Implementing Touchplan/LPS at WPA: Empirical findings

WORK PACKAGE 2 REPORT

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Executive Summary

Infrastructure projects are complex, constantly evolving, task-based endeavours. As a result, the construction sector has been constantly searching for appropriate technology as enabler to improve project performance. To increase predictable schedule performance and planning efficiency, the Western Programme Alliance (WPA) that include construction company McConnel Dowell, introduced the Last Planner System (LPS), together with the digital planning tool Touchplan®. This work package (WP) builds on the previous work package, which provides a systematic literature review of LPS with principles, methods, impacts, implementation challenges, and critical success factors.

The primary objective of WP2 is to understand how WPA rolled out LPS practice in their trial projects (i.e., Cherry Street and CLU) and thus learn the lessons and best practices for future roll-out. It also states the case for LPS becoming standard (best) practice across the industry supply chain for more collaborative and reliable production control of projects. Specifically, the following goals have been pursued:

(1) The status quo of LPS implementation at WPA projects.
(2) What are the benefits and challenges in terms of LPS implementation?
(3) What are the critical success factors of implementing LPS?
(4) To provide recommendations for better future roll-out.

Based on a mix of qualitative and quantitative research techniques including surveys, interviews, and site visits, extensive empirical evidence has been triangulated to achieve the research goals. The findings show that the introduction of LPS is welcomed, supported, and liked by most of the last planners and end-users of Touchplan, although there was resistance in the beginning. The nature of LPS and features of Touchplan are articulated among the project teams. They are drawn by the high degree of visibility, collaboration, tracking, interface management, among other features of Touchplan.

The findings also show that the top benefits (via questionnaire survey) that LPS brings are primarily associated with process improvement and social benefits. This includes (1) improved planning transparency, (2) improved communication and coordination between project participants, (3) increased awareness of task dependencies, (4) improved collaboration and cooperation between project participants, and (5) improved planning and control reliability. The interview results highlight benefits to business Key Performance Indicators (KPI), and several last planners acknowledged the roll-out of LPS/Touchplan had positive and direct impact on schedules, cost, OHS, and quality performance. The extent of its impact has yet to be quantified at this stage. Achieving effective adoption of LPS entails the application of critical

prerequires: (1) a champion, (2) continuous organisational support, (3) buy-in from last planners, (4) team effort, and (5) correct decisions using appropriate tools such as Touchplan.

The research also noted a few challenges in introducing LPS, including those top-ranked during the survey: (1) little understanding and support from supply chain partners, (2) marginal understanding and support from the broader construction industry and other stakeholders, (3) lack of consideration of resource levelling when making plans in Touchplan, and (4) staff turnover. Additionally, limitations of Touchplan also emerged from the interviews: (1) lack of situational awareness in Touchplan, (2) prone to human error, (3) limitation for occupation, (4) difficulty in updating and tracking, (5) hard to forego the use of whiteboards. Caution should be exercised, however, as such limitations were voiced primarily by the CLU team and were not an issue in Cherry Street.

Overall, the combined data collected presents strong evidence that the introduction of LPS via Touchplan has clearly been a success. To initiate a better roll-out, this study also makes the following recommendations, details of which can be found in Chapter 5.

- requires a great deal of effort to set up and prepare for a project to be LPS ready;
- training and skills development;
- grow together with the subcontractors;
- robust structure for communication and conversation to be in place;
- systematic implementation of LPS is desired;
- continue to invest in the "digitalising" the construction process;
- "COLLABORATIVE PLANNING" as a clause in the contract.

We are hopeful that more benefits from LPS are expected in future rollouts, and that there will be a compelling case for further adoption by the Australian infrastructure industry.

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Abbreviations and acronyms

ARU	Aviation Road Upgrade
CHS	Cherry Street
CLU	Cranbourne Line Upgrade
COS	Conditions of Satisfaction
CSF	Critical Success Factors
CPM	Critical Path Method
EOT	Extension of Time
FES	Ferguson Street
KPI	Key Performance Indicator
LPS	Last Planner System
LXRP	Level Crossing Removal Program
MDR	Mount Derrimut Road
MRP	Make-Ready Plan
OGR	Old Geelong Road
PDCA	Plan Do Check Act
DCAP	Detect Correct Analyse Prevent
PPC	Percent Plan Complete
UOM	University of Melbourne
WBS	Work Breakdown Structure
WES	Werribee
WPA	Western Programme Alliance
WP	Work Package

1. Introduction

Following the Work Package 1 report, which extensively reviewed the Last Planner® System (LPS) practices, the research team established the following objectives for the research project (see Appendix 1 – Work package 2):

(1) Understand the status quo of LPS adoption in two WPA projects; namely, Cherry Street (CHS), and the Cranbourne Line Upgrade (CLU).

(2) Explore the benefits and disadvantages of implementing LPS.

(3) Understand the critical success factors of implementing LPS.

(4) Propose strategies for better roll-out.

The research team then charted a path in pursuit of these objectives that could advance LPS roll-out. The results and recommendations included in this report are based on the cross-analysis of multiple data sources, including a WPA-wide survey with 43 usable results, 21 interviews with project members involved with the Cherry Street and CLU projects, and subject-matter and LPS practitioners from overseas (USA, Norway, Republic of Ireland, and India).

Any improvement in roll-out starts with understanding the status quo. This research provides a clear account of how LPS was adopted on two WPA projects. A clear understanding of the current situation provided the process with transparency. Several implementation gaps were thus identified. We have provided both strategic insights and actionable information that can help close the gap in terms of implementation. The research team is also investigating the benefits and challenges of implementing LPS in WPA projects. These are comprehensively surveyed, and the impact of schedule, cost, safety, quality, and behaviours were again discussed during the interviews. Lastly, the research team further explore the drivers and critical success factors, with a focus on support and roll-out strategies, drawing on the experience and perceptions of interviewees. This eventually resulted in the recommendations to guide practitioners toward reaching the next level of implementation.

The present report is composed of six chapters organised as follows:

- Chapter 2 outlines the research methodology. Two main techniques had been selected, questionnaire survey and interviews.
- Chapter 3 reports the findings from the questionnaire survey. Questionnaire survey only evaluated the perceived benefits and perceived challenges of applying LPS across WPA projects.

- Chapter 4 provides in-depth details of LPS implementation at WPA together with a wide range of issues being discussed, including critical success factors, support, areas for improvement, and roll-out strategies collectively from the interviewees.
- Chapter 5 puts forward a series of recommendations.
- Chapter 6 draws the conclusion and calls for additional improvement and refinement within WPA and as an industry in collaborative planning.

2. Methodology

2.1 Overview

The research effort follows a four-step process:

(1)   Systematic literature review.

(2)   Survey of the industry.

(3)   Interviews.

(4)   Workshops.

2.2 Questionnaire Survey

A questionnaire survey (see Appendix 2) targeted at employees of WPA was conducted during September to November 2021 with a total of 75 responses recorded on the Qualtrics survey application. The response rate was very encouraging following invitation emails sent out by the Innovation and Continuous Improvement Manager, Phil Hendy. This was followed by reminder emails on Mondays every fortnight. The weekly response rate for the questionnaire survey is as shown in Figure 1 below. From this sample of 75 responses, only 43 responses were valid meaning that there were sufficient data in the survey for processing. The remaining 32 responses were disregarded due to missing information such as respondent's role, project involvement and number of years of experience.
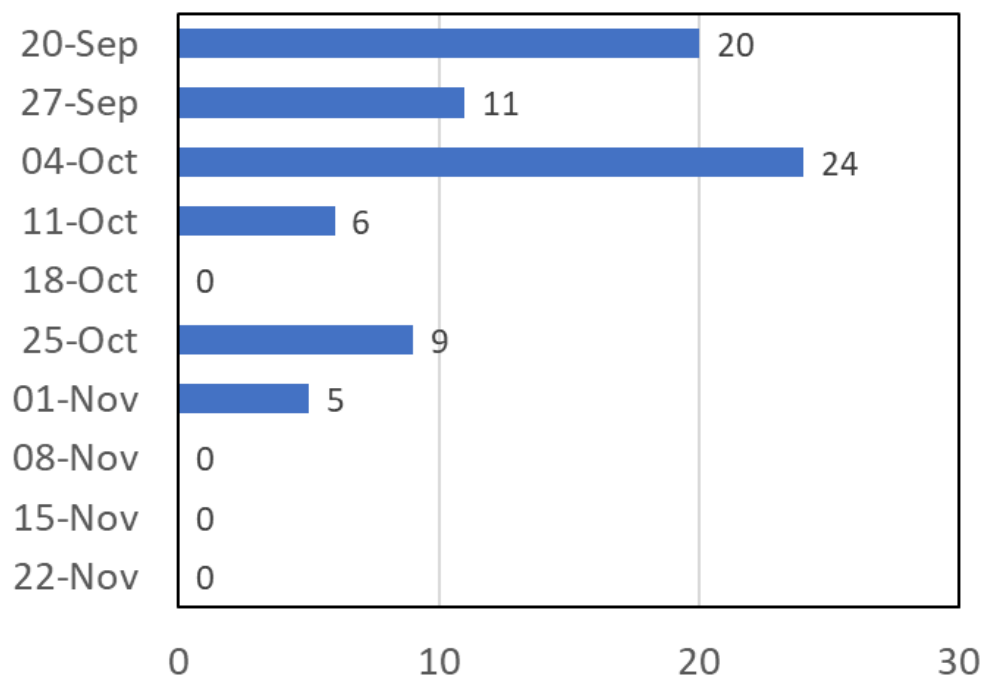
Figure 1: Responses to questionnaire survey recorded each week

The respondents reported a mean industry experience of 10.47 years of which 9.9 years were spent working on planning and scheduling activities. Figure 2 illustrates the distribution of

number of years of experience in industry, experience in planning and experience with LPS, respectively. These respondents exhibited a broad range of experiences in the construction industry. The LPS was a relatively new concept as nearly all respondents reported less than 5 years of experience with it. If one respondent who reported 30 years of experience with LPS is disregarded, the average number of years of experience is 1.3 years which coincides with the introduction of the LPS by WPA.
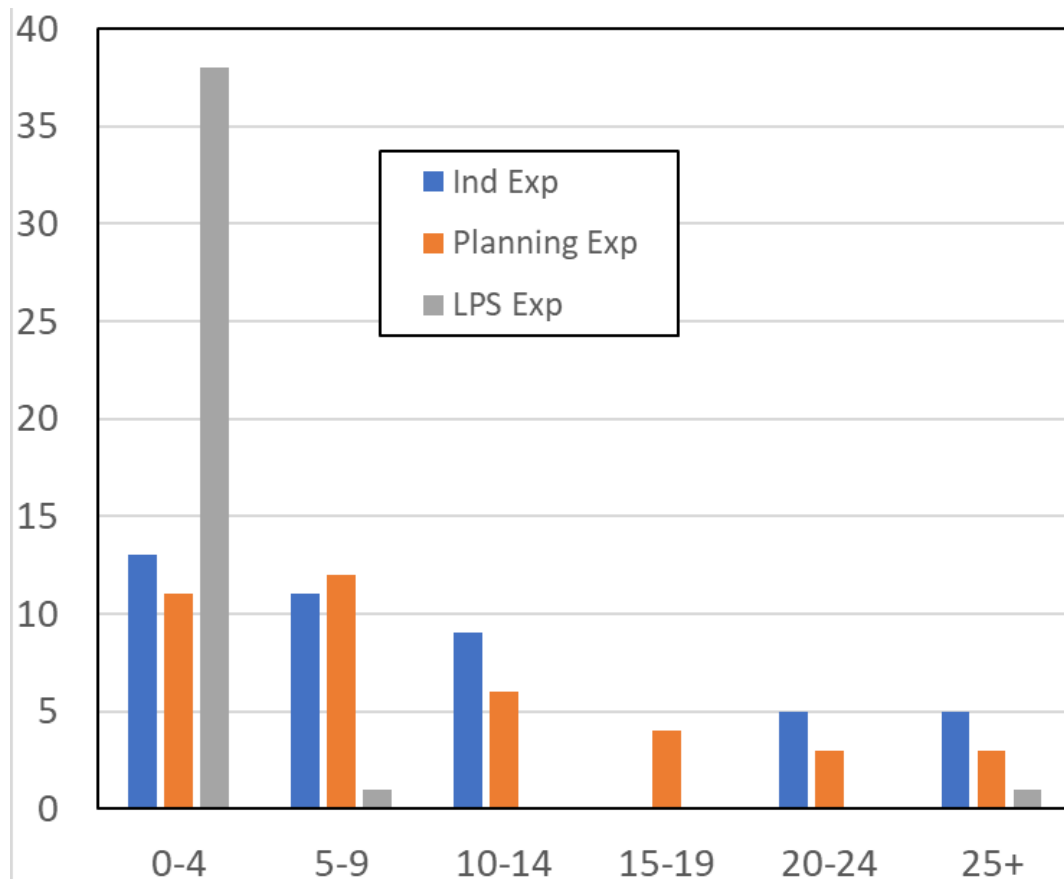
Figure 2: Number of years of experience of respondents

The respondents were requested to identify the projects they were involved in. This resulted in 7 locations including Old Geelong Road (OGR), Cranbourne Line Upgrade (CLU), Ferguson Street (FES), Werribee (WES), Aviation Road Upgrade (AVR), Cherry Street Upgrade (CHS) and Mount Derrimut Road (MDR). A total of 16 respondents were involved with CLU followed by ten at FES, 8 at MDR and 7 at both CHS and OGR. Note that these respondents may have reported their existing locations rather than the location where they spent most of their time using the LPS. Details of the location of these respondents are shown in Figure 3.
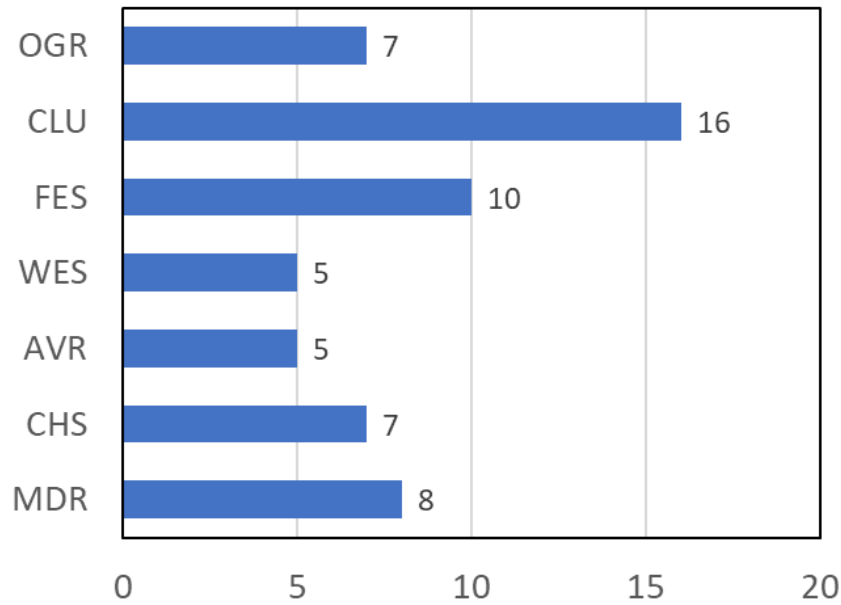
Figure 3: Projects sites of respondents

The respondents were further characterised by their roles as engineers, coordinators, superintendents, planners, or managers as shown in Figure 4 to discern their perception of LPS implementation benefits and challenges. Unfortunately, the sample of respondents only included one coordinator, one superintendent and one planner which will did not allow any meaningful analyses of their responses. With a total of 8 managers and 35 non-managers, it was potentially worthwhile separating their responses to establish their different perceptions of the LPS implementation.
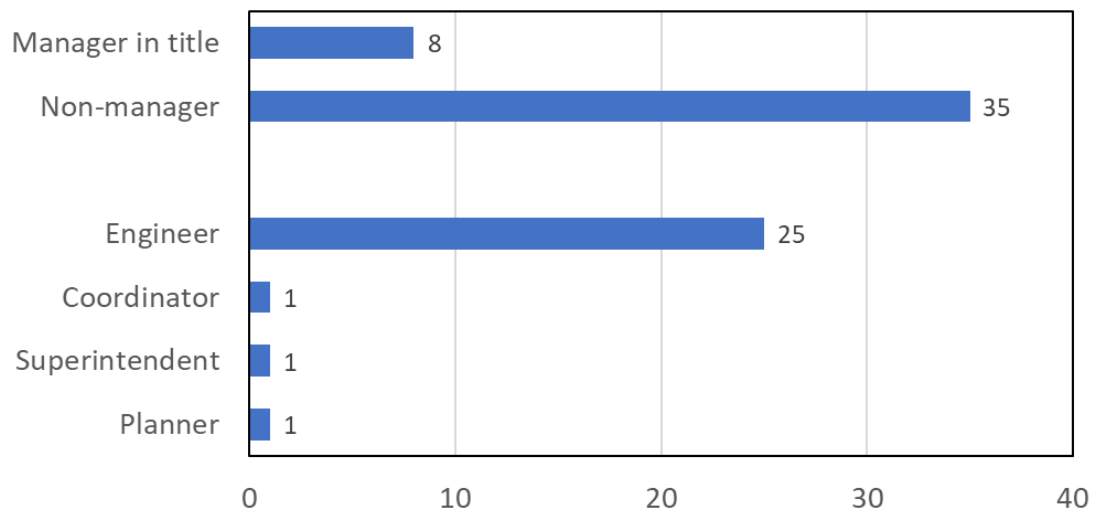
Figure 4: Distribution of roles and responsibilities of respondents

2.3 Overview of the interviewees

The research team interviewed 21 end users of Touchplan (Touchplan), 19 of whom were from two WPA projects: CHS and CLU (see Table 1). Each interview lasted approximately 60 minutes. Five interviews were conducted in person, the remainder online through Microsoft Teams. Details of the interview questions and interview process are presented in Appendix 3.

The interviewees had combined experience of 211 years. The most experienced interviewee had 21 years of experience, the least, 1 year, and an average was about 10 years. Most interviewees were engineers (9 out of 21), including project engineers, site engineers, and junior engineers. Five supervisors, three superintendents and two construction managers took part in the interviews. From a hierarchical point of view, one superintendent manages supervisors, and two project engineers report to the construction manager. The description of their roles and responsibilities can be found in Appendix 4. As Table 1 shows, the interviewees represented a group of individuals who were likely to have a good perspective on the adoption of LPS/Touchplan, as the majority were the end users of Touchplan. The interview results are presented in Chapter 4.

Table 1: interviewee demographics

No.	Name	WPA Project	Code	Job	Experience		
					Con	WPA	Touchplan
CHERRY STREET (CHS)							
1	Jason Harm	CHS	CHS1	Superintendent	21	4	8
2	Andrew Burke	CHS	CHS2	Project Engineer	10	1	1
3	Leo Jin	CHS	CHS3	Senior Project Engineer	10	1	1
4	Carlo Pettinau	CHS	CHS4	Senior Supervisor	20	1	1
5	Danny Lai	CHS	CHS5	Project Engineer	7.5	2.5	2.5
6	Liam Drever	CHS /AVR	CHS6	Project Engineer	5.5	2.5	1.5
7	Rosemary Rice	CHS	CHS7	Construction Manager	12	4	-
8	Saeed Joneidi	CHS /FER	CHS8	Project Engineer	8	3	3
Cranbourne Line Upgrade (CLU)							
1	*Steve Nouwens	CLU	CLU1	Construction Manager	18	2	1
2	Adam Aladin	CLU	CLU2	Junior Engineer	1	1	1
3	Marina Oliveira	CLU	CLU3	Engineer	7	1	1
4	Taehyun Ha	CLU	CLU4	Site Engineer	2	1	1

No.	Name	WPA Project	Code	Job	Experience		
					Con	WPA	Touchplan
5	Anthony Panayotides	CLU	CLU5	Site Engineer	4	4	1
6	Patrik Jariwala	CLU	CLU6	Project Engineer	2	6	2
7	David Trenh	CLU	CLU7	Junior Engineer	1	3	1
8	Joshua Touhey	CLU	CLU8	Supervisor	12	1.2	1.2
9	*Tory Barker	CLU	CLU9	Supervisor	10	1.5	1.5
10	*Steven Jopson	CLU	CLU10	Plant Supervisor	20	1.5	1.5
11	*Robert Crumpen	CLU	CLU11	Lead Superintendent	20	4	-
OTHERS							
1	Shane Denahy	AVR/FES	OTH1	Superintendent-Station	20	1	1
2	*Glenn Sutton	AVR2	OTH2	Supervisor	20	1.5	1.5

Note: CHS = Cherry street; CLU = Cranbourne Line Upgrade. AVR = Aviation Road; FES = Ferguson Street. Touchplan = Touchplan.

*denotes these interviews were conducted face to face, whereas the rest were conducted via Teams.

3. Survey Findings

3.1 Benefits of LPS

We identified a total of 43 potential benefits of implementing the LPS from a review of literature and professional reports. These were then classified into 12 themes which include Client, Cost, Design, OHS, Planning and Control, Productivity, Quality, Resource, Social, Sustainability, Time, and Workflow. Respondents were requested to rate the applicability of each benefit on a five-point Likert scale where 1-Strongly disagree, 2-Disagree, 3-Neutral, 4-Agree and 5-Strongly agree.

Taking the entire sample of 43 valid responses, the highest ranked benefits were mostly in the Planning and Control theme with 'improved planning transparency', 'increased awareness of task dependencies' and 'improved planning and control reliability' ranked in the top 5. These benefits were scored above 4.0 indicating that respondents either Agreed or Strongly agreed with these statements. Other statements in the Planning and Control theme which were ranked highly were 'Improve planning quality', 'Improve visualization and visibility of project data', 'Improved ability to manage complex project in a complex environment', 'Facilitate identification and elimination of constraints', and 'Resolve schedule problems effectively'. The next higher rank theme was Social which included 'improved communication and coordination between project participants' and 'improved collaboration and cooperation between project participants' ranked in the top 5. Two additional benefits in the Social theme, 'Improve accountability of project participants' and 'Better leadership of management team' were also highly ranked. The full ranking of these benefits is tabulated in Table 2.

Respondents did not agree with several benefits such as:
- 'reduce project duration',
- 'enable late selection of design alternatives', and
- 'reduce inventory on site'.

These were the only 3 items that received a score below 3.0 which indicated that the respondents disagreed with these statements.

Other themes that were marginally above a score of 3.0 were those pertaining to cost, OHS performance, quality, and sustainability. These were broadly viewed as neutral reflecting a minimal impact from the implementation of the LPS.

Table 2: Themes and ranking of benefits of the LPS

Themes	Overall	Mean	Var	Rank
Client	Facilitate the achievement of project targets	3.700	1.045	20
Client	Improve client satisfaction	3.472	0.828	25
Cost	Improve cost performance	3.056	0.740	39
Design	Integrated with design schedule and allow better understanding of design	3.188	1.319	36
Design	Enable late selection of design alternatives	2.871	0.649	42
OHS	Improve OHS performance	3.097	1.290	38
PlanCont	Improve planning transparency	4.351	0.734	1
PlanCont	Increased awareness of tasks dependencies	4.194	0.561	3
PlanCont	Improved planning and control reliability	4.135	0.787	5
PlanCont	Improve planning quality	4.054	0.886	6
PlanCont	Improve visualization and visibility of project data (PPC, causes of variance, etc.)	3.968	0.899	8
PlanCont	Improved ability to manage complex project in a complex environment	3.839	1.140	11
PlanCont	Facilitate identification and elimination of constraints	3.794	1.320	14
PlanCont	Resolve schedule problems effectively	3.781	1.015	15
PlanCont	Easy to obtain schedule information	3.710	1.346	18
PlanCont	Decentralized decision-making process	3.690	0.936	21
PlanCont	Improve learning process	3.548	0.989	22
PlanCont	Reduce unplanned work	3.500	1.226	23
PlanCont	Better response to unplanned events	3.424	1.189	27
PlanCont	Improve Percent Plan Complete (PPC) performance	3.273	0.955	32
PlanCont	Increased supplier and subcontractor commitment	3.214	0.841	34
PlanCont	Shorter meeting duration than traditional projects	3.172	2.005	37
Productivity	Increase productivity	3.324	0.892	29
Quality	Improve work quality leading to less rework	3.054	1.164	40
Resource	Better control of work in congested area	4.000	1.067	7
Resource	Reduce inventory on site	2.935	1.062	41
Social	Improved communication and coordination between project participants	4.294	1.002	2
Social	Improve collaboration and cooperation between project participants	4.147	1.220	4
Social	Improve accountability of project participants	3.935	0.862	9
Social	Better leadership of management team	3.839	0.873	11
Social	Improve trust level between project participants	3.735	1.231	17
Social	Improve social interaction	3.500	1.167	23
Social	Reduces self-interest behaviour of subcontractors	3.355	1.237	28
Sustainability	Enable sustainability and environmental advantages	3.207	0.813	35
Time	Meet schedule performance	3.750	0.879	16
Time	Reducing effects of time-related risk factors	3.452	0.923	26
Time	Support and improve identification of root causes of delay	3.324	1.256	29
Time	Decrease in expected time overrun values	3.310	0.650	31
Time	Reduce time buffer	3.222	0.921	33
Time	Reduce project duration	2.861	0.694	43
Workflow	Improved project effectiveness	3.892	0.766	10
Workflow	Improve information flows	3.824	1.059	13
Workflow	Improve workflow	3.706	0.941	19

3.2 Characterisation of Benefits by project

An examination of the top 5 benefits across six project sites indicate that the respondents were generally in agreement. Improved planning transparency was either the top or second ranked benefit for all projects closely followed by improved communication and coordination. Several interesting observations are:

1) the joint first ranked benefit of 'improved visualisation' at OGR, FES and AVR;
2) the high rank for 'improved information flows' at CHS;
3) the high rank of 'meet schedule performance' in WES, and
4) the high rank of 'decentralised decision-making process' at FES and WES.

