# COLLABORATING WITH A PERMITTING AGENCY TO DELIVER A HEALTHCARE PROJECT: CASE STUDY OF THE SUTTER MEDICAL CENTER CASTRO VALLEY (SMCCV)

**Isabel Alarcon[1], Digby Christian[2], and Iris D. Tommelein[3]**

## ABSTRACT

This paper presents a case study of the Sutter Medical Center project in Castro Valley, California (SMCCV). This project's commercial terms are established in an Integrated Form of Agreement (IFOA). This project stands out in several ways. One is the way in which the team used visualization tools to create transparency and to establish a common goal for the team. Another one is how the integrated team worked hand-in-hand with representatives of the state permitting agency to develop strategies and work methods to implement the Phased Plan Review (PPR) process. PPR is one option the team and the agency could pursue in unison to result in permitting for construction of this healthcare facility. This paper details the project delivery's operating system the team put in place in order to obtain increased certainty in the project's design, permitting, and construction phases. It includes examples regarding the actions team participants took to achieve this objective and relates these actions to lean principles they reinforced throughout their application.

## KEY WORDS

Phased Plan Review (PPR), Office of Statewide Health Planning and Development (OSHPD), Integrated Form of Agreement (IFOA), Design Management, Collaboration, Visualization, Transparency, Permitting, Healthcare Facility, Operating System.

## INTRODUCTION

This paper presents a case study of the Sutter Medical Center (SMCCV) project, located in Castro Valley in Northern California. This project's commercial terms are established in an Integrated Form of Agreement (IFOA) (Lichtig 2006). The IFOA supports one kind of Integrated Project Delivery[4] (IPD), defined by the Lean Construction Institute (LCI 2011) as "a delivery system that seeks to align interests, objectives and practices, even in a single business, through a team-based approach. The primary team members would include the architect, key technical consultants, as well as a general contractor and key subcontractors. It creates an organization able to apply the principles and practices of the Lean Project Delivery System." This

1 Graduate Student, Industrial Engineering, Univ. of California, Berkeley, CA, ialarcon@gepuc.cl
2 Senior Project Manager, Sutter Health Facility Planning & Development, ChristD2@sutterhealth.org
3 Professor, Civil and Environmental Engineering Department, and Director, Project Production Systems Laboratory (p2sl.berkeley.edu), 215-A McLaughlin Hall, Univ. of California, Berkeley, CA 94720-1712, Phone +1 510/643-8678, FAX 510/643-8919, tommelein@ce.berkeley.edu
4 IPD is a registered business mark by Lean Constr. Institute: US PTO - Class 37; Reg. # 2,971,009

definition of IPD differs from American Institute of Architects' (AIA 2007). The use of an IPD does not guarantee that lean construction practices will be applied throughout a project. Nevertheless, principles in IPD enable the pursuit of lean ideals.

The integrated team that delivered this project followed a distinct and lean approach in order to develop the design and obtain a building permit. They used the Phased Plan Review process tailored for this project in collaboration with the Office of Statewide Health Planning and Development (OSHPD). This paper presents the integrated team's operating system, put in place in order to fulfil their objective of increasing certainty in the project's design-, permitting-, and construction phases. The purpose of case study is to provide a conceptual framework in which to analyze the development of this project and present concrete examples that illustrate the actions team participants took to achieve their goals in the delivery of the project. The examples aligned with lean principles were reinforced throughout project execution.

## CONCEPTUAL FRAMEWORK

The Lean Construction Institute (LCI) has since 2007 been offering introductory seminars in which presenters describe how lean project delivery systems differ from 'traditional' delivery systems, in regards to 3 edges of a triangle, namely their (1) organization, (2) so-called 'operating system,' and (3) commercial terms binding project participants (also see Thomsen et al. 2009 pp. 10-17). In order to produce more optimal results at the systems level, attempts for performance improvement must consider all 3 domains, while maintaining alignment and balance between them.

