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White Paper — 21st Century Technology Series

6-Dimensional Business Information Modeling

Workflow Efficiency Drives Business Efficiency

In every industry, people are striving to deliver more with higher quality at lower cost. To do so, many industries have turned traditional ways of doing things upside down — they have engaged in huge paradigm shifts to reinvent their business processes. The driver for successful reinventions can always be traced to better alignment with **workflow**.

We define workflow as the total flow of functional operations, conducted by people or computers or machines, that allow an organization to execute its mission, the systems and processes that provide the optimal path to success. The more efficiently any organization executes its workflow, the more successful it will be. New technologies may allow workflows to be redesigned for greater efficiency. Business Information Modeling (BIM) programs are software programs that support workflow optimization.

An Example from the Construction Industry

In the 20th century construction industry, the workflow of building users was the last parameter taken into consideration during the design-build process, if, indeed, it was considered at all. Buildings were designed and built with little or no reference to the workflow that the building will house. Such a building will almost inevitably be unsuccessful, where a successful building is defined as one that facilitates the workflow of its inhabitants. (We are making an important distinction here between the success of the building and the success of the process of building it.) Until recently, buyers have accepted successfully completed unsuccessful buildings because that is the way it has always been — but it doesn't have to be that way!

Workflow-aligned building design can improve productivity 19%

A few pioneers are breaking the old paradigms, and the results of their work serve to emphasize its importance. Take the work of Gensler[1], a global architecture, design, planning and consulting firm working with clients to support their strategies and improve business performance through design excellence. Gensler's whitepaper, *These Four Walls: The Real British Office*, explores the effect of workplace design on productivity, job satisfaction, recruitment, and retention. In one cited case study, a client states that since moving into new offices designed by Gensler, staff retention has improved 150%. Since the cost of turnover is variously estimated as 30% to 150% of yearly salary, such a reduction adds significantly to that company's bottom line. Gensler, in fact, practices what we call workflow-driven design for office spaces. Their whitepaper, which examines such designs in the UK, cites a British Council for Offices[2] (BCO) estimate that building construction, building operation and staff salaries are in the ratio of 1:1.5:15. Building on that, another BCO paper[3] estimates that a 2% to 5% increase in staff performance can cover the total cost of providing their accommodation. In fact, the Gensler whitepaper estimates that, accumulating the impact of workflow-aligned design on job satisfaction, recruitment and retention, the potential productivity increase traceable to workflow-aligned building design is on the order of 19%.

The principle of designing to workflow extends to all manner and nature of building, as well as to the surroundings of the building. The trend toward requiring developers to design Master Plan Communities (albeit fairly primitive and with little feedback from the users when finished) rather than racks of housing acknowledges that a community has a workflow, a sequence of interrelated activities that take place

[1] http://www.gensler.com
[2] http://www.bco.org.uk/
[3] *The Impact of Office Design on Business Performance*, British Council For Offices, May 2005

within it, and that designing to that workflow improves quality of life in that community, which in turn gives greater value to the community and consequently to the developers' profit line.

In the 21st century, leaders in educational reform are arguing that school design can impact educational outcome as much as curriculum design. Innovative healthcare leaders are pointing to the impact that facility design can have on outcomes in their industry. Just as new advances in multi dimensional CT imaging are revolutionizing medical treatment for human beings by allowing doctors to view the workings of the human body in different ways, so will 6-dimensional imaging revolutionize the design of the facilities where that treatment is delivered by imaging the workings of the human workflow systems in the interior of the facilities. This realization that the ability to execute soars when form follows function is repeated again and again in multiple sectors of our society. The eventual waste caused by ignoring this principle is incalculable, as is the impact on the non-profit sector, which is frequently called on to mitigate the social results of dysfunctional design.

So why are buildings not designed from the workflow out — a design/build process driven by 6-dimensional modeling? Real 3-, 4-, 5- and 6-dimensional models are readily achievable today at modest cost using existing technologies and building on legacy applications where it makes sense to do so. Real 3- and 4-dimensional models have been used for decades in a few industries, such as the design and manufacture of airplanes and petrochemical plants. In the 21st century, these industries have moved firmly into 6-dimensional technologies.

In the construction industry, however, 2-dimensional representation remains the norm. The most advanced architectural firms are adopting 3-dimensional modeling as a design tool. In the trades, mechanical contractors led the move to 3-dimensional modeling as a working tool, and a few construction contractors have embraced 4-dimensional modeling as a working tool. Some outlier firms, led by mechanical engineering firms, are beginning to understand and apply 5-dimensional modeling. But true 6-dimensional modeling requires a paradigm shift in the approach to construction, and there, we suspect, is the sticking point. As other industries are achieving success by partnering with their clients, the building industry must learn to build for their clients' workflows.

N-Dimensional Modeling

To clarify what we mean by 6-dimensional modeling, we have prepared the following table to compare 1-, 2-, 3-, 4-, 5-and 6-dimensional models. Some companies are touting their 4-dimensional modeling capabilities today under diverse labels such as Building Information Modeling (also confusingly labeled BIM), but if you examine what they are really offering, the offerings fall under the definition of pseudo-4-dimensional modeling that we give in the table section **The 20th Century Way**.

