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White Paper — 21st Century Technology Series

i6dVCM™: A New Approach to Strategic Planning for Cities

*"You cannot **manage** what you do not **measure**, and you cannot measure what you cannot **see**."*

Executive Summary

One of the major challenges in today's City government planning and design environment is the increasing demand from the client — or city consumer — for rapid response and transparency in government services. Escalating and widely divergent expectations strain the City's planning and development infrastructure. While administrators are painfully aware that every dollar spent must be a well-spent investment, the rigorous analysis, planning discipline and up-front investment required to ensure this are easily derailed. Even absent eternal pressures, decision-makers grapple with unwieldy information structures that make it difficult to grasp all the impacts of a particular decision on inter-related or marginally related systems.

i	The ***integrated*** portal draws together data from disparate sources
6 d	A ***6-dimensional*** view correlates a physically 3-dimensional display to additional informational dimensions. X, y, and z axes and time, money and workflow are the 6 that we use most commonly, but in truth any dimension can be added to the model.
V C M	A ***virtual model*** is a highly realistic digital representation of reality — in this case, a ***city*** represented to a specified level of detail — which is also capable of receiving, displaying and integrating input from human interface or from sensors that relay data from the real world
™	i6dVCM™is a proprietary implementation of a mixture of technologies from various sources, including open source or GNU-licensed software and existing customer-owned software, developed by IDEAS, LLC

Today's technology, however, provides a relatively inexpensive way to assist decision-makers to rapidly see the broad systemic impact of different scenarios and make wise choices. A fully integrated 6-dimensional virtual city model (i6dVCM™) not only makes user-friendly engineering and design — or the creation of effective workflow — easy, it also makes it fully transparent. i6dVCM™ allows transparency of operations all the way from the design of government services to their actual operation. Multi-dimensional modeling with simulation allows both decision-makers and the public to see virtual models of proposed structures, infrastructure improvements or zoning decisions, for example. This multi-purpose technology can be designed to support first the decision-making process and then the implementation phase. Since you can now see things that were previously hidden, you can both measure and manage them.

i6dVCM™ accurately represents the physical and strategic reality of the City and has the ability to simulate the future impact of planning and zoning decisions. Modeling and simulation, once the domain of high-end super-computing installations, have now become affordable, cost-effective tools for the design, analysis, optimization and operation of small urban systems such as Santa Fe's. Web-based access can be the primary portal, allowing government entities, urban planners, private developers and architects, emergency response teams and citizens to all see the same view of Santa Fe without buying expensive and proprietary end-user licenses. Still snapshots provide the basis for printed reports while video snapshots can be burned to CD or digital tape to be distributed to citizens and media.

i6dVCM™ provides both tangible and intangible benefits to any planning entity. It allows decision-makers to access a wide range of information — potentially the City's entire information systems — from a single interface, and to run "what if" scenarios from that same interface. It allows the City to clearly project the future value of improvements based on performance, facilitating a true return-on-investment calculation. It

We kill $10 elephants.

provides a single consistent view of the City for all stakeholders, facilitating internal and external communication, eliminating redundancies and reducing miscommunication. It provides a clear and logical way to measure the success of improvements and to build on past experience to institutionalize best practices.

21st Century Planning Tools

Simulation and modeling are being used all over the world today to help city and regional planners optimize the design and operation of urban systems. Kick-started by pioneers such as the Manhattan Project, which programmed the first attempts to model nuclear explosions in the 1940s, the art and science of building simulations has now reached into every profession and discipline. While Los Alamos continues to build increasingly complex and far-reaching simulations using the 85 teraflops of processing power it controls in one of the world's largest supercomputing facilities, Second Life provides anyone the ability to inhabit a simulation on their desktop computers.