### ORGANIZATION

The domain called 'organization' refers to the way people communicate with and report to each other in order to deliver the project. Organizations delivering 'traditional' projects typically include three parties: (1) the owner, (2) the designer, and (3) the contractor. Designers (and design specialists) are involved early to design the product, and contractors (and specialty contractors) come in after the design is more-or-less complete and ready to make (build) the product. Communication happens through the channels established in the contract and informal channels.

In contrast, in IPD projects, construction managers and key specialty contractors are involved earlier in design. This makes it possible for all team participants to develop a shared understanding and offer frequent input about design factors and criteria, constructability and supply chain capabilities, etc., thereby decreasing the likelihood of rework and reducing lead times for feedback. In order to promote effective communication, team participants may be co-located. This was the case on SMCCV where the team combined such physical proximity with carefully thought-out methodologies for communication, cooperation, and coordination. In this type of organization, the project leader plays a critical role in establishing the expectations as well as the trust of team members, thereby creating an integrated high-performance team, regardless of who employs each team member.

### OPERATING SYSTEM

The domain called 'operating system' refers to the way work is managed and executed in the course of 'producing' the project. The 'traditional' approach is to break the project down to individual activities and to improve performance of each activity in order presumably to increase overall project performance. This piecemeal approach ignores that performance of one activity can affect other activities in the system, and it ignores the notion of 'flow' throughout the system.

In contrast, lean construction practitioners focus on work flow, and they aim to make it stable, predictable, and coordinated. The first step in managing work flow is to stabilize the work environment by shielding production from upstream variation and uncertainty (Ballard and Howell 1994). While maintaining reliable workflow, work must also be structured in order to maximize value and reduce waste. Tools used to achieve these objectives include: Plan Do Check Act (PDCA), A3 reports, Value Stream Mapping, Building Information Modelling (BIM), Virtual Design and Construction (VDC), the Last Planner System™, and Target Value Design (TVD).

### COMMERCIAL TERMS

The domain called 'commercial terms' is many times understood as the sole constituent of an IPD project; this is a misunderstanding. Commercial terms establish a framework including a structure to allocate risks and compensation in order to align the parties' interests with a collaborative approach and with the overall success of the project. The reason for equating IPD with only the 'commercial terms' edge of the triangle probably lies with IPD referring to "a Relational Contracting approach that aligns project objectives with the interests of key participants, through a team-based approach" (Matthews and Howell 2005).

As mentioned, participants on the SMCCV project have their commercial terms spelled out in an IFOA. This has motivated participants to align their interests and pursue common goals to benefit the project as a whole.

## PROJECT CONTEXT

California is well known for its earthquakes. Legislators have been particularly concerned in increasing seismic requirements for hospitals. State Senate Bill 1953 (SB 1953) requires owners to evaluate their acute care hospital buildings for seismic resistance. While other building codes in California have focused on life safety (i.e., requiring that buildings be designed to remain ***standing***—not collapse and crush people—after a large earthquake), SB 1953 is more demanding in that it requires acute care facilities to also remain ***operational***.

This legislation created upheaval among healthcare facility owners, as it forced them to rethink the use of their infrastructure, and to decide whether to either upgrade their existing facilities or to demolish them and rebuild new ones. SB 1953's mandate is unfunded by the state, but the rebuilding it requires of an estimated 52.4 million square feet (approximately 4.9 million $m^2$) or about 50% of current hospital floor space will cost an estimated $110 billion, not including financing costs (CHCF 2007).

The state established the Office of Statewide Health Planning and Development (OSHPD) to oversee the permitting of acute-care hospitals and other types of facilities. OSHPD (2005) reviews designs for new construction or renovation, and observes construction in progress to ensure compliance with what they approved.

