

# INTRODUCING LEAN IMPROVEMENT INTO THE U.K. HIGHWAYS AGENCY SUPPLY CHAIN

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## ABSTRACT

The U.K. Highways Agency's Lean deployment strategy was introduced in 2009 with the establishment of an in-house Lean division. This paper describes the way in which the Highways Agency has engaged with its supply chain, helping to build capability so that suppliers can undertake Lean projects and champion them within their own organisations. This is followed by a discussion of the methods used to assess the supply chain's progress in Lean, measure benefits and transfer knowledge gained from individual Lean projects so that those benefits can be multiplied across the highways sector. Four projects are then discussed, both within the supply chain and within the Agency, which show a range of Lean methods being used to support delivery of major projects and maintenance works.

## KEYWORDS

U.K. Highways Agency, lean construction, lean deployment strategy, supply chain, collaborative planning, visual management

## INTRODUCTION

The U.K. Highways Agency is an executive agency for the Department for Transport. It is responsible for the operation, maintenance and improvement of the 7000 km of strategic road network which comprises England's motorways and trunk roads.

Provision of new infrastructure is carried out by the Agency's major projects directorate. This employs contractors, usually through Early Contractor Involvement. Maintenance of the network is undertaken by the network development and delivery directorate which employs 12 managing agent contractors, various design build finance and operate companies, framework contractors and technology managing agent contractors. In 2009/10 the Highways Agency spent £1bn on capital projects and more than £1.5 bn on maintenance and other activities.

In its 2010/11 business plan the Agency was charged with delivering £114m of efficiencies. Given the current economic position and the government's drive to reduce the financial deficit there has been considerable pressure to further reduce costs and improve value for money, thereby achieving 'more for less'.

To support improvement of value for money, a new Lean Division was set up in April 2009. This new division had been established in response to the successful piloting of Lean and Six Sigma methodologies on several major projects, particularly on the M6 extension from Carlisle to Guards Mill, on which a saving was made of £4.7m. It was decided by the Agency's Board that there should be an active focus on three work stream areas. These were 'Managed Motorways', 'other Major Projects' and 'Maintenance and Renewals'. It was recognised that the implementation of Lean

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had significant potential benefits in terms of cost, time, and delivery of quality to the road-using public and other stakeholders.

As of July 2011 the Highways Agency's Lean team consists of half a dozen individuals trained in Lean with many years of highways industry expertise. The core team members are supplemented by staff seconded from other divisions within the Highways Agency, and team meetings are attended by affiliated Lean practitioners from supply chain organisations which include key consultants and contractors.

The Agency's Lean development strategy (Figure 1) has clear objectives, both for the immediate future and the longer term:

- (a) **Delivery of increased Value for Money (VFM) to road users;**
- (b) Time compression to enable major schemes and other key HA processes to be delivered faster;
- (c) Realisation of tangible and auditable benefits in terms of
  - Target Cost and Final Outturn Cost,
  - **Provision of Sustainability, and**
  - **Quality of Service and Infrastructure;**
- (d) Delivery of capability across the Highways community;
- (e) Delivery of measurable efficiency improvements;
- (f) Significant cultural shift towards continuous improvement;
- (g) Development of an industry standard for Lean Construction;
- (h) Generation of a talent pipeline; and
- (i) Evolution of the Agency to become a more agile and responsive organisation.

Some key aspects of the development strategy as well as some examples of Lean projects are presented in the following sections.

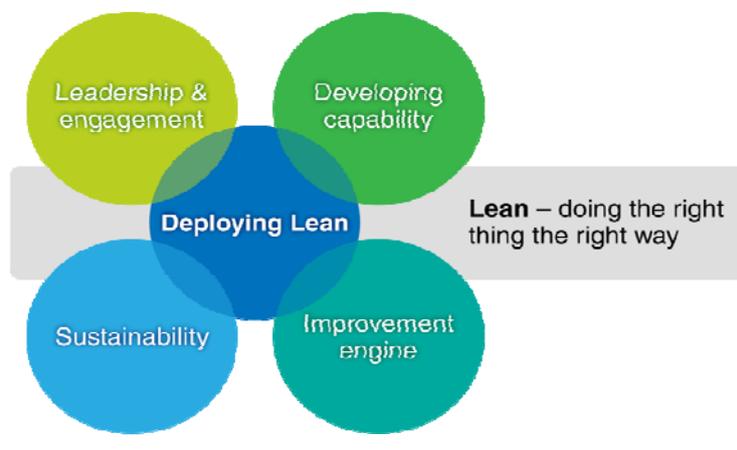


Figure 1 - Overview of the agency's strategy for deploying lean improvement across the supply chain.