Somewhere between Los Alamos' simulation of a nation-wide smallpox epidemic and Second Life's avatars, city and regional planners are building and using systems that can predict the performance of designs and plans. These systems provide public and private sector planners, architects and engineers an efficient tool for visualizing and evaluating different planning options to accelerate decision-making processes. Whether they are called virtual city models or urban simulations, these tools allow planners to view all aspects of a community, from complex topographic features to the smallest architectural details, from any perspective. Infrastructure design, traffic engineering and ecological impacts can be modeled prior to investment so that planners can display development concepts in a clear and well-structured way that integrates complex bodies of information to illustrate the whole in an understandable manner.

i6dVCM™

i6dVCM™ is IDEAS' vision of an integrated 6-dimensional virtual city model, an interactive and immersive real time visualization that offers planners the opportunity of visualizing, interacting with and manipulating complex data in a real-time 3-dimensional environment within the context of their particular real situation. IDEAS has previously released a White Paper on the topic of six-dimensional business information modeling which presents the theory behind 6-dimensional modeling; in this paper, we describe a particular application of integrated 6-dimensional modeling, i6dVCM™ for cities.

Figure 1: This is a snapshot of an interactive, terrain-based map of the City of Santa Fe with the City Council Districts overlaid. The realistic geography makes it much easier to orient oneself on the map.

A complete i6dVCM™ system begins with a virtual city model that accurately represents the physical and strategic reality of the City. This model can be made dynamic by adding the parameters, variables and constants, that define the physical and political dimensions of the City. The model then becomes 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 City, 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 and underlying data are accessible through the same web-based interface, with security protocols limiting access to sensitive information. Ultimately, it can be populated by agents that represent the citizenry as an aggregate to enable prediction of traffic patterns and other citizen responses to change.

Value vs. Cost

As a public agency, the City is charged with ensuring the health, safety and welfare of the community by providing the highest quality of service to achieve a better quality of life. While short-term costs act as constraints on the City's ability to execute, City management must strive to remain focused on the long-term investment value of its decisions. As it builds infrastructure, the City should be considering a minimum 50-year service life for every structure. This requires a considerably different planning protocol from that of a private corporation contemplating return on investment in consideration of a two-year tax depreciation write-off.

Fortunately, modern technology has provided a number of tools that can step in to support the planning effort in this situation. One of the greatest challenges facing an agency that wants to contract for long-term value is in defining and demonstrating that value. It is particularly difficult to illustrate the value of averted crises — that is, the cost of **not** doing something. The i6dVCM™ can simulate future structure and infrastructure usage and conditions under a variety of scenarios, allowing future costs and future cost savings to be concretely illustrated. This allows a true cost-to-value comparison and permits informed decision-making in an environment of transparency in government.

It is one thing to report to rate payers that actuarial calculations predict that traffic will exceed a certain road's capacity faster than it can be widened if it is built at two lanes now, and quite another to show the road jammed with traffic under scenario A and with traffic flowing smoothly under scenario B. It is one thing to post a JPG of a flat map on a web site showing the engineering drawing of that road with zoning notations in blocked out squares around it, quite another to show a flash movie that simulates a drive down that road with all of the forecasted development built up on either side.

Communications, Part 1

One of the enormous values of i6dVCM™ is, in fact, in the area of communications, both internal and external. Clear communication means that all stakeholders are looking at the same common definition of milestones, objectives and goals and can clearly see the impact of their actions on the achievement of those goals. i6dVCM™ facilitates clear communication in several important ways:

1. By enabling access to a single consistent view of the City or a specific area or aspect of the City, i6dVCM™ streamlines coordination among different departments, between the City and its contractors and among contractors. This has the advantage of facilitating collaboration, which tends to lead to cost savings, and it also goes a long way towards managing the risks of projects that involve multiple agents by ensuring that everyone is working off the same set of parameters and guidelines.
2. By enabling at least some level of access to all stakeholders, i6dVCM allows government to clearly communicate what it is doing and has done to ratepayers. When tax rolls are integrated into i6dVCM™, ratepayers can view the entire city from the perspective of their location in it and government can easily identify and communicate with ratepayers affected by any proposed activity.
3. In a fully integrated system, developers will be able to identify the prerequisites for integrating their development into the master plan for that area. Modules can be designed that allow a developer to interactively query the model for permissible density, infrastructure and drainage requirements, as well as for permitting and notification requirements, for multiple scenarios of ground coverage. This means that developers can have a clear understanding of how the rules would apply to their project before they submit their plans for approval. The city can eventually require that development plans be submitted in a form that can be immediately integrated into the model, so that affected ratepayers, elected officials and other decision-makers can clearly see the potential impact of any proposal, including any requested variances.

4. With a fully integrated i6dVCM™, customized access can be provided for insurers who can view development status in real-time. This would likely lead to significant cost savings in bonding and other insurance costs, savings that can be passed on to ratepayers through reduced costs for the City.

