CAPACITY in Open Building Design

CAPACITY means that something can accommodate something else. In formal terms, a building that offers capacity will have a "higher level" configuration of spaces and physical forms that can accommodate a variety of configurations on a "lower level." In other words, the configuration on the lower level can change without forcing change on the higher level, but a change on the higher level will force an adjustment to the lower level.

This is sometimes called FLEXIBILITY, but that word is not very good to describe occupied built form that is truly never finished. Buildings change, part-by-part, to remain useful. Open Building experts like to use the word CAPACITY to explain buildings with long-term asset value. This suggests openness to variety and change.

In Open Building, the "whole" of a building is divided into two or three levels of decision-making. I say "decision-making" because the idea of capacity is that decisions about changeable parts should not drive (but can influence) decisions about their container. Those making decisions about a container with good capacity will design it so that those (others) making decisions about what goes inside have good choices (not only one good choice and several not-so-good choices!).

- The higher level is often called the **BASE BUILDING or PRIMARY SYSTEM** (this is the long lasting part – the site, structure, main entries, main circulation system, space for mechanical systems to be deployed, the façade, and so on);
- The lower level is the **FIT-OUT or SECONDARY SYSTEM** (this includes the more changeable parts, which can change without forcing a change to the Base Building; this includes size of spaces included, functions, mechanical systems required for included functions, and so on).
- In many cases, a third and lowest level is useful to describe the decisions concerning fixtures, equipment and various finishes (This is especially useful in buildings expected to accommodate hospital or laboratory uses or other equipment-intensive uses, even including dwelling units which have more mechanical systems per square foot than office buildings).

In general, OPEN BUILDING organizes design decisions on these "levels" of decision-making. They correspond to conventional distribution of responsibilities in real estate development and management, such as office buildings and shopping centers. A building owner may be in control of the Base Building, while individual office tenants or dwelling unit occupants may each control their own FIT-OUT, designed by their own designers, who are usually different from the design team of the base building.

Of course some parts of the base building can change without causing disruption of other parts. For example in some building construction, the façade or building skin can be removed and replaced without effecting the skeleton. But often, changing the façade requires altering the room layouts because partitions meet the façade in certain places and form a dependency relation. In other building designs, the façade is structural and only the windows in the façade can change. A big question is whether the party occupying space behind the façade can control "their" façade or part of it. This is normal on the ground level of commercial buildings worldwide, but what about on upper floors? There are other examples, but these may make the point clear.

An OPEN BUILDING, therefore, is one in which the FIT-OUT cannot determine the BASE BUILDING, but one in which the BASE BUILDING is prepared to accommodate a variety of changing FIT-OUT over time.

To explain the idea of CAPACITY, it is often useful to refer to other examples of the design of infrastructures – because good base buildings really are a kind of architectural infrastructure.

Highways

Highways are designed with CAPACITY – to accommodate a variety of vehicle types that will themselves change over time (both type and design of each type). A highway is designed for a specific place and lies in a specific jurisdiction. It has to connect to other highways and roads; it must be designed in recognition of the geo-technical conditions (soil conditions, earthquakes, etc.); and it is designed to accommodate a relatively unknown future demand. There are experts who make demand forecasts. Also, a highway is designed not for one kind of vehicle of fixed dimensions, but is designed for a variety of vehicle types whose dimensions and other attributes vary within certain ranges. The "lanes" of the highway are sized to allow safe passage of trucks, cars, busses and even motorcycles. There are "rules:" vehicles are supposed to follow the speed limit, stay in the marked "lanes" and if changing lanes are supposed to signal. There are other design characteristics, such as curvature, maximum grade slopes, guardrails, sound barriers and so on. The vehicles using the highway are constantly evolving, but always within the constraints of the highways in existence.

Highway design engineers design highways. Other design teams design the vehicles that highways accommodate. The team that designed a highway in 1990 has retired by the time BMW or Toyota engineers design the vehicles that will use these highways in 2020.