Normalised scores for the benefits across all 6 projects are plotted in Figure 5. Three projects, CHS, CLU and OGR were evidently scored higher than the other three projects, AVR, FES and WES. Surprisingly, the WES project was given a score of less than 3.0 indicating that many of the respondents did not observe the benefits described in the survey.
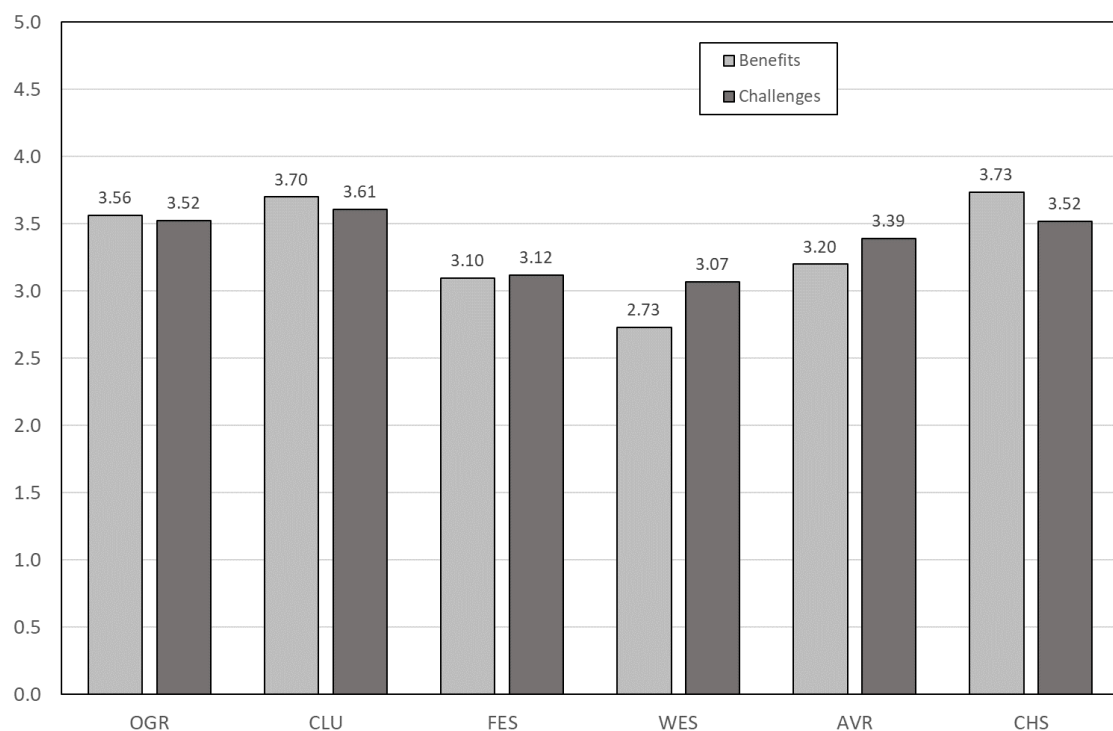
Figure 5: Scores for benefits and challenges across six projects

Table 3: Ranking of benefits by project

Theme	Benefit	Rank (OA)	OGR (7)	CLU (11)	FES (7)	WES (4)	AVR (5)	CHS (7)
PlanCont	Improve planning transparency	1	1	4	2	2	1	1
Social	Improved communication and coordination between project participants	2	3	1	5	4	6	4
PlanCont	Increased awareness of tasks dependencies	3	3	12	1	1	1	7
Social	Improve collaboration and cooperation between project participants	4	6	3	5	8	6	2
PlanCont	Improved planning and control reliability	5	8	2	4	3	4	4
PlanCont	Improve planning quality	6	3	7	11	7	4	11
Resource	Better control of work in congested area	7	8	5	14	10	10	3
PlanCont	Improve visualization and visibility of project data (PPC, causes of variance, etc.)	8	1	12	2	8	1	19
Social	Improve accountability of project participants	9	14	8	14	10	10	12
Workflow	Improved project effectiveness	10	14	6	11	10	14	21
Social	Better leadership of management team	11	6	10	20	10	23	22
PlanCont	Improved ability to manage complex project in a complex environment	11	11	8	9	10	10	7
Workflow	Improve information flows	13	11	30	14	10	16	4
PlanCont	Facilitate identification and elimination of constraints	14	22	18	5	18	10	12
PlanCont	Resolve schedule problems effectively	15	14	19	14	18	23	7
Time	Meet schedule performance	16	19	28	11	4	14	12
Social	Improve trust level between project participants	17	34	10	20	30	16	18
PlanCont	Easy to obtain schedule information	18	14	23	9	10	23	7
Workflow	Improve workflow	19	19	14	14	18	23	12
Client	Facilitate the achievement of project targets	20	19	20	26	39	35	34
PlanCont	Decentralized decision-making process	21	11	21	5	4	6	12

3.3 Characterisation of Benefits by manager vs non-managers

There are minor differences in the views of the managers compared to non-managers in the survey. Essentially, managers rated 'improved communications and coordination' as the top benefit while non-managers chose 'improved planning transparency'. Another benefit, 'improved planning and control reliability' was ranked second by the manager group whereas it was ranked fifth by the non-manager group. These minor differences highlight the distinct perspectives of the managers who are more concerned with 'communications and coordination', 'collaboration and cooperation' and 'planning and control reliability' in their project management teams. Operational staff are evidently more concerned with the free flow or sharing of information hence the top rank of 'planning transparency' in the survey.

Table 4: Ranking of benefits by managers and non-managers

Theme	Benefit	Managers (7)	Non Managers (30)
Social	Improved comms and coordination	1	2
PlanCont	Improved planning and control reliability	2	5
Social	Improve collaboration and cooperation	2	4
PlanCont	Improve planning quality	4	6
PlanCont	Improve planning transparency	4	1
PlanCont	Increased awareness of tasks dependencies	4	3

The normalised benefit scores for managers and non-managers were 3.782 and 3.528, respectively, indicating that the manager group were generally more convinced of these benefits compared to the non-manager group. A further analysis into the differences in their quantification of benefits led to only one statistically significant item. Managers were more optimistic about improving cost performance of projects with a Likert score of 3.9 (Agree) whereas the non-manager group recorded a score of 3.03 (Neutral).

3.4 Challenges of LPS

The literature listed a total of 33 potential challenges for the implementation of the LPS. To present these challenges in a positive light, the survey questions were posed as either potential improvements or additional benefits that could be obtained if improvements were formulated. These challenges were then classified into 5 themes which include Client and stakeholders, Communications, Last Planner System, and Organisation. Respondents were requested to rate the applicability of each potential improvement or additional benefit on a five-point Likert scale where 1-Strongly disagree, 2-Disagree, 3-Neutral, 4-Agree and 5-Strongly agree.

From a challenge perspective, the lowest ranked items were in the Client and stakeholder, Communication and LPS themes. In particular, the respondents pointed out that there was

little support from supply chain partners, marginal support from broader construction industry and other stakeholders. In the communications theme, while respondents felt that it was easy to communicate and collaborate, and that promises were transparent, areas of improvements could be found in the duration of meetings, the effort in planning using the LPS, the integration of late entrants such as subcontractors, and the consideration given to design inputs. From the implementation of LPS, statements were marginally positive included the ease of implementation, the estimation of extensions of time, a consistent approach to task breakdown, resource levelling, staff turnover, the running of pull planning meetings and monitoring progress during weekly meetings.

Several dimensions of the LPS and Organisation themes reported high beneficial scores indicating that these were properly implemented and consequently did not pose any challenges. These included the willingness and support of participants to implement LPS, their ability to resolve conflicts, and monitor the implementation, the ability to identify and analyse constraints, discuss committed tasks, and learn from variances. In the Organisational theme, respondents agreed that there was a continuous improvement culture in the organisation followed by adequate training and appropriate leadership in the implementation of LPS. Details of the mean scores for these challenges are tabulated in Table 5 below.

Table 5: Themes and ranking of challenges of the LPS

Themes	Overall	Mean	Rank
Client & S/h	There is support from the broader industry for implementing LPS	3.200	27
Client & S/h	There is support from other stakeholders or parties to implement LPS	3.233	24
Client & S/h	There is support from integrating supply chain partners or companies into LPS	2.889	33
Client & S/h	We can easily adapt to changes in project scope with the LPS	3.793	8
Comms	We find it easy to communicate with team members using LPS	3.871	6
Comms	We find it easy to collaborate with the members from other organisations using LPS	3.567	15
Comms	We find it easy to manage the late entrants (i.e., subcontractors) in using LPS	3.310	20
Comms	The plans and promises are transparent to all project participants	3.774	9
Comms	We have shorter meeting durations when using the LPS	3.267	23

Comms	We now spend less effort planning when using the LPS	3.033	32
Comms	We utilise the same standard planning procedures/guideline for all LPS projects	3.200	27
Comms	We consider design inputs in planning and control with the LPS	3.133	29
Comms	We review weekly PPC	3.536	16
LasTouchplanlan	I have a good understanding and knowledge of LPS for planning and control	3.742	11
LasTouchplanlan	I find it easy to implement LPS in large and complex projects	3.387	19
LasTouchplanlan	We are comfortable with the commitment process (e.g., committing to the completion of tasks) in weekly plans	3.867	7
LasTouchplanlan	I am willing to adopt LPS in this and future projects	4.000	2
LPS	I support the implementation of LPS	3.935	4
LPS	We can resolve schedule conflicts using LPS	3.935	4
LPS	We can quantify delays or estimate an Extension of Time (EOT) based on the LPS	3.233	24
LPS	We adopt a consistent approach to break down tasks	3.300	22
LPS	It is easy to monitor the process of LPS implementation	3.700	12
LPS	We consider resource levelling when making plans in the Touchplan	3.067	30
LPS	We have low staff turnover	3.037	31
LPS	We successfully run pull planning meetings	3.214	26
LPS	We identify and analyse constraints in our lookahead plan meetings	3.621	14
LPS	We monitor resources during weekly planning meetings	3.310	20
LPS	We discuss/negotiate on committed tasks in weekly planning meetings	4.000	2
LPS	We find the information recording processes in Touchplan to be useful	3.690	13
LPS	We review and learn from variances to committed tasks in our daily construction meetings	3.759	10
Organisation	There is appropriate LPS leadership in our organisation	3.500	18
Organisation	I have been provided with adequate training for LPS	3.516	17
Organisation	There is continuous improvement culture in our organisation	4.032	1

3.5 Characterisation of Challenges by project

An examination of the top 3 challenges across six project sites indicate that the respondents were generally in agreement. Their concerns were the support from supply chain, the effort in planning, and staff turnover. Two interesting concerns at the AVR project that were not mentioned at the other project sites were that 'information recording processes were useful' and 'review and learn from variances'. The list of concerns is listed in Table 6 below.

Normalised scores across all 6 projects were plotted previously in Figure 6 together with the benefits. The results for additional benefits were largely like the benefits where three projects, CHS, CLU and OGR were scored higher indicating that there were less concerns. The WES project was given a score of marginally above 3.0 indicating that the respondents were largely neutral for many of the statement.

Table 6: Ranking of challenges by project

Themes	Challenges	Rank (OA)	OGR (7)	CLU (11)	FES (7)	WES (4)	AVR (5)	CHS (7)
Client & S/h	Support from integrating supply chain	1	3	3	1	1	2	1
Comms	Less effort planning	2	3	4	5	1	3	3
LPS	Low staff turnover	3	3	5	1	1	1	1
LPS	Resource levelling	4	3	18	3	6	26	8
Comms	Design inputs in planning	5	8	2	10	6	3	8
Client & S/h	Support from the broader industry	6	1	14	5	6	9	3
Comms	Standard planning procedures/guideline	6	9	12	5	15	9	3
LPS	Successfully run pull planning meetings	8	1	15	14	15	3	16
Client & S/h	Support from other stakeholders	9	3	8	14	15	3	3
LPS	Quantify delays or estimate EOT	9	9	6	14	15	31	25
Comms	Shorter meeting durations	11	19	6	5	1	17	8
LPS	Consistent approach to break down tasks	12	30	13	3	6	9	19
Comms	Easy to manage the late entrants	13	9	15	10	6	9	3
LPS	Monitor resources during weekly meetings	13	24	20	10	1	26	8
LasTouchplanlan	Easy to implement LPS in large projects	15	19	10	5	15	17	8
Organisation	Appropriate LPS leadership	16	14	8	18	23	17	8
Organisation	Provided with adequate training	17	19	1	23	25	17	19
Comms	Review weekly PPC	18	13	22	10	23	16	16

Comms	Easy to collaborate with others	19	14	24	18	15	9	25
LPS	Identify and analyse constraints	20	24	15	29	29	25	25
LPS	Information recording processes useful	21	14	26	17	25	3	16
LPS	Easy to monitor implementation	22	19	23	23	29	17	19
LasTouchplanlan	Good understanding and knowledge	23	14	10	29	25	17	8
LPS	Review and learn from variances	24	9	26	23	25	3	19

3.6 Characterisation of Challenges by manager vs non-managers

There are obvious differences in the views of the managers compared to non-managers for these challenges (See Table 7). Both groups agreed that support from the supply chain and staff turnover were top concerns, but the non-managers felt that 'planning effort', 'design inputs' and 'delays and estimating EOTs' were of greater concern. Again, these differences indicate that operation staff were more concerned with the effort involved in the implementation of a relative new planning initiative.

An analysis of the differences in manager and non-manager responses highlighted only one statistically significant item. Managers reported that they were able to quantify delays or assess extensions of time using the LPS whereas the non-managers were ambivalent. This is likely due to the different perspective and understanding of this planning tool between these two roles.

Table 7: Ranking of challenges or additional benefits by managers and non-managers

Themes	Benefits	Manager (7)	Non-Manager (30)
Client & S/h	Support from integrating supply chain	1	1
LPS	Resource levelling	1	6
LPS	Low staff turnover	3	5
LPS	Successfully run pull planning meetings	3	13
Client & S/h	Support from the broader industry	5	9
Client & S/h	Support from other stakeholders	5	11
LPS	Identify and analyse constraints	5	23
LPS	Monitor resources during weekly meetings	5	14
LPS	Review and learn from variances	5	12
LasTouchplanlan	Easy to implement LPS in large projects	9	15
Comms	Less effort planning	9	2
Comms	Standard planning procedures/guideline	9	7
Comms	Review weekly PPC	9	19
LasTouchplanlan	Good understanding and knowledge	13	26

Organisation	Appropriate LPS leadership	13	18
LPS	Consistent approach to break down tasks	13	11
LPS	Easy to monitor implementation	13	24
Comms	Shorter meeting durations	13	9
Organisation	Provided with adequate training	18	17
Comms	Design inputs in planning	18	3
Comms	Easy to communicate with team	20	28
Comms	Easy to manage the late entrants	20	8
Comms	Promises are transparent to all	20	25
LPS	Information recording processes useful	20	20
LPS	Willing to adopt LPS	24	31
LPS	Quantify delays or estimate EOT	24	4

3.7 Summary of Findings

The highest ranked benefits for LPS were either in the Planning and Control, or Social themes.

The top five were:

1) improved planning transparency,
2) improved communication and coordination between project participants
3) increased awareness of task dependencies,
4) improve collaboration and cooperation between project participants, and
5) improved planning and control reliability.

All five of these benefits were scored above 4.0 indicating that respondents either Agreed or Strongly Agreed with these statements. This finding provides clear evidence of the contribution of the LPS to improved project planning and control, and the increased interactions between project participants. Managers were generally more optimistic about the benefits of the LPS implementation compared to the non-managers.

The survey also found evidence of strong leadership in the implementation of LPS in the organisation, the provision of adequate training, leading many respondents agreeing that they have a good understanding and knowledge of LPS for planning and control. Many respondents support the implementation of LPS and are willing to adopt this planning tool in their current and future projects.

Other supplementary advantages such as reduced project durations, reduced inventory, or enabling late changes to design were rated below 3.0 and evidently not supported by these respondents.

The survey also identified only two challenges to the implementation of the LPS. The most obvious was the lack of support from supply chain partners and the additional planning effort

required to implement this new planning tool. Many other factors were rated close to neutral indicating that these were neither beneficial nor constraints. These include factors such as staff turnover, integration of design inputs, support from industry or other stakeholders.

4. Interview findings

4.1 Introduction

Interviews were one of the principal data collection efforts of this research. This chapter presents a summary of the interviews, discusses the findings in more detail, and presents key observations. The goal of this chapter is to highlight what has been done well and what need to be addressed for future implementation. It is also designed to support managers as they make decisions about what needs to be maintained and/or improved on their journey towards mature collaborative planning development.

4.2 General understandings of LPS and the reasons for introducing it

4.2.1 Understanding of LPS

The interview began with the opening question of "What is your understanding of LPS?" Most interviewees acknowledged that they were either not aware of LPS or had very limited understanding of it (CHS2). However, there were a couple of interviewees who demonstrated excellent understanding of the concept. Not surprisingly, these interviewees were in "managerial" roles at the project site. Responses include:

*"LPS is managed through **a tiered approach**. With long-term planning with the planner and the main construction leaders, the emphasis is moved from planner–program to **worker–supervisors**."*
—Jason Harms (CHS1)

"LPS is to take the planning down to the last person who's involved in it."
—Rosemary Rice (CHS7)

One interviewee described himself as not knowing LPS but understanding what Lean Construction is. He noted that *"Touchplan is helping to implementing LPS."* Therefore, for the benefit of interviewees, we avoided the use of "LPS" and used "Touchplan" instead, which they were more familiar with.

All interviewees provided their perceptions of Touchplan (see Appendix 5 for more information), and some key features of Touchplan were revealed (see Table 8). The features commented on the most were visualisation, tracking and interactive features.

Table 8: Features of Touchplan from interviewees' perspectives

Features	Comments made by interviewees
Visualisation	"A digital version of a whiteboard" – CHS4 A visualisation tool to help with planning day-to-day activities on-site – CLU6 "A virtual whiteboard that moves the previous, physical whiteboard online, replacing the traditional, daily meeting with a whiteboard in the supervisor's office" – CLU8
Connectivity	"With Touchplan, connecting all the info needed from site and in resources" – CLU3
Flow of activities	"Global flow of activities leading into the key outcomes for the project" – CHS6
Tracking	"Using that for benchmarking and tracking" – CLU1 "Easy to track progress" – CLU2 "A tool that allows us to track what work is going on on-site and what resources are needed, and making sure that work progresses as planned" – CLU4 "The system will warn you about a clash when activities are not completed" – CLU11
Interactive	"Be able to see the interaction with/between multiple work activities and also if there are any issues related to access, environment or safety" – CHS8 "When it comes to planning construction activity, it is used as an interactive tool between site team and supervisors/management." – CLU7 "Ability to coordinate large teams when projects split over a few locations, and individual teams can plan independently" – CLU1 "An interactive way of looking at the next few weeks of work" – CLU2
Forum	"A collaborative forum through which the team can work through and look at things that need to be done" – CHS6
Making plan efficient	"A great planning system moving forward and more efficient with planning" – CHS4 "A better way to do planning, and I welcome it" – OTH1
Commitment	"Making commitments about what to run, what is going to be done, and when" – CLU1
Planning tool	"A comprehensive tool for planning – CHS8 "Good software/tool for daily and short-term planning" – CLU2 "A visualisation tool to …" – CLU6 "An innovative tool" – CLU7 "Company system; a new technology" – OTH1 "It is a planning system. Plan day-by-day and week-by-week" – CLU11 "Touchplan really is purely just for us to program works. And so, everyone within a broad spectrum can see what's going on. But any other of high-level meetings outside of that don't happen in Touchplan."

Visualisation. Compared to the traditional Gantt-styled planning system, Touchplan has improved the visualisation of short-term planning, the daily tasks in particular: the digital tickets developed by Last Planner visualise the sequence, tasks, duration, interfaces, etc., which makes planning transparent and Last Planner more accountable. Interestingly, two interviewees described Touchplan as the virtual/digital version of a whiteboard.

Tracking. From a high-level perspective, the tracking features were greatly appreciated by senior personnel (e.g. CLU1 and CHS7). However, at the ground level, several engineers pointed out challenges in tracking and updating (see section 4.6.5 – Limitations). As CLU11 noted, "*it is too easy to fudge the old planning system (e.g. whiteboard), whereas you can lock things in Touchplan*". When tasks (in tickets) are locked, it becomes a good starting point for tracking, and it can be easily traced back to historical activities (CHS7).

Interactive. It is encouraging to see that interviewees were highly aware of the interactive features of LPS/Touchplan. As a collaborative planning system, Last Planner aims to promote collaboration among team members; hence, interaction is a priority.

Commitment. Another key feature of LPS is the ability of Last Planner to make commitments in the tickets (tasks) they develop. However, the "commitment" feature was not well reflected among interviewees. As many interviewees pointed out, it is a comprehensive tool for planning, good software for daily to short-term planning, etc., but without a strong commitment in tasks, the team will not see an improvement in planning reliability. This explains the loose use of PPC at the CLU site, as PPC is a key measurement of LPS measuring the level of commitment to plans.

Other observations
- Awareness of LPS at Cherry Street is generally higher than in CLU. Almost all the CLU interviewees acknowledged that they were not aware of LPS.
- Knowledge of LPS/Touchplan in the "leadership" team is greater than in the engineer team. (The understanding of LPS varies from senior project members to engineers.)
- There is a lack of a unified understanding of LPS.

4.2.2 Drivers

We also sought interviewees' perceptions of the possible reasons why LPS/Touchplan were introduced (driver). Overall, the most frequently noted drivers include "visibility of Touchplan", "interactive collaborative approach", "quest for efficient approach", and "interface planning".

- The "visibility" and "collaborative" feature of Touchplan which emerged from interviewees' understanding of LPS have also been acknowledged as the top drivers.

- Interface planning was not mentioned in the earlier section, but a few good comments on interface, such as "Identifies clashes or slippages or whatever it ends up being early enough to allow for big plans to adjust" (CHS1); "Introduced for interface planning" (CLU8), indicate the previous system lacked this feature.

- From CLU, four interviewees mentioned "resource management tool" as being a unique driver, citing "Improve the resource and making resources and activities available to everyone", "Good for resources booking", etc.

- Quest for efficient approach also came up as a top reason for LPS adoption. CLU11 summarised it well: "introduced Touchplan for efficiency, cut the meeting shorter, gave a historical record for planning and put in targets and key milestones"
    - "The planning instead of the old-fashioned way is trying to be creative with different technologies to move forward, being more efficient in planning." – CHS4
    - "It was more about using Touchplan to replace what was just a whiteboard and an administrative type thing on-site to be a much better system."– CHS7
    - "Change a lot onsite so better use as day-to-day tool" – CHS7

- Push from the up level was mentioned by two interviewees, but they also noted that "This system works for the project, which is the reason for continuous implementation"

4.2.3 Recommendations

From Table 8, a few key features of Touchplan were acknowledged: visualisation, tracking, and interactive feature. However, "commitment" and "flow of activities", both key features of LPS, were appreciated only by very few interviewees, indicating interviewees still lacked understanding of LPS methodology. Given that the understanding of LPS among interviewees varies, the research team recommend the following practices to raise awareness of LPS/collaborative planning within projects.

1) The differences between LPS and Touchplan should be explained. A **workshop** on LPS would be valuable to prepare the project with basic understanding of LPS

principles and methods. This should be followed by training to onboard the team with Touchplan.

2) We suggest including a few classic readings of LPS in their training/induction package.

3) During the LPS workshop/Touchplan training, demonstrate the Touchplan features to the project team.

4) There are able "Last Planners" in each project who demonstrated extraordinary understanding of and commitment to this collaborative planning system, who should be assigned as local "champions" to teach team members.

4.3 LPS/Touchplan: implementation at Cherry Street

4.3.1 Introduction

Touchplan was introduced at the start of the project, brought in by Continuous Improvement and Innovation Manager, Phil Hendy. Many interviewees indicated that when they joined, implementation was already in place, and continued to use it. The project team is open to the use of LPS/Touchplan, and Touchplan has become the main planning tool on-site (CHS1). Nevertheless, not everybody is onboard with how LPS/Touchplan works and how it should work, and "*we expect it to evolve into a hybrid version.*"

4.3.2 Master Plan

When. The master plan was initially settled at the tender stage (CHS5). The team would have a meeting about the latest version of the program and check the changes (CHS7).

Who, and their responsibilities. According to CHS1 and CHS5, the attendees are mainly the superintendent, the company planner, the construction manager and the senior project engineers (SPEs).

