"SCOPING STUDY TO DEFINE A MAJOR RESEARCH PROJECT INVESTIGATING THE IMPLEMENTATION OF LAST PLANNER SYSTEM, COLLABORATIVE PLANNING AND COLLABORATIVE WORKING IN THE UK ROAD TRANSPORT SECTOR INCLUDING IDENTIFYING FUNDING SOURCES"

FINAL REPORT

March 2015

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Executive Summary

This report details the outcome of a scoping study undertaken to define a major research project investigating the implementation of the Last Planner System (LPS), collaborative planning and collaborative working in the UK road transport sector. The study includes the identification of funding sources for further research. The report is presented in 5 parts:

1. Literature review (section 2)
2. Snapshot of current practice (section 3)
3. New research proposal (section 4)
4. Appendix A - Available funding
5. Appendix B – Overview of UK road network

Literature Review: this section collects the current theoretical understanding of the Last Planner System, collaborative planning and collaborative working practice in construction. It also identifies the known drivers and barriers for LPS implementation in construction. Findings indicate that the concept of collaborative planning in construction is not a stand-alone concept as commonly understood by many lean construction practitioners especially in the UK; rather it is exclusively based on the LPS philosophy. The review identified the elements of the Last Planner System and established that it is applicable to all forms of construction including highways. The review also identified current drivers for LPS implementation in construction to include; demand for its use by client and owners; profit and benefits from pilot implementations; and the need to overcome problems associated with current planning among others. Furthermore, the review shows that LPS implementation challenges occur at both the organisational and project levels. The review also observed that some of the current premises on which Collaborative Working is based, lack the potential to develop into genuine collaborative working relationships as they rely on traditional contractual behaviours with scant regard to the softer aspects.

The literature review shows that the LPS has the potential to develop strong, collaborative working relationships among project stakeholders as it initiates the required conversations. These continue from the collaborative programming sessions through to evaluation and learning. The review recommends that in order to overcome some of the challenges observed in current implementation, effort and resources need to be committed to training and retraining of employees both at the organisational and project levels. This implies that, in addition to the current supply chain training[1] the Highways Agency must be committed to the training of its contractors (tiers 1, 2 and even 3) and internally. This training needs to address not only the use of tools and methods, but focus on the mind-set and behaviour changes needed for the new approach to work. This change should be built around trust and openness and is an essential precursor to the step change to project production and the design of effective project production systems.

Snapshot of current practice: This report presents the empirical findings from the investigation. The study explores the current implementation of collaborative practice collected through observation on five HA projects, interviews with thirteen practitioners and twenty survey repsonses collected at a focus group workshop comprising of tier 1 and 2 HA supply chain members. Findings indicate that collaborative programming/phase planning, measurement of Percentage of Planned Complete (PPC) and Weekly Work Planning

[1] Training delivered since 2009:
To HA staff: Awareness; 673, Foundation; 94, Practitioner: 53, Green Belt: 22, Black Belt: 1, Six Sigma: 18
Lean Supply Chain: Awareness: 66, Foundation: 48, Practitioner: 100, Green Belt: 19,

meetings (WWP) were the most implemented elements of the LPS. The study also revealed that collaborative planning (CP) is the common name used by the construction practitioners consulted although some of them were familiar with and also used the term Last Planner System to describe their collaborative practicies. The study showed that practices such as the Make-Ready Process, Look-Ahead planning, consideration for work flow, and acting on reasons for non-completion of tasks were only partially implemented. The study established that the client (HA) desire for for continuous process improvement within their supply chain organisations, and project complexity are among the current drivers for collabirative practices and that culture is the major barrier. The study concludes that the current practice of CP in the UK highway sector is based on the LPS of production control but some LPS elements are yet to be implemented. There is potential for developing collaborative relationships among project stakeholders and for extending these to the wider stakeholder community particularly the “next customers”. Further study on developing CP as practiced within the HA towards a more complete LPS practice is recommended to overcome cultural barriers to the new approaches needed to make the step change to project production.

Research Proposal: a research proposal “A step change in collaborative practice” has been developed. This project aims to reform the current application of collaborative practices in order to provide a clear foundation for the move to project production in road infrastructure (construction including design). The key objectives are to build upon the Last Planner System in order to:

- Define the essential components of collaborative practice
- Define the behavioural structures required to implement these
- Expose the interfaces and practices that support or act against collaboration
- Define the role of collaborative practice as the principal method for achieving the standard and stable processes that are a foundation of a lean production system
- Develop a practice manual that complements and integrates with the existing Process Control Framework in order to advance current practice towards production
- Provide knowledge in order to inform future training initiatives
- Integrate this work into a larger research project submitted to InnovateUK for funding under the Supply Chain Integration funding call.

Appendices: provide supplementary information concerning the HA operations and current sources of funding available used to inform the research.

Contents

List of Abbreviations

CP	Collaborative planning
CW	Collaborative working
FRS	First Run Studies
HA	Highway Agency
IGLC	International Group for Lean Construction
LCI	Lean Construction Institute
LPS	Last Planner® System
PDCA	Plan Do Check Act
PPC	Percentage Promised (Planned) Complete
RCM	Rational Comprehensive Model
RNC	Reasons for non-completion
VFRS	Virtual First Run Studies
WWP	Weekly Work Plan
UK	United Kingdom
USA	United State of America

Glossary of Terms

Collaborative planning: is a process that allows the collective involvement of stakeholders to make joint decisions and identify the best opportunities to be used in addressing the problem under consideration. Its origin is in Urban and Regional Planning, the principle is now applied in construction under the LPS. It occurs at the collaborative programming or phase scheduling stage in the LPS.

Collaborative programming or Phase scheduling: is the process of developing a realistic construction programme from the master programme which requires the direct input from the subcontractors, designers, main contractors and other stakeholders on the project. It reduces conflicts between activities and develops synergy between those involved in the process. It creates the principal opportunity for time compression.

Constraints: refers to the reasons why a task or activity cannot be started or completed as planned. On typical projects constraints could include: insufficient people, tools, equipment, information, materials, prior work not completed in time, and safe space not available

Daily Huddle Meeting: It is usually a daily short meeting used in managing production on site to ensure tasks are executed as planned on the day of production. It last between 10-15 minutes. It enables the team to detect 'bad' news early and plan for next day tasks. It is called daily stand-up meeting in the UK. In HA and in the supply chain these occur by a visual board which has displayed progress and the 3C's (Concern, Cause and Countermeasure)

First Run Study (FRS): an approach used to develop the construction process before the actual production or construction on site. It may also be called mock-up, prototyping, dummy or dry run in the UK

'**Last planner':** refers to the person or group of persons who do the work on site, so called because they develop the "last" or final plan for execution. Also called production planners. They should be involved in all the planning decisions.

Last Planner System: is an integrated and comprehensive production planning and control approach developed for the construction industry that creates predictability and reliability of delivery. It has five key principles to develop collaborative relationships among stakeholders and project participants forming a *project based production system* for the construction industry.

Look-Ahead Planning: is medium term planning used to screen project activities developed from the collaborative programme from all constraints, it usually covers activities that are due for execution within 4 to 8 weeks in a sliding window along the programme.

Make-Ready Process: is the process of removing the constraints to planned activities in the Look–Ahead window before the production on site. Its goal is to ensure only sound activities (that can be completed as planned) enter production by ensuring those doing them are responsible for identifying and removing the constraints.

Master or contract programme: is the programme that captures the entire tasks to be executed throughout the project, usually, its shows the duration of all activities on the project based on the contract presented on Gantt Chart or in Primavera.

Percentage of Promises Complete (PPC): is a percentage of the number of activities completed divided by the number of activities promised in the week under review. It is usually recorded and published on chart and made accessible to the project team for

learning. Also called percentage of planned complete. **NB:** in the HA the metric used is ***Percentage Planned Complete***

Production planning: refers to the Weekly Work Planning meeting which allows the 'last planners' to review the last week's work and make the commitment to what they can do in the coming week. Usually, the PPC and the reasons for non-completion are documented at the meeting

Production Planners: the people who do the work, so called because they have the best understanding of the detailed requirements for completing the work. Also called last planners, they should be involved in all the planning decisions for the project.

Reasons for non-completion (RNC): refers to identification why a particular activity was not completed in the week under review, these reasons are documented and published in bar charts and made available for the project team to see to facilitate learning. Action on non-completion includes root cause analysis and error proofing through new processes that address the root cause.

Stakeholder: any person or party that has an interest in or is affected by the work. This includes the supply chain and all its workers, the HA operations, design and maintenance, road users, the wider public, Local Authorities and Government and any such others who may be interested, concerned or affected.

Transformation Activity: the processing of resources towards the final product – includes operations, installation and/or assembly tasks. This definition can be extended to include advancement of the design information.

Virtual First Run Study: a preliminary planning stage in which the production tasks are explored with the supply chain to conceptualise differing trade approaches and requirements, can be likened to a "game plan" and can be followed by a physical first run.

Workable backlog: refers to activities that are sound and constraint free which could be easily sent to the production phase when required. It is also known as Plan B.

1. INTRODUCTION

1.1 *Background and rationale:*

The Highway Agency (HA) is a Government Agency that champions the application of lean principles in the delivery of its projects. The UK HA is not only strategic in its role as an executive agency for the Department of Transport it also operates, manages, improves, and maintains over 7000KM of motor ways and trunk roads in England comprising major road networks valued at £105 billion (HA business plan, 2014). Although this represents less than 3% of the entire road network in England, it carries 80% of all traffic in England. This places an enormous responsibility on the HA to deliver value to its customers and end users in a safe, efficient and effective way. The need to deliver value was further tensioned by both external and internal constraints surrounding the Agency such as the recent global recession, the UK budget deficit, reduction in the Agency capital spending budget and increased demand for travel placing an increasing strain on the network (HA report, 2010). The demand and expectation is further heighten by the recent £24 billion commitment by the UK government for the improvement and maintenance of road networks and the projected 40% increase in road use in the next six years (HA Business plan, 2014). In view of this, the HA is in a continuous search for means to meet customer demand whilst also improving the performance of the Agency in terms of safety, time, cost and quality through innovative ways such as the lean philosophy.

The UK HA commenced its lean journey in 2009 with a bold step in establishing an in-house lean deployment division charged with responsibility for deploying lean best practice across its projects and its numerous supply chain (Drysdale, 2013). The Agency has made a considerable investment in training to support this deployment[2]. Specifically, various lean principles and techniques have been implemented by the Agency. This includes but is not limited to collaborative planning, Visual Management, 5S, process mapping, and 5 whys. These principles have been implemented on over 246 HA lean projects with enormous benefits in cost and time savings, accident reduction and increased engagement among others. However, collaborative planning is among the most used lean techniques across the HA projects with its supply chain. Specifically, the application of collaborative planning with Visual Management across its projects has led to over £80 million savings in cost, 30% savings in programme and an increase in plan reliability from 40% to 70% with its supply chain (Fullalove, 2013; Drysdale, 2013).

However, it is worth stating that the role of the supply chain is crucial in the attainment of all these improvements by the Agency. For instance, 90% of the Agency expenditure is through its supply chain contracts (HA business plan, 2014). Again, this shows the important role the supply chain plays in delivering the HA's strategic goals to customers and end users. In recognition of these, the HA has not

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relented in its commitment to the development of its supply chain on lean construction principles as exemplified in its programmes; such as leadership and engagement, developing capability, improvement engine and sustainability (Drysdale, 2013). In the same vein, the HA has committed £5 billion to the development of a collaborative delivery framework to support the development of its supply chain (HA Business plan, 2014). To be specific, the HA has invested heavily on the development of its supply chain in lean construction practice especially in collaborative planning over these past four years. Due to benefits realised from its implementation on HA projects CP is incentivised through the contract on major schemes. However, over this time, no independent study has been conducted to examine the consistency in collaborative practice and the perceptions of the supply chain on the LPS, CP and CW. In order to kick-start this process this research snapshot of the current practice and perceptions along with the review of the current theoretical understanding of the LPS, CP, and CW in the construction industry.

