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Article

Challenges and prospects of applying asset management principles to Highway maintenance: A case study of the UK

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Abstract: *Past models and tools that support in the decision making process based on Asset Management Principles (AMP) are lacking in terms of the effective outcomes and transparency of the process in the highway maintenance. There is also little research on how to align the decision areas when applying AMP and how to improve the inclusive effectiveness. Hence, the paper focuses on examining the challenges and prospects of applying AMP in a highway maintenance agency or department. An exploratory research method was used through an extensive review of literature and an industry survey. The findings from the literature and case study review were used to design a questionnaire and conduct the survey. The survey results revealed that the AMP are only being implemented ineffectively in maintaining highways, and a strong commitment is required to improve the asset management capability for effective use of the asset data. It is highly recommended that the Highway Agency should issue a guideline for implementing asset management policy and also encourage associate departments to achieve asset management maturity level 3 so that ISO55000 certification can be achieved. The study concludes that there is still substantial work needed within the asset management process, particularly in highway maintenance before its effectiveness can be realised and measured.*

Keywords *– Asset management principles, highway maintenance, infrastructure, highway agency, policy, ISO55000*

1. INTRODUCTION

Highway infrastructures are the largest, most valuable, and visible assets, which are owned by the public in the UK. ISO55000 is an international standard, which covers the management of physical assets. According to ISO55000, assets are something with potential value to an organisation and for which the organisation has a responsibility. However, asset management covers the whole lifecycle of the physical assets, which include construction, maintenance and disposal. It is a well-established and executed discipline in the UK and internationally, for the management of physical assets according to a report published by the UK Highway Agency (HA, 2015). The report highlights that the adaptation of asset management principles demonstrates the benefits in terms of financial efficiencies, improved accountability of the assets, better value for money and enhanced customer services. However, there are significant challenges in managing the highway assets. Satisfying the growing expectations of the public for accessibility and eagerness of the highway networks, reliability of journey times, increasing scrutiny, transparency, accountability and media exposure while delivering the legal obligations, and maintaining the engineering integrity of the highway networks are examples of key challenges. Managing the impact of traffic growth under huge financial constraints with

a clear message of "more for less", and "making the most of what you have" is causing extra pressure on the use of existing physical infrastructure assets (HA, 2015). It is therefore essential to investigate the challenges and prospects of implementing the Asset Management Principles (AMP) within the highway infrastructure, particularly during the maintenance period so that the benefits from the AMP could be realised and achieved.

Previous studies have produced several asset management models and tools to support the decision making process of public organisations when adopting the asset management principles but there is still little understanding on how to align the decision process in the asset management and to improve its effectiveness. This study is based on the comprehensive analysis of existing literature relating to highway asset management principles with the aim of exploring how the UK Highway agency is responding to the challenges through the implementation of asset management principles against its reduced budget, and under different constraints. This paper outlines the public policies relating to asset management principles through an extensive literature review. Evaluation of a case study and the results of an industry based questionnaire survey, are discussed and recommendations for possible methods on implementing AMP more effectively into the highway maintenance sector are identified.

2. LITERATURE REVIEW

2.1 Asset Management

Asset management enables the realisation of values from the physical assets (ISO55000). It is a complex paradigm, requiring stakeholder's consensus on the values, policies, strategies and tactics, which are related to the infrastructure services, performance metrics, and associated management trade-offs (Spatari and Aktan, 2013). Van der Velde et al (2013) pointed out that asset management is the profession of balancing cost, performance and risk over the life cycle of an asset. However, the Institute of Asset Management (IAM) defines asset management as "the coordinated activities of an organisation to realise values from the controlled assets". This definition is expanded further as a discipline wherein an organisation can use its principles and concepts to raise the value of the assets by balancing costs, opportunities and risks against the desired performance of the assets (IAM, 2012). Asset management has been practiced for thousands of years and researched for decades, however, there is no common understanding of what it is (Scharven et al, 2011). Consequently, asset management is a relatively emergent discipline and there is limited literature, particularly in relation to transport infrastructures.

In the UK, the owners of transport infrastructures such as Highways Agency (HA), Local Authorities (LA), Network Rail (NR), and the Canal and River Trust (CRT) all have introduced asset management policies. For the Highway Agency and Local Authority highway departments, this has become more significant and valuable due to the recent times of austerity and the deteriorating conditions of the highway assets in the UK. The highway asset is the most valuable publicly owned asset (UK RLG, 2013). The majority of the population use the road networks daily so it is of huge importance to the economic, social and environmental wellbeing of the community and businesses (Kendrick and Taggart, 2006). Hence, it is crucial that the highway assets need to be maintained effectively to ensure that they are kept in a safe condition for all who use them whilst working under several financial constraints and reduced maintenance budgets. To address the above challenges, the Department for Transport (DfT)

stressed to enhance its capability of managing the assets and necessary skills so that DfT may be enriched itself as a high performing asset management organisation.

