



NASCIO
Governance
Series



Data Governance Part II: Maturity Models – A Path to Progress

Introduction

In the previous report on Data Governance¹ an overview of data governance was presented describing the foundational issues that drive the necessity for state government to pursue a deliberate effort for managing its key information assets. Data governance or *governance of data, information and knowledge assets* resides within the greater umbrella of *enterprise architecture* and must be an enterprise-wide program. There is a significant cost to state government when data and information are not properly managed. In an emergency situation, conflicts in information can jeopardize the lives of citizens, first responders, law enforcement officers, fire fighters, and medical personnel.

Redundant sources for data can lead to conflicting data which can lead to ineffective decision making and costly investigative research. If data from different sources conflicts, then the decision maker must research and analyze the various data and the sources for that data to determine or approximate what is true and accurate. That exercise burns time and resources. Accurate, complete, timely, secure, quality information will empower decision makers to be more effective and expeditious. More effective decision making leads to higher levels of enterprise performance. The ultimate outcome is better service to citizens at a lower cost.

When government can respond effectively and expeditiously to its constituents, it gains credibility with citizens. The opposite is also true. When government can't respond, or responds incorrectly, or too slowly, based on inaccurate information, or a lack of data consistency across agencies, government's credibility suffers.

This research brief will present a number of data governance maturity models² which have been developed by widely recognized thought leaders. These models provide a foundational reference for understanding data governance and for understanding the journey that must be anticipated and planned for achieving effective governance of data, information and knowledge assets. This report continues to build on the concepts presented in Data Governance Part I. It presents a *portfolio* of data governance maturity models. Future publications will present other important elements that comprise a full data governance initiative. These other elements include frameworks, organization, delivery processes, and tools.

Maturity models provide a means for seeing "what are we getting into?" The higher levels of maturity present a vision or future state toward which state government aspires and corresponds to not only a mature data governance discipline, but also describe a mature enterprise architecture discipline. The case has already been

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made in Data Governance Part I that state government will never be able to effectively respond to citizens without properly governing its information and knowledge assets.

In early 2009, the states are under severe economic stress—major revenue shortfalls, growing deficits and reduced public spending. State governments expect continued expenditure pressures from a variety of sources including Medicaid, employee pensions and infrastructure. Experts predict even more economic troubles for the states in fiscal year 2010 and beyond. A key ingredient for establishing strategies for dealing with continuing fiscal crisis is the ability to effectively harvest existing knowledge bases. Those knowledge bases must provide reliable, up to date information in order to enable judgment, discernment and intuition. These comprise what might be termed *wisdom*. Even with perfect information, wisdom is still required to make the right decisions and to execute on those decisions. State leaders will be forced to make tough decisions in the months ahead, certainly requiring wisdom. This research brief will focus on that first key ingredient—knowledge. So, state government must make the commitment to begin now to manage and govern its information and knowledge assets. Maturity models assist in helping state government prepare for the journey and that is what this report is intended to present. Governance will not happen overnight—it will take sustained effort and commitment from the entire enterprise.

As state government moves up the maturity curve presented by these models, there will be technological and business process ramifications. However, nothing will compare to the organizational fallout. It will take commitment and leadership from executive management to bring the enterprise along in a way so that it will be a positive experience for government employees and citizens. See NASCIO's publication "Transforming Government through Change Management: The Role of

the State CIO" for further discussion of organizational change management.³

The growing importance of properly managing information and knowledge assets is demonstrated by a number of predictions regarding data and data governance by the IBM Data Governance Council.⁴

IBM Data Governance Council Predictions

- *Data governance will become a regulatory requirement.*
- *Information assets will be treated as an asset and included on the balance sheet.*
- *Risk calculations will become more pervasive and automated.*
- *The role of the CIO will include responsibility for data quality.*
- *Individual employees will be required to take responsibility for governance.*

As described in the previous issue brief on this subject the delivery process must begin with an understanding of what the end result will look like, and what value a data governance initiative will deliver to state government. Value is defined by executive leadership and depends on the vision, mission, goals and objectives executive leadership has established for the state government enterprise. The value delivery process must also provide methods and procedures for monitoring how well state government is currently performing and the incremental steps for reaching the desired level of performance.

