The Infinit Life Cycle Grid: The Architecture of Environmental Information In Design

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I recently read the following in the *Journal of Industrial Ecology* (Vol. 1, No. 1, MIT Press), in reference to a new book, How Many People Can the Earth Support: "...but why not devote an equal number of pages to the bigger part of the problem...how to transform societies in which amassing material wealth is increasingly viewed as the purpose of life into societies that pursue equity, justice, safety, spirituality, and community with equal vigor? Granted in some ways ***we barely have the language to begin this debate***, and we certainly do not have the experience in societal transformation that we do in development .... planning." (emphasis added).

The Infinit Grid™ is a language well-suited to this challenge, as it is designed to organize and apply information about human life support needs relative to the natural environment's capacity to supply those needs. The language is derived from and expands upon three internationally recognized approaches: life cycle analysis, the grid system used in geographic information systems (GIS), and input-output analysis. The life cycle becomes the performance tool within the different scaled boundaries of the GIS grid system. GIS offers a nesting boundary system within which the degree of human and natural activity can be recorded and compared, and input-output analysis is used to understand the relationships between businesses. This paper focuses on the continuously linked inter-scalar Infinit Grid™ design method and its unique attributes: (1) it can work with many different resource flows; (2) it links environmental impact to a specific geographic location, providing context-specific analysis; (3) it is user-friendly as an icon driven language making it easy-to-understand for clients, design professionals, engineers, scientists, students.

Precedence

The scale within a scale performance concept is not new and has been incorporated in many disciplines over the last 30 years, including, for example, physics (Bolhm), biology (Margolis, Sagan), design (Eames), psychology, (Delong, Calhoun), ecology (di Costi), medical sciences (Miller), and the science of industrial ecology (Ayers).

Icons as Operational Components of the Infinit Grid™

Material, energy, information and currency are the primary flows in human / environment contexts. The complexity required to represent these flows is exponential and can hinder people's ability to understand them. The iconographic representation achieved by layering the degree of specificity of information at a given life cycle stage serves to "hide" this complexity and only "show" parts of the complexity as needed. This depth of information capacity is well-suited to object oriented programming, which has great flexibility in how performance modules are placed in different operational formats.

The icon is a pictogram that graphically represents an identifiable performance of a natural or human-constructed phenomenon. It is set within a frame that indicates, on the vertical axes, what it can be connected to, and, on the horizontal axes, potential environmental impacts relative to air, land and water. The frame also identifies a performance boundary, which relates to the GIS grid system with a specific geographic representation relative to site. Establishing a boundary is the key link from the virtual environment of the computer to reality.

In addition to the layering of information described above, the icon can switch at the same layer to another topic version of the same subject matter; for example, the energy used in a material flow process or information on manufacturers of products related to a particular life cycle stage. These capabilities offer not only a variety of user comprehension scenarios but make it easier to start collecting data and incorporating the use of the Infinit Grid™ with the least complex or most immediately useful topics first, and building on these without necessitating whole systems to be programmed at once.

The Infinit Grid™ Operating at the Macro-Scale

At the international level, the United States is representable as an icon. It has boundary and within that boundary it possesses a certain performance of monetary, energy, material and information exchanges. The U.S.' performance is of particular interest since its "footprint" has spread well beyond its boundaries to fulfill its material and energy demands, perhaps well beyond the external dependencies of other nations. Indeed, some believe that technology's ultimate challenge is reducing the "footprint" that represents current U.S. consumption patterns without negatively impacting lifestyle.

In order to understand how a particular life cycle works one must understand how it functions in its parts at the largest boundary of the nation as well as at the smallest boundary of the project. The nation is made up of 52,480 grid cells measuring 7 1/2 by 7 1/2 minutes. These cells can be aggregated to a larger or smaller size or they can be adapted in shape to political or natural boundaries using a grid cell geographic information procedure. In life cycle terms we can study the grid cells in terms of only those activities that are placed into the category of, for example, sources (e.g., all oil fields, biomass, waste materials that can produce energy), or processors (manufacturers of a wide variety that utilize the same materials). Similarly, companies that deal with waste materials can be identified at the other end of the life cycle. Interesting results can happen when the different life cycle phases are linked between various input and output flows, such that sources, for example, are replaced by re-sources.