Aircraft Carriers

Aircraft carriers are also designed for CAPACITY, and, like highways and buildings, for a limited capacity. Not ANY airplane can be accommodated in any given aircraft carrier. On the other hand, it would be a poor investment if a carrier were to be

capable of hosting only one aircraft type, of one design vintage, designed for one kind of armament or munitions. Because carriers are expected to have a long life, and aircraft and their cargoes change more quickly, the engineers designing the carrier's deck, elevators, holds and storage and repair shops consider a range of "users." Further, the engineers who design carriers are naval engineers, while the engineers designing aircraft are aeronautical or aviation engineers. The teams assembled for the design of an aircraft carrier has long since disbanded by the time the second-generation aircraft are designed.

Getting Started

The first step in designing an OPEN BUILDING project is to know the building site, budget, gross area, local design and technical regulations, and client expectations. Some client organizations have limited experience in procuring buildings, in which case the client depends heavily on the design team to structure the decision-making processes. In other cases, the client has long experience in building acquisition and may be more prescriptive.

Scenarios

Assuming the client wants to invest in a facility that will offer long service life, the design team needs lead the development of several scenarios (hypotheses) of possible use of the building over time. Each scenario contains a specific description of what uses / functions the building could serve during its life. This is difficult, because predicting the future is impossible. Ultimately, therefore, we should not attempt to forecast what will happen, but attempt to make provisions for the unforeseen.

An Iterative Design Process

Once a number of scenarios have been developed, the design team makes a first proposal for the design of a base building, starting with the first scenario. In doing so, the design team may revert to the familiar decision-making process and decide floor plans first, stack them up, and wrap a façade around them. Then, the design team must delete the floor plans, keep the Base Building, and attempt to insert the second scenario, doing a kind of test-fit. If the Base Building can accommodate both scenarios, the design team has done a good job and can proceed to try the third scenario.

In doing this work, however, it is normal that the design team has to think differently. The challenge is to keep all the scenarios in mind when asking:

- What building and structural geometry will accommodate all the scenarios while meeting site conditions and at the same time allow the deepest penetration of natural light into interior spaces;
- What building entry spaces and interior public space layout will work well for all scenarios;
- What internal and external circulation patterns makes sense and that can serve all

scenarios well;
• What floor-to-floor dimensions offer the best capacity for change of function given in the scenarios;
• How much and what distribution vertical mechanical equipment space is needed;
• How and where will horizontal mechanical systems be situated, so that change of uses attached to these systems will not disrupt the functions of other users;
• Etc.

Formal Capacity Analysis
When a schematic (10%) design is ready, the design team (often in concert with the client team) conducts a CAPACITY ANALYSIS of the proposed building. Interior designers often call this a TEST FIT. The capacity analysis of the base building design explores just how capable that base building is to accommodate the variety of uses/functions described in the SCENARIOS. Judgments must be made with incomplete evidence and uncertainty. Various tools are available to assist. One is the use of "zones and margins" or planning grids in designing. Cost modeling tools for analysis of the return on investment of specific open building strategies are also available and should be employed.

After completing an initial capacity analysis (drawings are needed along with numerical calculations, notes, etc.), the first "tentative" base building is modified based on what was learned in the capacity analysis and other kinds of studies (such as energy performance, work flow, and so on). It is usually the case that new information emerges from the initial capacity analysis, perhaps from outside the design team, but also from the designing itself. This may cause further adjustments to the original base building design. The building may need to be reduced in bulk or a new structural geometry introduced, or new energy performance requirements considered, and so on.

The modified base building is then subjected to another round of capacity analysis.

This process continues until agreement is reached that the base building has "good" capacity. Defining "good" in this sense is not a purely technical matter but involves judgments of various kinds. Certainly as much credible and unambiguous information and analysis as possible is vital to support decision-making. A design team experienced in designing for capacity may come to a resolution quickly, after exploring a number of scenarios. But it is also the case that this process is a learning process for the client, who may introduce variables and priorities during this process that it had not considered initially.

A Repertoire of architectural patterns, types, and systems
An experienced design team will work with a repertoire of architectural patterns, types and systems. This may constitute its "architectural brand." This is not new, but is what any design team brings to any facility design process. In this sense, an OPEN BUILDING design process is not different.

