

FOUR-PHASE PROJECT DELIVERY AND THE PATHWAY TO PERFECTION

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ABSTRACT

Proposes a conceptual framework for a systematic approach to improving the success of capital project delivery.

The Architectural, Engineering, Construction (AEC) community lacks a coherent, transferable conceptual framework for project delivery. This absence prevents deep learning within any given project, as there is no universal concept of perfect project delivery against which to measure the actual delivery. It also prevents meaningful learning about project delivery across projects due to the absence of a common approach in the analysis of project delivery that works for all projects regardless of type, location or context. Together these absences severely limit the extent and speed of learning regarding project delivery across the AEC community.

This paper proposes a four-phase concept of project delivery that aligns with the “V” diagram from systems engineering. This concept can be used to analyse project delivery on all actual projects, and can be used to describe the ideal state of perfect project delivery. Then, by comparing actual project delivery to perfect project delivery, strategies to move the actual toward the perfect can be formulated and actioned.

APPROACH

A taskforce of owners, designers, builders, academics and specialty consultants with extensive experience of complex AEC projects that employ best practices such as Stakeholder Value Definition, Target Value Design (TVD), Choosing By Advantages (CBA), Lean Design, Last Planner®, Building Information Modeling (BIM), Model-based Estimating, Lean Construction and Line of Balance (LOB) Production, pooled their knowledge in a year-long series of workshops to develop the content of this paper.

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KEYWORDS

Project delivery, theory, Lean Principles, Integrated Project Delivery, Virtual Design and Construction, Ideal State, Current State, Future State, “V” Diagram

BACKGROUND

Construction industry performance is poor (Ballard & Howell, 1994; Flyvbjerg, 2005; Diekmann, et al, 2004; GAO, 2009; GAO, 2013, Teicholz, 2013). Project delivery in the AEC industry is typically customized to the specific needs of the concept, planning, design, construction and use of the particular project, and does not emerge from an organized attempt to apply a coherent and accepted conceptual model of project delivery. Without such a method, there cannot be any rigorous testing of the actual against the conceptual for the purposes of improving the *totality* of the actual. At best we see local organized attempts to apply a new way of contracting, or a new way of planning construction work in the field, or a new way or coordinating the flow of materials to the site.

This is not true of the manufacturing industry. Manufacturing has theories to which it can adhere (Baudin, 2002; Hopp and Spearman, 2011). These theories provide an idealized and theoretical system of delivery against which to measure actual delivery and toward which to strive. Two “laws” from *Factory Physics* illustrate the point: 1) “Variability in a production system will be buffered by some combination of inventory, capacity, and time.” 2) “Increasing variability always degrades the performance of a production system.” Certainly manufacturing productivity has seen, and continues to see, increases in productivity while construction has not (Teicholz, 2013). Unlike in manufacturing where increased productivity and reliability has accompanied increased complexity, in the AEC industry increased complexity has been cited as one of the reasons for project failures (Arcila, 2012).

Lean construction arose as an attempt to provide a theoretical explanation of production that is applicable to the AEC industry (Koskela, 2000). Lean construction views production not simply as the transformation of input resources (labor, capital) into output assets, but instead as the generation of value through flows of materials, information and resources between transformations, structured to optimize the entire system rather than its parts.

Publication of the *Toyota Way* (Liker, 2004) advanced the conceptualization of Lean as a philosophy of management. In his 2005 *Creating a Lean Culture* (2nd ed. in 2010), David Mann argued that without changes in the way people and work are managed, application of Lean principles and methods will die out, despite their successes.

In 2009’s *Toyota Kata*, Mike Rother described in detail an essential management routine (*kata*), devoted to improving processes. Central to this routine is the ability to identify a process breakdown in the way work is performed in order to learn from that breakdown and thus improve our processes. This identification is difficult to do, since there is no ideal process against which to measure current processes.

This paper addresses the lack of an ideal by proposing a conceptual framework of project delivery that allows such an ideal process to be described, and provides the language with which to describe any given current project delivery method.

