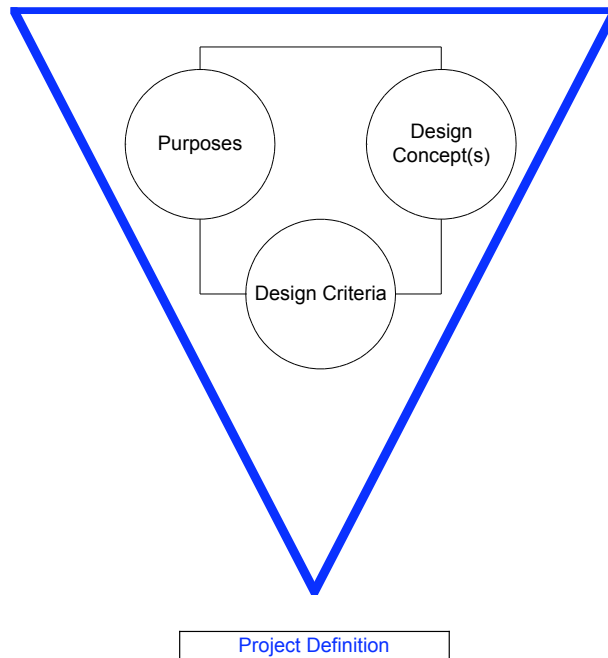


**Project Definition  
White Paper #9  
Lean Construction Institute  
by  
Glenn Ballard and Todd Zabelle  
October 10, 2000**

Project definition is the first phase in project delivery<sup>1</sup> and consists of three modules: Determining purposes (stakeholder needs and values), translating those purposes into criteria for both product and process design, and generating design concepts against which purposes and criteria can be tested and developed.



## **LEAN PROJECT DELIVERY SYSTEM**

The movement through these three is necessarily iterative, and need not follow any specific sequence, although purpose seems to be the logical starting point. What's important is to bring all three into alignment. Only then should the Lean Design phase be launched. But even then, it is possible that subsequent development lead back to project definition and an upgrading of purposes, criteria, or concepts. Such upgrading should be done whenever it adds value and when there is sufficient time and money to make the change. The cycle through the three modules is done to reveal to stakeholders the consequences of their desires and to reveal more and different value generation possibilities than they may previously have conceived. This becomes apparent when the

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<sup>1</sup> See LCI White Paper #8: the Lean Project Delivery System.

negotiation moves from what does something cost to “what is the value (cost / benefit) trade-off.”

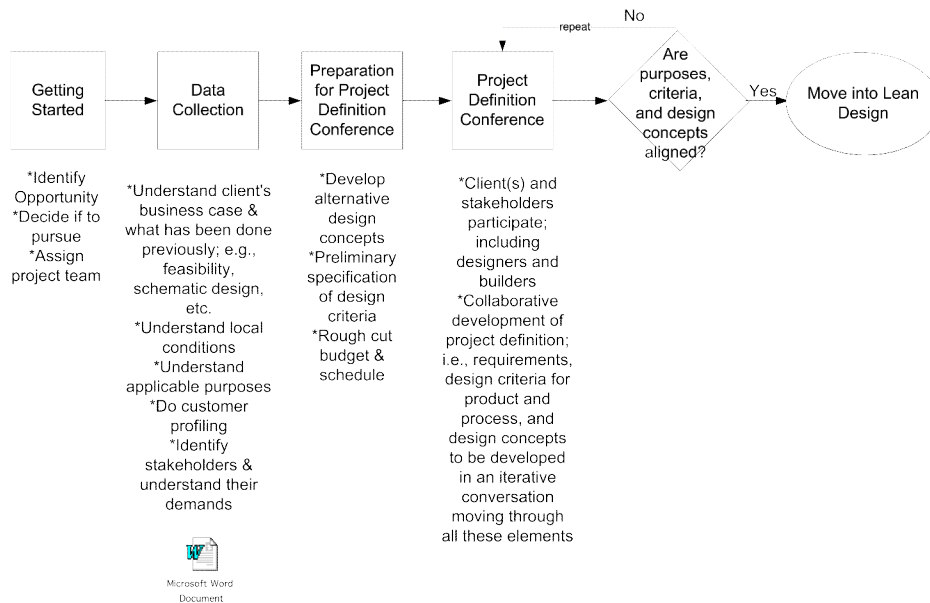
Architectural programming has much the same objectives as does project definition, but focuses primarily on issues relevant to architectural design such as space planning, and also often does not directly address the task of translating from purposes into design criteria. “Front end loading” is a term commonly used in the process industries to describe the predesign phase. In some models, “feasibility study” occurs prior to ‘project definition’. In the U.K. and the areas it has influenced, the term “design brief” is used to describe the document capturing the results of purposes determination and exploration of alternative design concepts. LCI’s project definition phase and process draws upon all these traditions, plus product development, but locates them within the Lean Project Delivery System.