A Repertoire of technical product solutions

In addition to a robust and evolving architectural repertoire, a good design team will also have ready a repertoire of technical or product solutions, but also be constantly searching for better ones and be ready to develop new solutions when necessary. Some of these products and technical solutions will be no different from any others used in facility design. But when unconventional technical products or solutions are known and believed to be useful to make a high-performing OPEN BUILDING, they should be included in the design team's repertoire and examined for their feasibility during the iterative design process outlined above.

Experience shows that for a building to offer effective CAPACITY for variable and changing functions or building user requirements now and in the future, substantial attention is needed on the mechanical, electrical and plumbing system solutions. One of the essential criteria for selecting these solutions is that they assure that making a change of any mechanical equipment in one user's space will never require that another user's space be entered or disrupted. For example, no piping serving one space will be hidden in the ceiling of the space below it, or in the walls separating that space from an adjacent space.

These technical systems include:

• **Pipes** of various sizes, materials and connection methods for delivering water, gas, and other fluids from Base Building distribution lines to each termination in each user's space. The pipes also include those to carry away waste, from laundry, bathing, kitchens and water closet, laboratories and so on. Some parts of each piping system will be in the Base Building, part in the Secondary System, and often some will be in the Tertiary System as well.

• **Cabling** includes wires for electricity, data and other low-voltage and communication requirements. Some parts of each wiring system will be in the Base Building, part in the Secondary System, and often some will be in the Tertiary System as well.

• **Ducts** include those for delivering conditioned air to user's spaces and also ducts for removing air.

Conclusion

It is reasonable to ask "What are the general criteria for a good primary system or base building?" Here is a suggested list:

- *Site capacity*
- *Building expansion flexibility*
- *Geometry of the structural system*
- *Natural light*
- *Floor-to-floor height requirement*
- *Loading capacity of floors*
- *Minimal internal structural walls*
- *Flexible facades*

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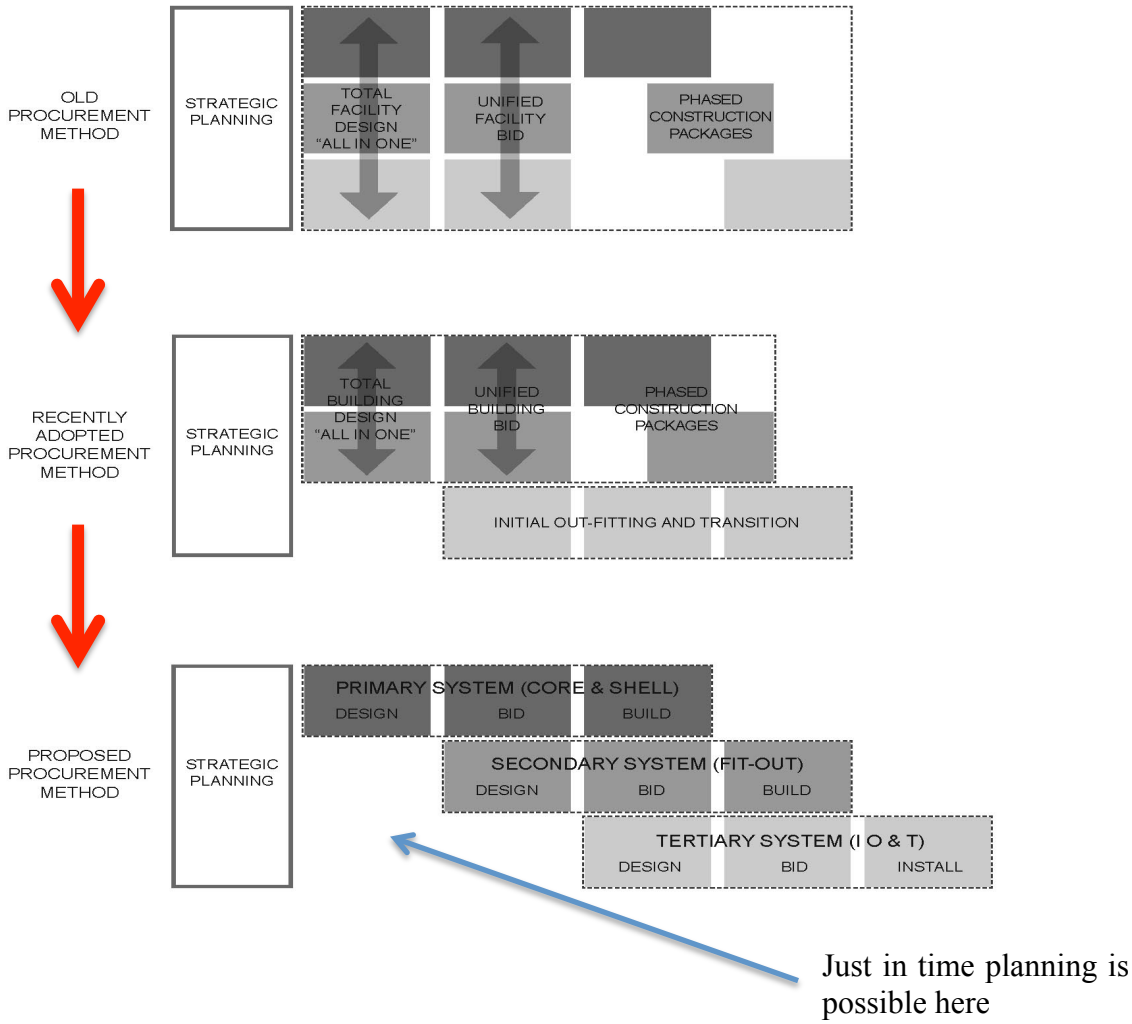
- *Separate systems*
- *Layout and MEP flexibility for the secondary system*
- *Opportunity for vertical mechanical equipment in the future*
- *Multifunctional use of rooms*
- *Capacity for variable inpatient bedroom sizes*

