Working Logic: Waste Project Management for the 21st Century - 10495
Peter Baston, IDEAS Business Technology Integration LLC (USA)
Ralph Phelps, Northern New Mexico Citizens Advisory Board (USA)
J. D. Campbell, Geosyntec Consultants (USA)

ABSTRACT

Project plans for waste management cleanup and disposal must involve both technical and scientific issues as well as many other cultural, social and public policy issues. The technical issues may be held to dictate the functional requirements of a waste management project, while the others dictate non-functional requirements. Both functional and non-functional requirements must be met for the project to be successful. Traditional methods of project management have separated non-functional requirements from the construction schedules and have used diverse organizational units to both define and implement social, cultural and educational needs. This leads to missed timing opportunities and to potential resistance to project goals due to public perceptions and misperceptions about what is being done and how and why it is being done.

The holistic, integrated project management system described in this paper can both improve the efficiency of the traditional aspects of project management and expand the scope of project management to encompass non-functional project requirements. Such a system can be built quickly and cost-effectively using technology that exists now and is in use in other industries. Environmental restoration projects are ideal candidates for this integrated approach: they are large; have multiple goals (surface, groundwater, transport); require options evaluations where risk factors require consideration of cultural, safety, community impacts and costs; and they definitely require open and transparent communication with all stakeholders. The holistic and integrated project approach presented in this paper ensures that solutions to environmental goals will be made in a timely fashion with planned and measured responses from those most affected by the work.

INTRODUCTION

Project plans would be much simpler if the management of radioactive waste could be neatly classified as another scientific and technical project, but the truth is, waste management involves issues of cultural and social impact; environmental justice and preservation; public policy at multiple levels; and communications, training and education — as well as complex science and technology issues. Decisions involving waste management are driven by all of these issues and more, and the variety of stakeholders who have an interest (or believe they have an interest) in waste management programs is broad and often bewildering.

Waste management project management does not just involve managing the waste: it includes managing communications with news media, legislators, the general public, the activist public and multiple agencies with overlapping jurisdictions. Project managers are held accountable for the success of the project in meeting not only its budgetary, scheduling and scientific and technical objectives, but also its objectives for transparency, accountability, public participation, communication effectiveness, education and training, social justice and equity, safety and risk communication, and socioeconomic and environmental impacts — all of which may well be

moving targets, and each of which is traditionally managed with a different information management tool or application.

This paper proposes an improved approach to project management that initially can be implemented using existing tools linked through some simple web-based data mining and display methods. As the benefits of this approach are realized, additional tools can be brought to bear to improve the quality of information available to managers and customers.

IDENTIFICATION OF STAKEHOLDER REQUIREMENTS

In software engineering, the project management team completes first a *Software Requirements Analysis* and then a *Software Requirements Document/Specification* to drive software development efforts. Usability engineering is the discipline responsible for making sure that the product not only performs the required functions to the specified quality standard, but also that the product is understandable and easy to use, even attractive, to the end user. In the field of waste management, there is no equivalent discipline responsible for making decisions and actions transparent, understandable and accessible to impacted stakeholders.

It's our thesis that if waste management efforts are to be successful from the perspective of all the non-technical issues identified in the first paragraph of the Introduction, the definition of project management must be enlarged to encompass exercises similar to the requirements analysis, requirements definition, usability engineering and usability studies used in software project management.

Project management begins by determining the goals, functions, and constraints that drive the project. But all of these will be different from the point of view of different stakeholders. Too often, waste management project plans are developed in an anthropologic vacuum, so to speak, behind the ivory walls of an isolated department in a national laboratory. Only when the project reaches the stage of permit application is the public relations department consulted, if ever. How, then, shall project managers be surprised when, a few days after the permit application bursts upon an unsuspecting public, the laboratory is besieged by protesters?

The stakeholder theory of organizational management identifies as stakeholders myriad groups who have an interest in the activities of the corporation beyond the legally defined shareholders, including communities, government agencies, political groups, trade associations, unions, associated corporations, prospective and current employees, prospective and current customers, the environment, the public at large and sometimes even competitors. This inclusive view of who has an interest in the activities of an organization has not penetrated to the field of waste management project planning, and it should.

The community of stakeholders for a waste management project is just as vast as that identified by stakeholder theory for a corporation. The overwhelming majority of those stakeholder groups will be non-scientists. Their value systems, educational background and concerns may be decidedly different from those of the individuals tasked with executing the project. Waste management is a discipline that is fundamentally about benefiting the community, yet the community consistently opposes many waste management projects — perhaps principally

because they do not understand the science behind either the goals or the process. Therefore, it should be mandatory that "non-functional" requirements for communications and community involvement be incorporated into every waste management project as critical tasks.