## **HIGHWAYS AGENCY STRATEGY FOR DEPLOYING LEAN IMPROVEMENT**

### **LEADERSHIP AND ENGAGEMENT**

After extensive research it was noted that the major reason for failure in deploying Lean in other businesses is with regard to insufficient senior level leadership. Consequently the agency has given a high priority to engaging with the leadership both within the agency and across our supply chain.

### **BUILDING CAPABILITY AND GROWING A LEAN COMMUNITY TO EXCHANGE IDEAS AND KNOWLEDGE**

Building the Lean capability of leaders, teams and individuals is key to ensuring that the required growth in Lean activity and benefits realisation is achieved. Over 200 practitioners have been trained both across our supply chain and within the agency from mid 2009 to early 2013. These practitioners are expected to carry out a Lean Define, Measure, Analyse, Improve and Control (DMAIC) project in parallel with their training. Waves of one day champion training have also taken place so that projects can receive support from informed senior managers.

Each project goes through the DMAICT stages to ensure that projects are clearly scoped, based on real and accurate evidence, and that the improvements which are implemented do make a difference, with controls in place that will ensure the improvements are sustained.

Although a key priority was to improve the problem solving capability using DMAICT lean sigma methodology Lean more of a philosophy than just a set of tools and techniques. The range of tools and techniques do enable the embedment of the Lean philosophy at a practical level.

The Lean division has therefore also trialled within Highways Agency schemes other Lean techniques which do not follow this structure. For example, Lean visual management, with a board as a focus for the team to communicate on a daily basis. Collaborative planning, a Lean Construction technique which allows all parties on site to plan together and improve the stability of the programme, with the possibility of finding ways to deliver early. Guides to visual management and collaborative planning have been created by the Highways Agency for use by suppliers. Also the use of 6S's to improve the efficiency of the workplace or depots for either major project so maintenance.

Once all these projects are completed, they must undergo a benefits realisation exercise through which the benefits are calculated and signed off by the Lean practitioner who led the project, the Highways Agency technical manager for the relevant work stream, the supplier contract manager/director and the Highways Agency project sponsor/manager. The benefits which are calculated are categorised as improvements in cost, time, safety, sustainability, culture and other benefits. There is a specific form used by all practitioners to calculate benefits, with a guide provided the Highways Agency to help them in doing so.

In order to promulgate knowledge more widely it is required that there be a knowledge transfer pack for each completed Lean improvement project. These knowledge transfer packs are stored by the Highways Agency in Supply Chain area of its website. This allows future Lean practitioners or other supply chain staff to

learn from previous projects and to be able to apply these improvements within their own workplace, and perhaps even be able to better them. As more Lean projects are delivered this will become a hub of Lean project outcomes that will then feed into the Agency's Managing Down Cost toolkit, which gives information to suppliers about new ideas and processes.

There are also quarterly seminars for the wider 'Lean community' which is attended by the Lean team and affiliated practitioners, plus other practitioners and champions who wish to share and gain knowledge. Presentations by members and guests of the community form much of the day, plus table discussions for exchange of ideas to take place. Visits have also been undertaken by members of the Lean community to best practice offices and factories in other sectors which are further ahead on the Lean journey and have achieved an impressive degree of maturity.

### **DEVELOPING LEAN WITHIN THE HIGHWAY SECTOR SUPPLY CHAIN**

In parallel with encouraging the take-up of Lean by the supply chain, the Highways Agency has developed a set of metrics known as HALMAT (the Highways Agency Lean Maturity Assessment Toolkit) with which to assess each main supplier's approach to Lean and continuous improvement. A maturity matrix was developed, against which suppliers would be required to provide evidence of achievement in ten key areas. These are 'strategic use of Lean', 'Lean leadership', 'delivering customer/client value', 'Lean structure and behaviours', 'process focus', 'standard work', 'process control and quality', 'planning, design and construction', 'maintenance' and 'supporting infrastructure'. This tool will be incorporated into the Agency's performance monitoring tool, the 'Motivating Success Toolkit' and used to identify which suppliers to engage with in future. The tool has been successfully trialled and will be launched this year. It is not expected that the supply chain will achieve high scores within a short space of time as the standard time for a supply chain to reach maturity in other sectors (such as automotive manufacturing and aerospace) is ten years.

The Highways Agency is one of several highways clients who are keen to see the industry embrace Lean and in doing so improve efficiency and provide "more for less" for the benefit of the taxpayer. The HMEP (Highways Maintenance Efficiency Programme) was formed in order to exchange information and drive forward the adoption of Lean and other efficiency improvement practices within English Highways authorities. This is a case of clients leading by example.