The process for establishing and sustaining an effective data governance program will require employing the following enablers:

- **Strategic Intent:** describes WHY data governance is of value, the end state that government is trying to reach, and the foundational policies that describe the motivation of executive leadership. This strategic intent should be described in the enterprise business

architecture. If state government does not have quality data and information, it will not achieve its objectives. Flawed data and information will lead to flawed decisions and poor service delivery to citizens.

- **Data Governance Maturity Model:** describes the journey from the AS IS to the SHOULD BE regarding the management of data, information and knowledge assets. In parallel to this journey regarding data governance is the journey that describes a maturing enterprise architecture operating discipline. State government must understand where it is today and where it needs to go. This is an important step in *planning the journey* in managing information as an enterprise asset. Data governance maturity models provide the means for gauging progress. By presenting intermediate milestones as well as the desired end state, maturity models assist in planning HOW state government will reach the next level of effectiveness, as well as WHEN and WHERE within state government.
- **Organizational Models, Roles and Responsibility Matrices (RASIC Charts)⁵:** defines WHO should be involved in decision making, implementing, monitoring and sustaining. Organizational models are a component of the enterprise business architecture. An enterprise wide initiative will require the authority of executive leadership and buy in from all participants. Proper representation from stakeholders is also necessary for managing risk. Collective wisdom can avoid missteps and false starts. Stakeholders and decision rights will vary depending on the specific issue or the nature of the decision.
- **Framework:** describes WHAT is governed including related concepts, components and the interrelationships among them. Decomposition of frameworks will uncover the necessary artifacts that comprise the components of the framework. The

framework for data governance will co-exist with other frameworks that describe other major components of the state government enterprise architecture.

- **Methodology for Navigating the Framework:** describes the methods and procedures for HOW to navigate through the framework, create the artifacts that describe the enterprise, and sustain the effort over time. This methodology will co-exist within the enterprise architecture methodology and touch on business architecture, process architecture, data architecture, organizational governance, data / knowledge management processes, and records management processes.
- **Performance Metrics:** to measure and evaluate progress and efficacy of the initiative. These are traceable back to strategic intent and related maturity models. These metrics need to be continually evaluated for relevancy.
- **Valuation and Security** of State Government Information Assets. As presented in the previous issue brief on data governance, proper valuation of data and information will determine the level of investment to ensure quality and appropriate security throughout the information asset lifecycle. This is where the data architecture and security architecture domains touch within state government enterprise architecture.

This research brief will focus on presenting various *data maturity models*. Future briefs or webinars will treat other foundational aspects of data and information governance. Some common themes presented by the variety of maturity models and their associated migrations to the higher levels of maturity can be described as follows and also reflect a maturing enterprise architecture.

- **From reactive to proactive understanding of the management of data and information**

- **From point solutions to managed enterprise solutions**
- **From “siloeed” data to synchronized data and information (i.e., consistent, quality data)**
- **From localized systems with inconsistent levels of data classification and security to consistent data classification and standards based managed security**
- **From myopic approach to data management to an enterprise wide view of information**
- **Migration to the capability to build efficient information and knowledge management**

Strategic Planning Assumption: Through 2010, more than 75% of organizations will not get beyond Levels 1 and 2 in their data quality maturity (0.8 probability).

Strategic Planning Assumption: Through 2012, less than 10% of organizations will achieve Level 5 data quality maturity (0.8 probability). - Gartner⁶

Implementing Data Governance – Maturity Models

There are a number of data governance maturity models that can assist in the planning and implementation of data governance. Each has strengths and can bring valuable perspectives, present characteristics, and form the foundation for subsequently planning a data governance delivery process. Reviewing and evaluating maturity models should occur early in the process in order to establish an understanding of the end state. This understanding is necessary to properly plan a data governance program. It must be understood that the delivery process is an *ongoing enterprise operating discipline* which fits under the greater umbrella of *enterprise architecture*. As with many of the concepts presented by NASCIO, successful implementation of data governance requires an *enterprise perspective*. This perspective will be portrayed in the higher stages of the maturity models presented in this report.

