supplier 2 operates a long running, comprehensive apprenticeship scheme, which produces qualified maintenance technicians. As well as facilitating the training of new staff, Supplier 2 is able to retain them. The combination of retaining newly qualified trainees as well as experienced personnel is crucial for the performance of the function. As discussed by (Parida and Kumar, 2006), increased experience, knowledge and skills has a direct contribution to the effectiveness of the maintenance department. The retention strategy of Supplier 2 is worthy of further investigation. Supplier 1 and 3 expressed their frustration with the skill set of their maintenance technicians. The lack of experience and skills across both Suppliers having led to working practice which caused increase risk to maintenance performance and the business. Discussions with Supplier 1 revealed that during maintenance activity, resolving the task often required consultation with the senior maintenance engineer. This was due to some of the technician team having reduced confidence and technical ability. Supplier 3 related that maintenance staff were inflexible in their activities, retaining traditional practice and working only within the confines of their engineering discipline. This was often to the detriment of the business. These issue were compounded by the cost management culture with Supplier 1 and 3, where technician development through training was not prioritized.

## *5. A new approach*

The research completed up to this point has demonstrated the inconsistency of maintenance practice in the automotive supply chain. It is proposed the construction of a maintenance strategy development tool will improve the performance of a maintenance department within the supply chain, by providing a framework from which it can meet current and future challenges. Also, the tool will be able to allocate the resources available in the most effective manner through the decisions taken. The context of the automotive environment and supply chain will be demonstrated through the focus of the decision elements, which may be noted in Table 3. The identification of constraints and influences from the preliminary and semi structured interviews conducted to date, have been distilled and categorized against the decision elements established by Pinjala et al (2006). Other elements are listed within that work, but are not required. An additional element with an external focus has been added to accommodate feedback provided from the rich data.

| Identified constraints and influences | Key Maintenance decision elements | Structure/ Infrastructure |
|---|---|---|
| Senior management attitudes | Human Resources | Infrastructure |
| Parent Company and Organisational culture | | |
| Training | | |
| Equipment and spares | Maintenance facilities | Structural |
| Technology | | |
| Skills | | |
| Staff resources | Capacity | Structural |
| Production system | | |
| Maintenance shift system | | |
| Budget | Maintenance measurement, planning and control. | Infrastructure |
| Key performance indicators | | |
| Audit | | |
| Supply chain partner | Supply chain | External |

*Table 3 Maintenance strategy elements for the Automotive supply chain*

The decision elements listed and their underlying influences and constraints, will form the cornerstone of the development work going forward. The additional element of the 'Supply chain' provides a direct link to the gap in maintenance research which is the focus of this work.

If the tool is used to its full extent, it is anticipated that it will provide the opportunity to focus the maintenance strategy development on areas which have been identified, through this research, as being an operational issue for maintenance effectiveness.

## *6. Conclusions*

Although maintenance within a manufacturing environment has been well researched, the context of the automotive supply chain provides opportunity for development. This research has established that maintenance practice is inconsistent within each case study participant. The influences and constraints which have forced the inconsistency include:

- Senior management attitudes
- Parent Company and Organisational culture
- Training
- Equipment and spares
- Technology
- Skills
- Staff resources
- Production system
- Maintenance shift system
- Budget
- Key performance indicators
- Audit
- Supply chain partner

The consequences of these constraints affecting the performance of the maintenance department are substantial. Poor performance of a maintenance department can directly affect the relationship with the customer, by disrupting on time delivery of a quality product. Additionally, to alleviate the risk and poor performance, creation of safety stock prevents the business operating efficiently. This constant pressure raised by the delivery requirements of the OEM, causes multiple issues within the automotive supply chain. Not least the financial management of the business and the resulting operational 'fall out'. If a business is to survive within the automotive supply chain environment where an annual cost down culture prevails, then removing or alleviating the root cause of these constraints is of great benefit.

Many of the barriers described within the interviews had been in evidence for a number of years, to the frustration of the staff involved. The findings demonstrated that any review and development of the incumbent maintenance policy was varied and often audit based. Additionally, a lack of communication and sharing of best practice between the supply chain encouraged isolated maintenance development. Discussions revealed that any maintenance programme which was in place across each of the three Tier 1 suppliers was generic or self-developed and not the result of a strategic plan for the department. The selection, organization and implementation of the maintenance programme was very much aligned with decisions made by operational staff, such as the Maintenance Engineer. Any development and improvement of the maintenance department was focused upon the more obvious structural elements such as staff resources and equipment. This allowed issues with infrastructure to remain, thus preventing effective long term development. The lack of

development of infrastructure elements, has led to the business missing the opportunity to exploit the potential longer term benefits.

