Engaging Front Line Team Members to Improve Workflow

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Abstract

A series of projects focused us on improving the way handoffs occur, not just between trades, but between as many people in the supply chain as we could currently affect.

Our paper and presentation illustrate the progression of problems, countermeasures implemented and lessons learned. Our method relies upon the lean concept of defined small amounts of work reliably, quickly and smoothly flowing. It requires a timed plan for every amount of work. Some noteworthy outcomes were achieved from the changes made to our workflow planning method.

We believe it is imperative that our industry adopts techniques to remove constraints, errors, miscommunication and waste while making work safer, more coordinated and more adaptable. That is when workers can say they enjoy what they do. That is when work finishes sooner at improved cost. Our version of the standard work required to plan and assure workflow is shared here for the reader.

Introduction

Every aspect of design and construction has its front line – the people who must produce the work of providing decisions and services as well as those who construct the facility itself. The statement by Todd Zabelle that “Buildings leak at the intersection of contracts” implies that hand-offs are crucial. (Ballard, 2008)

A series of problems was observed preventing us from getting the entire outcome that the Last Planner® System (LPS) was claimed to achieve. LPS is important to us because we believe in its logic and are investing in it. It is central to our approach to improving the value delivered to customers. We had the tools and shared the process steps with our teams. But application was difficult. Was it differences in countries? Labor agreements? Owner agreements? Subcontract agreements? Personnel knowledge, skills or traditions? Motivation? Teaching ability? Training length? The possibilities were daunting. We sought help but the answers weren’t changing the outcomes.

After several such experiences, we were able to identify a set of common symptoms and think about their root causes. Better definition of the handoff was necessary. When matched against a specific lean manufacturing principle and practice, a countermeasure began to appear. Simplifying the effort required by the last planners was key to making reliable promises. We used a specific way to do that.

Our experiment with this countermeasure was very successful. It is helping expedite and improve value. Fortunately it worked when repeated and is being tried on our other projects.
Background

One of the authors, Koga, had been involved in efforts applying lean construction in Integrated Project Delivery under an Integrated Form of Agreement at the Cathedral Hill Hospital project (aka Van Ness and Geary Campus) and Sacramento General Hospital projects for Sutter Health from 2007-2013. That author’s subsequent involvement in the other cited projects provides a common thread in this paper.

Beginning in 2013, Koga participated in the Validation effort for a replacement hospital in Moose Jaw, Saskatchewan, Canada for the Five Hills Health Region. He next had a role assisting Dave Hagan, Dave Shoemaker and Jonathon Mortag as they collaborated with Graham Construction personnel and the design partners in guiding design and construction of this project in 2014. Beginning that year, Koga also had some involvement in coaching lean construction at Essentia Hospital, Fargo, North Dakota, which had a traditional construction management contract, not an integrated form of agreement.

On one hand, there was some successful use of LPS. But this paper is about improvement, so we will expose our concerns, which are combined in this list though each did not occur at every project.

- Last Planner was not always correctly applied by the Last Planners (design or field).
- The intensity of project demands regularly caused fire-fighting, not planning.
- Owner input to inform design was not always timely, and perhaps not well sought.
- Complete information enabling construction was often absent.
- Clash detection fell behind design; construction was advancing faster than both.
- Some of the contracts did not encourage collaboration, e.g. Hard bid, Piece Work, Unit Price and those not a part of a risk pool. Some of these contractors worked in traditional protective ways.
- Some companies had difficulty tracking actual cost and contingency to inform production.
- Despite efforts at mapping work flow with some tradesmen, the information was forgotten.
- Changes in field leadership created new disconnection from prior mapping effort.
- The participation of some foremen in Last Planner was often superficial at best.
- Some workers openly rebelled against planning or felt insulted by requests to plan in this way.
- Some foremen did not have the knowledge or skill necessary to plan in this way.
- Sometimes workers would say there was too much disarray to enable a good plan.
- It was difficult to establish firm milestone targets, consequently milestones could be ignored.
- There were some significant material delivery problems affecting plans.
- Takt time was too abstract or seemed impossible and therefore ignored by workers.
- Takt areas were established based on traditional boundaries, and were often large.
- Most foremen would not provide colored-up plans committing to a quantity by a specific time.
- There was an instance of letting work statements advance to the next week without the foreman declaring that pending holidays meant a large crew would be away for two weeks.
- There were several instances of not openly declaring delayed material shipments until the current week, and then pushing the planned-work statement back into the future.
- Above-ceiling system work required a different plan than below-ceiling room work.
- Based on the LPS plan, workers had all week to finish a task.
- Incomplete work was shoved repeatedly into the next week and schedule delays occurred.
Large work descriptions were divided into chunks and progress couldn’t be confirmed.
Tracking large volumes of completed work accurately is a time-consuming job.