How do we distinguish between "real" and "pseudo" 3- and 4-dimensional modeling? Let's begin by reviewing some definitions:

- Model: a schematic or mathematical representation of a real system that accounts for its known properties and is used to simulate a process, predict an outcome or analyze a problem
- Dimension: measurable size or magnitude; Cartesian coordinate; aspect, feature, characteristic
- Parametric design: a design process driven by the application of parameters and constraints that represents objects through vector geometry

We begin with the assertion that true multi-dimensional modeling must be parametric. It represents the object of the model by generating a vector representation based on defined parameters (the dimensions defined as the aspects, features and characteristics of the object). Such a model can be manipulated directly by acting on the model itself as it is displayed on screen or it can be manipulated by changing one or more parameters. Moreover, the model is dynamic, since it is possible to define parameters such as the laws of gravity or hydrology or the characteristic movement patterns of crowds as dimensions of the model. It also incorporates feedback loops that report back the calculated (pre-construction) or real (post-construction) impact of specific design decisions. This allows the viewer to see the downstream consequences of design decisions as dynamic simulations during the pre-construction phase and opens the door to real-time “what if” analysis before, during and after construction.

Bi-directional communication is also integral to 5- and 6-dimensional models. On the chart below, 5-dimensional modeling is defined simply as true 4-dimensional modeling with the ability to feed back information from the real world to the model. In building construction, for example, the parameters for design translate into building performance metrics. Now we have the ability to build truly “smart” buildings with Heating/Ventilation/Air Conditioning/Data (HVACD) systems with integrated SCADA[4] using ubiquitous sensors and power over Ethernet to operate both the building and the business equipment in it intelligently in support of the workflow.

Table 1 — N-Dimensional Modeling Types and Characteristics

Direction of Control	Tools to ...	Types of Models	Characteristics
Controlled by construction = lowest initial, highest lifetime cost	Design Bid Build	**The 20th Century Way:** • 1-dimensional model = planar representation or verbal description • 2-dimensional model = CAD plan • 3-dimensional model = Extruded CAD or isometric view tied to Cartesian coordinates along X-Y-Z axes, created and displayed by raster technology • 4-dimensional model = 3-dimensional model with a non-integrated Bill of Materials (BOM) or project management plan	• Fixed dimensions (size and coordinates) • Closed system • Static
Controlled by workflow = highest value, lowest lifetime cost	Design and Build	**The Turn of the Century Way:** • 3-dimensional model = Parametric model with unlimited Points-of-View (POVs) created and displayed by vector technology; the whole or any of its parts may be moved or resized on the fly and affected components will be altered according to the parameters and constraints defined by the user • 4-dimensional model = 3-dimensional model with integrated project management, containing parametrizable quality, scope, time and cost information (including BOM)	• Flexible dimensions (size, coordinates and parameters) • Open system • Dynamic • Relational (“complex”)
	Design, Build and Operate Building Operate Business	**The 21st Century Way — BIM:** • 5-dimensional model = 4-dimensional model capable of receiving readings and information from sensors and intelligent components of the structure and sending control instructions back • 6-dimensional model = 5-dimensional structural model with integrated parametric workflow model	• Flexible dimensions (size, coordinates and parameters) • Open system • Dynamic • Relational (“complex”) • Bi-directional

When construction is complete, the 6-dimensional model becomes the building’s operational control program, making continuous adjustments to the building’s operating infrastructure, perhaps even to the internal layout, to ensure that building operation is optimized for business success. The model, of course, must be connected with the business information systems so that it can track productivity and profitability against projections and make adjustments to the building accordingly. This, then, is a true 21st century

[4] SCADA stands for **S**upervisory **C**ontrol **A**nd **D**ata **A**cquisition, a computer system for collecting and analyzing real time data. Power plants, refineries, water systems and telecommunications are among the industries that have been routinely using SCADA systems to monitor and control their operations since the 1990s.

Business Information Modeling system, and it is an essential component of the executive's control panel, perhaps even the primary interface for today's executive to control the operation of the business.

Business Information Modeling

What is BIM? Some Definitions

A cursory search of the literature will reveal innumerable "definitions" of Business Information Modeling. Many are taken from the perspective of the information technology systems of the business. Many focus on interoperability or facilitating the exchange of information among project stakeholders. Some refer to business processes, or to Business Process Modeling, as a subset, natural successor or necessary precursor of Business Information Modeling. Some simply say that BIM stands for Building Information Modeling and ignore the business part of the building. Our contention is that Building Information Modeling is meaningless unless information about the business workflow is used to define the building: the Business Information Model must control the Building Information Model.

To preclude any ambiguity, for the purposes of this white paper, we will define a Business Information Model (BIM) as a dynamic, 6-dimensional virtual surrogate of a business and the environment within which it operates. Information about the workflow of the business is incorporated into the model and the model continues to collect and deliver information about how the business is operating throughout the life of the business. It is, in fact, a real-time on-line simulation of the business that operates in the virtual world in every respect as its counterpart operates in the real world.