According to Davis (2012), a key principle in asset management is a line of sight, which means an approach within an organisation that looks to line up the work that is done directly on assets with the objectives of the organisation. Moreover, it is a discipline that recognises and aligns the risk of owning and operating a particular asset to fulfil the aims of the organisation that operates the assets management. The principles of asset management derive from the practical experience and reasoning, and aid to inform both strategic asset management and its practical applications to the life-cycle of the asset. These principles are asset acquisition, disposal and life-cycle management decisions, which are integrated into an entity's strategic and organisational planning. Furthermore, asset planning decisions are based on the evaluation of alternatives, which measures risks and benefits, and applies the public's core procurement principle of 'value for money across the asset's life-cycle'.

2.2 Asset management in infrastructure

Due to the economic crisis in 2008, many agencies and local councils were under huge pressure to satisfy expectations of the public in terms of reliability, safety and availability of the infrastructure networks under reduced financial constraints (Arts et al, 2008). Asset management has emerged as an approach which can help to achieve more value with fewer resources (Moon et al, 2009). The performance of public infrastructures has a strong influence on the economic viability and social development of nations (Scharven et al., 2011). To overcome these issues, the agencies are seeking new actions and processes to manage their physical assets more effectively and efficiently.

Moreover, Too et al. (2006) scrutinised some of the current asset management practice by government agencies in Australia and found that these agencies used a strategic approach despite the different frameworks adopted in practice. Later research suggested that organisations responsible for the management of infrastructure assets have to satisfy the needs and conflicting demands of the various stakeholders (Too, 2012). On one side, the public expect high quality of service and continuously improvement of the infrastructures. Whilst on the other side the asset owners or regulators, often the government, want to limit the spending on infrastructure maintenance costs by introducing new regulations whilst also demanding the safeguarding of the public interest (Wijnia and Herder, 2009). Therefore, the asset management authorities are increasingly under pressure to manage such pressures from the stakeholders, which is articulated and displayed in Figure 1.
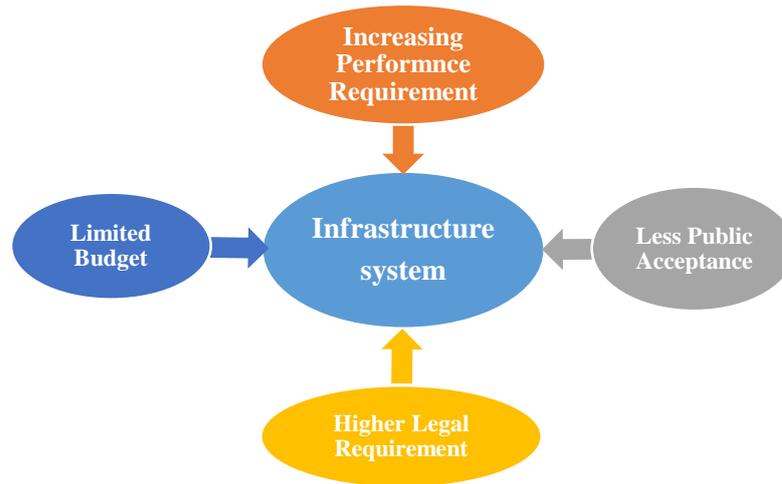
Figure 1: Pressures on infrastructure system. (Source: Van der Velde et al., 2013)

Due to such pressure, the asset management discipline has increased the attention of many infrastructure operators to asset management policies. After all, asset management is the profession of balancing cost, performance and risk over the life cycle of an asset (Van der Velde et al., 2013). However, when getting into the details of the infrastructure system, it becomes clear that the total operation of an infrastructure is not only dependent on the physical assets, but also on other elements such as information, financial means, human aspects and intangible aspects. Therefore, it is no surprise that asset management has been adopted by infrastructure organisations as a mechanism for recognising the values from their assets based on the conflicting demands that need to be managed.

2.3 Challenges of implementing asset management

Asset management is not something that can be introduced to an organisation overnight. Indeed, it is often described as a journey that can take many years and can involve a huge effort to introduce and embed the necessary changes to be implemented to engage asset management values (Godau, 2008). IAM (2012) describes asset management as a way of thinking and should take account of everything an organisation does. Godau (2008) discusses the efforts of Brimbank City Council, a metropolitan council in Melbourne, Australia, to enable a cultural change to empower staff to take responsibility of the asset management, and also focus on delivering the improved services in a sustainable way. However, a case study, which documented the efforts of a Dutch infrastructure agency in implementing AMP, reveals that the senior management required to be convinced of the strategic value of the asset management and aligning it with organisation objectives, although asset management principles were being implemented in the organisation (Van der Velde et al., 2013).

A number of authors have highlighted the importance of having a data inventory of all types of assets as the first step in implementing an asset management system (Godau, 2008; Too, 2012; Van der Velde et al., 2013; Brint and Black, 2014; Migliaccio et al., 2014). These arguments are supported by the IAM (2012). However, it has been widely recognised that the implementation of an asset management information system and the subsequent collection of asset data is often an expensive and resource intensive task (Van der Velde et al., 2013). Godau (2008) noted that introducing an asset management information system creates considerable

pressure for the capture of field data in an accurate and timely manner. This can be a particular problem in infrastructure when many assets can be eroded resulting in missing or incomplete information (Van der Velde et al., 2013). This is supported by the research, which was conducted by Wijnia and Herder (2009), and exposed that many asset managers expressed concerns over the quality of data contained in the information systems they rely on. In the case study of the Dutch infrastructure agency, Van der Velde et al (2013) found that a large investment was required to get the asset data to a level sufficient to meet the requirements of the asset management programme that need to be implemented.

