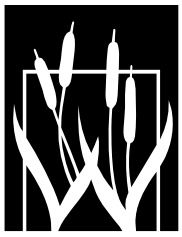

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Earned Value Management

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Table of Contents

1. Objective

The objective of this paper is to present the Whitemarsh approach to constructing, producing, and employing earned value management in the accomplishment of database projects. This paper mainly addresses the earned value for labor as it represents the most problematic component of database projects. Earned value management for materials and facilities is straightforward and is addressed in a separate section.

2. Topics Covered

The topics is this paper include:

- Background and Literature Search
- Requirements for Earned Value Management
- Whitemarsh Support for Earned Value Management

3. Background and Literature Search

A Google search for "Earned Value Management" produced over 250,000 hits. For sure not all were examined. Three stood out: The first from Wikipedia, and the second from a consulting firm and the third from an independent consultant and educator. The third has a great tutorial.

3.1 Wikipedia... "Earned Value Management"

Link: http://en.wikipedia.org/wiki/Earned_value_management

Earned Value Management is a technique to measure project progress in an objective manner. Earned value combines measurement of scope, schedule, and accomplishment. The key components that must exist are:

- Project plans identify the work to be accomplished.
- Valuation or budgeted costs of the planned and scheduled work.
- Earning rules that quantify the earned value of accomplishment.

- Comparisons of planned work and its planned costs to actual work accomplishment and costs.
- Cost-based allocations of the overall project budget to individual "deliverable units" of a project plan.

The key steps for simple or small projects are:

- Define the work....(WBS), that is, tasks and deliverables.
- Assigned a planned value to each step.
- Define rules that determine when the step is completed, or acceptably partially complete.
- Perform the project.
- Accumulate the earned value as the project progresses.
- Accumulate the costs as the project progresses.
- Compute the earned value vs actual costs vs budgeted costs "curves."

The Wikipedia article then states that for large and complex projects, you need to add: PERT, Gantt, and Critical Paths networks to assess schedule and time.

3.2 Oak Associates, An Earned Value Tutorial (Mark Durrenberger, PMP)

Link: http://homepages.dcc.ufmg.br/~clarindo/arquivos/disciplinas/eu/material/artigos/EVTutorial.pdf

Earned value is a method for managing projects based on the regular comparison of actual project costs to planned costs and to completed work. The phrase, earned value, comes from the concept that when a deliverable is completed, its value has been earned.

Steps:

- Identify each project deliverable.
- Develop a schedule for the completion of each deliverable.
- Assign a value to each deliverable.

The example in the Oak Associates tutorial deals with building an outside deck. It addresses the basic issues of computing the key metrics, setting out a schedule via Microsoft Project, and setting a baseline that is then used to measure progress against. On point in the Oak example is that they run into an unexpected problem that throws off their estimate and schedule. In general, the project is on schedule until they try to dig their last four-foot footing hole. They ran into a boulder. Whoops. So much for the schedule, the baseline and the estimate.

From an earned value point of view, the project expended 36 staff hours but can only take credit for 26. They're 34% behind. The tutorial then goes into all the different possibilities for corrective action which are really only three: maintaining the project schedule, maintain product features and performance, or maintaining project cost. For each of these a general approach must the chosen. These too are only three: sacrificing the quality of the deck, sacrificing the schedule, or by sacrificing cost. Once decisions are made and the client agrees to the remedy, a new baseline is created and the work restarted.

The tutorial represents the real world in that almost always something goes wrong. In this case, it was not the work plan, the costs, or the schedule. It was the completely unexpected "boulder." Overall the tutorial is quite good and addresses the key issues of dealing with projects that get into trouble.

Readers are encouraged to access the entire Oak Associates paper. It has the example detailed including greater explanation of how to deal with unexpected situations.

3.3 Dennis J. Frailey, Tutorial on Earned Value Management Systems

This next example from Dennis Frailey is more focused on the computations of the key measures and then the derived measures. It too includes an example that enables a greater focus on the mechanics of computing key earned value "numbers" and addressing earned value management issues once the "numbers" are known. The example provides a classic scenario of how earned value is computed. With Frailey's permission, the entire example is provided here. First, here is a link to his excellent article.

Link: http://www.dfw-asee.org/archive/Earned_Value.doc

Frailey states that you compute the following at the end of each earned value assessment scheduled time period:

- Budgeted cost of work performed (BCWP).
- Budgeted cost of work scheduled (BCWS).
- Actual cost of work performed (ACWP).