In 2006, when P2SL worked with industry to study causes for long permitting lead times, (http://p2sl.berkeley.edu/events.htm), the permitting phase of major, new acute-care facilities in-between the completion of design and the start of construction took on the order of 18 months longer with OSHPD review than on projects without

OSHPD review. This OSHPD review process is a stumbling block in the middle of delivery process and comes at a huge opportunity cost to the owner, users, and other stakeholders. An alternative to shorten this process is presented with Phased Plan Review (PPR), which is “the process that engages the Facilities Development Division (FDD), at its sole discretion, early in the project design, continuing through the development and submission of documents during the conceptualization, criteria design, detailed design, implementation documents, agency review, construction and closeout phases. Within each phase, milestone(s) will be established at which point(s) specific, agreed upon segments and/or elements of the design and/or building systems are completely designed and/or are defined in their entirety” OSHPD (2008).

Accordingly, the project team as well as OSHPD understand that the PPR process imposes demanding requirements on them: everyone must submit their deliverables in a timely fashion and work in a coordinated and collaborative manner. Failure to achieve this may cause the system to perform even worse than it would perform using a traditional review process.

## SUTTER MEDICAL CENTER CASTRO VALLEY

The Sutter Medical Center in Castro Valley, California (SMCCV) is a $320 million project that includes the construction of a new, state-of-the-art hospital on the Eden Medical Center campus (Figure 1). This project has been groundbreaking in its innovative use of an 11-party IFOA. This project is currently in construction and is expected to be completed in 5 years’ time. People familiar with the industry say the ‘traditional’ project delivery might have taken 7 years.

A six-member team manages this project. The team, called the Core Group, has representatives from (1) Sutter Health (owner), (2) Eden Medical Center (Sutter affiliate, owner), (3) DPR construction (general contractor), (4) Capital Engineering (mechanical and plumbing design), (5) Devenney Group (architectural design), and (6) J.W. McClenahan (plumbing specialty contractor).

Digby Christian, Sutter Health Project Manager, explains the functioning of the team as follows: “The core group meets every two weeks to ensure the project is managing all the risks as optimally as possible. All decisions are required to be unanimous, and for the two years that we’ve been meeting, we have met that requirement. A much larger group comprising all the designers, builders and specialty consultants meets at least every two weeks to resolve any strategic issues affecting the whole project”(SMCCV 2010).

## INCREASING CERTAINTY IN THE DESIGN/PERMITTING PROCESS

### FIGHT THE “DRAGON OF UNCERTAINTY”

Production philosophy has come to an important statement “Variability is the universal enemy” (Koskela 1992). Fighting variability is equivalent to increasing predictability which is fundamental in project management. Many actions of the SMCCV team in early stages were steering towards obtaining a predictable workflow in later stages. The team strongly believed that many improvements might not have a real impact if they would not be able to achieve a stable workflow environment. Accordingly, reducing uncertainty was a fundamental and a minimum requirement in all actions taken on this project. Christian's (2011) "dragon of uncertainty" (Figure 2) illustrates how uncertainty can threaten schedules and control budgets.

Figure 1: Webcam picture of Sutter Medical Center Castro Valley as of 17 March 2011 (http://oxblue.com/pro/open/suttermedical/castrovalley)

Figure 2: Dragon of Uncertainty (Source: Digby Christian, Healthcare Owners Conference 7 February 2011)

### OWNER ENGAGEMENT

Owner engagement throughout project delivery is fundamental in order to pull together the project delivery team and lead the improvement process. In the SMCCV project, Sutter Health's involvement in the project was driven by their clearly-stated and defined goals regarding project performance (P2SL Lean Healthcare Owners Conference 02/07/2011)

1. Structural design completion by December 31, 2008
2. Project cost shall not exceed $320,000,000
3. Hospital shall open fully complete and ready for business by January 1, 2013
4. Healthcare delivery innovations (design, technological)
5. Environmental stewardship
6. Design and construction delivery transformation. IFOA contract, Target Value Design, Building Information Modeling and Virtual Design and Construction (BIM VDC) utilization, active engagement with OSHPD, etc.

Clear and quantifiable goals help team participants to develop a common understanding of what is to be achieved. They also define an objective base to measure against when participants are involved in decision making.