To continue the parallel with software project management, software developers some time ago discovered, in many cases to their deep chagrin, that their ability to deliver on non-functional requirements — such as the aesthetic design of the user interface — can have an equal or greater impact on product sales than their ability to deliver on functional requirements. This is a lesson it behooves the waste management community to understand. If the technical and scientific issues dictate the functional requirements of a waste management project, then the issues of cultural and social impact; environmental justice and preservation; public policy at multiple levels; and communications, training and education dictate the non-functional requirements — and the project will not be successful until it has met **both** functional and non-functional requirements.

Moreover, the matrix of interaction of all those different requirements will be unique to each site. Whether the local community is more focused on water quality or air quality may depend on whether the clean up site is located in a densely populated, smoggy region or in a sparsely populated desert region. The economic and social impact of clean up operations will depend on the industries and workforce already present in the region. Cultural impacts may depend on whether many non-local workers will have to be hired and whether this is because of lack of numbers in the local workforce or because the local workforce lacks the necessary skills and qualifications. The permutations and combinations are almost limitless, and so the plan to meet the local non-functional requirements will be unique to each project.

The Example that Gave Rise to this Paper

The authors of this paper are all members of the Northern New Mexico Citizens Advisory Board (NNMCAB), the Site Specific Advisory Board for advising DOE regarding the environmental restoration work at the Los Alamos National Laboratory (LANL). It is one of the eight local site boards chartered under the Environmental Management Site-Specific Advisory Board umbrella charter. Site Specific Advisory Boards were developed to advise DOE and to involve stakeholders more directly in Department of Energy cleanup decisions. The local site boards provide the DOE with information, advice, and recommendations concerning environmental restoration, waste management, and technology development activities. They provide input and recommendations on difficult and sometimes controversial national and site specific issues such as future use, risk, management, clean-up levels, economic development and budget prioritization activities. Local site boards were created in part to establish public trust and confidence in the Environmental Management program and the DOE.

Local site Board membership is intended to reflect a full diversity of views, cultures, and demographics from affected communities and regions. These boards should be composed primarily of people who are directly affected by site cleanup activities, including stakeholders from local governments, Tribal Nations, environmental and civic groups, labor organizations, universities, industry and other interested citizens.[1]

---

[1] Information about Department of Energy Office of Environmental Management Advisory Boards and Working Groups can be found at http://www.em.doe.gov/Pages/AdvisoryBoards.aspx.

The Los Alamos National Laboratory is located in the northern part of the state of New Mexico, in the US Southwest and is surrounded by Native American reservations. New Mexico itself is a sparsely populated state (16 people per square mile) that enjoys a unique demographic and cultural profile characterized by strong Hispanic, Mexican, and Native American cultural influences. It belonged first to Spain then to Mexico, before becoming a US territory in the mid-nineteenth century and a state in 1912. It has the highest percentage of Hispanics of any state, at 45 percent according to the 2008 US Census estimate, and is one of four majority-minority states identified in 2008, with an estimated 58 percent of the population belonging to a minority group as classified by the US Census.[2]. Eighty-three percent of New Mexico's Hispanic population is native born and about 75 percent of these trace their heritage to the original Spanish colonists who settled the area 130 years before the Mayflower landed at Plymouth Rock.

New Mexico also has about 186,000 Native Americans, including Pueblo peoples, Navajo, Apache and Ute, constituting the third-highest percentage of any state and the fifth-highest total number of any state.[3] Although it is common to refer to the Pueblo peoples in the aggregate, it is important to note that there are over 20 different Pueblo nations, each speaking a distinct dialect of some nine languages. Acoma Pueblo, whose people claim to have inhabited the pueblo continuously since 1150 A.D., is considered the oldest continuously inhabited community in North America. In the wake of the 1847 Taos rebellion, most of the local leadership was arrested or hanged, and so there has never been a peace treaty signed between the US government and the natives of Taos Pueblo: technically, they are still at war. Many more interesting tidbits of local lore could be included here, but we believe the point has been made that the area is historically and culturally unique.

New Mexico is one of fours states classed by the use Census as "majority-minority" in 2008, but the majority is not monolithic. The two largest minorities, Hispanic and Native American, have very different cultural and spiritual beliefs. Tourist bureaus and economic development agencies promote the state as "multi-cultural," but in practice this means reconciling the three very different political, economic and social perspectives of Hispanics, Native Americans and "Anglos" (as those of all other ethnic origins are popularly referred to) in order to reach communal decisions. Each of the pueblos is an independent nation and has the right to negotiate individually with the federal government regarding treatment of its lands. Native American sovereign governments are largely immune from regulations under state law and may or may not choose to negotiate with state governments. In this cultural climate, the difficulties of reaching out to and including "a full diversity of views, cultures, and demographics from affected communities and regions" are challenging.