It should be expected that data governance maturity models will also “mature” as industry, government and society continue to “learn” how to manage and leverage data, information and knowledge, and most importantly *act* on that learning. Geospatial resources and social networks are but two examples of change.

GIS and geospatial resource management initiatives have demonstrated the value of high level associations and correlations. Social networks have demonstrated the value of group knowledge, and mass collaboration.

The current issues in information management began with the way systems were developed. Application teams worked in isolation. Applications were built for *immediate return*. And project teams were incented and pressured to deliver immediate results without proper consideration for long term enterprise value and cost. Point solutions contributed greatly to the current circumstances described in Data Governance Part I. Data governance initiatives must anticipate the necessity of dealing with the data fragmentation that exists as an aftermath of these circumstances.

Current federal programmatic funding guidelines and restrictions *have not* contributed toward creating enterprise wide initiatives such as data governance. Therefore, funding for enterprise wide initiatives must come from a state general or technology fund. Data governance including master data management *should* be factored into every project including those that are federally funded. Reviews *should* be conducted to ensure projects and programs are in compliance with state government principles, standards and methods. Federal funding reforms *should* take into account the level of effort associated with such compliance and provide the latitude and flexibility to invest responsibly at an enterprise level so state government can do what it needs to in order to build long term value for the state. This will require strong partnering and collaboration between state and federal government.

There is the need for proper governance structures that provide appropriate representation, decision rights, and renewed methods and procedures to ensure state government is not simply responding to federal mandates and restrictive reporting requirements. And that state government

isn't forced into "siloed" solutions because of funding restrictions. Rather, state and federal government work together to develop funding mechanisms that give states the flexibility they need to build long term value, shareable resources and increased efficiency. Such an approach should also allow or even encourage collaboration between state and local government on joint initiatives.

As state government begins to think of data, information and knowledge as one of the most critical enterprise assets, the use of maturity models provides a means for assessing where the organization is today and what will be required to migrate to the desired end state. Maturity models also assist in setting expectations. The journey the enterprise must take in developing the capabilities to properly manage, and harvest value from its knowledge assets will not be an easy trip. Maturity models also assist in planning what is feasible in the near term—particularly

when state government is facing severe fiscal stress. Nevertheless, even during times of fiscal stress, state government must make progress so it can better manage limited resources in the near term, and emerge from such times ready to move forward. It will require constancy of purpose⁸, consistency in executive support, and a sustained effort by the entire enterprise. One other aspect to this subject is the need to view data, information and knowledge from the citizens' perspective versus agency specific perspective. The citizen would like to "see" *one state government*—not a collection of agencies.

This research brief will look at a sampling of data governance maturity models and draw some conclusions regarding the role of maturity models in developing data governance within state government.

One of the key drivers of EIM [Enterprise Information Management] is to overcome decades of "silo-based," application-centric development, in which each system maintained its own version of data and process rules to suit local performance needs. This resulted in duplication and a lack of agility within the organization. - Gartner⁷

TABLE 1: DataFlux DATA GOVERNANCE MATURITY MODEL

| | Level of Maturity | Characteristics |
|---|---|---|
| 1 | Undisciplined <i>(Think Locally, Act Locally)</i> | There are few defined rules and policies about data quality and integration. There is much redundant data, differing sources, formats and records. The existing threat is that bad data and information will lead to bad decisions, and lost opportunities. |
| 2 | Reactive <i>(Think Globally, Act Locally)</i> | This is the <i>beginning</i> of data governance. There is much reconciliation of inconsistent, inaccurate, unreliable data. Gains are experienced at the department level. |
| 3 | Proactive <i>(Think Globally, Act Collectively)</i> | It is a very difficult step to move to this phase. The enterprise understands the value of a unified view of information and knowledge. The enterprise begins thinking about Master Data Management (MDM). The organization is learning and preparing for the next stage. The culture is preparing to change. |
| 4 | Governed <i>(Think Globally, Act Globally)</i> | Information is unified across the enterprise. The enterprise has a sophisticated data strategy and framework. A major culture shift has occurred. People have embraced the idea that information is a key enterprise asset. |

“Process failure and information scrap and rework caused by defective information costs the United States alone \$1.5 trillion or more.” - Larry English, Information Impact International, Inc.¹⁰

DataFlux

The DataFlux Data Governance Maturity Model is very comprehensive. As the enterprise moves through the sequence from stage one to stage four, the value harvested increases and the risk associated with “bad data” decreases.