### RISK IDENTIFICATION AND MITIGATION

Some management approaches define risk according to the probability of an incident occurring times the estimated magnitude of its impact. In this project the aim was not to reduce probability of occurrence, but rather to have the integrated team control potential risks. A preliminary analysis revealed the crucial role that OSHPD played in many of the possibilities of delay so they were integrated in the project team. Causes of design rework in California hospital projects are use of an inappropriate review process along with owner and scope related issues (Feng and Tommelein 2009).

The project team used this insight and their experience early on, to develop a list of potential risks that could impact project performance significantly. This list included: Late owner changes in program; Late owner decisions on major medical equipment; Varying interpretations of the code; Incomplete information (elevators, stairs, and fixture requirements); Post-approval changes to structure; Incomplete coordination of gravity systems; and Late seismic bracing coordination. This list helped team members to engage in honest conversations about the potential impact of changes and to emphasize a revision of all of the facilities requirements. Furthermore, it helped them focused on the importance of knowing exactly what the owner wanted, to prevent late changes in plans, which OSHPD also had highlighted as a major reason for delays in review. These conversations resulted in early agreements on floor plans and requirements. When this agreement could not be reached, the team explicitly built flexibility into their design. Late changes can also be prevented by revising plans that may have been validated before the design was detailed. Validation of plans depends on what information is available at the time and consequently may change greatly as a project approaches construction.

A key action taken by the SMCCV project delivery team was to consider waiting to start design, in order to allow the owner group more time to finalize its clinical program. The team worked hard to create this extra time by continually revising its collective design process to shorten the overall duration thereof: they were able to delay the commencement of design by 8 months. The team could achieve this time compression in part because they had implemented a planning method that visualized the pathway to a complete design; to our knowledge, no other rational, reliable way exists to execute the compression of design like that. The visual plan allowed the team to collaboratively and continuously restructure their pathway in order to reduce the amount of time needed to complete design. At that point of maximum compression, they could not reduce the design time any more. The 8 months of extra time granted to the owner group put acute pressure on them to finalize their program.

This was a very bold move since it might seem counterintuitive to delay the start of design in order to speed up the design revision process. However, the delay of the start of design had a very clear objective: establish as precisely as possible what the owner really wants. The 8 months were mainly spent by lead designers meeting with user groups. Spending this time at the beginning enabled the team to manage changes before they caused expensive rework on the rest of the project. The team highlights this as a key point in reducing the impact of changes in the project.

### MAKE WORKFLOWS EXPLICIT

Recognizing that risks would manifest themselves in the course of design, the team created design workflows and did so in a highly visual and explicit way. Development of the design workflow engaged the entire team. They presented their work in an easy-to-digest format for the purpose of soliciting constructive debate about what it would actually take to complete design in a way that increases certainty and minimizes risk. This process helped the team buy into the process and practical conversation of “Is this really what is going to happen?,” “Is that really what you are going to do?,” “Is that enough time to do it?,” “Is it really going to take that long?,” as well as “Why are you doing that?,” “Why do you need that?, etc. Christian’s (Sutter’s PM) instinct is that without that, the team would not have been successful.

### VISUALIZE HIDDEN DEPENDENCIES AND MILESTONES

The team paid a great deal of attention to mapping the decision process and all factors involved, in order to provide an effective support structure for the PPR process.

Significant uncertainty pertained to the clinical program since it provided the base input to design; changes in this program could result in design changes. Early on, the team recognized that the clinical program had to be complete in order to reduce rework and increase reliability of the design workflow. Once the clinical program was complete, the team began to plan the design process to work in the logic of the PPR. A traditional design plan includes schematic design, design development, design detailing, and production of construction documents and final deliverables. However, this tends to create cycles of rework and miscommunication that make the overall duration longer. In contrast, the PPR process does not follow the same logic: common understanding of the project was essential to be able to advance in the design process through recognition of all dependencies and establishment of milestones. This was possible due to early consolidation of the team in contrast to the traditional contracting practice where general contractors and major trades are hired when a majority of design is finished.