---

[2] US Census Bureau (2009-05-14). "Census Bureau Releases State and County Data Depicting Nation's Population Ahead of 2010 Census." Press release. http://www.census.gov/Press-Release/www/releases/archives/population/013734.html. Retrieved 2009-11-11
[3] US Census Bureau (2002). "The Native American and Alaska Native Population: 2000" http://www.census.gov/prod/2002pubs/c2kbr01-15.pdf. Retrieved 2009-11-11.

Cochiti Pueblo
Jemez Pueblo
Laguna Pueblo
Nambe Pueblo
Ohkay Owingeh
Picuris Pueblos
Pojoaque Pueblo
San Felipe Pueblos
San Ildefonso Pueblo
Sandia Pueblo
Santa Ana Pueblo
Santa Clara Pueblo
Santo Domingo Pueblo
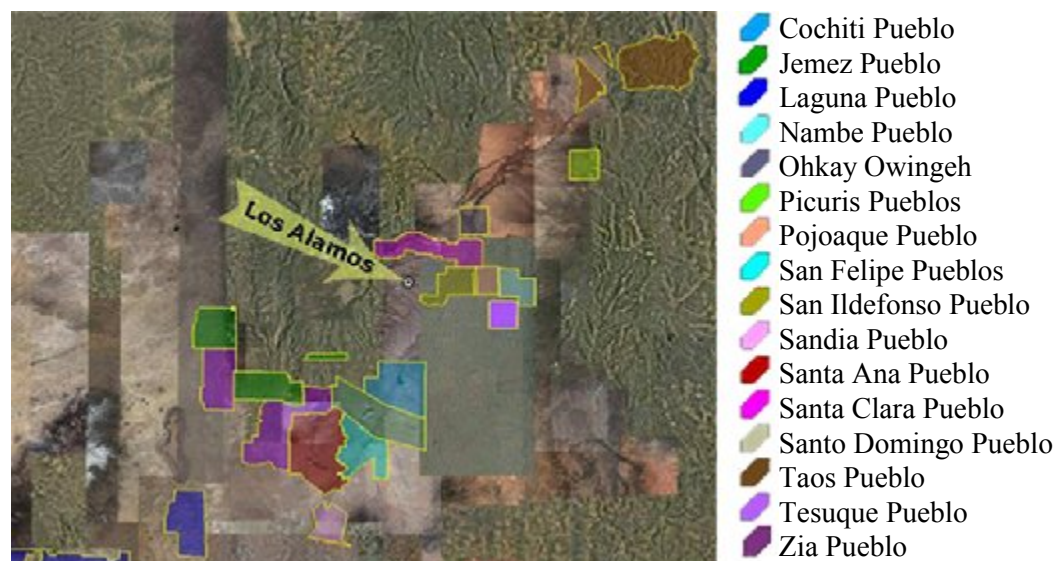Taos Pueblo
Tesuque Pueblo
Zia Pueblo

Fig. 1. Satellite image shows LANL location surrounded by 16 different pueblos, each with its own sovereign tribal government.

The experiences of the authors during their service on the NNMCAB — which have included miscommunications, misunderstandings, extended searches for reliable information on which to base recommendations and meeting sessions with spirited discussions, all involving many highly educated, highly intelligent and well-meaning participants — have driven home to us the need for a change in the way waste management projects are project managed. The *status quo* can be improved for the federal employees who are trying to execute, for the public citizens who are trying to stay informed and for the activists who are trying to hold their government accountable.

STAKEHOLDER REQUIREMENTS FOR NEW PROJECT MANAGEMENT TOOLS

Looking at the situation cited in our example, what shall be the stakeholder requirements for project management tools? To begin with, it is our belief that the LANL team charged with project execution will benefit from using the tools to manage their activities. For this stakeholder group, the requirements are very traditional: the ability to provide and demonstrate time and resource management by task — to develop plans, assign resources to tasks, track progress, manage budgets, analyze workloads, update all of the above, and report all of that out. We shall call these the functional requirements.

We have said that the non-functional requirements are dictated by issues of cultural and social impact; environmental justice and preservation; public policy at multiple levels; and communications, training and education. The requirements dictated by these issues are largely subsets of the functional reporting and update requirements, although input taken from stakeholders outside of the project team itself should not be allowed to directly change the plans. However, there must be a number of different avenues to accept input and a number of different avenues to report out.

Moreover, the tools must be usable and accessible. Traditional project management tools are not typically suited to making it easy to deliver or receive information. To begin with, they usually do not address the real needs of the users themselves. Traditional project management software is arcane and complex in both its structure and its interface. More often than not, software protocols force users to modify their activities to conform to a one-size/one-industry-fits-all model. This is because the software is built around the task database, not the objectives and deliverables in context — the trees, not the forest. More relevant to the issue of communication with outside stakeholders, licenses lock organizations into vendor-centric applications that exclude participants not using these expensive applications.

