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Last Planner System® in Design

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Abstract

The Last Planner System® (LPS®)of production control enables project team members to come together to plan their collective work with the goals of improving flow and reliability. Last Planner® is widely used in multiple geographies, project scales and project phases. This paper considers its application during the design phase(s) of a project. The authors build on the concept that there are two distinct activities of design that parallel the distinction between Designing and Making (Ballard et al., 2009.) and propose standard work to be incorporated into LPS during the earlier design phase. The work began with simple questions:

- What are the challenges of LPS in Design that we can respond to?
- What enhancements to LPS could be recommended to ease its use in Design?

Introduction

Interviews with experienced practitioners confirmed that there are two different activities in the design process that may overlap. Speaking of the differences between Design and Construction, Ballard et al. (2009) used the terminology Designing and Making. The research reported in this paper found that distinction within design, and uses the terminology Ideation and Production as defined by Christian and Pereira (2020) in LPS Metrics 2.0:

Ideation (Early-Design)

The different terms commonly used to describe this phase or parts of this phase include but are not limited to: Ideation, Value Definition, Validation, Conceptual Design and early Schematic Design.

In this major phase the focus is two areas:

- Project team alignment on the major milestones, what those milestones are and what they require
- Creating a built-environment solution that best aligns with the post-project objectives the key stakeholders

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There is a high-level of discovery in this phase. Consequently, whatever plan of work is put together is subject to frequent and significant revision (Christian and Pereira 2020).

Production (Later-Design)

The different terms commonly used to describe this phase or parts of this phase include but are not limited to: Mid to Late Schematic Design, Design Development, Construction Drawings, Implementation Documents, and Production Design.

Compared to the construction phase which it supports, this Later-Design phase has more of an emphasis on decision sequencing and planning information workflows. There are more opportunities to do work at risk, or start work based on reasonable assumptions rather than fully finished prior work. Having noted that, LPS® in this phase is very similar to LPS in the construction phase (Christian and Pereira 2020)

It has been well established from the interviews that LPS in Production (Later Design) is working well. Subjects consistently reported both underutilization and specific enhancements that would allow teams to more effectively organize their work in Ideation (Early Design). Further, the ongoing failure to distinguish between these two major activities causes a great deal of confusion among project team members and likely contributes to a resistance to the use of LPS methods by the design community. Note that while the Ideation and Production activities are generally sequential, they commonly overlap and are prone to repetition as part of the iterative nature of design currently practiced. As an example, teams report moving through Ideation and Production activities for each presentation, proving out the 'back to the drawing board' idiom.

Ideation and Production activities have parallels in the Toyota Product Development System (TPDS) and the Toyota Production System (TPS). It is important to note that the philosophy and processes of these Systems are different. The TPS has a generally accepted goal of Minimizing Waste (Liker, 2004) -- the systematic elimination of anything that does not add value for the customer -- while the TPDS has a goal of maximizing Innovation (Kennedy, 2003). Toyota does not have a detailed step-by-step process describing how to do product development. They have a simple project plan that highlights key dates and responsibilities. (Kennedy, 2003) The analogy of Cooking a meal vs creating a recipe (Ballard, 2019) is useful in differentiating objectives of these two systems. Kennedy noted that a Responsibility Based System of Planning and Control is a key pillar of the Toyota Product Development System. His description closely matches the Last Planner System.

> *"Architects often feel they need to ferociously protect their process, or the CM will compromise innovation and design quality."*

Our effort to improve the value of Last Planner System® (LPS) in Design began with an investigation of the entire design phase – from ideation through production documentation to construction. The goal of this work was to improve and define value for design professionals that would result in a broader acceptance and adaption of the LPS by design professionals, especially in the earliest phases of a project. From benchmark research, subject interviews and discussion, the research team recommended a focus on the Ideation (Early Design) phase of a project. This work identified five basic benefits that can be taught, measured and evaluated by design service providers in particular and cross functional project teams in general. The five benefits will lead to a greater

understanding, acceptance and use of the Last Planner System in the earliest phases of a project:

1. Differentiate Ideation and Production design activities
2. Define milestones focused on decisions
3. Capture and share a clear design process
4. Define criteria as the first step in that process
5. Onboard Designers including techniques such as Reliable Promising and Retrospectives

The Last Planner System (LPS) was developed for the AEC industry by Greg Howell and Glenn Ballard independent of any knowledge of Toyota or Lean. However, its principles align well with Lean principles including the Responsibility Based Planning and Control (Kennedy, 2008). The application of LPS in design and construction has increased productivity, improved collaboration, reduced risk, and provided benefits to projects of all scales, scopes and complexities. These benefits have made the Lean production model valued and widely accepted and adopted in the construction phases. Survey findings of construction industry clients by McGraw-Hill Construction in 2013 support this assessment:

- 84% found that adopting Lean has led to higher quality projects.
- 80% report greater customer satisfaction.

"In fact, as more owners become familiar with the impact of Lean, it may evolve from a competitive advantage to a necessity." Anecdotal evidence also supported this conclusion – Many LCI Conference presentations have documented the successful application and benefits of LPS for project management and delivery.

However, as noted above, designers have generally shown resistance to embracing The Last Planner System, both in the ideation and production phases of Design. [Kerosuo et al., 2012]. The literature reviewed and multiple interviews reported that designers found it difficult to use the Last Planner System approach to create a network of commitments and generate similar productivity and behavior metrics (PPC) that measure and improve project flow, that other downstream team members have found valuable to establish to deliver work within budget and schedule constraints in the production/construction phase of a project. Our researchers hypothesized that insufficient LPS training, loosely defined metrics, an uncertain design process, and concern regarding loss of autonomy contribute to this lack of adoption.

In the earliest ideation phase of design, it was reported that the standard measure of commitments broke down and project teams reverted to reactive planning vs. proactive planning. In this mode scheduled handoffs and decisions were extended and misunderstandings were commonplace (Fosse and Ballard 2016, Tugra and Theis 2016).

LPS acknowledges the shortcomings of traditional highly detailed waterfall forecasts and thus recommends overall milestone planning to establish process and planning in greater depth as the team gets closer to completing the work. It is best described as a mechanism for transforming the work that should be done into what can be done, forming an inventory of work made-ready from which the Last Planners commit to what they will do (Ballard 2000).

LPS consists of four planning stages: (1) Master Scheduling: Summarizes all the work that should be done in abstract terms based on deliverables that release work. (2) Phase Scheduling: Defines project phases and is used to coordinate actions that extend beyond the lookahead window. Phase schedules provide more details regarding what should be done and when. (3) Lookahead Planning: Presents a time frame of roughly two to six weeks and is the stage where tasks are broken down and made ready. (4) Commitment Planning: Indicates the most detailed planning stage that results in commitments to deliver the work that was placed on the Weekly Work Plan (WWP) (Ballard 2000; Tommelein and Ballard 1997).