The PPR requires a deeper and more thorough understanding of interdependencies in order to allow 100% complete documentation with minimal rework. Each step in the design process must be analyzed, in order to understand what is being produced and how it is affecting what other specialists are producing. This detail makes it possible to sequence decision making in a way that directly supports the PPR. The breakdown of interdisciplinary work and decisions in the process were analyzed in detail with all the decision makers. This provided insight in all the hidden dependencies and the team could identify and plan for them in advance in order to assure that all aspects involving each decision would be accounted for in time.

The design planning process started with identifying what design decisions—if changed later—would generate large amounts of design rework. This led to a non-traditional sequencing of design decisions, which were rolled up into a series of major design-deliverable milestones, each major design-deliverable having a detailed list of what the specific sub-deliverables would be. This allowed for an in-depth discussion on what inputs would be necessary at each point and what outputs were expected from each activity for each flow of work for each detailed sub-deliverable.

This process was supported using Building Information Modeling (BIM) technology. 3D models served as powerful visual aids to the team while discussing inputs and outputs, and evaluating where each trade partner could get involved. It is important to note that no actual trade drawings were produced yet at that time. The model enabled to 'walk through' decisions about locations of shafts, major routings through the hospital, etc., before going into the specific design details for any discipline. This primary coordination effort allowed to transition into construction with a certainty for approval and minimal rework.

## REDESIGNING THE DESIGN PROCESS

Traditional design process follows a roughly linear process with many cycles for review and rework. The architect develops each phase (schematic design, design development, construction documents) and begins a back-and-forth feedback process with the general contractor, mechanical, electrical, structural, etc. This process can be extremely time consuming and require considerable amounts of rework. In addition, the lead times for each phase are composed of the sum of the lead times for each feedback cycle. The detailed process for planning the interdisciplinary work required for each design submittal changed the way that design teams usually function.

As mentioned, Sutter formed an integrated team at an early stage where trade partners, contractors, and architects would meet and go over the project. In these meetings design modifications would be requested (e.g., shift in wall positions, changes in width), analyzed and resolved.

In a later stage, the coordination meetings moved to a room-by-room basis. The meetings were held in the 'Big Room' equipped with tables, boards, smart-boards, paper plans, projections of BIM models and everything necessary to 'Collaborate, Really Collaborate' (as in the 'Five Big Ideas'). Sometimes, as many as 50 team members were engaged in these room-by-room analyses, checking everything from mechanical and architectural requirements, to the position of power outlets for medical equipment. Even though these meetings took a long time, they took extra lead time and rework out of the system. Meeting participants discussed changes and introduced them into the BIM model in real time. At the end of the meeting the modified model(s) were uploaded to the project server. The team used paper documents as minutes to document changes in each meeting.

### FACILITATE REVIEW PROCESS

Early on in the project, through interaction with OSHPD, the team recognized that to achieve flow in the review process, design documents had to be made such that OSHPD could easily understand and review them. Submittals to OSHPD need to provide the proper level of information—nothing more and nothing less. Providing excess information can distract reviewers and have them comment on aspects that are not in their jurisdiction, whereas submitting less information causes rework and back checks.

The design team developed listening skills to hear what changes could make OSHPD's review process easier. For example, the drawing of smoke compartments went through a series of format and colour-coding changes in response to reviewer feedback (Figure 3). Colour coding is a means of mistake-proofing (poka yoke) or, at least, of reducing the likelihood of misinterpretation (Tommelein 2008).

Furthermore, the submittal and review process worked smoothly thanks to OSHPD and the team having established well-used communication channels. This required a trust-based relationship in order to be able to meet the schedule of submittals. In PPR, several months of face-to-face contact to discuss partial submittals precede any final submittals. A relationship thus develops for communicating issues and comments about the project. Reviewers familiarize themselves with the project and offer input on how to resolve issues in the rolling comment log (comments were posted and responded to each and every week). The team resolved minor issues with OSHPD 'over the counter' reviews so that, at the end, back checks were minimized.