### **EXAMPLES OF LEAN PROJECTS**

#### **Lean Sigma 'DMAIC' (Define, Measure, Analyse, Improve, Control) Blacktop laying on A1 Dishforth to Leeming**

Encouraged by the success of Lean at the M6 Guards Mill project, which saved £4.7m, both the Highways Agency and Carillion/Morgan Sindall Joint Venture were very keen to explore process improvement on their scheme at A1 Dishforth to Leeming.

One of the first steps was to establish capability on site. A Lean project team and a steering group were formed, made up of Lean practitioners (the equivalents of Six

Sigma Green Belts), and Lean project champions, with an overseeing master 'black belt' provided by the trainer.

In October 2009, the scheme hosted a 'Recognise' workshop. This gave staff the opportunity to identify opportunities that lay ahead in the project. One concern was the logistical challenge; it was anticipated that delivering the scheme would require some 250,000 wagon loads of deliveries, averaging 60 vehicles per hour over the construction period. Following considerable discussion, the Lean project team set about challenging the blacktop laying rates, with the intention of improving upon the 1000 tonnes per day allowed for in the construction programme.

In line with DMAIC methodology, the first steps were to define the problem. This involved looking at the many factors behind the variation in asphalt laying rates, as well as identifying the common causes of delay. Daily outputs were then Measured over a 2 month period, and further Analysed with the aid of the statistical software Minitab. This assisted in highlighting inefficiencies, as well as demonstrating bottlenecks within the process. A time and motion study further showed that on a "perfect day", faced with continuous supply of asphalt, the blacktop gangs' capability could be doubled to 2000 tonnes per day. It was clear the project's success hinged on establishing this continuous supply.

Improvements were then implemented. These included:

- (a) The use of multiple batching plants within close proximity of the site, each producing the same type of asphalt rather than regularly changing;
- (b) Contingency plans to prevent plant breakdown, including night time maintenance and text alerts should an incident occur;
- (c) Changes in working patterns, i.e. changing sequencing so that all pavement joints were cut the previous evening in order to prevent morning delays;
- (d) First delivery on site at 7am, with continuous supply up to 5pm;

By using the old tank road through MOD Catterick instead of the A684. It has been possible to extend daytime delivery times so that laying can be continuous from 7am to midnight through October 2010. The most achieved in any 24 hour period has been 3500 tonnes.

With the above improvements in place, daily outputs can exceed the 2000 tonne output, with the end result that the programme's critical path is predicted to be reduced by 17 days. Through the accompanying reduction in preliminaries and labour and plant costs requirement a total saving was made of £602 000, of which £523,031 is expected by the end of 2011.

#### **COLLABORATIVE PLANNING**

On the M53 Bidston Moss Viaduct Strengthening project, over £1m of savings have been attributed to Lean deployment on the scheme. Through collaborative planning in the design and construction phases, a culture of continuous improvement has been developed across the project.

The £89.9m scheme involves strengthening the multi-span box girder viaduct together with refurbishment works in order to restore the network to full capacity. Costain was awarded the contract in January 2009. Detailed design and investigation

was undertaken during Phase A of the Early Contractor Involvement Scheme (ECI) prior to main construction starting in May 2010.

Collaborative planning was established early in the design phase and deployed on all further activities. Integrated project meetings, weekly in design and daily for construction are used to set programme targets, establish which tasks in the plan have been achieved and identify key barriers to progress. This process provided the percentage of planned tasks completed (commitment reliability).

In design, collaborative planning drove better communication and transparency helping to improve commitment reliability by 34%. This helped the project meet an accelerated design programme and complete Phase A one month ahead of programme.

Commitment reliability in construction improved from 78% to 90%. In addition, trends affecting production on site were identified and dealt with in a timely manner. This approach ensured root causes of any problems were treated and not just a reaction to the symptoms. Collaborative planning during Phase A and advanced construction works provided increased confidence of production capability enabling rates for certain activities to be reduced realising a reduction in target cost of over £300,000. During Phase B construction improved commitment reliability has led to further labour efficiencies exceeding £380,000.

In construction, weekly collaborative planning has also been used to improve short term look-ahead planning. All key supply chain partners are engaged in examining the whole programme and challenging themselves to exceed targets by either reducing the time needed to complete individual tasks, or by running tasks in parallel. This has resulted in commitment reliability for look-ahead planning improving from 59% to more than 85%.

As a result of collaborative planning significant programme benefits are currently forecast, including programme savings in excess of £400,000.

In parallel with these collaborative planning activities, standard work processes have also been mapped and reviewed to identify and implement improvements.