Interviews and dialogue within the Designer Subject matter expert panel agree that the LPS processes, presuppositions, and principles apply equally in design and construction, but different methods may be more appropriate to one or the other for performing those processes and applying those principles.

The use of data-based performance metrics of LPS have had limited adoption by Design professionals. From the literature search and interviews it has been noted that the standard LPS metric of PPC is a useful measure for tracking commitments generally, but in many instances did not provide enough granularity or timeliness to the project team as to where there were interruptions in the flow of design decisions, or during a "lookahead", identifying other real and or potential roadblocks that would impede a performer's commitment for a deliverable. Given that decisions by Users, Authorities Having Jurisdiction or other entities are key deliverables, it is important to ask two questions: "who makes the decision?" and once identified, "what do you need to make the decision?". Although identifying the customer requirements of a task is a key tenet pf LPS, it is often overlooked during Ideation.

During the Ideation phase, design decisions often have very short durations and unpredictable future task sequences. Tasks are frequently completed out of sequence. There is a preponderance of new unplanned work introduced both by clients and from uncovering "new" information appropriate to solving a unique design problem. Thus, tracking PPC has not always been of value for project teams to indicate if the design schedule was being accomplished or commitments made were reliable. However, it was reported that with coaching and use of BIM models project teams found PPC a valued measure of a team's meeting commitments. (Ballard et al. 2017, Khan, 2015)

To overcome some of the short falls of the PPC metric in the Ideation phase, some design teams have adopted agile methods and the metrics and associated methodologies of Scrum and Kanban. These are measured by "burn down rate", components and include: Total backlog of tasks defined from a plan (the number of post-its on the wall) and accumulated number of completed tasks (the number of "OK" post-its on the wall). (Fosse and Ballard. 2016, Modrich and Cousins 2017)

However, LPS functions, processes, presuppositions, and principles (as defined in Ballard and Tommelein's 2016 Current Process Benchmark for the Last Planner System) apply equally in design and construction, but different methods may be more appropriate to one or the other for performing those processes and applying those principles.

(Reference Future Research recommendation #14 from the 2016 Current Process Benchmark.) It is accepted that methods should be continuously improved and invented—there is no such thing as a Lean method apart from its fitness for purpose in pursuing the Lean Ideal consistently with Lean principles. (Ballard 2020)

Production Control Principles (IGLC 17 in Taipei by Ballard, Nickerson & Hammond 2017) takes this question further by considering if LPS applies to design, given differences between designing and making such as emergence and uncertainty.

The metrics that have proven beneficial in the Ideation phase of Design through production include the following. (Modrich, R and Cousins, B 2017)

Kanban Metrics:

- Work-In-Progress, WIP – How many Items were worked on
- Lead Time – How much time an item is in the system
- Touch Time – Time the performer took to complete an item
- Throughput – Number of items/values delivered
- Flow Efficiency – Lead time against touch time

Other than these detailed metrics specifically related to the Kanban Method, other metrics have been proposed by the Metrics team. (See section X of the LPS Process Benchmark 2020)

Literature Review

While the Last Planner System (LPS) is most frequently associated with a Lean approach to construction, several recent studies have investigated the potential benefits of implementing LPS during a project's design phase. Improvements in the planning and control of production, and increased collaboration in design decision-making were identified as two broad categories of positive LPS outcomes in the literature. Findings also suggest modifications to the standard LPS protocol that may be appropriate in its application to design. Four studies summarized in the planning and control section and three in the collaboration in design decision-making.

Planning and Control

In a case study of an eight-story, 22,000m^2 office building in Oslo, Norway, Fosse and Ballard (2016) examined the applicability of LPS in planning and control of the design process. Prior to the implementation of LPS, the authors observed that the project suffered from several negative characteristics common to traditional design process management including unclear handoffs (i.e., poorly described and sequenced tasks), no confidence in time allocated to perform design work, low volume of deliveries per week, and decreases in positive group dynamics (i.e., increasing friction and poor communication among members), and was in danger of not submitting a design proposal by the required deadline. Fosse and Ballard (2016) contend that each component of LPS—planning, lookahead, checking, and learning—represent effective remedies to challenges inherent in traditional design management.

After transitioning to LPS, the design team submitted a successful bid on time, carefully addressing the needs of the client within the cost parameters of the project. Increases in average Percent Plan Complete (PPC), over time, suggest that LPS helped the

design team improve planning and meet hand off commitments throughout the process. Additionally, better team alignment and task sequencing were achieved, as well as improved process transparency and clearer task descriptions. Not all components of LPS were utilized (e.g., root cause analysis for noncompletion of planned tasks) but could likely be applied. The authors concluded that with proper training LPS was highly effective in managing the design process in the case study and recommend its broad application on future projects.

In two action research studies on improving design workflow with LPS, Khan and Tzortzopoulos (2015) worked closely with design practitioners to implement, monitor, and evaluate the effectiveness of weekly work planning (WWP) sessions during the design development phase of two projects: 1.) a seven-story, 14,865m^2 hotel project being built in Melbourne Beach, Florida, 2.) a 6-story, 8,819m^2 apartment building in Sebastian, Florida.

Data analysis revealed a 12% rise in average overall PPC in the hotel project and a 14% rise in average overall PPC in the apartment project, suggesting an increase in task planning reliability and a decrease in workflow variability with WWP implementation. Additionally, both projects were completed ahead of schedule, which resulted in an increase in production cost efficiency.

Questionnaire results revealed that practitioners' perceptions of the effectiveness and usefulness of WWP in the design process were resoundingly positive with 100% of respondents either strongly agreeing or agreeing that LPS was more effective as a design planning/control tool than tradition WTP (89% strongly agree, 11% agree). The use of BIM in a lean way in the two projects (discussed in detail in an IGLC22 conference paper by the authors of this paper) were believed to be partly responsible for the improvement in design workflow. The authors also included recommendations for successful implementation of WWP in building design process.

To better understand the application of the LPS in design—in particular the unique challenges of managing several design projects, at the same time, with short lead times—Wesz, Formoso & Tzortzopoulos (2013) investigated LPS in a case study carried out at a Brazilian company specializing in the design, fabrication, and assembly of steel structures (e.g., warehouses, supermarkets, factories, shopping centers).

After implementing LPS with two design teams, an adaptation of LPS, specific to the context of the company, was created and extended to four additional teams. An evaluation of the implementation process for all six teams was conducted using data collected from interviews, participant observation, and analysis of existing metrics.