Collaboration and communication issues have traditionally been dismissed as being external to the role of project management. In the past decade, Collaborative Project Management Tools (CPMT) have become popular. They add a layer of electronic conferencing, messaging and document management functionality to the traditional project management tools. This is a step in the right direction, but note that we identified these as *adding a layer*, not as having been integrated into the functionality of the tool itself. Furthermore, almost all of these remain vendor-centric: clients must have access to a software client or a web page reached only by login and password in order to see any status information or provide any input.

Outreach and communications are traditionally also seen as an *added layer* to project management. For example, a web site may be established to provide project status updates to the general public. To populate this site, the project manager typically forwards a static report to a communications professional who reformats it and then posts it. A very sophisticated team will publish reports from the project management software directly to a webpage using an XML template or its equivalent. Once the report is published, it is no longer linked to the project management software — it has become static and blind to any activity that takes place after publication. Furthermore, it has become unverifiable, because it has been separated from the data repository from which it was drawn. In extreme cases (e.g., Madoff, Parmalat[4]) the report can easily be manipulated to show results that are entirely divorced from reality.

So let us list the stakeholder requirements for real 21st century web-based project management tools:

- Disparate stakeholders must be able to communicate and collaborate in real time. Communication must be direct and singular (write once, use many times) and collaboration must be active and productive, that is "collaboration" means that more than one individual acts on the output directly and each individual's actions contribute to the end result without any intermediary.

- Real-time status must be available to any stakeholder in their preferred format and preferred idiom on demand. Scientists will want to see readings from scientific instruments displayed

---

[4] Bernard Madoff was convicted on multiple counts of fraud in 2009 after his Wall Street firm, Bernard L. Madoff Investment Securities LLC, was revealed to be a giant Ponzi scheme. His clients were not given on-line access to their accounts but received paper statements through the mail which were later found to be complete fabrications.

In 2003, the Italian food and dairy multi-national Parmalat was saved from failure by a government bailout after it was discovered that the company's assets had been inflated by €3.95 billion through the insertion into a database of a forged document which Bank of America accepted without verification as collateral for an extended line of credit.

to four decimal places in tabular form, the community at large will want to see them displayed graphically so that it is easy to see if readings meet, exceed or fall short of easily distinguishable targets.

- Supplemental and background information must be easily accessible through the same interface that provides access to the project management tool. Think "drill down" and "drill up," with no requirement that the individual seeking information be familiar with an arcane indexing and filing taxonomy.

- The project management tool must be organically integrated with the applicable design and execution tools **and with reality**. Drill down should include drill laterally — for example, if a user is looking at a Gantt chart that shows a task identified as "drill a monitoring well," the user should be able to bring up the engineering drawings for the monitoring well directly from that screen, and read the progress being made towards completion of that task from a remote video camera or from in-place sensors.

- Any information served up by the project management tool must be readily verifiable and fully auditable. Any user should be able to trace the source for summary statistics directly to the raw data, and identifying information should remain continuously attached to every datum.

PROJECT MANAGEMENT TOOLS FOR THE 21ST CENTURY

This paper proposes that a holistic project management system — one that meets all of the requirements set forth above, both functional and non-functional, for all aspects of one or multiple projects simultaneously — can be built readily, rapidly and inexpensively using 21st century parametric modeling, cloud computing and social networking technologies. It is important to understand that this technology exists now, many of the building blocks for it have been in use for years and can be considered mature technologies, and there are no excuses for not demanding its use. To emphasize this, we will be exemplifying how the technology works by referencing an existing solution, Working Logic™, developed by one of our authors[5]. It is by no means the only solution that can deliver integrated parametric project modeling, but it is not pie in the sky: it can be purchased today.

The Premises

To be successful, design of such a tool must begin from the outside in, with a full inventory of reporting audiences and detailed usability studies that sketch out the "working logic" of interactions between stakeholders. Parametric systems that incorporate this logic as workflow model information as a virtual representation of the project and provide the ability for disparate team members to communicate and collaborate in real time, for management to view real-time status on demand through focused dashboards, and for outside stakeholders to view the same data in user-friendly mashups.

---

[5] Disclosure: Working Logic™ is a holistic project management system that includes workflow components and software components. It is sold by IDEAS business technology integration LLC, a consulting firm of which the primary author of this paper is one of the principals.