Projects with another client in 2014 exposed another problem to solve. How can foremen make reliable commitments when the Owner must stop access to work areas on short notice due to the Owner’s schedule? The project managers and foremen were cooperative in trying to use LPS, but the work interruptions made them feel that committing to dates was impossible. In addition, the discovery of existing conditions during demolition also made reliable promising difficult.

Related Work
This is not the first time that construction teams have seen such problems or sought solutions. As shown on their website, members of the Lean Construction Institute have attacked it for nearly two decades. Location-Based Management System, Takt-Time Planning and Flow Line Visualization are examples of techniques that have been developed. A June 2014 paper provides observations of their use and many resource citations. (Tarek Yassine, 2014)

We had experience with location-based management plans, but our issues were not just unbalanced work forces. The impact of work stoppage was also a different type of problem. Then a new project and its challenges was started in early 2015. Our approach needed improvement.

Analysis
We had many questions as we prepared for this new project whose construction was being fast-tracked.

The Last Planners (LPs) at the prior projects were often frustrated and uncooperative.
Why? One reason was that they didn’t see the planning yielding unique results.
Why? The LPs (couldn’t, wouldn’t, didn’t) make reliable promises.
Why? They say the work will take what it takes. The milestones will get pushed accordingly.
Why? Because so many of the variables can’t be controlled.
Why? Because the planning system was not responsive enough to the everyday pressures.
Why? The problems were large and require a lot of time.
Why? Some problems involve the entire building, others entire floors or parts of floors. Some problems are parts of systems. Then there are many problems having nothing to do with area size.
Indeed one of those problems was probably based in training and rigid adherence. Another was contracts. Another was scope clarification. Still another was skills.

Indeed there were many problem types. They were affecting the delicate balance of aspects typically seen to support customer satisfaction. Excellent productivity was missing. We had to engage all parties, from design to supply chain. We had to adjust our approach for better acceptance and get better productivity at the new project.
We looked at questions directly involving the LPs:

- Why was takt meaningless and not being leveraged well? [It was absent or poorly defined.]
- Why was planning difficult for workers? [Some do not have the training or experience.]
- Why were color-ups not colored up? [Became too quickly inaccurate so why bother.]
- Why were promises not fulfilled? [Too large. Too busy. Too many promises for time available.]
- Why were estimates, forecasts and actuals misaligned? [Variance in ability of personnel.]
- Why was tracking output time-consuming? [Not motivated to track output.]

We also noticed something common to our problems: the one week framing of time for assignments.

It enabled a significant lag in time before alarming us that work was not going to be complete that week. It enabled excess optimism about completion. It enabled procrastination. It enabled planning within the current week rather than before the current week. It hid problems. It was difficult for an honest tradesperson to accurately predict with certainty the specific amount of work that could be completed in one week. It created large inventories on the floor. It required large areas of work to be complete before a handoff was made. It created large areas of completed work to be idle and waiting for workers. It was too easy to push work into the weekend requiring overtime pay or into next week because, “what else can you do?” The one week window was too long.

“But it won’t make any difference,” they said, “It is the way we’ve always done it and changing that …just can’t be done!”

**Problem Statement**

How can workers receive useful directives that consistently prepare for and respond to current working conditions and improve throughput?

**Hypothesis**

Make production assignments small, visible and flowing.

The amount of work in an assignment must be achievable and make sense to the worker.

Production involves all project delivery contributors.

**Countermeasure Development**

In lean manufacturing, everyone from sales to shipping has a role in producing the item shipped. The same can be said for production of a construction project.

In lean manufacturing, producing to takt means having an overall system or process that produces to the demand rate of the plant’s customer.