1.2 *Research Aim and Objectives:*

The overall aim of this project is to define and deliver a major research proposal that will hit at the heart of changing working practices through collaboration in its widest sense.

In order to achieve this aim the following steps will be undertaken:

1. Define the scope and scale of operations that influence the successful operation of the total UK road network and codify that information (how can we understand the big picture) – see Appendix 2
2. Review the current theoretical understanding of LPS, collaborative planning and collaborative working (what do the experts say) – sees Section 2
3. Undertake a pilot survey from tier 1,2,3 & 4 supply chain companies to provide a snapshot of current practice (what do the practitioners say) – see Section3
4. Identify current funding opportunities in the UK & Europe and how they may be harnessed – see Appendix 1
5. Review the information collected in steps 1 – 4 and prepare a research proposal accordingly – see Section 4

The findings are presented in three sections supported by two appendices.

1.1 Research Methodology:

Mixed research design that uses a qualitative-exploratory approach and quantitative cross sectional survey was employed in collecting data from tier 1 contractors working in the UK Highway sector and lean construction practitioners based in the UK. The qualitative exploratory approach was considered appropriate for the study as it allowed the study to obtain detailed information on the perceptions of construction industry practitioners on LPS/CP and CW in the UK highway sector. Data for the study was obtained from extensive literature review, site visits and observations, informal interviews, semi-structured interviews and survey. The triangulatory approach adopted for the study not only provided different standpoints to answer the aim of this investigation but also helped in increasing the depth

and quality of the research findings (Bouma, 2000). The mixed methods approach was used to minimise bias to the study.

The study commenced with an extensive literature review on the LPS/CP and CW, which enabled the study to understand experts views. Specifically, publications from the International Group for Lean Construction and similar publications elsewhere on LPS/CP and CW were reviewed and presented in the literature review (section 1). Based on the literature, an interview instrument consisting of three sections was developed. The first section sought to know the background of the respondents, section 2 sought to know the perception of the respondents on the LPS/CP and CW, while section 3 sought to know drivers and barriers for implementing LPS/CP and CW. Evaluation instrument was also developed which was used to evaluate LPS/CP implementation on HA projects. The instrument has three scales; full implementation, partial implementation and no implementation observed to capture the state of current implementation on the projects sampled. Both face-to-face and online interviews via Skype™ were used to obtain information from the respondents. The respondents included lean improvement managers, lean consultants, principal planning engineers, planners, project managers, lean improvement directors and representatives from tier 1, 2, and 3 contractors. Purposive sampling was used in selecting the respondents and the projects evaluated to ensure that only those with experience in LPS/CP participated in the study. Thirteen (13) interviews were conducted comprising HA tier 1, and 2 contractors, clients, and lean construction consultants while 5 HA major projects were evaluated (4 in construction and 1 in design and maintenance). Twenty (20) responses were received from the focus group workshop comprising of tier 1 and 2 HA supply chain. The result of the analysis and discussion are presented in the subsequent sections.

2 Literature Review – theoretical understandings

2.1 Overview of Literature Review

A review of peer-reviewed publications on the LPS, CP and CW was carried out to establish the theoretical understanding of these and how they are applied in the construction sector. This review also sought to understand the drivers and challenges of LPS implementation through a review of LPS case study reports published by the International Group for Lean Construction (IGLC) in conference papers between 1993 and 2014 (www.iglc.net).The IGLC database is the largest and most comprehensive source of scholarly publications championing the application of lean in construction and LPS implementation. Case studies on LPS implementation from over 16 countries were examined. Other sources were also identified (see reference list) to supplement the IGLC database.

2.2 Background to Collaborative Planning

The term collaborative planning (CP) became conspicuous in Urban and Regional Planning literature after the Second World War in North America. Its use is associated with urban planning decisions and allocation of resources in cities due to the failure of the rational comprehensive model (RCM) approach to planning (Guton and Day, 2003; Mortun, 2007). The RCM school of thought argued that, since planning is a technical scientific discipline, planning decisions can only be performed by the experts (Guton, 1984; Susskind, 2000; Wondolleck and Yaffe, 2000). However, this approach to urban planning was challenged in the 1960s and the concept of CP was introduced. CP is a planning approach that allows collective involvement of stakeholders (i.e. those which the planning decision will affect) in making collective decisions and identifying the best opportunities to be used in addressing the problem under consideration. The concept of CP has also diffused into the construction industry (Ballard, 2000).

In the construction industry, the origin of collaborative planning (CP) can be traced to the research work carried out in the 1980s on construction productivity improvement by Glenn Ballard and Greg Howell (Mossman, 2014). The principal outcome of the research was the development of the Last Planner System of production control. According to Ryall *et al*, (2012), and Ballard, (2000) the generally used philosophy for collaborative planning in construction is the Last Planner® System (LPS). Although, some lean consultants in the UK tend to view collaborative planning in construction as a stand-alone concept (Daniel et al, 2015b). The goal of the LPS is to deliver more reliable and predictable construction projects through increased engagement of the parties in identifying relationships and matching them with plans. This ensuring collaboration and commitment from participants which delivers value for all the stakeholders on the project (Kalsaas, 2012; Koskela and Ballard, 2006, Ballard, 1994).

2.2.1 Development of Collaborative Planning in UK Construction

Figure 1 below shows the major time line in the development of CP in the UK construction. The need for collaboration in the UK construction industry date back to the earlier construction industry reports such as Bossom and Banwell among others. All these reports emphasises the need for construction process improvement to enable the industry deliver more value. Specifically, the Latham report (1994) observed the adversarial nature of the industry and called for a more integrated approach for executing work in construction. The report also recommends the use of partnering and collaborative working at all level in construction. Similarly, the Egan report of 1998 also challenges the lack of collaboration in the industry and recommends the use of lean techniques in the delivery of construction project (Egan, 1998). It is worth to state that all these call for collaboration is not just in term of planning alone, but in the entire delivery process of construction products. Following the Latham and Egan recommendations various construction improvement programmes were created. This includes; the construction lean improvement programme (CLIP), the

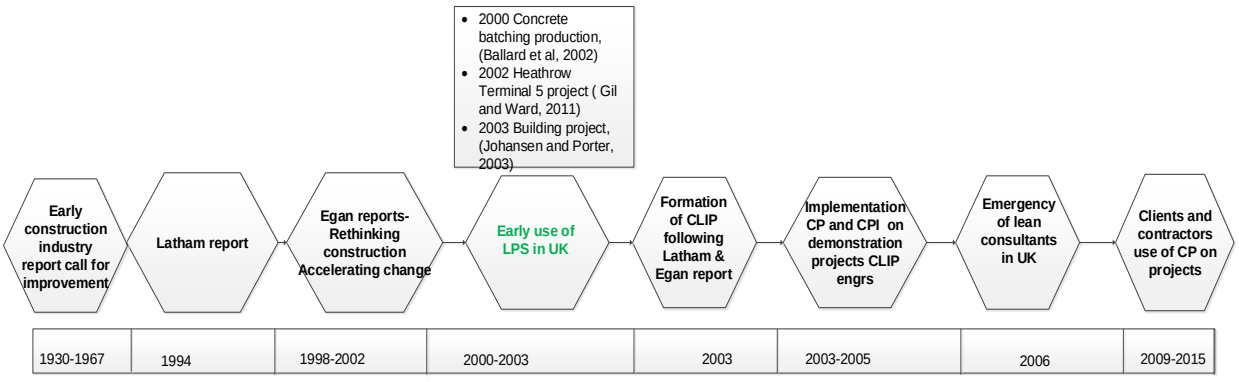

Figure 1: Development of collaborative planning in UK

Constructing Excellence (CE), Construction Industry Board (CIB) Construction Best Practice Programme (CBPP), and Movement for Innovation (MI) (Constructing Excellence, 2007). The formation of CLIP by the Building Research Establishment (BRE) in 2003, lead to the implementation collaborative planning (CP) and construction process improvement (CPI) on demonstration projects. However, before this time as shown on the time line the LPS and its collaborative planning element have not only been developed, but has also been

implemented in the UK construction industry (Ballard and Howell, 1998; Ballard et al, 2002; Gil and Ward, 2011). The LPS was developed from research into productivity improvement studies in 1992 by Ballard and Howell (Ballard and Howell, 1998; Ballard et al, 1996). It can be argued that the successful implementation of the LPS and its associated collaborative element on Heathrow Terminal 5 project could have also contributed to the formation CLIP in the UK (Gil and Ward, 2011). This could be so since Sir John Egan the Chair of the Rethinking construction report was the chief executive of the Heathrow Terminal 5 Project. In addition to this, LPS was also implemented on building projects and in concrete production in the UK. This shows that the LPS of production control was already in the UK construction industry before the formation CLIP. However, comparing the elements of LPS implemented in the earlier implementations in the UK with the collaborative planning implemented by CLIP reveal some variations (Daniel et al, 2014b). Nevertheless, collaborative planning in the UK construction industry has grown beyond the CLIP programme. Currently clients and general contractors are using the concept to drive performance improvement across their project and to also improve their competitiveness. In the UK big clients such as the Highways Agency, Ministry of Justice, Severn Trent water, Anglian One among others are championing the process.

2.3 The Theory Underpinning the Last Planner System

The LPS has gained prominence in the construction industry in recent times and its influence on project delivery seems almost magical (Daniel *et al*, 2014a; Kalsaas *et al*, 2014). The LPS developed by Ballard and Howell in 1992, focuses on reducing the workflow uncertainty identified as a missing component in the traditional project management kit (Ballard and Howell, 2003; Koskela, 1999). This missing component has been identified by lean construction researchers as a contributory factor to the poor performance of construction projects (Ballard and Howell, 2004; Howell and Ballard, 1998). However, the LPS is an integrated and comprehensive approach that intends planned construction activities are predictable and reliable at the implementation stage on construction site (Mossman, 2014; Ballard, 1994). It is worth noting that its application is not limited to the construction stage alone, as it is also effective at the design stage and in decommissioning.

The influence of the LPS is largely due to the theory and principles that informed its development. These are derived from the theory of decision-making and uncertainty in the production process (Ballard, 1994; Ballard *et al* 2009) and include the Transformation, Flow, Value theory (Koskela, 1992; Koskela and Ballard, 2006); and the Language/action perspectives (Flores, 1982 and Hayek, 1945) where it was opined that the knowledge needed for planning is dispersed among individuals. More importantly, the underlying theories of the LPS revolve around planning, execution, and control. According to Ballard and Howell (2003), LPS focuses on planning and production control as opposed to directing and adjusting (cybernetic model) in the traditional project management approach. There are 5 key principles in the LPS and these are; (1) ensure tasks are planned in increasing detail the closer the task execution approaches. (2) ensure tasks are planned with those who are to execute them (3) identify constraints on the planned task to be removed by the team beforehand (4) ensure promises made are secure and reliable and (5) continuously learn from failures that occur when executing tasks to prevent future reoccurrence.

The Last Planner is the person or group of persons charged with the responsibility of doing the work. Last Planners not only do the work, but are also actively involved in developing the programme for the work and ensuring work is made ready before sending it to the work phase (Mossman, 2014, Adamu and Howell, 2012). The duties of the Last Planners are

therefore to ensure that work is planned efficiently to create flow in the construction process and to ensure such work is executed at the optimal level. The implementation of the Last Planner System is based on 6 major processes (see section 2.4). Extensive case study reports show that the system works effectively on any project (Highway, rail, building, ship building, heavy civil engineering works etc) that requires the coordination of human elements (Drysdale, 2013; Adamu and Howell, 2012; Aslesen, and Bertelsen, 2008). Last Planners are also called production planners

2.4 The Last Planner System Implementation Process

The LPS implementation is based on 6 key processes as shown in Figure 1 and subsequently discussed. These progressive processes yield significant benefits especially in developing a collaborative relationship. However, lack of full implementation has adverse effects on both the upstream and downstream flow of construction activities (Mcconaughy and Shirkey 2013, Mossman, 2014). Unfortunately, many construction organisations are yet to pay full attention to flow in their implementation effort and continue to focus on optimising tasks (transformation).