Teams focused on detailed design (4 teams) had an average PPC between 68% and 78%, compared to teams (2) responsible for conceptual design, whose average PPC were 64%, and 61%. LPS implementation was found to increase process transparency, produce stronger commitment in deliveries, and improve collaborative decision-making. The researchers noted difficulties in implementing medium-term planning in the case study, likely due to the complexity of the design process. A model to address medium-term planning was proposed.

To reduce uncertainty in design management, Rosas (2013) proposed combining the application of the Design Structure Matrix (DSM)* and the Last Planner System (LPS) methodologies. While DSM is a powerful visualization tool that facilitates the management

of design iteration, it does not control the implementation of the optimal design sequence, which is the benefit of LPS (Rosas, 2013).

Drawing on the results of a case study of the fast-track development of a new urban area, comprised of more than 430 homes and several non-residential buildings in the Peruvian Andes, Rosas (2013) found that the combination of DSM and LPS improved the reliability of plans, informed the optimal design sequence, and facilitated corrective action by the work team as needed. However, issues with fragmented planning, lack of on-site integration, and the flow of information persisted to some degree during the project despite the integration of the DSM and LPS as a methodology for lean design management.

*See (Hammond, 2007) for detailed explanation of Design Structure Matrix (DSM)

Collaboration in Design Decision-making

Kerosuo et al. (2012) compared collaboration between designers in traditional design meetings and LPS meetings to determine whether implementing LPS tools changed interactions, the number of completed tasks, and the temporal orientation of participants. The case study focused on the renovation of a school, originally built in the 1970s, which implemented BIM in the design and construction process. The study found that the number of design tasks completed during meetings increased after the implementation of LP tools, design teams were more proactive, and interdisciplinary communication improved.

Although little research has been undertaken on how decisions are made during the design phase, Schöttle et al. (2018) argue that how project teams make decisions is critical to project success. Using case study and action research, the research team assessed decision-making on four projects: an academic office building, a large academic medical center, a complex tunnel infrastructure project, and an IT campus. Each project utilized LPS, BIM and the big room concept and were assessed on (1) decision-making method, (2) structure of the decision-making process, (3) governance process, and (4) documentation process. Tracking tasks throughout the decision-making process using LPS helped the multidisciplinary teams to stay focused and make collaborative decisions on time, especially when owners were involved. Furthermore, combining Choosing by Advantage (CBA) with LPS and Target Value Design (TVD) increased effectiveness and reduced waste in the design process (Schöttle et al. 2018). The findings are limited to four cases and the full potential of Lean methods in the decision-making process has not been fully tested in design. A more structured research comparing different project types regarding decision-making in combination with Lean methods such as CBA could give transparency to the benefits and strategies for implementation.

Arroyo and Long (2018) report on a successful team that implemented several Lean design methods and practices to make design decisions in a large capital project for a major U.S. technology firm. The study detailed collaborative decisions the team made using a synergistic combination of “Set Based Design (SBD) to explore alternatives, Target Value Design (TVD) to refer to project targets, Last Planner System (LPS) to manage the timing of decisions, Choosing by Advantages (CBA) to guide the decision-making process, and A3 reports to manage the discovery process and to validate the design team recommendations to the owner” (p. 468, Arroyo & Long, 2018).

Increases in client satisfaction, improved decision documentation, and better design efficiency were observed. Additionally, trust and respect grew among team members.

Research Methodology

Researching subjects vs subjects as researchers: This study was conducted by a highly experienced group of Subject Matter Experts (SME's) – practitioners with first-hand knowledge of applying the Last Planner System during the design phases of a project. The group engaged a Researcher to conduct a literature review and consolidate themes in a report. The literature review themes were the framework for a discussion among the SME's. Over several work sessions the SME's developed and refined a list of interview questions and subjects. The interviews were led by the Researcher; transcripts and conclusions were reviewed by the group to distill and prioritize improvements opportunities. During the distillation additional SME's were identified for input based on expertise judged to be beneficial to the work.

The methodology employed in this initiative took strong cues from Collaborative Action Research as defined by Agyei (2019). The major idea is to "research 'with' rather than 'on' people." Researchers in Action Research are users who are elevated to the level of research partner and are equipped with the right tools to systematically investigate their own behaviors, to develop co-ownership of knowledge, and to eventually change a situation for the better (Reason and Bradbury, 2001). In practice this method stimulated much discussion by the group and a steadily iterative focusing of themes.

There is a problem-solving nature to this methodology (Reason et al. 2001) that parallels the processes in a project delivered with Lean techniques. Reflection and judgement are equal partners to data gathering. Given the background of the SME's this was an effective way to organize the group and keep the process moving and focused.

Understanding the Factors Unique to Ideation activities of the Design Process

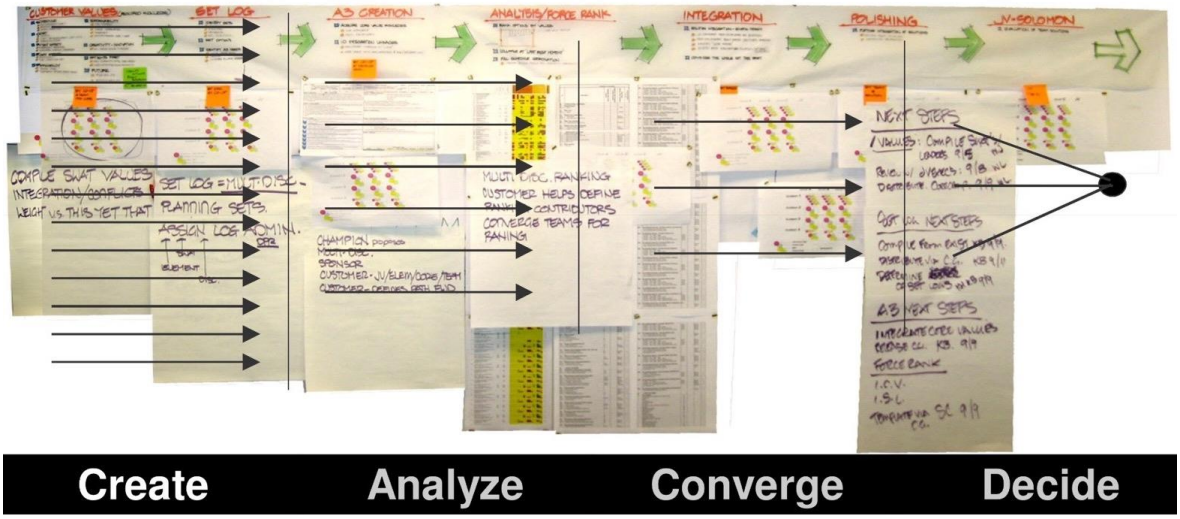
From our Survey of the Literature, interviews with design professionals with experience using the Last Planner system in the Design Phase and through conversations with subject matter experts, we found several important conditions of modern design practice that are reshaping project delivery.