According to Too (2012), informed decisions can be made more accurately through interpretation and analysis if an accurate and up to data asset inventory is maintained. This was recognised by Brimbank City Council who initiated an asset management improvement programme to develop the asset management capability within the organisation as part of their drive to embed asset management as a corporate function (Godau, 2008). Although a number of models based on quantitative data have been suggested to support the decision making process (Ortiz-Garcia, et al., 2005; Brownlee, et al., 2007; Stratford, et al., 2010; Burnett and Vlok, 2014). The case studies of three infrastructure authorities conducted by Too (2012) found that infrastructure organisations need to have experienced people, who know and understand both about the asset and how the asset interacts in the bigger operational picture.

2.4 Asset management in highway maintenance

Applying asset management principles to highway maintenance is not a new practice. There are a number of research case studies exploring its adoption in Japan, the United States and the Netherlands (Moon et al., 2009; Van der Velde et al., 2013; Lownes et al., 2010). It has also been adopted by some highway authorities in the UK but there have been wide ranging approaches to its implementation (UK Road Liaison Group, 2013). Within the existing literature, the use of asset management in a highway maintenance context is often referred to as Transportation Asset Management (TAM). A number of definitions of transport specific asset management are shown in **Error! Reference source not found.**.

Table 1: Definitions of Transportation Asset Management

Organisation/Author	Definition
National Cooperative Highway Research Program (NCHRP) (2002)	*"Transportation Asset Management is a strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their life-cycle. It focuses on business and engineering practices for resource allocation and utilization, with the objective of better decision making based upon quality information and well-defined objectives."*
US Department of Transportation (USDOT) (1999)	*"Asset management is a systematic process of maintaining, upgrading, and operating physical assets costs-effectively. It combines engineering principles with sound business practices and economic theory, and it provides tools to facilitate a more organized, logical approach to decision-making. Thus, asset management provides a framework for handling both short- and long-range planning."*

County Surveyors Society (2004)	*"Asset management is a strategic approach that identifies the optimal allocation of resources for the management, operation, preservation and enhancement of the highway infrastructure to meet the needs of current and future customers."*
Organisation for Economic Co-operation and Development (OECD) (2001)	*"A systematic process of maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale, and providing tools to facilitate a more organised and flexible approach to making the decisions necessary to achieve the public's expectations"*
Institute of Public Works Engineering Australia (2011)	*"To meet a required level of service, in the most cost effective manner, through the management of assets for present and future customers."*
Bittner & Rosen (2004)	*"TAM is a systematic process of operating, maintaining, and upgrading physical assets cost-effectively. It combines engineering and mathematical analyses with sound business practice and economic theory."*

All of these definitions in Table 1, bar one, state that asset management be systematic, strategic, and customer focussed. These themes are particularly relevant to highway maintenance that justify the large budgets allocation so that a safe and serviceable network can be provided (Satirasetthavee and Pannapa, 2007). Highway infrastructure is of a particular importance as it ensures the mobility of people and eases the transport of goods. Therefore, exceptional attention should be given to the construction, repair and maintenance, and upgrading of highway assets (Hallberg and Racutanu, 2007). The definition offered by Bittner and Rosen (2004) recognises that TAM needs to be a mixture of both engineering and business decisions. Highway assets deteriorate over time and the rate of weakening depends on how much they are used and what environmental conditions they are exposed to (Selih et al, 2008). Therefore, highway authorities need an efficient method to highlight the potential maintenance schemes (Brownlee et al, 2007).

Moreover, in the case of highway maintenance in Australia, Canada, England, and New Zealand, David et al (2005) found that an organisational culture and a decision making process is a critical challenge to asset management for transportation programs and successful asset management requires top-level commitment. They recommended that a national asset management steering committee needs to be created using AMP in order to evaluate and invest in the regional system, distribute information, provide necessary training, develop a web-based asset-management toolbox, and conduct more research on asset management topics.

Particularly, in the case of New Zealand, it was found that asset management focuses on organisational attention and the ability how to manipulate asset data at an area network level, which supports the change behaviour and outcomes but is ineffective to measure the performance of the organisation, that might be meaningful and relevant. It was noted that the data collection is the critical task to successful implementation of the asset management policy, but inaccurate and conflicting data are worse than having none at all (David et al, 2005). However, in the case of Canada, Alberta Infrastructure and Transportation (AIT) is the only state-level agency responsible for managing the road assets and the entire organisation has been reinvented to incorporate a different business and decision making culture. Asset management is viewed as an important means of determining the best business decision for a large portion

of the agency's budget. However, in the case of New South Wales Australia, Roads and Traffic Authority (RTA) has a high level of consistency among the agency's levels of decision making and RTA use the performance measures system to make the asset management plan. The RTA has adopted a thoughtful approach to asset management as it pertains to PPP (Public Private Partnership) projects (David et al, 2005).

Moreover, the AMP allow these business decisions to be made by providing reliable information about trade-offs to the decision maker (Moon et al, 2009). Asset management lends itself to highway maintenance as it allows cost, risk and whole life performance to be enhanced so that maintenance interventions can be made at a time that provides the best value for money. This also leads to a more sustainable built environment as the need for new assets could be reduced and a more efficient use of resources could be mobilised (Selih et al, 2008). Based on the practices adopted in Australia, Canada, England, and New Zealand, it is concluded that the challenges and prospects of implementing the asset management principles are different from country to country and organisation to organisation in any country. The next section describes about the research methodology adopted in this study.