For example, if we go back to our material example and narrow our field to building materials and still further to lumber (as a subset cluster of materials) and materials that have shown potential to displace lumber as a subset of that, we find that the amount of biomass waste that could be used on a national basis to take the place of wood in buildings is almost double the amount of lumber used for all building nationally each year. So the icon representing lumber used in the U.S. construction industry, relative to total resources available and total resources used, indicates a potential ratio surplus of about 2:1. We also know that the U.S. construction industry's transportation activities (moving materials through the life cycle, from source, to processing, to use) represents about 7% of the nation's total energy budget Thus, one can extrapolate the amount of virgin lumber that can be displaced with recycled-content biomass, and begin to quantify the potential reduction in the transport phase of the life cycle resulting from this substitution strategy.

In order to represent the true life cycle of a process, one must factor in impacts up and down stream (e.g., not only how each life cycle phase relates to other phases and to the environment). Contained within the Infinit Grid™ is the Toxic Release Inventory (TRI) and federally-designated non-attainment zones in the U.S.. By folding the monetary input-output model of the U.S. economy into the GIS component of the Infinit Grid™ we have established a means of relating nearly all businesses to each other throughout the U.S.. This relationship is important to understand how the life cycle can be represented on the land and how impacts can be depicted if any of the many phases within the life cycle fall into non-attainment. When this occurs the Infinit Grid™ indicates there is a problem, which should prompt the specifier to consider another product to reduce the environmental impacts.

The Infinit Grid™ Used at the Regional and Master Planning Scales

We will address two planning scales in this paper: regional planning, as in regional science, and master planning, as in planning a sustainable village. The practice of each has interesting and slightly different ramifications relative to life cycle. The assumption with both is that one is trying to use the life cycle (from sourcing to resourcing) within a given boundary with an objective of "responsible" planning. At a regional scale, such as a multi-county planning region, the Infinit Grid™ language will enable one to see how the goal of "buy local" can be achieved through planning as many life cycle stages as possible to occur within the regional boundary. The more steps that occur within the region, the more jobs that are created within the region. Similarly, as the different life cycle phases are better integrated, waste from one becomes food for another, as with industrial ecology. The result is a reduction of environmental impacts associated with waste. Regional planning can also be represented in life cycle terms by associating different planning roles, such as transportation, natural resources, and economic development, with different life cycle phases. In this way, the life cycle can be used to integrate what are often disconnected functions and roles within the planning profession.

On the scale of master planning, life cycles can be reflected in the way land and building types are laid out. For example, *sources* of energy, food, water, materials, wastewater treatment become part of the spatial planning process. Similarly, other life cycle phases such as transport, process, distribute, and use can be spatially tracked and organized. The important connection to previous methods is that each life cycle phase can be subjected to land suitability procedures similar to those used in ecological land planning. For example, the location of transport corridors has ecological suitability as does the sourcing location of resources, processing, and distribution, for example. To date, ecologically-based master planning subjected the use stage of the life cycle (the buildings) to land suitability. Using the Infinit Grid™ language, life cycle procedure asks that one does what they can at the smallest scale possible that is inclusive of all life cycle responsibilities. The procedure in its broadest use can enable one to understand the land in its fullest use potential over time leaving areas sufficient enough for proper regeneration of re-sources.

The Building Scale: Regionalized Public Demonstrations

Every region should have public demonstration projects which exemplify state of the art sustainable planning and design practices. These projects should catalyze ongoing initiatives in both the public and private sectors. One such example at the building scale is CMPBS' Advanced Demonstration Building Project, originally funded by the Texas State Energy Conservation Office, which is designed as a blueprint of green building issues needing to be addressed into the next millennium. These include extensive use of regionally-sourced recycled-content materials, including 98% recycled-content steel and 97% recycled-content concrete, and a flexible post and beam structural system able to respond to changing spatial needs over time.

The building incorporates an icon-based language system to identify sub-systems such as water catchment, wastewater treatment, and energy. These icons parallel those described within other scales of the Infinit Grid™, which follow the life cycle using a color-coded system. As the project evolves, the computerized icon system will show sub-system performance based on monitoring techniques. This technique provides an excellent format for the general public and design professionals to better understand the how's and why's of building performance relative to site, and relative to other buildings in the region.