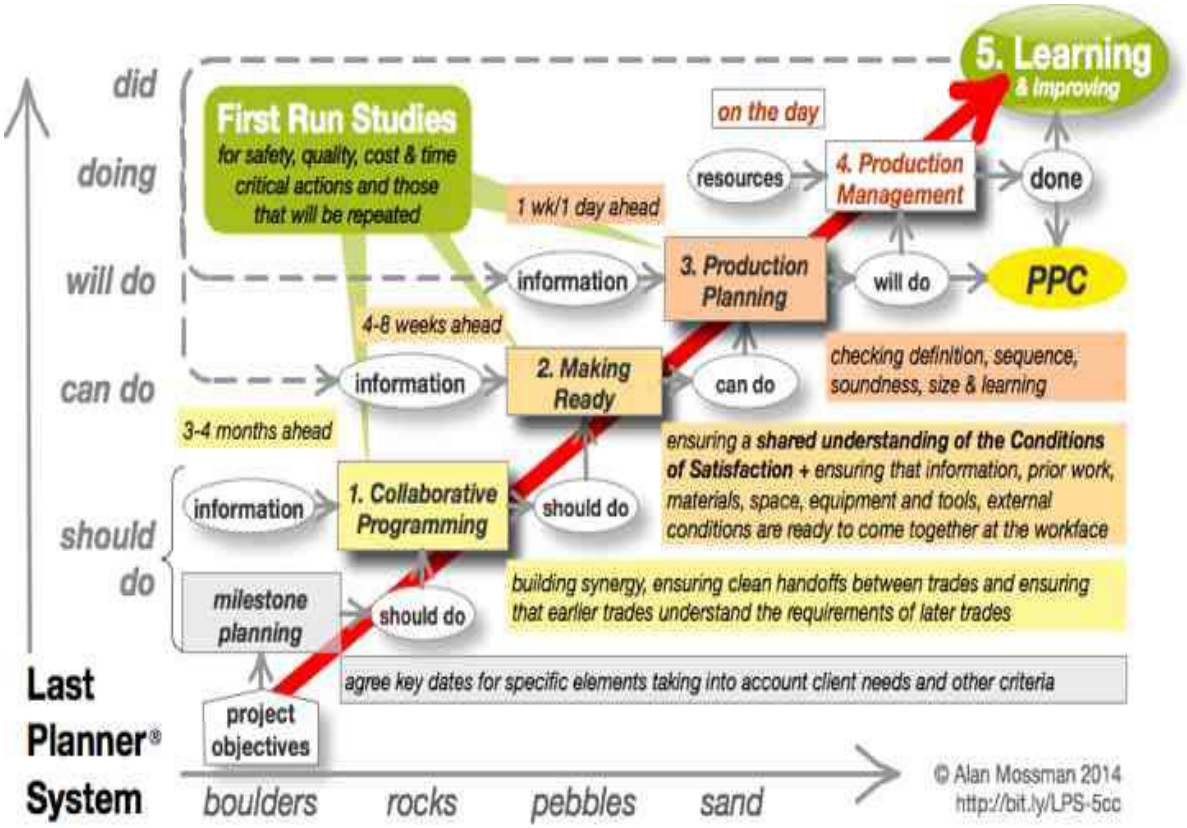

Figure 2: The Last Planner System implementation process
Source: Mossman, 2014 (used with permission)

2.4.1 The Master Plan or Milestone Planning

The Master Plan or milestone planning captures the entire task to be executed throughout the project and at the same time shows the length of time required for each activity to be completed. It identifies the project milestones and initiates the means for achieving them (Ballard, *et al* 1997; Zimina and Pasquire, 2012). This is usually referred to as the contract programme and presented on a Gantt Chart or in Primavera. It forms the basis for the development of the collaborative programme or phase planning. The purpose of the Master Plan therefore, is to show the target (milestone) for accomplishing a given task, and to use

such information to steer the project delivery through the collaborative programming or phase planning meetings (Ballard, 2000)

2.4.2 Collaborative Programming or Phase Planning

Collaborative programming is a process used in developing a reliable construction programme from the master or contract programme by direct involvement of the subcontractors, contractors, suppliers, designers and other stakeholders on the project including the client. It builds strongly on the concept of "next customer" to understand the interfaces in the process. It is prepared early in the project planning through logical arguments used to agree how one activity ends and the next starts - called handing off (Mossman, 2014; Anderson *et al*, 2011; Ballard, 2000). Hans *et al*, (2006) observed that the collaborative programme is usually developed from the master programme through series of dialogues and input from subcontractors, suppliers, specialist contractors, designers and others who are party to the project. This increases transparency and builds trust within the project team and is essential in growing a common understanding (the eighth flow) of all aspects of the project.

However, this approach has been viewed to be non-existent in the traditional approach of project planning which is characterised by a lack of trust and little collaboration in agreeing procedures for delivering the project (Zaghloul and Hartman, 2003; Austin and Baldwin, 2002). Ballard and Howell (1998) argued that the non-existence of collaborative programming in developing construction tasks and activities is among the major causes of construction project failures. Other terms used for collaborative programming in the construction industry include*: Detail planning; Detail programming to completion; Phase Scheduling; Collaborative planning* and *High level planning* among others. It is worth noting that this process is commonly called collaborative planning by practitioners in the UK, while phase scheduling is the common name used for it in Lean Construction Institute literature (Ballard, 2000; Ballard and Howell, 2004). In practice, the approach not only leads to a reduction in construction programme, but also enables the team to develop a common understanding of the task (Pasquire, 2012). Hans *et al*, (2006), Anderson *et al*, (2011), assert that collaborative programming of construction activities reduces incidences of change in orders, delays, rework, non-value adding activities, and litigation at the construction phase. Furthermore, Hans *et al*, (2006); Ballard and Howell, (2004); Ballard and Howell, (1998) stress that in collaborative programming, the planning activities and tasks must be done in detail and collaboratively with the team. This will make the construction programme transparent, reliable, and predictable.

2.4.3 Look-Ahead Planning

The Look-Ahead planning is a medium term plan for project activities and is developed from the collaborative programme. Usually, the tasks that will occur within three to six weeks in the Look-ahead window will be screened for constraints in all eight flows including information, permissions, resources, space etc. The project team members then identify every constraint for the proposed assignments for action in the make-ready process (see below). In doing this, the problems that could affect the task negatively will be identified so they can be removed before the commencement of the task, thus eliminating delays and waste from the production process (Ballard, 1997; Porwal, 2010; Zimina and Pasquire, 2012). However, in the traditional way of managing projects, the Look-Ahead plan (master programme) only provides advance notice of the start date of an activity and does not consider work flow sequence, matching work flow with capacity, or maintaining a backlog of workable activities (Ballard *et al*, 2009). In implementing the LPS, the purpose of the Look-Ahead planning is: (1) to create workflow between activities in the project (2) to ensure that the available labour and resource matches the work (3) to ensure

prerequisite tasks are completed as planned (4) to group work that is closely related together for easy execution and (5) to identify tasks that need to be planned together. In this way constraints to all eight flows are properly recognised to enable effective “Make-Ready” and eliminate the waste of making do (Koskela 2004).

2.4.4 Make-Ready Process

The Make-Ready process is used to eradicate the constraints to planned activities identified in the Look-Ahead programme before they pass into production on site. The Make-Ready process focusses on matching the available resources for work with the present realities on the construction site, so as to ensure production can proceed at an optimum level (Ballard, 2000, Ballard and Howell, 1998). Daniel *et al*, (2014b); Ballard, (2000) observed that the Make-Ready process helps in controlling the production system on site. Ballard, (2000) observes that most scheduled activities in the traditional approach to planning are not achieved as planned because they are not ‘Made-Ready’ before the commencement of the task on site. The implication of this for the production system is that the expected work flow will be elusive. Lindhard and Wandahl, (2012) and Koskela, (2000) affirms that the lack of flow and the failure in removing constraints from the construction process generates numerous non-value adding activities in the construction phase. The goal of the Make-Ready process is to ensure that only sound activities move into the backlog of sound assignments for use in the Weekly Work Plan (Mossman, 2014, Lindhard and Wandahl, 2012, Ballard, 2000) ensuring that only sound work enters the production phase on site. The Make-Ready process is undertaken collaboratively so that agreement can be reached on what “Can Be Done” – it considers all eight flows

2.4.5 Production Planning and Evaluation or Weekly Work Plan (WWP)

Production planning also known as the Weekly Work Plan is done to review the task planned in the previous week in order to plan for the week ahead collaboratively with the team. During the WWP, only sound work or assignments collaboratively developed from the Make-Ready process are allowed into production. Here, the last planners’ i.e. those responsible for doing the work make promises (commitments) on what “Will Be Done”. The reliability and predictability of the construction programme is a function of the soundness of work or assignments sent into the WWP and the commitment of the work force to do them. This approach requires stakeholders on the project to report the position of the previous week’s planned tasks. Only a “Yes” or “No” answer is given to indicate if the planned tasks were achieved or not, whilst also recording the reasons for non-completion. In recording the reason for non-completion (RNC), 99% completion is a No answer. This RNC enables the team to identify the root causes for the failure. This in turn enables the team take necessary actions to address the identified reasons, for future learning (Ballard, 2000; HA, 2010; Mossman, 2014) and for error proofing future activities to prevent the same thing happening again. In practice, the production planning and evaluation planning enables each subcontractor or team leader on site to propose the production plan for the week ahead after successfully reviewing the previous week’s work plan. This not only enables the team to understand the interdependencies of tasks (next customer), but also requires the team to only promise what they are sure they ***will*** do not what they might or will try to do.

2.4.5.1. Daily Huddle or Production Management and Control

Production management and control occurs on the day of production. The production management and control meeting is also known by the following names; Daily Huddle and Daily Stand-up Meeting among others. It is a daily conversation that occurs on the day of production with the last planners either at the start of work or at the end of work to assess the progress of the planned tasks for the day and review the next day production. Through this meeting, ‘bad’ news is delivered early which considerably helps in taking mitigating

actions to address problems early and accordingly (Mossman, 2014). The production management and control meeting could be weekly during the design stage and daily at the construction stage. The approach is used to maintain the entire production system thus ensuring the designed or intended output is achieved at the end of the production process. Production management and control entails the coordination of production planning, material coordination, and the control of planned tasks and production units (Ballard, 2000). According to Ballard and Howell, (1998) production management and control focuses on ensuring that the workable backlog of tasks is delivered as indicated during the work phase. Koskela and Howell (2002) and Ballard and Howell, (1998) argued that these cannot be achievable in the traditional project management approach since its model is based on project control rather production control.

2.4.5.2 Measurement and Learning

Mossman, (2014) observed that production evaluation and measurement in the LPS context enables the team to maintain commitment to the overall goal of the project, thus addressing the client's needs while also making the supply chain aware of what is required of them. The key metrics measured in the LPS implementation are; the Percentage Promised Completed (PPC), the Reason for Non-Completion (RNC) and a developing Reliability Index. PPC is used to measure the completed work against the actual work promised to give an indication of productivity, while the RNC can be presented statistically to provide visibility of the frequency and distribution of the factors inhibiting production.

$$(PPC) = \frac{Total\ Number\ of\ Activities\ Completed}{Total\ Number\ of\ Activities\ Promised} \times 100\%$$

In practice, PPC measurement, and recording of RNC not only encourages learning but also provides a clear indication of productivity (Daniel *et al*, 2014b, Kalsaas, 2012; Liu and Ballard, 2008). This has been confirmed in Liu and Ballard, (2008) where their study revealed a strong correlation between PPC and productivity. Daniel *et al*, (2014b); Ballard,(2000) assert that the uniqueness of LPS metric measurement is the learning loop which is embedded in the system as shown in Figure 2. This is contrary to the 'push' approach used in traditional project management which hinders learning.