Project definition is best done collaboratively, with the involvement of the project stakeholders themselves. Typical stakeholders include the client (holds the contract; pays the bills), users of the facility, governing agencies (e.g., local building department), designers, fabricators, installers, operators, maintainers, and neighborhood associations. Clients can be multi-headed; e.g., they might include facilities management, engineering, marketing, maintenance, the various groups that will actually use a facility, and possibly more.

Some stakeholder purposes may not be subject to change, at least within the time frame of the project, and so might better be called “demands”. Laws are an obvious example, but in extreme cases, even interest group positions can harden into non-negotiable demands. Codes are often subject to interpretation and possibly alternative action such as having wind tunnel tests done in order to more precisely match structural requirements to wind loads than can be provided in the code wording. However, the interpretation of a decision maker in the governing permitting agency may take on the force of a demand.

Collaboration takes place in a series of project definition conferences, the desired outcome of which may be a go/no go decision on the part of the client and the team.

## Project Definition Process



Quite a bit of information needs to be collected prior to the first project definition conference. The following are guidelines developed for N.L. Barnes, an LCI contributor:

1. Select team (to be done by the client sponsor, with help from the project manager once assigned)
  - Assign Barnes team & prep. for collaborative design meeting
    - technical integrator
    - controls manager
    - engineer
    - superintendent
    - administrative manager
  - Contract with architect & prepare for collaborative design meeting
  - Select and prepare specialty contractors & specialty engineering firms for participation in the collaborative project definition process
    - civil
    - substructure
    - structure
    - skin
    - mechanical
    - electrical
    - plumbing
    - fire protection
    - vertical transportation
    - other (e.g., commissioning or decommissioning specialists)
2. Gather information (the technical integrator [engineer] is responsible, but may delegate some tasks)
  - Governing entities
    - identify governing entities
    - describe & understand approval and permitting processes
    - determine & understand applicable codes & requirements
  - Site info.

- site visit by project team
  - location & configuration
  - drainage
  - physical context; e.g., adjacent structures
  - access/egress
  - utility tie-ins
  - soils
  - wind loads
  - seismic
  - Schematic design (if previously produced)
  - Design criteria from model or similar projects
3. Owner purposes (to be done by the client sponsor and project manager)
    - Understand the owner's business case
    - Determine owner's purposes
    - Prepare owner for collaborative design meeting
  4. Target budget & schedule (to be done by the project controls manager and supt.)
    - State assumptions
    - List issues to address, in priority order
    - Develop an estimating matrix
    - Identify major milestones, including end date, and long lead items.
    - Determine if target price is needed. If so, set for each facility system.

[In the collaborative design meeting, one desired outcome is agreement on target budget & schedule, which subsequently should be modified only if doing so adds value for the client.]
  5. Stakeholders (to be done by the project manager, with input from the client sponsor)
    - Identify stakeholders; e.g., for Faskin Project:
      - City of San Rafael Dept of Public Works
      - City of San Rafael Building Dept (permitting and inspection entity)
      - Tenants
      - Facilities Manager
      - Leasing Agent
      - Etc.
    - Determine stakeholder demands (find proxies for future tenants; perhaps survey data or post-occupancy evaluations of similar facilities)
    - Invite key stakeholders to participate in the collaborative design meeting

LCI recommends further defining the design space through seeking in-depth understanding of location and applicable laws, codes, and standards, in addition to understanding the client's business case and the demands of other stakeholders. Doing so, we suspect, will drastically narrow the range of possible design solutions. For example, permit requirements may dictate to a considerable degree what documents will be produced during the design process. Codes and standards may dictate or restrict major design decisions.