Thus, 21 years after the founding of the International Group for Lean Construction, we may be at a new turning point wherein we move the application of the Lean philosophy away from an exclusive focus on designing and making things, and toward how we manage project delivery in its totality.

INTRODUCTION

Four-phase project delivery is a conceptual framework that allows an ideal state of project delivery to be described. It allows the direct application of the Lean philosophy to describe the *ideal state*, the *current state* and the formulation of strategies to create a *future state* to move the project delivery method from the current state toward the ideal state. Furthermore it incorporates ideas from systems engineering wherein great effort is expended to ensure one builds the right building, and then one expends great effort to ensure that the building is built right. See Figure 1 below.

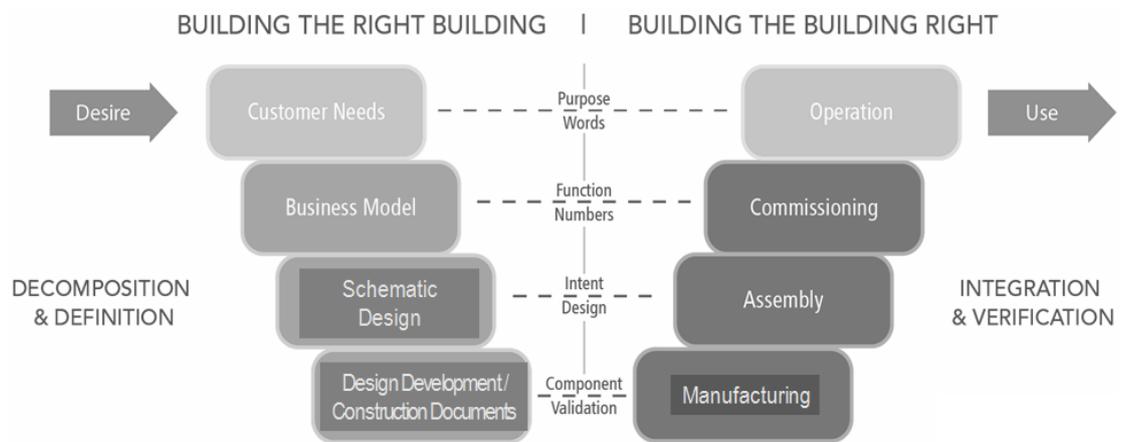


Figure 1: System “V” diagram for the building industry (Rubel, 2012)

Under the proposed concept of four-phase project delivery all project delivery is conceptually the same, regardless of the individual project's specifics. Thus all projects can use this shared language to transfer learning to and from other projects. Any single project can potentially provide learning to all other projects. This delivery model provides the potential for large scale fast improvement across the AEC industry as has been seen and continues to be seen in the manufacturing and software industries.

In this paper we first describe the concept of four-phase project delivery and its terminology. We then illustrate how that concept and terminology can be used to describe Perfect Project Delivery. Next, we show how it could be used to describe and analyze actual project delivery. Then, we show how comparing the two (Perfect and Actual) can be used to illuminate the breakdowns that are experienced. Lastly, we show how valuable lessons for a particular project can be learned by employing the language of this framework, and then spread outward to the full AEC community.

FOUR-PHASE PROJECT DELIVERY

OVERVIEW

In four-phase project delivery the project starts with defining the value the project is required to produce by establishing the human concern that it needs to address, and by defining the constraints and preferences that will be used to guide and assess its progress. Subsequently, ways are found to represent solutions so that they can be assessed. From those assessments a solution is selected and made real. Finally, value is captured from that realized solution. All projects essentially go through these four phases of Value Definition, Representation, Realization and Value Capture. Projects are successful to the extent these phases are well-executed and the connection between them is well managed.

What follows describes the conceptual framework in more detail. It illustrates the framework with the human concern that a way be found to make the seas around the fictional coastal town of Forlise safer for seafarers.

THE FIVE ELEMENTS

Four-phase project delivery consists of five elements, four of which are phases and one of which is the boundary between two of the phases.

- Value Definition
- Representation of the Solutions
- Boundary of Realization
- Realization of the Solution
- Value Capture from the Solution

Value Definition, Representation, Realization and Value Capture can overlap and are listed in chronological order of their start points. The Boundary of Realization lies between the Representation and Realization phases.