Once these are computed, Frailey provides simple derived metrics that employ these computations to know if your project with respect to time and budget is on-time, ahead, or behind:

1. Schedule Variance (SV) = Budgeted Cost of Work Performed (BCWP) - Budgeted cost of Work Scheduled (BCWS). If 0, perfect. If >0, you're ahead. If <0, you're behind.

2. Schedule Performance Index (SPI) = Budgeted Cost of Work Performed / Budgeted Cost of Work Scheduled. If 0, OK. If >0, ahead. If <0, behind.

3. Cost Variance (CV) = Budgeted Cost of Work Performed - Budgeted cost of Work Scheduled. If 0, OK. If >0, you're under budget. If <0, you're over budget.

4. Cost Performance Index (CPI) = Budgeted Cost of Work Performed / Budgeted cost of Work Scheduled. If 0, OK. If >0, under budget. If <0, over budget.

Frailey's article provided a very simple example that illustrates how earned value management is employed: Baking Cookies. This example employs copyrighted material from Dennis J. Frailey (Copyright @2000, Dennis J. Frailey, All Rights Reserved). We are grateful for his permission to use the material.

Project: Suppose you are making cookies for a large party to be held tomorrow. Suppose the following are your plans:

Plans:
- 40 cookies per batch
- 5 batches per hour (200 cookies)
- Schedule: 5 hours to make a total of 1,000 cookies
- Budgeted cost per cookie is $0.05
- Total budget is $50.00 for baked cookies, or $10 per hour

Progress Report at End of Hour 1:
- 150 edible cookies have been made (some were burnt and had to be thrown away)
- Total actual cost of worked performed is $9.00 (ACWP)

Analysis:
- BCWS (Budgeted Cost of Work Scheduled) = $10.00
- BCWP (Budgeted Cost of Work Performed) = $7.50 (Earned Value) [150 cookies x .05 per cookie]
- ACWP (Actual Cost of Work Performed) = $9.00 [from above]

Therefore:
- SV (Schedule Variance) = BCWP - BCWS = -$2.50 (you are behind schedule)
- SPI (Schedule Performance Index) = BCWP / BCWS = 0.75 (you are running at 75% of the planned schedule)
- CV (Cost Variance) = BCWP - ACWP = $7.50 - $9.00 = -$1.50 (you are $1.50 over budget)

- CPI (Cost Performance Index) = BCWP / ACWP = 0.833 (you are running over budget by about 17%)

Readers are encouraged to access the entire Frailey paper. It includes definitions, formulas, another example, and a quiz.

4.0 Requirements for Earned Value Management

The remainder of the material in this Whitemarsh Short Paper on Earned Value Management focuses on the requirements that must exist to support earned value management, and the contribution that Whitemarsh's approach to project management brings to the effort.

From the literature search, the following are essential for both successful project management, and for earned value assessment. If these are absent, project success is accidental.

- A clear set of well defined, accomplishable, and measurable deliverables.
- A clear set of standards to judge whether a deliverable has been accomplished.
- An ability to know when and how work can be divided among multiple persons.
- A method of determining parallel and serial deliverable accomplishment efforts.
- An ability to know all the different staff and skills necessary for deliverable accomplishment.
- A clear set of well defined, accomplishable, and measurable tasks that result in accomplished deliverables.
- A clear set of staff hour, unit-effort-based, allocations to accomplish deliverables via tasks.
- A strategy to assess staff and quantify the velocity at which they work, in order to accomplish deliverables.
- An enumeration of work environment factors that affect the rate of deliverable accomplishment.
- A strategy to quantify and assign work environment factors to individual deliverable accomplishments.

5.0 Whitemarsh Support for Earned Value Management

The Whitemarsh support for earned value management centers on its project management database. Every calculated statistic needs to be found in the database along with all the supporting project management data that is collected on a regular basis during a project's execution. After a brief review of the key entity-clusters, each is described in greater detail.