3. RESEARCH METHODOLOGY

This sections describes the design of questionnaire and adopted methods of industry survey followed by the survey results and discussions. Moreover, a case study strategy was also used to analyse and evaluate how the highway department in the UK is currently conducting highway maintenance and implementing the asset management principles. Case studies allow the researchers to explore within its context of topic (Saunders et al, 2012). The observations, made during a case study aid to form the basis on how these principles might be influencing the highway maintenance decisions. The case study was compiled by drawing the author's experience and knowledge, and findings from a comprehensive review of literature.

The research data was collected through the use of a questionnaire survey. Staff working in the directorate responsible for highway maintenance, known as Network Delivery and Development (NDD), were invited randomly to complete the questionnaire after ethical approval. The NDD directorate consists of approximately 500 people spread across nine regional and operational divisions in the UK. Each division is separated into a number of teams with different responsibilities. The set questions were based on themes arising from the case study (Saunders et al, 2012) and the outcomes drawn from the literature review with the aim of exploring the respondents' views of implementing the asset management principles and how these principles influence the way in which highway maintenance is conducted.

The questionnaire was administered using a web-based system, Survey Monkey™, and it was self-completed by the respondents. A set of twelve closed-ended questions and one open question were set with the aim of covering a wide range of issues and making an effective analysis. Open questions aimed to provide additional thoughts or opinions of the respondents whereas the closed-end questions consisted of category and rating questions with the aim of collecting quantitative data (Saunders et al, 2012). The questionnaire was delivered to the targeted respondents via email after successful running of the pilot study. The link to the questionnaire was sent with a covering letter explaining what the research was about and why it was being conducted. It also stressed that the provided information would be used in the strictest confidence. Next section describes the evaluation of a real case study from the UK to

analyse the effectiveness of implementing the asset management principles in the highway maintenance.

4.0 EVALUATION OF CASE STUDY

A case study was carried out to investigate how highway maintenance is currently being conducted, and to identify the evidence of how asset management principles are being implemented. The case study also supports the identification of the key challenges faced in implementing AMP and evaluates existing relationships with the facts found from the literature review. The Strategic Road Network (SRN) in the UK is made up of 7,000 kilometres of motorways and trunk roads and accounts for 3% of the surfaced road network (Cook, 2011). Despite making up such a small proportion of the surfaced road network, more than 30% of all road journeys and more than 65% of road freight journeys use the SRN (POST, 2014).

In the UK, the highway network is the largest physical asset owned by the UK government and has an estimated value of approximately £99 billion (HA, 2011). Hence, there is a high strategic importance to ensure the highway asset is maintained to a standard that ensures the SRN has a high rate of availability and be efficient to run smoothly throughout the year. Since 2010, the HA has also had to struggle with reduced budgets due to austerity measures implemented by the government (HM Treasury, 2010). Figure 2 shows the actual spend on maintenance by the HA between 2009-10 and 2013-14. There is a significant drop in spend in 2010-11 with the levels of spend remaining fairly static since then.
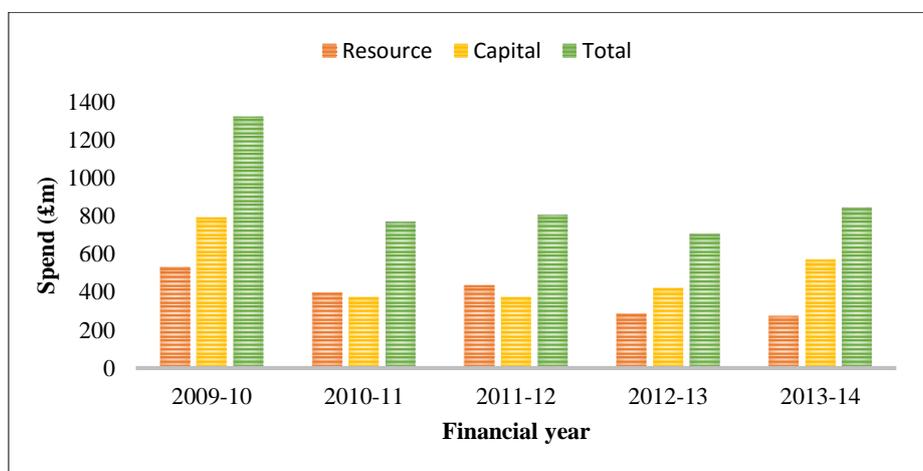

Figure 2: Highways Agency maintenance spend. (Source: Highways Agency Annual Reports 2009 – 2014)

In addition to the budget cuts, the Department for Transport (DfT) published the strategic road network performance specification for 2013-15 with a number of efficiency targets, including reducing the annual maintenance spending from an average of £900m to £700m by the end of 2014-15 (DfT, 2013). The document also called for the HA to develop some decision support tools that aid to model the maintenance investment levels, asset priorities and resultant condition levels. These factors made the HA an ideal case study since it was already exploring alternative methods of delivering highway maintenance. The case study provided a sound foundation for the study and opportunity to present the findings in the paper where the

observations were explored further through the questionnaire survey. Section 5 presents the survey results and critical discussions.