Brian Lawson, an architect and professor of architecture, tells about a client asking him to design an addition onto his house<sup>2</sup>. A visit makes it apparent that adding space will be very difficult and costly. What's more, there seems to be plenty of space already. Questioning reveals that the problem is really the noise level in the house, so the design problem appears to be one of providing sound insulation of spaces rather than adding spaces. But Lawson drills deeper and discovers that the noise problem is really the

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<sup>2</sup> Lawson, Brian (1997). How Designers Think, 3<sup>rd</sup> edition. Architectural Press, Oxford, U.K.

children playing loud music. He solves the problem by suggesting headphones. He loses a commission but gains a friend. This story illustrates the importance of really understanding the client's situation and not simply accepting their initial statement of needs.

Involvement of the team that is to design and build a facility can occur at very different stages of the client's project development process. The client may or may not have done a systematic feasibility study, may or may not have already selected a location, may or may not have determined even the type of facility or its intended use. Stakeholders such as tenants and operators may or may not have been previously identified. Consequently, one of the first tasks of the designer-builder is to determine which of these decisions have already been made, to understand those previous decisions (and possibly provoke reconsideration), and to facilitate making those decisions that remain.

Project definition conferences draw on the tradition of architectural charettes, an excellent example of which is the Neenan Company's Collaborative Design Process<sup>3</sup>. Neenan structures the day in a series of one hour work sessions, in which predetermined teams execute assignments. Between work sessions, each team reports out its findings and questions, and a new set of assignments are made. Teams are formed around building systems; e.g., foundation, superstructure, skin, HVAC, etc. and consist of various specialists representing design, supply, and installation. In some cases, Neenan has been able to get building department inspectors to attend and participate in the sessions, which reportedly has allowed them to explain in advance what requirements they will be applying, and also given the design-build team the opportunity to present their strategy and approach. Client representatives with decision making authority must participate.

Frequently, project definition conferences require more than one day. Between sessions, action items are assigned to collect missing information or explore alternatives. Again, the trigger for moving forward from project definition into design proper is alignment of purposes, criteria, and concepts.

Note that multiple design concepts may be carried forward, either for the entire facility or perhaps for a facility system. For example, multiple building envelopes may deliberately be carried forward without decision, in expectation of making a better decision after more thorough exploration of those alternatives and after further development of interdependent systems. This practice is discussed more thoroughly in White Paper #10 as regards Set Based Design.

#### Post Occupancy Evaluations (POE)<sup>4</sup>

In the Lean Project Delivery System, POE is shown as a feedback loop from the end of one project to the beginning of the next. As such, it represents the multitude of feedback loops that promote learning throughout the delivery process. POE itself is simply the evaluation of a project delivery process after the facility is in use. In some cases, POE is restricted to facility systems such as HVAC, but more generally, the idea is to determine by inspection, measurement, and questioning, how the facility is actually being used (e.g., how are functional spaces being used compared to the design intent), how the facility is performing (e.g., energy consumption, wear rates, factory yield rates), and how well it

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<sup>3</sup> The Neenan Company (TNC), Fort Collins, CO. Contact: Mike Daley.

<sup>4</sup> Wolfgang Preiser is among the leading authors on POE. Search his works for references..

meets the needs of its users. This checks both the adequacy of the design process and of the building process.

Although originating in evaluation of buildings, POE can be used for any type of facility, including factories, bridges, tunnels, etc. Repeated application can build a database of design criteria for various facility types. Such a database can be a valuable input into projects dedicated to designing and building such facilities. For example, POE databases could be a source of information on the needs of users identifiable by type but not specifically, as is the case when a facility is being produced on speculation of future sale or lease. They can also be valuable for improving facility performance from project to project. For example, studies of lighting have related specific physical factors, job satisfaction, and productivity. As part of a comprehensive POE of California prisons, it was discovered that epoxy paint is not a good surface for shower room walls and floors. Although cheaper than ceramic tile at first installation, it requires frequent repainting and costs more in the long run.

POEs are still most commonly used in the facilities management programs of public agencies such as the Naval Facilities Engineering Command and the U.S. Postal Service. However, they offer benefits also to private facilities managers as well as developers and designers of all disciplines.