- The planner provided the client with an update either fortnightly or monthly, based on a discussion among site staff and the ouTouchplanut from Touchplan (CHS7).
- Engineers have obligations to liaise with the planners and work on team progress with respect to the master program for the project (CHS6). They discuss scope of work with subcontractors and bring the information for further discussion in master plan meetings (CHS5).
- Subcontractors are not involved at this stage. However, in the form of separate consultation, the engineers will get in touch with subcontractors to gain an overview of the work and set everything up (CHS1&5).

Main activities. In the master planning meeting, the team talked about how to progress towards milestones, or whether the program was running early or late (CHS7). In CHS1's words, "*the team would work out the milestones, key phases, and activities, which match with the critical path program in P6*". CHS5 noted that the focus is on the deadline, from which milestones are determined. CHS5 continued with an example: "*use occupations as the deadlines that are required to be met, including CSR cut over, beam lift and level crossing removal.*" The master plan was available to all project teams, except it was saved in the drive and did not print out (CHS5).

4.3.3 Phase Planning

When. There were no separate phase plans in the project (CHS7). Phase planning was done in the master program meeting, as the master program indicated what the phases and milestones were. The program was not too complex to have the next level down (CHS7). CHS5 pointed out that phase planning was running only in early stages once a month, and that there would be more if there were changes in the methodology and/or plan (CHS5).

Who. The superintendent oversaw the phase planning meeting. The attendees were mainly the same as in the master plan meeting (CHS1&5). Generally, no subcontractors were involved in the phase meeting (CHS5). However, one interviewee (CHS1) acknowledged that subcontractors may be brought in if relevant.

Main activities. The phase planning session is also seen as a detailed planning stage: *Pull from milestones and breakdown these phases further into process but will not go into too much detail* (CHS1&5). According to CHS1, individual teams looked after certain *packages* and set their *own phase plan*, if it could be aligned with milestones. Participants went through what the individual team needed to do to accomplish a milestone and then set tasks together in the phase plan, along with the means required and the estimated time required to complete the tasks.

- **Time.** Did not consider time buffer; only thought what could be actually achieved (CHS1); would add contingency to activities if necessary (CHS5).
- **Milestones.** No flexibility to change milestone activities at this stage due to rail network, but with flexibility to accommodate change (CHS1&5).
- **Whiteboard.** Used whiteboards and stickies instead of Touchplan to visualize some of these sequences and durations (CHS5). As CHS2 explained, Touchplan was used more at a short-term level, so the phase plan level was implemented only to a limited amount.
- **Update.** Project engineers would also provide relevant project information, and the company planner would update the plan in P6 (CHS5).

Information

- basic understanding of what the team need for the activity (CHS1);
- discussion on duration and process of the activities (CHS5);

- discussion on resource management (CHS1); Project engineers ran the resource discussion to see what resources are required and the higher-level management team made the decision (CHS5);

- discussion on productivity resourcing and what's going to be done before the activities and after (CHS5);

- information experience-based or referenced from previous projects (CHS5).

4.3.4 Look-ahead planning (make ready)

According to CHS1, the look-ahead plan was developed using a "*pull planning*" approach. To be more specific, the team started to look at work activities and work backwards (*which could be either planning forward or backwards*) from a fixed milestone. The purpose of look-ahead planning was:

- to define a higher level of detail, including the key or main activities required to achieve the desired outcome (CHS2);

- to get everyone to look at the master program, talk to their subcontractors and supervisors, and put tickets in Touchplan with respect to the details of what was coming up in the next six weeks. The team were required to map out any constraints and milestones and interdependencies between those activities and use Touchplan to facilitate the mapping out of the plan and any changes required (CHS7).

PE reviewed the master program and pulled out the key things that needed to happen in the next of six weeks and grouped them into activities that could last a few weeks long (start before the meeting) (CHS6).

- **Work breakdown (WBS).** The engineer would consider duration of work and split it into shifts (CHS1). Most of the activities would be segregated into a day's work (e.g., piling, earthwork, drainage). This is better for reporting, as a small breakdown can show in detail how many promised works have been done (CHS6).

- **Crew size.** The engineer would assess the crew size and check if the program was still on track (CHS1).

- **Interface.** Engineers should be able to see who needs to do what and by when to achieve the overall program goals (CHS6).

- **Duration.** Would put accurate duration of activities into the plan by anticipating the duration with productivity rates and quantities. Sometimes might add some contingency, but not always (CHS8).

- **Sequence.** Identify <u>relationships</u> among activities through <u>discussion in the meeting</u>, start to link activities across the team (CHS6); the <u>Linking Function</u> in Touchplan was used at times to set predecessors and successors (CHS2).
- **Milestone.** Would use the same key dates of milestones for different activities (CHS4); regularly use milestones to identify any key dates or constraints (CHS2).

When, how long, and look-ahead window. It is supposed to be a fortnightly meeting (CHS6), which is in line with the WPA's onboard LPS guide. However, CHS1 mentioned it was run *as needed* and had become part of the weekly meeting. The meeting lasts for no more than an hour, and usually around 30 minutes. CHS3 noted that the look-ahead plan is for his own use, so there was no separate meeting and no collaboration with other teams and subcontractors. His team went through each item on the two-week look-ahead program, and everyone in the team contributed. Two interviewees (CHS6/7) noted that the look-ahead window was six weeks, and two (CHS1/4) acknowledged two weeks to a month, depending on the work.

Who. There was a consensus that the make-ready meeting was for the construction team only. A few interviewees also mentioned that the team would also involve relevant subcontractors and others who were delivering the works (CHS1/CHS8). However, CHS2 indicated there were no foreman or subbies, and CHS7 echoed that they initially tried to pass it to the subcontractors and extend the invitation to major subcontractors for planning the work. Three interviewees noted that relevant subbies were involved, or that initially, at least, they were informed. It was unclear who chairs the session. The superintendent (CHS1) and supervisor were in charge of the meeting and went through the make-ready plan, whereas the construction manager (CHS7) also claimed she chaired the session.

Constraint Identification and Resolution. At Cherry Street, according to the interviewees, a standard constraint analysis and resolution process is established and utilised. This means that should constraints be identified, the team would review options to either mitigate or remove them (CHS2). The constraint function was used in Touchplan to record constraints identified through weekly discussion in the meeting as progress towards it (CHS7). This function might not be being used as intended (CHS6).
- *Constraint tickets.* If implemented correctly, constraints would be included in Touchplan in the form of constraint tickets; however, such identification could also be accomplished using a whiteboard when going through the daily sessions. On the tickets, information includes what kind of constraints there are, who is responsible for them, and the by which they should be resolved (CHS7).

- *Conversation*. The constraint function was not used in Touchplan or discussed formally, but conversations existed without records (CHS1).
- *Frequency*. To resolve constraints, there would be a discussion week by week for a start, followed by a daily discussion approaching the start date (CHS7).
- *Escalation.* The escalation process is in place to manage constraints at site level through the PIO system (CHS1).
- *PIO*. The constraint ID process is conducted in conjunction with PIO, where a great number of constraints and issues are being identified (CHS1). If they seriously impact the work, constraints ended up on the PIO board, which needed to be addressed immediately or elevated to a higher level of management to be resolved (CHS8).
- *Unresolved*. Constraints might not be fully resolved before entering the weekly plan (CHS2), but the team identified and planned for a path forward (CHS1).

Typical constraints identified might include:

- approvals and documentation (e.g., methods and safety measures signed off by the clients)
- interdependent work (CHS7)
- constraints related to work schedules (CHS8)
- requirements for further design information (CHS2)
- approvals for of ongoing work (CHS2).

There was one comment from CHS6, who mentioned that "*constraint … sometimes may be set as milestones (i.e., start of occupation, permission to disturb the track*)." Constraints and milestones are two different things. Constraints are a limitation or restriction that prevents an activity or set of activities (i.e., milestone) taking place.

VMC. The VMC meeting was scheduled for Monday at 9 a.m. on either a weekly or fortnightly basis (CHS6), allowing the team to discuss the program (CHS3). It will not go into details of what the team were going to do or what has been achieved so far. It is more like a presentation, often one PPT slide to highlight the progress on-site, so it is not actually a line-by-line planning meeting (CHS3). The VMC meeting also helps to flesh out what problems have been encountered, what constraints have been encountered, and what options there may be.

4.3.5 Weekly Planning

Friday Commitment Meeting. Scheduled on Fridays at 2 p.m. The meeting is chaired by the superintendent and attended by the entire site team (CHS7), including subcontractors

(CHS2/CHS7). They are asked to comment on tickets. If anything has changed, they are also informed in the meeting (CHS5). Subcontractor participation is to ensure that information is as accurate as possible. Also, supervisors work closely with subcontractors (CHS6). As CHS 1 noted, Friday's meeting is for pressing the "promise now" button in Touchplan, which results from engineers' preparation during the week to ensure the next week's plan is ready. During the meeting, the team discusses everyone's tickets, and the superintendent gathers all the information to identify clashes and resolve them. Also discussed are constraints, resources, and restrictions (CHS5).

The superintendent presses the promise-now button (CHS5 and CHS7). The commitment session provides an opportunity for

- analysis to ensure that teams that might have planned independently during the week do not have any interfaces or issues (CHS2)
- checking if the team are still on track with the plan (CHS1)
- providing input to the planner if there is data the planner cannot obtain from Touchplan (CHS6).

There are still some **challenges:**

- The team does not always fully buy-in, so the plan reflected in Touchplan may not be as accurate as it might be (CHS2).
- There may be many tickets that were either ignored, skipped over, or rescheduled later dates, so it became difficult to purely analyse the data. Rescheduling might not be updated in Touchplan (CHS2).

Requirement on the activities

- Try to restrict activities to a day or two at a time so people cannot play around with the durations. The team would try to restrict activities to no longer than a week (CHS7).
- Make sure that larger activities in the six-week look-ahead plan are split down into days or delivered as key scope, deliverables, and packages at work (CHS6).
- This particular interviewee would undertake to sit down with the supervisor and work on it together to break down activities (CHS6).
- The team would gain a better understanding of constraints, potential activities or events that have been planned for. Ensure everything planned will happen during the next week and make that commitment (CHS6).
- To solve interfaces, the engineers would ensure activities involving the critical path of the program took place before others (CHS8).

Criteria required to hit the promise button. Below is a summary of what criteria will be checked against the ticket before hitting the promise me button.

- The next week's activities are ready to go (CHS1).
- All the *prerequisites* are in place. Check resources, constraints, traffic management plan, permits, and safety to make sure they are good to go (CHS8).
- All the *resources* are ready with no constraints (Inaccurate crew size is not a problem; Touchplan is task based) (CHS5).
- *Confidence* in promising, because everyone had to promise what work was going to be done the next week. A lot of conversation, both formally and informally, was triggered to make sure the commitment is realistic. There is relatively high confidence that everyone is on the same page before sitting down in the weekly meeting (CHS6).
- People were *confident* of the promise because the whole team made collaborative commitment to it. People would raise issues for group resolution if needed (CHS7).

4.3.6 Daily coordination meeting

The daily coordination meeting is sharp and efficient, lasting 5–30 minutes to half of an hour (CHS2/3). Run in face to face during construction, chaired by superintendent (CHS3).

- Engineers oversaw daily plans. The construction manager or superintendent presents the daily plan and makes sure the task is completed (CHS8).
- Daily sessions mainly discuss the sequence of work (CHS8).
- Site coordination, reviewing Touchplan and looking at upcoming activities and what activities have been achieved on each shift (CHS2).
- Go through tickets daily, and go through today's, tomorrow's and the day after tomorrow's activities, but generally focus on what happens the next day (CHS3).
- At 2 p.m. daily, confirm activities for the day and the following day. Also, confirm what resources are needed and what deliveries are coming in (CHS7).
- Breakdown of six-week look-ahead plan to a more granular level in daily sessions, which does not necessarily need to be done in the meeting (done by engineers, supervisors, or a combination of both) (CHS6).

4.3.7 PPC, variance and learning

Percent plan complete (PPC)

At Cherry Street, the PPC target was set at 80% (CHS5). PPC was initially low but improved (CHS5), with average PPC sustained close to the target at 70–80% (CHS1). CHS6 also

commented that the initial PPC data was not accurate, mainly because people added incorrect data, and that better alignment with the work was achieved after improvements were made to the process.

- According to CHS6, PPC will be reviewed but not necessarily during the weekly session. Touchplan reporting in weekly VMC sessions.
- The superintendent presents the matrix every week in the weekly plan meeting (which only focuses only on two weeks at a time).

However, there were two interviewees who were not aware of PPC (CHS4, a senior supervisor; and CHS8, a project engineer). CH8 noted that they used PIO instead. One interviewee (CHS3) noted that there was no visibility of PPC but understood that PPC was being used as a reporting tool.

Pressure of low PPC?

There is a consensus that low PPC is not stressful but depends on the significance of activities.

- CHS5 explained that there is a reason for everything.
- CHS6 noted that they were "*not stressed, as delays already occur, but [they] have to check in Touchplan if there is a delay*".
- "*It really depends on the activities; I am not worried if a broad activity is delayed by a single day*" – CHS1

Only CHS8 indicated he would be stressed if many of the activities are not completed on time. It suggests the CHS team does not use PPC as a stick to "beat team member with" which is good. As Mossman and Ramalingam noted, when workers feel psychologically unsafe, learning stops and team members' attention shifts from advocacy for the project to protecting themselves from blame, claims or other sanctions (Mossman and Ramalingam, 2021).

Learning

According to the interviewees from the CHS, the VMC session is one of the key venues where learning would occur following the presentation on PPC, and discussions were triggered about why certain activities or parts of the project were falling behind (CHS2/CHS6). That said, CHS6 also pointed out that the VMC only discusses the significant issues that will have been reflected in PPC, not the minor changes which will not be escalated to VMC. Ideally, these minor changes should be picked up during the daily huddle meetings, as CHS5 indicated, and daily root cause analysis should happen of activities or tasks that are not on schedule. Often, it will be pushed back to subcontractors on the next job, as they are also part of the learning process (CHS5). Additionally, a few interviewees noted follow-up actions are taken (CHS4) after discussing what they needed to do (e.g., increase resources depending on how critical the activity was).

Another venue where learning could potentially occur is during look-ahead planning, as CHS7 noted "[we] *put everything into different categories, so if certain categories were not getting good results, we talk about what's going wrong there in the six-week look-ahead meeting with all the senior engineers.*"

Learning is the basis for continuous improvement.

- CHS5 noted, "*[I am] not doing shift reports but definitely take lessons learned to prevent it from happening again.*"

- "*Lessons learned sessions to find out the reason for non-completion. Use those lessons and to make sure we are implementing good planning.*" – CHS8.

4.4 LPS/Touchplan: implementation at CLU

4.4.1 Introduction

Touchplan was introduced as a business case to CLU during the initial setup, a few months after the commencement of the project. Before its introduction, the project team used a whiteboard to write down what work was going to happen over the week and what resources were needed. When Touchplan was rolled out, everything moved online (CLU4). Eventually, everyone involved in the project was introduced to it and started getting their own swim lanes and digital tickets. A few CLU interviewees recalled that when they joined the project, Touchplan had already been implemented, and that they were briefed by a manager. CLU11 attended a couple of Cherry Street meetings to observe how his counterparts (JH) ran a Touchplan session and brought it here to CLU. The management team introduced it as part of the everyday planning session, and the team were given training on how to use daily. CLU7 commented that "*Initially, Touchplan was used as a scheduling tool, more interactive. More recently, it has been used as resource booking tool … it still does its purpose to track and schedule but not to its best advantage*".

4.4.2 Master Plan and Phase Planning

At CLU, all the interviewees claimed that the high-level long-term **master plan** was not developed using Touchplan (or LPS) (CLU1&6). This is because when Touchplan was introduced in CLU, the project was already at the construction phase, so the master plan had already been produced (CLU7). However, interviewee CLU5 noted that senior project managers would prepare their own long-term programs.

Like the master plan, interviewees claimed that **phase planning** was not conducted using Touchplan at CLU (CLU1&6).

- The project plan was not transferred from P6 to Touchplan by the company planner (CLU1).
- Project engineers would prepare their program for the next six months (CLU5).

4.4.3 Look-ahead planning (make ready)

Overview. The look-ahead meeting was enforced and chaired by the construction manager (CLU7). The team was attempting to hold the make-ready meeting in the big room (CLU2). All the project engineers develop their **look-ahead plans** and identify key constraints individually (CLU1). Each team was responsible for their own tickets in the meeting and would go through every swim lane (CLU2). So, the proportion of time in a typical look-ahead planning session would be:

- one-third each for constraints, scope and problem resolution (CLU6)
- up to 80% focusing on constraints and 20% on resourcing (CLU7)

The make-ready plans are constantly adjusted and updated/revised every week (CLU5 and CLU7). CLU7 acknowledged this is a continuous process, and that engineers would then update the change in Touchplan.

- *The activities* in the make-ready plan, especially the critical activities, come from higher level (the project engineer or senior project engineer), as noted by junior engineers such as CLU4. This is because junior engineers could not access the higher level program, so all the tickets were mainly based on discussion. Therefore, tickets for their team were put into Touchplan after the discussion in the meeting (CLU7).
- *Milestones* were also from the longer-term plan (CLU2).
- The *duration* of activities in the plan was usually set in consultation with supervisors (CLU5) and confirmed with the supervisors (who execute the work) through *informal* discussion (CLU4).

Communication and collaboration. From the following comments, it is clear that engineers cannot develop tickets alone, even though they are the ones working in the background to understand if there are clashes with any of the other work groups based on the master program (CLU6). Communication with others was frequently mentioned as a key behaviour at this stage of planning.

- The effort to develop a make-ready plan involved constant *informal* communication with other teams and sometimes needed the involvement of another supervisor (CLU7).
- This interviewee developed the look-ahead plan with the *support of a project engineer* and involved everyone else who was relevant (this is a collective effort).
- The team would collaboratively look at resource requirements, restrictions and worksite access issues (CLU2).
- Check with supervisors and subcontractors if they can supply certain resources (CLU7).

Other software

- CLU6 noted that the company planner developed the four-week look-ahead plan in P6.
- CLU5 highlighted that the project program was now moved to an Excel worksheet, which included the entire long-term program to forecast. Tickets were then taken from these programs (CLU5).

Identification of constraints and their resolution process

- The team would first talk about everything related to the scope and then identify constraints and/or dependencies. There was no standard procedure to resolve constraints. The engineers would ensure all constraints were removed before execution (CLU6).
- The team would also communicate with other teams working in the same area in terms of constraints, but not creating the "constraint" tickets (CLU2).
- It was the engineers' responsibility to consider and discuss constraints, as well as resolve interfaces in the make-ready meeting. If the activity could not be ready before entering the weekly work plan, it would be either moved to the next week or action taken immediately (CLU7).
- When constraints were identified, the engineers would put all subsequent activities on hold and figure out the following actions. The team might have a separate meeting about the constraints with other relevant teams. The engineer would also flag constraints in a meeting or during weekly meetings (CLU5).
- To solve clashes, contact the project engineer and other senior project engineers responsible for delivering those works, and arrange meetings to investigate the problem.
  - a series of meetings, depending on the complexity;
  - involve supervisors, superintendents, and relevant subcontractors (CLU6).
- The team would identify constraints and ensure they were resolved before entering into the weekly plan meeting (CLU4).
- The diamond-shaped milestones and circular constraints are used very loosely. If there were major constraints, they might be put in the major milestones (CLU1).
- Not using constraints function in Touchplan at all (CLU2).

Visual Management Centre (VMC). The VMC meeting was conducted every Thursday (CLU5/CLU7), which was later moved online (CLU1). Attendees are from across the whole team, and the meeting is chaired by the construction manager (CLU5). The VMC meeting gave an update to each team and raised issues that could not be solved within the team. As

CLU7 described, the VMC meeting is only for higher level. During the meeting, the construction manager would use graphs to show how much work had been completed, as well as the top (three) opportunities and top (three) risks. The entire team went through a few issues, including (1) what their scope was (2) what the upcoming milestones are (3) what the risks are and (4) what the essential constraints are (CLU1).

When, how long and how many weeks look-ahead. CLU 1 acknowledged that the look-ahead planning session is conducted in weekly meetings and that there was no separate meeting for it (CL1, CLU3, CLU4). CLU7 noted that there was an hour-long meeting each Tuesday morning. In terms of duration, it was reported that meetings lasted for approximately 60–90 minutes (CLU6). CLU4 suggested the meetings sometimes lasted for less than 30 minutes, but up to an hour if there was more to discuss.

The majority of interviewees noted the look-ahead window maximum of four weeks (i.e. CLU1, CLU3 and CLU4). CLU2's experience was planning a two-week look-ahead, which is combined with the weekly plan meeting. Interestingly, CLU6 revealed that the activities planned for the next four weeks look-ahead are not put into Touchplan.

Who. Everyone from every team (i.e. CSR, civil, track, structure) is involved (CLU2). and everyone had their own program (CLU3):

- Supervisors are mentioned several times (CLU4-7), but CLU8 offered a different view, noting that supervisors should not be involved at this level of planning, as only the engineers had their own program in a few different look-ahead windows. Touchplan was more used as a resource and interface management tool for supervisors.
- Subcontractors' teams are involved (CLU6-7), but not with the wider team (arguing it should ideally be done with the wider team) (CLU6).
- Included individual supervisors (from labours or subcontractors), site engineer, project engineer (CLU4).

What information was discussed. The team would go through activities, locations, clashes, support services (by the plant manager), and activity requirements (CLU2). In CLU4's view, the **scope of works** are the key things that will be discussed – what need to be done in the next four weeks (CLU6).

- Supervisors provided details of activities and durations, and resources required (CLU4).
- The engineer would list all constraints to further discuss in the meeting (CLU5). Discuss constraints and justify the reason for longer duration (potential delays) (CLU4).

Typical constraints. When asked what typical constraints were, the following were mentioned:

- Typical constraints might be weather, permits, subcontractors, and physical constraints (CLU1).
- Typical constraints could be procurement items, a handover from a third workgroup that has not happened. Resources can also be constraints (CLU6).
- Typical constraints might be start and finish times; methods, labour, predecessors, duration, interfaces between different teams, and site preparation (CLU7).
- Information presented in the meeting might involve constraints, interfaces, and checking if the program still works (CLU5).
- Discuss what works to do and their duration, bringing in resources, any assistance from a safety point of view. Go through certain activities and ensure resources are correct (CLU7).

Other comments

- However, one interviewee stated that for their team, there was no discussion across teams, only inputting their own activities and checking with other's activities. They would still check if resources, labour, or crew were shared across disciplines, as well as interfaces, and conduct informal discussions with other teams (CLU3).
- Similarly, this interviewee, who claimed there was no make-ready meeting for their team, did not think a make-ready meeting would work, as there are already occupation meetings. He assumed there would be limited buy-in from the team (CLU3).

4.4.4 Weekly planning

Weekly work planning. There was no separate weekly planning session (CLU6). However, the weekly plan was developed progressively throughout the week (CLU1). All short-term activities are taken from a longer-term program that the engineers had. (CLU2).

Weekly Plan in Touchplan

- Location-based swim lanes to allow better visualization of interfaces (CLU1).
- No buffer is allowed due to cost (CLU5).
- Try to make tasks no more than a couple of days. Otherwise, the task would be broken into a few smaller tasks (CLU8).

- There was no formal documentation of interface issues, only conversation to decide which one would take priority. They may be recorded in the site diary, but this is more about costing (CLU8).

Weekly Commitment meeting (Friday). Friday's commitment meeting is a promise session to plan for what is going to be done during the next week. The team went through tickets for the whole of the next week (CLU1/CLU2), which was already developed by engineers, then the supervisor could move tickets if needed (CLU8).
- The promise-now button will be pressed by the engineers (CLU1) or Steve (CLU3), indicating the task is locked/committed for the coming week.
- To save time on planning, those tasks that have already been completed should be indicated before the meeting (CLU3).

Discontinued weekly commitment meeting. During the interviews (around September 2021), it was surprising to learn that the Friday weekly session had stopped running a few months previously. Instead, the team moved everything into the daily session by extending their duration. They still made promises, but not on high-priority ones. Some claimed the team was not making any promises on tickets. The decision was made due to
- limitations of Touchplan – promised tickets could still be deleted or changed (CLU4).
- There was no good outcome, as people only talked about what they had seen on Touchplan (tickets), which was not productive.
- Might bring it back (CLU8).

Criteria before hitting the promise-now button
- Would check all the criteria before hitting the promise-now button (CLU2).
- Criteria for hitting the promise button stated by CLU2:
  - The majority are external resources, so basically contract with an agreed scope, their commitment of attendance on a given date.
  - Preplanning around safety; information needed.
  - Approval and permits.
  - Induction for everyone regarding what is required to start the activities.
- Criteria claimed by CLU8: mainly confidence in promised tickets and information provided by the subcontractors/self-performed staff; personal experience to judge the duration, resources or crew size (CLU8).
- The supervisors reviewed the tickets during the meeting. Tickets would be locked by the end of the day by the construction manager (CLU8).