Tony Fisher, President and General Manager of DataFlux, presents an excellent overview of information governance maturity on the SAS website.⁹ Fisher is speaking about “Data Maturity” in that presentation. The scope of his discussion is relevant to the subject of this research brief—the broader view of data governance maturity models. Again, the terms can get fuzzy in different conversations—data governance, data management,

knowledge management, data assets and information assets. DataFlux has recently modified their maturity model to emphasize a *business perspective* that drives the need for managing data as an enterprise asset, and the employment of means such as organization, process, and technology to achieve the necessary levels of data quality. The phases in the DataFlux model are presented here (Table 1).

DataFlux developed each stage of data maturity by describing the characteristics of each phase of maturity and how to move to the next phase. These characteristics are formulated into four major dimensions that must be addressed as state government matures its data governance. The dimensions are: *people, policies, technology* and *risk*. DataFlux has presented

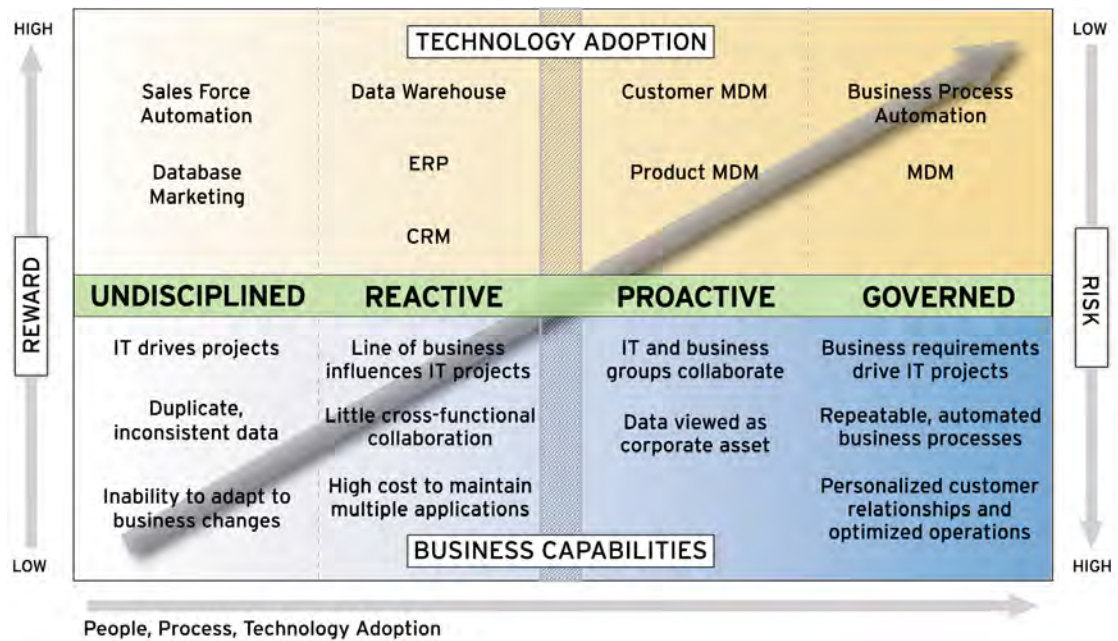
TABLE 2: DIMENSIONS IN THE DataFlux DATA GOVERNANCE MATURITY MODEL: LEVEL FOUR – “GOVERNED”