Takt = (available production time per day / customer demand per day). (Chet Marchwinski, 2008)

When a part of the process cannot produce exactly to takt, they produce to a pace that shows an awareness of the takt, called “takt image.” (Chet Marchwinski, 2008)
For example, if the cycle time of a widget line is four times longer than the takt, then four widget assembly lines are required because only their combined output can produce at the rate of the plant’s “customer demand.” That is, if customers want or buy one widget every 5 minutes, and a line requires 20 minutes to produce a widget, then 4 lines are needed to meet demand. The plant establishes a takt image in the form of a pull signal every 20 minutes for each line so that in concert they achieve takt.

This also enables adjusting takt image for a line as its capability changes though takt remains unchanged.

Assuming there is enough demand to require continuous flow, knowledge of the takt image helps the assembler and manager know when their process is working at the correct pace. (Ideally the assembly process will have a pull signal set to the takt image.)

Cycle time is an actual rate. We can also use the example to explain the desire for the line’s “cycle time” to run equal to the “takt image.” The takt image is a target rate. (Chet Marchwinski, 2008)

The individuals packaging the widgets and putting them in cartons or putting cartons on a pallet may use yet another term to identify their pack-out rate. It is pitch. “Pitch is the amount of time needed in a production area to make one container of products. The formula for pitch is

\[
\text{Takt time} \times \text{pack-out quantity} = \text{pitch} \quad \text{(Chet Marchwinski, 2008)}
\]

Pitch is an important concept. “Pitch, in conjunction with the use of a heijunka box [to level the mix and volume of production by distributing signals] and material handling based on paced withdrawal, helps set the takt image and pace of a facility or process.” (Chet Marchwinski, 2008)

As previously stated, we observed many problems on jobs that called a work week “takt time” without having actually calculated that cadence from demand of the Buyer.

We wanted to adjust this per our hypothesis. Our customers do not buy pieces of a building. It is only valuable to them in its entirety. They take occupancy once. We should calculate takt once, not per construction process, according to the convention of customer demand. We can then calculate takt image and pitch. To enable this, we have to define the output, the pack-out quantity, of our processes. Then we have to balance them so interference is avoided and good handoffs can be made. This can help get closer to one piece flow and that will be necessary to improve “order lead time” (the entire time from order to delivery). These calculations for a building are demonstrated in the example.

**Building Example**

**Takt**

Owner requirement: 200 work days available from start to occupancy. 96,000 SF gross building area. Working 1 shift. (Technically I should also subtract for lunch, work breaks, meetings and other mandatory pauses in an 8-hour day because takt is based solely on available work time. I would subtract them for a real project, but will keep this simple.)

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(8 \text{ available production hrs per day} \times 60 \text{ min per hr}) / (96,000 \text{ GSF} / 200 \text{ work days}) = 1 \text{ min per 1 GSF}.
\]

Defining takt from the perspective of this project’s Owner means that every 1 minute of the working time of the 200 work days, a one SF sized portion of the building is completely assembled.
On the various charts used in kaizen to balance production rates or manpower, takt is drawn as a horizontal line at a number on the y-axis. It is a production time target, as is takt image.

**Takt Image**

When manufacturing widgets, there are sub-processes that come together to enable achieving takt. Similarly specific building process unite to achieve takt. But to localize the metric for each process, we calculate its takt image, considering that building phases and processes are sequential in some cases and parallel in others. Here is an approach recognizing relationships and respecting takt as a single outcome.

**Sequential Path 1:** Foundation phase to Structure phase to Enclosure phase to Buildout phase.
- Takt Image of Foundation phase: Schedule says 20% of the 200 work days, then 0.2 min per GSF or 1 min per 5 GSF. This can be further translated based on the footing area supporting building gross area.
- Takt Image of Buildout phase: Schedule says 60% of the 200 work days, then 0.6 min per GSF.

**Sequential Path 2 (parallel to Path 1):** Equipment phase to Distribution phase to Controls to Start Up.
- Because it is parallel to Path 1, calculate by using the takt again as if unconsumed.
- Takt Image of Distribution phase: Schedule says 40% of the 200 work days, then .4 min per GSF or 1 min per 2.5 GSF.