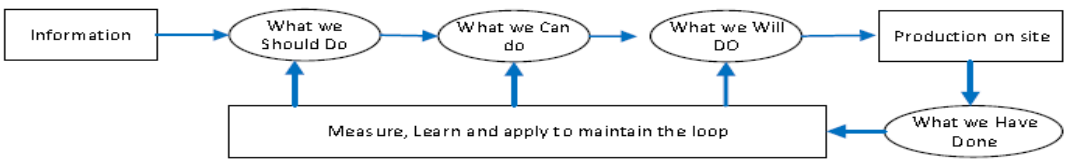

Figure 2: The learning loop in the Last Planner System

Source: Daniel *et al*, 2014b; Ballard, 2000

When PPC and RNC are considered together in this way learning is coupled to action in the moment as opposed to at the end of the project. This makes projects very resilient and responsive to change and flexion. Root cause analysis of RNC opens up the possibility to develop appropriate actions to eliminate causes of non-completion through the design of new systems and processes.

2.4.6 First Run Studies

A First Run Study (FRS) is an approach used to aid understanding of the construction process before actual production or execution on site. It is used in the redesign of activities that are considered to be critical in the production process which may also be repetitive in nature, for instance, a prototype building (Ballard and Howell, 1998). However, Mossman, (2014) argued that FRS is not limited to repetitive tasks alone, but on all activities that are critical to the success of the project in terms of time, quality, cost, and safety. In the UK, this process is commonly called Mock-up or Prototype among others. The process encourages continuous improvement and allows standard work to be developed and constraints to be identified. Hackett and Pasquire, (2014) identified Virtual First Run Studies (VFRS) as a form of 'Proof of production' based on collaboration and discussion in advance of the physical First Run through an activity.

The LPS implementation processes as discussed enable all stakeholders on the project to develop a collaborative relationship during the planning and execution of tasks on site. In fact, Daniel *et al* (2014b) and Mossman, (2014) describe the LPS implementation process as set of social conversations that enable the team to build trust and commitment, thus making the construction programme more predictable and reliable.

2.5 Last Planner System in Construction

The LPS of production planning and control has been implemented across different sectors in the construction industry since its first experimentation in the 90s. A comprehensive review of the International Group for Lean Construction conference papers on previous implementation efforts indicates that LPS has been implemented on over 56 construction projects in different parts of the world. These include building construction (Junior *et al*, 1998, Medes and Heineck, 1999; Alarcon *et al*, 2002, Kalsaas, 2014); heavy civil engineering construction (Ballard, 1993, Howell, 1994; Kim and Jang, 2005; Kim *et al*, 2007); highway and infrastructure projects (Kim and Jang, 2006; Drysdale, 2013) and includes ship building and pit mining (Aneslen and Berstelen, 2008; Rosas, 2011) just to mention a few. The implementation of LPS in all sectors of the construction industry further attests to its potential in stabilising the production process. Furthermore, it magnifies the assertion of Mossman, (2014) that the LPS works effectively wherever human and material resources need to be managed. Its implementation in construction has been reported in over 16 countries with different numbers of implementation cases. These countries include; USA, Brazil, Norway, UK, and Nigeria among others (Ballard, 1997; Soares *et al*, 2002; Kalsaas, 2014; Johansen and Porter, 2003; Adamu and Howell, 2012). Again, this shows the universal application of the LPS in construction.

2.5.1 Last Planner System Implementation Drivers

The LPS has been identified as one of the major lean techniques that could pave way to other lean practices in a construction organisation. Researchers have argued that the LPS does not only create an atmosphere for collaboration, but also learning and the creation of new knowledge among workers on construction projects (Skinnarland, 2012; 20; Kalsaas, 2012). But the other question that needs answering is; what are the drivers for implementing the LPS in a construction projects? Lead *et al*, (2005) defines driver "as any natural or human-induced factor that directly or indirectly causes a change in an ecosystem". Here an ecosystem is any system or network of interconnecting and interacting parts, and applies to a business. This means that an ecosystem on a construction project refers to the network of stakeholders and the interrelationships that must occur for the delivery of the project. To be

specific, the client and the supply chain form the ecosystem on a construction project. This means that drivers for LPS implementation in construction must refer to those natural or human induced factors that directly or indirectly motivate the project team to adopt the LPS and change their approach to working. These factors could be extrinsically or intrinsically motivated.

In the first place there needs to be a dissatisfaction with the traditional approach of planning and managing construction projects. This method is largely based on guesses and assumptions causing variation in the production system and the need to overcome this has been identified to be among the drivers for implementing LPS (Samudio and Alves, 2011; Johansen and Porter, 2006; Ballard, 1993; Koskela, 1999). According to Howell and Ballard (1998), planning in traditional project management focuses on activity to activity thinking, always seeking to complete activity bit by bit and as soon as possible without considering the impact of completing or not completing the activity on the entire production system. The outcome of this approach is variation and absence of workflow in the production system. For instance, Ballard (2000) reported that only 53% of planned tasks are completed as planned in the traditional approach of planning and managing project. Due to this shortfall, project teams are seeking for innovative ways to overcome the anomaly so as to improve project performance.

Furthermore, Ballard *et al*, (2007) identified the following drivers for the implementation of LPS in construction; (1) Owner and client demand,(2) internal demand for a better way of working (3) desire to reduce stress on project managers (3) desire to reduce variation and waste and (5) desire to improve communication with project team. Additionally, Ogunbiyi, (2014) also identified drivers such as the need to meet customer or client expectation, gaining a competitive edge, and the desire for continuous improvement. This suggests that the drivers for LPS implementation could be viewed from two perspectives; external drivers and internal drivers. For example, the demand from the owner or client for LPS implementation is externally motivated. While factors such as the desire for LPS implementation for better way of working for enhanced performance, the desire to improve communication between project teams, and desire for continuous improvement could be viewed as internal drivers, as they can be initiated by supply chain organisations. This shows that the driver for LPS implementation is not from client alone, but it could also come from the contractor's quest for continuous process improvement. However, the push from the client and owner for a change in approach to work in the construction industry seems to be on the increase. According to Ogunbiyi, (2014), regularly procuring clients are desperately seeking innovative means to plan, design, construct, and manage their projects in order to maintain their business values.

2.5.2 LPS Implementation Challenges in Construction

It has been observed in the past that the LPS has not been widely accepted in managing production process in construction (Mossman, 2009; Johansen and Walker, 2007). This could be due to the new nature of the idea of production systems in the construction industry. However, recent reports indicate that the application of the LPS in managing production in the design and construction phases is on the increase (LCI website, 2015). This could be due to its many benefits in stabilising the production processes and reducing variability by increasing workflow (Fernadez-Solis *et al*, 2012; Ballard and Howell, 1998). Even with this growth recognition, its implementation in construction is still marked with numerous challenges. Researchers in lean construction have attempted to underscore the implementation challenges of LPS in construction (Ballard, *et al*, 2007; Hamzeh, 2009; Porwal,*et al*, 2010, Fernandez-Solis *et al*, 2014) As shown in Table 1 Porwal *et al*, (2010) identified 12 major challenges associated with LPS implementation as observed from

previous studies between 2002 and 2009. As revealed in Table 1, lack of training and resistance to change are among the commonly reported challenges in the studies presented

Table 1: Last Planner System implementation challenges

	Challenges	Garza J.M. et al. (2000)	Alarcon L.F. et al. (2002)	Fiallo C. M. et al. (2002)	Kim Y.W. et al. (2005)	Koskenvesa A. et al. (2005)	Arbulu R. et al. (2006)	Ansell M. et al. (2007)	Ballard G. et al. (2007)	Jang J.W. et al. (2007a)	Jang J.W. et al. (2007b)	Kemmer S.L. et al. (2007)	Kim Y.W. et al. (2007)	Sterzi M.P. et al. (2007)	Alsehaimi et al. (2009)	Hamzeh F. R. (2009)	Jara C. et al. (2009)	Liu M. et al. (2009)
1	Lack of Training		✓		✓	✓			✓	✓						✓	✓	
2	Organizational Inertia & Resistance to change /"This Is How I Always Done It" attitude		✓	✓		✓		✓	✓					✓	✓			
3	Human Capital & Lack of Understanding of new System & Difficulty to make Quality Assignments/Human Capital –Skills and experience				✓		✓					✓	✓			✓	✓	✓
4	Lack of Leadership / Failure of Management Commitment / Organizational Climate		✓				✓		✓									✓
5	Lack of commitment to use LPS & Attitude towards new systems	✓							✓						✓			✓
6	Bad team chemistry & Lack of collaboration						✓		✓					✓				
7	Stakeholder Support	✓								✓		✓						
8	Contracting and legal issues/ Contractual Structure	✓								✓								
9	Empowerment of field management /Lengthy approval procedure from client and top management										✓				✓			✓
10	Extra resources/more paper work/extra staff/more meetings/more participants / Time		✓								✓							
11	Partial Implementation of LPS & Late Implementation of LPS																	✓
12	Physical Integration						✓											

Source: Porwal *et al*, (2010)

Furthermore, in a related study, Fernandez-Silos *et al*, (2012) identified 13 specific LPS implementation challenges from the review of 26 case studies. The topmost implementation challenges from the review were resistance to change, lack of commitment to LPS, lack of training and experience, and lack of management support among others. It is worth to note that some of the LPS implementation challenges identified in Porwal *et al*, (2010) were also identified in Fernandez-Solis *et al*, (2012). This shows that the implementation challenges identified by Porwal *et al*, (2010) are valid and more needs to be done to overcome them. Further examination of these challenges shows that they could be classified to assist practitioner address them appropriately. Fernandez-Solis *et al*, (2012); Porwal *et al*, (2010) observed that the LPS implementation challenges can be classified into two i.e. the challenges observed at the implementation phase in the organisation and those observed by the 'last planners' on site at the point of implementation.

Hamzeh, (2009) also classified the LPS implementation challenges into local factors and general factors. The local factors relate to the project related challenges while the general factors are those relating to the organisation implementing the LPS. Challenges such as lack of management support, absence of training for site workers on LPS, contractual and legal

issues, resistance to change, and late implementation among others could be faced by the implementing organisation, while challenges such as lack of understanding of the new system, lack of planning skill, lack of commitment to the use of LPS, lack of collaboration and involvement of site operatives in the process by site mangers among are the some of the challenges experienced at the point of implementation on site. This shows that likely strategies for overcoming LPS implementation should have due consideration for these classifications. According to Liker, (2004) in implementing lean, the organisation must be willing to change and the people (workers) must be ready to accept the new approach for the needed change to happen.

Figure 3 indicates recent findings on LPS implementation challenges in construction from a systematic and comprehensive review of IGLC papers conducted by the authors.

