Walden 3-D, Inc.

Continuing to make a positive difference!

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1. **comments on relevant news items;**
2. **observations on scientific and technology developments;**
3. **in-depth description of the pros and cons of relevant new products; or**
4. **a summary of a technical advance.**

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W3D Journal Edition 01: The Walden 3-D Design Process

Executive Summary

The Walden 3-D Design Process is a semi-automated way to turn data into decisions. The process is conceptual, as is this description of it. Practical implementations will be discussed in future editions.

Data are instances of specific meanings occurring in the real world. Raw data might be alphanumeric tables. A specific instance and it's meaning might be zip codes or the values of a seismic trace or well log. Information is data in context, related to a specific purpose. For example, base maps show the location of platforms and seismic surveys.

Knowledge is the progressive gathering of bits of experience, along with the links which associate these disparate parts into a unified whole. Knowing where to drill or where to build comes with experience. Wisdom is knowledge of what is true or right, coupled with good judgement, and is embodied in those who remember the recipe and can tell the stories. We all hope for some wisdom when we make choices, i.e. that we will not later have regrets.

Decisions are a selection among choices, hopefully based on data and its derivatives. Typically in business and technology choices are based around whether to proceed or not.

The Walden 3-D Design Process starts with an opportunity and ends with the operation and maintenance of a project. It requires limiting the project scope, based on the availability of resources, and seeks to use the best experience and technology available to meet the opportunity. This process is data dependent, and the more data the better probability the results will be meaningful. It starts with searching for patterns in this data, and using the derived patterns for classifying (hopefully semi-automatically) the data itself and the work processes surrounding the data. Classification is a key basis of all science and the best of business. These classifications form a basis for a hierarchical organization of data and processes, from which can be derived many of the parameters necessary to visualize the data and processes in correct spatial, temporal, and activity context. In fact, projects and work flows can be simulated and optimized, creating a tremendous financial economy-of-scale on the cost of the raw data. Immersive Reality (W3D Journal 04) presentation of projects and processes defined in information space allows natural and high bandwidth communication to designers, scientists, and management. When the data and processes are accurately defined in N-Dimensional information space (x, y, z, time, and attributes 1-to-N), traditional presentations, like construction drawings and drilling plans can be automatically derived. Eventually the design process will result in the automatic generation of a kit-of-parts. We anticipate robotic assembly of this kit-of-parts. Probably more important, project documentation will also become more automated, including documenting the continuous improvement of Best Practices (W3D Journal in 2001).

The Walden 3-D Design Process improves decisions and provides better utilization of available data, visualization, simulation, optimization, and documentation to optimally operate and maintain a project. The process has two main categories: data collection; and implementation. These categories will be outlined and described, and then followed by conceptual descriptions of using the process in construction and reservoir characterization.

Outline Summary of the Data Collection portion of the Walden 3-D Design Process

1. Identify Opportunity [function of time, dollars, location, and attributes]
2. Specify Project Scope [function of schedule, budget, scale, and disciplines]
3. Poll Network-of-Minds [function of experience, expertise, and trust]
4. Collect and capture relevant data [function of Step 2 and Step 3]
5. Find patterns in data [function of Step 4]
6. Classify Data [iterative function of Step 5 and Step 7] (IDEF-1X)
7. Define Processes [iterative function of Step 5 and Step 6] (IDEF-0)
8. Derive Visualization Parameters [function of Step 6 and Step 7]

Description

Data, and a lot of it, is the key to the Walden 3-D Design Process working. Computers and pattern finding enable reversal of traditional data analysis. Historically we look at the data and derive a conclusion, then we evaluate these conclusions to derive summary conclusions. The Walden 3-D Design Process is built around the concept of automatically deriving the final summary conclusions from the data using advanced pattern finding techniques (W3D Journal in 2001) and then iteratively confirming or refining these summary conclusions using data mining techniques (W3D Journal 11).

IDEF-0 and IDEF-1X are the first two of fourteen sets of public domain definitions for information exchange. IDEF (ICAM [Integrated Computer Aided Manufacturing or more generally Information] Definition Exchange Format) is a formal language which is easy to learn and use. It can be presented as lines and boxes for those who think like geologists, or as hierarchies for those who think like engineers. This language was originally developed for the U.S. Air Force to allow enterprise wide exchange of the design of airplane parts as the ICAM-DEF. IDEF-0 defines activities or process and IDEF-1X defines the data structures for things like computer data bases. Future issues of the W3D Journal will provide more detailed descriptions of IDEF technologies, and specifically will describe the Knowledge Backbone℠ (W3D Journal 09), The key points to understand in relation to the Walden 3-D Design Process are the facts this formal language is easily learned by anyone in an organization, is hierarchical, has feedback loops allowing iterative process definition, automatically creates the object-oriented relationships necessary for scene graphs in a visualization environment (W3D Journal in 2001), and is extensible.