### DEAL BREAKER REVIEW

A 'deal breaker' is a plan review comment based on a code issue that is significant to the extent that it could affect the design, and delay the process, if not bring the process to a halt altogether. It is akin to 'ringing an andon and possibly stopping the assembly line,' thereby preventing defects to go forward in a production system.

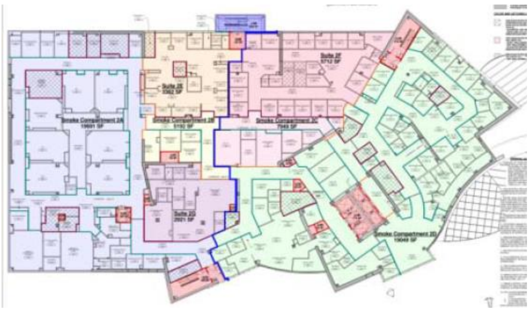
An OSHPD plan reviewer would identify a deal breaker on the plan and that deal breaker must be resolved and conditionally accepted by FDD prior to design progressing to the next milestone. Resolution may occur through phone calls, meetings, or e-mails and must be documented through drawing revisions. Comments made during a plan review that are minor in nature may be back-checked during the next milestone review.

First, the architects submitted to OSHPD reviewers just a sketch coloured by means of pencils. They considered this to be good enough for that design phase, as they had not yet designed formal floor plans at the time.

Figure 3: Pencil-coloured sketch of smoke compartments

In follow-up meetings, OSHPD reviewers mentioned that colour-coded plans extracted from the BIM model would be helpful. Accordingly, the architects' next submittal included such drawings (Figure 4).

Figure 4: Colour-coded plans extracted from the BIM model, showing smoke compartments



In subsequent conversations, OSHPD reviewers commented that plans were hard to read given the colour palette chosen and contained too much information in one plan. The architects thus modified the colour palette and colour-coded plans with simplified information (Figure 5).

Figure 5: Colour-coded plans with simplified information and modified colour palette

After this, the final submittal was in a different colour palette and the design was split into two different plans which made the information much easier to read (Figure 6).

Figure 6: Final submittal of plan with smoke compartments

The deal breaker review is a process that takes place after submittal. In this case, deal breakers were discussed before submittal. A good working relationship with OSHPD made if possible for the team to work in a proactive manner.

This was the case with the Central Utilities Yard where, in early design, the team had developed different alternatives, all subject however to code interpretation. The team therefore needed to meet with OSHPD before submitting anything for review. The team brought the model, laid out the alternatives and their intent, and then discussed code interpretations in order to get feedback. The meeting was not intended to produce the final design but it allowed all parties to express concerns and as a result, brainstorm as a team. This action enabled them to mitigate the very real risk of having to redo work in the future and impact other trades involved in the process.

### EARLY ENGAGEMENT OF SUPPLIERS

Trade partners have information that, if not available in due time, can cause delays and changes in the project. Their early engagement is necessary to confirm possible assumptions and to validate plans, to perform constructability analysis, and thus to reach better solutions to challenges in project design. Engagement of the elevator supplier and the stair contractor led to important changes of documents prior to their submittal to OSHPD. Some of the modifications impacted shaft sizes and electrical equipment, which would have caused delays and rework had these trade partners joined the project later. Early involvement of the toilet supplier, responsible for 205 fixtures, allowed the detection of problems with the original criteria for fixtures (wall mounted) and the project design. During a Big Room design review they detected the lack of adequate in-wall space for piping and weight-bearing capacity issues in bariatric rooms. The team developed an A3 report to conduct and document the decision process. The decision to switch from wall-mounted to floor-mounted fixtures reduced the wall plumbing needs, which in turn freed space inside the room. During the analysis the team detected that the fixtures in the BIM model were not accurate so it was inducing errors in the design. This detection and modification took place before any related design was submitted to OSHPD.