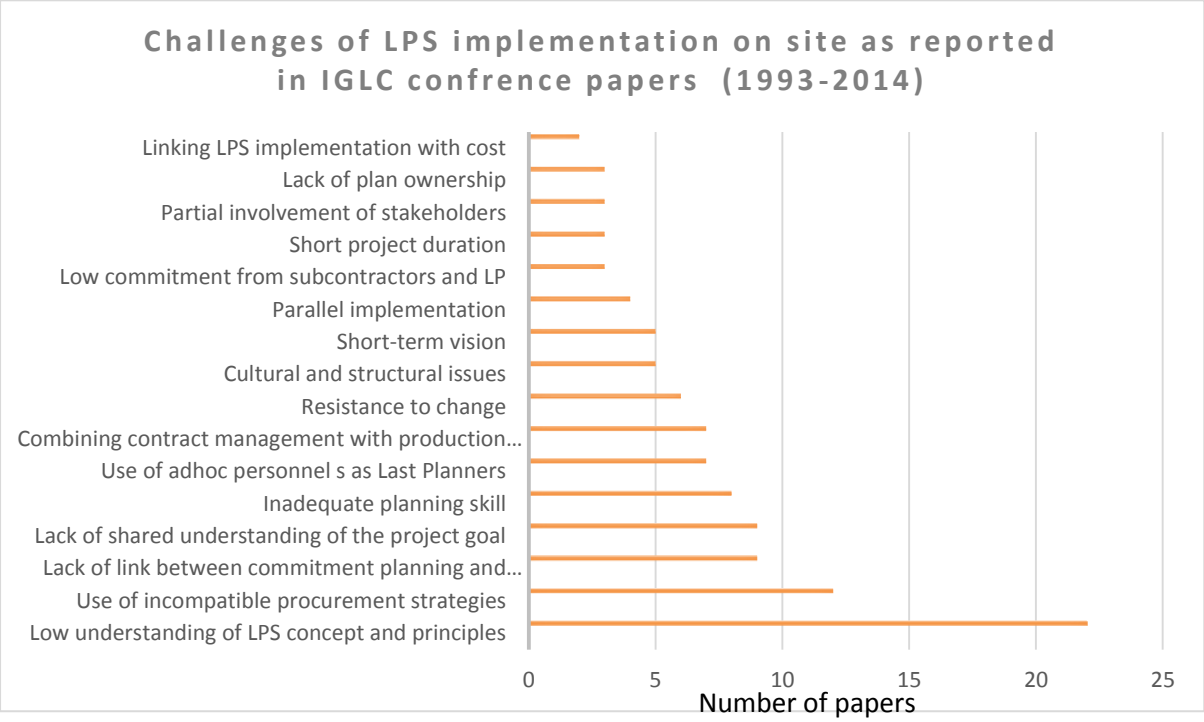

Figure 3: Last Planner implementation challenges in construction

Source: Authors' review of IGLC paper on LPS implementation

Findings in Figure 3 and those from previous studies such as Fernandez-Solis *et al*, (2012) and Porwal, (2010) show the need for training to improve on the LPS implementation. Liker in his book The *Toyota Way* highlights the need for training in its 9th principle (Liker, 2004). The principle states that *"Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others"*. Training as emphasised here is not just in having mere technical knowledge of the LPS process, but rather a mind-set change training, which could further help in overcoming some of the other identified challenges by focusing on the flow of understanding.

This shows that any organisation seeking to deploy the system across its businesses must be committed to training at all levels. But who will be responsible for the cost of the training? According to Fernandez-Solis *et al*, (2012) developing human capital within the organisation will enable the organisation to implement LPS effectively. Loosemore *et al*, (2003) also argued that the best investment to improve the construction industry should be in human resource development. However, as crucial as training is to LPS implementation, it is initially an additional cost to the organisation even though it can be offset by improved performance.

2.6 Collaborative Working and the Last Planner System

Collaborative working (CW) is concerned with the joint working of all stakeholders on the construction project, to efficiently and effectively deliver the project to the specified standard (Xue *et al*, 2010). The concept of collaborative working is gaining more attention in the construction industry both at the organisational and project level. This is because the knowledge and technical ability needed to deliver a project is dispersed across the project team members (Hayek, 1945). However, some organisations who claim to be involved in collaborative working still base their working practices on the traditional project management model. For instance, Xue *et al*, (2010) and Baiden *et al*, (2006) opined that in the current traditional approach to procuring projects, construction project stakeholders tend to seek their individual benefit at the expense of the collective goal of the project; this hinders CW among the stakeholders. In reality, this approach to working will hinder the industry from reaping the benefits of CW. According to Baiden *et al*, (2006) and Evbuomwan and Anumba, (1998), time and cost overrun are common occurrences on construction projects, which is partly due to the lack of collaborative working among the stakeholders. For instance, in the UK construction industry, current reports indicate about 50% of construction projects experience both cost and time overruns (Crotty, 2012).

It can be argued that some so called CW arrangements put in place by organisations lack the capacity to develop into genuine collaborative relationships among the stakeholders on the project. This is because some of these so called CW projects still operate based in a claim and blame culture with a focus on individual benefit. This characterises the traditional approach of managing construction projects and is a coherent paradigm. Udom, (2013) observed that CW seems to exist in principle rather than in practice. It was further observed that on some of the projects that claim to be applying CW, not all the participants on the project are allowed to sign into the collaborative contract. This could be due to the quest by the parties on the project to safeguard their individual interests which promotes a transactional rather than relational approach (Sarhan et al, 2015). According to Briscoe and Dainty, (2005) construction clients distrust their main contractors while the main contractors also keep their subcontractors at a distance This implies that for genuine CW to develop, trust and openness must exist among the stakeholders(Latham, 1994). Udom, (2013) suggests that in developing CW, beyond the contractual provisions, soft skills such as having regular meetings with all the stakeholders on the project should be encouraged. This is an integral part of the LPS.

The LPS as is earlier described is a production management system that assists in the development of collaborative relationships through social conversations which Mossman, (2014) calls the “5 + 1 conversations”. These six conversations or process were discussed extensively in section 2.3 of this report. Through these conversations (or the LPS implementation process) collaborative working relationships between stakeholders on the project are enhanced, adversarial relationship minimised and CW maximised. Generally, construction is a team based industry and without effective support from every member of the team, the goal of the project cannot be achieved. In other to achieve this objective, the construction process must be managed to ensure a common understanding, building trust and relationships, and ensuring workers are allowed to make promises on their own, to enhance CW (Pasquire, 2012). The LPS makes this possible through the social conversation process especially during collaborative programming and weekly work planning (Daniel *et al*, 2014b, Mossman, 2014). Mossman, (2014) opined that when such relationships are developed effectively, it enables CW for quality and on-time project delivery, the two pillars of lean production as illustrated in Liker’s Toyota Production System House (Liker, 2004).

2.7 Conclusion to Literature Review

The aim of this literature review is to report the current theoretical understanding of the LPS, CP, and CW in the construction industry and to specifically identify LPS implementation drivers and barriers. The study established that the concept of CP in the construction is not a stand-alone concept as it is commonly viewed by many lean construction practitioners especially in the UK (Daniel et al, 2015b); rather it is exclusively based on the LPS philosophy. More importantly, the review shows that CP is one among many processes of the LPS implementation in construction. This suggests that limiting the LPS to collaborative planning or collaborative programming alone could lead to losing sight of other elements that make up the LPS, thus hindering the full benefit of implementation.

The review indicates the potential of the LPS in developing collaborative relationships among project stakeholders through the implementation process discussed in section 2.4 of this report. In fact, the LPS implementation process does not only enable all the stakeholders on the project to develop trust, and commitment to construction programme, but also, enables the team to develop a common understanding on the project goals. These lead to increased workflow and a more reliable and predictable project delivery.

This review has also shown that the LPS implementation is applicable to all forms of construction be it building, heavy civil engineering, highway and infrastructure, mining projects or ship building with remarkable success across major countries of the world.

Furthermore, the review established that the current drivers for LPS implementations in construction can be broadly classified into two; external drivers and internal drivers. The review indicates that dissatisfaction and the need to overcome the evils (time and cost overrun) associated with the traditional planning approach, the demand from clients and owners for its use, internal drive to gain competitive edge for continuous improvement and enhance performance, and profits/benefits achieved from previous pilot implementations are among the key drivers for LPS implementation in construction. This suggests that the driver for LPS implementation should not be limited to clients and owners alone as erroneously viewed in some quarters. However, the review observed that the demand for its use from the client side across its business so as to sustain business value is on the increas

The study revealed that LPS implementation is on the increase in construction; however this is not without challenges. The review indicates that lack of training, a low level of understanding of the new system, partial implementation, lack of management and leadership support, and resistance to change among others are the challenges of LPS implementation in construction. Evidently, LPS implementation challenges could be classified into two; challenges face by the implementing organisation and those faced by the ‘last planners’ at the point of implementation on the project. It has been observed that previous implementation efforts tend to focus on project performance improvement through the application of tools and methods (Pevez and Alarcon, 2006).

The review shows that the factor that informed the need for the use of LPS and CP in construction is the same for CW that is; not getting things done in an efficient way. However, the study argues that the way in which CW is implemented in practice often lack the potential to develop genuine CW relationship. The premise on which some of the so called CW practices are based lack the potential to develop genuine CW relationship. In view of this, the study suggest that beyond signing CW contracts, soft skill such trust, openness and developing a next customer awareness to break up the silo mentality should be encouraged. These can all be realisable through the LPS.

The study concludes that the LPS has the potential to develop collaborative working relationships among project stakeholders when implemented holistically, since it is capable of initiating collaborative conversations. These continue right from the collaborative programming sessions through to evaluation and learning. The review recommends that in order to overcome some of the challenges observed in LPS implementation, effort and resources must be committed to training and retraining of employees both at the organisational and project levels not just on the use of tools and methods, but also on the mind-set changes needed for the new approach to work. This should be built around trust and openness.

3.0 Snapshot of Current Practice

An empirical study was undertaken to provide a snapshot of current practice within the HA. It should be noted that on the majority of projects the term *Collaborative Planning* was used. The term *Last Planner* was also commonly used. These two terms were used interchangeably and seemed to be understood (incorrectly) to be the same thing. For the purposes of this report the term *Collaborative Planning* (CP) has been used to describe HA practice unless directly quoting a practitioner or actually talking about the Last Planner System.

Table 1 gives an overview of the HA projects included in the study. Project PO1 is a road widening project, and the CP process was internally facilitated by the company's continuous improvement manager who has over 4 year experience in CP in conjunction with the project planning team. The implementation commenced at the early stage of the project. On Project P02, CP was used in design and maintenance work management. The project entails designing, scheduling, constructing and delivering the scheme; the process was internally facilitated by the project manager, internal lean champions and internal lean practitioners with initial support from a lean consultant. Project P03 is a road widening project with other associated infrastructure development including drainage and bridges. Here the process was internally facilitated by the principal planner and project manager with other members of the project team. Projects P04 and P05 are road expansion projects with the construction of associated infrastructures. The CP was facilitated by external consultant on project P04 with some support from the internal lean deployment team in conjunction with the planning team. While on project P05, the process receives support from both an internal and external lean team. As shown in Table 1, all the organisations observed claimed to be knowledgeable of the use of CP. Furthermore, all the organisations observed are among the top 20 UK construction contractors and their facilitators claimed to be knowledgeable in CP. Additionally, the observation was not limited to the construction stage alone, but it also includes its use in design and maintenance, thus giving a wider perception on the use of CP on HA projects. Additionally, the project durations are long enough to enable a trend in the current practice to be clearly captured. The findings and discussion from the observation are presented in subsequent sections.

Table 1: Background information on some of the HA projects evaluated

Project code	Nature of project	Project duration	Area of application	Experience in CP in organisation
P01	Highway (construction)	36 months	Construction stage	4 years

P02	Highway (maintenance)	119 months	Design/ construction	2 years
P03	Highway (construction)	40 months	Construction	4 years
P04	Highway (construction)	36 months	Construction	4 years
P05	Highway (joint venture/construction)	22 months	Construction	4 years

3.1.1 Background information of the participants surveyed and interviewed

The analysis of the survey reveals that 58.8% are from tier 1 suppliers and 41.2% from tier 2 suppliers. Since both tier 1 and 2 are sufficiently represented in the survey, the level of bias in the findings is minimised'. In terms of experience in CP, 29.2% have 1-2 years' experience while 35.3% have 3-4 years' and 5 years' and above experience. This implies that majority of the respondents have some knowledge of the implementation of CP in construction. Furthermore, in terms of the experience of the respondents in construction 47.1% have 21 years' and above, 17.1% have 2-5 years while 11.8% and 23.5% have 6-10 years and 11-16 years pf experience respectively. This means the majority of the respondents have significant experience in the construction industry providing quality and richness to the data obtained.

The longevity of experience of the participants means the traditional approach is well known which should enable them to differentiate the traditional approach to managing projects from the CP approach. The respondents occupy various posts in their organisation such as operations director, lean deployment manager, contract manager, and business improvement managers among others. Again, this further shows that the respondents are directly involved in the implementation process. The findings are presented below. The 13 interviews comprise 4 lean construction consultants, 6 general contractors (tier 1) and 3 subcontractors (tier 2).