The paper describes a holistic project management systems solution that adheres to four basic design principles: full and easy integration with each user group's typical daily work process; different viewpoints into the same project data for different stakeholders; a parametric approach that allows the same core information about the workflow to be viewed from any perspective — the overview can be exploded to any level of detail and rotated to any point of view; and complete integration of the parametric model and reality to ensure integrity of status reporting.

Fig. 2. On the left, the walls illustrate the lack of data sharing and interconnectivity between the individual project management tools used by different stakeholders. Meetings, charrettes, reports, conference calls are all used to overcome the barriers between the information systems of different stakeholders that cause data to be "thrown over the wall", after which the agency in question asserts that they have provided information. The diagram on the right symbolizes the interconnectivity that results from full implementation of parametric project management tools.

Working Logic™ was developed from the premise that the walls that normally separate the design, the real world and the management of, first, the project and, ultimately, the deliverable as it operates once it has been completed, can all be demolished by using parametric systems with a web-based interface. With the parametric model displaying project status in real-time, in a format that is easily accessible to all project stakeholders, there is no need for the monthly (or weekly or daily) status meeting: those who need to know simply log onto the system through any internet connection and observe the current status. Full transparency is achieved by verifiable and auditable drilldown to the raw source data for any information served up by the project management tool. This defuses mistrust at the same time that it holds project actors unmistakably accountable for their results.

A fully integrated parametric project model also allows transparent oversight and multi-party visibility into the project status. How much would public confidence in waste management projects increase if project status were visible to the public on the web in real time? And, incidentally, how much more efficiently could projects be executed if there were no additional effort required on the part of the project team to deliver the status information?

To ensure that a project remains grounded in reality, the project plan must be grounded in the workflow, with a clear eye on the output the workflow is designed to produce. It is important not to confuse the project with the result: project status must not become the target output of project management, project managers must not be distracted from actual management — that is, the task of directing or controlling the project. Most project management exercises begin with a list

of tasks and dates for each task. In Working Logic™, this timeline is actually the **last** step in the process of defining a project workflow.

Defining a project workflow begins with a clear definition of the project goal, objectives and deliverables, and, more importantly, a clear **understanding** of the project goal, objectives and deliverables. A project has a single goal, and that is defined by the customer, whether internal or external. When we are speaking of a waste management project, this first step may in fact be the most difficult. Here are the criteria that Working Logic™ imposes to begin a workflow:

- The goal is clearly stated and described
- The goal statement may reference several objectives
- Objectives are tied to stakeholder needs
- Deliverables are concrete, measurable and clearly described

Using Parametric Virtual Models to Enhance and Ensure Communication

The workflow for setting up a project in Working Logic™ includes feedback loops that verify, through bidirectional communication, that the goal has been described in terms that are understandable and acceptable to all stakeholders, and that they are all committed to the same goal. An important parametric tool to support this first step is augmented reality modeling, which allows non-technical audiences to understand what is being proposed by showing the proposed end result in simulation in a model that closely resembles the reality it represents and can be viewed from any perspective. What-ifs can be executed on the fly by changing the parameters, which will result in the model being redrawn in exactly the same context.

In the example of the environmental restoration efforts at LANL, it permits any project taking place on the Pajarito Plateau to be observed in its geographic context, not on a 2-dimensional map, but in virtual reality. The three primary stakeholder groups see the Pajarito Plateau from three very different cultural contexts. For local Native Americans, the geographic context of the area of the Pajarito Plateau is set by the four sacred mountains that define its boundaries. Mountains may be sacred, and specific places on mountains may be sacred. Is the new well on sacred ground? Is it in view of sacred ground? For the Hispanics who have farmed the land for five hundred years, the geographic context is set by its water sources. An organic and interconnected system of *acequias* or irrigation ditches has supported agriculture in the high dessert for over ten generations, and the *acequia* associations that manage the ditches and their water flow are powerful political subdivisions of the state that may receive state funds for improving ditch infrastructure directly from the legislature. Does the new well impact water flowing into the *acequias*? Does it or its maintenance access impinge on *acequia* lee lines or right of ways? Stakeholders from both these groups can literally pace the land in a virtual walk-through to get answers to these questions.

At the same time, the model is not just a film-like picture of the real place. It is a mathematical construct that can respond to changes in its parameters by altering the representation according to a defined rule set. So other stakeholders may wish to know: which strata will a test well penetrate? How does the location of the well relate to the location of nearby aquifers? And how do the answers change if the depth is changed?

Communication is the hidden keystone of successful project management, and successful communication depends on a common vocabulary and common points of reference. Among disparate stakeholder groups, this is not likely to exist. Providing information through "pull" methods that allow users to approach the data from their own point of view goes a long way towards establishing that common point of reference. This process of bidirectional communication should begin long before the Gantt chart has been populated, because it supports the foundations of the project plan. If that initial communication about goals and objectives is at cross purposes, the entire project foundation is built on a bed of sand and will crumble at the first ill wind. In Working Logic™, these steps are required to establish the key parameters of the project workflow and therefore they can neither be skipped nor ignored. The tool itself can be configured to require responses from stakeholder representatives as a prerequisite to granting permission for the next step in the project management plan.