Phase 1: Value Definition

There are three distinct outcomes from Value Definition:

- The Human Concern
- The Project Constraints
- The Project Preferences

The Human Concern establishes why the Project needs to exist. The Project Constraints define the solution space within which possible Solutions must lie. The Project Preferences establish the criteria against which multiple Solutions will be measured in order to determine which is the better Solution to the Human Concern.

Example:

The people of Forlise wish to initiate a project. They define the Value they ultimately wish to capture from this project by noting the following:

“We have the very human concern that there are dangerous submerged rocks off our coast and, during inclement weather, ships tend to sail close to the shore and wreck on the rocks with great loss of life. We are constrained by the fact that we have just one hundred gold pieces to pay for the project, and to avoid the next round of carnage we must complete the project within nine months before the commencement of the next trading season. Because this will consume almost all our savings, we would prefer if possible that the project also provide for us a post office, a library, a conference center and a significant level of local tourism.”

Phase 2: Representation

During this phase Solutions are represented and analyzed.

The townspeople consider two drawings of two ideas they have had. One is a drawing of an inhabitable stone column with a large wood-burning glass house at its top described as a “Lighthouse.” The other is of an enormous glowing inflatable eyeball known as an “Eye Warn You.” Attached to the drawing are assessments of cost, schedule and what additional items can be built with the leftover money.

There are three distinct requirements of this phase.

- 1) Any Solution is represented such that it can be analyzed to verify that it addresses the Human Concern.
 - *The Lighthouse solution explains how the light at the top of the tower works and how ships, once they see it, will know it is a man-made warning of dangerous waters and will know not to sail closer to it. The Eye Warn You solution explains how terrifying it will be to see such a thing on the water, and thus naturally ships will steer clear.*
 - 2) Any Solution is represented such that it can be seen that it lies within the solution space as limited by the Project Constraints
 - *Bills of material for both solutions with current market prices are shown; as are estimates of labor hours, and from that the costs and time to construct are described. This list of items shows that both can be built on time and within the budget. Also scale diagrams are provided that show that a ship could see either solution from beyond the location of the submerged rocks and thus avoid wrecking.*
 - 3) Any Solution is represented such that it can be analyzed against the Project Preferences.
 - *The plans also show what excess funds from the primary work are left over and how it can be employed to provide a post office and/or a library and/or a conference center and/or elements that will bring tourists to the town from far and wide.*
- The represented Solution that addresses the Human Concern, lies within the solution space as defined by the Project Constraints, and also most effectively meets the Project Preferences will be the one that is selected.

- *Though everyone loved the idea of the Eye Warn You, it wasn't clear to all how easy it would be to see at night. Also, though tourism would certainly increase, the library, post office and conference center would have to be separate construction efforts and there would barely be enough funds for just one of those facilities. In contrast, the Lighthouse was felt to be something that would be visible night and day and, impressively, it incorporated all the additional functions into the ground level of its tower. As such it was not clear the Eye Warn You fully addressed the human concern, and though it did fall within the project constraints of time and budget, it did not address the project preferences for additional facilities as completely as the Lighthouse. Thus, the townspeople of Forlise enthusiastically endorsed the Lighthouse project.*
- At this point the selected Solution is moved from the Representation phase through the Boundary of Realization into the Realization phase.

Boundary of Realization

This is the boundary that lies between Representation and Realization. It is the point at which the quantity and rate of resource consumption typically accelerates by the greatest margin.

This is the point at which drawings of stone blocks become the stone blocks themselves. The cost of work to quarry, ship and place a stone block as compared to drawing one is immense. The gold in the Forlise treasure was barely touched during the representation phase, but now as we move through the Boundary of Realization to the realization phase the gold gets consumed far more quickly.

Phase 3: Realization

During this phase the selected Solution is realized and prepared for the Value Capture phase. Labor is procured and physical assets are procured and/or fabricated and/or assembled and/or commissioned and/or activated in a way that is believed to align with how the Solution was represented.

