INTRODUCTION

Buildings must perform in response to a number of complex technical demands. Methods and criteria exist for measuring technical performance. The CIB Congress in Gavle, Sweden highlighted progress in this direction. In addition, buildings must perform in regard to a variety of complex social demands over their useful lives. In the most general sense, these social demands - having to do with both functionality (regulated and measurable) and preferences (values and choices) - can be characterized as belonging to two spheres of interests:

• Performance concerning the public good
• Performance concerning the private good

This division of performance - matching two fundamental spheres of interests - seems to hold true in all economies. These two clusters of interests - public and private - represent forces that are invariably reflected in and are in turn influenced by the built environment. They are indispensable for each other - in society as in the built fabric. Each sphere pushes for enlargement of its sphere of control, for application of resources within the space of its control, and for manifestation of its values and choices. In their balancing we find the resolution of forces that makes the built environment whole and yet capable of transformation. These forces can be found to work hierarchically, at a number of environmental LEVELS:

the community at large
the neighborhood ........................................ URBAN TISSUE
the building owner or occupants as a group .... BASE ARCHITECTURE
the individual occupant or household .......... FIT-OUT
the individual person

These examples of LEVELS exist in every culture. A similar hierarchy was the basis for the Ekistics matrix developed by the Greek planner Doxiades (Doxiades, 1963) and used as a framework for research and documentation in the built environment. These levels may be more or less normalized in the regulatory and legal apparatus, and in local habits and conventions. But aside from the extent to which these are formalized, it is correct to say that built fields are organized in respect to an hierarchical structure, particularly as it has to do with division of territory, movement from one territory to another, and in the distribution of services across territorial boundaries. (Habraken, 1998)

But because buildings are not only technical artifacts but have to do with building cultures (Davis, 1999), description of buildings in either technical OR social terms only is inadequate. We must address the complexity of physical systems by describing building in a way that brings decision and control hierarchies into view with technical systems over which control is exercised.

TECHNICAL DESCRIPTION OF BUILDINGS
In North America, professionals charged with writing technical specifications use the Construction Specifications Institute's MASTERFORMAT of 16 divisions (CSI). For example, Division 4 - masonry - contains product information related to the masonry trades and systems. Division 16 - electrical - contains product information related to the electrical trades, and so on. While this alignment of products and trade jurisdiction is not absolute, there has been a long and consistent effort to relate products to trades.

**Construction Specifications Institute Masterformat**

<table>
<thead>
<tr>
<th>Division</th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>General requirements</td>
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<tr>
<td>2</td>
<td>Sitework</td>
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<td>3</td>
<td>Concrete</td>
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<td>4</td>
<td>Masonry</td>
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<td>5</td>
<td>Metals</td>
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<td>6</td>
<td>Wood and plastics</td>
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<td>7</td>
<td>Thermal / moisture protection</td>
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<tr>
<td>8</td>
<td>Doors and windows</td>
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<tr>
<td>9</td>
<td>Finishes</td>
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<tr>
<td>10</td>
<td>Specialties</td>
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<td>11</td>
<td>Equipment</td>
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<td>12</td>
<td>Furnishings</td>
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<td>13</td>
<td>Special construction</td>
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<tr>
<td>14</td>
<td>Conveying systems</td>
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<tr>
<td>15</td>
<td>Mechanical</td>
</tr>
<tr>
<td>16</td>
<td>Electrical</td>
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</tbody>
</table>

While this has been an effective tool for organizing construction documents and standardizing specification writing for decades, several difficulties result from its use as a research tool or as a basis for specifying products or systems that combine divisions. One problem is that increasing numbers of "products" incorporate elements from a number of these categories. These "hybrid" products do not neatly fit the 16 divisions. One example is "systems furniture", a "product" now widely used to fit-out large office spaces with partitions, furniture, cable management floors, air conditioning and lighting. Such complex “product bundles” - often delivered as single-sourced products with associated warranties - cross strictly technical categories such as these.