5. SURVEY RESULTS AND DISCUSSIONS

Based on the results from the literature review, the staff members from all divisions and teams working in the highway maintenance divisions were selected randomly to take part in the survey because it is assumed that these staff have some sort of knowledge and experience about the asset management in providing highway maintenance. The designed questionnaires were distributed to the selected group of staff by email, post and some of them were approached personally. However, a total of 78 out of 470 responses were received, a response rate of 16.6%. A breakdown of the number of responses gathered from different teams/sections of the highway maintenance divisions in the UK is shown in Table 2. Moreover, the confidence interval and error of survey results at 95% of confidence level is calculated and presented in table 3. The discussion of survey results with corresponding tables and graphs are shown under different sub sections below.

Table 2: Breakdown of responses received by each team

Team	Response Percent	Response Count
Asset Development	45%	35
Service Delivery	25%	20
Contract and Performance	11%	9
Business Support	13%	10
Emergency Planning	3%	2
Roadside Technology	3%	2
Responded questions	100%	78

Table 3: Confidence interval and error of survey results at 95% confidence level

Survey Responses results					
				Confidence Interval	
Survey responded Team	Responses	Proportion	Lower Bound	Upper Bound	Error
Asset Development	35	0.45	33.8%	55.9%	22.1%
Service Delivery	20	0.25	16.0%	35.3%	19.4%
Contract & Performance	9	0.11	4.4%	18.6%	14.2%
Business Support	10	0.13	5.4%	20.2%	14.8%
Emergency Planning	2	0.03	-0.9%	6.1%	7.0%
Roadside Technology	2	0.03	-0.9%	6.1%	7.0%
Total	78	1.00			
Confidence Level			95%		

5.1 Asset management awareness

In order to determine the level of the awareness of asset management, the respondents were asked to rate their level of awareness. The survey results, which are shown in Figure 3, showed

that none of the respondents had no awareness of asset management and only 16% felt their awareness was low, indicating that the HA has made efforts to make staff aware of asset management. The majority of the respondents (46%) felt that they had some awareness but the remaining 38% had a high awareness of the asset management. This trend suggests that the HA has done well in raising awareness of asset management as a discipline as it seeks to become a leading asset management organisation.
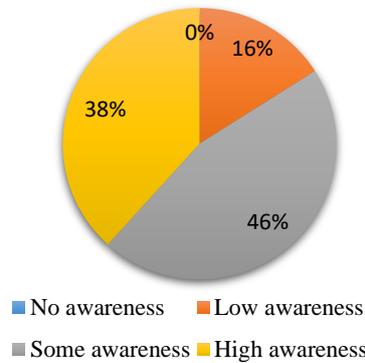

Figure 3: Level of awareness of asset management

The survey results also reveal that there is a spilt amongst the teams regarding the level of awareness, as shown in Table 4. This can be explained by the functions performed by each team. The asset development team is responsible for the decision making process whether or not an asset requires a maintenance intervention and direct involvement in the management of the assets.

Table 4: Asset management awareness by team

	Asset Development	Business Support	Contract and Performance	Emergency Planning	Roadside Technology	Service Delivery	Historic Railway Estates
High awareness	61%	0%	56%	0%	0%	29%	0%
Some awareness	33%	45%	44%	50%	50%	14%	100%
Low awareness	6%	55%	0%	50%	50%	57%	0%

The contract and performance team are responsible for the development of the contracts setting out the requirements of the service providers. As a result, their awareness is high since asset management became a key feature of the contracts. In contrast, the awareness within the remaining teams was lower because they are not being directly involved in the asset management decision making process. However, the asset management principles may only apply to what they were doing but not about their awareness in the process.

5.2 Asset management knowledge

In the survey, the awareness level of the asset management team within the NDD (Network Delivery and Development) division was asked as a question to determine the perceived level

of the asset management knowledge. The majority of respondents rated their knowledge at either 3 or 4, receiving 30% and 34% respectively of the responses (see Figure 4).
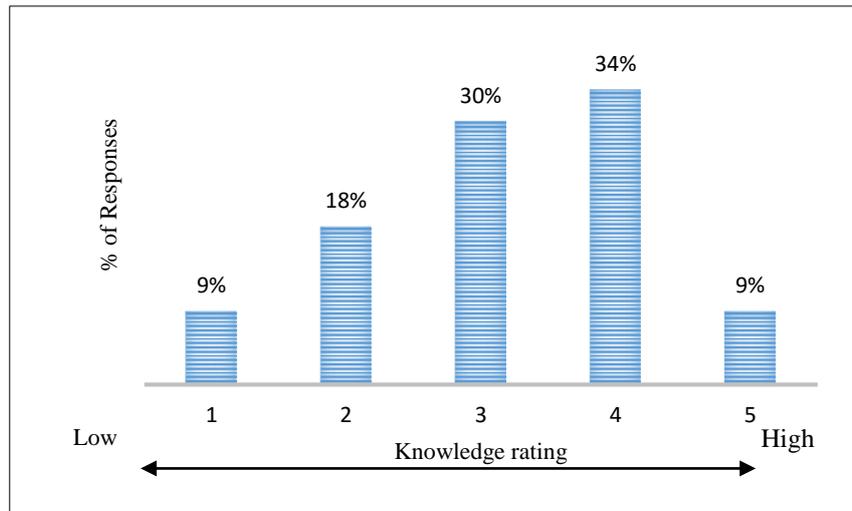

Figure 4: Rating of asset management knowledge

The findings after analysing the responses across the teams reveal a similar trend between Asset Development, Contract and Performance and Service Delivery groups rating their knowledge level at either 3 or 4. The lowest knowledge of asset management lies with Business Support where 9% of respondents from this group rated at 1 and 18% rated at 2.