You Cannot Manage What You Do Not Measure

In the past two decades, the concept of performance measurement in government has been pushed out to every level of government. While the goal of making all agencies somehow accountable for their activities may be laudable and may have been enthusiastically embraced by the agencies themselves, many public agencies found that agreeing on the definition of feasible, understandable, empirical performance measures was a huge stumbling block to implementation. i6dVCM™ is not only a system, but also a process. Because any 6-dimensional model is by definition parametric — because, that is, it is driven by parameters that are explicitly or implicitly defined as the model is built — it forces organizations that employ one to define successful performance in measurable ways. Note that this does not mean that all success metrics must be quantitative rather than qualitative, merely that they can be measurably defined.

In a later part of this document we will discuss usability engineering and the process of defining the interfaces for i6dVCM™. A similar exercise can be conducted to define successful or desirable outcomes of urban planning. Some of these may be purely quantitative, such as fiscal calculations; some may be purely negative, such as an absence of flooding; and some may be qualitative, such as attractive parks and recreation areas. The point is that these not only become the parameters that drive the simulation, they also become the City's own performance measures.

In a fully integrated i6dVCM™, the performance measures defined at the design point can be followed throughout the life of any program, project or structure. This allows the City to establish a track record which can be followed by agencies to inform future decisions. Indeed, since a 6-dimensional model incorporates bi-directional communication, the model itself can read the performance of its components and adjust its projections accordingly. Over time, this significantly increases the accuracy of simulations and the reliability of planning projections.

What If

The ability to run accurate simulations of complex systems is no longer seen as an exotic product of supercomputing nerds. We will address some of the features of this computing discipline in the Technology section of this document, but the point we want to make here is that this is a readily available mature technology that can be deployed on affordable systems. Simulations can be designed based on broad aggregate parameters or on very narrow refined parameters assigned to a larger number of agents; the latter will require significantly greater computing resources, the former will provide a grosser simulation.

IDEAS can work with the City to establish an acceptable level of detail for the simulation and facilitate workshops to define the parameters that drive the simulation. With that input, the i6dVCM™ can provide very accurate simulation. This allows planning and zoning decisions to be tested *in silico* against the City's planning goals and objectives as well as against physical constraints such as topography and infrastructure limitations.

Since the fully integrated model is parameter-driven, the assumptions that drive each scenario are visible and explicit in the definition of the parameters. Scenarios can be defined by directly manipulating the model or by defining a table of parameters. In either case, the outcome can be visually modeled in three-dimensional virtual reality as well as reported in conventional tabular formats.

The Technology

From a technology perspective, there are several aspects to i6dVCM™, each of which could be described at length. The key point is that i6dVCM™ is not a shrink-wrapped package: a model must be engineered for each city, incorporating all the specific geographic, social, cultural, political and economic singularities of that city. In this section, we present a summary overview of some of the technologies that are incorporated into the model. While in some cases we may be able to describe generally the technologies that are used, specific technologies are not chosen for a particular model until completion of the second phase of development as described below. We can expand on any of the following segments on request.

Communications, Part 2

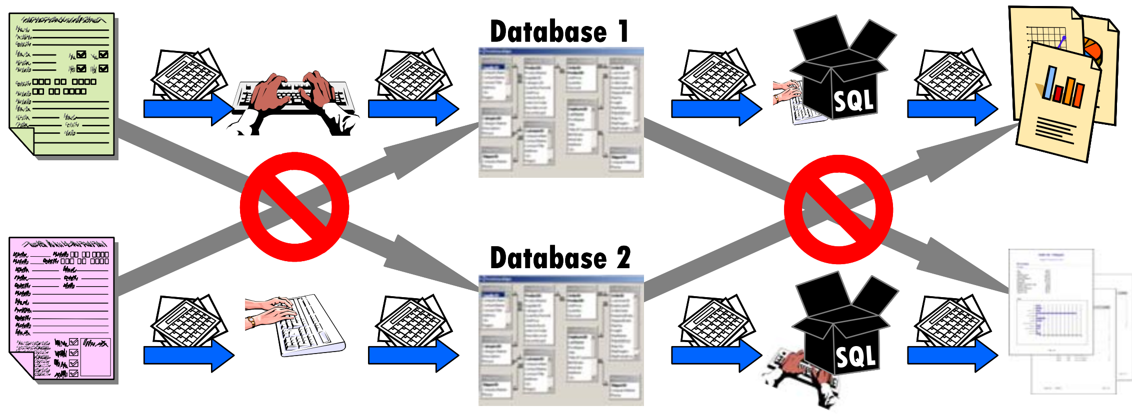
"Communications" speaks not only to the transfer of information among various human beings, but also to the transfer of information among systems and the transfer of information between humans and systems. Since the first caveman painted the first pictograph, humans have developed more and more complex systems to preserve and share information. As the amount of available data has continued to increase in the past several centuries, the systems for managing it and for summarizing huge amounts of data into a form of comprehensible information have become increasingly complex.