All of the lean construction consultants have over 20 years in the construction industry and over 10 years' experience in the use of collaborative planning. The respondents that participated in the interviews occupy high level positions in their organisations which include lean improvement manager, principal planning engineer and improvement managers each with over 20 years in construction and 5 years using CP. The client and the subcontractors have over 5 years' experience in the use of CP. This shows that the interviewees are knowledgeable and able to identify the drivers and barriers for CP implementation.

3.1.2 Collaborative planning practice on Highways Agency projects (findings from the project observations)

The literature review identified 17 major practices associated with the implementation of production planning and management in LPS implementation. The observation of the implementation of these practices (fully, partially, not visible) was undertaken on 5 HA projects to provide a snapshot of current practice. The incidence of practice observed is presented in Figure 1. The study reveals 3 major LPS practices that record high full implementation on the projects observed; they include having initial collaborative planning/phase scheduling meetings, measurement of Percentage of Planned Completed (PPC) and having short term Weekly Work Plan (WWP) meetings. On all the projects evaluated, the initial collaborative programming/phase scheduling meeting was fully implemented. This is likely to be due to its potential to enabling the fragmented project team

to develop a common understanding of the project, creating a synergy between the parties on the project.

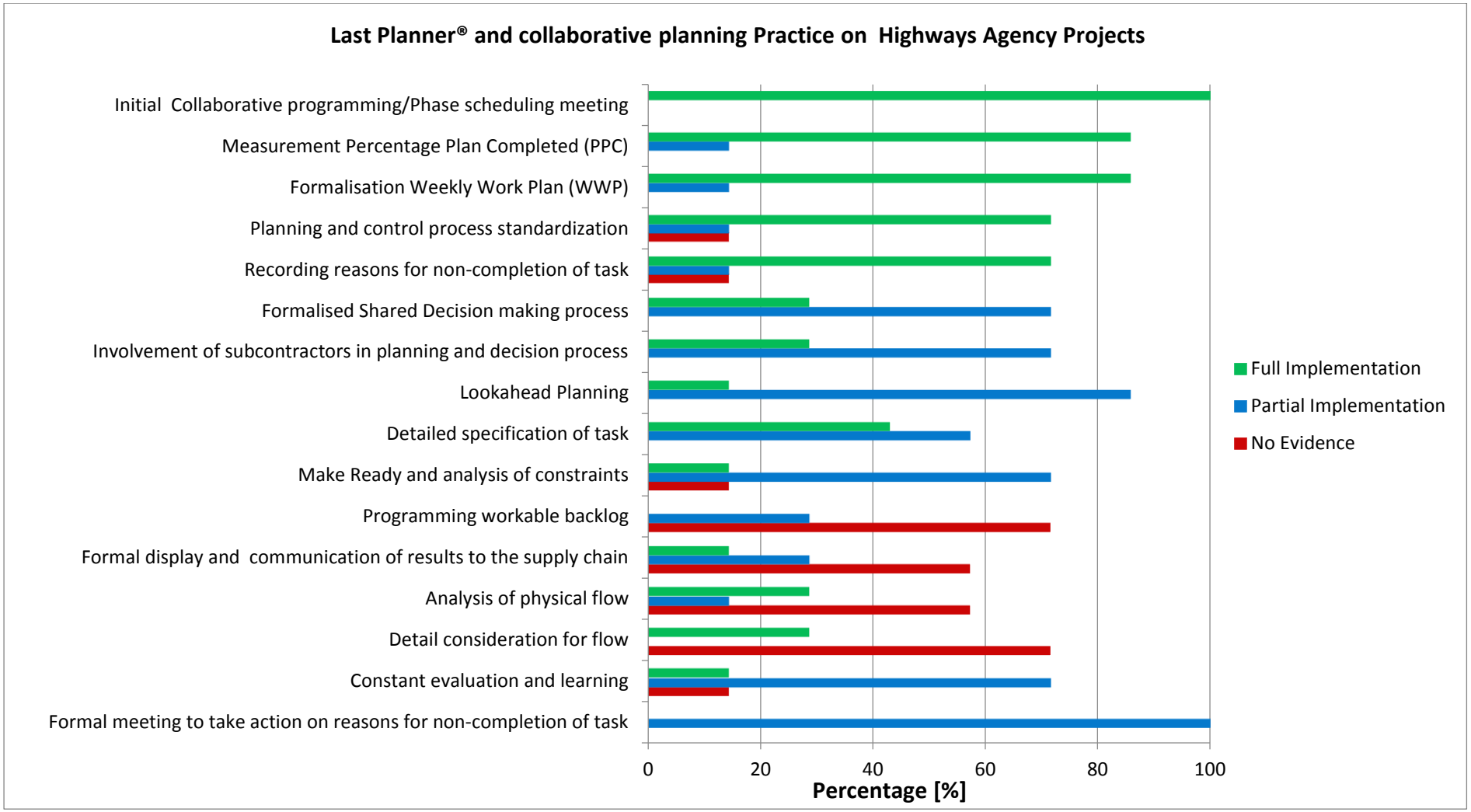

Figure 3: Last Planner System practices on HA projects

Furthermore, the collaborative programming/phase scheduling process creates a supportive environment for the deployment of other elements of the LPS. However, it must be noted that the LPS is not limited to collaborative programming/phase scheduling alone.

The study revealed that measurement of PPC and the WWP meeting were fully implemented on most of the projects observed. More importantly, this finding follows that of Daniel *et al*, (2015a) who identified the measurement of PPC, WWP meetings and collaborative programming/phase scheduling to be among the elements of the LPS most consistently reported by the IGLC as implemented in previous studies. Dave *et al*, (2015) also observed from their study that WWP meeting is the most implemented element of the LPS. This implies that the frequency of the use of these elements on HA projects is similar to those implemented elsewhere. However, these practices vary from one HA project to another. While this is done with full involvement of the supply chain on some projects, on other projects, the supply chain were only partially involved as revealed by the survey result. The asset management customers (maintenance and operations) were not included in the meetings. The use of these elements on most projects that claim to use the LPS could be attributed to their capacity to develop the following; allow other elements of LPS to develop in the organisation, development of initial collaboration among the team and also helping to stabilise the production process. According to Ballard, (2000) LPS metrics such as PPC help in attaining construction process improvement and productivity.

One distinction noted was that PPC on HA projects is the measurement of *Planned* tasks completed. However, under the LPS it is more usual to refer to this as *Promised* tasks completed. This distinction is important as the focus on promises has a cultural and behavioural impact moving the focus towards commitment and next customer satisfaction.

The analysis reveals seven practices that were partially implemented on the projects observed. Previous studies such as Alarcon *et al*, 2002; Liu *et al*, 2009; McConaughy and Shirkey, Dave *et al*, 2015; and Daniel *et al*, 2015b identified partial or late implementations as a major challenge to LPS implementation in construction. This could be due to a lack of discipline or other internal issues that may occur at the point of implementation. According to Hamzeh, (2010) LPS implementation requires commitment and discipline both at the organisational and project levels. The partial involvement of subcontractors on some of the HA projects evaluated calls for concern as it presents an indication of the persistence of the traditional approach to managing projects. Briscoe and Dainty, (2005) observed that clients tend to distrust their main contractors while main contractors also try to keep their sub-contractors at arm's length. Also, on all the projects observed, no formal action was discerned to be taken to address the reasons for non-completion (RNC) that had been recorded. According to Ballard, (2000) the purpose of recording RNC is to enable the team to collectively act to address the identified issues and to prevent future occurrence. This enhances learning. It can be argued that if no formal actions are taken to address the RNC recorded, then the recording itself becomes a waste of time and resources.

The study also identified 4 key practices that lacked evidence of implementation on the projects observed. These include; programming a workable backlog; a lack of consideration for flow; analysis of physical flow and formal communication of feedback to the supply chain. The lack of consideration and analysis of flow was evident on most of the projects evaluated. For instance, during the interview, one of the respondents was asked; 'what action do you take when an action is completed earlier than planned?' The response was "we don't do anything; we take it as a bonus". This shows a lack of understanding of flow in the production process and the importance of load levelling and stability in the production process both of which are likely to be disturbed as a result of the unplanned early completion.

The study revealed that although metrics such as PPC, RNC are measured and recorded, these metrics are not formally communicated to the supply chain on some of the projects observed. The implication of this is that the supply chain will not really know of what is happening on the project. This in turn may have a negative impact their ability to commit to the project goals and objectives going forward. This subtle adherence to traditional thinking is reinforced by using the term Planned in PPC instead of Promised – only the supply chain "Last Planner" can *promise* whereas the project manager can *plan* on their behalf.

3.1.3 Level of involvement of supply chain in collaborative planning implementation

The study also sought to take a snapshot of the level of involvement of the supply chain in CP implementation across HA projects through a small survey. Respondents were asked to indicate the level of their involvement in the CP implementation. The result of the analysis is presented in Figure 2. Findings indicate that the Weekly Work Planning Meeting is the topmost CP process, with 52.9% of the respondents agreeing they are fully involved in the process. It is worth noting that while over 70% of the projects observed had full implementation of the WWP; the survey result of 52.9% shows a slight deviation between the tier 1 and tier 2 supply chain member perceptions.

The high level of involvement of the subcontractors in the WWP shows the importance of engaging the supply chain in the weekly production planning meeting in the collaborative planning implementation process. However, under LPS the engagement should not be limited to weekly planning meeting alone, as this cannot develop the collaborative conversations achievable from the holistic implementation of the system. Furthermore, the study reveals that the majority of the respondents agreed that the supply chain were partially involved in some of the CP process. As shown in Figure 2, they include but are not limited to; identification and removal of constraints to planned task; having access to a Visual Management and Communication board; consideration for physical workflow on site; look ahead planning; development of collaborative programme; creation of lesson learnt files; identification of production programme risk and opportunities among others. However, among these factors, identification and removal of constraints to planned task and having access to Visual Management and Communication board were the topmost. In fact, 64.7% of the respondents stated that they were partially involved in these.

The place of full involvement of the supply chain in the above mentioned processes is also crucial in the implementation of the LPS. This is because over 70% of the tasks on the programme are usually executed by the supply chain. The goal of the LPS is to allow "the people doing the work to do the planning". In practice, the full involvement of the supply chain will not only lead to the development of sound assignments by the removal of constraints before the commencement of work, but also contribute to the formation of better workflow. Ballard, (2000) stated that the full involvement of the supply chain in the planning and removal of constraints in the LPS implementation process should be a model to be adopted on all implementations.