| | |
|--|---|
| <p>People</p> <ul style="list-style-type: none"> ▪ Executive sponsorship. ▪ Data consumers actively participate in strategy and delivery. ▪ Roles are established such as data steward. ▪ A data governance expertise center exists. ▪ The organization truly embraces data quality and adopts a “zero defect” policy for data collection and management. | <p>Policies</p> <ul style="list-style-type: none"> ▪ New project framing embraces a portfolio perspective considering the full impact on existing data infrastructure. ▪ Automated policies are implemented to ensure data consistency, accuracy and reliability across the enterprise. ▪ Service Oriented Architecture (SOA) approaches have been employed to manage meta data including data quality, data classification, identity management, and authentication. ▪ Policy perspective is preventative rather than reactive. |
| <p>Technology</p> <ul style="list-style-type: none"> ▪ Data quality and data integration tools are standardized across the enterprise. ▪ Data monitoring is continuous, proactive and preventative involving appropriate metrics. ▪ The enterprise has established its master data model – or The Enterprise Data Model – data models are maintained using consistent approaches and standards. ▪ Data models capture semantic business rules that provide the business understanding and technical details of all enterprise data. | <p>Risk</p> <ul style="list-style-type: none"> ▪ Enterprise risk management is proactive providing proper balance across the enterprise portfolio. ▪ Master data is tightly controlled across the enterprise but allows the enterprise to be dynamic. ▪ Enterprise data is consistent, reliable, and available to enable effective decision making. |

that although there is no single path to reaching the higher levels of data governance, whatever path is taken, it will require careful attention to these four dimensions. Each stage has an associated profile detailing these four dimensions. One of the strengths of this maturity model is these detailed descriptions. The

descriptions are self evident regarding how to move up the maturity ladder. As an example, the four dimensions that apply to the *target maturity level—Level Four*—can be characterized as shown in Table 2.¹¹ Further detail on this model and the profiles for the other levels of maturity can be found in the article cited.

FIGURE 1: DataFlux DATA GOVERNANCE MATURITY MODEL



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The latest version of the DataFlux data governance framework is as shown in Figure 1. This framework also presents the technology adoption that characterizes the various phases. Each level of maturity has associated “business capabilities” or business behaviors, and examples of technologies employed. As the enterprise progresses to the higher levels of data governance maturity, there is greater reward—return on information and knowledge assets—and a parallel reduction in risk.