A related difficulty is that a number of companies now own a number of subsidiaries each making discrete parts. This corporate strategy of horizontal integration is now visible internationally: e.g. the large manufacturing company Wiremold in the US has been acquired by the large French company LeGrand. Another example is the Masco Corporation, a large US corporation that manufactures and provides thousands of home improvement and building products and services through the more than 50 US and foreign companies in its worldwide family. This company has adopted a corporate strategy seeking to combine products from its parts stable in new ways aimed at the consumer market. This is requiring adjustments to supply chain logistics, marketing (including e-commerce), skills training (multi-skilled workers), and perhaps adjustments to the regulatory environment.

A final difficulty in strictly technical descriptions of parts is that when one takes the point of view of the party ordering or procuring a building or a space in a building (an end user, investor, agency), interests focus not so much on the many thousands of discrete parts and their "performance" but on particular "bundles" of parts under the control of a given party such as a business renting space, a developer building a new office building, or a household

*figure 1 (Construction Specifications Institute)*
making a dwelling. Usually, these "product bundles" or element groups cross CSI technical divisions. A user may not be interested in the performance of the ceiling system per se but in the behavior of the work (or living) environment as a whole. For example, a building owner will procure a building devoid of internal layouts or equipment (a "base building"). She understands that individual tenants will independently specify their own spaces, and that over time, this individualized "fit-out" will change. She and the tenants occupying the building see their work and control as organized on levels that cross the technical classifications shown above.

A LEVELS DESCRIPTION OF BUILDINGS

If we overlay "levels of control" on the "technical description" of buildings, we have a diagram in which we can identify performance more accurately than looking at technical systems and control separately.

**Three Tier Model of Control Distribution**

<table>
<thead>
<tr>
<th>Masterformat (CSI Specification Standard)</th>
<th>Base Building</th>
<th>Interior Construction FIT-OUT</th>
<th>Furnishings Fixtures Equipment</th>
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</thead>
<tbody>
<tr>
<td>division 1: general requirements</td>
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<td>division 2: sitework</td>
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<td>division 9: finishes</td>
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<tr>
<td>division 10: specialties</td>
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<tr>
<td>division 11: equipment</td>
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<tr>
<td>division 12: furnishings</td>
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<tr>
<td>division 13: special construction</td>
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<td>division 14: conveying systems</td>
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<td>division 15: mechanical</td>
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<tr>
<td>division 16: electrical</td>
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</table>

*figure 2: Three Tier Model of Control Distribution*

In this diagram, we find terms conventionally used to describe the organization of large buildings. These terms - base building, interior construction or FIT-OUT or INFILL, and FF&E - are largely technical but are inherently related to "bundles" of elements under the control of a particular party. The base building is the bundle of parts and decisions that effect all occupants (structure, foundation, roof, main services, stairs, public corridors and elevators, etc) The interior construction, FIT-OUT or INFILL includes non structural walls, equipment, doors, lighting, and private circulation space, etc., specified per tenant. The FF&E is furniture, finishes and equipment also specified per tenant. (Kendall, 1999) The terms signify that "the party controlling the base building" has interest in the entire bundle of products making that environmental level. The same follows for the other "levels". In some cases, the two lower levels (Interior Construction and FF&E) are combined into single product bundles and single-sourced. An example is Steelcase's Pathways product, which, offers total slab-to-slab interior environments to the office market and is now marketed as part of a consortium offering whole buildings (Workstage.com). This overlay
of control and parts tells us about performance in reality: performance concerns the inescapable interdependencies and interrelations of technical systems under the control of certain parties. (Dove, 2000)

CONFLICT REDUCTION, CONTROL and TIME

Building performance focuses on reduction of conflict and optimizing value. In a dynamic society with highly disaggregated exercise of power over building decisions, there is nothing worse than having construction processes and a built environment that produce conflict among the parties involved (and the parts each controls). The success of a performance based way of specifying and evaluating buildings must therefore account for the behaviors of - and performance specifications for - complex built environments when control over them is distributed.

Buildings are not "lumpy" wholes that, once built, remain static. Buildings are constructed and later change by the decisions of certain parties who control the many thousands of discrete parts making buildings. Such parties exercise control by means of organizing parts into certain "bundles" convenient for their purposes.