First, Projects have become more complex and require more specialized knowledge than ever. Historically, designers would consult with their office library, Sweets Catalog, or Engineers to learn about the systems and materials and methods of the many products that are used in a project. They would use this information in the Design Phase without much regard to availability, cost or other issues that would affect the construction team's and overall project schedule or budget. As complexity has increased it has become critically important to get reliable input and review of design decisions regarding the project's key design elements early on from materials and systems specialists as well as, trade partners who can offer cost and schedule information based on real world conditions.

Second, Technology has offered many benefits for dealing with increased complexity, but ironically has also opened the door to both more complexity and transparency.

Building information modelling (BIM) and 3D Parametric models have required a new workflow that has made the traditional delivery gateways of SD, DD, CD's somewhat obsolete. Design professionals who have adopted BIM have realized that they can provide upstream users with prototypical alternative solutions that best fit the project and user needs prior to formally handing off CD's to Owners and Contractors.

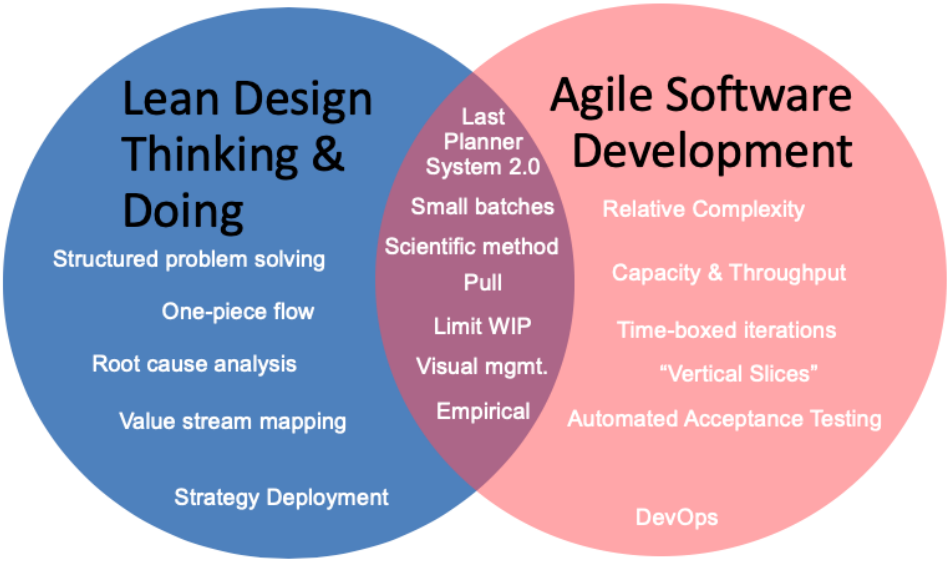
Newly developed criteria for design has evolved to define the completeness of design elements that can be used by all stakeholders, to determine the suitability of a design element for a project. Key Design elements and subsequent handoffs are defined by their Level of Development (LOD). This terminology is widely accepted in the AEC industry. It was initially developed in 2011 to enable practitioners to specify and articulate the content of 3D Models at various stages in the design and construction process. This approach outlines a common language for describing what a 3D model information can be relied on by downstream users. LOD defines model geometry with three of the most common uses in mind – quantity take-off, 3D coordination and 3D control and planning. [see http://bimforum.org/lod/]



Finally, as a result of the cost of funds and "speed to market", owners are requiring projects to be completed sooner. When project deliver is not properly planned to account for a "fast track" delivery process projects have many issues, primarily not meeting budgets and schedules promised to stakeholders and customers. A consequence of these trends is that the traditional Beaux Arts concept of the architect working in isolation late into the night has been replaced by diverse teams working concurrently on different project aspects with different project tools. This shift has created more demand for adaptive, transparent project controls such as the Last Planner System during the ideation phase of a project.

Lessons from Others

In addition to LPS methods, project teams are using tools such as Agile and Scrum to track tasks and progress. Lean and Agile a classic combo, made better by Design Thinking. Together, these challenge the project team to explore the design problem and ask the right questions.



The initial goal of an Architect or Design professional is to discover the essence of a design problem. Through a combination of intuition and assembly of facts/evidence of a complex web of information the Architect then synthesizes a form and begins to solve the "Design Problem." A substantial portion of this heuristic problem solving is based on the ability of both the designer and the design team to make assumptions and move forward without the benefit of a proven outcome.

In the past, much credit has been given and even taught in schools of design that the individual designer's skill is their intuitive ability to create a form or solve a design problem. This methodology and cultural value have had a significant impact on how the design service providers have traditionally approached problem solving, and their process of managing the design phase and its deliverables. However, new non-traditional management (evidence-based design) and production planning is evolving that supports understanding the design workflow and democratizing the role of the designer. Also, the complexity of today's projects, coupled with the speed of delivery and digital technology (BIM) require that design service providers become less siloed and more integrated with the project production team.

Designers are rarely satisfied with their first good idea. This is not just the "artist" seeking to prove their gift as an individual genius, but a commitment to improving the design by not accepting the first idea. This results in improved project and ultimately providing more value for the users of a building, an improved manufacturing process or other product of a design effort.

Ideation Differences from Production or Construction

Design Ideation, unlike Design Production or Construction embraces the consideration of many alternatives simultaneously and from a myriad of materials to discover the best "fit" for the client's business case and user needs. The nature of design work is non-sequential. It is "knowledge work" vs. physical work, and the details of the solution are

not known in advance. Innovation is a valued measure of Design Excellence. Innovations in form or function are highly valued by design professionals. Examples of this are the Architect giving form to the elevations and details or the engineer selecting building systems, materials and details that contribute to the overall value and others in the "information supply chain". The goal of Ideation is to maximize innovation while the goal of production is to minimize waste (Kennedy footnote).