In order to display data in an immersive reality environment (W3D Journal 04), the data needs to be displayed as points, lines (including vectors), surfaces (including texture mapping of images on topography), volumes (including time-lapse changes within data

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volumes), or animation sequences. For the most part the parameters necessary to display data in one of these forms is inherently part of the data itself. Automatic derivation of these visualization parameters is one of the next significant steps in the evolution of visualization technologies. This step can be as straight forward as translating lines from either a blueprint or a CAD system or a geotechnical interpretation system into lines in 3-D space. This step can be as complicated as deriving form by wrapping shapes around complex data clouds, automatically developing hierarchies, or volumetric data types, which define manufacturing assembly order or the geohistorical aggradation of stratigraphy. The visualization difference in these type of data derived parameters is one of scale.

Outline Summary of the Implementation portion of the Walden 3-D Design Process
09. Simulate Project [function of Step 8] (IDEF-2)
10. Optimize Simulation and Work Flow [iterative function of Step 9] (IDEF-3)
11. Present Project [iterative function of Step 9 and Step 10]
12. Derive Construction Drawings, Drill Plans, etc. [function of Step 11]
13. Automatic Generation of a Kit-of-Parts [function of Step 11 and Step 12]
14. Robotic Assembly of a Kit-of-Parts [function of Step 13]
15. Document Project and Best Practices [function of Steps 1-14]
16. Operate and Maintain Project [function of Step 15]

Description

In many cases, it is becoming cheaper to simulate a project with electrons in information space than it is to build it in physical space with atoms and molecules. This statement implies it is also cheaper to make mistakes in immersive reality than it is to make the same mistakes in the field. One of the significant benefits of computer simulation is the promise that needed changes can be identified and tested in real time with some reasonable incremental cost. Defining controls, processes, resources, skills, and other project variables in the planning stage allows optimization. This will be particularly useful when the optimization is derived from a simulation engine, which allows testing of various work flow options. We probably need two or three more orders of magnitude in compute and graphics power, in addition to algorithm development, to see widespread application. Given there is an order of magnitude more compute power available every five years, this capability will be in widespread use within 10 to 15 years.

The Walden 3-D Design Process starts with an opportunity and ends with the operation and on-going maintenance of a project. It requires limiting the project scope, based on the availability of resources, and seeks to use the best experience and technology available to meet the identified opportunity. As discussed above, this process is data dependent, and the more data the better probability the results will be meaningful. Finding patterns in this data, and using the derived patterns for semi-automatic classifying the data, defines work processes surrounding the data, as well as data structures. Classification is the basis of all science and the best of business. Data classifications form a basis for a hierarchical organization of data and processes, from which can be derived many of the parameters necessary to visualize the data and

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processes in correct spatial, temporal, and activity context. Projects and work flows can be simulated and optimized, creating a tremendous financial economy-of-scale upside on cost of the raw data. Simulation and optimization are probably the biggest needs, or the weakest links, depending on your point of view. Immersive Reality (W3D Journal 04) presentation of projects and processes defined in information space allows both natural and high bandwidth collaborative communication between designers, scientists, and management.

When the data and processes are accurately defined in N-Dimensional information space (x, y, z, time, and attributes 1-to-N), traditional presentations, like accurate construction drawings and drilling plans can be automatically derived from the computer. Eventually the design process will result in the automatic generation of a kit-of-parts. There are several different object oriented kit-of-parts design-build efforts coming to market. Construction drawings are already becoming obsolete. We anticipate robotic assembly of this kit-of-parts. Probably more important, project documentation will also become more automated, including documenting the continuous improvement of Best Practices (W3D Journal in 2001). The Walden 3-D Design Process improves decisions and provides data, visualization, simulation, optimization, and documentation to enable optimal operations and maintenance of a project. This introductory presentation is simplistic, because of a lack of field trials, limited understanding of the AEC (Architecture, Engineering, Construction) industry, and attempting to generalize a process which can be used across many disciplines.

Construction Application Scenario

Imagine the following not too future scenario (although it was 20-30 years out when the W3D NetWork-of-Minds first discussed it in the late 1980's):

A young couple gets a transfer from Dallas to Houston. They fly down on a house hunting trip to visit a new Real Estate Company.