Thus the control of parts changes hands - initially the designer controls parts, then the contractor takes them in hand, and finally the user gains control of the parts and, in time, changes them to suit specific preferences, and so on. But change is not uniform within a built field or a building, nor is it continuous. Observation over a period of time reveals certain patterns of stability and patterns of change. Many agree that these patterns of change can be described according to levels, connecting technical systems and those parties exercising control.

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**Architecture**  

**Open Building**

> the base building concerns what is shared by everyone

> the fit-out concerns what is decided by each tenant independently

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**Figure 3 Distinction between a Base Building and a Fit-Out Level (Kendall)**

Defining performance has always been difficult. (Blach and Christensen, 1986)(Russell, 1981) Agreements concerning terms of reference and operational definitions have been illusive for all but the most technical measures. In part the difficulty has arisen from the separation of issues: questions of “control” (i.e. who decides about what, when) have largely been avoided from technical discourse because they involve power. Yet, the use of levels can lead to an improved use of the "performance concept", linking use and products, control and technical description.

**USING LEVELS TO MAKE RESIDENTIAL BUILDINGS PERFORM BETTER:**
A recent book - **RESIDENTIAL OPEN BUILDING** (Kendall and Teicher, 1999) - discusses the evolution of a way of residential building based on the idea of “performance” according to “levels” as described above. The book shows 25 buildings and a dozen infill systems developed in the process of implementing open building principles. The book also presents several innovations in organizing the finances of such buildings. The scope of the book is international and focuses on residential architecture.

![Figure 4: Principle of Distinguishing Base Architecture from Fit-out (KSI Japan)](image)

Figure 4 illustrates the basic principle found in all residential open building projects – a clear distinction between serviced base architecture and the more individual – and industrially produced - fit-out. The following projects exemplify principles that are the basis for harnessing advanced manufacturing and supply chains logistics in the service of housing for the 21st century, based on the use of levels.

**NEXT 21, OSAKA, JAPAN**

Built in 1994, NEXT21 is an experimental 18-unit housing project in Osaka, Japan. It anticipates the more comfortable life urban households will characteristically enjoy in the 21st Century. The project was conceived by Osaka Gas Company in collaboration with the NEXT 21 planning team. The NEXT 21 Construction Committee developed the basic plan and design.

The building frame (or "skeleton"), exterior cladding, interior finishes, and mechanical systems were designed as independent building subsystems, each with a different repair, upgrade and replacement cycle following "Century Housing System" principles. Design of the 18 units began after design of the building frame, and continued during skeleton construction.

Individual dwelling units were designed by 13 different architects. Each unit's interior and exterior layout was freely designed within a system of coordinating rules for positioning various elements. The generous floor-to-floor height allowed for the introduction of utility distribution space above ceilings and under raised floors; therefore, ducts and piping can be routed independently of structural elements. Main beams have reduced depth mid-span allowing ducts and piping to pass over the beams without use of "sleeves" to the main horizontal utility zones under exterior corridors or "streets in the air".

NEXT21 was constructed as a whole, but designed in such a way that its various subsystems can be adjusted with improved autonomy. To test this objective, one 4th-story unit has been substantially renovated. All work was accomplished from within the unit, using hanging scaffolding, thus minimizing disruption to abutting inhabitants. A substantial amount of the materials removed - especially of the facade - were successfully redeployed to make the new facade. The project continues to explore new methods for building urban housing, experimental infill systems, and means of accommodating varying lifestyles with reduced energy consumption. The second phase
of NEXT 21 includes renovating other units, introducing a new group of inhabitants, and continued evaluation of the energy systems.