In construction LPS is ***Task*** based (Establish a sequence of tasks & then measure the commitment of the production team to complete the tasks, pulling backwards from a milestone) LPS Process Benchmark 2020 in Design recognizes that this does not work for design due to the non-sequential/iterative nature of design and in the ideation phase redefines the process to be a ***Results*** based process. A results-based process is a cyclic process of combining and narrowing subsystem targets. While finding the right answer is the goal, asking the right questions is critical. It seems correct to say that the ability to specify the tasks involved in producing Design's results is far lower in Design than Construction, especially in Ideation. However, both processes are results oriented. It has been argued that the appropriate response to that fact in Ideation is to estimate how to divide the available time between research, generation, evaluation and decision and to be prepared to adjust those allocations as the team moves through those steps (a private communication with Glenn Ballard)

Production always involves both designing and making, but they are quite different activities. Consider these differences:

- Creating a recipe versus preparing a meal
- Doing work over again in construction is waste—while generating multiple possible design solutions is advised for delivering value...Glenn Ballard

The research findings indicate that teams using LPS examine information flows during the ideation phase of design as one of the five elements of the update. Designers workflow is mostly "knowledge work." That is, while both designers and builders solve problems, the builder's "problems" are mostly known once a design has been completed, provided that product and process design have already both been produced. Thus, a Designer starts with a hypothesis and an approximation of reality. They then investigate these with research (Design Thinking). As the design comes into focus the design team "fixes" the design solutions and creates drawings, models and other documentation of design decisions (Design Doing).

LPS Process Benchmark 2020 creates the opportunity to acknowledge long held design beliefs and values while establishing an improved process to fit contemporary realities of construction projects. Multiple Design Disciplines have needs for information. Engineers are both providers and customers. Thus, completion of designs in the ideation phase requires continuous questioning and pivoting from the initial ideas for some key design elements and other decisions to be left for the "last responsible moment".

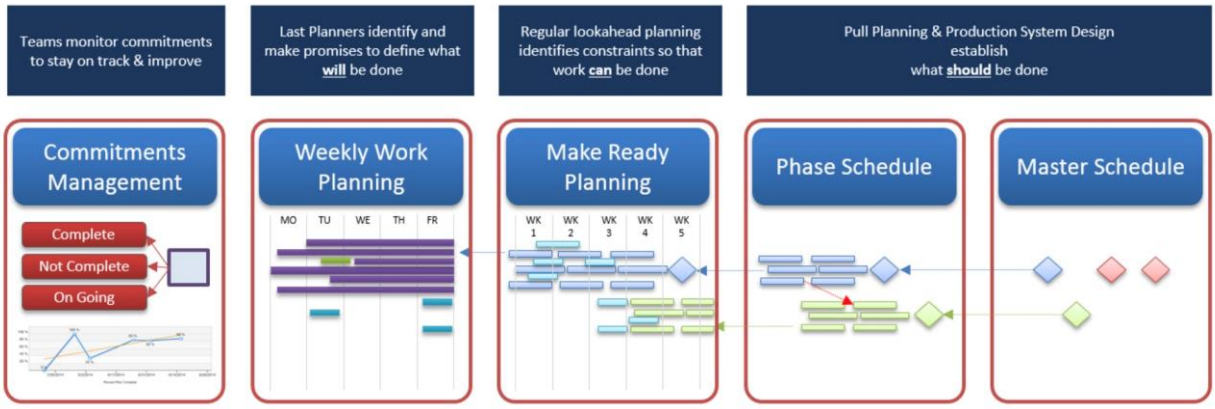
Designers need "play time" or "noodle time" to process the information (Schrage 1999). Though perceived as wasting time by some, this is really about learning and is a normal step in refining the design workflow. Solutions often are not readily available and require more information and "processing" time to resolve. This often results in designers need to "pivot" to pursue a new concept or synthesize new design details to respond to new information. This often requires significant rework of a design and thus change the

schedule or budget as originally estimated and may not be completed by the time when the construction team needed to procure it or use the design documentation to install it. This impedes the overall "Flow" of the project.

Lean Construction Institute (LCI) Official Statement regarding the value of LPS in the Design Phase:

- More about information flows and decisions than material flow,
- More pathways and sequences of work to get to the same milestone,
- More expertise in planning and replanning needed than in construction.

"Design Service Providers have not been exposed to this way of describing and training for LPS."



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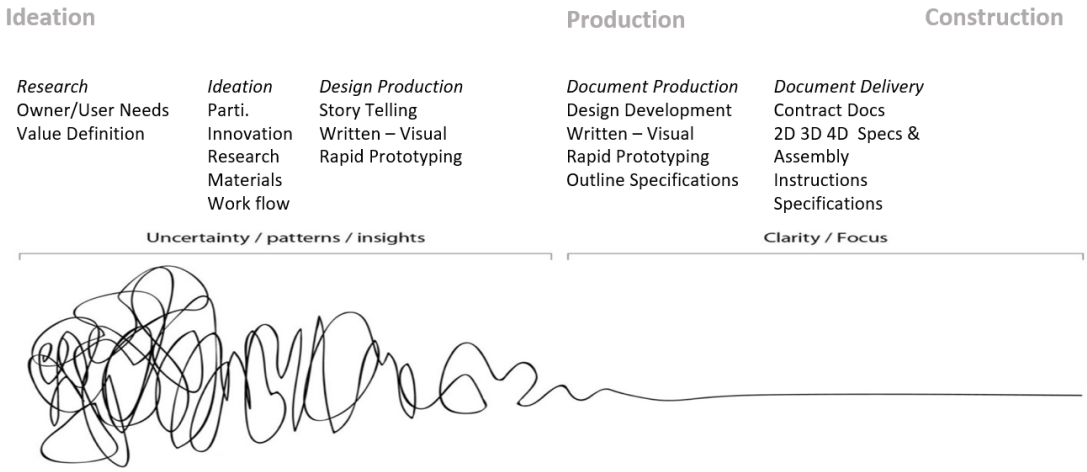
Key Takeaways

The following five key benefits of LPS were found to be of value for Designers. They represent the key findings of improvements of the Last Planner System in Design for LPS Process Benchmark 2020. They were derived from conversations with the research team and interviews with firms with direct Last Planner System experience with projects of all sizes and in all parts of the US.

As stated above, these are:

1. Differentiate Ideation and Production design activities
2. Define milestones focused on decisions
3. Capture and share a clear design process
4. Define criteria as the first step in that process
5. Onboard Designers including techniques such as Reliable Promising and Retrospectives

Differentiate Ideation and Production design activities



IDEATION
- **Decisions** Release Knowledge
- Flexibility Pivot or Adjust as needed (Agile)

PRODUCTION & CONSTRUCTION
- **Deliverables** that Releases Work

Define milestones focused on decisions

The Literature review, interviews, and our subject matter experts all identified vague deliverables as a common challenge during design. (i.e. 50% Schematic Design is not a deliverable) In the ideation phase a common challenge is that performers are redirected as a result of discoveries and refinements of the project's program. The result is that Traditional waterfall scheduling (Push) frequently does not adequately reflect the time required to deliver design decisions and adequately predict develop design deliverables and work packages. LPS and Pull Planning in the Design Phase asks and answer "what is the information I need from others before I can make decisions that will create a deliverable work package?"