### USE OF BUILDING INFORMATION MODELLING

The team used BIM to meet two strategic objectives: (1) design for fabrication and (2) development of an integrated 3D working model. SMCCV had all construction trades participate in the design process upfront and arrive at the shop drawing stage together. This enabled the team to virtually 'build the model.' The project has a working design of the hospital in 3D, allowing individual contractors to each use their own preferred modelling software and then follow a process to integrate the various renderings. The use of BIM and collaboration technologies in this project are worthy of a study on their own, as they are enablers of intense collaboration.

## PROJECT OUTCOMES

The SMCCV project is currently in construction; many of the outcomes are yet to be determined. However the results of the operating system put in place during the design phase can be observed in the examples given earlier. The collaborative design and modelling process (Figures 3-7) resulted in the ability to build directly from the model and yielded cost and time savings yet to be evaluated through the increased degree of prefabrication of components. Design was completed in less time than traditional projects and its quality was much higher. The fabrication level design gave higher level of certainty to the project construction team.

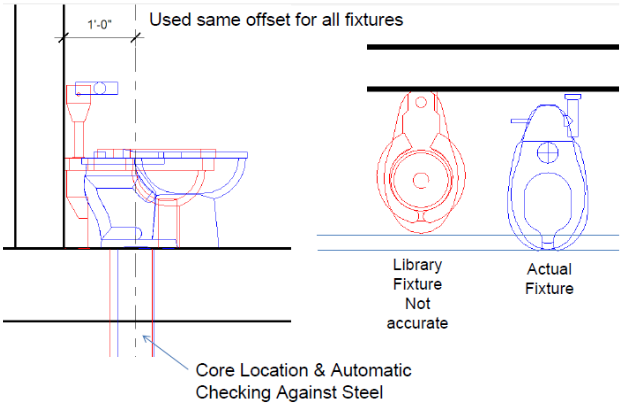



Figure 7. Changes in Toilet Fixture in Early Detection of Problems

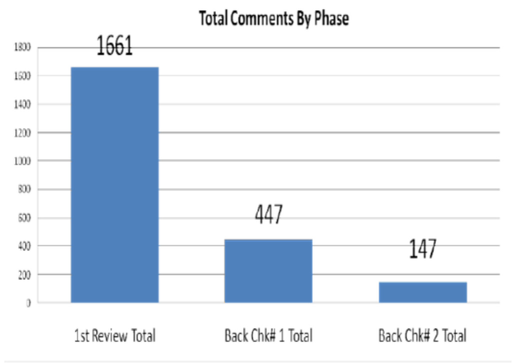



Figure 8. Total Comments by Phase (Source: P2SL-LCI Healthcare Owners Conference 02/07/2011)

Quantitative metrics to evaluate an operating system are difficult to identify. Metrics that the team deemed representative of system performance are the lead times for permitting, and the number of comments and back checks.

The lead time from the beginning of the structural review to the start of construction of the SMCCV was 11.5 months. This is considerably shorter than the time incurred previously on comparable projects. The reliability of the work was demonstrated by a 100% fulfilment of deadlines in the project review plan.

Figure 8 shows the decrease in comments in each review cycle; no issue went beyond a third back-check cycle. During the second cycle many comments were resolved 'over the counter' because by then, they already had been addressed. This success is attributable to correct sequencing of packages, the revised decision making process, as well as the fluidity of conversations and smooth working relationships.

## CONCLUSIONS

The SMCCV team proactively designed a project operating system to increase the degree of certainty of work flows. Their analysis revealed the high dependence on OSHPD in many of the risks they would face. Incorporating OSHPD into the team was a strategic move that enabled the team to manage many of those OSHPD-related risks internally.

This team collaborated through the use of technology and integration with OSHPD, and thereby effectively improved the performance of the permitting process. Collaboration in construction permitting is becoming increasingly relevant as there is a tendency in society to increase regulations, esp. regarding sustainability and safety issues. Successful construction projects should be able to produce and sustain effective work processes while facing an increasingly constrained environment.

The findings in this paper focus on the design phase of the SMCCV project, before construction took place. Results of actions taken are yet to be observed. A challenge in evaluating results is identifying metrics and causal relationships. Future studies of this and other projects should address this challenge in order to provide input for quantitative analysis that can further identify key drivers in project delivery.