5.1 Earned Value Management Database Overview

The Whitemarsh project management database's design, depicted in Figure 1, consists of a number of entities. All these entities are traditional and are interconnected through one-to-many

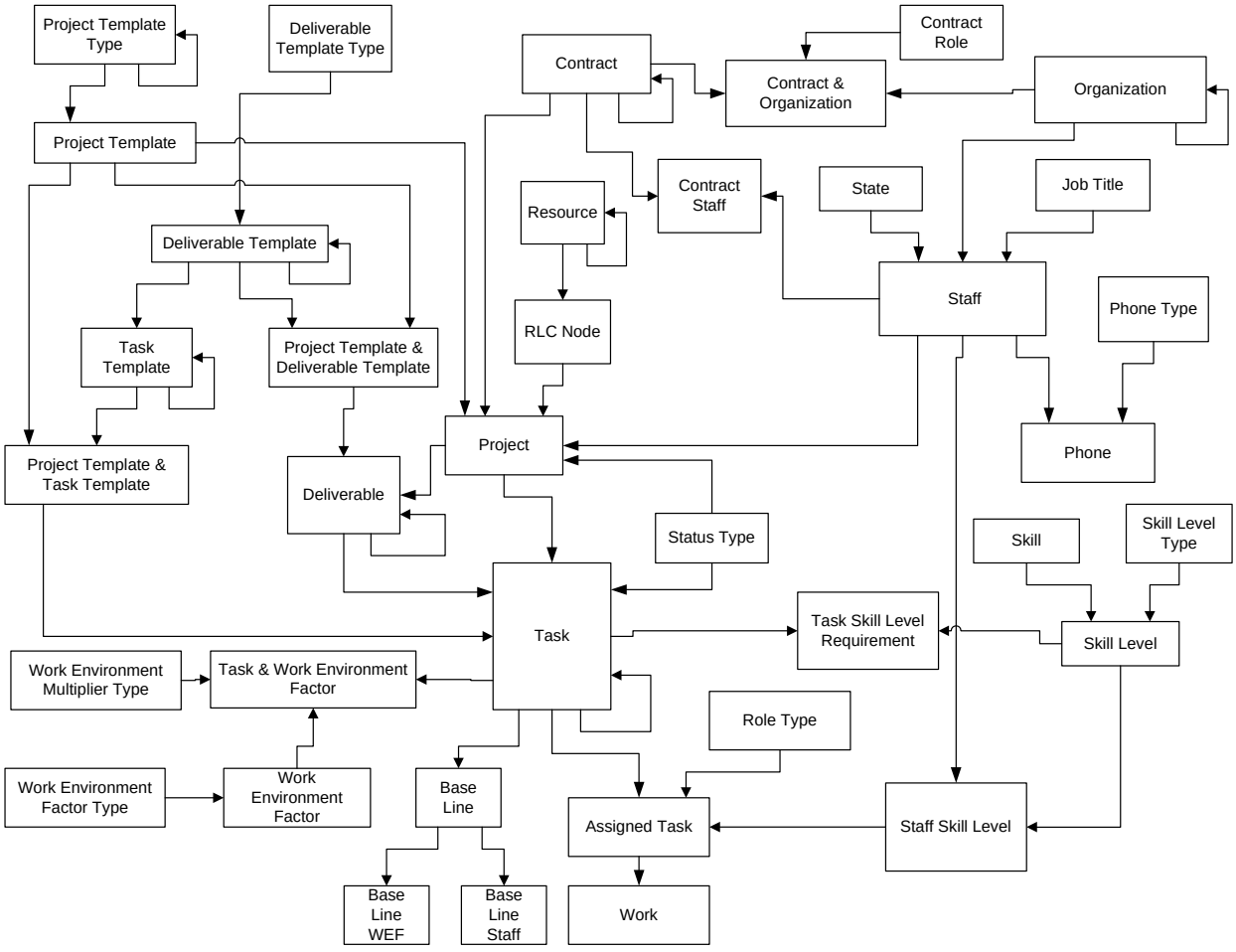

Figure 1. Data model for a highly engineered project management database.

relationships (line with an arrowhead) except for those entities that show a one-to-many relationship from an entity to itself. Organization (upper right) contains such a relationship. This relationship means that the entity contains subordinate organizations.

For example, an Information Technology organization contains the Information Resource Management organization, which in turn may contain the Data Administration organization, and Database Administration organization.

The eight recursive entities are:

- Contract
- Deliverable
- Deliverable Template
- Organization
- Project Template Type
- Resource
- Task
- Task Template

The entities from Figure 1 are also divided into six distinct clusters, which are:

- Contracts, organizations and contract [staff] resources
- Resource and Resource Life Cycle Node
- Project, Deliverable, and Task Templates
- Project Staff
- Project Building and Estimation
- Project Work

In general, the *Contracts, Organizations, and Contract [staff] Resource* cluster of entities represent the environment within which projects take place.