*Among many other things the blocks are procured; as is the glass; the fuel for the fire; a hole is dug for foundations; skilled stone masons are hired; trees are cut and the logs **are** used to build cranes to swing the blocks into place. Once all the work is done, the post office, conference center and library are stocked and furnished. **Finally**, as the sun sets a torch is dropped onto the fuel and the Lighthouse is activated and goes into operation.*

Phase 4: Value Capture

During this phase the physical assets as created and activated during the Realization phase are used to address the Human Concern.

The light from the Lighthouse, now visible from far out at sea, warns seafarers of the dangerous rocks. They know to keep their distance and avoid a watery grave. The people of Forlise send and collect letters and parcels at the post office, borrow and return books at the library, and hold meetings at the conference center. Tourists who come to see the Lighthouse stop by at the town square to have lunch, and book rooms at the local hostel to stay the night. Thus the Value is captured.

IDEAL STATE: PERFECT FOUR-PHASE PROJECT DELIVERY

The “V” diagram as adapted to the building industry in Figure 1 is found to be a highly effective way to represent this conceptual framework – as shown in Figure 2, below.

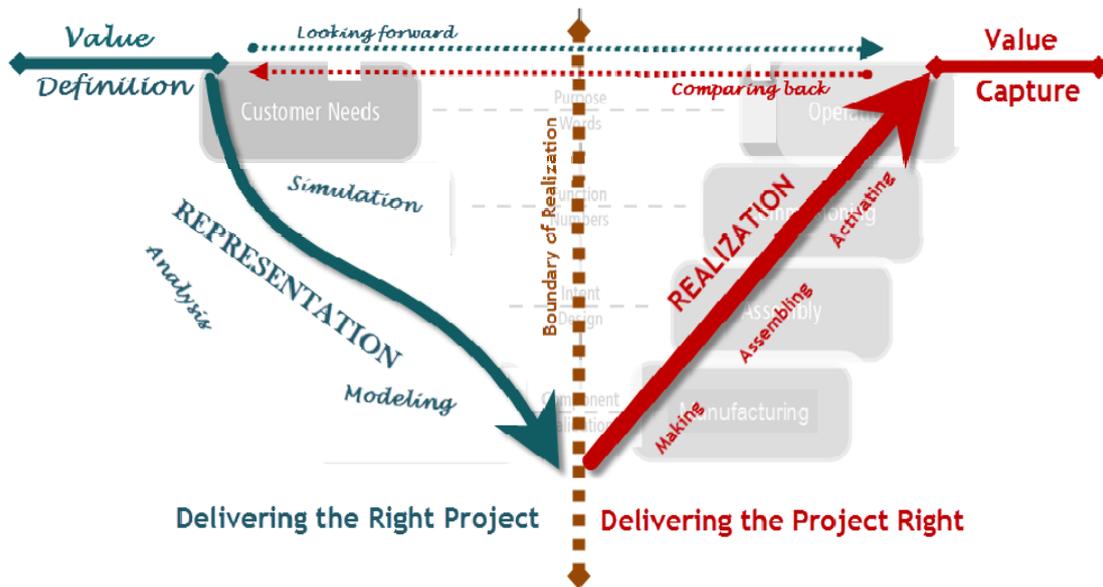


Figure 2: System “V” diagram of Four-Phase Project Delivery

In perfect four-phase project delivery, Value Definition and Value Capture continually compare against one another to ensure they are aligned. Value Definition looks forward into the future to perfectly discern what value it is that needs to be captured. At the end the value that is captured is compared back to the value that was defined, and zero variance is discovered.

During Representation analytical methods, simulations and models that have perfect predictive abilities are used to ensure that the project aligns with the Value Definition. This phase also looks forward to Realization in the sense that it ensures all representations are realizable. Thus, the effort expended during Value Definition and Representation ensures that the right project is delivered.

During Realization that which was represented is perfectly realized and as such is capable of delivering all of the value predicted during Representation.

During Value Capture the project is activated and delivers the required defined Value. The effort that was expended during Realization and Value Capture ensures that the project is delivered right.