### Cross Functional Teams

A cross functional team is one drawn from multiple specialists. In the product development world, a cross functional team responsible for selecting the design concept for an automobile might consist of representatives from finance, marketing, body design, body and chassis engineering, power train engineering, manufacturing, and key suppliers. As already stated, the cross functional team required for effective project definition consists of representatives from the various stakeholders, which include the client (of which there can be many; e.g., facilities management, marketing, occupants, etc.), the production system representatives (designers, manufacturers, installers), governing agencies (inspectors, neighborhood associations), and sometimes even the general public, as is often the case for public works projects.

Teams are formed by facility system, rather than by skill sets or function. For example, if designing a building, you might have a different cross functional team for each of the following building systems: foundations, superstructure, skin, HVAC, lighting & power, controls, interiors, etc.

A common mistake is to involve such specialists separately, but fail to bring them together. This often occurs because of addiction to a command and control philosophy, and fear of losing control if the specialists actually start talking to one another. The type of control appropriate to the Lean Project Delivery System is achieved through facilitation, not through command. Value is generated through positive iteration of the purposes-criteria-concepts cycle. Only by facilitating conversation among the various specialists in the cross functional team can maximum value be generated for the project stakeholders.

Another mistake to avoid is relegating the builders on the team to the task of assessing the constructability of design already produced or estimating the cost of design options produced by others. The intent is rather to simultaneously explore both product and

process design, since both have implications for client satisfaction and value generation. Further, costing should be done integrally with designing, not thrown over the wall.

## QFD

Quality Function Deployment (QFD<sup>5</sup>) is a tool for translating from the Voice of the Customer into the Voice of the Designer<sup>6</sup>; i.e., from purpose-driven needs into design criteria. The customer may want to be able to ‘hear a pin drop’ on the stage of a theater when sitting in the back row, but the designer needs to know what decibel level to use in selection and configuration of materials and components.

QFD is implemented as a series of translations, moving from the general to the detailed level. The matrix below correlates a client’s desired characteristics of a roofing system with the relevant metrics. Consider, for example, the desire that the roof be fire resistant. Exactly what does that mean as regards design decision making? The metric specifies that the roof system must meet the requirements of U.L. 790 Class A. Another example: The client wants the roof to have a 20 year manufacturer’s warranty. The relevant metrics include the requirement that the membrane be .060 thick, metal must be stainless steel, etc.

This translation contributes to the task of helping clients understand the consequences of their desires. For example, once it is revealed that stainless steel is required to get a 20 year warranty and the relative cost of stainless steel is determined, that might influence the client to change their minds about the warranty period.

QFD might also be used to rate various design concepts against desired characteristics of the facility. That contributes to the goal of revealing more and different opportunities to the client than they may previously have conceived. As you might suspect, such matrices can be used in many different ways to facilitate project definition.

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<sup>5</sup> QFD was developed for use in product development processes. The seminal text is Akao, Y. (1990). *Quality Function Deployment: Integrating Customer Requirements Into Product Design*. Productivity Press, Cambridge, 1990.

<sup>6</sup> In LCI documents, the term “design” and its variants is used to designate design in its larger sense, including engineering.

Customer Desire	Quality		Function		Deployment		Metric												
Facilitates Rooftop Equipment Maintenance	*	*					100 lb sf live load capacity												
Meets Building Codes			*				Provide concrete pavers in walkways												
Factory Mutual Insurable				*			Min. .25 inch per foot of slope												
Fire Resistant					*		FM 1-90												
Good Sound Resistance						*	U.L. 790 Class A												
Provides Energy Rebate From Utility						*	10 lb sf of Mass												
20 Year Manufacturer's Warrantable			*				R=24 Avg												
Allows for replacement							Two layers of insulation												*
Meets Aesthetic Requirements of Neighbors							Metal must be stainless steel												*
							Membrane must be .060 thick												
							Seams must be taped - no glue												
							Non-Combustible deck												
							Equipment supports min of 36 inches high												
							Use aggregate surfacing												

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Concept Generation

Once purposes have been provisionally determined and target design criteria produced, it becomes possible to evaluate alternative concepts for the facility that will embody those criteria and fulfill those purposes. It should be noted that concepts can be generated as a means for clarification of purposes. As previously stated, there is no right or wrong sequence for moving through the project definition modules. An architect or engineer may hear a bit about what a client wants in a new building or system, then begin generating sketches to explore and sharpen her understanding of those desires. The key is not sequence but rather the ultimate alignment of purposes, criteria, and concepts.