The *Resource and Resource Life Cycle Node*[1] entity represents the target of the project, that is, the area of the business benefitted by the project. For example, for manufacturing, finance, human resources, or land use planning.

The *Projects, Deliverable, and Task Templates* entity cluster enables the definition of the templates employed in the actual building of projects. Defined across the enterprise, these templates enable standard project execution and accomplishment measurement.

[1] Resource and resource life cycle node has the exact same definition as it does within the Whitemarsh metabase and also the process of Resource Life Cycle Analysis of Ron Ross.

The *Project Staff* entity cluster enables the inclusion of the staff as resources for a contract, and also permit the specification of the specific types and performance ratings of skills that a person may bring to a specific project.

The *Project Building and Estimation* entity cluster represents the entities that support building projects. Projects and associated tasks are initially created through the use of the Project Deliverables, and Tasks Templates. Once projects and associated tasks are created, they are modified by attaching work environment factors and specific skill-level based staff assignments. Only then can task and project resources be computed.

Finally, as task work is accomplished, the *Project Work* entity is valued. As actual work is accomplished, it can be reported through any of its related entities.

5.2 Database Support for Earned Value Management

The meta entity clusters necessary for earned value management are:

- Contracts, Organizations, and Contract [staff] Resource
- Projects, Deliverable, and Task Templates entity
- Project Staff entity
- Project Building and Estimation
- Project Work

The sections that follow show how the data for these meta entities are necessary for earned value computation and management.

5.2.1 Contracts, Organizations, and Contract [staff] Resource

While doing earned value management for a given project is important, the real earned value management contribution is from its applicability across functions and/or entire organizations. A clear requirement of being an advanced CMMI level is earned value management. That's because with earned value management, results are reliable, repeatable and the recycling of the lessons leaned is critical to CMMI level 5. These meta entities enable projects to be set within context of an overall enterprise.

With these entities, project earned value analyses can be conducted across individual staff members, organizations, and contracts.

5.2.2 Projects, Deliverable, and Task Templates

The most critical earned value management meta-entities are project, deliverable, and task templates. While every project is different in terms of the quantity and possibly sequence of what is built, virtually all projects end up designing, building, testing, and maintaining objects within discrete, well-engineered object classes. That is, requirement specifications, database designs, data update processes, reports, analyses, testing plans, and the like. The Whitemarsh short papers, *Manufacturing Project Plans*, and *Function Points*, and *Project Metrics* all contribute to a comprehensive understanding of how to develop reliable and repeatable project plans that consist of highly engineered, standardized building blocks.

Each deliverable template consists of well defined components that are highly engineered, are created through a detailed set of steps, are stored in a metadata management system such as the Whitemarsh metabase, and are integrated with all other deliverables of the same class in an integrated and non-redundant fashion. Included with every deliverable are unit-effort staff-hour metrics. These staff hour metrics result in project estimates only after staff are allocated, and only after a project is set within specific work environments.

Because of these characteristics, every deliverable is able to be compared to every other deliverable of the same class with respect to the time required for development, the staff employed in the effort, the organizations required for the construction, and the like. Because of this, projects with earned value management computations too far away from the mean can be quickly identified and examined to understand the deviations.

Task templates provide a standardized set of process steps through which deliverables are constructed. A key value from these process steps ensures that no critical element is missed or not done in an appropriate manner. For example, a critical missing element might be that database designs are created without the benefit of a business information system generator to prove the adequacy of the database's design. Essentially, these process steps act as a comprehensive set of construction checklists along with suggestive processes.

In a way similar to deliverable templates, task templates enable cross functional and inter-organizational comparisons in terms of time and staff.

The key benefits from the earned value management evaluated projects that are based on deliverable and task templates are that these templates act as objective mechanisms that permit productivity determination across functions, organizations and staff. When this is done, the differences in actual costs from planned or scheduled costs become readily apparent. Additionally, there can be feedback lessons from a larger collection of similar deliverables and tasks. When this is done, the following can be computed:

- Budgeted cost of work performed (BCWP),
- Budgeted cost of work that was scheduled to be performed (BCWS), and
- Actual cost of work performed (ACWP).

These can be determined with greater confidence because the results are comparable across projects, deliverables, tasks, staff, and organizations.