The traditional design gateways SD, DD, CDs are not granular enough to express the complexity of decisions, mutual responsibilities, commitments and tasks required to adequately solve a design problem or problems and to plan manage risk associated with estimating design deliverables and complete design work packages on time in the ideation phase. Managers build in buffers to cover unknowns that would likely delay the handovers. This practice introduces risk and often requires frequent adjustments and replanning to meet deliverables and or the information that is delivered is incomplete, or initially unknown and not accounted for in design schedule estimates.

Designers reported they benefited from initially working from a forward pass and then replanning using a Pull or backward pass planning cycle. This is very similar to an Agile methodology used in computer software development and by combining an Agile/Kanban board to record decisions and track weekly progress of information flow the design teams report that they have more success with LPS.

The literature review, interviews and subject matter experts confirm that LPS can successfully be used to establish major milestones with specific deliverables or decisions associated with them and also define a subset of more flexible intermediate milestones used through the ideation phase of design.

Capture and share a clear design process

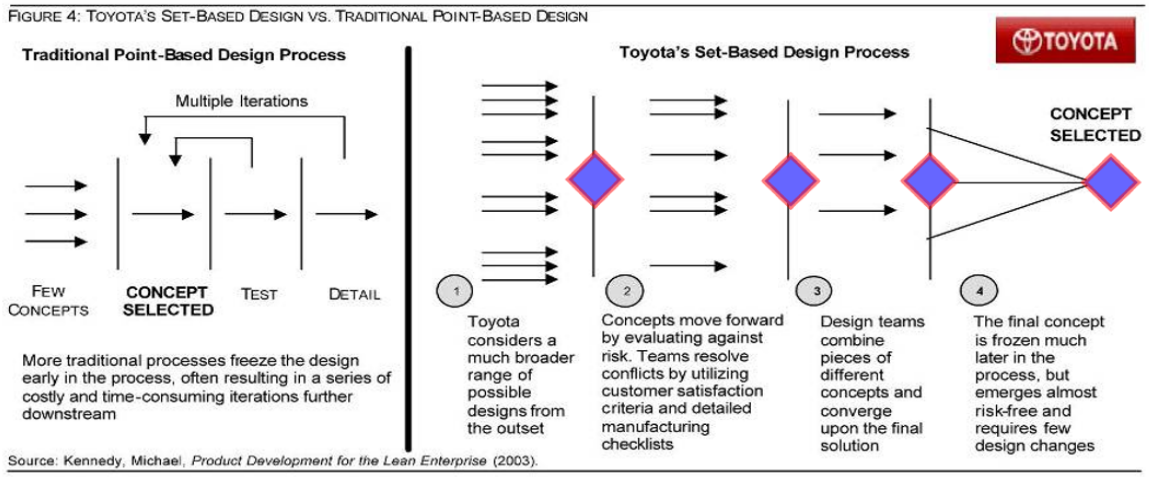
There is an opportunity to clarify the design process for a given project. Note that this is not a suggestion to standardize the design process. The design process does not have to be consistent across the industry – it can vary by project or be adjusted during a project. Having established that, it may be useful to look at design processes common to Product Development, specifically the establishment of Design Criteria before beginning Design Work (many would argue that establishing Design Criteria is part of Design Work), (Kennedy 2003, Ward et al. 2018).

The Last Planner System is positioned to provided structure and transparency to the design process on a given project. In a traditional project where the design happens largely separate from the constructors or users, LPS can set the milestones for decisions, generally from abstract to specific. In a Design Thinking influenced process with significant research and prototype activities, LPS can support the timing of these phases. With a Lean influenced process that includes goal setting, conditions of satisfaction, set based alternates and Choosing by Advantages, LPS can set the timing of decisions based on downstream needs of other team design partners, constructors and users. Perhaps the largest contributor to reliability is the inclusion of a proven solution in the considered alternatives – LPS can easily support this milestone.

This common understanding by the project team of the design process is a major enabler of workflow. Rather than an enigmatic, black box process proceeding at an uncertain pace, LPS provides the opportunity to think of it as an operating system for the project. Though the Last Planner System is commonly applied from end-to-beginning it is also useful to create designer workflows from front-to-back. A BIM Execution Plan is also a supporting structure for establishing the design process – it captures who will do what when and to what level of detail.

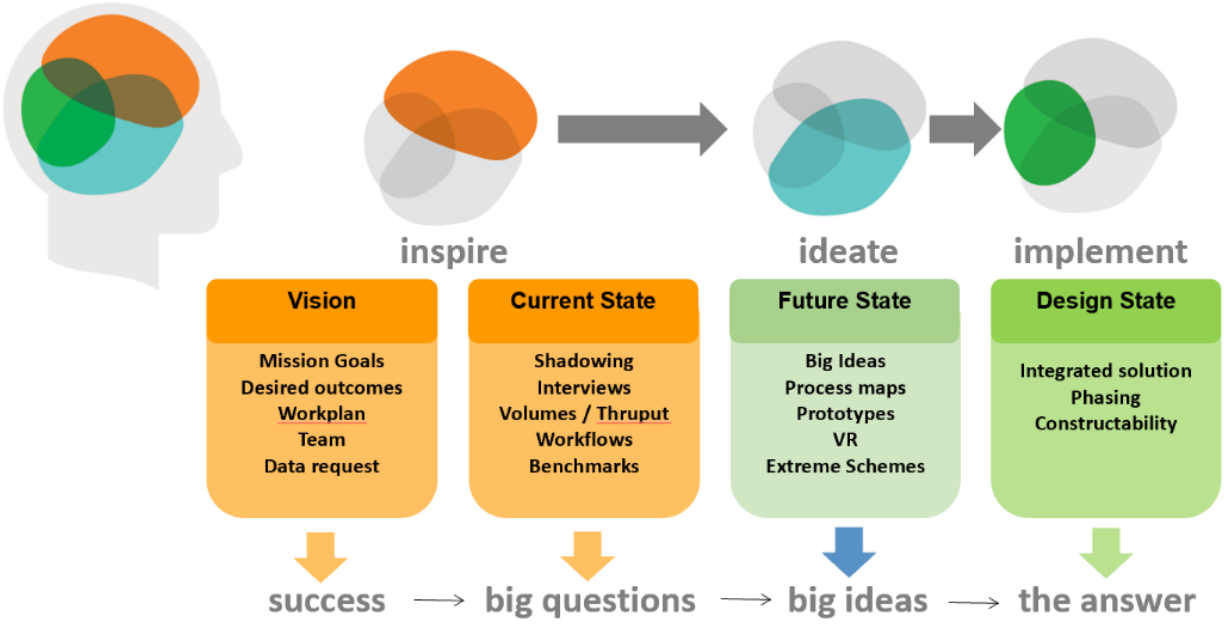
An aspect of this are swim lanes and increasing awareness of the reliance of downstream tasks on predecessor activities. The Phase Pull, Lookahead and Weekly Work elements of LPS emphasize interdependence of tasks and set up both reliability and communication in design (see opportunity #5. Personalizing commitments and shared ownership are enhanced by creating Conditions of Satisfaction at each milestone in the design phase, a logical outcome of implementing LPS in design. (Romano Nickerson, research team member).