Workflow Is the Foundation

The actual foundations of the project plan are the workflows that are what really happens to complete the project. Typically, an overall workflow describes the entire project while more detailed workflows are revealed as drill-downs under individual steps in the overview, leading eventually to a sequence of tasks that can be transcribed to a timeline to generate the ubiquitous Gantt chart if it is still required.

Though the terms are often used interchangeably, for the purposes of this paper it's important to distinguish between the workflow and the process map. In the context of this discussion, **the workflow is the reality**, the process map is only a diagrammatic snapshot of the workflow. Augmented reality with virtualization through parametric modeling can provide a different snapshot of the workflow — a simulation — that is accessible to a much wider audience than a traditional process map. It also forces examination and validation of the inter-relationships between tasks, deliverables and objectives, because the workflow must be played through to generate the objective. If the workflow is physically impossible, or will be derailed by an external constraint, it will not play through. A paper diagram of the workflow can, deliberately or unwittingly, lie just as deeply as Madoff's statements; a simulation driven by visible assumptions and constraints cannot. (But if there is a stakeholder audience that prefers to see the workflow rendered or displayed as a process map, the same parameters that draw the simulation can draw a process map.)

Each deliverable (component of an objective) must be concrete, measurable and "owned" by an individual who is ultimately accountable for its completion. The workflow for each deliverable reveals the required inputs and the steps that add value to create the deliverable (output). We will talk about building quality assurance into the workflow later, but for now let it be clear that the workflow is integral to the tool. The project management user interface may include to do lists, for example, and as a user clicks off the to do, she/he simultaneously updates his/her personal calendar and the project workflow. If the workflow is properly integrated into the project management process, then the simulation (and the process map if one has been drawn) will also be continuously regenerated to reflect the impact of real activity, recorded as it happens.[6]

---

[6] This is much easier to visualize when the project being managed is carried out using the computer as a tool. For example, one can easily see how checking a document into a version management system as final could trigger the

Thus status is reflected real-time in any representation of the workflow, which will automatically cause planned future workflow to adjust. Workflow-driven project management software reflects these changes as real-time updates to the process map and only subsequently and consequently to the timeline. In Working Logic™, milestones are defined as markers. In the conventional language of Gantt charts, they are not simply "zero-time tasks," but "zero time **roll-up** tasks" that can be achieved only through completion of predecessor task sets. Milestones are thus directly and immediately impacted by the early warning system that allows management to decide when corrective action is needed.

Lean the Process Map and Design in Quality

It's axiomatic that the process map plan should be subjected to rigorous quality scrutiny in the pre-planning and planning stages — in other words, the process should be "Leaned" during planning. This is the time to look for bottlenecks and break them, to look for parallelism that can provide buffer time. This is the time to build in quality. Item three on Deming's 14-point list was "Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place."

With parametric modeling, the workflow can be optimized virtually: by the time the project is in the real world, the optimal flow has been modeled and tested in simulation. This gives the project manager almost as good an advantage as 20-20 hindsight! But proper management does not stop with proper planning. As the workflow progresses, real-time statusing opens the door for continuous improvement and feedback, so that the model is both validated and refined. The proper role of management is not to micro-manage task status, but to monitor workflow in search of opportunities for improvement.

Anchor the Project to Reality

The workflow, and consequently the timeline, must also incorporate as parameters any exterior constraints that impact the workflow, such as seasonal restrictions, holidays that create resource restrictions, dependency on outside events, etc. While the parametric model can incorporate and continually reference the constraints of the real world (such as hydrologic models, for example) or the impacts of unexpected, uncontrollable events (such as natural disasters) traditional 2D engineering programs or project management programs cannot.

Suppose that in a drainage redirection project the schedule becomes threatened because a supplier cannot deliver the specified discharge pipe. The Gantt chart can tell you what the schedule impact will be if delivery is two weeks late. It can also tell you what the schedule impact will be if you substitute a different pipe from another supplier who can deliver on time. But the Gantt chart cannot tell you that if you make this change to the discharge pipe, the downstream result will not be consistent with your project goal or that the substitute pipe is not

---

completion of the writer's billing time sheet, the writer's personal to do list, the project job cost accounting, the project workflow and the project manager's dashboard, all with the same single mouse click. But with ubiquitous computing, physical activities can be reported in to Working Logic™ through wireless SCADA, instrument readings, etc.

built to withstand the impact of a flash flood and therefore likely to fail in this application. The risk, of course, is that the project manager on the ground, whose single imperative is to meet schedule, will accept the substitution without consulting the hydrologic engineer, who is off to another project because he has completed his single imperative of producing construction drawings. In fact, similar scenarios happen all too frequently on project sites.