## ACKNOWLEDGMENTS

We thank Sutter Health, DPR Construction, The Devenney Group, OSHPD Staff, and others on the SMCCV project team who presented their project the P2SL Healthcare Owners Conference on February 7, 2011, as well as others who participated.

Research for this paper was supported in part by gifts made to the Project Production Systems Laboratory (http://p2sl.berkeley.edu/). All support is gratefully acknowledged. Any opinions, findings, conclusions, or recommendations expressed in this paper are those of the author and do not necessarily reflect the views of contributors to the Project Production Systems Laboratory.

## REFERENCES

AIA (2007). *Integrated Project Delivery: A Guide.* American Institute of Architects, available online at <http://www.aia.org/contractdocs/AIAS077630>.

Ballard, G. and Howell, G. (1994). “Implementing Lean Construction: Stabilizing Work Flow.” *Proc. 2nd Ann. Mtg. Int’t. Group for Lean Constr*., Santiago, Chile. (in Lean Construction, A.A. Balkema Publishers, Rotterdam, Netherlands, 1997.)

CHCF (2007). “Seismic Safety: Will California’s Hospitals Be Ready for the Next Big Quake?” *Issue Brief*, Jan. 2007, Calif. HealthCare Found., Oakland, CA, 5 pp.

Christian, D. (2011). Presentation at Lean Healthcare Owners Forum, Project Prod. Systems Lab., UC Berkeley, February, <http://p2sl.berkeley.edu/events.htm>

Feng, P.P. and Tommelein, I.D. (2009). “Causes of Rework in California Hospital Design and Permitting: Augmenting an Existing Taxonomy.” *Proc. 17th Annual Conf. Int’l. Group for Lean Construction* (IGLC 17), Taipei, Taiwan, 15-17 July.

Koskela, L. (1992). “Application of the new production philosophy to construction.” *Technical Report #72*, CIFE, Dept. of Civil Engrg., Stanford Univ., Stanford, CA.

LCI (2011). Lean Construction Institute “Glossary” <http://www.leanconstruction.org/glossary.htm> (January 2011).

Lichtig, W. (2005). “Sutter Health: Developing a Contracting Model to Support Lean Project Delivery.” *Lean Construction Journal*, 2(1) April.

Lichtig, W.A. (2006). “The Integrated Agreement for Lean Project Delivery.” *Constr. Lawyer*, 26 (3) Summer, American Bar Assoc., 8 pp., available at: http://www.mhalaw.com/mha/newsroom/articles/ABA_IntegratedAgmt.pdf.

OSHPD (2005). *Cal.’s Hospital Seismic Safety Law: Its History, Impl., & Progress.* <http://www.oshpd.ca.gov/fdd/seismic_compliance/SB1953/SeismicReport.pdf>

OSHPD (2008). “Phased Plan Review White Paper.” Downloaded on 2010-10-31 from <http://www.oshpd.ca.gov/FDD/Plan_Review/Documents/PPR_White_Paper_final_08-19-08.pdf>

Matthews, O. and Howell, G. (2005). “Integrated Project Delivery: an Example of Relational Contracting.” *Lean Construction Journal*, 2(1).

Sutter Health (2011). “Who is Sutter Health.” <http://www.sutterhealth.org/about/intro.html> (January 2011)

Sutter Medical Center Castro Valley SMCCV (2010). “Q & A with the Project Manager” <http://suttermedicalcentercastrovalley.org> (January 2011).

Thomsen, C., Darrington, J., Dunne, D., and Lichtig, W. (2009). “Managing Integrated Project Delivery.” CMAA. <http://www.cmaanet.org/files/shared/ng_Integrated_Project_Delivery__11-19-09__2_.pdf>

Tommelein, I.D. (2008). “‘Poka Yoke’ or Quality by Mistake Proofing Design and Construction Systems.” *Proc. 16th Ann. Conf. Int. Gr. Lean Constr.*. Manchester, UK.