A Set Based Methodology



The Integration Events

Define criteria as the first step in that process



Enhanced Ideo diagram

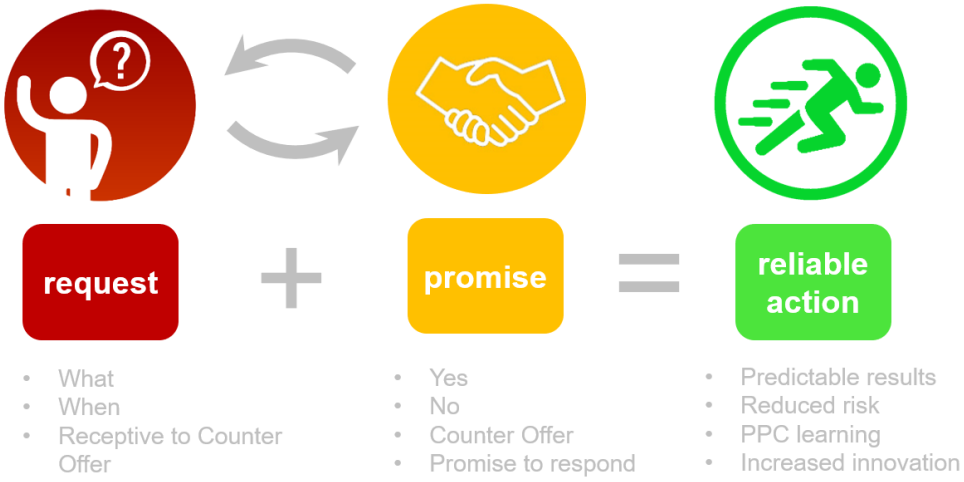
Onboard Designers including techniques such as Reliable Promising and Retrospectives

The literature review, interviews and Subject Matter Expert reviews indicate that Onboarding is generally not implemented during the design phases of a project and often does not included "upstream" actors in the earliest planning and strategy meetings.

Onboarding benefits during production or construction also apply to design:

- Common understanding of the Client's Vision and goals
- Understanding of benefit of planning the workflows and mutual responsibilities and accountability of individuals on the project team.

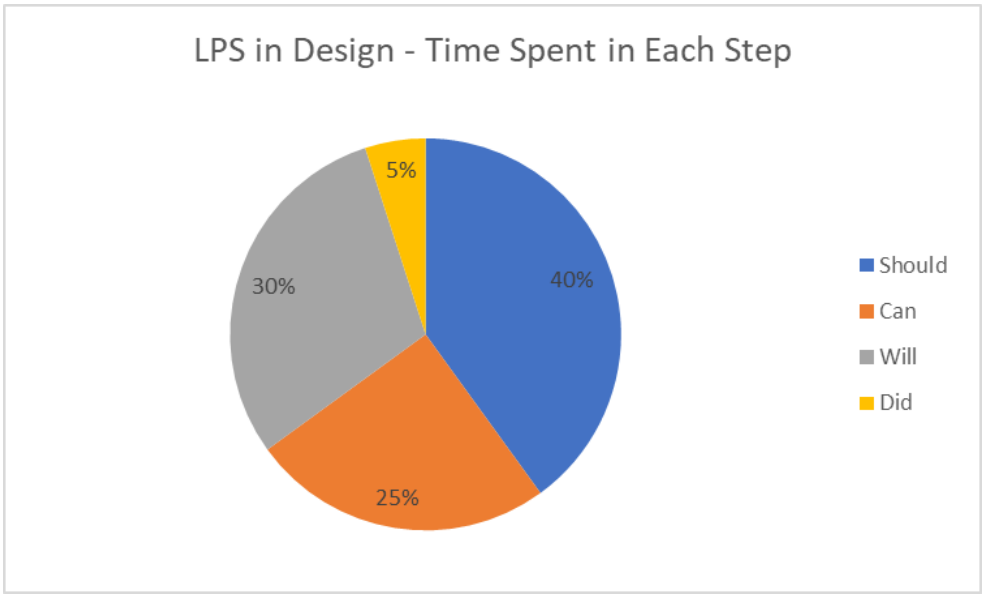
It is recommended that emphasis be placed on the Network of Commitments in a project as part of this onboarding. Reliable promising is a simple but rigorous system that supports increased reliability and specificity on projects and ultimately smoothing workflow. Deliverables in a traditional design process are typically vaguely defined and organically adjusted to describe the amount of work accomplished. The hypothesis is that adopting training and use of the Reliable Promising methodology as standard work as part of the Last Planner System will improve team performance during design.



This Reliable Promising training brings effective behaviors to the design process, these include:

- Specificity re request
- Engagement re being able to say no or make a counteroffer
- Communication re negotiating
- Accountability for both parties
- Willingness to assess, learn and improve

Interview subjects reported the distribution of time spent using the Last Planner System is as shown. The low amount of time in the Did segment was a factor in the recommendation to emphasize reliable promising as part of onboarding. Only 5% on average of respondent's time was spent in learning/improving.



Training in conducting retrospectives as part of onboarding is recommended. The Learning from Breakdowns segment of this research project identifies techniques and opportunities. From Keep/Stop/Start exercises to team health surveys and tracking, Learning and improving during design drives performance culture:

- Assessment
- Self-awareness
- Role in team
- Prototype mentality vs legacy mentality

Guidelines

The key differences between LPS Process Benchmark 2016 and LPS Process Benchmark 2020 correspond to design phases, milestone definitions and designer onboarding:

	LPS Process Benchmark 2016	LPS Process Benchmark 2020
Design Phases	None specified	Ideation, production, construction
Milestone definitions	Completed tasks or products	Completed decisions
Design process	None specified	Clearly defined with an emphasis on establishing criteria
Designer onboarding	None specified	Culture and tools alignment including flow and reliable promises

As stated in Location Based Planning, coordinating between interdependent players is a key issue in planning work. The Design Phases of a project involve a remarkably diverse group, end users, executive leadership, the construct team, and the design team. The design team itself is diverse. On a major project there may be 15 to 20 disciplines, owner groups and Authorities Having Jurisdictions represented. The following guidelines apply to Design Phases:

Who is involved in LPS planning at Project Level during design phases?