The survey results suggest that the majority of staff agree their knowledge rating towards the higher end of the scale but a senior manager agreed their knowledge rating as 2. This might reflect that the asset management knowledge within the asset development team is higher than expected. The senior managers also felt that they only had some awareness of the asset management process. This indicates that the HA needs to do more in improving the asset management capability among senior levels to ensure that an appropriate perception of knowledge is gained by the remaining staff. It also supports the findings from the literature that increasing asset management capability can prove to be challenging.

5.3 Asset management definition

To understand the basic concept of asset management, respondents were asked to choose the definition they felt that best describes asset management from a list of options as below:

1. Asset management is a corporate function that allows an organisation to extract maximum value from its assets
2. Asset management is a decision making process to decide when the best time maintain or renew an asset
3. Asset management is a system that tells you when an asset should be replaced
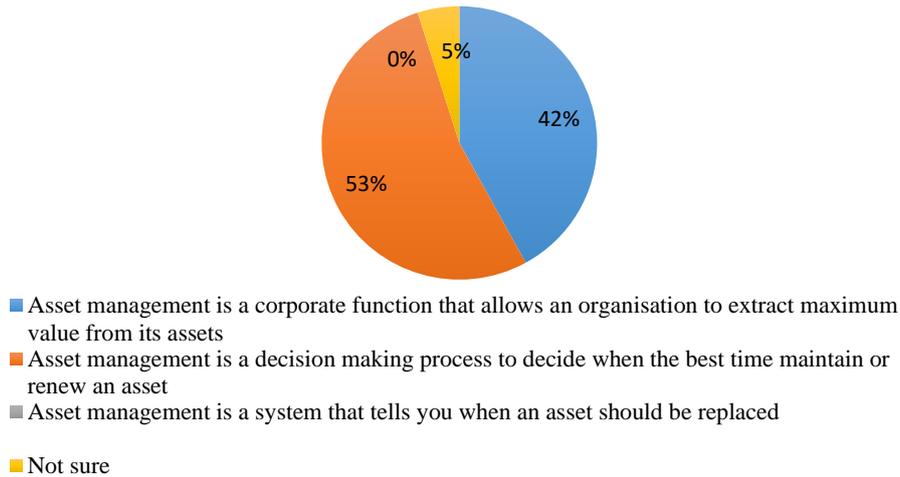4. Not sure

Figure 5: Responses about statements of best describing asset management

The first three responses are valid according to the literature review. However, the complexity of the description reduces from option 1 to 3. Figure 5 provides the result of the responses received. None of the respondents recognised that the most simplistic description of asset management was appropriate; however, around 5% indicated that they were not sure. The most complex option was selected by 42% while the remaining 53% selected the mid-range option.

5.4 Asset management standard

Respondents were asked to identify whether or not they were aware of the asset management standard ISO55000. The results of the responses are shown in Figure 6.
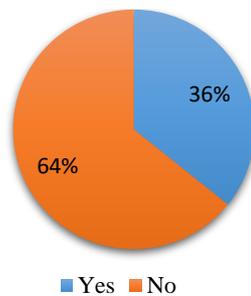

Figure 6: Split of responses about asset management standard ISO55000

The results reveal that 64 % of the respondents are unaware of the standard while 36% are aware of the standard. If staff members are unaware of the standard then it is likely they will be unaware of what is required in order to achieve maturity level 3. However, as ISO55000 is relatively new, it might indicate that staff members have not yet been made aware that this has replaced PAS55. This result may also be an indication that as part of the drive to meet the asset management requirement of the 'Strategic road network performance specification 2013-15' (Department for Transport, 2013), the HA is focussing its asset management capability at those who are likely to be asked to demonstrate the requirements for level 3 maturity are being adhered to. This would explain why the standard is not widely known about throughout NDD.

5.5 Asset management function

The literature review revealed that the transport asset management authority should be a mixture of both engineering and business decisions in order to be effective.
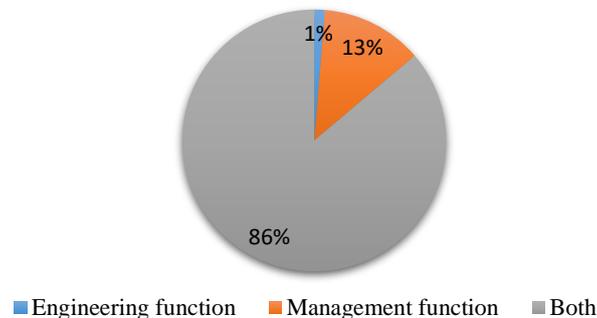

Figure 7: Response about asset management is engineering or management function, or both.