In the 20th century, the accepted manner of collecting and organizing actionable information became to accumulate records in databases and then combine the data into pre-formatted reports presented as printed volumes. Many of these databases were designed decades ago when only mainframe computers had the horsepower to correlate thousands and millions of records. Although the databases may have been migrated to other forms of servers, the underlying structure and processing logic remain the same.

The proprietary database: a system for organizing textual or numerical data

In the 20th century paradigm, textual or numerical data is collected on paper forms or in other media external to the database. The forms, or web pages, are designed by page layout or web designers who have no experience of collecting or using the data. The layout is designed to be esthetically appealing. How often have we had the experience of trying to handwrite our "full address" on a line two inches long and with ¼ inch of space above it, or trying to type it into a web form that truncates the street name halfway through? And in how many instances must data entry operators move their attention from top to bottom of a paper form several times during input of each record to find pieces of data that have been collected in a different sequence from that required for data entry?

Figure 2: How databases collect data and report information



The data is then input into the database, most often[1] by being transcribed by data entry operators. The database has a rigid structure of tables, fields and required formats that is unique unto itself. Often the nature of the data being collected and the information desired from it has changed radically since the original design was laid out by programmers, who in any case had no knowledge either of the data collection methods or the needs of the information consumers. Once it has been warehoused in the database, a cadre of programmers is required to write queries — most commonly in an arcane programming language called SQL (Structured Query Language[2]) — that convert data to information and to format the information into reports.

There are many reasons to seek alternatives to this method, and perhaps the most pressing are the amount of time required to complete the various steps and the number of opportunities for the introduction of error (indicated on the diagram by the arrows over calendars). Data is seldom entered in real time; more frequently, concern for the integrity of the database demands a timed posting sequence. Reports are as they were written; if management requires different calculations to be made — for example, if new performance measures are dictated to a government agency by the elected representatives of that jurisdiction — programming the revised reports can take months. If the field structure does not include the requisite datum, additional programming time will be required at the front end and the data will likely have to be manually entered[3].

Of greater concern is the fact that both of these activities are executed by programmers who are very far removed from both the sources of the data and the uses of the information — today, they may be continents removed. Moreover, the language itself is difficult and arcane; since there can normally be no direct view of the raw data by a third party, any report is, in effect, incapable of being audited for accuracy. (On our diagram, this is represented by the "black box" that sits on the programmer's keyboard. Ask a roomful of certified auditors how many are knowledgeable of SQL and you will be met by blank stares!) Finally, the queries are unique to the database for which they are written, as are the reports. Information in different databases, even if logically correlated, cannot be combined into a single report without additional manual intervention.

Geographic Information Systems (GIS): 2D systems for representing 3D data

Geographic information systems (GIS) have come a long way in the 35,000 years since the first caveman traced representations of animals and their trails on the wall of a cave. Proprietary GIS technologies such as ESRI's ArcGIS and Mapinfo's GIS software suite are complex, arcane systems for capturing, storing, analyzing and managing geographically-referenced data to provide information for a variety of purposes beyond basic cartography, including resource and asset management; urban, logistics and emergency planning; and marketing and demographic analysis.

GIS collect spatial and attribute information into separate repositories organized as relational database structures. The architectural logic for this approach can be traced to 1855, when Dr. John Snow's map of the Soho outbreak in the London cholera epidemic of 1854 graphically overlaid

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[1] Data can sometimes be ported directly into a database if collected by electronic means. This process is used, for example, to transfer banking and credit card transaction information from point-of-sale systems to bank databases. A great deal of time and money must be expended to construct and validate the reference table that is used to place the data into the appropriate fields in the appropriate format, and continuous validation is required, particularly if the porting mechanism changes the format of the data.