Departures from standard may be granted by the Highways Agency if a proposed design is submitted which does not comply with current standards, but can be demonstrated to yield significant benefits and the adverse impacts, if any, remain tolerable. However, with multiple stakeholders involved along the process, there is opportunity for delays to occur. These delays can pose a risk to scheme delivery if they occur on the critical path.

The objective of this project was to reduce delay and waste in the process. Both traditional Lean methods and data analysis were used to find common causes of delay and waste.

A workshop was held at which participants represented stakeholders along the process. All participants were invited to use a common 'fishbone' diagram and the practice of 5 Whys (asking 'Why' repeatedly in order to find the root causes of problems within the process). Doing so helped to expose reasons why delay might be occurring and did so in a way that represented the perspectives of all the participants.

To investigate in greater depth the causes of delay, analysis was also undertaken of a year's worth of departures data. From looking at a year's worth of records (financial year 2008/2009), and concentrating on road geometry departures, a rejection rate of 26% was identified as contributing to delay within the process (Fig. 6). Rejection, or not getting the application 'right first time' represents waste within

the system, especially since departures have to be resubmitted and delay in receiving approval may impact on the programme of the scheme associated with the proposed design.

Reasons for rejection were investigated, and common causes identified. It was discovered that common causes of rejection tended to be basic errors such as not attaching a risk assessment (30% of all rejected departures), not including an accident summary and commentary (22% of all rejected departures) and not discussing cost and other benefits (21.4% of all rejected departures). More sophisticated errors occurred, but the percentage of these occurring was lower.

In response to these findings, the team in the Highways Agency which manages departures created a filter by which those departures which contain the most basic errors are returned to the submitting designer. This gives designers a chance to correct these errors and resubmit without the departure having to undergo more steps in the process before review and certain rejection by the technical specialist. This saves the time of a valuable staff resource, delay in addressing a simple omission and consequential delay to other departures the technical specialist has to process. Whereas, previously, internal reporting of the departures processes has concentrated on time taken to deal with departures, a move towards also reporting what percentage of departures are 'right first time' according to subject area can help to monitor the quality of departure of submissions and identify waste which needs to be reduced. This therefore makes better use of the capacity within the process and frees time within the Highways Agency and the supply chain.

#### **LEAN VISUAL MANAGEMENT**

The first trial of Lean visual management took place in early 2009 on a bridge repair project (Lodge Lane) on M6 Junction 23 which was undertaken by the Area 10 Managing Agent Contractor (MAC 10), AOne Plus. Boards were put up in the site office, showing daily regularly updated information for the following categories: health and safety, minutes of the last meeting, site attendance per contractor, planned inductions, general comments, weekly measures, project plan and delay, project cost information, continuous improvement activity (including problem solving sheets) and traffic management for the week ahead. Meetings of ten minutes were held every day, dealing with each of the categories one by one.

Because the boards acted as a focal point for team communication, all important issues could be captured there and discussed as a team during the daily meetings, saving time that might otherwise be spent having to transfer knowledge via several informal discussions. Rather than solving problems informally, they could instead be addressed using a formal problem solving technique which used the knowledge and abilities of all attendees and which sought to put in place countermeasures to the root causes of the problems. As an overall result, teamwork improved and all staff had a clearer idea of what needed doing, who was doing what, and how well the work was progressing.

*Since the trial took place, all sites on the MAC 10 construction management framework have employed Lean visual management. The practice has proved very popular on site, to the extent that subcontractors have introduced it elsewhere, not just on highways projects. Furthermore, Lean visual management boards and daily meetings are the first experience that many people have of Lean, so this is also a*

*good way of demonstrating the benefits of Lean, and of promoting a continuous improvement culture. Visual management has also been trialled on routine maintenance works and in design offices.*

## **CONCLUSION**

The work carried out so far by the Highways Agency and its supply chain demonstrates the possibilities of Lean, especially since it has delivered a Benefit Cost Ratio higher than 30. By March 2013 the Agency's Lean division can claim planned (potential) savings of £90m, of which £52.4m is realised, and these are to be shared between the Agency and its supply chain. There is still more potential, however, not only in future individual projects, but also in the multiplication of benefits that can occur when lessons from past projects are adopted and taken further in future highways related work. Lean transformation is the process by which organisations take Lean principles and, through a planned programme, ensure that they are adopted in order to provide a more competitive capability. This is, for each organisation, a major change management programme. To illustrate the strategy for Lean deployment in practice four examples from over 200 held within the agencies project tracking system are given below. Further information can be found on the agencies lean improvement portal:

<http://www.highways.gov.uk/specialist-information/lean-improvement/>