Phase 1: Perfect Value Definition

(Note: In the interest of space the description of the ideal state in the example below has been simplified. Only two Solutions are evaluated whereas in true perfect delivery a comprehensive solution space would be explored and evaluated.)

In perfect Value Definition every stakeholder is properly identified and consulted, and each describes their value needs from the project with perfect clarity.

Example:

More than the people of Forlise are consulted. The officials that oversee the Laws of the Land describe that in six months the new Withstand-a-Thousand-Year-Hurricane Law comes into effect. Complying with this law becomes an added project constraint. Also the people of Forlise, with perfect prompting by meeting facilitators, remembered that they cared about impacts on the environment and expected any Solution to be carbon neutral.

Phase 2: Representation

During this phase Solutions are represented perfectly and analyzed perfectly to verify with no chance of error that they meet the Human Concern, can be executed within the Project Constraints, and are compared against the Project Preferences to see which solution meets them most completely.

A transdimensional portal is opened through which the citizens of Forlise can witness alternate futures.

They see the Lighthouse being built; they see the months pass; they see the invoices. They see the impact on cost of meeting the new Hurricane Law and for installing the wind turbines and solar panels on the Lighthouse to make it net carbon neutral. They see there will be no money for the library, or conference center or post office. They see that tourism will increase by 17% once the Lighthouse is open. They see that shipwrecks will fall by 85%.

In the future where the Eye Warn You project is approved they see that the natural enzymes in the organic tree moss membrane of the giant eye mean that without external power, it still glows as bright as the moon. They see how the Government agrees that offshore structures are exempt from the Hurricane Law, and that as such there is enough gold left to build a carbon neutral, Hurricane Law compliant Library. They see that shipwrecks decline 95% and that tourism soars upwards 90%.

The represented Solution that addresses the Human Concern, lies within the solutions space as defined by the Project Constraints, and most effectively meets the Project Preferences will be the one that is selected.

This impressive and 100% reliable (and thus perfect) analysis by Representation showed that the Eye Warn You solution will satisfy the Human Concern within the Project Constraints, and more completely satisfy the Project Preferences than the Lighthouse. As such the townspeople confidently selected the Eye Warn You Solution as their project of choice.

Boundary of Realization

The selected Solution is moved from the Representation phase through the Boundary of Realization into the Realization phase. It is the point at which the quantity and rate of resource consumption typically accelerates by the greatest margin.

Phase 3: Realization

During this phase the selected Solution is perfectly realized. It precisely aligns with the Solution as represented in the Representation phase. The Solution is then activated so that it is fully ready for the Value Capture phase.

Everything proceeds precisely as predicted via the trans-dimensional portal.

Phase 4: Value Capture

During this phase the physical assets that were created and activated during the Realization phase are used to address the Human Concern.

Once again, everything proceeds precisely as predicted via the trans-dimensional portal. Shipwrecks fall 95%, tourism rises 90%, a carbon-neutral library is built in compliance with the Hurricane Law – and all within the budget of 100 gold pieces, and within 9 months. What a wonderfully successful project that was!

By successful we mean it addressed the Human Concern, within the Project Constraints, per the Project Preferences, and the Value Capture aligned precisely with the Value Definition.

CURRENT STATE: ACTUAL PROJECT DELIVERY

Any actual project delivery can be considered the Current State, and now that we have a conceptual Ideal State (i.e. perfect four-phase project delivery), the actual project delivery can be analyzed and then compared to the Ideal State.

The analysis of the Current State is against three primary criteria. Sub-bullets describe examples of what analysis could be undertaken.

1. The perfection with which the value captured aligns with value definition.
 - Identify captured value during the Value Capture phase, and compare that to what was identified during the Value Definition phase.
2. The perfection with which each of the four phases been executed.
 - Identify whether there has been a Value Definition phase on the project and the accuracy and coherence of that Value Definition.
 - Ascertain how widely held and non-variant the Value Definition is among project participants and project stakeholders.
3. The perfection of the connection between the four phases.
 - Identify the processes employed to ensure the Representation aligns with the Value Definition.
 - Identify the accuracy and frequency with which the Value Definition can be simulated during the Representation phase.
 - Identify the processes employed to ensure the Realization aligns with the Representation.