[2] SQL is a COBOL-like language first developed in the late 1970s and standardized in the mid-1980s. The complexity and size of the SQL standard means that most databases do not implement the entire standard, resulting in implementations that are inconsistent and, usually, incompatible between vendors. Critically, date and time syntax, string concatenation, nulls, and comparison case sensitivity often vary from vendor to vendor. The language is very complex but the standard does not specify database behavior in several important areas, often leading to unintended or inaccurate results.

[3] See footnote 1, with the additional requirement that all of the tables and relationships in the database must be reviewed to ensure that the new datum is correctly correlated in a compatible format to existing data.

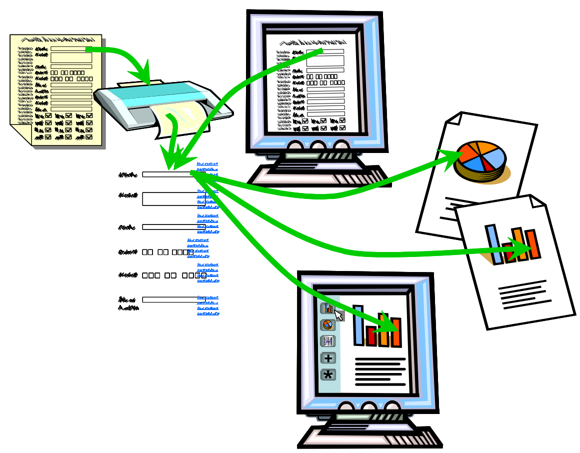
clusters of cholera cases on a city map, allowing him to pinpoint a contaminated water pump that may have been the source of the outbreak and have it disabled. The process of converting geospatial coordinates into a 2-dimensional cartographic representation and overlaying symbolic representations of statistical information on the resulting map has since been heavily automated but not substantively improved in the intervening century and a half.

These systems suffer from the same weaknesses as the databases described above that collect and organize only textual and numerical information: they are highly proprietary in form and function, requiring expensive licenses and skilled operators to acquire or enter the data and produce the reporting; report formats must be predetermined and painstakingly programmed; the reports are output as paper or static electronic documents (such as PDFs); updates must be initiated or performed manually, so that the information released for public access is often woefully outdated; and there is no way for a member of a different profession to validate or verify the data (they are not easily auditable by a disinterested third party). Furthermore, they represent 3-dimensional geospatial data as 2-dimensional reports, often making it extremely difficult for untrained readers to truly grasp what they are looking at.

Multi-Dimensional modeling: the 21st century paradigm for using and managing data

Fully implemented, a parametric system like i6dVCM™ uses simple web interface language to bypass all the drawbacks of proprietary 20th century databases. Data are identified by clear hypertext labels. Forms for data collection are built in simple web languages and if a paper form is required it is printed directly from the web form, so that it is identical in layout and design.

Figure 3: Data labeled with hypertext is easily stored and retrieved without complex tables or programming.



When data is collected via a web form, it is immediately available to be aggregated with previously collected data. Because data are identified by hypertext labels and not confined to structured tables, the same datum can be used in many relationships. It need be entered only once, and can be instantly compared to specific criteria for validation.

The same language generates information reports and formats them, so that the report displayed on screen as a scrolling XML page is exactly the same as that sent to print. Report generation can be interactive, so that new relationships can be displayed on the fly. For public access, simple kiosks can provide touch-screen access to standardized reports and data queries.

i6dVCM™ is integrated, meaning that it provides a unified and uniform portal to all of the underlying data and information that drives the model, and that any existing and future source of data can be incorporated into the model. The city's existing information resources can be incorporated into the model. Middleware or data mining techniques can be built into the model to mine existing databases, including GIS data repositories, where they are known to be accurate or capable of being made accurate. If the data is suspect, it may be more realistic to create new XML data repositories that are more accurate and auditable. When the system has been fully integrated, data entry redundancy will be eliminated. As soon as information is entered into the system, it will be available to inform the model and it will be visible to anyone who queries the model. Further, any digital data which is labeled with hypertext — such as data from external sources or instrument readings from rain gauges, digital temperature gauges, traffic counters, speed sensors, etc. — can be integrated into the model in real time.