TABLE 3: EWSolutions DATA GOVERNANCE MATURITY MODEL

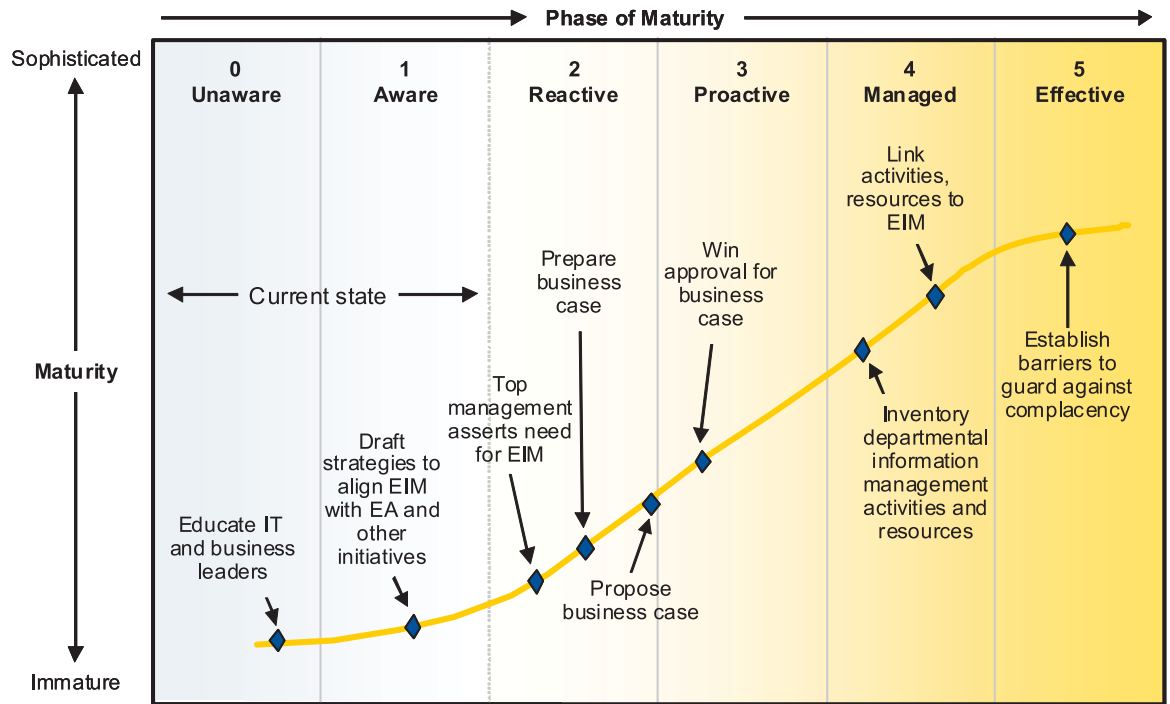
| | Level of Maturity | Characteristics |
|---|-----------------------------|---|
| 1 | Informal Processes | <p>Reactive, dependent on a few skilled individuals, responsibilities assigned across separate IT groups, few defined IT roles, data regarded as a minor by-product of business activity. Redundant, undocumented data, disparate databases without architecture, minimal data integration and cleansing, point solutions.</p> <ul style="list-style-type: none"> ▪ Little or no business metadata ▪ Diverging semantics ▪ Some commonly used approaches but with no enterprise-wide buy in ▪ Little or no business involvement, no defined business roles ▪ Reactive monitoring and problem solving |
| 2 | Emerging Processes | <p>Beginning to look at enterprise wide management and stewardship, no standard approaches, early enterprise architecture, growing intuitive executive awareness of the value of information assets.</p> <ul style="list-style-type: none"> ▪ Initial forays in data stewardship and governance but roles are unclear and not ongoing ▪ Initial efforts to implement enterprise-wide management, but with contention across groups with differing perspectives ▪ Enterprise architecture and master meta data management projects are underway ▪ Some processes are repeatable |
| 3 | Engineered Processes | <p>Standard processes, enterprise information architecture, active executive sponsorship, central metadata management, periodic audits and proactive monitoring.</p> <ul style="list-style-type: none"> ▪ Ongoing, clearly-defined business data stewardship ▪ Central enterprise data management organization ▪ Enterprise data architecture guides implementations ▪ Quality service level agreements are defined and monitored regularly ▪ Commitment to continual skills development |
| 4 | Controlled Processes | <p>Measureable process goals are established for each defined process.</p> <ul style="list-style-type: none"> ▪ Quantitative measurement and analysis of each process occurs ▪ Beginning to predict future performance ▪ Defects are proactively identified and corrected |
| 5 | Optimized Processes | <p>Quantitative and qualitative understanding used to continually improve each process.</p> <ul style="list-style-type: none"> ▪ Value is monitored continuously ▪ Understanding of how each process contributes to the strategic business intent |

EWSolutions

EWSolutions presents a maturity model they title the “EIM Maturity Model” which presents five phases. EIM refers to *Enterprise Information Management*. The phases in the EWSolutions model are presented in Table 3. The full presentation

of this model is presented in EWSolutions course materials.¹² EWSolutions present their maturity model early in their training on data governance and stewardship which demonstrates the value of maturity models as a communication and planning tool.

FIGURE 2: Gartner EIM MATURITY MODEL



Gartner

Gartner introduced their enterprise information management maturity model in December of 2008 (Figure 2).¹³ Gartner makes the point that enterprise information management (EIM) is not a single project. Rather, it is a program that evolves over time.

Gartner presents that “managing information as an asset” has gained new attention by top management. Further, over the next five years industry will focus on managing information as a *strategic asset*. Gartner developed their maturity model to provide guidance to organizations that are

serious about managing information assets. It is important to understand this maturity model accompanies Gartner’s definition of EIM. This maturity model also presents action items for each level of maturity (Table 4). Gartner’s EIM concept presents an integrated, enterprise wide approach to managing information assets and has five major goals that comprise an EIM discipline (Figure 3).