Hence, to identify the perception of the asset management within NDD, respondents were asked whether they believe asset management is an engineering function, or a management function or both. The survey results, which are shown in Figure 7, reveal that the majority of the respondents (86%) indicated that they believe asset management is a combination of both engineering and management functions. This demonstrates that the HA has recognised the importance of considering both functions when developing its asset management capability. In doing this, the HA is ensuring the appropriate skills are in place so that it could adjust risk, performance and cost effectively when making decisions relating to the highway asset.

5.6 Highway maintenance decision making

The survey results reveal that the majority of respondents (89%) do believe that asset management can be used to make more informed and effective decisions (see Figure 8).
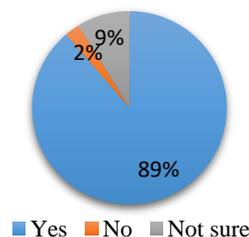

Figure 8: Responses about staff involvement in highway maintenance decisions

This reflects that the HA has the intention to introduce a decision support tool to assist asset managers when making highway maintenance decisions. This also suggests that NDD asset managers are eager to use asset management principles for highway maintenance decisions. This question has received a high response to the Yes option despite only 9% of respondents rating their knowledge of asset management as 5. This would suggest that staff felt their

knowledge of asset management could be increased by providing more training than they have received so far so that they could make informed and sound decisions.

5.7 Value for money

The literature review revealed that the HA with greater funding certainty would be able to form a long term strategic plan in order to achieve better value for money. Whereas the survey results, shown in Figure 9, the majority of respondents (84%) thought that better value for money can be achieved in highway maintenance using the asset management principles. Just 1% thought it could not be achieved while the remaining 15% indicated that they were not sure.
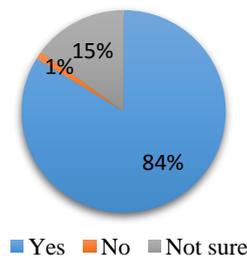

Figure 9: Responses about value for money in highway maintenance

The survey findings suggest that staff recognised asset management capability in the HA has increased with confidence in the highway maintenance decisions for better value for money.

5.8 Asset data

From literature, one of the main challenges of implementing asset management was identified as the collection, availability and quality of asset data. To verify this finding, two questions were asked about the HA: is there sufficient data about asset management and how do they rate the quality of available data. Respondents were asked to rate data quality on a scale from 1 to 5, with 1 being low quality and 5 being high quality. The results of the survey are shown in Figures 10 and 11.
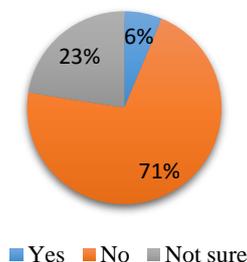

Figure 10: Responses about the Highways Agency has enough data about the assets
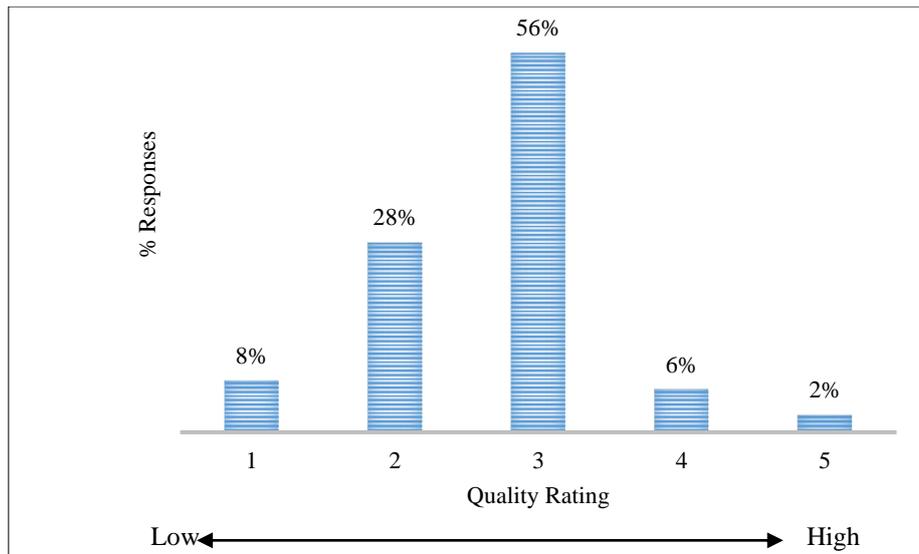
Figure 11: Rating of asset data quality

Only 6% of respondents knew that the HA has enough data about the assets it manages while 23% indicated that they were not sure and the remaining 71% thought there was not enough data. The quality of the data was rated the mid-range of 3 by 56% while a rating of 2 received the second highest number of responses at 28%. Just 2% of respondents rated the quality of the data at 5. These results are supported by the judgements of Wijnia and Herder (2009), in which people do not think the available data good quality for making informed decisions in an efficient way for the management of highway assets.