Other meetings

- The senior project engineer and construction manager run the PIO boards, and the team discuss them on a weekly basis. There would be a reward if people came up with improvement opportunities and innovations (CLU8).
- The team's own meeting with subcontractors weekly to discuss issues (1 hour) (CLU2);
- CLU3 claimed there was a weekly Tuesday-morning meeting (VMC) not based on Touchplan:
    - Go through four weeks look-ahead.
    - All engineers and supervisors plan to organize resource materials and permits.
    - Had a whiteboard and put everything on it, including the constraints log.
    - Updated Touchplan based on information on this whiteboard.
    - Discussed constraints, confirming quality of activities.
    - Brought subcontractors in as well.

4.4.5 Daily coordination meeting

Judging from interviewees' responses, the daily coordination meeting is one of the most important. The project adopted a daily-promising style but through informal conversation (verbal commitments) (CLU7). There are three separate daily sessions for three different areas at 10:00 a.m., 10:45 a.m. and 11:00 a.m. (CLU7). These meetings are heavy, especially for superintendents such as Robert Crumpen (CLU11), who look after all three locations. Given their nature, some team members will dial-in instead of physically attending.

The daily meeting, run by supervisors (CLU8), is to confirm activities for the day and the next day. In the meeting, the team review all the tickets in Touchplan (added by engineers prior to the meeting), including location, resources, duration, crew size, etc., and check with the relevant supervisors and engineers (CLU7) that everything makes sense (CLU8) and is ready for the next day (CLU2). There are a few things prioritized in the daily meeting.

Resources. Booked resources would be confirmed by the plant manager (CLU2) or made in the meeting (CLU5). For example:
- traffic management: a week in advance
- rail safety workers: the day before
- material: two to three days in advance
- trucks, the day before (CLU5).

Scope and interface. In the meeting, check if resources are correct or if there are any interfaces/clash issues with other work groups (CLU5/6/8).

Again, the engineers took responsibility for completing the booking and ensuring everything is booked in properly and confirmed with everyone. Subcontractors have regular catch-ups or casual discussion. (CLU5);

Constraints. Check activities with all the identified constraints to see if the activity is ready. This is normally done outside of Touchplan (CLU6). All the clashes and interfaces should be resolved before the daily session (interface is not really an issue, just to identify) (CLU6).

- Booking of resources from subcontractors in the meeting (CLU4).
- Resource manager only in charge of safe working and traffic management (CLU6).
- The function of managing resources was mainly used for track prediction person at Level 3 for plant booking, not for machines and labour (CLU4).
- In daily sessions (Touchplan meeting) with subcontractors, discuss scope for the next day and resources to get them booked. Also discuss interfaces if there are any (CLU6).
- Making sure everything is booked in properly and confirmed with everyone. Also discuss interfaces and make judgement in daily sessions (CLU7).
- Engineers carry the responsibility for completing booking with subcontractors by regular catchups or casual discussion (CLU5).
- Check activities with all the identified constraints to confirm the activity is ready. Done outside of Touchplan (CLU6).
- All clashes and interfaces should be resolved before the daily session. (Interface is not really an issue, just to identify) (CLU6).
- Everything should be put in by 12:00 p.m., and tickets should be confirmed at that time (CLU3).
- Make-ready activities at daily level so there is more control; confirm everything by 2:00 p.m. (CLU7).

4.4.6 PPC, variance and learning

PPC

It was discovered that end users of Touchplan were not familiar with PPC, except for CLU1, who noted it was in the high 60s or low 70s, and CLU11 indicated "*we used to, but stopped for a while, as everyone got too busy; normally above 70%".* CLU2 indicated: "*I have heard about it but not actually used it.*" He did not use it because he only attends the meeting where the construction manager will present the data and go through with the team every week at

the start of implementation of Touchplan. Instead, monitoring tickets daily to conduct action takes precedence. Other comments include:

- There is no measurement of works not on the critical path (CLU5).
- Does not benefit the plant team and more for the construction team (CLU10).
- "*At this stage, I don't think we really need to improve (say from 70% to 80%). I think it is more finetuning and, to be honest, working for that is what the project needs. The guys are doing the planning, the tickets are there, and they are discussing the interface. So, from a planning level, that is working, and things are getting achieved*" (CLU11).

Stressed by low PPC?

Based on the interview results, the CLU crew were not too worried about the low PPC or non-completion of activities but care more about the reasons why and how to justify it.

- CLU1 argued the PPC number cannot tells us anything. Weather has a huge impact on the work.
- Moderate stress (CLU2), as will be asked by the construction manager.
- "Need to justify the reason why it is not completed and extend the duration to when it will be finished", which has become a common approach (CLU2/3).
- Look for alternatives. Activities not completed are managed daily (CLU5).
- Change the date and justify it (CLU6). If lots of activities not completed on time, try to balance with activities completed earlier. If still not the case, escalate it as an issue.
- Will be extremely stressful and ask for assistance from the manager (CLU7). Currently use own Gantt chart to track activities and present to CM how many days and how much extra is needed.
- Follow-up action during Friday meeting.

Learning and learning methods

Learning occurs when

- works are finished later than planned (tickets not closed) (CLU1 and CLU2)
- after every shift for those keeping a shift diary (CLU4)
- after finishing a big job when there will be reflections/learning (CLU5)
- If problems cannot be solved by the PE (CLU6).

Of these, the second learning can occur daily, but keeping a diary does not share the learning with the team. As Mossman and Ramalingam (2021) noted, sharing information is a small but important part of building a shared understanding. A very good opportunity that facilitates everyday learning is publishing project PPC data, which helps the team as a whole to learn.

However, CLU was not actively channelling effort into this; hence, a huge opportunity of everyday learning is missed.

There are a few voices such as CLU3 noting that "*there is no learning, as every week we are looking forward to the week ahead".* CLU7 commented that *"there is no standard learning process, and we have to assess it by the engineers in their own way …Touchplan is not offering full analysis, no details … learning is more at higher level*."

In terms of methods adopted to investigate variance and promote learning, according to the interviewees, this includes:

- Conduct 5 whys to prevent the root cause from reoccurring, not allocating blame.
- Conduct root cause analysis.
- Most problem-solving is happening outside meetings in the form of informal conversations.
- Escalate to the upper level and understand what is wrong with the schedule.
- Follow-up actions through regular weekly updates and daily catch-up sessions to ensure there is resolution for every issue.
- Do shift reports to record delays or issues; obtain as much information as possible (CLU5).

4.5 Implementation gaps and opportunities for improvement

The following suggestions are made in response to the implementation gaps observed from both the Cherry Street and CLU projects (see Appendix 6 and 7).

4.5.1 Master plan

Master planning is the first step of LPS. It defines the project at a high level. The master plan was prepared in the early stages for both projects and is intended to be a rough framework stating project milestones. It is developed in P6.

4.5.2 Phase planning

Each major stage of the master plan is broken down into its component tasks during phase planning. The phase plan sets the standard process for the phase and a base for the detailed schedule. Implementation wise, the CHS team was on the right track in terms of implementing phase planning.

- The "pull" concept was used, implemented backwards from target completion to start, although CHS7 indicated this was not a new planning method 101.
- Work structuring. Work was broken down when each team looked after certain packages (work structuring), which are likely be different from one unit/area to the next. This promotes flow.
- Scheduling. The process of assigning dates and time to planned tasks arranged in proper sequence towards a milestone.

On the contrary, phase planning was unfortunately a missing link at CLU, where opportunities to break down the major stages of milestone plan (master plan) into its component tasks were missed. Given the scale of the CLU project, phase planning should be adopted and would be useful.

The research team learned from another piece of LPS software, VisiLean, that they have four tabs for different levels of planning (see Figure 6), one of which is the "phase planning" tab, where the last planner can conveniently switch between tabs for different planning types. In Touchplan, however, end users might feel undertaking phase planning was optional if there is no such set-up in the beginning; hence, their focus is on both weekly and daily short-term planning.
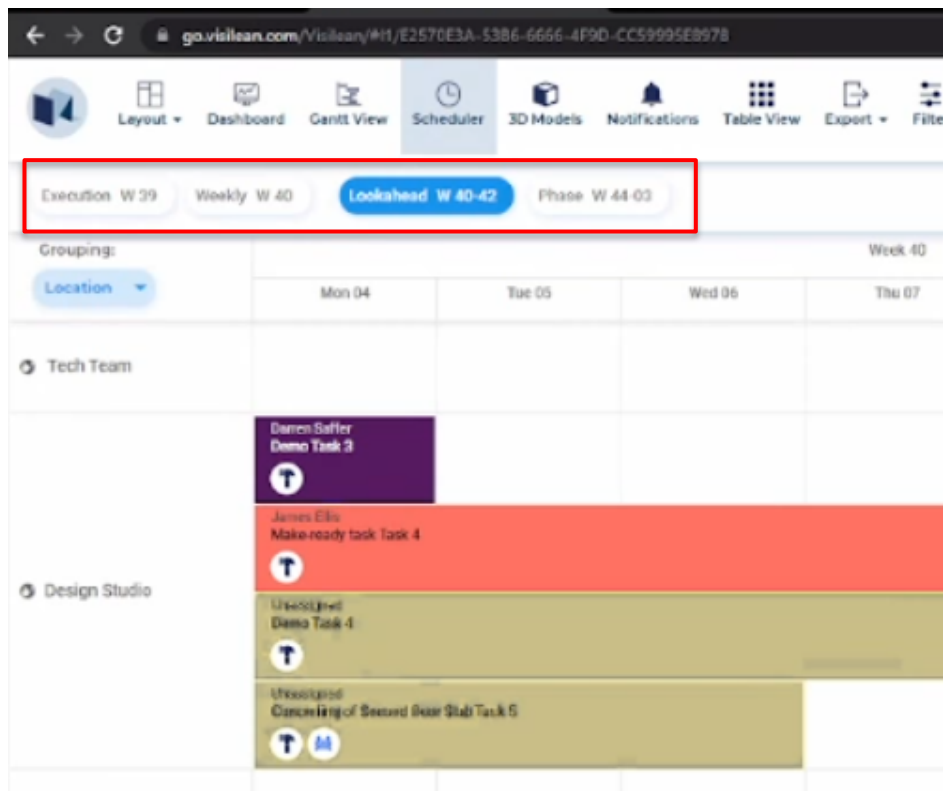
Figure 6: Snapshot of the VisiLean platform.

Future roll-out should consider the following:

- Emphasis should be placed on the **purpose** of pull phase planning, which serves as a bridge between the master plan and the look-ahead plan.
- Despite the size of project, it is still important to have phase planning in place to **break down** the entire project into multiple processes or phases.
- It could be worth introducing the concept of "conditions of satisfaction" (CoS). CoS refers to a clear expectation of hand-off criteria to be clarified between two work packages' hand-offs. This prevents defects passing down the line and helps the customer (predecessor) and supplier (following activity) to understand what is required from each other. CoS was not a term heard in relation to phase planning during the interviews.

Further, given that the CHS team has had experience of phase planning (using a whiteboard), there is an opportunity for future projects to implement phase planning entirely in a **digital** environment. The last planners from each team can add tickets of longer duration within the identified phases/work structure using the P6 master plan as a reference. The ouTouchplanut of phase planning can then serve as a reference for look-ahead planning.

4.5.3 Look-ahead planning (make-ready process)

Look-ahead planning takes a more granular approach to work packages, ensuring that all *prerequisites* are complete for each work package before it is released to the weekly planning meeting. One of the key tasks in look-ahead planning is identification and removal of constraints that make the tasks ready.

It is encouraging to see that the Cherry Street project emphasises the importance of look-ahead planning. CHS1 (superintendent) noted that look-ahead planning is perhaps the most important among the four levels of LPS. Additionally, CHS has established a screening process to identify and resolve constraints that might disrupt the flow of work (see Section 4.3.4). However, at CLU, the look-ahead planning exercises mentioned by some individuals has shown significant departure from the benchmark LPS method. Normally, the look-ahead should allow enough time to identify and manage engineering, fabrication and/or delivery of any long-lead items that the project team needs to coordinate, often 4–6 weeks (see Figure 7).
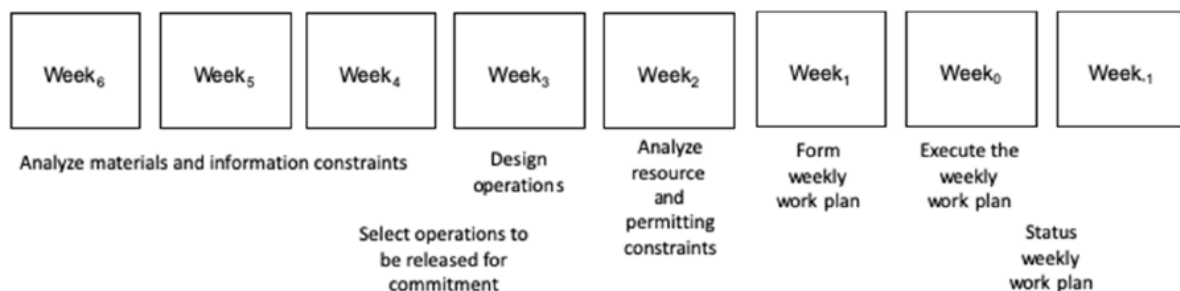
Figure 7: Timing guide for look-ahead and weekly work planning
Source: Ballard and Tommelein (2021)

What some teams at CLU did was to develop the tickets for the coming week or the week after, and finetune the tickets daily (CLU4/CLU11). In other words, the weekly tasks are NOT from a four- or six-week planning window but resulted from tickets that were added from the previous week (see Figure 8). Shortening the look-ahead window allows only one week's worth of time to make-ready the tasks at the risk that some activities may require more time to deal with the constraints before being ready.
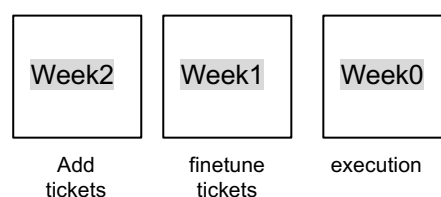

Figure 8: look-ahead planning at CLU.

As for constraint ID and removal, it is evident that the constraints' function was loosely used, although this exercise was mentioned during interviews. According to the constraints log generated on 18 February 2022 (from Touchplan), there were only 26 constraints officially recorded in the Touchplan system by the role assigned as "general".

Secondly, the description of constraint is inconsistent and is likely only known by whoever created it. For example, one constraint noted as "Delivery – Precast Deck Units to South of E-Creek. 12 No. Units at 45-minute truck spacings. 40T Franna to unload". This reads like an activity not a constraint. Such a description may be known only by the ticket owner, but it may prevent the team easily comprehending what this constraint really means.

Thirdly, there were no updates to the master or phase plans after a change in the make-ready plan. One comment claimed that they use the master program to exchange information among the wider team. It was not necessary to have a discussion or meeting among the wider team, but everyone would interpret its effect on the master program in their own way. They would use the master program to check interfaces during construction (CLU6).

There are a few practices worth considering:
For look-ahead planning, we suggest:
- Follow a minimum of a four-week ahead window, using a pull method to develop activities that will be undertaken during that time. A good example to refer to is the timing guide for look-ahead planning (Figure 7).
- A look-ahead planning guide including update requirements from changes made, from a look-ahead planning to the master schedule.

For constraint ID and removal, we suggest:
- A flowchart is needed to visualise this process from identification to resolution in multiple scenarios. For example:
    a. If constraints are unresolved, what is next, or what is plan B?
    b. What kind of constraints should be escalated to PIO?
- Use constraint tickets more rigorously in Touchplan in future projects.
- Revisit the key triggers for constraints. The literature reminds us there are eight triggers (previous activities, materials, people, equipment, information, safe space, external conditions, and shared understanding). One good approach is to run a workshop to showcase what are the common constraints and resolution strategies.

- Document those constraints discussed in PIO using a consistent approach (e.g., A3 reporting as for knowledge capture and learning).
- Use simple metrics such as (1) number of constraints, (2) constraints per week, and (3) average constraint removal time (CPT) to evaluate the efforts/work in constraint management.

4.5.4 Weekly planning

The promise sessions were held on Fridays. A decision was made to halt the promise session at CLU in mid-2021, and the reasons are noted in **section 4.4.4**. This decision showed poor commitment and lack of buy-in. If this step collapses, then PPC learning will naturally fall apart, which was the case at CLU. This one-hour session allows the last planner to commit to performing specific tasks in a specific location at specific time during the week. Not making a "promise" (commitment) to those tickets will compromise the reliability of the plan and affect the degree of predictability of getting work done. Also, this promise session should allow the last planner to say "NO" if they are unable to commit to the next week plan. Discontinuing this activity will strip off the last planner's right to do so. We **strongly suggest not foregoing this exercise** in future projects.

Some overseas practices set the promise session on Thursday,[1] leaving Friday, as a buffer for some tasks which require last-minute finetuning before making the commitment. One interviewee had a similar thought, noting "*Friday is too late to change the program. Everything should be set by Wednesday".* In view of overseas practices and comments from the ground, we also suggest **commitment be set on Thursdays**.

4.5.5 Daily coordination meeting

The daily coordination meetings were well organised at both projects.

4.5.6 PPC, variance and learning

PPC. PPC was set at 80% at Cherry street, whereas at CLU, although the team roughly knows where their weekly PPC stands, no PPC target was set from the outset. The PPC measures had a bumpy start due to inaccurate data but got it right thereafter (Cherry Street). PPC was loosely used at CLU, however. The interviewees knew about it but did not actually use it, let alone see the benefits of it. Comments such as "*the tickets are there, it is working… but I don't*

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[1] LCI also recommends holding weekly promise session on Thursday's.

think we really need to improve PPC (say from 70% to 80%)" seems to show that the project team see adding the tickets in Touchplan as all about implementing Touchplan/last planner. Arguably, without PPC evaluation (check), the team will struggle to know the degree of plan reliability and plan predictability. This was clearly a missing link at CLU in terms of evaluating PPC, analysing variance, and trigger learning. Moreover, improvement of PPC was not a priority. Rather, the project team were satisfied as long as the tickets were added and closed off.

Variance and learning

The reasons for variance function was used and was seen in both the Cherry Street and CLU projects. A closer look at these reasons reveals that weather, resource unavailability, site conditions, and others were the main causes. In many "others", no specific reasons were given. It should be further specified if the reasons fall out of the predetermined categories. The superintendent should consider the use of Frequency of Plan Failures (Ballard and Tommelein 2021) during the VMC meeting. It is unknown if this frequency chart is shown at the VMC meeting. If not, it is worth charting it, as a frequency chart is able to visually indicate the relative frequency of each category of plan failure. When frequency of specific categories of plan failures are tracked over time, it reveals the extent to which root causes have been identified and countermeasures taken to prevent reoccurrence (Ballard and Tommelein, 2021).

As for learning, it is encouraging to see that learning did occur on some occasions, particularly when project fell behind. However, how lessons (learned) were captured was unknown. We suggest the following practices should be in place for future projects:
- Induction for PPC, and reasons for variance to be incorporated in the Touchplan onboard training. Adding tickets is a "plan", execution the work is "do", what is equally important is the measurement of PPC which is a check and the PDCA cycle is closed with an action, which is the analysis of plan failure.
- Assist the project team to set a reasonable PPC that is attainable. Setting around 60%–70% could be a good starting point.
- Instil continuous improvement culture.
- Training on problem-solving methods.

4.5.7 Last Planner

Another departure is the role of last planner. At WPA projects, the engineers are mainly the last planners, who, after discussing with supervisors/subbies, diligently add the tickets to Touchplan. Engineers may not have the full information, but with active consultation and

collaboration with supervisors/subcontractors, engineers do close the information gap. WPA had adopted this approach perhaps due to the following reasons:

- The site crew, supervisors in particular, are too busy and often are not tech savvy.
- Unlike the building sector, where it is common that the work is entirely subcontracted out, in the civil engineering section, the head contactor does keep self-performing crews.

However, the ideal situation is certainly that the people who are closer to the *Gemba* is the last planner. In view of the above the engineers shall still be the leading Last Planners. To be more specific:

The look-ahead planning and weekly commitment session should be led by the superintendent and are supported by engineers. The roles and responsibilities described by the interviewees seem the following:

- Project engineers are the right person be involved in the phase planning, as their work is related to breaking down the scope into work packages and overseeing all engineering and responsibilities required to deliver those works on-site. This is in line with the focus of phase planning.
- PE/SE should also be responsible for look-ahead planning, given they have medium-term planning focus. Their engagement with subcontractors will help them foresee constraints in the make-ready process.

As for weekly planning and adding tickets, site engineers or JE are the perfect candidate. The reasons are as follows:

- Close to *Gemba*. As CLU3 put it, connecting site and office as well as directly coordinate subbies, foreman and supervisors.
- Their work has a tracking element. Adding tickets allows them to closely monitor what to track and their status.
- They are the ones potentially resolving the constraints emerging from the make-ready process (e.g. preparation of permits).

4.6 Benefits and limitations

The third section of the interview guide explored what impact LPS/Touchplan has had on their projects. In the earlier section, the questionnaire ranked respondents' perceptions of benefits that LPS could bring to WPA projects. The interview findings aim to validate the survey results, with a broad focus on project performance and project members' social behaviour. The readers should note that the information presented, and recommendations made in this section are based on the experience and perceptions of the participants in the study. The team did not collect actual project performance data to support the analysis presented. Meanwhile, the limitations of Touchplan were also explored in this section. Appendix 8 presents the findings from the interviews with regards to program, cost, quality, safety, and behaviour changes.

4.6.1 Program

Interviewees from the Cherry Street project have more positive perceptions of the impact of LPS/Touchplan on the program. Evidence includes:

"better schedule performance, as able to visually see each of the activities and sequencing." – CHS2
"be able to see from Touchplan with an end date." – CHS3

The comments underline that the visibility of planning and plans is regarded to have a positive impact on schedule performance. The project team need to see the activities, sequencing, interfaces, and other information in a better way instead of an abstract way. Previously, with the presented bar chart in P6, the program is an iconic abstraction in that time is proportional to the length of a bar, and activities are identified as discrete activities (Boyd, 2021).

In addition, another conclusion that we could draw here is perhaps that the adoption of LPS/Touchplan also enhances Touchplan end users' (last planner) understanding of program, as indicated by half of the Cherry Street interviewees, as evidenced below:
"Better and more detailed understanding on what is needed and what is the targeted dates when pulling from milestones." – CHS1

"Simpler and easier to understand than a traditional construction program done in P6 in this project. P6 is limited in its long-term capabilities, especially with complex linking between activities." – CH2.

"Traditionally, only senior engineers are in charge of everything. In LPS, everyone understands the plan a lot better." – CHS7

"Touchplan gives everyone clear understanding of the program" – CHS8

This is an important observation, as the development of tickets is actually a result of coordination and communication between engineers, supervisors and subbies. LPS/Touchplan enables engineers to actively seek needed information from those who can provide it before they add the tickets to Touchplan. This process helps the engineers to develop a better understanding of tasks, people, locations, materials, drawings, time, information, and resources, and also promotes a common understanding of project goals among stakeholders (Pasquire, 2012, Koskela 2000). This will support the smooth flow of work, collaboration, and commitment from all project participants (Koskela and Ballard, 2006).

At CLU, according to CLU11, "*program wise, it is 12 months ahead of the program",* and Touchplan implementation may have contributed to this significant time reduction. CLU interviewees were reluctant to attribute this to the use of Touchplan. Two comments were made as follows:

"Not sure about schedule performance, as cannot identify direct influence" – CLU1

"Touchplan is not going to make people build the job any quicker. High-risk work hasn't been put in Touchplan. It's been on a whiteboard. A lot of stuff is not put into Touchplan" – CLU8

CLU11 noted that *"the whole job is pretty much based on a signalling program. We are fortunately in a low-risk area, so I'll get an early start getting approval to start early, and there's a lot of prep work getting into these projects to get approvals."*

4.6.2 Cost and Resources

Success in cost performance depends on the management of construction resources, budget management, construction methods and communication (Meeampol and Ogunlan, 2006). In terms of the impact on cost performance, the findings are not consistent.

Better cost performance – CHS1 acknowledged that better cost performance of a CHS project is perhaps achieved as a "*consequence of better planning*". Several interviewees highlighted that sharing resources results in better cost performance, and that Touchplan is able to help in that regard. CHS2 elaborated: "*for large civil jobs, resources can be shared between teams, and thus cost can also be shared."* This comment was echoed by CLU2. This is in line with the literature notes on maximising the use of resources to positively influence costs. CLU11 elaborated on this by giving an example:

"there's heaps of efficiencies in cost saving. For example, you're looking at an area, and you'll go, or someone will pre-book a level-three in an hour. So, you'll say, well, you don't know what's in that area, you know. Based on his experience and what he can say and then, straightaway you'll have efficiencies."

Indirect or no impact. There are also views that cost improvement might be an *indirect* benefit of Touchplan (CHS6) or no cost reduction (CLU10).

The relationship between Touchplan and cost performance was not established here, partially due to the unavailability of cost data (including cost of resources, for instance). What we may conclude here is that thanks to the dedicated resource swim lane, as well as the dedicated resource manager, the resource requirements are well coordinated simply by looking at the resource requirement added in the swim lane. That helps maximise the use of plants and minimises the double booking/idling of plants.