**Pitch**

Pitch is a time interval, or pace, at which we must fill one container with product (each trade’s work content). A pull signal set to the pitch helps avoid overproduction. Pitch helps account for work velocity and balances the work force. The container in this building example can be a room or set of rooms.

The formula Pitch = takt time x pack-out quantity is the same as Pack-out quantity = Pitch / takt time.

Let’s select a pitch that will negate many of the problems previously stated as caused by using 1 week. Let’s try ½ week or 20 hours=1200 minutes. Let’s substitute the takt image time for the Buildout phase.

\[
\text{Pack-out quantity} = \frac{1200 \text{ minutes}}{0.6 \text{ min per GSF}} = 2000 \text{ GSF}.
\]

Once the buildout process is fully charged, every 20 hours a contractor has one pass to achieve the goal of completing 2000 GSF. We then divided the work to account for multiple contractors and passes.

It will be very important to divide the floor area into lots of approximately 2000 GSF that contain the right amount of work content and resources so that work is not waiting for workers and workers are not waiting for work. It is important to find lot boundaries common to all to get conflict-free handoffs.

A table for the buildout process will use pitch numbers for the columns and either trades or lots for the rows. If trades are used, the cells will contain lot numbers. If lots are used, the cells will contain trades. The pitches should equal the schedule duration for the phase used to calculate takt image.

Schedule buffers can be built into the table. This can help reduce the impact of weather, the Owner’s need to restrict access to an area and other surprises. When an incident like weather causes a work shutdown, the workers identify their place in the plan by reference to the pitch number and lot number without confusion of being locked into a calendar date.
To clarify, lots are not only room boundaries. A “lot” bounds an amount of work. The work is contained in the lot. We say that the “work content” of a “lot” is performed during a “pitch.” So a quantity of beams to place in a day can be a lot. A 3-dimensional portion of a structure can be a lot. A quantity of ductwork can be a lot as can a quantity of light fixtures or switches. However it is best to define lots that have meaning to many trades to enable interaction, communication and handoffs.

An advantage of using pitch and lots is that the general contractor does not need a color up from each trade to determine whether work is progressing correctly. One look at the work in the lot will tell.

Using the terms pitch and lot to describe activity when making reliable promises in Last Planner is adequate, easier and communicates more information than is typically stated.

The terms pitch and lots can also convey information to designers when making requests.

Pitch and lot are terms the worker can relate to daily. It enables engaging them quickly. They do not have to think about takt time. They become concerned only with whether they made the lot ready for the next trade and whether the trade in front of them is done on time. The same is true when the work of designers is put into this table.

Advantages in safety, housekeeping, congestion, inventory, communication and collaboration abound.

Experiments

Three experiments helped develop and refine our countermeasures. Each experiment taught us. Here in the words of construction representatives are the problems, constraints, countermeasures and outcomes they experienced.

Site A

We regularly experienced interruptions in workflow due to this client’s operations. In the production board set up in 2015, we made a row so the pitch could be shown instead of the calendar date. Therefore we scheduled an amount of work content per pitch in a lot. This was helpful to our crews because their plan for construction is regularly interrupted by the factory’s schedule. Instead of saying we will start Monday’s work on Thursday, we say Pitch 3 was originally scheduled for Monday and Tuesday. Now due to the restriction on work, do the activities of Pitch 3 this Thursday and Friday. The board is set up to require minimal resetting of info on it. We didn’t have to move any sticky notes or change the pitch number. We just change the calendar day written down and sometimes the shift number. But all the production logic is unchanged and we can list a "lot" of work within a pitch.

In a factory, pulling the andon cord can stop production. They still have to complete the work content that was to occur (in the paused pitch). If their system is stable, they cannot just start producing faster to catch up. That could affect quality. They would use a buffer or they might turn on a spare but idle line. (In construction, we would add manpower which is like turning on an idle line.) But the factory must still complete the work that occurred in the paused pitch and then proceed to the next pitch. The buffer used on our construction pitch board maintains work flow and throughput in a similar way.
Site B

The Customer for Site B requested expediting their two-story 84,000 GSF healthcare facility on its green field site due to market pressure to be operational as quickly as possible. Design and construction overlapped and many enclosure and interior details were drawn even as steel was being erected. There were also constraints on cost. Most believed that either the target for schedule or the target for cost could be hit, but not both, for surely any schedule slippage would require increasing labor on site.