Prior to visiting Houston they have logged onto the web and filled out an extensive form defining their current and planned family, including personal preferences on things like facade, color, family gathering places, etc. Using census and other public data bases, the Real Estate Company has performed a pattern analysis on their data, and compared the results to similar patterns previously identified. For instance, they know this couple is tall, 6'2" and 5'11" and their two sons will probably both be over 6' 4". Therefore, the Real Estate Company has focused on house plans which have tall rooms and large atriums.

There are fifteen houses in the Real Estate Company's database, which are in the price range and location of interest to the couple. Of these houses, three of them have been built digitally and are available for review in an on-site immersive reality theater. When the couple arrives the first step is to take a virtual or computer simulated walk through the three digital houses. The real estate agent notes things each person likes and things they

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do not like, including a simulated drive through traffic, the distance to the grocery store and school, and proximity to their church. With this new data, eight of the identified potential houses no longer fit the criteria. Together they are able to quickly learn the best route to visit these houses moving through the virtual city.

At each of the three houses the real estate agent notes previously unrecognized preferences. These visualization parameters are electronically transferred back to the Real Estate Company offices, and converted to visualization parameters by the office Modeling Engineer. When the couple gets back to the office they are invited to go back into the immersive reality theater to evaluate a new project being built.

They are told they would be one of the first families to move into the housing complex. However, the entire project is so well represented, it does not take any imagination for the couple to visualize living there. Their proposed house has all of the desired characteristics of view, size, ceiling and door height, expandability, and proximity to institutions important to their family. The wife quickly realizes she does not really like a periwinkle blue room off of a lime hallway, as had been derived from her preferences. With a few tweaks by the Modeling Engineer, they are ecstatic about "their new house," and it doesn't take much work with the agent to finalize a contract. As they leave to return to the airport, the agent tells them their new house will be ready for them to move into in two weeks.

Because the visualization they have reviewed is accurate, the equivalent of construction drawings are already in the computer. On signing the contract they are electronically transferred to a manufacturing facility in Detroit (formerly an automobile factory). The plans are directed to fabrication units, and through composite extrusion, plastic and metal component growth, and traditional fabrication, a pre-wired, pre-plumbed, and pre-colored kit-of-parts is assembled by robotic and human power within a couple of days. The components are labeled, loaded on a truck, and shipped to Houston within a week.

During this same week, the utilities are piped, and the foundation is poured. Once the truck arrives from Detroit it takes less than a week to assemble, inspect, and finalize the construction. Embedded sensors allow workmen to measure and monitor and insure the project is within acceptable tolerances. Inspectors are able to use the same sensors to insure the latest building code requirements are being met. Upon completion of the construction, landscaping engineers are brought in, and, just like has been prototyped at DisneyWorld for decades, there is a completed natural environment overnight.

The sensors notify homeowners when minimal maintenance is required. When the family changes, with a new child or a child leaving for college, it is easy to redesign and try out virtually a reconfiguration of walls, bookcases, and cabinets. In fact, texture mapping digital photos of how the house looks at any particular time, creates completely accurate virtual representations.

From their first rushed visit to a completed house took less than three weeks and cost significantly less than traditional ways of building a house. It is hard to imagine a happier customer. To make this work there needs to be Landscaping farms, like at DisneyWorld, and the ability to bring in or switch out mature trees and plants overnight. The idea of prefabricated housing implies mobile homes which will be an impediment to selling on the high end. However, these concerns will become muted as simulations demonstrate the ease of reconfiguring rooms and walls to accommodate changes as families age, and as people see how others create personalized statements with their homes made using the 3-D design process.

Geotechnical Application Scenario

Imagine a large oil field with 1,000 wells and 5 pay zones. The traditional way to do a reservoir characterization study is to build cross sections through each well where there are logs, and to repick tops and correlate lithologic units. This becomes a full-time job for several geoscientists. As they do this work they build a spatial model of the field in their heads, which allows them to integrate new data faster, and enables their decision making. This is a manpower intensive way to build interpretations on previous data and then to derive summary conclusions. The existing process has a problem because most of the information and knowledge only exists in the geoscientists' heads, and is therefore not available when they are sick, on vacation, and it is not easily transferred to others.