The practice by MACE Ireland maybe worthwhile noting, which is to increase the forecast of the cost associated with the work monthly. This is closely related to the make-ready planning of the 4–6-week look-ahead.

MACE Ireland (Kevin McHugh)

The project Kevin refers to is a hyperscale data centre project in Ireland which is an 86,000-square-meter structure consisting of eight single-storey data halls and an administration building. The project digitalises LPS through VisiLean. In their look-ahead planning, trade contractors were tasked with preparing and submitting a six-week look-ahead for the remote-working period. This resulted in more than 800 tasks being generated in the look-ahead period. More interestingly, the manager had another metric for the client.

The client wants the construction project payment forecast to be within 1.5% in terms of accuracy. Kevin's team is using this opportunity to improve the forecast of the value of the work they are going to do in the four-week look-ahead plan to arrange payment, driving people to have real quality of information into the weekly work plan, as the more ambiguous the forecasting, the more difficult it is to get any value from them. This challenging requirement from the client really increases their ability to improve look-ahead planning.

The project also attempts to focus on different themes every month and to improve. For example:

- Focus on labour for four weeks in a row and get the labour forecast right.

- Then focus on quantities for another four weeks and then get the quantities improving.
- Then plug this information into Power BI to give a total view of all the critical data and information.

4.6.3 Quality and Safety

Exploring whether quality or safety had improved after the introduction of Touchplan, below are a few comments made by interviewees.

- "*Touchplan enables works to have <u>less interface</u> between activities*" and "*less rework when one activity disrupts or impacts on another*" – CHS2
- "*There's <u>no interfacing packs</u> between various work activities, which improves safety performance*" – CHS2
- "*Touchplan helps coordinate site team and identify <u>interfaces</u>*" – CHS3
- "*Touchplan helps with understanding where we've got activities happening at the same time that might have a direct <u>interface</u> on-site*" – CHS6

These comments point to a common keyword, **interface.** Digitising the weekly planning provided greater transparency between teams which increased engagement with the production control system (McHugh et al., 2021). It seems to infer that when the interfaces between the works are identified, understood, and coordinated, it is less likely that rework and safety issues will emerge. Touchplan addressed this as follows:

- Have dedicated swim lanes distinguish each discipline.
- The "interface" was regarded as a typical constraint during look-ahead meetings and daily meetings and discussing these constraints/interfaces helps the team to comprehend the interface.
- If the complexity of the interface is understood and coordinated, the risk of poor quality is reduced.

Secondly, another point is the attendance at meetings of safety and quality personnel. These professionals bring their speciality to the meeting and enable the team to be more prepared for any potential quality and safety issues.

- *CLU3 noted this could be attributed by a quality person in the meeting.*
- *Safety person looking at these activities – CLU1.*

Thirdly, we heard people commenting:

- "*More organized and not rushed to complete the activities so more preparation is undertaken*".
- "*More consideration of the resources in terms of volume, quantity or productivity rate*".

- *"With increased transparency of site conditions" – CLU2.*

Quality improvements were achieved with adequate resources in terms of workforce and time.

4.6.4 Behaviours

Apart from potential benefits brought to the project performance, the social benefits such as better collaboration, etc., behavioural changes were also noted (see Table 9).

Table 9: Impact on project teams and individuals

No.	Communication	Engagement and involve	Collaboration	Teamwork	Confidence	Trust	Commitment	Identify problem	Problem solving	Accountability	Planning ability
CHS1							X	X			
CHS2					X			X			
CHS3	X		X	X		X	X		X		
CHS4	X		X	X		X	X		X		
CHS5	X								X		X
CHS6											
CHS7											
CHS8	X		X								
CLU1							X				
CLU2	X		X	X	X						
CLU3				X		X	X		X		
CLU4	X		X						X		
CLU5	X								X		
CLU6	X		X				X			X	
CLU7	X			X			X		X		
CLU9			X							X	
CLU10											
CLU11		X								X	
OTH1	X						X	X	X		
OTH2		X	X								
Total	**10**	**2**	**8**	**5**	**2**	**3**	**8**	**3**	**8**	**3**	**1**

Note: CLU8 noted no behavioural change. CLU10 made no comments on this matter.

Communication

The behavioural change in communication is recognised by interviewees. CHS3 explained that civil jobs tend to have less communication, as everyone is in charge of different areas. However, according to his observations, the change in communication is one of the biggest

behavioural changes, as there is definitely more communication within and across disciplines. There is more discussion among the teams during meetings with respect to problem identification and problem-solving (OTH1). CST8 again highlighted that as people are more heavily involved in planning meetings, information sharing is facilitated. Interviewees from the CLU project (CLU2 and CLU4) mentioned that the communication of information is much better when the Touchplan meeting is implemented.

Collaboration

Improvement in team collaboration has been frequently mentioned by interviewees. Interviewees found that with the improved visibility brought by Touchplan, everyone in the team are aware of what is going on on-site every day (CLU4). Different disciplines can better organize their work based on others' plans (CLU9). Both CLU2 and OTH2 highlighted that they know what others on-site are working on, which brings everyone onto the same page and triggers more discussion about how to plan safely and avoid clashes. With improved collaboration, CHS3 commented that subcontractors are prompted to commit to their work in the following few days.

Commitment

Interviewees also brought up improvement in commitment as one of the behavioural changes. With the benefits brought by Touchplan, the quality of commitment has been greatly improved. CLU1 commented that the team used to commit to five days and then adjusted it to three days to ensure they could complete the work on time. In addition, both CLU1 and OTH1 found that by asking the team to commit to what they are going to plan for the next few weeks, the whole team is more connected, which again results in a positive impact on teamwork and collaboration.

Teamwork

Another behavioural change mentioned frequently among interviewees is the improvement of teamwork. CHS5, CLU 2, and CLU7 commented that teamwork is the biggest behavioral change when implementing Touchplan. Compared to the other two projects, CLU has a big working site, which involves a larger number of end users and resources. Therefore, with the support of Touchplan to increase the transparency of the details of activities, plant managers and other management team members could better manage and share resources. Engineers also gain a visibility of what is happening throughout the whole construction site (CHS4). The implementation of Touchplan brings everyone in the team together onto a digital platform so everyone can be working on the same plan, rather than each team working in a silo with their own program (CHS2, CLU4). Some interviewees emphasized that the connection between

different teams is enhanced through Touchplan meetings by regularly bringing up issues in front of the whole team and allowing conversation to happen during the meeting (CHS1, CHS3, CLU1, CLU5, and OTH2).

4.6.5 Limitations

Limitations of Touchplan were also investigated (see Table 10). Interviewees did point out several limitations of Touchplan from their experience. The key areas of focus for interviewees were software related.

Table 10: Limitations of Touchplan.

No.	Disadvantage/limitation	Category
CHS1	• You lose the ability to grab someone and have a side conversation	Social
CHS2	• Limited buy-in from downstream, design team. • Accidentally move activities. • Redundant tickets – person must take responsibility to update, not just create. • Senior staff prefer whiteboard for more detailed planning, especially during rail occupation. They reverted to whiteboard.	Limited buy-in not a limitation Software Software Preference for whiteboard
CHS3	• Less value for smaller projects (say less than $30 million). A few guys can deliver this. No need for Touchplan. • Duration in Touchplan is not accurate	Scope Planning capability
CHS4	• Limited buy-in from the team • Team prefer whiteboard as much easier and quicker to use	Ditto to CHS2 Whiteboard
CHS5	• Difficult to update	Software
CHS6	• Potential opportunities for improvement: Linking activities and move of individual activities	Software
CHS7	• Limitation for night shifts	Software
CHS8	• No disadvantage. Touchplan is perfect.	
CLU1	• Do not implement strict PPC • LPS does not include critical path	Implementation
CLU2	• No Negatives	Software
CLU3	• When finished earlier, still have to justify and being questioned why? • Cannot visualize site	Software
CLU4	• Promised tickets can still be deleted or changed • Cannot trace tickets	Software and human error
CLU5	• Too clunky to use as a booking tool. • Cannot accommodate fast changes on-site. • Doesn't allow easy update (compared to an Excel sheet)	Software
CLU6	Too much effort to update for signalling work	Process
CLU7	The reporting/ backtracking function is missing from Touchplan.	Software
CLU9	• Prefers whiteboard the old-school way, uses it as his work bible (put in his own words on whiteboard), as being not tech-savvy	
CLU10	• Better to have time slots if want to integrate resources utilisation in Touchplan	Software

No.	Disadvantage/limitation	Category
CLU11	• Limitation of visual site. Need to be able to see that landscape so the ticket can talk to the picture • the swim lane needs to be flexible for project areas	Software
OTH1	• No disadvantage. He is very positive about Touchplan	
OTH2	• cannot break down work into small activities in Touchplan otherwise congested so much and too much info, hence whiteboard is still useful and be needed	software

Note: CLU8 made no comments on this matter.

Lack of the current situation awareness

The most noticeable limitation of Touchplan from the software perspective is that the tickets cannot talk to the tasks in the context of the site environment (CLU11). McHugh et al. (2021) described this as ambiguity and a lack of awareness of the current situation, which can be supported by the collection of and access to multiple picture files and real-time images. Although two screens are set up, one projecting the Touchplan screen and the other with Propeller images in the (VMC) meeting room, the interviewees expect more advanced visual features. CLU11 noted: *"Ideally, you'd have Touchplan at the base of it, and maybe a Propeller image of the site on top. And then you could go and write this, so you're only working off one screen, so you don't need to go to one person and just run the main and say, let's click on this one ticket. This specific photo comes up as you click on the ticket."* At the moment, there is no better solution to integrate the two pieces of software.

It is common to have multiple screens in overseas projects. One example is from MACE Ireland. As Figure 9 illustrates, the setup in their big room for collaborative meetings comprising master plan (VisiLean), 3D model, and associated drawings. The implications for WPA are perhaps to increase the numbers of screens to three with

- Touchplan showing the plans;
- Propeller showing the site images;
- drawings.
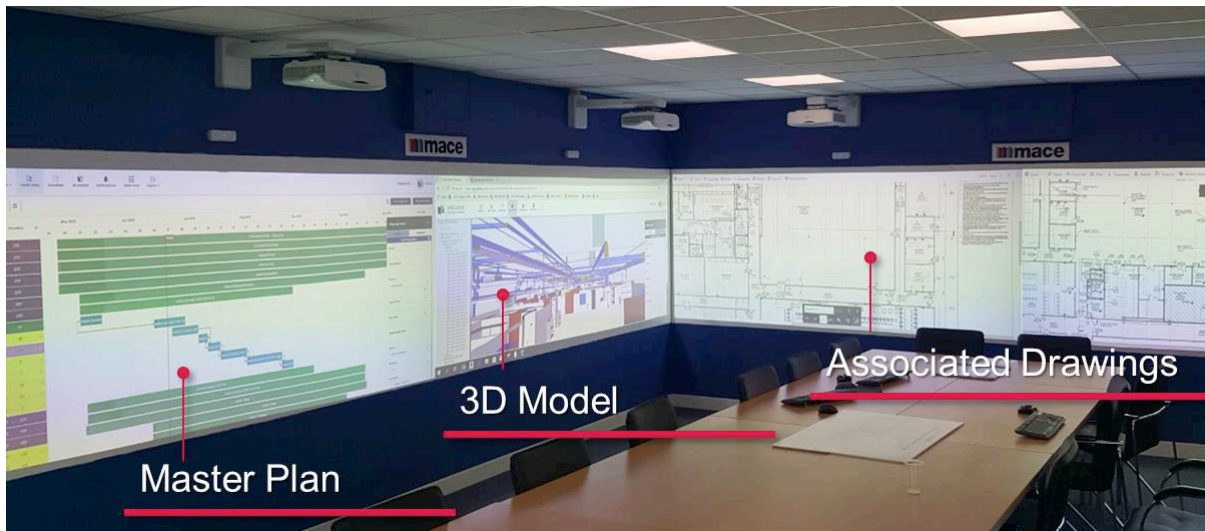
Figure 9: Picture of digital display room setup, having plan and 3D model side by side along with the associated drawings. Source: McHugh et al. (2019).

Moreover, a recent webinar titled "How combining technology can help you lead a jobsite" (Link) discussed the very limitation described by one panel member as "pain in butt" to have two screens side by side or that tickets do not talk to the picture. The webinar showed the integration of Touchplan and another piece of software, OpenSpace, side by side (see Figure 10) which seems to be a recent development. Further improvements are expected, for example:

- The ticket should have a hyperlink that pops up showing a location picture.
- This may also facilitate excellent daily reporting with a list of activities, but also photos.
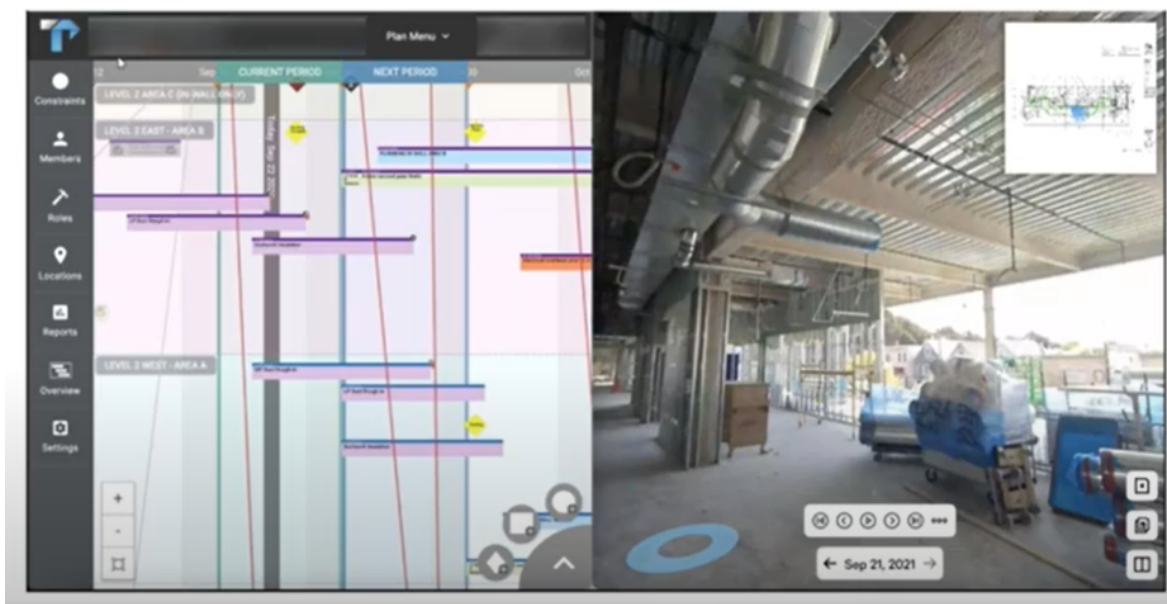
Figure 10: A snapshot of Touchplan and Openspace

Updating and tracking

Another issue is related to updating Touchplan (CHS5 and CLU5-7). It was noted by interviewees that they find it is either difficult to update or that too much effort is required to update tickets for a particular trade/discipline (signalling work). These interviewees pointed out that the work on site may change a lot throughout the week. Therefore, information in the tickets promised is often required to be updated to accomplish the newly updated program. Compared to an Excel sheet, CLU5 noted that Touchplan does not allow for easy and fast updating. This is perhaps because once the tickets are "locked"/committed, it leaves very little room for change, or perhaps because they are not fully trained on Touchplan's reporting function, which can be used to extract "reporting" information. CLU6 also emphasised that for the signalling work, updating becomes very challenging. Given that the current swim lanes are location-based, signalling work is separated in all six different construction areas, which results in a large number of tickets. As highlighted by CHS5, manual update of each ticket is expected when the program or activity is changed, which again indicates that more effort is required. Because of this, several engineers prefer to explore a separate reporting tool and turn to Excel sheets to keep the necessary changes, which are easier to update.

Human error

Another feedback regarding limitations is that human errors would occur in creating tickets: "accidentally move tickets" and "promised tickets can still be deleted or changed". The former can be unintentional, but the latter sounds deliberate. Therefore, it is advised to:

- set some DO-and-DON'T rules for tickets and make it consistent
- create or maintain a no-blame culture that encourages exposing problems. Promised tickets being deleted or changed also reflects that whoever is doing this wants to hide the problem instead of revealing it
- compile a "common-mistake-in-Touchplan" reference so end users can potentially find a solution on their own.

Whiteboards

In most supervisors'/superintendents' offices and meeting rooms, a whiteboard is left with some notes on it (see Figure 11). A few end users noted that the team still "prefer" the whiteboards for numbers of reasons:

- For detailed planning, and it is "*much easier and quicker to use*".
- I am old-school, not tech-savvy.
- My own notes go there, sometimes serving as a reminder.
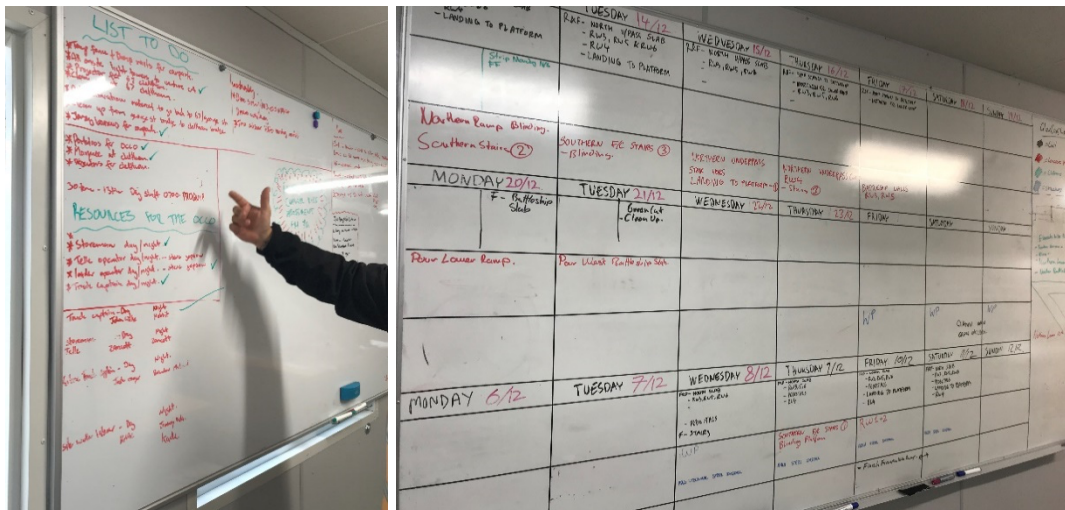
Figure 11: Various whiteboards at CLU (left) and Aviation 2(right)

Admittedly, the old whiteboard system is appealing, as it is a more conventional way of making plans and also it brings people in front of whiteboards to discuss issues.

"I do not think this little side wide things that are needed to be put into Touchplan. Like this sort of stuff in resource, that is my own personal 'Touchplan', my second brain here, as we are quite busy on-site every day. So, when we refer to this, oh yeah, that's all I had to do that. So reminder of things that we need to organize" – CLU9.

The resource manager also provided his opinion on the whiteboard he used.

"with plan, you have to break down when they need to be aware of what time, if you look in the resource swim lane in Touchplan, it is all just jumbled up. It is not in any sort of order. This is because everyone just adds their tickets, they are what they need. And then me or Dale will decide to put it in an order that works. So, we still need an avenue outside of Touchplan to do that, which is our whiteboard." – CLU10

"Additionally, to benefit the operator, they do not have access to Touchplan, so we will add something for operator when they need something on the whiteboards." – CLU10

Planning on a whiteboard may differ from planning in Touchplan and lead to confusion if both methods are used on the job site. At CLU, particularly in look-ahead planning, discussions in front of a whiteboard form the basis for engineers to develop digital tickets; however, this process should be the other way around. We suggest that the CLU crew consider the following for future projects:

- Not using the whiteboard as a single source of truth and instead use Touchplan as such.

- Using one to feed into the other is "double-handling" information, which, from a lean thinking perspective, is wasteful. Ideally, should be a single planning system: Touchplan.

- However, knowing some site crew and operators are not tech savvy and are unable to access Touchplan, and that for many years the whiteboard has become a "safe" place for non-tech-savvy individuals on-site, it is not advisable to completely remove it.

- CLU11 jokingly acknowledged that if people were not tech-savvy we would put good engineers around them. This could be strategy worth thinking about in terms of assembling a team.

- When using the whiteboard together with Touchplan, if some CLU interviewees note personal notes, too much information could overwhelm the tickets, etc. Hence, whiteboard could be a venue for those personal side notes.

Limitations for occupation

This was voiced by an end-user who had experience with extensive occupation work when there would be multiple shifts daily and a need to plan activities at an hourly level. Several interviewees noted that Touchplan cannot accommodate extensive occupation work, and that when detailed planning is required, people revert to the whiteboard.

4.6.6 Recommendations to improve project performance

The research team recommends that the project manager who seeks to improve **project schedule performance** should address practice as follows:

- Visualise sufficient schedule-related information.
- Have appropriate meeting content and appropriate participants in meetings.
- Verify the necessary schedule-related information before adding it to digital tickets.
- Maintain sufficient and consistent interaction with subcontractors/supervisors to obtain schedule-related information.

To improve **project cost** performance:

- Appoint a dedicated resource manager.
- Have clear visibility of resource requests pulled from the ground from look-ahead on a weekly and daily basis.
- Have effective communication between the resource manager and the team.
- Have effective collaboration during the scheduling process.

The following practices for improving project **quality and safety** performance are recommended:

- Visualise sufficient schedule-related information.
- Have appropriate participants in meetings, safety, and quality professionals.
- Make the schedule support a project culture associated with accountability, collaboration, and build-in quality first-time (no rush to do the work).
- Ensure there are sufficient opportunities to gather volume, quantity, or productivity rate for consideration.

On individual's behaviour, where communication, commitment and problem-solving are rated the most visible behaviour changes, the team recommends the following practices to maintain and reinforce such behaviours:

- Make the schedule support a project culture associated with collaboration, commitment and problem-solving.
- Have clear schedule visibility among project stakeholders (transparency).
- Have sufficient schedule-related information to gauge performance.
- Maintain sufficient and consistent interaction with project stakeholders (communication).
- Maintain clear communication channels.
- Have an effective communication plan.
- Have effective collaboration during the scheduling process.

Also, the research team should prioritise those less-mentioned but equally important behaviours.

- Provide training on various problem-solving methods, especially on problem identification.
- Maintain regular catch-up/training and other forms of support to improve Last Planners' ability and be more confident in their planning ability.
- Make the schedule support a project culture associated with accountability.

4.7 Roll out LPS for future projects

The last section combines responses from the interview questions on:

- what are the critical success factors that drive successful implementation of LPS/Touchplan;
- what support is available and needed to improve future implementation of LPS/Touchplan;
- general suggestions for future roll-out.

4.7.1 Successful initiative

When asked if they thought the LPS implementation was a success, in general, all interviewees at Cherry Street noted a positive YES. The majority at CLU also agreed that it is a successful initiative, except for some slight reservations from a few interviewees, which are listed below:

- CLU4 (site engineer) indicated a "maybe", noting that Touchplan should not be used as a booking tool.
- CLU7 (junior engineer) indicated "yes to a degree", noting that Touchplan performs its function but that there are many areas where it could improve.
- CLU8 (supervisor) commented that it was "not a failure", noting that "*it has a good start, and gets better as more people use it, embrace it and learn the functionality of it*".

4.7.2 CSF

Given the overwhelmingly positive perception of the introduction of Touchplan, the follow-up question was: *What enables the success of such an initiative?* hoping to identify the critical **success factors (CSF)** that supported the LPS/Touchplan implementation thus far. Table 11 lists the factors that emerged from interviewees' responses. There is no weighing attached to it, but the frequency recorded at the bottom row of the Table showed which are more significant ones than others. The following paragraphs describe the most significant ones mentioned most by interviewees. Details can be found in Appendix 9.

Table 11: CSF

No.	Commitment	Champion	Trust	Support	Buy-in	Less interface	Team efforts	Touchplan itself
CHS1								
CHS2		x						
CHS3	x							
CHS4		x	x	x				x
CHS5		x		x	x			
CHS6				x	x			x

No.	Commitment	Champion	Trust	Support	Buy-in	Less interface	Team efforts	Touchplan itself
CHS7		x			x			
CHS8								x
CLU1				x				x
CLU2		x			x		x	x
CLU3	x				x		x	
CLU4								x
CLU5								x
CLU6								x
CLU7								x
CLU8	x							
CLU9						x		
CLU10	-	-	-	-	-		-	-
CLU11							x	
OTH1							x	x
OTH2	-	-	-	-	-		-	-
Total	3	5	1	4	5	1	4	10

Note: CLU10 and OTH2 did not comment on CSF.

Champions

Having a champion (or champions) was the top CSF suggestion of CHS interviewees. The Cherry Street project's superintendent (Jason Harms) was applauded as a passionate champion and strong believer in LPS/Touchplan. More than half of the interviewees mentioned Jason's name when answering this question.

"having a champion to drive, follow the process" – CHS2.

"Jason drives it well" – CHS4

"Jason firm on implementation, being supportive" – CHS5.

"Jason's passion for it really drives the whole system. Jason managed all the resistance from engineers". – CHS7

"Jason also trains late entrants" – CHS5

These comments define the key qualities of an LPS champion.