Note: One of the key variances to analyze would be that between value defined in the Value Definition phase and the value captured during the Value Capture phase. Indeed, there is potential within this conceptual framework to have a common agreement across the AEC community that this variance is the key criteria in assessing project success.

FUTURE STATE: THE PATHWAY TO PERFECTION

The pathway to perfection is as follows:

1. Compare the Current State to the Ideal State.
2. Identify the variances.
3. Identify root causes for the variances.
4. Identify strategies to minimize the variances.
5. Implement the strategies.

Implementation of the strategies moves the Current State of project delivery along the 'pathway to perfection' to the Future State.

IMPROVED LEARNING

After identifying variances between defined and captured value a deeper dive can be made to identify causes. Using the language of the proposed conceptual framework, more insightful questions can be asked and more illuminating answers therefore elicited. One very clear example of variance between defined and captured value would be total project failure prior to completion:

Five months into construction, a light wind blew in during lunchtime and the lighthouse collapsed inwards on itself. Fortunately no-one was killed. Insufficient funds remained in the town treasury to restart the project and thus the project was canceled. The citizenry of Forlise was sad indeed.

Under traditional thinking the typical questions asked might be, "Who was your general contractor?", and/or, "Who was you inspector?" and/or, "Who was your structural engineer?" The lessons learned might be to never use that general contractor / inspector / structural engineer again. However, such lessons have very little broad application to the AEC community in general.

Under the thinking and analysis proposed in this paper one can ask instead, "How accurately did the Solution in the Representation phase align with the Solution in the Realization phase?" And a deep dive to get the answer might uncover the following:

"It was found that the drawings did not represent with enough fidelity the blocks to be used in the construction of the walls of the Lighthouse. It was noted that the actual blocks for the walls were roughly hewn rather than delineated by the perfect planes in the drawings. This roughness caused the stacking of blocks on top of one another to be unstable. It was this instability that ultimately led to the collapse of the structure. The realized blocks deviated from the represented blocks in terms of their geometry and so the stability analysis conducted on the represented blocks was not applicable to the realized blocks. Therefore, it was in that geometric deviation between

Representation and Realization of the stone blocks that the cause of project failure lay.”

A broadly applicable hypothesis could arise from this learning. Namely, that the risk of project failure increases as the deviation between Representation and Realization increases. This being because as that deviation increases the applicability of analyses conducted during the Representation phase to the Realization phase decreases.

Such learning would have the potential to be of immediate use to the AEC community as a whole because the learning is described in the language of the proposed four-phase conceptual framework of project delivery. As any project delivery method and any learning can be described in this language, any learning has the potential to be applicable to any project delivery method.

Furthermore, the learning is available for testing for validity across many different project contexts and thus fast evolution of the learning can take place. In this case perhaps this would lead to a further finding that that the validity and importance of the hypothesis increases with project complexity.

Compare this to noted traditional mindset that ‘learns’ that one should not use certain people or companies. The learning is narrow and might even be faulty, and contributes little to the knowledge base of the AEC community.

One final thought is that with such a broadly applicable conceptual framework we can perhaps even start to learn lessons and start to propose meaningful hypotheses on those most challenging projects of all, wherein the Value Definition varies as Solutions are uncovered and tested against the Preferences.

CONCLUSIONS

Four-phase project delivery can be considered an application of the foundational “V” diagram concept that has been so powerfully and successfully used in manufacturing and software development.

Four-phase project delivery provides to the AEC community a conceptual framework for describing current, ideal and future states of project delivery that is applicable to all projects regardless of type, location, complexity, duration, value or contract form. Because of this broad applicability it provides a method of analyzing project delivery that creates learning and knowledge from a vast number of projects that the whole community can understand and potentially use. This large base of knowledge is then potentially applicable across all projects and thus can be far more rapidly and thoroughly tested and validated. Because of this, four-phase project delivery provides the potential for rapid overall improvement in project delivery across the AEC community.

We have always known, intellectually, that a pathway to perfection must exist for all processes. The conceptual framework of four-phase project delivery has the potential to be that pathway for our AEC community.

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