TABLE 4: Gartner EIM DATA GOVERNANCE MATURITY MODEL

| | Level of Maturity | Characteristics |
|---|-------------------|---|
| 0 | Unaware | <ul style="list-style-type: none"> ▪ Strategic decision made without adequate information ▪ Lack of formal information architecture, principles, or process for sharing information ▪ Lack of information governance, security and accountability ▪ Lack of understanding of meta data, common taxonomies, vocabularies and data models |
| <p>Action Item: Architecture staff and strategic planners should informally educate IT and business leaders on the potential value of EIM, and the risks of not having it, especially legal and compliance issues.</p> | | |
| 1 | Aware | <ul style="list-style-type: none"> ▪ Understanding of the value of information ▪ Issues of data ownership ▪ Recognized need for common standards, methods and procedures ▪ Initial attempts at understanding risks associated with not properly managing information |
| <p>Action Item: Architecture staff needs to develop and communicate EIM strategies and ensure those strategies align with [the state government] strategic intent and enterprise architecture.</p> | | |
| 2 | Reactive | <ul style="list-style-type: none"> ▪ Business understands the value of information ▪ Information is shared on cross-functional projects ▪ Early steps toward cross-departmental data sharing ▪ Information quality addressed in reactive mode ▪ Many point to point interfaces ▪ Beginning to collect metrics that describe current state |
| <p>Action Item: Top management should promote EIM as a discipline for dealing with cross-functional issues. The value proposition for EIM must be presented through scenarios and business cases.</p> | | |
| 3 | Proactive | <ul style="list-style-type: none"> ▪ Information is viewed as necessary for improving performance ▪ Information sharing viewed as necessary for enabling enterprise wide initiatives. ▪ Enterprise information architecture provides guidance to EIM program ▪ Governance roles and structure becomes formalized ▪ Data governance integrated with systems development methodology |
| <p>Action Item: Develop a formal business case for EIM and prepare appropriate presentations to explain the business case to management and other stakeholders. Identify EIM opportunities within business units [agencies and divisions].</p> | | |

| | Level of Maturity | Characteristics |
|--|-------------------|---|
| 4 | Managed | <ul style="list-style-type: none"> ▪ The enterprise understands information is critical ▪ Policies and standards are developed for achieving consistency. These policies and standards are understood throughout the enterprise ▪ Governance organization is in place to resolve issues related to cross-functional information management ▪ Valuation of information assets and productivity metrics are developed |
| <p>Action Item: [Agency and division] information management activities should be inventoried and tied to the overall [state government] EIM strategy. EIM must be managed as a program not a series of projects. Chart progress using a balanced scorecard for information management.</p> | | |
| 5 | Effective | <ul style="list-style-type: none"> ▪ Information value is harvested throughout the information supply chain ▪ Service level agreements are established ▪ Top management sees competitive advantage to be gained by properly exploiting information assets ▪ EIM strategies link to risk management, productivity targets ▪ EIM organization is formalized using one of several approaches similar to project management. The EIM organization coordinates activities across the enterprise |
| <p>Action Item: Implement technical controls and procedures to guard against complacency and to sustain information excellence even as the [state government] changes.</p> | | |