5.9   Highways Agency strategic goals

The results of the survey, which are shown in figure 12, exposed 49% of respondents felt the HA does have clear strategic goals, while 32 % felt that they do not have clear goals and 19% were unsure. Over half of the respondents were not clear whether the HA needs to do more or to explain its strategy more clearly. This will help to increase the asset management capability by improving the understanding of how asset management could help towards achieving the strategic goals set by the highway agency.
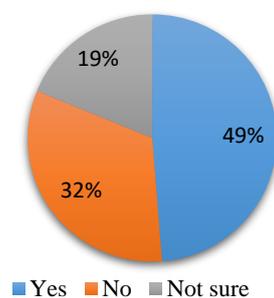

Figure 12: Responses about Highways Agency has clear strategic goals

5.10 Open ended responses

Finally, respondents were given the opportunity to provide comments relating to their experiences of asset management in the HA. Twenty respondents provided additional comments, eighteen of which related to the questions that could be used for analysis. After asset management five main themes emerged from the comments. These are listed in Table 5 with the number of times a reference was made to each.

Table 5: Themes referenced in open ended question

Theme	No. of references made
Lack of asset management capability	7
Funding uncertainty	2
Lack of data	5
Poor quality data	4
Lack of long term planning	5

The most referenced theme is related to respondents feeling that there is a lack of asset management capability in the HA. The second theme related to the amount of data and quality of data being referenced five and four times respectively. The comments made support the findings of the questions asked relating to data but also mentioned the issues relating to the location and availability of data. A number of respondents made reference to the HA having to rely heavily on its service providers (SPs) to collect and manage data. The remaining two themes referred to the funding uncertainty and lack of long term planning, which are closely related and the respondents' comments indicate that the HA have to struggle with its implementation of asset management until these issues can be resolved. However, the transformation of the HA to a government owned company is necessary to address those issues.

The survey also exposed that the HA still face many challenges to implement the asset management principles that were identified from the literature. The majority of staff working in the NDD board have some or high awareness of the asset management, which demonstrates that the HA is making efforts to implement the asset management principles. The level of perceived asset management knowledge is also reasonably high, although only 9% of respondents rated their knowledge at the highest at the end of the scale. Staff members clearly recognised the potential benefits to implementing the asset management principles but the issues relating to quantity and quality of data, as well as the restrictions of the current policy and strategies, are seen as obstacles/barriers to its successful implementation.

6.   CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions:

It is concluded from the literature that a reduction in highway maintenance budgets has led to a reduction in the outputs of the structural maintenance that are being carried out in the UK. Hence, highway departments have been forced to carry out more reactive maintenance rather than planned, preventative maintenance. This approach is not providing required benefits to the taxpayer with the best value for money. Further challenges have arisen due to increasing public demand for high quality highways, pressures from a predicted surge in traffic demand

over the next two decades, and the uncertainty surrounding levels of funding and pressures to spend all available budgets within a financial year.

Moreover, the case study reveals that the challenges of ensuring the asset management implementation are: direct from the top, improve the asset management capability among employees, and awareness of the importance of having enough and high quality asset data for easy access, interpretation and making information decisions. The case study also reveals that asset management principles are already being used by the HA in terms of considering the whole life costs associated with an asset. Improving asset management capability has been recognised as an enabler to becoming a leading asset management organisation. This has been achieved through staff training, improved asset data collection techniques, developing tools that allow making effective decisions with the available data, and by striving to become compliant with an internationally recognised asset management standard. However, the HA does not have an asset management policy to set strategic asset management objectives.

Furthermore, the survey reveals that HA staff also feel that the constraints of current policy and strategies are key challenges for the successful implementation of AMP. However, the case study highlighted that the HA is aware of the challenges it faces in implementation and has started to become pro-active in overcoming them. Senior management have committed to rolling out a programme of asset management training, use new and innovative techniques to improve asset data collection and presentation, and change the policy and legislation governing the HA. It was also found that the HA has not yet fully implemented the AMP. The results from the survey discovered that there is an awareness of asset management and knowledge is reasonably high. The benefits of the asset management are recognised and the majority of staff believed that it will improve the way the HA conducts highway maintenance. Finally, the paper concluded that the challenges encountered in implementing AMP will restrict the realisation of the benefits in highway maintenance.

6.2 Recommendations

It is highly recommended that asset management has the potential to help highway departments enrich the value from the assets they manage. Hence, it requires a committed investment in terms of money and resources to develop suitable asset management systems in highway maintenance. The government should issue guidance about how a highway department should develop an asset management policy. Local highway departments should also be encouraged to follow the lead of the HA and reach an asset management maturity of level 3 and ISO55000 certification of their asset management capability. This would ensure that asset management is being used effectively and consistently by highway departments in the UK. The discipline would benefit from further studies that need to be conducted into the asset management theme. The implementation of AMP in highway maintenance is still in its infancy. Therefore, it would be beneficial to run a longitudinal evaluation with the aim of improving the current practices in highway maintenance. It would be more useful if this was carried out after the HA has become a government owned company to start delivering the performance requirements of the Roads Investment Strategy. An exploratory analysis could then be performed to show the difference between before and after implementing asset management principles for future studies.

6.3 Limitations

The data collection for this research was limited to one organisation. It could be argued that richer data could be collected by investigating different departments responsible for the local road networks. A comparison of similarities and differences could then have been made. The study should also have looked to explore the views of the HA's supply chain to investigate how they are responding to the implementation of asset management principles. The next limitation was the time restrictions and limited the scope of the data collection.

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