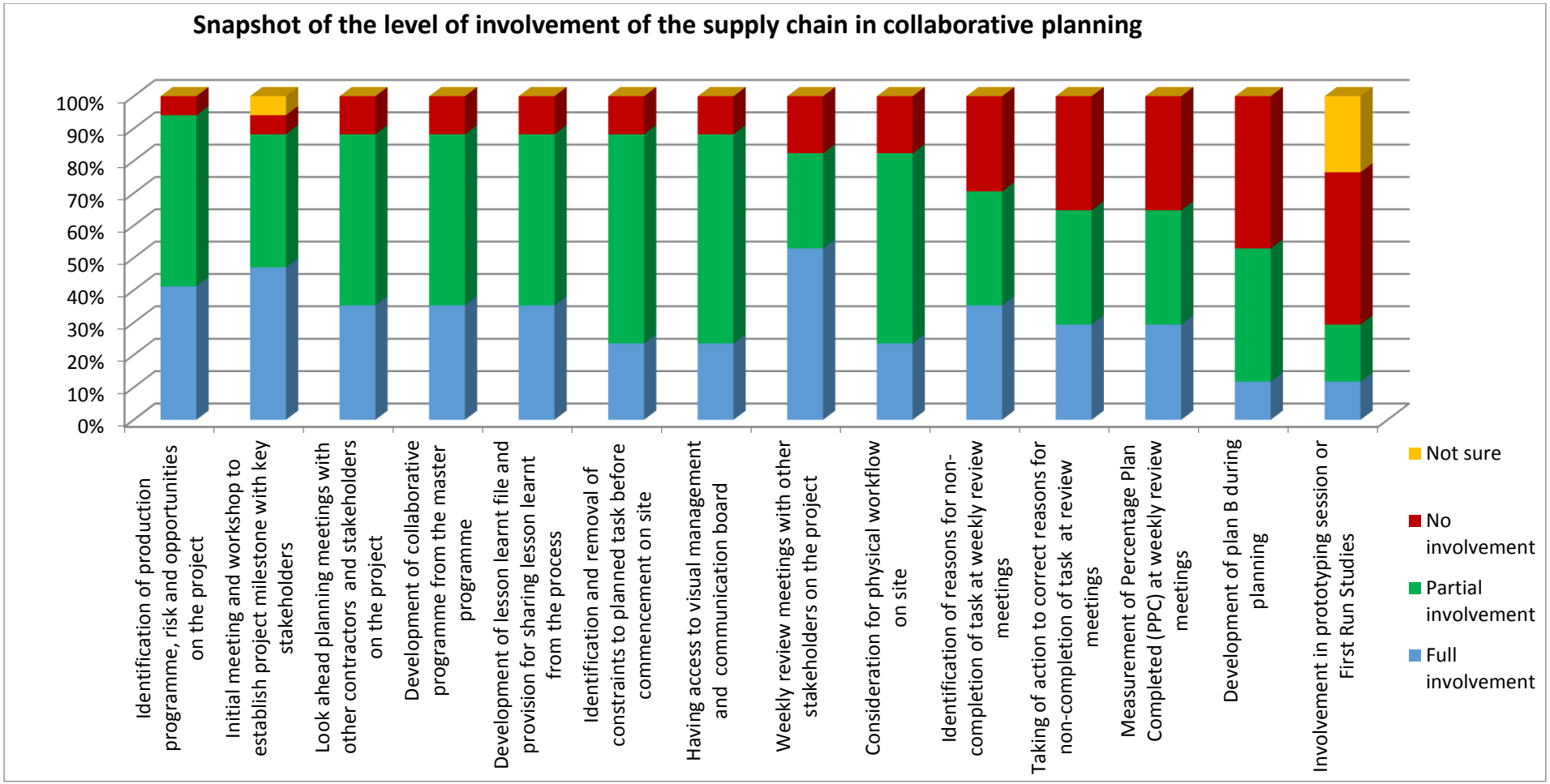

Figure 4: Snapshot of the level of involvement of the supply chain in collaborative planning

Furthermore, the use of different forms of Visual Management (VM) device were observed on the 5 projects, however the survey results reveal that the majority of the supply chain have only partial access to the VM device. Again, this could limit the level of conversations and common understanding that could develop between the different stakeholders on the project.

3.2 Findings and discussion from the interviews

The focus of the interviews was to identify the current perception of LPS, CP and CW including drivers and barriers. The interview findings are presented and discussed in the next section.

3.2.1 Current industrial perception of Last Planner System and collaborative planning in the UK

Figure 3 reveals the current perception of LPS and CP among construction professionals in the UK. 100% of the respondents agreed that collaborative planning (CP) is the commonly used name for Last Planner System (LPS) in the UK construction industry. Different reasons were given for the use of the term CP as a substitute for LPS in the UK. 40% of the respondents interviewed, mainly lean construction consultants, stated that the term CP was adopted due to the trademark on the LPS which could restrict its usage. One of the consultants interviewed stated that:

*"We cannot use the term freely because of the Lean Construction Institute trademark on it, this will also make it difficult to use especially on complex projects with many stakeholders". (**Consultant**)*

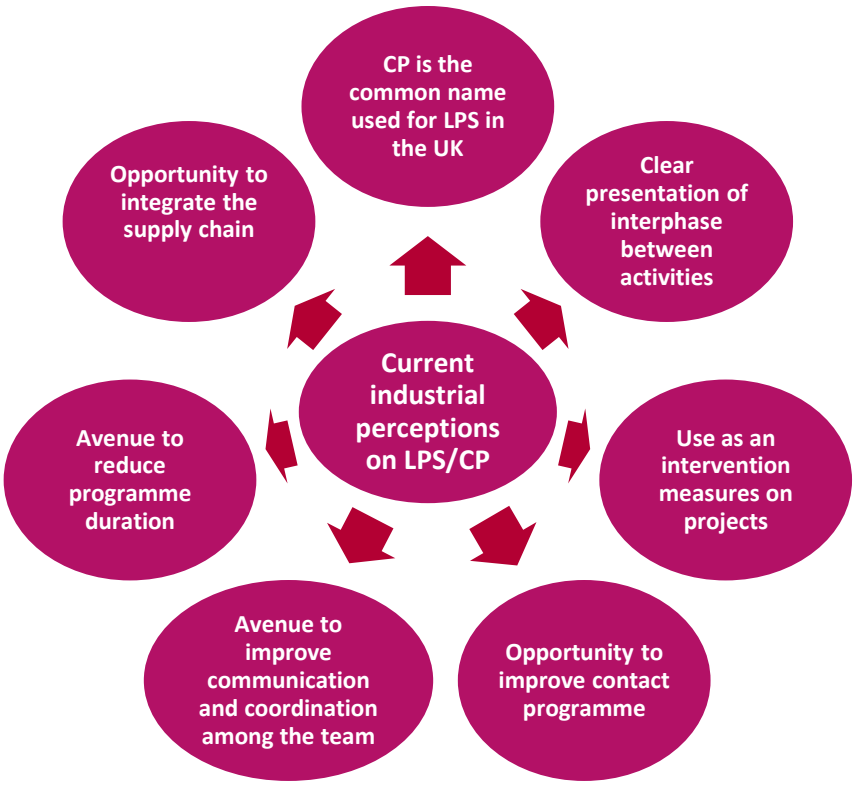

Figure 5: Current industrial perception of CP

As observed by the consultant, the term LPS cannot be used freely for commercial purposes such as consultancy and coaching, as approval must be received from the LCI before any such use (LCI, 2015; Mossman, 2014). It can be argued that the push for the use of the term

CP in the UK construction industry instead of the LPS is coming from the consultants and not the supply chain in the construction industry. This is strategically done to protect their business interest. However, for non-commercial use such as implementation in company businesses, it is allowed by LCI (LCI, 2015; Mossman, 2014). It is worth stating that the trademark on the LPS only limits the commercial use of it as indicated on the Lean Construction Institute website (LCI, 2015). This implies LPS can be used by construction organisations in managing projects although further restriction has been imposed by an EU registered trademark this does not seem to significantly change this position.

Other respondents opined that CP is easier to use with the supply chain as it is self-explanatory. 80% of the respondents interviewed acknowledge the fact that CP as used by practitioners in the UK construction industry is based on the LPS developed by Glenn Ballard and Gregory Howell. However, as revealed by the evaluation and survey results, it is still only partially implemented. Furthermore, the construction industry practitioners interviewed perceived that CP provides opportunity to understand the interface between construction activities while also helping with the integration of the supply chain.

One of the subcontractors interviewed stated that: *"the CP process allows us to see the work load clearly and well enough".* While one of the clients interviewed stated that "*the CP/LPS process to us is an integration forum for our supply chain."*

This usually occurs during the collaborative programming or phase scheduling meeting where all major the stakeholders on the project meet to agree on the logic between activities and the development of synergy with other stakeholders on the project. However the LPS does not stop at the collaborative programming or phase scheduling stage alone, rather it continues through to Look-ahead Planning, Make Ready, Weekly Work Planning meeting, Evaluation and Learning (Mossman, 2014; Ballard, 2000) which lead to increased certainty of delivery. The majority of the consultants, contractors and clients interviewed however, perceived that the CP process is principally an opportunity for programme and task duration reduction. One of the consultants stated that:

"We usually achieved significant reduction in programme after the CP process".

Although the CP process could lead to reduction in construction programme, that is not the focus of the LPS. Holding on to such view by the consultants could defeat the goal of the LPS. The goal of the LPS is to develop a reliable and predictable construction programme through the CP process and not just to achieve programme reduction (Dave *et al*, 2015; Ballard *et al*, 2007; Ballard, 2000). This suggests that the CP process could also lead to increase in duration of construction programme but that programme will be reliable and predictable reflecting the likely optimum duration of the project. All the consultants, client, and contractors interviewed agreed that CP is currently used as an intervention measure on projects. However there are plans to expand the current use as intervention measure in some quarters. For example, one client said *"our initial goal is to use it as an intervention measure on projects but we hope to use it across all our business now".* Again, this suggests that there are early benefits (so called low hanging fruit) from the implementation effort at the project level, thus motivating the organisation to implement it across its business.

3.2.2 Current drivers for the implementation of CP on HA projects

Figure 4 indicates the current drivers of CP implementation. The analysis of the interview revealed that 80% of the respondents agreed that the demand for its use by the client stands as the core driver for the use of CP on projects. 60% agreed the combination of client demand and the internal drive for continuous improvement by the organisation are the drivers for the implementation of the CP on their projects. Only 20% of the respondents,

mainly contractors indicated it was part of their internal process of driving the continuous process improvement. These findings suggest that clients still remain the major influence in driving the implementation of the CP in construction. According to Ballard *et al*, (2007) client and owner's demand, and desire for a better way of working are among the major drivers for implementing CP in construction. This finding is further supported by an earlier assertion by Ogunbiyi, (2014) where it was observed that regularly procuring clients are constantly seeking innovative ways of delivering projects with better performance. However, with 60% of the respondents indicating internal desires for continuous process improvement as a driver implies that main contractors could also drive the process.

Figure 6: Current drivers for CP implementation

Furthermore contractors and subcontractors opined that the quest for good working relationships and the simplification of the Primavera and Gantt programme during the collaborative programming meeting are major drivers. Some of the contractors interviewed stated that:

"The primavera and Gantt chart programme is so unfriendly to us, it needs simplification, the CP process makes it simpler"; "the level of conversations between the supply chain with the primavera and Gantt Chart programme is low, collaborative programming session improves the conversation."

From the above statements it can be argued that the desire to develop a common understanding of the project goal and process by all the team on the project is among a major driver for the use of CP in construction. The need for developing common understanding among stakeholders on construction projects has been discussed extensively in Pasquire, (2012). Also, project complexity was considered among the drivers for the implementation of CP in construction. One of the main contractors said:

"How could we have managed this complex project well without the LPS/CP process?"

This shows the role CP plays in delivering the project. It can be argued that the more complex a project seems to be, the more appropriate the use of the LPS is as postulated by Ballard.

3.2.3 Current barriers to CP implementation on HA projects

Figure 5 reveals some of the current barriers to CP implementation on HA projects. 100% of the respondents identified cultural issues as the major barrier to CP implementations on the project. This finding is contrary to previous studies such as Daniel *et al*, 2015a; Porwal *et al*, 2010 where lack of training was identified as the topmost barrier. The cultural issues identified occur both at the project and organisational levels. One of the cultural issues that occurs both at the project and organisational levels is "*resistance to change".* All the respondents interviewed identified it as a major barrier at the project phase and in the organisation implementing the process. Here are some transcripts from the respondents:

"They like doing it their own way, people are too busy they go into firefighting approach". ***(Consultant***)

"Changing the way people work is very challenging. It is difficult to embrace all the tools. We only do the high level planning. The site people are too busy to do all the bits." ***(Contractor)***

"The guys doing the job for 30 years will always ask; why do you want me to do it differently?" ***(Consultant)***

The above statements present an overview of the resistance to the new way of working in the UK highway sector. Although this finding may not be necessarily new, it shows how deep rooted the cultural issues affecting the implementation of the CP in UK construction are. For instance, Johansen and Porter, (2003) identified cultural and structural issues as barriers to the implementation of the LPS in the UK construction industry. Also, the geographical dispersion of projects was identified as a barrier to CP in the UK. The effect of the dispersion of projects is that the supply chain cannot be maintained effectively from one project to another. This is not least because some subcontractors are unwilling to move from their present location to another due to the challenge of acquiring the right labour.