- Be able to drive the implementation and be firm on the implementation.
- Be able to manage resistance.
- Lead by example.
- Be able to pass the knowledge on to team members, including late entrants.
- Be approachable for catch-ups.

Organisational support

Apart from the champion driving the implementation on the ground, support from the organisation is also essential. Phil Hendy oversees the roll-out of Touchplan across all WPA projects, and his support represents the organisational support. His support in the beginning,

helping the team set up the use of Touchplan, is of particular importance, and his continuous support along the way is crucial.

"Phil provides support" – CHS4

"Phil and Jason provide support to the whole team" – CHS6

"Phil set up a couple sessions with the developers" – CLU1

"I was on the phone with him (Phil) more or less daily when we first started Touchplan at CLU" – CLU11

"Leave Phil to generate reports"

It seems there was an over-reliance on Phil supporting LPS on projects and JH in the CHS project. The site will quickly slip back to how they previously planned things if these key people's support didn't exist. The absence of best-practice guidelines and an implementation health check was a barrier which, if resolved, could provide an implementation roadmap, consistency, and remove the reliance on the lean team. Based on benchmark and Appendix 10, the future roll-out should consider developing a list of key elements of LPS health check.

Buy-ins

The next CSF is the buy-in from the ground. This was echoed by many interviewees, including:

"buy-in from our supervisory team, and engineers as well." – CHS6

"resistant from the team at the start but after seeing the results, all settled." – CHS5

"People are committed." – CHS3

"initially some resistance from the engineers." – OTH2

Several interviewees noted that at the start it was not easy because of resistance. However, one of the resolutions to overcome resistance and get the team's buy-in is to demonstrate the benefits of using Touchplan to them and make end users of Touchplan understand the benefits.

Team efforts

Team efforts were also acknowledged, thanks to Touchplan, which allows everyone to be involved and plan the works on the digital platform. As one interviewee noted, *"this is the platform that allows everyone to contribute; everyone in the team should put tickets in"* (OTH1). In Touchplan's dashboard, the team's participation and activities are visible. In CLU there are eight team members who had developed more than 100 tickets. There are other indicators,

such as "ticket update" and "plan views", which are useful indicators demonstrating the team's engagement and contribution.

"Everyone can understand benefits of Touchplan and put efforts into it" – CLU2
"Everyone put efforts to the success" – CLU3
"Most of them put into effort in structuring their activities." – CHS6
"Put strong engineers around people are not too tech savvy" – CLU11

Touchplan software itself

The Touchplan software itself was another CSF, particularly with CLU interviewees, where the conversation on CSF is more focused on the features of Touchplan from an end-user perspective. It has been highlighted that: *"All the good advantages of Touchplan contribute to the success of implementation"* – CHS8. A closer examination of the comments on the technology, that feature that end-user perceived as success factors are:

Easy to use
"the *offline environments* so that we could start practising it and getting it right" – CLU1

"Easy interface to use for most of the team member. No need of huge amount of training." - CHS6

Show benefits quickly
"Everyone can understand *benefits* of Touchplan…" – CLU2

"Activities from different teams are all visible in Touchplan" – CLU6

Functioning
"as long as it is *doing its work*" – CLU3

"does its *function*, but lots of areas to improve on" – CLU7

Facilitate behavioural change
"could *make people accountable* for their scope and resources booked in … could use it for interfaces" – CLU6.

"Not too much interfaces as there is more communication with engineers" – CLU9

4.7.3 Supports already in place and for future

The research team also investigated what support is already available and what support is required for future roll-out. There are **TWO** broad forms of support made available: training and catch-ups. Details are in Appendix 10.

Training

Perceptions vary across different levels in projects (see Table 12).

Table 12: perceptions/experience about training

Superintendent/ supervisors	Engineers (i.e. Site engineers/junior engineers)
Coached by Phil/WPA guys/Touchplan guys – CHS1	Not aware of training; not aware of LPS guide – CHS2
	Not sure what support is available.
Initial support from Phil, together with Jason, who talks about adding tickets and does constraints; Jason also trains late entrants – CHS5	No training for me. But can apply to get training from innovation manager. Just read a guide and went ahead, self-explanatory – CLU2
Intro to what LPS is and then focus on software training – CHS7	Not aware of any. Not formally trained; only briefed by manager CLU3
Late entrant – will do some basic training – CHS8	Some people showed me how to add tickets – CLU8
Some training and guidelines; teach new engineers how to use Touchplan - CLU4	
Some Touchplan training that happened early on – CLU6	
Some formal training previously – CLU7	
I haven't had any training on Touchplan. Only engineers showed him what to do in Touchplan. Just from engineers show me how to use it. I have had seen some emails about it over the last year and a half. But I am busy to get to one of the sessions – CLU9	
I didn't get any training from anyone. I am able to do all I need to do on it. So, if I needed to do anything further, I'd probably look for the training. I just need to know how to add a ticket and show that it is been completed as planned. – CLU10	
Phil set up a few training sessions, initially a couple of hours, every two days, and breakaway to weekly. And same training session for supervisors and engineers. When the team become self-sufficient the team will train the rest – CLU11	

This infers that although there was training provided, the level of penetration differs. Whereas the managerial level may well receive the necessary training, the junior/site engineers, who

are the ones adding the tickets, did not received enough training. Instead, CLU adopted a people-train-people strategy assuming that first, Touchplan is self-explanatory and easy to use, and second, that the engineers may only need to know how to add the tickets as their primary function, not necessarily the advanced features.

In an interview with Touchplan's staff (USA), the following training and onboarding opportunities, which are broken down into three steps, were highlighted:

- Admin user[2] onboarding: an hour-long training for admin users on the project.
- Project setup call: to discuss the breakdown of the phase plans within their project.
- Basic user[3] training: 30-minute training sessions. Two key areas of focus: (1) how to create and prepare digital sticky notes in Touchplan before a collaborative planning session, and (2) plan and check the completed activities off and make it complete.

Other than that, there is additional support:

- weekly trade partner webinars (every Tuesday)
- recurring basic user training in Australia time, on a biweekly basis, but not getting the attendance that they expected. Currently paused.

Another interview with an LPS practitioner from **Norway** should be noted:

- The company has a department which is for Lean Construction, works with Lean Construction, and they go out and help projects get started. The project can get in touch with them and seek training help.
- There was one day where it was just a full day's workshop, an introduction to what the Last Planner System is in general. Had those LEGO games.
- A few workshops specific to developing the milestone plan, and that connected with exactly the project.
- Some process mapping is also included.
- For the first a few weeks, say five or six weeks in the beginning, the trainer will be here every time to be involved in various LPS meetings.
- After that, the project team took over.
- An engineer got involved in running that to keep the process going.
- Over the course of a few months, the people from the Lean Construction department (HQ) will pop in every now and then just to check how the project is going.

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[2] Admin users are essentially facilitators of collaborative planning sessions.
[3] Basic users are subcontractors and trade partners, but in WPA contexts, basic users are also engineers.

- When confirm it is running, they did not need to get involved too often.

Catch-ups

Regular catch-up were mentioned by several interviewees from both projects.

"Phil organises regular session to check the use of Touchplan and potential opportunities for improvement" – CHS6.

"Regular catch-ups and some formal training previously" – CLU7

4.7.4 What support may be required

When asked what other support is required for the future, most interviewees commented on this indicating that something could be done to improve the implementation of LPS across WPA projects. Table 13 provides a summary.

Table 13: More support needed

No.	More trainings	Site visits and best practices	Support and tips from phil and his team	Buy-in from everyone	Workshop and session to gain support	Make it business as usual	Discussion with all key construction leaders
CHS1	x	x	x			x	x
CHS2	x	x					
CHS3	x						
CHS4	x						
CHS5				x			
CHS6		x			x		
CHS7		x					
CHS8							
CLU1							
CLU2					x		
CLU3	x						
CLU4		x					
CLU5						x	
CLU6		x					
CLU7	x				x		
CLU8	x	x					
CLU9	x						
CLU10	x						
CLU11	x		x				
OTH1				x			
OTH2	x						
Total	**11**	**7**	**2**	**2**	**3**	**2**	**1**

More training

From superintendents to engineers, there is a consensus that more training is desired. The training is expected to be formal, sufficient, basic, and targeted. Those motivated Touchplan end users such as CLU3 and CLU8 expected to learn all the features of Touchplan, including the high-level advanced functionality.

"a more formal approach is needed to train new staff, and internal and external users, as well as subcontractors." – CHS2

"at least 30-minute session to learn about Touchplan" – CHS3

"more on training, especially for experienced staff to minimise their resistance to change" – CHS4.

"need formal training and learn all Touchplan features" – CLU3

"some basic training of how to use it to everyone will do. People who want to learn more can learn more high-level functions." – CLU8.

Recommendation
- There should be prerequisite or induction-styled training on the use of Touchplan.
- People-train-people seems to prepare the new entrant to be onboarded fairly quickly, but just knowing how to create the tickets in Touchplan without knowledge of other features of LPS/Touchplan is far from being competent at working with Touchplan and getting the best out of it.

Site visits and best practices

Site visits and sharing best practices were also strongly agreed upon. A few typical comments include:
"See actions from another project, dial into Touchplan session in another ongoing project" – CHS6.

"hear from people involved in the project the whole way. See what other people thinks that contribute to the success will be interesting" – CHS7.

4.7.5 Rolling out strategies

Interviewees were also probed for their perceptions of the strategies for future roll-out of Touchplan/LPS across WPA's future projects (see Appendix 11). Generally speaking, the strategies collected from the interviewees fall into three areas: people, process, and technology.

People

- Leaders – know how to use the system and see the benefits in the system.
- Champion – require a champion and other people follow.
- Team members – have the team members who are going to be running the project together. Spend time with the right people so that they're trained and know how to use LPS/Touchplan, and then get their buy-in.
- Key personnel – supervisors who run the meetings and engineers to take care of the engineer side of things. PE/other engineers can assist/help with their site.
- Everyone – everyone needs to be accountable for what they are doing, especially in supporting roles such as resource manager, where his work ties in to make everyone' job easier. The supporting roles do not expect to not have any feedback or not have any accountability.
- Subtractors – needs wider implementation in the industry, especially at subcontractor levels.

Process

- Before the project
    - Have a plan to start the project off rather than doing it midway through; needs to be done at start.
    - Training and Touchplan workshop before start to demonstrate best practices.
    - When we train the team, they're trained in the way we want it to run.
    - Make sure that this is budget in.

- A structure in place
    - Need to set a structure. There is no **standard** structure for Touchplan implementation across projects.
    - Meeting style should be redesigned, as there are currently too many meetings.
    - Adapt to sui; for example, being in a rail environment, there are different controls, bookings and things that you have to do (e.g. the job pack system).
    - Support at the start to stay in the right direction.

- Dos and Don'ts
    - Ensure all parties use Touchplan. To include all construction activities, kick off meeting, training for all team members, set expectations, and be consistent.
    - Should not use as a booking tool.

        o   "Ban the whiteboard and force people to use it"

Technology

- Show 24-hour planning if possible.
- See some further depth and details in the system.
- Make the program a lot easier and more user friendly for the non-tech-savvy people to use and understand a bit better.
- Import mud map into Touchplan.
- Have integration with P6.
- Breaking the master P6 program into Touchplan but with occupations scheduled for three weekends, a week, and then a month. This is hard.
- Improve the program itself to allow standard input of tickets.
- Use the full functionality of Touchplan.
- Put more emphasis on statistical parts.

The strategies fall under the technology group indicate variety of expectations that WPA could potentially address in future roll out: (1) Build more support around those lack digital competence; (2) Provide more training/workshop for those wanting to explore further and learn more functionality of Touchplan; (3) For those wanting to have more reality awareness, and integration with P6, there is no quick solution to that quest. Alternative suggestions are made in recommendation 6 – continue to invest in digitising the construction process.

5. Recommendations

Recommendation 1 – Setup and preparation

Appoint an LPS champion

It is crucial for a construction firm to appoint a person (or team) who will champion the implementation process who is committed and who will drive and oversee the implementation of the LPS plan. The champion needs to hold a "managerial" position, who must have authority and be accountable for the effectiveness of the LPS practice implemented. This creates employee confidence in the implementation agenda.

Set up a team committed to LPS (get buy-in)

Often people felt that when there is champion in the team, people will follow, and getting the team's buy-in is also key. "Buy-in" was acknowledged as a critical success factor that drives the successful implementation of LPS/Touchplan adoption, and lack of it was noted as a challenge. The case studies of CLU and CHS have shown that there was always resistance in the beginning. Spend time not only with the right people in the team to develop their competence and commitment but also work with the less committed, resistant ones. One good approach is that champions lead by example and also provide support to foster employee confidence in transiting to Touchplan. They also offer training support.

Have a step-by-step guide in place

It is encouraging that WPA has already had the **Touchplan/LPS onboard procedure**. This is a very good starting point, but many of the interviewees are not aware of this internal document. To address one of the interviewees' suggestions, "adapt to suit" styled implementation, it would be good to have a step-by-step LPS execution plan/guide for the project that takes into account the *uniqueness* of the project and incorporates useful lessons learned from previous projects (e.g., swim lanes, integrating propeller (mud map), etc.).

Set expectations

- Carefully consider the responsibilities of "last planners" when developing site organisation charts for projects in terms of their roles and responsibilities. For new employees, especially those who will be potentially identified as last planner, before onboard to projects, their role and responsibilities should be specified in their job description (i.e., what they are expected to do as a last planner).
- Acknowledge what Touchplan can offer and what Touchplan cannot offer. Provide guide/support to minimise the limitations of Touchplan.

Recommendation 2 – Training and skills development

Upskilling employees is a priority for construction companies in their journey from the conventional method of working to using digital tools; in this case, planning and programming. Our observation is that people with significant time and knowledge on-site haven't always been trained with the necessary digital skills that are needed to comprehend the digitalised LPS exercise. Attention needs to be paid to helping employees adapt to new processes and the introduction of software. Creating opportunities for employees to take the initiative in learning about the Lean, Last Planner, and Touchplan is also critical. To this end, companies should design training to be the way the leadership want the Touchplan/LPS to suit the project and to run.

Provide training based on employee Lean and digital competence levels

Employees need to be equipped with the generic, role-specific competencies, and skills of LPS/Touchplan.

- Continue to subscribe to Touchplan's basic training for all team members, and possibly extend it to subcontractors and partners.
- Make sure that this is budget in to give access of Touchplan to subcontractors.
- Not everyone needs to know everything, but all team members should gain competence in the use of certain basic features of Touchplan: adding tickets, updating tickets, and understanding swim lanes, for example.
- Make the training on advanced features (i.e., the statistical part of Touchplan/LPS) available. Encourage engineers/supervision team to go for it.
- Training on LPS methods is also needed, and the following topics are relevant and highly desired:
    a. pull planning;
    b. constraint ID and removal;
    c. problem-solving and PDCA;
    d. visual management

Workshops

- Conducting a workshop on LPS would be valuable to prepare the project with a basic understanding of LPS principles and methods.
- Hold a Touchplan workshop *before* the start of a project to demonstrate best practices, further depth, and details in LPS and Touchplan.

- The project teams should consider having leadership team meetings or workshops to discuss LPS execution plan, strategies, communication plan, and other important topics.

Recommendation 3 – Grow together with subcontractors

Construction firms need to ensure their supply chain has the necessary skills and capabilities to deliver a project, together with the main contractor, using a collaborative planning approach. Although in WPA project, there are close to half who are self-performing employment, they still engage with the other half, who are subcontractors of various sizes. Not all of the firms WPA working with their supplier network will have such capabilities and understanding of Lean/LPS, and WPA may need to support their supply chain to develop these capabilities. This may involve WPA helping to equip subcontractors so that they can use the same or similar hardware and software or tool when working in WPA using Touchplan. The lean-thinking approach reminds us that a "growing together" approach may be valuable here to build and upskill a supplier network with the ability to work on projects using Touchplan. The research team recommends adopting a supportive approach:

- Be transparent – invite the relevant subcontractors to short-term planning meetings as well as look-ahead meetings.
- Be accessible – give them access to Touchplan.
- Be collaborative – engineers to coordinate them and assist them to develop digital tickets in Touchplan.
- Be supportive – involves hosting workshops, training sessions, and site visits to learn their challenges and offer training support.
- Be firm – for large subcontractors involved in the collaborative planning, it may be worth "trailing" mandate elements of the LPS/Touchplan as part of the agreement with these able subcontractors.

Recommendation 4 – Robust structure for communication and conversation

By now, we all know LPS is a collaborative planning tool. Alan Mossman described the five planning sessions of LPS as five key conversations. The findings uncovered how the two WPA projects run LPS/Touchplan meetings. As interviewees noted, *"we want to see some further depth and details in the system"* and "*meeting style should be redesigned, as currently too many meetings*". It is worth developing a structure that will facilitate effective communication and collaboration both internally and with subcontractor networks. Our recommendations are made in the following areas:

Standardise the "tickets"

Tickets play an important role in facilitating the collaborative planning. Adding tickets by engineers triggers communications and collaboration between among members. There was one comment noting that there are "*no guidelines for how to populate ticket information*", although the development of the digital ticket is self-explanatory. This was a question asked during the interview. A summary of current practice can be found in Appendix 12. To address this, it is worthwhile establishing guidelines on standardising what should go onto the tickets, including constraint tickets.

Communication routines

From the interviews, we mapped out the communication routines and mechanisms that support LPS planning sessions at both projects (see Appendix 13). It is evident that the communication mechanism at the Cherry street project is more established, whereas there are a few missing links at CLU. We suggest that the project team be aware of communication routines and mechanisms that support collaborative planning, and it could be articulated in a communication plan.

Redesign the meetings

We mapped out the two meeting structures at the Cherry Street and CLU projects (see Appendix 14). We suggest a template of such should be made available for future projects, but customisation should be built in to suit the project. This is complementary to what has been indicated in Section 5.2, Meeting Details of the **LPS procedures (WPA)**.

Last planners in clusters

The future roll-out could consider the establishment of individual cluster groups (see Figure 12 below), who can meet and develop medium- and short-term plans by creating tickets in Touchplan. It is clear that communication and collaboration between engineers and supervisors has been established. However, the cluster setup will enable them to work even more closely. Each cluster/team leader should then report their team progress to the construction manager and superintendent during the weekly meeting.

- The cluster leader can be a project engineer (from the construction management team) or supervisor (from the superintendent team).
- Site engineers and junior engineers are under each cluster and known as last planners.
- A cluster can be discipline or swim-lane based.
- Each cluster group will perform look-ahead and weekly planning and identify constraints.

- Each cluster leader should then report cluster progress during VMC meetings.
- The master programme will need to be updated regularly in a meeting involving various cluster groups.
- The superintendent or construction manager will monitor the overall process.
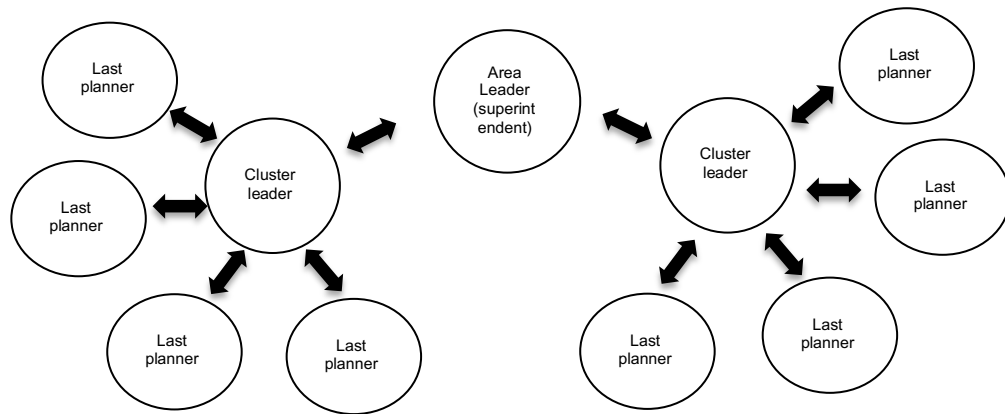
Figure 12: Last Planner in cluster.

Recommendation 5 – Systematic implementation

Ballard and Tommelein (2021), In the report titled *2020 current process benchmark of LPS* noted "*LPS is a system of interconnected parts. Omission of a part destroys the system's ability to accomplish its functions*." Having observed the implementation of LPS at the WPA projects, we recommend that future roll-out should maintain what has been consistently adopted (strengths) and find ways to address the least-implemented components of LPS, such as "pull planning" via Touchplan, learning from breakdowns, and others. We have made specific recommendations on each component of LPS (see **Section 4.5**).

Further, future roll-out should introduce an evaluation framework to regularly assess conformity with the elements of LPS. The idea is to surface the least implemented area and strategies

Recommendation 6 – Continue to investing in digitalising the construction process

Touchplan was selected as the digital tool to facilitate the use of collaborative planning in the WPA project and to improve planning efficiency. A large number of interviewees like it and support the implementation; however, a few limitations of Touchplan were exposed and it is hoped these can be addressed in future use. These include:
- Import mud map into Touchplan.
- Integrate Touchplan with P6.

The Toyota Way principle reminds us that using technology should be thoroughly proven to be beneficial to the process and to people, and Touchplan has passed this test. Even if there are limitations, we should be hopeful that the development of Touchplan should address these, and linking OpenSpace is one such example. Meanwhile, having the Touchplan screen alongside the Propeller screen should do the job. We recommend that:

- A guide on how to maximise the integration of Touchplan and Propeller images should be provided to the team.
- Worth considering the setup of a third screen in VMC room to projecting associate drawings

As for the integration of P6, Touchplan and P6 are very different software serving different purposes. The former is for the short term, whereas the latter is for longer-term planning. One thing that they have in common is work activities. The WPA project team should investigate the importance of work breakdown structure (WBS) and WBS method and find a way to develop an inventory of predetermined activities for different work scopes and/or trades. This can be potentially incorporated into the job pack so that the project team can refer to it and help them to understand not only how to develop a task with proper naming and contents but also the interfaces of work activities (i.e., naming, etc.). A good example of this is Lendlease (USA), which, although in the building sector, developed a list of 6000+ activities using the WBS method for a typical healthcare project.

Alternatively, the project team is expected to be more diligent when updating changes from the medium/short planning onto the master/milestone plan. This is an important part but often tedious and time consuming. This calls for even closer collaboration between planners and engineers. A communication plan might be needed to clarify when, how often, and what questions should be addressed.

Recommendation 7 – "COLLABORATIVE PLANNING" as clause in the contract
From the interviews, it is clear that the P6 schedules are still very much viewed as documents that need to be produced and submitted to the owner to address compliance with the contract and serve as a baseline for progress and payment monitoring. We recommend that clauses associated with schedule development in the contract between the owner and WPA or WPA and subcontractors should be developed in a more participatory environment, including different tools and methods to support its development, in the hope that the schedule is not

recognised solely as a compliance document but instead evolves as participants give input to its constant development. A few example clauses are shown below:

- Parties shall jointly develop the schedule, the target cost, project goals, and definitions.
- The core group shall engage in and meet regularly.
- The team shall employ pull planning to develop the schedule, collaboratively developing weekly work plans that are used to track progress.
- Constructability and work structuring are part of the process of collaboratively designing the project and planning its execution (which impacts work packages and the flow of activities in the schedules).
- Activities and processes from multiple stakeholders are included in the schedule and submitted for review, validation, and approval by the core group.

6. Conclusion

6.1 Summary

In closing, consider again the essential question of the study: What are the strategies for improvement of LPS roll-out? The research team addressed these questions, along with additional research questions and outcomes, with the help of participation of three main groups:

- 75 survey respondents interacted with the survey, from whom the team obtained 43 usable responses representing all WPA projects.
- 21 end users of Touchplan participated in 21 interviews, totalling 1260 minutes of interview time, 19 of whom were from two WPA projects: CHS and CLU.
- Several other experts and international LPS practitioners from Norway, the Republic of Ireland and the U.S. were also interviewed, as well as representatives from software providers such as VisiLean and Touchplan.

From its interaction with this diverse set of industry participants, the research team was able to pursue the following research questions:

Research Question RQ1: What are the barriers and challenges to LPS adoption?

Outcome 1: A list of challenges were surveyed among WPA participants. What emerged as the key challenges included "little support from supply chain partners", "resource levelling", "staff turnover", etc. The results suggest that some LPS elements were inconsistently implemented. The interviews provided additional context for the limitation of LPS, and the primary challenges were Touchplan-related, such as lack of site image integration, hard to update and track, human error, limitation for occupation, and cannot get rid of whiteboard. These challenges mainly occurred at CLU.

Research Question RQ2: What is the relationship of project performance to LPS practice?

Outcome 2: Similarly, a list of benefits was surveyed among WPA participants. The top five were:

1) improved planning transparency
2) improved communication and coordination between project participants
3) increased awareness of task dependencies
4) improved collaboration and cooperation between project participants
5) improved planning and control reliability

This question was revisited in the interviews, and were validated. Further, the interview results extend the benefits to business KPIs with several last planners acknowledging that roll-out of

LPS/Touchplan does have a positive and direct impact on schedule, cost, OHS, and quality of performance.

Research Question RQ3: What project characteristics are essential for the successful execution of the LPS?