Fortunately the construction partners were collaborative and friendly toward one another. But workers generally did not believe that more planning would be productive since all plans seem to fail anyway. “Besides,” they said, “there wasn’t enough information to plan from.”

Construction had begun by ripping up frost to place footings. Above ground, very thick concrete vault top slabs were formed and readied for the first pour on March 27, 2015. Structural steel erection was due to begin April 20. The exterior enclosure details were still being determined and the team was working from sketches. It included stone work and a new panel system, sun shades and curtainwall.

Amid the urgency the general contractor wanted the team to use a new type of planning effort for the interior buildout, something to do with “pitches.” The GC also wanted the drywall contractor to learn to use BIM modeling software, model the walls and coordinate with the MEPFP trades. “Who had time for planning?” some asked.

But all the foremen, superintendents and project managers did plan together with assistance by Boldt’s performance resource persons. The team was told to make a plan that tightly coupled work flow and reduced waste to deliver each room by the last responsible moment. A new term, Pitch, was introduced and it was set at 20 hours. Handoffs would occur at noon on Wednesdays and quitting time Fridays. The building’s interior was divided into 23 areas based on work content plus special rooms and corridors. Adherence to milestones was paramount. Tasks were not allowed to be moved to the next week. It took many small group meetings and comparisons to budgets. By June 18, a Pitch Plan was published for work beginning July 13. This included all of the work above and below the ceilings. A report card dated Sept 2 indicates all areas on target except for a few that had to be re-planned. In fact, to everyone’s amazement, the Owner took occupancy by Dec 31, 2015. Even all of the paving, parking and landscaping was complete. The exterior and interior design is very striking. It contains several exotic materials. The project was safely completed below budget.

Why were we successful? What was different? Certainly it was helped by immense collaboration in lieu of the hundreds of RFIs and Change Order arguments that traditionally occur. Certainly some prefabrication helped. But the project also ran into some resource shortages and bad weather. We believe that in addition to the aggressive project start, planning the interior buildout to a short 2-1/2 day pitch helped very much.

First, it decreased the invisible waste of “work waiting for workers” and “workers waiting for work.” One foreman commented that it removed the stress from his work! It made planning daily deliveries easier. It helped reduce congestion even though there were 130 workers inside. It helped avoid excess inventory on site which improved both safety and the ease of getting around. Workers received clear
work areas – just like they wanted. Housekeeping was very good. Production was assigned strategically and workable backlog was determined. Buffers helped absorb several impacts.

Combined with the Boldt Production System (a form of Last Planner) constraints were addressed early and few crept into the current week. The foremen were empowered to ask and get answers. Planning using the pitch areas (later called “lots”) made it easier for the foremen to more accurately define reliable promises. They owned the plan and held one another accountable. Throughput flowed.

Site C

Site C was a customer with a very aggressive schedule for demolition and remodeling of 100,000 sf of space while customer employees partially occupied the space. Any possible improvement in the safety of all parties (owner employees, guests, suppliers and craftsmen) had highest importance closely followed by improvements in quality, production and cost.

The team felt this was an ideal opportunity to apply Boldt Production System (BPS) planning with its visual display management. While the overall project was a significant success (zero injuries and an on time and under budget delivery), we did encounter challenges along the way. The following challenges and countermeasures present this further.

**Human Factor Concerns:** This management process is a change to the norm and many people are resistant to change. Levels of resistance from the Last Planners varied depending on their age, experience, planning capabilities and willingness to try new things. There are other factors such as worry about being held accountable for not achieving their projected goals, getting up in front of a group of their peers to present their plan or challenging others who are not meeting their goals which in turn holds them up.

Countermeasures for these concerns were sometimes discussed and set in place to avoid potential concerns later in the process. We found it helpful to explain the overall process at the beginning of the project and tell why the team was using this planning process to achieve the customer and team goals. We not only wanted to be sure to complete the project, we wanted each team member to learn and grow as part of the process. We coached and mentored along the way. People can be uneasy asking for help so we asked how they were feeling about the process. We found one on one discussions to work very well for this type of coaching.