The issues identified within this research have demonstrated that the context of the automotive supply chain provide substantial challenges to a maintenance function, and its effectiveness to the business. An over reliance on maintenance development being driven from the 'bottom up' has led to fundamental issues with the infrastructure of each business. Addressing the elements which have been identified in a strategic manner, would re-engage the required personnel within each business to develop the longer term activities of the maintenance department. It is anticipated this technique of strategy development could be used across Tier 1 and Tier 2 suppliers, encouraging a unified approach to maintenance.

## *7. References*


Albert H.C. Tsang, 1998. A strategic approach to managing maintenance performance. *J. Qual. Maint. Eng*. 4, 87–94.

Al-Turki, U., 2011. A framework for strategic planning in maintenance. *J. Qual. Maint. Eng.* 17, 150–162.

Baglee, D., Jantunen, E., 2014. Can Equipment Failure Modes Support the Use of a Condition Based Maintenance Strategy? *Procedia CIRP* 22, 87–91.

Berges, L., Galar, D., Stenström, C., 2013. Qualitative and quantitative aspects of maintenance performance measurement: a data fusion approach. *Int. J. Strateg. Eng. Asset Manag*. 1, 238–252.

Crespo Márquez, A., Moreu de León, P., Gómez Fernández, J.F., Parra Márquez, C., López Campos, M., 2009. The maintenance management framework: A practical view to maintenance management. *J. Qual. Maint. Eng.* 15, 167–178.

de Vaus, D.A (2001) *Research Design in Social Research*, Sage Publications, London

de Wit, B., Meyer, R (2010) *Strategy: Process, Content, Context*, 4th Ed, Cengage, Andover

Doran, D., 2004. Rethinking the supply chain: an automotive perspective. *Supply Chain Manag. Int. J.* 9, 102–109.

Doran, D., 2001. Synchronous supply: an automotive case study. *Eur. Bus. Rev.* 13, 114–120.

Gray, D.E (2009) *Doing research in the real world*, London, Sage Publications

Hill, A., Hill, T. (2009) *Manufacturing Operations Strategy*, 3rd Ed, Palgrave Macmillan, United Kingdom

Kelly, A (2000) *Maintenance Strategy*, Butterworth-Heinemann Oxford

Kumar, U., Galar, D., Parida, A., Stenström, C., Berges, L., 2013. Maintenance performance metrics: a state-of-the-art review. *J. Qual. Maint. Eng*. 19, 233–277.

Muchiri, P.N., Pintelon, L., Martin, H., De Meyer, A.-M., 2010. Empirical analysis of maintenance performance measurement in Belgian industries. *Int. J. Prod. Res.* 48, 5905–5924.

Muchiri, P., Pintelon, L., 2008. Performance measurement using overall equipment effectiveness (OEE): literature review and practical application discussion. *Int. J. Prod. Res.* 46, 3517–3535.

Parida, A., Kumar, U., 2006. Maintenance performance measurement (MPM): issues and challenges. *J. Qual. Maint. Eng.* 12, 239–251.

Pinjala, S.K., Pintelon, L., Vereecke, A., 2006. An empirical investigation on the relationship between business and maintenance strategies. *Int. J. Prod. Econ.* 104, 214–229.

Porter, M (1980) *Competitive Strategy: Techniques for analysing industries and competitors*, The Free Press, New York

Renna, P., 2012. Influence of maintenance policies on multi-stage manufacturing systems in dynamic conditions. *Int. J. Prod. Res.* 50, 345–357.

Samson, D (1991) *Manufacturing and Operations Strategy*, Prentice Hall, Victoria

Singh, P.J., Smith, A., Sohal, A.S., 2005. Strategic supply chain management issues in the automotive industry: an Australian perspective. *Int. J. Prod. Res.* 43, 3375–3399.

Slack, N., Lewis, M. (2011) *Operations strategy*, 3rd Ed, Pearson, Harlow

Thun, J.-H., Druke, M., Hoenig, D., 2011. Managing uncertainty - an empirical analysis of supply chain risk management in small and medium-sized enterprises. *Int. J. Prod. Res*. 49, 5511–5525.

Waeyenbergh, G., Pintelon, L., 2002. A framework for maintenance concept development. *Int. J. Prod. Econ*. 77, 299–313.