What Drives the Project in the Real World Must Drive the Plan

In the real world, money is highly likely to be the primary driver for activity. Therefore, project management must include cost information. The "baselined" timeline, drawn from the workflow, illustrates the balance point between time and costs. The plan is only as good as its connection to reality. A timeline that is not tied to resources at some level has no more connection to reality than one that is not tied to other constraints (networked). A timeline that is not baselined is equally useless. The timeline view is useful only as a means to continuously assess threats to the milestones: tasks that threaten milestones are the critical flow, and in the case of a problem on those tasks, the project manager must focus resources on critical or bottleneck tasks. Without the tool of parametric modeling, most project managers simply bounce from crisis to crisis.
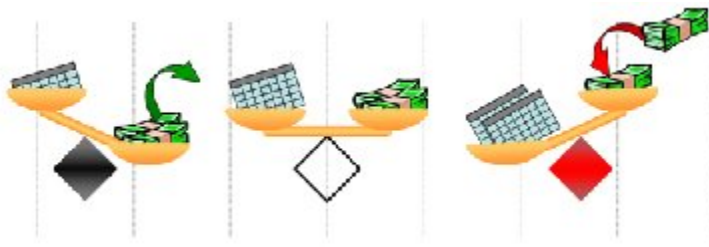

Fig. 3. A representation of a milestone completed early, on time, or late.

Parametric design software simulates the real world by establishing the parameters that define the objectives of the project and building simulations of them by simulating each step in the workflow that leads to their achievement. Parametric management software allows us to build a simulated workflow that behaves in every respect the way its real counterpart behaves. The fanciful diagram in Fig. 3 represents a milestone on a Gantt chart as a literal balance point between time and costs. The black milestone met before the baseline schedule saves money; to balance a slipped (red) milestone, more money must be put in place. Either way, the remainder of the project will be impacted.

By defining deliverables so they are measurable, planners can identify means of verification that can be fed back into the parametric model in real time, in many cases through automated monitoring processes. Parametric modeling software can simulate in real time the effects of deviations — in time, cost, expected outcomes or any other factor — from the planned workflow, as well as projecting the optimal recovery plan to achieve the objectives within any preset constraints of quality, time or cost for the entire project. This allows management to immediately view the long-term cost-benefit impact of any project activity so that it can make rational decisions.

Workflow is the flow of work — it is neither static nor determinate. The dilemma in connecting workflow to project management has been that, until recently, there has been no way to represent workflow symbolically so that it could be referenced away from the work site. Parametric modeling allows just that. So with parametric management software, the project manager and stakeholders have an open window to read status from the real world.

Parametric modeling also allows the introduction of easy ways to reference the relationships that drive the model. It is not necessary to venture into complexity science, which holds that relationships **are** reality, to understand that changes in an early stage of a project will impact subsequent stages. Managing a project with a focus on the goal requires that changes be validated on the workflow before they can be tested on the timeline. Through parametric modeling, the impact of a change on the end result and all its parameters can be immediately displayed and, equally importantly, quantified. The corollary to "you cannot manage what you do not measure" is that "you cannot measure what you do not see." Parametric modeling provides a clear window to reality.

What About Quality?

Traditional project management also does not consider the quality of the outcome, whereas in reality a task finished on time but with poor quality may pose an equal or greater threat to a milestone than slippage. For example, a planting of groundcover intended to anchor a slope completed in an unusually cold November may require 100 percent rework in the spring, threatening a milestone labeled "stabilize bank with vegetation to limit erosion."

Using the multiple dimensions of parametric modeling allows the project engineer or manager to incorporate quality into the design from day one. Cost-benefit analysis of different features is hugely simplified as the model simply simulates the outcome in a manner that is visible to all. This greatly increases the likelihood that the project will complete successfully: that is, that the end result will meet, or preferably exceed, the stakeholders' expectations.

THE TECHNOLOGY EXISTS TODAY

At the beginning of this paper, we said that it is a functional requirement that those charged with project execution must be able to use the tools to manage their activities. Integrated parametric modeling and integrated information modeling, the technologies behind Working Logic™, are mature technologies that are in daily use today, making things easily visible so they can be better and more easily managed. The models draw related data together to show the whole picture of the health of a process, organization or project.

Through a single point of entry, a user can drill down to the narrowest level of detail, trace dependencies and follow trends. Information, structures, projects can all be managed through an interface that rapidly reveals through recognizable patterns what's working and what isn't. On the back end, data is mined from inside and outside sources and updated in real time to show influences and correlations; correlations become active parameters, making it easy to develop projections and create "what if" scenarios.