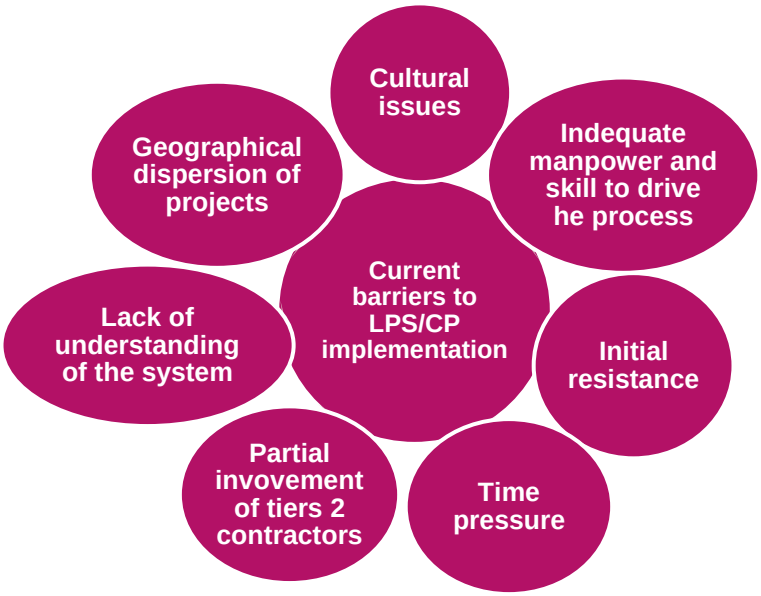

Figure 7: Barriers to LPS and CP implementation on HA projects

The study also reveals that the tier 2 suppliers are only partially involved in the CP implementation process – this was also a finding from the project observations and in the interviews conducted. Some tier 2 subcontractor interviewed (formally and informally), stated that are not fully involved in all the CP process by the tier 1 contractors. Another barrier is time pressure. Many participants in the CP process feel it is time consuming. One of the consultants interviewed stated that:

"People believe they don't have the time to do it" **(Consultant)**

Again, these findings show that the major barriers to CP implementation are around people and not process or technology.

3.3 Current construction industry perception of collaborative working

To understand the perception of industry professionals of collaborative working (CW), the respondents were asked to provide the meaning of collaborative working, its practice and barriers.

3.3.1 Collaborative working meaning

Here are some of the meanings of collaborative working from the respondents:

"It is an integrated working approach. It enables the team to visualise where they are heading to. It gives all the team on the project the focus or target of the project. Collaborative working is different from cooperation as cooperation does not have a defined rule like CW." ***(Project manager and Lean improvement manager)***

"I guess CW is to all help each other to achieve a specific goal, but cooperation is not as strong as CW." ***(Operation Director).***

A common theme from the above meanings of CW is that there is specific goal or target which the entire stakeholders must be working towards. This suggests that in any CW arrangement, each party is working to achieve the goal of the project not an individual organisation's interest. According to Xue *et al*, (2010) Collaborative working is concerned with the joint working of all stakeholders on the construction project, to efficiently and effectively deliver the project to the specified standard.

3.3.2 Collaborative working practice

Some of the collaborative working practices identified by the respondents include, *having face to face meetings; having regular working group meetings; clear project plans and transparent reporting*. The above practices show the need for continual conversations in order for a CW relationship to develop on a project. All the above mentioned practices are directly embedded in the LPS. This implies that LPS has the potential to develop CW relationships among stakeholders on the construction project. However, to achieve the practice on a project, commitment and discipline is required on the part of the stakeholders on the project.

3.3.3 Barriers to collaborative working

The major barriers to CW identified by the respondents are *lack of trust* and *traditional procurement.* The description of these barriers to CW is clearly captured by one respondent as quoted below:

"Lack of trust is the key barrier to CW, we must be willing to share our expertise freely with all. If there is competition, CW will not function effectively. Also traditional procurement is a blocker."

These findings further emphasise the need for using a procurement approach that supports collaborative working. For example, under the traditional procurement, some contractors base their profit on the claim that could arise during the construction of the project. This will undoubtedly thwart the development of collaborative relationships on the project. Although the LPS works well on any project, most of the projects where it has been implemented used some form of collaborative procurement (Fernandez-silo *et al*, 2012; Drysdale, 2013; Ballard *et al*, 2007).

3.4 Conclusions from the snapshot review

The aim of the study is to provide a snapshot of the current industrial perception of LPS, CP and CW on HA projects, including drivers and barriers. The study shows that construction practitioners largely believe that CP is based on the LPS of production control developed by Ballard and Howell in 199 and that collaborative planning (CP) is the common name used for the Last Planner System. The major arguments for the common use of the term CP instead of the LPS are due to the trademark on the LPS and the ease with which the supply chain can understand the purpose of the CP process from its name. However, the information on the LCI website indicate that the term LPS could be used freely by people or organisations for non-commercial purposes.

The study went further to establish that some of the current practices of CP on the HA projects observed align with the LPS production planning and control principles identified in the literature. Specifically, collaborative programming/phase planning, WWP meetings and the measurement of PPC[3] were done extensively on most of the projects observed. This shows that the HA and its supply chain have developed over this time in their continuous construction process improvement effort. Furthermore, the full and continuous implementation of these elements on most of the projects observed shows the extent of the benefits realised from the implementation process. This includes developing collaborative relationships and building a synergy among project stakeholders for better performance. As a result it is proposed that the HA and its supply chain could build on these to reap more benefits from the LPS.

Also the study shows that practices such the Make Ready Process, Look-Ahead planning, consideration for work flow, and acting on reasons for non-completion of tasks among others were only partially observed in the current CP practice. It is worth noting that these elements are vital to the development of the production planning system in any organisation. One of these elements is the Make Ready Process that focuses on ensuring flow in production process by the development of a workable backlog of sound activities before their placement in the production phase. Failure to achieve this can be detrimental to the production line as planned task cannot be achieved no matter the level of detail because the necessary conditions are lacking.

Although, the study reveals that PPC and RNC were recorded on the projects observed, it is concerning that no deep and systematic actions were observed to address the (RNC) recorded on any of the five projects. Furthermore, the recorded RNC, and PPC are not made accessible to the supply chain on all projects. Recording reasons for non-completion of tasks without an appropriate and formal mechanism to address them not only amounts to waste of time and resources from a lean perspective, but also hinders the continuous process improvement and learning opportunities that deliver certainty and are an intended outcome. The purpose of metrics such as PPC and RNC in the LPS of production control are to enable

[3] HA uses Percentage *Planned* Complete whereas LPS uses Percentage *Promised* Complete

the project team to learn from breakdowns (problems and failures) in order to improve performance and productivity. The lack of formal communication of performance metrics to the supply chain will not only hinder the development of a common understanding of project goals, but will also limit their ability to commitment (promise) to tasks planned.

The study revealed that the current perception of CP by HA construction practitioners is that the process is beneficial to all the stakeholders on the project and not just the client alone. Specifically, the process allows all the stakeholders to have a clear picture of the project goals and objectives, define the workload for subcontractors, and see the interrelationship between different tasks on the programme. This has not only improved the level of engagement among the project stakeholders, but has also enhanced the performance of each team on the project reducing the overall programme of work.

The study established that the demand for the use of CP by clients, internal desire for continuous process improvement by organisations, and project complexity are among the current drivers for the implementation of CP. This implies that the use of CP is not due to the demand by the HA alone, but also due to the internal desire for continuous process improvement and for better performance. The internal drive for continuous improvement within the supply chain suggests that developments in current CP initiatives by the HA will not only be embraced by the high tier contractors, but could also be driven down the supply chain.

The study shows culture is the major barrier to CP implementation in the UK highway sector. It shows up both at the project and organisational level in the form of resistance to change from the old way of working. Due to this resistance by the construction team on site, CP elements were only partially implemented on some of the projects observed. This implies that in implementing CP in the highway sector, it would be advantageous to devote effort to training of the employees both at the project and organisational level on the new way of working and not just on tools and methods alone. Furthermore, the study reveals that absence of trust and lack of feedback could limit the collaborative working relationship among construction project stakeholders. A better conceptualisation of the differences between planning and promising would help to overcome these problems.

In conclusion, this scoping study has revealed that the current practice of CP is based on the LPS of production control. This shows the potential of LPS to develop collaborative relationships among project stakeholders; however some elements of the LPS are yet to be fully explored or implemented at the project level due to cultural barriers. The level of engagement could be stepped up to include customers involved in the management of the asset (maintenance, operations and so on).

4.0 Review of Findings and New Research Proposal

Based on the findings, the following recommendations are made for the Highway Agency and its supply chain to enable the next level of benefit from CP implementation to be achieved.

4.1 Recommendations at project level

- The implementation should be extended to include the full range of LPS elements and not be limited to collaborative programming or phase scheduling alone. This will increase the benefit that can be realised.
- The Make Ready Process with full consideration for flow conditions, and the development of a workable backlog should be incorporated in the Look-Ahead

planning. It is important that the role of the workable backlog and the requirement to only release sound work into production is fully understood.

- Mechanisms should be created to link the weekly Look-Ahead meeting with the other daily meetings in order to realise more from the collaborative process
- Beyond the recording of the RNC, a formal and consistent mechanism for taking action to address the identified RNC should be developed preferably incorporating root cause analysis and error proofing.
- The use of standard and stable processes will enable better responses to RNC and greatly aid the development of better processes (new standards) and error proofing solutions
- Key metrics such as PPC, RNC and other performance indicators should be published and made accessible to all stakeholders on the project for increased engagement.
- The tier 1 contractors should do more to fully engage tier 2 and 3 contractors in the collaborative production process
- Tier 2 and 3 contractors should be given more access to the Visual Management board
- Tier 2 & 3 contractors should be involved in and drive the identification and removal of constraints from activities to facilitate *Promising* as opposed to *Planning*.
- Consideration should be given to the creation of a "Big Room" with a standard layout for wider adoption of visual management along with standard work and information/understanding of flow on linear sites.

4.2 Recommendation for the Highways Agency and Tier 1 suppliers

- The HA should maintain the present drive for the implementation of LPS/CP in the UK highway sector but should include a revision of the training syllabus to highlight the difference between LPS and CP. Standardisation of the implementation approaches by CP practitioners across the HA is desirable to remove relearning/resetting of Tier 2 & 3 sub-contractors as they move from project to project.
- Knowledge transfer of standardised approaches across the supply chain from one project to another should be developed in order create a more sustainable change environment. This development and training should be extended to lower tier contractors.
- In selecting the supply chain, due consideration should be given to contractors who can collaborate effectively or develop the appropriate collaboration skills.
- The inclusion of LPS and collaborative working practices should be clearly stated and communicated across the supply chain and the Agency.
- A mechanism to survey to the lower tier supply chain on each project should be developed to evaluate the level of engagement in the LPS processes.
- Training on change management should be organised especially at the project level for the supply chain to help minimise cultural barriers.
- The tier 1 contractors should engage with tier 2 and 3 contractors early for better integration and engagement
- The HA should motivate tier 2 and 3 suppliers through free training on LPS and provision of incentives where necessary based on performance.

4.3 Recommendations for further research

- Further detailed study is needed to measure the benefit realised from the implementation of LPS and/or CP in terms of time, cost, quality, safety, rework, disputes and claims, and level of engagement among others using case study. This should be based on a proven scientific approach.

- Future study should investigate collaborative working relationship enablers and commitment indicators to support better and more rapid implementation of LPS/CP.
- Study into effective commitment/promising mechanisms to grow trust and certainty is required. This will enable projects to pull on the appropriate expertise and leadership to complete projects as planned (time, cost and quality)

This further work is needed in order to provide a stable platform for the step change development to project production needed to meet the high demands about to be placed on the SRN. These recommendations are formulated into a further research proposal with the intention of submitting this to the Innovate UK call for Collaborative and Integrated Supply Chains (closing date 22 April 2015

4.4 Outline proposal for next research project – see attached template.

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