Virtual City Models, City Planning and Simulation

i6dVCM™ virtually represents reality through the three-dimensional model which incorporates several sources of basic geographical and architectural data. This virtual reality is animated through a simulation generated through simulation technology. The complexity of the simulation is balanced to allow users to evaluate planning scenarios in real time and to compare alternative concepts. Urban simulations can incorporate parameters that are particularly relevant to the local ecosystem (for example, watersheds and flood plains), local culture (for example, the evolution of the city's boundaries and skyline across the centuries), local visions (for example, sustainability profiles of city projects/location of LEED-certified buildings/waste stream analysis) or any other set of parameters that the city deems important, whether they are physical characteristics, human activities or natural events.

Some planners trace the foundations for computer simulation of urban environments to Jay Forrester's 1969 book, *Urban Dynamics*. Whatever the original stimulus may have been, a great deal of research and development has gone into the creation of today's VCMs. A primary motivator is the perception that nobody understands the traditional 2-dimensional map representations of city plans except (perhaps) the planners. Because these are 2-dimensional representations of a 3-dimensional problem, they are perceived as being too abstract to convey any real information.

The goals for existing and in-development VCMs range from creating a good working visual representation of the function, size and locations of the features of an urban landscape to building a polished final rendering that incorporates actual video of the represented landscape. In any case, the model must begin by incorporating all of the potential landscape components, such as terrain, buildings, roads, vegetation, water, lighting and atmospheric conditions. The minimum amount of simulation that seems to be acceptable in a VCM to be used for urban planning is the ability to generate buildings procedurally based on footprints defined by zoning codes. A very complicated simulation might include individual avatars of all the inhabitants of the City going about their daily business. Key to the credibility of such models is the ability to validate the assumptions that motivate the agents. While highly complex models use algorithmic semantics to examine the validity of the computations, we prefer to target an intermediate level of complexity that relies on easily visible assumptions drawn from the current lexicon of the potential users.

Non-linear Data Access

One of the characteristics of the information age is a completely new way of accessing information. While in the past we relied on indices that arranged their entries according to a linear taxonomy, today we skip from one reference to another on the web through hyperlinks. The webmaster may have a taxonomy that guides how pages are stored in directories, but the end user need never know its structure. The web researcher flits from one subject to another following her own mental associations, and each person may follow a completely different sequence of links to arrive at the same page.

The origin of non-linear data access may lie with the web, but impatience with taxonomy has migrated to all media. The popularity of 211, 311, 411 and 511 services is another reflection of the new approach to information: while the 211 operator may rely on a rigorously organized data base to find the answers, the caller simply calls one number to ask questions about the social services he needs, which may be provided by a dozen different public or private agencies.

We are going to describe here a possible portal configuration to provide citizen access to information about the City in a non-linear fashion. For simplicity, we'll illustrate the portal as a web application, but of course it could equally reside on kiosks in public libraries and the lobbies of government buildings, where clicks become touch screen taps. And the information displayed on each screen can be printed as a legibly formatted brochure by clicking one button which will take the information and lay it out for print.

"Neighborhood Portal" might begin with a view of the entire City, as shown in Figure 4. There are radio buttons on the left that might have fly-over descriptions. The user can enter an address, or not. If there is no address, the information displayed will be city-wide.

Figure 5 shows the result of a query for "My City Council District" entered with no address: the map displays all City Council Districts. The map is interactive: the user can navigate in to find a certain area. Mouseovers can be defined to show more information.

Figure 4: Example of a "Neighborhood Portal"

Figure 5: Click on a radio button to add information to the topographic map.

At the bottom of the panel, the user can choose what features are displayed on the map, and whether to display in topographic or map format. Clearly, there may be more choices than those shown here, and the radio button choices may also be expanded or changed.

In Figure 6, an address was entered, and the map zoomed to show that address in the chosen context. Note that the overlays of other districts are suppressed.