Planning/Design was lead by Osaka Gas and Next 21 Planning Team (Utida, Tatsumi, Fukao, Takada, Chikazumi, Takama, Endo, Sendo). The Building Architect was Yositika Utida and the Shu-Koh-Sha Architectural + Urban Design Studio. Construction coordination and modular coordination principles were managed by Seiichi Fukao. Design system planning was lead by Kazuo Tatsumi and Mitsuo Takada. Dwelling Design Rules were formulated by Mitsuo Takada, Osaka Gas, KBI Architects and Design Office. (SD 25, 1994) (Next 21, 1994) (Kendall and Teicher, 1999.

figure5: Next 21, Osaka, Japan

PATRIMONIUMS WONINGEN / VOORBURG RENOVATION PROJECT

Patrimoniums Woningen, a large private housing association, owns a property containing many five story multifamily buildings near Rotterdam. In 1988, the association decided to rationalize management of the property and to begin to upgrade it. They decided to modernize the housing stock by renovating vacant rental units as they became vacant. At the same time, economic and facilities analysis indicated the need to begin a long-term upgrade of the entire site. Included in this work were base building improvements including the addition of elevators and balconies and upgrading the mechanical systems, and various site improvements. The owner also decided to add two-story townhouses at the corners of the large apartment blocks creating a sense of security and privacy to the inner courtyards. The original sidewalk – accessible storage rooms on the ground floor were replaced with entry level apartments for the elderly and the handicapped.

Several companies have been hired to do the dwelling unit renovations. One of them Matura Infill Systems, a company specializing in interior fit-out of dwelling units, had developed an advanced system based on open building principles. Their product has been used to fit-out a number of the units on a one-at-a-time basis.

During the two weeks required to gut out each newly vacant unit, the new tenant met with the architect. A floor plan and equipment and finish specification were selected from among several options. The drawings were then transmitted to Matura. One month after being vacated, the unit was again ready for occupancy with an entirely new interior reflecting the new tenant’s preferences. The Matura Infill System solves the problem of horizontal routing of dwelling specific mechanical systems. It uses two new products as part of a “lower system” in which all
the technical systems are organized. The more consumer–oriented “upper system” – including doors, partitions, cabinets, fixtures and finishes – are selected from available products in the open market. Together with a software system, the two new products for technical systems constitute the patented Matura Infill System.

The Base Building is the permanent part of the building, providing overall serviced spaces divisible into individual dwelling units, of different sizes, so that differences in demand can be met.

The Fit-Out has to do with the individual layout within the dwelling unit, providing installations, walls, doors, utilities, kitchen and sanitary equipment and finishes.

In this way TWO DISTINCT MARKETS are served, each with its own distinct clients, time frame and products. The BASE BUILDING market is dominated by institutional clients such as investors, housing associations and private developers. Its products are in the public domain: they are site bound and are part of the political decision making process. This market is largely free of the individual consumer’s selection process. Base Buildings have relatively long lives.
The FIT-OUT has the potential to develop into a true consumer market, capable of meeting the increasing variety of individual demands. Dwelling improvements in response to individual preferences made possible by rising incomes can be realized more easily. FIT-OUT - as a distinct product bundle - can effectively support the renovation of existing buildings or adaptive conversion to housing.

Clearly separating the BASE BUILDING and the FIT-OUT has distinct advantages. Technical systems in a normal housing project are embedded in the load-bearing structure, installed by a number of different trades causing interdependencies that complicate the design and construction process. Errors and conflicts are a familiar part of this work.

Open Building advocates separation of systems – particularly the equipment and utility systems – on levels. What is needed to make this separation work in practice has been extensively studied, and includes the use of “INSTALLATION CARRIERS”, such as channels in the floor, raised floors, multiple ducting in the base building, special installation walls, and so on. Some of these require special provisions on the base building, others not. When existing buildings must be renovated, making specific provisions for fit-out is difficult. In that case, INSTALLATION CARRIERS as part of the FIT-OUT make sense.

When the bulk of the utility lines (drainage, cabling, ductwork) are free of the BASE BUILDING, it is easier to design and build.

Separating the production of BASE BUILDINGS and FIT-OUT means that SYSTEMATIC PRODUCT DEVELOPMENT is less difficult to achieve because DEPENDENCIES are reduced and those remaining are more manageable. THIS IS A PREREQUISITE FOR REAL INDUSTRIAL PRODUCTION. In addition, with innovation of both products and methods of production, great variety can be achieved in a WELL CONTROLLED PRODUCTION PROCESS with INHERENT OPPORTUNITIES FOR QUALITY CONTROL.