5.2.3 Project Staff

One of the great imponderables of any project is assignable staff. No two are alike. How are their differences incorporated within the allocation of staff hours to a task? The key to the determination is the creation of skill level multipliers. Every person has a job description that includes tasks that can be performed within specific task types. If a staff member is among the "eagles" the multiplier is less than zero. Normal is 1.0, and "turkeys"are greater than 1.0.

As staff are assigned to tasks, their skill level multipliers are used to adjust the unit-effort staff-hour metrics associated with every deliverable. The resulting staff hour estimate is thereafter affected, one more time, by assigned Task and Work Environment Factors.

The benefit from the allocation of staff in this way is that the estimates are able to be normalized to account for the individual performance levels of individual staff members. Differences in Budgeted Cost of Work Performed (BCWP). and Budgeted cost of Work Scheduled (BCWS) can be explained because the likely differences will be the allocated staff. As work is done accomplished, the Actual Cost of Work Performed (ACWP) is likely to be closer to the Budgeted Cost of Work Performed (BCWP). and Budgeted cost of Work Scheduled (BCWS) that were created at the start of the project. The final benefits from this staff assignment approach is that the affect of a given staff member across multiple efforts can be compared. So too can the presumed benefit from assigning staff with certain skills and skill levels.

5.2.4 Project Building and Estimation

At the start of the process building and estimating project plans, the deliverables and tasks are known, the staff and staff skill levels are known. Remaining to be determined are the work environment factors within which projects "live," and the allocation of these work environment factors to staffed tasks.

The work environment tasks relate to the tools employed, the availability of client subject matter experts, the use of development tool sets and the like. Once these work environment factors are allocated to staffed-tasks, a final project estimate can be created. These created estimates become the Budgeted Cost of Work Performed (BCWP) and (Budgeted cost of Work Scheduled (BCWS) parts of earned value management. Work environment factors either shorten or lengthen estimates. For example, from the table that follows, if the Work Environment Factor doesn't apply the allocated factor is 1.0. If it does apply, and there is robust support then the Work Environment Factor is 1.0. But if there are no supports, the task effort estimate is multiplied by 1.3, or an extra 30%.

Work Environment Factor	Multiplier Effect on Estimate	
Equipment available for analyst/programmer	1.00	No effect
	1.00	Workstation connected with shared CASE and Metadata Management System
	1.10	PC with stand-alone case tool environment.
	1.25	PC with no case/metabase environment
	1.30	For no equipment available to the staff, except through an administrative person

5.2.5 Project Work

As projects are performed, costs in terms of staff expenditures, equipment, travel, and other project related costs are accumulated. Task status is also recorded, that is, completed, or percent complete. Depending on the Earned Value Management rules, earned value credit might be allowed for a partially complete task. For different tasks, for example the purchase, delivery, and setup of a computer, earned value might only accrue when the computer becomes operational..

At the end of an effort or period of time, the accumulated costs represent the Actual Cost of Work Performed (ACWP). It is likely that the Actual Cost of Work Performed (ACWP) will be very close to the Budgeted cost of Work Scheduled (BCWS) and Budgeted Cost of Work Performed (BCWP) because of all the work expended to develop the deliverable and task templates, the work unit effort estimates, the skill levels associated with the assigned staff, and the task and work environment factors.

5.3 Materials and Facilities Earned Value Management

Calculating the earned value for materials and facilities is rather simple. For facilities such as the rental of office space, utilities, property taxes, and the like the calculations for both actual and planned costs consists of setting out a schedule of when bills are due and then taking the earned value when the monies are paid.

For materials the process is a bit more difficult. It commonly involves an initial set of plans, estimates, and a schedule for when materials are needed, acquired, become operational, and are paid. At the point when a material becomes operational the earned value can commonly be taken. If a material becomes operational but the monies are not paid or an invoice is not received then the earned value is accrued. The accrual is reversed in a subsequent month when the invoice is received and the monies are paid.

The earned value calculations, that is for:

- Budgeted cost of work performed (BCWP),
- Budgeted cost of work scheduled (BCWS), and
- Actual cost of work performed (ACWP) .

are all able to be calculated with the understanding that the "work" is actually a material.

6.0 Conclusions

The estimate is the most critical element in earned value management. When the estimate is very accurate, there is a high probability that the performed work will closely match the planned and scheduled budgets. When this happens, the various ratios are close to 1.0 . That is:

- Schedule Variance (SV) = Budgeted Cost of Work Performed (BCWP) - Budgeted cost of Work Scheduled (BCWS). If 0, perfect. If >0, you're ahead. If <0, you're behind.