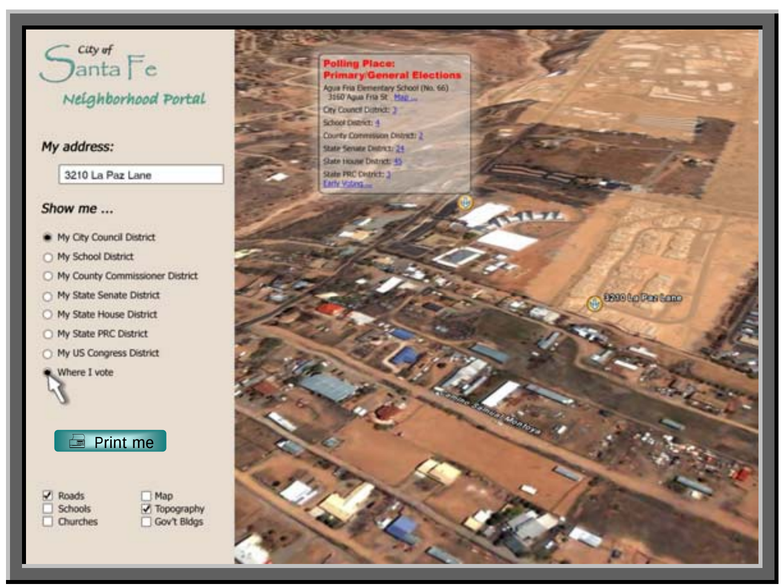
In Figure 7, a mouseover generates a floating information box that provides links to other information about the specific area being queried. Clicking through on the links will either populate the map with more markers — e.g., schools, fire stations and police stations within the viewed area — or raise a new window with an information page, which may be on a completely different site. The information box should also contain links that make the site bi-directional — links to surveys or e-mail forms to collect citizen input or queries.

Figure 6: Zoom in to a single district

Figure 7: Mouseover for information display

Figure 8: An "intelligent" information box displays when a particular data set is queried.

Click on "Show me where I vote" and the view will zoom again so that the citizen can see the entered address and its geographic relationship to the polling place. This time, the floating information box comes up automatically, and it includes information that is relevant to the question, as well as links to sources for more information — "drill down" links. The first link is to a map and directions to the polling place from the entered address.



Adaptability

i6dVCM™ is not a "finished" standalone product, nor is it intended as such. As greater computational power becomes economically accessible, the City will want to add levels of detail that may not have been feasible when the model was created. As the model proves itself, the City will want to incorporate more aspects of City management into the model. As users become more comfortable with the model, they will ask for more features.

A late-stage, fully integrated model incorporates bi-directional information flows. Based on this feedback, it will demand continuous adjustment of the algorithms that define the consequences of specific actions to improve accuracy. To a great extent, the model will learn these adjustments itself, since the simulation, though not necessarily highly complex, will likely be agent-based and adaptive. Adaptive systems, also called self-learning systems, use techniques such as neural networks and fuzzy logic to compare predicted outcomes to real outcomes and adjust the algorithms that led to the prediction accordingly. This technology is mature and well-established: one of its most widespread applications is in smart SPAM filters.

Scalability

i6dVCM™ is designed to support modular deployment. The City defines its priorities, and those components are the first to be completed and deployed. However, such a model has no theoretical limit to the amount or type of information that is included and correlated to previously deployed components. Practical limits will be imposed by the efficiency of computing equipment and the quality and availability of information, and these are addressed as they are found. Because the model is housed on one or more central servers and viewed through a web client, improvements and upgrades can be rapidly deployed in a way that is completely transparent to users.

The Development Process

We have stated that i6dVCM™ is a customized system designed specifically for each City. It is modular, and modules can be developed sequentially so that the first features required by the City are immediately deployed even as additional features are being developed. The development, however, will be predicated on completion of a number of preliminary steps to establish and describe deliverables.

Usability Engineering and Workflow Analysis

Usability engineering is a fundamental principle of IDEAS' methodology. If it is not explicitly designed to easily and fully integrate with the organization's workflow, any technology implementation will not be used and is therefore unusable/useless. 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, or, more simply, the systems and processes that provide the optimal path to organizational success. Six-dimensional business information modeling (BIM) systems are software programs that support workflow optimization, and i6dVCM™ is a form of BIM specifically designed for cities.