**INDUSTRIAL PROCESSES for FIT-OUT PRODUCTION**

In the development of FIT-OUT systems, a number of challenging issues must be addressed:

1. A great variety of demand must be met in engineering, design and production.
2. Per-unit FIT-OUT bundles demand new design, engineering, and logistics management.
3. Orders for a FIT-OUT bundle penetrates the sales, design, engineering and production process.
4. Each FIT-OUT package is a complex bundle with hundreds of details and thousands of parts.
5. Time between order and delivery is very limited.
6. A high quality end product demands a fail proof process.

To meet these challenges, efficient information management throughout the entire process is of critical importance. This means that the development of FIT-OUT systems depends on using the most advanced computer software, object-based libraries, and seamless information flows. Design databases must be linked to production and to installation work.

In the automobile industry, all of this is normal practice. The building industry is much more complex. In addition, each building site is different in many ways. The separation of BASE BUILDING and FIT-OUT is advantageous in solving the complexity of industrialization in the housing process.

**INDUSTRIAL PROCESSES for BASE BUILDING PRODUCTION**

With most of the utility and installation parts allocated to the FIT-OUT level, the BASE BUILDING can be built more efficiently. The predictability of the on-site construction process is increased by reduction of the number of independent trades and by elimination of the complexity of the installations. This enables SYSTEMATIZATION of the production of elements for on-site erection. True systematization of building provides variety, not the numbing uniformity of so-called “industrialized” buildings of the past.

**THE FAÇADE: PARTLY BASE BUILDING and PARTLY FIT-OUT**

A distinction similar to the Base Building – Fit-Out distinction is also possible in the building façade. Certain parts of the façade can be decided along with the Fit-Out, within an architectural framework of permanent parts. Just as the CAPACITY of the BASE BUILDING can be studied for variable FIT-OUT, the façade can be evaluated for its capacity for individualized but partial FIT-OUT components. The NEXT 21 project is the most advanced example of this. This suggests a future industry for façade components, designed to produce variety by the way they can be safely combined to meet technical requirements.
CONCLUSION

The performance concept in buildings has been a guiding principle in the building research community for more than forty years. (Russell, 1981) Basing building procurement and bidding processes on desired performance rather than on specific solutions has been especially interesting to innovators interested in harnessing industrial production. Both Life Cycle Assessment (LCA) and Life Cycle Cost (LCC) are techniques (ISO 1997) with wide acceptance in the scientific community but with insufficient application in practice.

Other methods have been developed linking cost / benefit analysis to issues of flexibility and change. (Geraedts, 2000) Still other design methods have evolved enabling a careful analysis of the “capacity” of a structure (base building) to accommodate a range of “lower level” configurations (fit-out), allowing careful calculation of spatial norms and market demands in residential construction. (Habraken, et al, 1976)

Performance is a useful concept when associated with particular products, components or systems. This paper suggests that evidence from practice and from the behavior of ordinary buildings subject to both stability and change points to the importance of the use of levels as a new way to understand performance, linking technical criteria and criteria having to do with patterns of use and control.

This essay adopts the view held by those advocating the open building approach, that improving the performance, quality and capacity of buildings will occur most fruitfully when “performance” and "innovation” are aligned with principles of open building, as evidenced in the projects discussed:

• The idea of distinct Levels of intervention in the built environment, such as those represented by base building and fit-out, or by urban design and architecture.
• The idea that users or inhabitants may make design decisions, as well as professionals.
• The idea that, more generally, designing is a process with multiple participants including many kinds of professionals.
• The idea that the interface between technical systems allows the replacement of one system with another performing the same function. (As with different fit-out systems applied in the same base building)
• The idea that built environment is in constant transformation and change must be recognized and understood to enable professionals to be effective.
• The idea that built environment is the product of an ongoing, never ending design process in which environment transforms part by part.

REFERENCES
19. van Randen, Age. OBOM Research Group, TU Delft.

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