- Schedule Performance Index (SPI) = Budgeted Cost of Work Performed (BCWP) / Budgeted Cost of Work Scheduled (BCWS). If 0, OK. If >0, ahead. If <0, behind.

- Cost Variance (CV) = Budgeted Cost of Work Performed (BCWP) - Budgeted cost of Work Scheduled (BCWS). If 0, OK. If >0, you're under budget. If <0, you're over budget.

- Cost Performance Index (CPI) = Budgeted Cost of Work Performed (BCWP) / Budgeted cost of Work Scheduled (BCWS). If 0, OK. If >0, under budget. If <0, over budget.

However, if an estimating infrastructure is not present, that is, if there are no reliable and repeatable deliverable and task templates, no carefully calibrated skill levels, and no task and work environment factors with which to determine an accurate estimate, the likelihood that an estimate matches the costs incurred during work accomplishment is very low.

Organizations faced with severely mismatched estimates and actual costs that are, notwithstanding, required to accomplish the work according to the original estimates can react in only one of the following ways:

- Take a loss on the effort because it is accomplished through the expenditure of additional paid-staff effort.

- Convince that client that the bad estimates are due to reasons beyond the control of the developer.

- Convince the developing staff to expend significant quantities uncompensated staff hours to complete the work.

- Reduce or eliminate planned project tasks and deliverables that address, for example, review, testing, documentation, and quality control.

7.0 References

The following references to Whitemarsh materials provide a more detailed exposition practical application of the significant content of this paper.

The following documents are available free from the Whitemarsh website:

Papers and Materials Available for Free	
Paper	**URL**
Comprehensive Metadata Management	http://www.wiscorp.com/ComprehensiveMetadataManagement.pdf
Metabase Overview	http://www.wiscorp.com/Metabase.zip
Whitemarsh Data Modeler, Architecture and Concept of Operations	http://www.wiscorp.com/MetabaseDataModelerArchitectueandConceptofOperations.zip
Information Systems Planning: Book, Course, and Presentation (short and long) – samples Knowledge Worker Framework: Book, Course, and Presentation (short and long) – samples	http://www.wiscorp.com/EnterpriseDatabase.htm
Database Architecture Classes: sample	http://www.wiscorp.com/DatabaseDesign.htm
Resource Life Cycle Analysis: Paper	http://www.wiscorp.com/MetabaseProducts.htm
Database Project Work Breakdown Structure – sample	http://www.wiscorp.com/DatabaseProjects.htm
Resource Life Cycle Analysis Metabase Module User Guide	http://www.wiscorp.com/metabase_demo.html
Metabase System (Free Version) Request form	http://www.wiscorp.com/freemb.html

Short Papers: • October 2006 - Modeling Data and Designing Databases • February 2008 - Engineering and Managing Information Systems Plans • April 2008 - Manufacturing Project Plans • June 2008 - Function Points Strategy for Business Information System Estimating • September 2008 - Project Metrics	http://wiscorp.com/short_paper_series.html

The following documents are available for Whitemarsh Website Members. The URLs that follow provide descriptions of the pages. Members should log in and proceed to the appropriate page, e.g., Enterprise Database, find the book, paper, or course and perform the download.

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Data Management Program - Metadata Architecture For Data Sharing Data Management Program - Database Interface Architectures Data Management Program - Projects And Data-Asset Product Specifications Data Management Program - Work Breakdown Structures Knowledge Worker Framework Database Objects Managing Database - Four Critical Factors	http://www.wiscorp.com/wwmembr/mbr_products_edb.html
Data Architecture Classes Guidelines for Data Architecture Class - Data Warehouse Iterations of Database Design	http://www.wiscorp.com/wwmembr/mbr_products_dd.html

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Data Management Program - Metadata Architecture For Data Sharing Data Management Program - Database Interface Architectures Data Management Program - Projects And Data-Asset Product Specifications Data Management Program - Work Breakdown Structures Knowledge Worker Framework Database Objects Managing Database - Four Critical Factors	http://www.wiscorp.com/wwmembr/mbr_products_edb.html
Information Systems Planning: Book, Course, and Presentation (short and long) Knowledge Worker Framework: Book, Course, and Presentation (short and long)	http://www.wiscorp.com/wwmembr/mbr_products_edb.html