The design of a fully integrated i6dVCM™ must therefore include a rigorous usability engineering exercise that includes as many potential users of the system as possible. IDEAS conducts a series of interviews and workshops to discover the current as well as the desired workflow. Process maps (diagrammatic snapshots of workflow) are prepared and studied to see how technology can be strategically applied to support the workflow. Working with city management, IDEAS identifies the optimal way to support working processes through i6dVCM™ deployment. This analysis drives the design of i6dVCM™ and the prioritization of module development

System and Workflow Inventory

We have said that i6dVCM™ is intended to be an integrated system that leverages existing information technology investments. Alongside the usability engineering and workflow analysis, IDEAS can conduct an inventory of current information assets. This includes not only the physical inventory, but also a clear map of current systems utilization and an analysis of what's working and what's not. We can examine not only the systems themselves, but also the information sources and information formats used by the systems.

This inventory serves two purposes: it identifies components that can be used as is and integrated into i6dVCM™, and it identifies gaps between the optimal design surfaced through the usability engineering exercise and the present state of the City's systems. This information is used in the design phase.

System Design and Development

i6dVCM™ incorporates four primary components: the model itself, the simulation component that makes the model dynamic, the underlying data repository and the interface that allows users to interact with, visualize and manipulate the data and the model. The system design will incorporate the optimal combination of open source, industry standard and off-the-shelf products to deliver information in a way that leverages and integrates the City's existing investments in information resources wherever possible. Most frequently, the most urgent need is to improve visibility and communications in planning and zoning, so we begin with the physical model of the City.

The design philosophy will be to limit customization of the program components as much as possible; customization of the model is accomplished through the definition of specific parameters that are unique to the City. This will ensure the longevity, scalability and upgradeability of the model for the foreseeable future. The model will reside on an appropriately configured server and access will be through a web client. Upgrades, maintenance, improvements will be performed once on the server and become available to all users immediately.

Populating the model

Once an architecture has been defined, the first step will be to populate the model with basic digital geographic data. This will include:

1. land surveying geographical data (digital cadastral map)
2. digital terrain models (DTM) and digital surface models (DSM)
3. digital aerial imagery, orthophotography
4. site plans, floor plans, cross sections and views of city buildings as available
5. location photographs and material and surface textures as applicable

The image is hyperlinked to the underlying data, providing a visual portal to any query. Other interfaces can be integrated as desired — drag-and-drop components, Boolean search boxes, text indices, etc.

Integrating data repositories and configuring security

The integration of existing data repositories is an independent component that can be developed alongside any of the others. The primary design goal would be to have single portal access to information repositories from the first launch of the model. Security protocols are incorporated into the design to control both access to information and access to tools for manipulating the model. The process and tools that will be required to accomplish this will not be known until completion of the system and workflow inventory, and it might not be economically feasible to integrate this component at the first stages.

Building simulation components

The components that drive the simulation are called agents. Each agent acts independently in accordance with its guiding principles, which are programmed in as mathematical algorithms or parametric tables. Agents can be "thin," that is many in number but simple in their internal rules, or "thick," that is fewer in number but more complex in their internal rules. Some components of the simulation will be relatively easier to define and program. For example, there are commonly accepted calculations for ground absorption of rainfall in this region that can be immediately incorporated into the simulation by the creation of a “rainfall agent.” Other components, such as the movement of citizens along roads, may require more work, such as ethnographic studies to define patterns of activity. During the usability engineering and workflow analysis stage, stakeholders will define the components that are most urgently required to be animated in the simulation and those will be developed first. As users gain more experience with the system, the nature and number of agents will likely be subject to review and adjustment.

Test segment deployment and roll-out

As segments of i6dVCM™ are completed, they will be tested and rolled out to beta users. The model itself will be the first component to be rolled out, as that is the foundation for other components. Depending on the complexity of the interfaces required to access existing data repositories and integrate their display into the model, access to underlying information sources will likely be the next functionality to be rolled out. Simulation components will be added in the priority order established by stakeholders. Once each component has been approved by the contracting agency, access will be opened to other parties as appropriate.

i6dVCM™ is a holistic, integrated process to collect and manage information and to make it visible and understandable to a wide variety of stakeholders. Its architecture promotes data integrity, transparency, auditability and, above all, usability. It is modular, permitting phased implementation; scalable; and non-restrictive as to platform or interface. It is a 21st century approach to information management that facilitates proactive planning for the 22nd century.