Outcome 3: An inventory of drivers, critical success factors, and barriers to implementation of LPS this is specifically for WPA projects. These factors define what characteristics are essential for the execution of the LPS.

Research Question RQ4: How can we improve on the implementation of LPS for future projects?

Outcome 4: We have gathered a few thoughts from the ground (i.e. last planers and end-users of Touchplan for future rollout). We also interviewed several experts from overseas. Finally, the team combined the results and outcomes in this report. We offer seven recommendations.

6.2 Moving forward within WPA

Moving forward, as WPA seek to achieve higher maturity levels of collaborative planning in the form of rolling out LPS and Touchplan, the research team also recommend the development of a maturity model as a team exercise for project members to score their projects and learn which areas of their efforts might be lagging.

6.3 Moving forward as an industry

This study sheds light on how LPS has been interpreted and applied in an Australian context through large infrastructure projects. It supports previous studies available in the literature at large that have to apply LPS or collaborative delivery of projects. However, unlike previous studies found in the literature, the findings herein are based on "last planners'" experience using the software – Touchplan without knowing what LPS is. The study aims to identify gaps between the use of LPS from the ground (LPS as done) and the LPS method (LPS as benchmarked) in terms of implementation. The study also identified the benefits of and challenges in using LPS. Lastly, roll-out strategies were formulated. All strategies support WPA, as they have already embarked on their journey towards more collaborative environments and, more specifically, hope to carry this out across all WPA projects and make the necessary improvements.

Questions still remain as to why some of the elements of LPS are not consistently being used, despite survey respondents and interview findings indicating that these practices, which are

part and parcel of LPS, have had a great impact. How these inconsistences in implementation can be addressed and how the challenges of implementation are handled it will be incumbent on industry practitioners and LPS champions to continue sharing experiences and positive outcomes of collaborative scheduling through the digital platform to reinforce the need for these practices and the benefits derived from them.

The scheduling process is ripe with the potential to be supported by digitalisation. This has been voiced by interviewees who hope to see a merging of images from Drone as a background landscape, where digital tickets can pinpoint the exact location where an activity could be undertaken. The research team is hopeful this kind of vision will soon become a reality.

Further, a diligent effort is needed to address how data will be collected, processed and used to predict the reliability of project scheduling, perhaps through *machine learning* algorithms. Attempts were made by Soman and Molina-Solana (2022) to generate constraint free look-ahead schedule with machine learning framework. This has certainly not been discussed in this study, as the industry still has old-school practitioners who are slow to embrace technology, not to mention digitalisation.

7. Appendices

Appendix 1: Research proposal (Work Package 2)

Work package 2

Tasks: Carry out data collection, conduct interviews to complete two case studies (tentatively, the Cranbourne and Cherry Street projects) of current practice of utilising LPS in infrastructure projects.

Method and data requirements:

The method will be multiple explorative case studies. The data collection methods are listed in Table 14 with method in the left column and comments in the right column. The primary data sources are obtained through physical access to these two project sites and staff (Cranbourne and Cherry Street).

Table 14: Data collection methods

Method		Description
Primary data	Field notes	Observation, informal interviews, etc.
	Observations	Purpose is to understand the project dynamics, the adoption of LPS elements, and its fit in the environment.
	Questionnaire survey	Questionnaire survey among project participants, allowing them to report the benefits achieved, and constraints, barriers, and challenges to LPS adoption.
	Interviews	Proposed interview participants will be according to job position and experience within WPA; e.g., the scheduler, construction manager from principal contractor, supervisors, foreman of major subcontractors.
Secondary data	Master plan and phase plan	Primavera P6 – (WPA to provide)
	Look-ahead plan and weekly plan	Touchplan – (WPA to provide)
	Site diaries	(WPA to provide)
	Productivity data and others	(WPA to provide)

Secondary data will be supplied by the WPA team. As our last correspondence with WPA noted, UoM researchers will be given access to all necessary data inputs from LPS software (Touchplan), P6, site diaries, productivity data and other project performance data in order to make a proper evaluation of the application of LPS in both the Cranbourne and Cherry Street projects.

Step 1 – Document the current "version" of LPS being used in the two study projects: Multiple site visits, observations, informal interviews with project participants, together with the project data supplied by WPA in terms of the use of LPS would enable the University of Melbourne

team to understand the process of adoption of LPS, and to document the degree to which the key elements of LPS had been adopted, and general perceptions about LPS adoption.

Step 2 – Interviews: interviews of the key project personnel will be conducted to allow for discussion pertaining to the "how" and "why" of these processes and provide reasons. This would help address RQ3.1 ("*what scenarios are suited to using the LPS?*"). Other interview questions will pertain to the strengths and weaknesses of the current planning system (LPS) over the traditional CPM planning system. This would help clarify RQ2.1 ("*advantages (benefits) and shortcomings of using LPS*"). The interview data will be analysed via content analysis and a coding process. As an alternative option here, the data collection at Step 2 can be via questionnaire survey.

Step 3 – Fieldwork and evaluation: Two sets of the longitudinal data will be required and collected; one is on LPS metrics and the other is on project performance:
- LPS metrics: percent planned complete (PPC), percent of constraint removal (PCR), constraints log, recorded reasons for incomplete assignments, etc. We understand that PPC data can be pull out from Touchplan (software application).
- Project performance: cost and schedule deviation (cost and time), number of rework orders (quality), accident frequency (safety), productivity and others.
- If any of the aforementioned data are not readily available, the University of Melbourne team will work in cooperation with WPA to record the necessary data during the fieldwork period (March-June 2021), approximately 4 months' worth of data.

The University of Melbourne team will conduct statistical analysis to examine the correlation between selected LPS metrics and project performance.

Step 4 – Survey: Given a comprehensive list of benefits, constraints, barriers and challenges, and other aspects of LPS adoption will be derived from work package 1, we will then conduct a questionnaire survey among project participants, allowing them to self-report the barriers and challenges (RQ1) to LPS adoption, and benefits achieved and shortcomings (RQ2.1). Questions will be formulated using a 7-point Likert scale and request participants to indicate their degree of agree or disagreement with a series of statements.

Step 5 – Comparison: we anticipant the findings from both case projects will differ to certain extent. Therefore, this gives us opportunity to make comparison of the two projects. Lastly, we can compare the present study to the "best practices" for implementation of LPS globally

that had been documented in the literature. This would help address RQ5 ("*How can we improve on the implementation of LPS for future projects?*").

Deliverables: The report will indicate the extent to which LPS has been adopted in these two case study projects. The analysis of the quantitative data will provide insights into the relationship of project performance with LPS practice (RQ2). The report will also provide a better understanding of what scenarios suited to LPS use (RQ3.1), and how the LPS functions, not only at the technical level, but in terms of its social impact, building relationships, improving communications, and fostering learning among construction teams (RQ3.2). Furthermore, the report will evaluate the adoption of LPS by investigating benefits and barriers through surveys. Lastly, through comparison, the report will also recognise the similarity and difference between the two case projects, and explore possible remedies to reduce any barriers, constraints and challenges being experienced.

Appendix 2: Questionnaire Survey

SURVEY ON BENEFITS AND IMPLEMENTATION CHALLENGES OF LAST PLANNER SYSTEM AT WPA PROJECTS

We aim to examine the benefits of implementing the **Last Planner System (LPS)** at several WPA projects. We obtained a list of potential benefits through a review of similar LPS implementations globally. We are also looking to identify challenges or constraints to planning and scheduling that can be improved upon. This successful completion of this study will inform on future LPS implementations by the WPA and likely to promote the adoption of LPS in the construction industry.

Please be assured that all data collected from this survey will be kept strictly confidential and will only be used for the purpose of this study. No respondent or company will be identified. Should you have any queries, please contact Dr Gao Shang at shang.gao@unimelb.edu.au.

Section A - Personal Particulars

Designation: _____

Project Location: _____

Year of experience in the industry: _____

Year of experience using LPS: _____

Date: _____

Section B: Benefits of implementing Last Planner System

Please tick the most appropriate boxes based on your experience with the implementation of LPS in your project.

	What do you think are the benefits of this new planning system?	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	Improve planning and control reliability	☐	☐	☐	☐	☐
2	Improve project effectiveness	☐	☐	☐	☐	☐
3	Reduce project duration	☐	☐	☐	☐	☐
4	Improve cost performance	☐	☐	☐	☐	☐
5	Improve work quality leading to less rework	☐	☐	☐	☐	☐
6	Reduce time buffer	☐	☐	☐	☐	☐
7	Improve Percent Plan Complete (PPC) performance *(PPC = total promises completed / total promises made)*	☐	☐	☐	☐	☐
8	Increase productivity	☐	☐	☐	☐	☐
9	Improve workflow	☐	☐	☐	☐	☐
10	Improve information flows	☐	☐	☐	☐	☐
11	Improve communication, coordination, and collaboration between project participants	☐	☐	☐	☐	☐
12	Improve social interaction	☐	☐	☐	☐	☐
13	Facilitate identification and elimination of constraints	☐	☐	☐	☐	☐
14	Support and improve identification of root causes of delay	☐	☐	☐	☐	☐
15	Improve OHS performance	☐	☐	☐	☐	☐
16	Reduce inventory on site	☐	☐	☐	☐	☐
17	Better Control of Work in Congested Area	☐	☐	☐	☐	☐
18	Better response to unplanned events	☐	☐	☐	☐	☐

	What do you think are the benefits of this new planning system?	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
19	Enable late selection of design alternatives	☐	☐	☐	☐	☐
20	Easy to obtain schedule information	☐	☐	☐	☐	☐
21	Resolve schedule problems effectively	☐	☐	☐	☐	☐
22	Integrated with design schedule and allow better understanding of design	☐	☐	☐	☐	☐
23	Reduces self-interest behaviors of subcontractors	☐	☐	☐	☐	☐
24	Decrease in expected time overrun values	☐	☐	☐	☐	☐
25	Reducing effects of time-related risk factors	☐	☐	☐	☐	☐
26	Enable sustainability and environmental advantages	☐	☐	☐	☐	☐
27	Facilitate the achievement of project targets	☐	☐	☐	☐	☐
28	Shorter meeting duration than traditional projects	☐	☐	☐	☐	☐

Section C: Implementation of using Last Planner System

Please tick the most appropriate boxes based on your experience with the implementation of LPS in your project.

	State if you agree or disagree with these statements?	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	I have a good understanding and knowledge of LPS for planning and control	☐	☐	☐	☐	☐
2	I find it easy to implement LPS in large and complex projects	☐	☐	☐	☐	☐
3	There is LPS leadership in our organisation	☐	☐	☐	☐	☐
4	I have been provided with adequate training for LPS	☐	☐	☐	☐	☐
5	There is a continuous improvement culture in our organisation	☐	☐	☐	☐	☐
6	There is support from the broader industry for implementing LPS	☐	☐	☐	☐	☐
7	There is support from other stakeholders or parties to implement LPS	☐	☐	☐	☐	☐
8	There is support for integrating supply chain partners or companies into the LPS	☐	☐	☐	☐	☐
9	I support the implementation of LPS	☐	☐	☐	☐	☐
10	I am willing to adopt LPS in this and future projects	☐	☐	☐	☐	☐
11	I have a good understanding/knowledge of using LPS for project planning and control	☐	☐	☐	☐	☐
12	We can resolve schedule conflicts using LPS	☐	☐	☐	☐	☐
13	We can quantify delays or estimate an Extension of Time (EOT) based on the LPS	☐	☐	☐	☐	☐
14	We find it easy to communicate with team members using LPS	☐	☐	☐	☐	☐
15	We find it easy to collaborate with the members from other organisations using LPS	☐	☐	☐	☐	☐
16	We find it easy to manage the late entrants (i.e., subcontractors) in using LPS	☐	☐	☐	☐	☐

	State if you agree or disagree with these statements?	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
17	We adopt a consistent approach to break down tasks	☐	☐	☐	☐	☐
18	The plans and promises are transparent to all project participants	☐	☐	☐	☐	☐
19	We are comfortable with the commitment process (e.g., committing to the completion of tasks) in weekly plans	☐	☐	☐	☐	☐
20	it is easy to monitor the process of LPS implementation	☐	☐	☐	☐	☐
21	We have shorter meeting durations when using the LPS	☐	☐	☐	☐	☐
22	We now spend less effort planning when using the LPS	☐	☐	☐	☐	☐
23	We utilise the same standard planning procedures/guideline for all LPS projects	☐	☐	☐	☐	☐
24	We consider design inputs in planning and control with the LPS	☐	☐	☐	☐	☐
25	We can easily adapt to changes in project scope with the LPS	☐	☐	☐	☐	☐
26	We consider resource levelling when making plans in the Touchplan	☐	☐	☐	☐	☐
27	We have low staff turnover	☐	☐	☐	☐	☐
28	Other(s):	☐	☐	☐	☐	☐

Please add any additional comments that you think may be useful.

_____

_____

End of questionnaire (thank you!)

Appendix 3: Interview

The goal of the interviews was to capture the details of how LPS/Touchplan was used in WPA projects and identify the common features across the two projects that define this process.

The interviewees were recruited based on their experience of Touchplan. First, a register of team participants was generated from Touchplan, where the participants had added most tickets and viewed the plan were the two criteria, indicating they are the frontline last planners. Second, Phil Hendy nominated a few suitable candidates with roles ranging from supervisor to superintendent.

Once interviewees agreed to be interviewed, they received the informed consent document that outlined the risks and benefits of the interview and additional details about the study.

IMPLEMENTING THE LAST PLANNER SYSTEM AT LEVEL CROSSING REMOVAL PROJECTS

Researchers: Dr. Gao Shang, Dr. TK Chan, Yiqin (Iris) Yu – University of Melbourne

Section 1 - Details and experience of the respondent

Q1. Can you please tell me a little about yourself?

Required info:

- Name:
- Job title:
- Describe your main responsibility on this project:
- Job function:

  □ Owner (LXRP) □ WPA - Engineering □ WPA - Design □ WPA – Construction

  □ Subcontractor □ Other

- Experience (no of years)
  - Both in WPA and in construction
  - In LPS

Q1a. What is your understanding of LPS?

Section 2 – Implementing Last Planner System (LPS)/Touchplan

Q2. Describe how LPS was introduced and implemented in the current project?

Q3. What are the reasons for using LPS/Touchplan, from your perspective?

Q4. What types of meetings do you attend in relation to LPS?

Prompts: □Master Plan (undertaken once during Development Phase)   Proceed to Q5

□Phase Plan (undertaken every 3-4 months)   Proceed to Q6

□Make-Ready (aka 3-10 week Look-ahead) Plan   Proceed to Q7

□Weekly Plan   Proceed to Q8

Q5. Master Plan

Q5a. What are the main activities during a Master Plan meeting?

Q5b. What information has been presented and discussed during the meeting?

Q5c. Does the master plan accurately portray/represent the current state of the project?

Q6. Phase plan (pull planning)

Q6a. How is a Pull Plan meeting usually run? Describe the main activities during a Pull Plan meeting?

Q6b. What information has been presented and discussed during the meeting?

Q6c. Do you add buffers into the activity durations?

Q6d. Does the plan have flexibility to accommodate changes in the projects? How does the team set milestones? (Negotiate?)

Q7. Make-Ready Plan (MRP) (aka the look ahead plan)

Q7a. Describe the main activities during a Make-Ready Plan meeting?

Q7b. What information has been presented and discussed during the meeting?

Q7c. Describe a typical constraint that was addressed during the most recent MRP meeting.

Q7d. Did you consider the resource allocation at this meeting? (Or during MRP or Weekly plan?)

Q7e. How are constraints identified and resolved?

Q8. Weekly Plan meeting

Q8a. Describe the main activities during a Weekly Plan meeting?

Q8b. What information has been presented and discussed during the meeting?

Q8c. What are your criteria for making a commitment (before hitting the "promise now" button)?

PPC and learning

Q9. What do you do when an activity is completed earlier than planned?

Q10. Will you over-estimate the duration to ensure that tasks are completed on time? Or assign more workers only when you foresee a delay or a slow start?

Q11. How would you react if the weekly PPC is below target?

Stress level: none/slightly/moderately/very/extremely stressed 5-point scale.

Q12. And what actions are carried out when the weekly PPC is below target?

Q13. Would learning from every variance to plan (e.g., root cause analysis) help to achieve a higher weekly PPC? How often has this been carried out? Are these sessions useful? What lessons learned have been put into practice? Give examples if possible.

Other

Q14. How do you usually manage resources (machinery, equipment, and labour)? Is the LPS/Touchplan useful for this?

Section 3 – Impact of LPS on Project Performance

Q15. Compared to your experience in previous construction projects, what has LPS/Touchplan brought to this project?

Example: advantages or benefits

       - Assist to achieve the project schedule?

       - Improve project cost performance?

       - Improve project quality?

       - Improve safety performance?

       - Improve team collaboration？

Disadvantage caused by LPS/ Touchplan implementation if any?

Q16. What are the behavioural changes in the project teams, if any?

Examples: communication, collaboration, commitment, teamwork, trust, problem solving, etc.

Section 4 – Rolling out LPS for future projects

Q17. Do you think the LPS implementation was a success? What do you think contributed to the success of the LPS? Who, what actions, what other enabling factors?

Q18. What support is available for LPS/Touchplan within WPA?

Prompts: □LPS training □Touchplan Training □LPS guides □Regular catch up □ Coaching

Q19. What support do you need to improve the roll out of LPS/Touchplan?

Prompts: □more trainings □workshop □best practice sharing □site visits □Other:

Q20. Are online LPS meetings as *effective* as meeting in person?

Q21. What can WPA do to improve LPS implementation on the next project?

Please note, your responses remain *confidential* and will only be reported in the aggregate. No views or comments will be linked to any individual. Your responses will help WPA improve on future LPS implementations and address participants concerns, if any.

Thank you.

Appendix 4: Roles and responsibilities

S/N	Roles	Responsibility	Summary
CHS1	Superintendent	• Oversee all the construction work from a safety, programme, and cost perspective • Responsible for managing all the crews on the ground and managing budget safely	• Look after the entire project and oversee the construction works
CLU11	Lead Superintendent	• Look after the project when general superintendent not there.	• Manage all the crews on the ground • Supervise the supervisors and subcontractors in various disciplines and trades
OTH1	Superintendent	• Commercial Construction Role – build the stations • Supervise other supervisors and subcontractors in the structural steel installation in mechanical, electrical, and plumbing scopes and in finishing landscaping, or the construction side of rebuilding a station.	• Key focus is on safety, programme, cost
CHS4	Senior Supervisor	Work as senior supervisor under Jason to fulfill different roles on-site	• Report to superintendent • Manage junior engineers and supervisors from the subcontractors • Look after the workforce • Key focus on programme and safety
CLU8	Supervisor	• Report to superintendents • Manage more junior engineers and other supervisors (from the subcontractors)	
CLU9	Site Supervisor	• Look after the workforce • Responsible for Health and Safety • Also work with the program and offer health and safety advice	
OTH2	Senior Supervisor	• No superintendent in this project, so report to general supervisor • Look after the workforce and subcontractors	
CHS7	Construction Manager	In charge of delivery in terms of making sure that the project hit program and budget and safety.	• In charge of the delivery of project • Construction focus
CLU1	Construction Manager	• Construction manager reports to the delivery manager • Delivery includes being responsible for safety, communications, and environment • Constructions more construction focus	• Report to delivery manager • Key focus is on programme, budget, and safety, communication, and environment
CLU10	Plant Manager	• Ensure that all plant coming to site is compliant and up to standard • Order in any plant requirements Any drawing plan required and manage the costs involved	• Supporting role • Manage plant • Key focus on plant compliant, cost, utilisation

S/N	Roles	Responsibility	Summary
CHS2	Project Engineer	Responsible for overseeing team engineers in the project, delivering the construction job function	• Engineer side of role, reporting to construction manager • Manage subcontractors and site engineers • Engaging subbies, build up scope and review drawings • Packaging the scope into various delivery packages of work • Programme and planning program, cost control, and quality (medium term planning focus)
CHS3	Senior Project Coordinator	Responsible for the fit-out of the Cherry Street underpass	
CHS5	Project Engineer	Programming and planning program, cost control, and quality, for medium-term planning only	
CHS6	Project Engineer	• Engineer side of role, lower-middle management level • Looking after engaging subcontractors, building up scope and reviewing drawings • Packaging scope into various delivery packages of work and overseeing all engineering and responsibilities required to deliver those works on site • Making sure that subcontractors are complying with the safety management and work management procedures, and making sure all quality documentation is getting captured during the process and then upload and pass on to the client for close out of the project	
CHS8	Project Engineer	Look after these structures, the bridge structure, substructure, and superstructure	
CLU6	Project Engineer	• Planning works, programming the works, executing the works • In charge of the scope • Manage subcontractors and site engineers	
CLU3	Site Engineer	• Connect issues on-site and in the office (project engineers and construction managers) • Create daily reports and bring photos of activities happening on that day • Book and procure materials and inspect deliveries • Responsible for issuing permits • Directly coordinate subcontractors, foreman and supervisors	• Connect issues on-site and in the office • Coordinate subbies, foreman and supervisors • Forecast work • Programme, quality, permits, daily reports and photos
CLU4	Site Engineer	• Make sure all the site works progress as required, as planned • Track everything with the cost, all the works how it's progressing • Look after the quality aspects and make sure meeting all specifications	
CLU5	Site Engineer	• Manage the works on-site on a weekly basis • Forecasting four to eight weeks' worth of work • Making sure the program is on track and meeting all the quality/budget criteria, health, and safety	
CLU7	Junior Engineer	• Coordinate site works and plan and execute those on a daily basis	• Coordination • Quality and cost tracking
CLU2	Junior Engineer	• Quality assurance so there'll be collecting quality documents inspections of work • Cost tracking, preparation of permits safety documents, etc. on a short-term basis	

Note: CHS = Cherry street; CLU = Cranbourne Line Upgrade.

Appendix 5: Level of understanding of LPS/Touchplan

S/N	Roles	LPS	Touchplan
CHS1	Superintendent	LPS is managed through **a tiered approach**, with long-term planning with the planner and the main construction leaders. Emphasis moved from planner–program to **workers–supervisors**	• Last Planner System is managed through a fairly tiered approach, with long-term planning with the planner and the main construction leaders • Set up a program but then run it daily • Supervise workgroup on-site and look after daily target with short-term look-ahead plan, aiming at reducing time and cost • Emphasis is moved from planner–program to workers–supervisors
CHS2	Project Engineer	Very limited	• Very limited
CHS3	Senior Project Coordinator	Not aware	• No understanding
CHS4	Senior Supervisor	Not aware	• A digital version of a whiteboard. Great planning system moving forward and more efficient with planning
CHS5	Project Engineer	Knows LPS (trained by Phil)	• Not Mentioned, but assumed to be knowledgeable
CHS6	Project Engineer	Collaborative forum, overview of things to be done, global flow of activities	• A collaborative forum through which the team can work and look at things that need to be done • Global flow of activities leading into the key outcomes for the project
CHS7	Construction Manager	LPS is to take the planning down to the last person involved in it.	• Aware of LPS – to take the planning down to the last person who's involved in it – all the way down to the site level is involved – the Last Planner in the project will be a combination of the engineers and supervisory team on-site
CHS8	Project Engineer	Comprehensive tool for planning	• A comprehensive tool for planning • Be able to see the interaction with/between multiple work activities and also see if there are any issues related to access, environment or safety
CLU1	Construction Manager	N.A.	• Making commitments to what to run, what is going to be done, and when • Using that as benchmarking and tracking • Ability to coordinate large teams when projects split in a few locations and every individual team can plan independently
CLU2	Junior Engineer	Not aware	• An interactive way of looking at the next few weeks of work • Good software/tool for daily to short term

			• Easy to track progress and get a good understanding of what is happening on-site within or across the team
CLU3	Site Engineer	Not aware	• No understanding of LPS • With Touchplan, connecting all the information needed from site and in resources
CLU4	Site Engineer	Not aware	• A tool that allows us to track what work is ongoing on-site, what resources we need, and making sure that works progress as planned
CLU5	Site Engineer	Not aware (but knows Lean)	• Does know Lean, but not LPS. • A Lean process to make sure that the planning systems on-site are the most efficient • Touchplan is helping to implement LPS
CLU6	Project Engineer		• A visualization tool to help with planning day-to-day activities on-site
CLU7	Junior Engineer		• LPS is basically an innovative tool used to assist with scheduling • When it comes to planning construction activity, it is used more as an interactive tool between the site team and the supervisors/management • Touchplan is probably the nominated program for LPS for the team on this project and across WPA
CLU8	Supervisor	Virtual whiteboard or digital whiteboard used on a daily basis	• Touchplan – a virtual whiteboard that moves previous physical whiteboard online • Traditionally do the same meeting on a daily basis on the whiteboard in the supervisor's office • The operators still use the physical whiteboard
CLU9	Site Supervisor	• Benefits with programming • Be able to look back on anything happened site wide, receive information such as status, responsibility and requirements	• Traditionally use whiteboards, claimed it as 'Work Bible' Touchplan is purely used for programming and look ahead.
CLU10	Plant Manager	• Planning the day and look ahead • A result of technology evoluation and upgrade from whiteboard	• Whiteboard still in use as operators do not have access to Touchplan
CLU11	Lead Superintendent	• A planning system • Can plan day by day to week by week to have a longer planning period and then link the activities to	• /

		identify clashes. • Use it for bookings and interfaces	
OTH1	Superintendent	• Touchplan was something that was part of the McDowell systems and procedures • New technology • As a new employee, learnt this new technology and use on a daily basis	•
OTH2	Senior Supervisor	• A planning tool that combines multiple tasks around the job to clarify the phase and allows the team to tell whether the program are slipping or moving as well.	• Company system, new technology • A better way to do planning. and I welcome it

Note: CHS = Cherry street; CLU = Cranbourne Line Upgrade. AVA = Aviation Road; FER = Ferguson Street. Touchplan = Touchplan.