The single point of entry for these models is a web-based mashup: the user's web browser combines, integrates and reformats disparate data from a diverse set of sources, independent of the source platforms. A typical use might be to overlay information pulled from one or more data bases on a map or virtual geography, so that when the user clicks on a particular location, the relevant information about that location will be displayed on the same page.

One enormous advantage to using a browser-based mashup is that the interface can be personalized through simple web design strategies. This allows different users to call up the information that is relevant to them without being distracted or confused by information that is not relevant to their immediate need. These are the dashboards that synthesize the five major indicators of project health into a status snapshot understandable at a glance that stays open on the project manager's desktop and is continually updated in real time. For an individual assigned to a task, the interface can be adjusted on the fly to fully integrate with the user's daily work process. The project management interface becomes the engineer's calculator and blueprint, the technical writer's document repository, the geophysicist's lab notebook — and therefore the status of all of their work product is rolled up to the project manager's dashboard in real time.

Another advantage is that through the incorporation of cloud computing, the information needed or wanted by any individual user can be assembled and served no matter where it resides. This is particularly important for integrating data stored in legacy systems, which has become easier to mine and serve up with advances in web technology. Since the data is mined directly and not reinterpreted through a mapped port to a newer platform, traceability and auditability is fully maintained. And since the information is assembled on each page from any number of sources at the time it is called up, there are no issues of software capacity limits or scalability.

By integrating all of the project work into a single open-ended data map, the Working Logic™ project management environment supports the clear and constant communication that is a prerequisite to project success. Accurate decision records are always available because the process of reaching a decision creates the record as it happens. Every stakeholder can have a clear vision of the impacts and consequences of the project on the objective that is their focus of interest through the virtual model. Finally, using a browser interface makes public information universally accessible to all stakeholders at low cost.

The model imposes full transparency and open communication because it requires that prerequisites, assumptions, constraints and dependencies be spelled out in quantifiable and measurable terms, and these can always be seen by drilling down through the task or objective that depends on them. Further, because their definition is a prerequisite to developing the project plan, relationships between tasks and the resulting dependencies are organically integrated into the workflow.

CONCLUSION

We said at the beginning of this paper that, in our experience, the *status quo* of project management for waste management programs begs for improved. The project managers of waste management projects may be well trained in, and long accustomed to the use of, traditional project management tools for scientific and technical projects, but these tools do not meet the

needs of other stakeholders. Waste management project managers cannot exclude issues of cultural and social impact; environmental justice and preservation; public policy at multiple levels; and communications, training and education from their planning. Objectives for transparency, accountability, public participation, communication effectiveness, education and training, social justice and equity, safety and risk communication, and socioeconomic and environmental impacts must be integrated into the project management plan. These concerns cannot be addressed through a Primavera or Microsoft Project Gantt Chart.

What is needed is a 21st century project management tool that does not guard project status information but widely disseminates it; that does not require data to be handled and manipulated multiple times for different audiences, but that allows any stakeholder access to summaries built on the fly to address their specific concerns and the ability to drill down through those summaries to see the raw data at will. To meet this need, the tool we want to use for project management should look like this:

- A project management tool that is designed to easily and fully integrate with the user's daily work process, so that it will be used. The design of a successful project management solution, as any software or process design, must begin with usability engineering. If it is not designed to easily and fully integrate with the user's daily work process, it will not be used and is therefore unusable/useless.

- A project management tool that is accessible to all stakeholders, protecting sensitive information by login security, and that offers different stakeholders different viewpoints into the project. The Tribal Council should be able to enter the project management tool through a virtual geography interface that allows them to orient themselves from the four sacred mountains and a geophysicist should be able to enter the same project through the periodic table.

- A project management tool that allows a consolidated single project information repository to be viewed by any authorized user through an overview that can be exploded to any level of detail, rotated to any point of view and expanded to include contextual data on demand, while retaining intact the inter-relationships that drive dependencies. There are no obsolete versions, no outdated reports and no partial excerpts — only a single source of information into which different stakeholders dip different spoons. Yet the user who proposes to change one aspect of the workflow cannot remain ignorant of the domino effect of the proposed change.

- A project management tool that is predicated on complete integration of the parametric model and reality, ensuring integrity of status reporting. It must present real status in response to any inquiry, without any need for information to be reformatted, ported from one platform to another or rewritten. A user viewpoint fails the test of usability if it requires interpretation or explanation by an "expert" to be understood by the viewer.

Such tools exist today. They are easily accessible to any organization that has the desire to implement them. And in our opinion, they are a requirement if waste management projects are to be completed successfully in the eyes of all stakeholders.