Business Information Model (BIM) = dynamic, 6-dimensional virtual surrogate of a business and the environment within which it operates

We use the term "business" to describe any activity involving actions and transactions, commercial or non-commercial. One of our family members is an engineer for the National Park Service: she is involved in the "business" of designing and implementing ecostructure for preserving our national parks. So BIM is invaluable to any organization, whether for profit or not for profit. In his monograph *Good to Great and the Social Sectors,* Jim Collins points out "The critical distinction is not between business and social, but between great and good.[5]" Collins continues to challenge the perception that the social sector faces different realities than the business sector by driving home the point that the success of an organization depends on its ability to deliver superior performance over a long period of time. This is true whether the organization is an airline, a builder, a supermarket, a flood control authority, a school district or a YMCA.

Responding to Change

A key concept in Collins' book *Good to Great* is the acknowledgement of the fundamental dichotomy that drives a great business: "enduring great companies preserve their core values and purpose while their business strategies and operating practices endlessly adapt to a changing world.[6]" He refers again to this concept in the monograph for the social sectors, and shows how it remains valid for any type of organization. We quote Collins, but any number of experts and analysts have pointed out the same principles: the successful organization will respond nimbly and quickly to changing conditions but never veer from its vision (or mission or purpose or core competency or …).

What Collins calls the core values and purpose of the organization, in our lexicon are the prime parameters, the guiding principles that inform the model. These are constant, they do not change over time and they should always drive the workflow, the operation of the organization. Business strategies and operating practices (in our lexicon, the goals and the workflow) are subject to — in fact required to — change in response to changing conditions. How fast and how effectively an organization adapts its goals

[5] Collins, Jim. *Good to Great and the Social Sectors*. New York: HarperCollins Publishers, Inc., 2001, page 195
[6] Collins, Jim. *Good to Great*. Boulder: Jim Collins, 2005, page 2

and workflow to changing conditions, as well as how precisely those changes cleave to the original (and constant) guiding principles, determines how successful it will be.

BIM Guides Pro-Active Change for Superior Results

A BIM is a model that accurately represents the physical and strategic reality of an organization. The representation is driven by parameters, variables or constants that define the dimensions of the organization. For example, if we build a BIM for a flood control authority, it begins with the topography and the hydrology of the region (constants) and it allows immediate visualization of the impact on a watershed of paving or building over specific areas (variables). It allows the authority to specify the rate of flow permitted through each channel or river (parameters). Flood control structures — dams, detention ponds, drainage channels, etc. — are shown as built and are also available in a library to rapidly demonstrate what if scenarios. Those that are built already collect information, along with remote weather monitoring stations that are tied into the BIM, about the real fall and flow of water and compare that information to the hydrology assumptions that drove the original model. The feedback informs the model: if the assumptions are validated over time, the design of the next structure is based on the same calculations; if they are invalidated, the model suggests revised hydrology calculations for that terrain based on the collected experience.

A BIM is a single, interconnected system that correlates intangible values, tangible real constants, operational reality and real and projected costs. It allows different stakeholders to access different viewpoints into the business, from a mile-high bird's eye view to the drill-down view that provides actionable details, and to access these viewpoints through a simple web-based interface that does not require individual desktop licenses. All of the supporting documentation, all of the cost data, all of the detailed design documents are accessible through the same web-based interface. If necessary, security protocols limit access to sensitive information through password login or other security protocols.

In the example cited above, for instance, the Executive Director of the flood control authority should be able to — in a single session and without leaving his keyboard — bring up an overview satellite or aerial photographic image of his entire area of authority, drill down to a close-up of a specific culvert (perhaps even a web-cam view) access the details of how and when that culvert was constructed (including the specifications and drawings, materials characteristics, manufacturer or construction company that provided it and what it cost) and read both the current and the historical flow of water through that culvert in cubic feet per second. Moreover, the flood control authority's BIM should be able to speak to the county's BIM to determine who owns the land on either side of that culvert and whether maintenance of that particular culvert is the responsibility of the state or the authority, and in fact what maintenance was last performed and by whom.

If this seems unrealistic, it may be because our expectations have been largely shaped by the sales propaganda of companies that are selling 20th century mass-produced technology, whether it fits or not. As each organization is different, each BIM will be different. There is no one-size-fits-all shrink-wrapped box that delivers a BIM for everyone, but the 21st century is about mass customization, not mass production. A BIM that is based on commercial products integrated with flexible open-source software bridges can include and leverage existing data sources and processes to provide all the features we have named at reasonable cost and speed.

Assuming that it can be done, why would one want to do it? The answer, again, will vary depending on the organization. If we return to the example from the building industry, a potential productivity increase of from 2% to 19% would seem to make a compelling case for a private company to invest in a BIM for its production facility. For the flood control authority, the ability to leverage the always limited resources of a public agency to provide better protection to its ratepayers is a compelling motive. For a school district, the potential that better learning environments will lead to better student outcomes is a powerful incentive. The bottom line is that a well-built and well-used BIM can help any organization increase its real value by improving its ability to deliver superior performance over a long period of time.