Ulrich and Eppinger<sup>7</sup> offer a five step process for concept generation. They stress that the process of concept generation is itself iterative, like the project definition process of which it is a part.

- 1. Clarify the problem.
- 2. Search externally (users, experts, benchmarking, etc.)
- 3. Search internally
- 4. Explore systematically
- 5. Reflect on the solutions and the process

<sup>7</sup> Ulrich, Karl T. and Eppinger, Steven D. (2000). Product Design and Development, 2<sup>nd</sup> edition. McGraw-Hill, New York, NY.



Explicit identification of the functions the facility or its systems are to satisfy is almost always important in problem clarification.<sup>8</sup> Ulrich and Eppinger advocate the use of a Concept Classification Tree in Step 4. The idea is to take one function and list the alternatives for performing that function, then the alternatives for realizing each of those, etc. They illustrate with a handheld nailer that is the product being developed. One function of the nailer is to store or accept energy, which can be chemical, pneumatic, hydraulic, electrical, or nuclear. Each of these can be exploded in turn; e.g., chemical energy could come from fuel-air systems or explosive systems; electrical energy could come from a wall outlet, battery, or fuel cell.

Ulrich and Eppinger advocate consideration of all alternatives, no matter how unlikely the application, because it may provoke a creative idea. It is obvious that nuclear power would not be used for a nail gun, but consideration of that alternative might lead to a technology that is appropriate.

Evaluation and selection of concepts occurs through application of purposes and criteria to alternatives. Concepts should be rejected only if they are clearly inferior or impractical and cannot be improved in the time available. The remaining concepts should be maintained and carried forward until the ‘last responsible moment’<sup>9</sup>; i.e., that point in time at which there is no longer sufficient lead time to realize that alternative. This practice is consistent with the lean principle of doing work only when it releases work to others, and is the essence of Set Based Design.

### 3D Modeling

Although pencil and paper sketches will likely continue to be useful tools for presenting alternative design concepts, 3D models can also play a role. Using a library of objects, limited models can be produced very quickly, allowing better visualization and also making it possible to quickly test appearances, consistency of dimensions, etc.

### Summary

The purpose of project definition is to produce and align purposes, criteria, and concepts. Tools used include:

- Post Occupancy Evaluations
- Cross Functional Teams
- Stakeholder, Location, and Regulations Analysis (Information Collection)
- Quality Function Deployment
- Concept Generation (Function Analysis)
- 3D Modeling

### Research Questions

LCI has a research project underway on Project Definition. All LCI Platinum Contributors are welcome to participate. Current participants are Barnes and Boldt.

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<sup>8</sup> Value Engineering’s function analysis may be useful here.

<sup>9</sup> This expression emerged in an LCI workshop for BAA’s Heathrow Terminal 5 Design Team in London in the summer of 1998.

Many questions remain, some a matter of better understanding what has already been done by others, some belonging to descriptive research, and others matters for experimentation. The literature review and descriptive research will be done through PhD students. Descriptive data will also be collected from LCI contributors and experiments will be performed with LCI contributors that wish to participate.

- Literature Review-do a thorough survey of what others have done and are doing that is relevant to the Project Definition phase of the LPDS.
- Descriptive: To what extent and with what frequency is project definition done on current projects?
- Descriptive: What techniques are successfully used in practice to identify stakeholders and determine stakeholder purposes, to translate purposes into design criteria, and to generate and evaluate facility and facility system concepts?
- Experimental: How to create the conditions needed for successful project definition; e.g., how to persuade clients to allow specialty contractors into pre-design, how to get the participation of suppliers before decision has been made to employ their services?
- Experimental: How can product development techniques from manufacturing be adapted for use in capital facilities project definition?
- Experimental: How to maintain, store, and retrieve project definition information so it is evergreen and accessible, and thus contributes to the goal of system transparency?
- Experimental: What are the measured benefits of implementing project definition within the LPDS?

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