- As many trades as possible, including: GC, architects, consultant engineers, MEP, Steel Framing, vendors. Owner engagement is very strongly recommended

How is the Owner involved?

- In design phases, early and deep owner engagement in work planning is very important because owners make the decisions that enable next series of work. In design, milestones usually revolve around decision points and are frequently just decisions.
- Contracts traditionally are specific about decision points using traditional milestones that are based on deliverables.
- An effective technique is to consider decisions more than deliverables. By capturing what is needed when LPS will support an intentional design process.
- Owners have asked for help to re-write their contracts to include LPS and other Lean techniques. The industry has great resources to help the understanding of how Lean tools deliver better projects

How do designers get involved in overall project LPS?

1. Start with an intentional education process for designers
2. Celebrate successes to support deeper use in a project or design organization
3. Assign champions to drive accountability
4. Understanding of what methods resonate with the design team to record information (i.e. sticky notes on paper, swim lanes, software, etc.)
5. Start with discussion about the design milestones that affect the project.
6. For overall milestones understand when clients can make decisions, what can be changed and what cannot be changed.
7. Use pull planning portion to determine frequency and attendees of meetings during the design phases.
8. Sort tasks / deliverables into stand-ups, integration events, pull plan replan-updates and new pull planning
9. Sweet spot for most design teams is to continuously advance plan in 2 to 3-week chunks. This is similar to the 2-week SCRUM approach. It requires discipline and focus of the design team to keep the chunks at this scale and not revert to 3 to 6-month milestones.
10. Learning and Retrospectives
11. Cross pollinate w/ other project teams. Designers have an opportunity to create a common repository of retrospectives and lessons learned as a way to capture and share knowledge.
12. 5 whys is a useful tool for designers when evaluating Percent Planned Complete

Who is involved in an LPS design team?

Architects, interior designers, structural engineers, MEP engineers, medical equipment planners, civil architects, landscape architects, other supplemental consultants and Owners.

- In Ideation Phase (the focus of this paper)
  - LPS is most valuable in terms of identifying the last responsible moments to make design decisions.
  - LPS is used to plan what information is needed from the owner, decisions that need to be made and the work and materials needed to be able to make decisions.
  - Design work in this phase is based on a sequence of decisions.
  - It is difficult for owners to 'touch the work' of the design team. Techniques such as 3P (Production Preparation Process), and Design Thinking can overcome this difficulty.
  - There is an opportunity to think of the Last Planner System as an operating system for a design firm. Designers often unaware of their standard design process. The simple act of recording the design process can result in an intentional design process or firmwide Design Process Guide
  - In addition to pulling from back-to-front it may be useful to work front-to-back to clarify the design process.
  - Increasing sensitivity to networks of commitments is very effective. Strengthening relationships can help with this as can the parade of trades simulation.
  - Defining the Conditions of Satisfaction for each milestone is key. Shared, personalized ownership of the milestones is important.
  - Clarifying and capturing the milestones in this non-linear phase is a big opportunity. Once established the milestones can be moved to establish a more effective sequence or flow.
  - A Kanban or Scrum approach to intermediate milestones is useful to align the thinking of a group.
  - Pre-work such as a Pull Plan Homework Sheet is an effective tool that enables a group to sequentially map discipline flows quickly, clearly and comprehensively.
  - There is a cultural belief amongst architects that altering a design process will result in decreased design quality.
  - The best practice is to identify stakeholders at a very early stage, capture their quantitative and qualitative (emotional) requirements and use this work to test the relative multiple design alternates. This is the model design process used in manufacturing.
- In Production Design (somewhat similar to manufacturing)
  - Last Planner supports controlled information sharing across all the different parties that are participating -- the capturing, the constructability, and the coordination of what was created in the ideation phase.
  - Capturing tasks and pulling backwards is simpler in this phase.
  - LPS is used for delivering a set of documents, what needs to be included in those documents, what decisions need to be made to get the appropriate permit and has the appropriate information to start construction.
  - In this phase LPS offers great benefit for the team to see how a complete set of construction documents goes together. This creates the opportunity to optimize the project deliverable and reduce work.

  - There is an opportunity to build poke-yoke based quality checks into the system during this phase.
- In Construction
  - LPS's positive impact is more connected interaction with the field staff and understanding project status or upcoming constraints. The big opportunity is to be more proactive instead of reactionary with solutions.
  - The work of the design team in this phase is to understand how to respond to the needs of the construction.
  - LPS identifies Request for Information (RFI's) and submittal response times. The system has the potential to eliminate RFI's and minimize submittals.

Summary of critical issues for non-completion of plans in design

- Issue: Owners don't understand the impact of their decisions or lack thereof. Designers are pretty flexible in the way we accomplish our work and we adapt our process around available information. Designers are good at making assumptions that are close but may not be there.
- Mitigation: Have owners involved in the process and not just in the meetings. Creating a collaborative environment and empower everyone within the design team.
-
- Issue: Having good reliable information during the design process about products, materials, cost, constructability and what the client wants.
- Mitigation: Strong communication. Last planner allows you to identify exchanges of information so that designers can identify that a response is needed on the feasibility and cost of a certain system at a certain time.
-
- Issue: Whether using Post Its or VPlanner (software) it is common for team members to write tasks for others. Frequently, the person writing the task does not identify the deliverable very clearly.
- Mitigation: Team members should be allowed to write task requests, not create tasks. Reliable Promising is a reliable, systematic approach to making requests, defining deliverables and creating tasks.
- Issue: There is difficulty predicting duration during design (Wesz et al. 2013)
- Mitigation: Use a chunk approach to make smaller milestones for better time determination. This is most effective as a team discussion.

Summary of suggestions for improvement of LPS Implementation in Design

- Consider introducing the system as a way to open up communication.
- Creating the culture from an early phase with information and development, so that not only the construction managers or civil engineering teams know about it, but the architectural and design team also know about this workflow.
- Better training for people to write their tasks in a more formalized approach, such that there's clarity in the request or what the task is.
- Consider an email or instant messaging notice in electronic systems (i.e. VPlanner) when tasks are created.
- Use a strong facilitator and a team that is open to the process.

- While the basic Last Planner System principles apply in both design and construction, a planned Takt Time in design has not been developed.
- It is important to get the support of everyone on the team including the leaders in the organization. There is an opportunity to 'onboard' organization leaders. Leadership presence at LPS sessions is very effective.

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