**Increased Level of Planning & Tracking Results:** We asked team members to plan in a much more detailed way and to look at activities out ahead as far as possible, in many cases 6 to 8 weeks. This allowed the planners to identify potential or existing constraints for design information or supply chain concerns. As the activities moved ahead into the 2-week window, planning shifted to daily tasks. We asked the front line leads to state in detail the exact work to be done, the specific area the work would occur, the specific quantity of work, and the resources required to perform the work. The next very critical step was to track the results of performance against the plan. That is where many Last Planners get a bit nervous asking, “What happens if I don’t meet my goals?” Part of management’s role is to be sure to help the Last Planners understand that all plans will have some level of variation. If the goal is too low, the team will get the planned work done with time to spare. This can be good, but the team
also had workable backlog activities to enable reassigning workers. Therefore, performance to plan was a continuous cycle which allowed for adjustment based on performance.

**Visual Display Management:** Visual display boards are easy to use and understand. The key benefit to this system was the ability for all Last Planners to clearly understand how their work directly impacted each of the other trade partners. If one of the teams fell behind, the ripple effect was very real and immediate. Managers had to be clear with all Planners that the overall goal was for everyone to succeed holistically and not just as individual entities. The boards helped to clearly identify constraints and to determine who owned resolution of the constraint and when. Any team member could take a picture of the planning boards with their phone or tablet device and had easy reference to the plan. The boards were also always available in the planning area for anyone to reference eliminating worry about having the most current printed schedule.

**Work “Lot” Sizes:** We integrated the use of specific work areas called Lots into our Boldt Production System. Traditionally work areas are determined geographically for a specific period of time, even several weeks. With lean we try to determine them based on the amount of work that could be accomplished during one week and in a sequence that makes work flow. With Customer C, the team used large Lot sizes for the first phase of the work. Success for this first phase was acceptable, but we felt improvement could be made because the large Lots didn’t allow for quick enough adjustments to the plan when variances were discovered. During the second phase, there were initially three areas. Then the Lot sizes and performance periods were approximately cut in half making 7 lots instead of 3. This allowed the team to adjust the plan faster when variances were discovered. It also removed the invisible waste of vacant work areas waiting for workers. It helped us meet the schedule.

**Learning**

The experience of running experiments involving live projects expedited our learning. There is also the pressure of putting one’s ideas at risk. Here are some things learned from a technical perspective:

- Engaging front line workers in planning production lots by pitch is possible and worth the effort.
- Collaborative planning reduces frustration when encountering difficulties.
- We quickly and usefully connected project takt, takt image and pitch achieving balance of labor.
- Planning “work lots” by pitch enables adapting to quickly changing conditions.
- Early identification and removal of constraints is essential to continuous work flow.
- Workers have a “good day” when the planned commitments are achieved with quality on time.
- Reliable completion of small amounts of work accelerates flow and throughput.
- Planning “work lots” by pitch is closer to one-piece flow and helps reduce the 8 wastes (defects, overproduction, waiting, non-utilized talent, transportation, inventory, motion, excess processing).

To answer our problem statement briefly, this means front line team members must collaboratively design small, rapid task agreements and focus on what is important to front line worker success.
We learned that engagement with those performing the work, whether in design or construction, begins with connection to the parameters of the Owner’s request for value and must result in small clear bounded directives. Those directives are most effective when occurring in a repeatable planned process, not a spontaneous fire-fighting mode. The process should have a consistent cadence that can be felt when working. The process sequence should consist of small promises that can be performed quickly.

Training in the way to plan enhances the skills learned on the job. It should teach that connected collaborative workers are more effective than independent contractors acting aloof of one another. That collaboration should consist of plan-building agreements determined by the front line team members and guided by the superintendent. It should mitigate issues like ensuring adequate resources early. The result should be a fair distribution of work that equalizes motivation and can be performed to a cadence.

The supervisors are there to set direction by explaining what is needed then follow up with a consistent check-in process. A visible visual display helps direction-setting, development of interdependent promises and the check-in. The verbal communications of supervisors and the front line workers with one another should be kept friendly and build relationships lasting into the future.

We are using what we have learned and, as it is shared, trust that it will be improved further.

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Works Cited