The User Scale: The Role of Participatory Models as Part of the Infinit Grid™

The Infinit Grid™ language can also be useful at the user scale, as demonstrated with our development of the Eco-Village Game™, funded by the U.S. Department of Energy. Imagine a meeting for a sustainably planned ecovillage with 40 to 50 families all trying to understand and use sustainable planning and technology. The room is divided into two groups of people: those who want to design their home immediately and those who want to learn about a certain topic, such as photovoltaics or composting toilets. Each person within the second group is asked to "represent" one life cycle or life cycle phase (e.g., photovoltaics, wastewater), get familiar with their topic, and wear a badge to signify what they represent. The ECO-VILLAGE GAME™ simulation pieces are placed on large tables representing two scales: the community scale (1" = 16') and the household scale (1" = 2'). Each scale possesses spatial footprints of each life cycle using the same icons as are on the badges.

Simulation activities include both inside and outside issues, from where furniture and rooms are placed inside to the amount of outside space needed for vegetable gardens and rainwater harvesting systems. The simulation helps a household make decisions on how to organize their structure, and to determine what sub-systems should be fulfilled at the household scale vs. the community scale (e.g. vegetable gardens might have a better fit at the village scale). The phenomenon of space miniaturization at the doll house scale proportionally decreased the time to simulate everyday activity (1" = 2' is equal to 1/24 and has been experimentally shown to simulate real time at about 1/12 real time - or it takes 1/12 the amount of time to simulate real activity). Since each life cycle possesses a real time (time in labor) that it takes to operate and maintain that life cycle, it is soon discovered that this family or that wants to pass on certain responsibilities to the community (e.g. they either don't have the time or the space to properly accomplish that life cycle task).

As one moves from the household to the village scale, the group now is faced with figuring out how to absorb those spatial requirements, such as vegetable gardens, that were rejected at the household scale (and recorded on the "pass-on-responsibility chart"). These 1 : 192 footprints have also been simulated by the Eco-Village Game™ in actual 2-D color coded and icon identified footprints. At this time a village team of life cyclers is appointed that simulates the "pass-on-responsibility life cycles", who are in charge of the remaining footprints at the village scale.

The magnifier effect is quickly apparent (again in both scale and time). The fish pond requires as much area to grow the food for the fish as is required for the pond (a total footprint of about two acres per 10 families). Land area requirements for growing straw for straw buildings are about three and one half acres per family, and land required for sustainably managed wood heat is 3-12 acres per family. Thus, it is apparent that all these village's needs are significant relative to the 186-acre parcel about to be purchased, and so begins further discussion about priorities relative to village self-sufficiency and extending the footprint to the next scale (region beyond village).

The Importance of Simulation in the Context of Global Sustainability

The simulation tools being created by the Infinit Grid™ as a means of transforming society towards a sustainable future from the psychology of space and time may have considerable merit. Simulation and the acting out of our life styles in such a manner that we can see the effects not only in numbers but in space and time is a key in our transition to a sustainable world. The Infinit Grid™ tries to accomplish this at many levels: home, village, nation. The ramifications of understanding people's ability to conceptualize space and time is more instrumental than we might imagine. In a seminal paper, Alton Delong summarized work done by Heinz Von Forester and J.B. Calhoun first published in 1971. Calhoun arrives at a formulation which specifies that, "...conceptual evolution and the increase of conceptual 'space' is directly related to population size, such that with each successive doubling of population there is a parallel doubling of conceptual space. Conceptual space is defined as ideas, values, roles, codes, etc. which permit people to process increased amounts of information and social contacts in a double sized group at a rate consistent with maximizing gratification in the original sized group. ..... with every doubling of the population a unique phenomenon occurs: there is a quantum jump in the character of space such that conceptual evolution takes place."

As this phenomenon develops over time, "...totally different conceptual structures possessing different values, different perspectives, and different ways of coping with life" develop over the evolution of history. Von Forester noted a peculiar temporal structuring in which conceptual space jumps occur at every successive doubling of population requiring half the time as the previous doubling and the previous leap in conceptual space. According to his diagram, each conceptual revolution occurs sooner and with the subsequent population doubling throughout human history. An interesting correlation is that the point at which a so-called compassionate world is likely to occur is at a world population of approximately 20 billion. According to most projections by ecologists, the global holding capacity relative to the ability of the environment to cope with humans without total collapse is at about 10 billion.

Conclusion

Simulation activities, such as described, help to identify the impacts, or footprint, of our lifestyles and constructed environments on several scales, from the home and village, to the region and nation. These techniques, such as the Infinit Grid™, will be important tools in determining appropriate pathways towards a sustainable world.

A bibliography for this paper is available from the Center for Maximum Potential Building Systems.

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