Interactive interpretation systems have revolutionized reservoir characterization. The time to accomplish the process has been decreased by orders of magnitude and the quality of the interpretation results has greatly improved. Workstations do all of the data handling, and allow the interpreters to get data into them quicker, enabling better and quicker interpretations. For the most part, this has remained a mapping process (W3D Journal 02). New developments in automated picking, 3-D visualization, and immersive environments are greatly improving on workstation interpretations (W3D Journal 04) because the summary conclusions are arrived at quicker. For instance, three-dimensional relationships between tops in different wells can be immediately evaluated by walking around in data displayed in an immersive environment.

Using the Walden 3-D Design Process moves more of this same process into information space, allowing an even more automatic derivation of summary conclusions. Having these summary conclusions right up front, and then mining the data to confirm the conclusions, can improve, yet again, this interpretation process in both time and quality. The key is to gather all of the data possible from each of the producing wells. This includes well logs, tops, mud weights, production histories, petrophysical data, bottom hole temperatures, fault cuts, lithology descriptions, etc. Each type of data is spatially and temporally isolated. Applying advanced pattern finding algorithms (W3D Journal in 2001) allows the data to be evaluated across information space. Anomalies in various types of data are correlated with reservoir sands, seals, known migration paths, and production histories to derive summary conclusions. For instance, production from sand 3 dropped off slightly when production from sand 2 was enhanced, and this change was most notable around a certain set of wells implying there was a fluid breakthough from sand 3 to sand 2. Drawing this summary conclusion, deriving visualization parameters from the anomalous raw data, and then simulating how, where, and when the possible fluid breakthrough occurred in an immersive environment allows for detailed peeling of the data onion to confirm or disprove the information based hypothesis.

Geocellular models for reservoir simulation can be optimized in terms of rock properties and fluids using these types of information space derived clusters. Wrapping envelopes around these clusters will allow the derivation of a spatial and temporal hierarchy of relationships, ranging from sequence stratigraphy relationships to fluid movement. The results of the evaluation are presentable at any stage of the process, allowing decision makers to stay in touch with the data and the data derived consequences. Well plans and facilities become part of a holistic approach to the evaluation. As the locations of additional infill wells are derived, the operation and maintenance of the field becomes a direct analogy to the operation and maintenance of a house, or a building, or a city. As the next year passes it is the intention to build case history analogs to demonstrate these concepts as the basis of a Best Practice library.

Acknowledgements and Next Steps

The Walden 3-D Design Process was derived from a series of meetings in about 1989, which culminated with a planning meeting hosted by Raymond Gardner of The Gardner Partnership Architects in Cedar City, Utah. The Walden 3-D Design Process is a semi-automated way to turn data into decisions. The process is conceptual, as is this description of it. Practical implementations will be discussed in future editions of the Walden 3-D Journal. Many of the ideas come from the work of Bill Bavinger, who was a professor at Rice University at that time, and has since come to an untimely death in a car accident on an icy road in Oklahoma. We have described these concepts to several groups over the last decade. Hopefully by writing them down and sharing them through the W3D Journal, we will identify industries or companies which are interested and able to fund specific projects using this process. There is detailed testing required on several components in order to turn these concepts into the Urban Machine Bill Bavinger wrote about (W3D Journal in 2001), or the automatic lithology and fluid predictor the W3D Journal Editor has envisioned. Detailed descriptions of these components are scheduled, and if there is sufficient funding through the newsletter or as separately funded projects, there will be test projects and reports on the success and failures of those projects.

PostScript

Thank you for reading the W3D Journal Edition 01.

The W3D Journal is priced at US$3,000. per 12 Editions per subscribing companies, payable in advance. Each subscriber has a contact person who is responsible for distributing passwords within their entity and for answering questions about access the W3D Journal. There is a 20% discount for companies who purchase 72 Editions up front; i.e. instead of US$15,000., the price is US$12,000. Payment can be made by credit card on-line at http://www.hgol.net, and the Subscription Agreement is available at http://www.walden3d.com/journal/subscription.html .

The editor has struggled with pricing, especially since everything is free on the web. However, the cost is less than many companies will spend on legal fees evaluating the innocuous Subscription Agreement, which is necessary to share the documentation of Intellectual Property. Furthermore, within the framework of the editors values of sufficiency, sustainability, and stewardship (see: http://www.walden3d.com/values), excess beyond what is sufficient for a modest western lifestyle (if 10 kids can be called modest) will be fed back into the system to enable sustainability as fulfillment of the self-imposed stewardship to continue to make a positive difference. "Fed back into the system" means funding research projects, paying experts to document their work in science and technology, doing pilot projects, cutting subscription prices, and in all cases making the results available through the Walden 3-D Journal.

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