I referred to decision-making. Conventional design processes ask that all players and all data and information be known at the beginning of design process. This is now called IBS (Integrated Building System). This is shown in the top diagram. In a large hospital, which may require 5-7 years from decision to build to occupancy, this requirement is impossible to accomplish. Some clients (e.g. US Department of Defense Health Agency) have adopted a limited "serial" decision-making process (middle diagram). Open building suggests further step, shown in the bottom of these three diagrams:



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A SHIFT OF PERSPECTIVE IS REQUIRED

The idea of CAPACITY is intuitively obvious and is already applied in many architectural and interior design firms when doing office buildings. Some use a more formal approach than others, and the best use this information explicitly in presentations to clients. In general, what I am suggesting requires a shift of perspective:

FROM	**TO**
•Assets understood as static	*•Assets understood as subject to transformation*
•Decision making focused on the initial acquisition of an asset	*•Decision making over time (assets will be transformed over time)*
•Flexibility focused on technology	*•Flexibility focused on sequenced decision-making over the buildings' life*
•Flexibility separated from sustainability	*•Flexibility ENABLING sustainability*
•Flexibility as an option	*•Flexibility as a requirement*

I remember from discussions of the groundbreaking INO Hospital project in Bern, Switzerland, that the jury had long discussions about which of the 10 entries to the competition for the Primary System was best. In that case, only architects who had never designed a hospital were invited to compete. All were given the same information. Giorgio Macchi, the chief architect of the client (The Canton Bern Office of Properties and Buildings) was head of the jury; there were other architects too. No specific criteria were given to the 10 entering architecture firms. They were given no detailed program of requirements/ functions but had to design a good base building! They had to think about the challenge and submit their own proposal.

Thoughtful clients will realize that architects should not be given some kind of formula, but that they should be able to use their skill and imagination about how to make a primary system. This is why we need to do a good job when we are teaching - to set the attitudes and skills, and then expect architects to do their best work.

Open Buildings provide CAPACITY for variable and changing user requirements and preferences. Open Buildings are open in the sense that they are not designed first by defining floor plans but are designed with the capability of accommodating a range of floor plans over time. Capacity Analysis is the design method used to evaluate a schematic base building design in an iterative process that continues until the decision is made that the proposed base building is a good investment for present and for the future. In this sense, Open Building implementation involves fundamental rethinking of decision-making.

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