Appendix 6: Level of implementation of LPS/Touchplan at Cherry Street

	Consistently implemented	Inconsistently implemented	Consistently Not Implemented
Make-ready plan	• Activities are taken from long-term plans • Pull activities from fixed milestone activities • Big activities broken down into workable pieces • Involvement of partial downstream parties • Screen activities before entering make-ready plan with respect to resources and duration requirements • Standard constraint analysis process	• Informal discussion on resource allocation • Incomplete information in tickets added in Touchplan • Each team has different make-ready processes • Engineers from each team develop the make-ready plan separately • Constraints may not be fully removed before entering weekly work plan	• Keep formal constraint records • Balancing activities with the capacity of crews (e.g. crew size)
Weekly plan	• Activities extracted from make-ready plan • Involvement of lower-level parties • Requirements of activities discussed in detail • Update on current progress against the plan set forward • Replan activities if no longer relevant • Weekly commitment to the next week's plan	• Attendance in the commitment meeting is not compulsory • Management of resources as part of the weekly plan	• Space for team negotiation during commitment meeting • Accurate Crew size in the ticket • Subcontractors buy-in to reliable promises • Formal workable backlog
PPC	• PPC used to measure plan reliability • Weekly PPC analysis	• PPC analysis is conducted in the VMC meeting	• Publish PPC to all parties • PPC training to all parties
Learning	• PPC learning to analysis issues and delays	• Learning occurs when a large number of activities are not completed	• Formal learning and problem-solving process • Formal record of reason for non-completion

Appendix 7: Level of implementation of LPS/Touchplan at CLU

	Consistently implemented	Inconsistently implemented	Consistently Not Implemented
Make-ready plan	• Activities taken from long-term plans • Involvement of downstream parties: supervisors of labour and subcontractors • Screen activities before entering make-ready plan with respect to resources and duration requirements • Identify and remove constraints to make them ready before entering weekly work plan • Confirmed duration of activities with supervisors • Pull from milestones identified from long-term activities	• Each team has different make-ready processes • Engineers from each team develop the make-ready plan separately • Make-ready program developed and updated using Excel and not updated in Touchplan • Engineers are responsible for identifying the constraints with limited input from supervisors • Some teams rely on informal discussion with supervisors and other teams to remove constraints • Crew size identified for cost tracking use • Supervisors have no access to Touchplan	• Clear linkage between long-term and mid-term plan • Keep formal constraint records • Balancing activities with the capacity of crews (e.g. crew size)
Weekly plan	• Extract activities from make-ready plan • Check quality criteria before committing to activities • Update daily changes in the weekly plan • Involve of lower-level parties • Discuss requirements of activities in detail • Detailed resource management	• Weekly work plan prepared by the engineer for their individual team • Collaboration with subcontractors happens informally • Attendance in the commitment meeting is not compulsory • Swim lanes are location-based • The responsibility for reliable promising is allocated to engineers • PPC not published	• Tracking of PPC • Formal workable backlog • Weekly commitment to the next week's plan
PPC	/	• PPC used to measure plan reliability	• Publish PPC to all parties • PPC training to all parties
Learning	• Conduct 5 whys to identify root causes • Record issues and delays in the shift report • Monitor daily activities	• Engineers investigate problems by consulting with subcontractors	• Root-cause analysis only occurs for important activities • Root causes not recorded • Formal learning and problem-solving process

Appendix 8: Impact of LPS on WPA projects

No.	Project KPIs					
	Schedule	Cost	Quality	Safety	Resources	Understanding the programme
CHS1		√				√
CHS2	√	√	√			√
CHS3	√	√				√
CHS4			√			
CHS5	√				√	√
CHS6					√	√
CHS7						√
CHS8		√	√		√	
CLU1	x	x	x	√		
CLU2					√	√
CLU3			√	√		
CLU4						√
CLU5					√	
CLU6						
CLU7				√		
CLU8	x	x	x	x		
CLU9	x			x		
CLU10		x			√	√
CLU11	√	√	√	√	√	
OTH1	x		x	x		√
OTH2						√

Note: √ = yes. X = no.

Appendix 9: Critical success factors and supports provided in WPA

No.	Success implementation (Yes/No)	Critical success factors	Support available	Support required
CHS1	Yes	• N/A	• Training on LPS and Touchplan Coached by Phil/ WPA guys/Touchplan guys	• Discussion with all key construction leaders • More training • Making this business as usual • Getting the guys to understand how to effectively get the most out of it • Support and tips from Phil and his team • Site visits and best practices
CHS2	Yes	• Have a champion to drive and follow the process. • Touchplan is not included in the contract with subcontractors – need to improve.	• Not aware of training. Not aware of LPS guide. (He is new). Only learn through regular catch-ups	• Training for new staff, internal and external uses, subcontractors, a more formal approach. Agree to site visits and tours.
CHS3	Yes	• People are committed • Good commitment from management team: insisting on all these items and insisting on implementation of this software	• Two-minute session from Superintendent to teach how to use Touchplan Touchplan is quite user friendly and intuitive PPC obviously not covered in the two-minute brief – he does not know about it	• At least 30-minute session to learn about Touchplan
CHS4	Yes	• Built trust in the team • Jason driving it well • Useful for occupation, too • Phil provides support	• Not sure about support available	• More on training, especially for experienced staff to minimize their resistance to change
CHS5	Yes	• Jason firm on implementation, being supportive • Resistance from the team at the start but after seeing the results, all settled	• Initial support from Phil – Phil and Jason talk about adding tickets and consider constraints • Jason also trains late entrants	• Have buy-in from everyone
CHS6	Yes	• Have the buy-in from our supervision team • Buy-in from engineers as well – most put in effort to structure their activities • Jason and Phil provide support to the whole team	• Reach out to someone like Phil or someone in the team that is good at Touchplan • Phil organizes regular sessions to check the use of Touchplan and potential	• See actions from another project, dial into Touchplan session in another ongoing project Preliminary workshop and

No.	Success implementation (Yes/No)	Critical success factors	Support available	Support required
		• Easy interface to use for most team members – no need for huge amount of training	opportunities for improvement • invite experts in to provide feedback	sessions to get team's support for the initiative
CHS7	Yes	• Jason's passion really drives the whole system – buy-in and a champion to push it • Jason managed all the resistance from engineers	• Phil came and gave some training sessions • Jason provides assistance if needed • Intro to what LP is and then focus on software training	Hear from people involved in the project the whole way – see what other people think contributes to the success
CHS8	Yes	• All the good advantages of Touchplan contribute to the success	• Training, but Touchplan is clear and straightforward enough for everyone to use • Late entrant: will do some basic training	No
CLU1	Yes	• Phil set up a couple of sessions with the developers • Some offline environments so that we could start practising it and getting it right	• Sessions with developers, people-teach-people (it's quite simple), learn to break long durations into shorted durations	• N/A
CLU2	Yes	• Everyone can understand benefits of Touchplan and put effort into it • Pushed by management but also have buy-in from staff	• No training for him, but can apply to get training from innovation manager – just read a guide and went ahead, self-explanatory	• Support is very good for this roll-out – everyone knows how to use it – workshop to discuss other features may be useful (e.g. constraints)
CLU3	Yes	• Everyone put efforts into the success • Resource manager is important person – safety person, too • No resistance from the team so far	• Not aware of any training – not formally trained, only briefing by manager (regular catch-up)	• Need formal training and learn all Touchplan features
CLU4	Maybe	• As long as it is doing its work	• Some training and guidelines – teach new engineers how to use Touchplan	• Best practice sharing
CLU5	No	• Not as a booking tool	• No support is available	• Should be construction manager's decision
CLU6		• Could make people accountable for their scope and resources booked in • Could use it for interfaces – activities from different teams are all visible in Touchplan	• Some Touchplan training happened early on	• Best practice sharing and site visits

No.	Success implementation (Yes/No)	Critical success factors	Support available	Support required
CLU7		• Does its function but lots of areas to improve on	• Regular catch-ups and some formal training previously	• More training and workshops
CLU8		• A good start and gets better as more people use it, embrace it and learn the functionality of it	• Some people showed how to add tickets	• No coaching – some basic training on how to use it for everyone will do – people who want to learn more can learn more high-level functions – also, interesting to see how others doing it
CLU9	Yes	• Not too much interfaces as there is more communication with engineers	• No previous formal training. Only engineers showed him what to do in Touchplan	• More training
CLU10	Yes	• N/A	• No formal training Steve showed CLU10 around the Touchplan	• Not necessarily unless there are some functions that are required to learn
CLU11	Yes	• People's buy in (A little bit resistance initially) • Put strong engineers around people are not too tech savvy	• Support from Phil Hendy. Set up a few training sessions, initially every two days and later change to weekly • The team is self-sufficient. Once the team has been trained, old staff will give training to new staff	• Need support to adapt to this type of job. Rail system and high rise is different • Further support: bring some training for supervision
OTH1	Yes	• Enables everyone to be involved and plan the works. Everyone in the team should put tickets in. Everyone can contribute to it.	• Firstly, trained by Phil. • Other engineers in the project are capable. • Drove it initially at Aviation rd. Great support from Phil. • Attitude mindset, not technical mind.	• Overcome the resistance from the very powerful superintendent in Ferguson Street
OTH2	Yes	• Not mentioned CSF but discussed some current constraints	• No training. • Told through by colleagues how to use it.	• More training

Appendix 10: Methods used in LPS

Methods for specifying "Should"	
Work structuring	The process of breaking work into pieces, where pieces will likely be different from one production unit to the next, so as to promote flow and throughput
Scheduling	The process of assigning dates and times to planned tasks arranged in a logic network (e.g., depicted as an activity-on-node precedence diagram) in order to produce a schedule, which includes milestones and the start and end time of activities (activity durations)
Pull planning	• It is call pull planning because the first pass is done backwards from target completion to start. • should be done sufficiently in advance of planned start to allow time for "making ready" • should involve all who are responsible for delivering the work and with authority to make decisions, plus others who can provide needed information; e.g., specialists in safety, quality, logistics, and auditory engineering • involves the identification and definition of the milestone, or key event that the team will be pulling to • Identifying the conditions of satisfaction of the milestone is critical to a successful pull plan
Location-based planning	Participants in pull planning will likely take into account where tasks are to be done and how much space will be needed to perform them, considering space needs to a lesser or greater degree
Methods for lookahead planning (make ready)	
Constraints analysis and removal	Constraints can be either physical (availability of plotter before printing, rebar installation prior to concrete placement) or information (soils report before foundation design, engineering details before fabrication, permit before hazardous work)
Task breakdown	The task breakdown taxonomy used in LPS understands projects as composed of phases, phases of processes, processes of operations, and operations of steps
Collaborative design of operations	Operations consist of steps to be performed by one or several workers, consequently the design of an operation specifies those steps, their durations, their sequence, who performs each step, and pathways for workers, equipment, and materials
Methods for increasing workflow reliability	
Reliable promising	Reliable promises are the result of the commitments we make to each other out of respect for each other's concerns
Criteria for committing to tasks daily/weekly work plans	• task definition - tasks are defined so that performers understand what is to be done, where, when, by whom; can determine what is needed by way of materials, information, tools, and equipment to perform the task; and task completion can be easily assessed • task sequence - tasks can be performed now without incurring a penalty later • task size - tasks are sized to the capability of those who are to perform them within the time constraints of the plan • tasks soundness - general tasks have had all constraints removed prior to start of execution
Visual controls	a visual control for a production system must convey in simple visual cues: • appropriate measurements • up-to-date information (not a print-out of last week's information), or

	• what's really possible (not an out of-date schedule posted on the wall).
	Simple graphs and charts posted in public places can be very effective.
Underloading resources	To allow for variation that cannot be reduced at a moment in time, resources are asked to plan to produce less than what they could produce if there were no variation in arrival times of inputs or in processing durations.
	Underloading creates capacity buffers. Over time, these capacity buffers are to be reduced as variation is reduced
Daily hurdles	Meetings each day by groups of interdependent players, at which each, in turn, shares what commitments they have completed, what commitments they need help with or cannot deliver
Methods for assessing the state of the project relative to its targets	
Milestone variance (MV)	The state of the project relative to its schedule target is assessed using the metric milestone variance defined as the number of days early or late a milestone is expected to be reached
Percent required complete (PRC)	PRC provides the information needed to calculate the days early or late; namely, what required tasks were not completed in the previous week
Method for assessing the health of the planning system	
Commitment level (CL)	• track what scheduled tasks are critical and the tasks released for commitment from the lookahead process are tagged as critical and noncritical • The percentage of required tasks that are committed to be performed on weekly work plans
Percent plan complete (PPC)	• PPC measures workflow reliability • PPC measures the percentage of completed tasks relative to those that were planned at the beginning of the week
Tasks made ready (TMR)	• TMR measures the ability of the team to identify and remove constraints ahead of the scheduled start of specific work tasks • TMR compares the weekly work plan against an earlier week in the lookahead window
Tasks anticipated (TA)	• TA measures the percentage of tasks for a target week that were anticipated in an earlier plan for that target week
Frequency of plan failures	• Those not completed when planned are assigned to a category which describes the cause of the plan failure or variance
Methods for learning from plan failure	
plan-do-check-act (PDCA)	a rough-and-ready method of formulating and testing hypotheses and is the tool most commonly used to test the effectiveness of countermeasures identified through Five Whys analysis of plan failures
detect-correct-analyse-prevent (DCAP)	• Detect - breakdowns (variations from target) as close as possible to their origin • Correct – take corrective action so production can continue • Analyse – analyse the breakdown to root causes (perhaps using Five Whys) • Prevent – develop and test countermeasures in order to prevent reoccurrence

Appendix 11: Perceptions on roll out

No.	Roll-out strategies (from interviews)	Themes
CHS1	• **Set the team** at the start with almost a step-by-step guide (as to when we're doing the phase planning, when we're doing the master plan, how are we going to manage the screen, so on and so forth). • Have the **team members** who are going to be running the project together. • Have a plan moving forward to start the project off rather than doing it sort of midway through; needs to be done at start. • When we train the team, they're trained in the way we want it to run. By doing that, then it's set up to succeed.	People & process
CHS2	• Ensure all parties use Touchplan. To include all construction activities, kick off meeting, training for all team members, set expectations, similar fashion, and consistency.	Process
CHS3	• Needs wider implementation in the industry, especially at the subcontractor levels.	Process
CHS5	• Get buy-in from everyone • Show 24-hour planning if can	People & Technology
CHS6	• See some further depth and details in the system. • Improve the program itself to allow standard input of tickets.	Technology
CHS7	• Make sure that this is budget in.	Process
CHS8	• Import mud map into Touchplan	Technology
CLU1	• Breaking the master P6 program into Touchplan but with occupations scheduled for three weekends, a week and then a month, it is hard. • They work back from milestones, hence the pull.	Technology & Process
CLU2	• Touchplan workshop before start to demonstrate best practices.	Process
CLU3	• Next project should have training and workshop before start.	Process
CLU4	• Put more emphasis on statistical parts.	Technology
CLU5	• Should not use as a booking tool. • Meeting style should be redesigned as currently too many meetings.	Process
CLU6	• Have integration with P6.	Technology
CLU7	• Use the full functionality of Touchplan	Technology

No.	Roll-out strategies (from interviews)	Themes
CLU8	• More about spending time with the right people so that they're trained and know how to use it, and then get their buy-in. • Leaders – know how to use the system and see the benefits in the system • Key personnel – supervisors who run the meetings and engineers to take care of the engineer side of things. Also, run the reports and PE/ other engineers can assist/ help with their site.	People
CLU9	• Make the program a lot easier and more user friendly for the non-tech-savvy people to use and understand that a bit better. • I like to understand Touchplan a bit more, and is happy to add tickets, as acknowledged that supervisors knew the site better than the engineers, only provided more training is given.	People & Technology
CLU10	• "Ban the whiteboard and force people use it" (said jokingly). • Still need whiteboards for other things that are around planning, with direct planning, draw things in. As a plant manager, still need the whiteboard, just for the fact that he needs to put everything in chronological order for operators. • Be game to introduce PPC on managing the plant book reliability. Everyone needs to be accountable for what they are doing. This is because his work ties in to make everyone else' job work. If he is not performing, then he needs to be told. He does not expect to not have any feedback or not have any accountability.	Process& Technology
CLU11	• Adapt to suit, for example, being in a rail environment, there are different controls, booking and things that you have to do it (e.g., the job pack system). • Support at the start to stay in the right direction.	Process
OTH1	• Require a champion and other people follow.	People
OTH2	• Need to set a structure. There is no standard structure for Touchplan implementation across projects.	Process

Note: CHS4 has no comments on rolling out strategies.

Appendix 12: What goes onto the tickets

Look-ahead planning. What goes onto the ticket for look-ahead planning are the duration and sequence (CHS6/CHS7), which is the focus. In terms of materials, CHS7 indicated, "*not considering resources and resource allocation*" or considering at a high level of approximation (CHS6), as engineers did not spend a lot of time on resourcing, whereas a supervisor might do so. Informal conversations among supervisors and engineers will happen after the look-ahead session to discuss further resourcing (CHS6). CHS1 argued that they will start thinking about the materials needed for short-lead items. CHS4 noted, "*Put into different staging, requirements and procurement to make sure of achieving an outcome for that date*".

Short-term planning. At the end of the week, the team would look ahead to the next week's work (CHS2). Engineers put in a ticket for a week or two weeks look-ahead before the meeting (CHS5). Below is the information that should be included on the tickets.

- Estimate duration by discussing with the subcontractors and making reasonable adjustments (CHS3).
- Number of resources built into the area (CHS4).
- Crew size and duration (CHS4). Although this function was not popular among others (such as CHS2), who noted that the crew size indicated on the tickets was not accurate. The same crew always to do the work until it is finished. The supervisors would not demand that workers move from one area to another. Subcontracting all the works out so it was up to the subcontractor to bring a certain number of workers onto the site (CHS7).
- Discuss activity requirements: machinery, resources, permits, subcontractors (CHS4).

At CLU, the team put in tickets weekly, mainly for one-week ahead (CLU5). Finetuning of tickets occurs daily (CLU4/CLU11). A few site engineers at CLU acknowledged that they have consultations with supervisors (CLU5) and subcontractors (CLU6) before adding tickets to Touchplan. The bulk of the conversation between engineers and the foreman is completed by Thursday (CLU1). The engineers were responsible for ensuring subcontractors are coordinated (CLU1). CLU8 also highlighted that supervisors *should not* take responsibility for adding tickets, as there is more work to do on-site. All tickets for the next week should be finalised by Friday by the engineers (CLU2).

- The engineer would put in the tickets, including support staff, for their scope of work (CLU8).
- Touchplan interfaces currently split into areas, including support resource tickets (including name of supervisors and engineer) (CLU5).
- There was no negotiation on tickets (CLU3).

- Do not put crew size in (too many shared resources) (CLU3).
- Crew size is indicative, but the duration is accurate (CLU3 and CLU2), with no buffer put in (CLU2).
- Crew is generally the same on-site everyday unless extra are needed (CLU5).

Appendix 13: Meeting process mapping at Cherry Street and CLU

CLU Project

```
Critical Path
Programme
in P6
   │
   ▼
Prepare program for  ──▶  Fortnightly        Discountinued         Daily
the next 6 months         Make-ready         Weekly                TouchPlan
                          Plan Session       Commitment            Meeting
                              │              Meeting                   │
                              ▼                  │                     ▼
                          Look ahead             ▼                 Go through
                          activities in      Review tickets        today's and
                          the next           and go through        tomorrow's
                          couple of          any unsolved          tickets
                          weeks              constraints and          │
                              │              issues                   ▼
                              ▼                  │                 Book
                          Go through locations,  ▼                 resources
                          clashes and support  Commit for
                          services             tickets for the
                          (by the plant manager) and  following week
                          activity requirements.
                              │
                              ▼
                          Identify issues                          VMC
                          and constraints                             │
                          in conjunction                              ▼
                          with PIO                                 Discuss
                              │                                    current
                              ▼                                    program
                          Escalate issues                             │
                          that cannot be                              ▼
                          resolved to the                         Examine
                          higher level                            escalated issues
                                                                  and discuss
                                                                  solutions
```

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Appendix 14: Meeting structures at the Cherry Street and CLU projects

Cherry Street Project

Plan level	Responsible	When	Where	Time scheduling	Site and resources	Constraints
Milestone planning	Planner in charge of P6, and provides client with update Engineers to update planers	In Tender Stage	P6	• Determine *milestones* and key phases based on deadlines • Ensure activities match with critical path programme in P6 • Ensure occupations can be met	/	/
Phase planning	Superintendent chairs meeting	Once a month together in the milestone planning meeting (early stage) Only if there are changes in methodology and plan (afterwards)	Whiteboard and stickies	• Individual team set their own phase plan if it was aligned to what milestones • Discuss what is needed to accomplish milestone and set activities and durations • Does not consider time buffer	PE ran basic discussion on resource management	/
Look-ahead planning	Project Engineers to prepare make-ready program Construction Manager/ Superintendent/ Supervisor chairs meeting	Fortnightly (30–45 mins)	Touchplan and Whiteboards	• Using pull planning approach detail work activities from fixed milestone • Take out long duration of works and start splitting into shift by shift • Set predecessors to activities using Linking Function in Touchplan • Estimate duration of activities based on productivity rates and quantities	Check crew sizes and program status Discuss materials needed for short-lead items Check on interfaces to see who needs to do what and by when to achieve overall program goals	Identify constraints and issues in conjunction with PIO Standard constraint analysis process. Once it's been identified, would review options to either mitigate or remove constraint
Weekly commitment	Superintendent	Friday 2 p.m.	Touchplan	• Entire site team required to comment on tickets and inform about any changes • Superintendent presses the promise-now button	Discuss resources management	Discuss constraints and restrictions
Daily Touchplan meeting	Engineers are charge of daily Touchplan meeting	Everyday 2pm (5–30 mins)	Touchplan	• Review sequence of work • Review tickets for today's, tomorrow's and the day after	Site coordination	/

Plan level	Responsible	When	Where	Time scheduling	Site and resources	Constraints
	Construction manager/ superintendent presents daily plan and checks progress			tomorrow's activities (focus on what happens the next day) • Review duration by discussing with the subcontractors and making reasonable adjustments	Review activity requirements: machinery, resources, permits, subcontractors Build number of resources into specific area	
VMC	Construction Manager	Monday 9 a.m. (either weekly or fortnightly)	Touchplan; Propeller	• One PPT slide to highlight the progress on site • Discuss about the program	/	Flesh out what problems that have been encountered, what constraints have been encountered and what options may have

CLU

Plan level	Responsible	When	Where	Time scheduling	Site and resources	Others
Milestone planning	Planner	Before construction phase	P6	/	/	/
Phase planning	Project engineers prepare their program for the next six months	Not in place	P6	/	/	/
Look-ahead planning	Construction manager chairs look-ahead meeting All project engineers develop their **make-ready plans** and identify key constraints individually	Weekly on Tuesday Morning	Touchplan, Excel worksheet and P6	• Constantly adjusted and updated/revised every week • Activities and milestones are from higher-level program • Duration of activities result from consultation with supervisors and confirmed with the supervisors (who execute the work) through informal discussion.	Review locations, clashes, and support services (by the plant manager) and activity requirements.	• Review scope and discuss constraints/depen dencies • On hold activities when constraints identified.
Weekly commitment	Project engineers responsible for weekly plans and promise-now button	Friday 2 p.m. (but discontinued)	Touchplan	• Team puts in tickets weekly, mainly for one-week ahead finetuning of tickets occurs daily	• Touchplan interfaces currently split into areas, including support resource tickets • No crew size in the tickets as there are too many shared resources	• Location-based swim lanes to allow better visualization of interfaces
Daily Touchplan meeting	Supervisors chair the meeting Engineers are responsible for completing booking	Daily sessions at 10 a.m., 10:45 a.m. and 11 a.m.	Touchplan	• Daily promising through informal conversation • Review and confirm activities for the day and the next day (in Touchplan)	• Booked resources confirmed by the plant manager • Check if resources are correct or if there are interfaces/clash issues with other work groups	• Check activities with all identified constraints to see if activity ready

Plan level	Responsible	When	Where	Time scheduling	Site and resources	Others
	and ensuring everything booked					
VMC	Construction Manager chairs the meeting	Every Thursday	Touchplan; Propeller	• update to each team and raise issues that could not be solved within the team • use graphs to show how much work had been completed, as well as the top (three) opportunities and top (three) risks • the entire team goes through scope, upcoming milestones, risks, and constraints	/	/

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