FIGURE 3: Gartner EIM GOALS

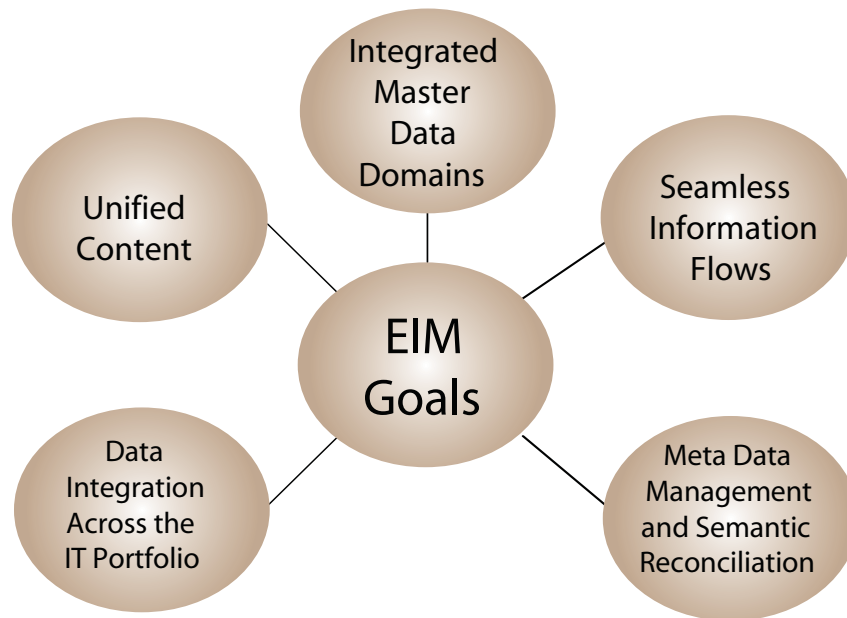
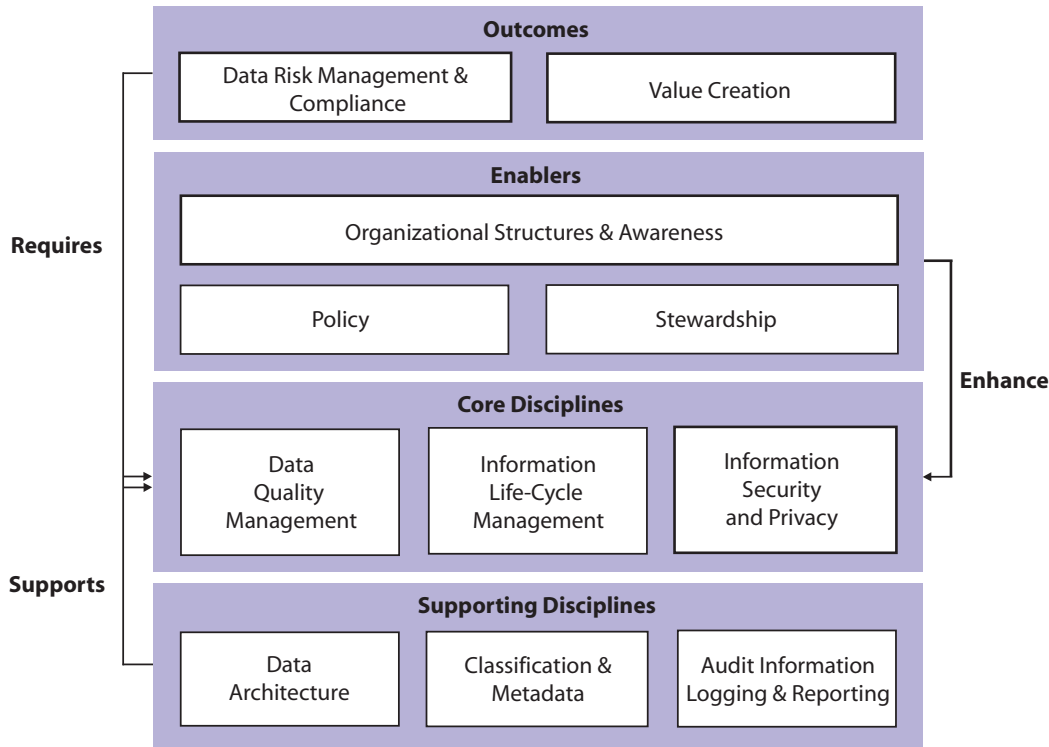


FIGURE 4: IBM Data Governance Council – DATA GOVERNANCE DOMAINS

Elements of Effective Data Governance



IBM

Data governance has risen to such prominence that IBM has created a Data Governance Council.¹⁴ One of the initiatives from this council is a data governance maturity model based on the Software Engineering Institute (SEI) Capability Maturity Model (CMM).^{15,16} The Data Governance Council's Maturity Model defines a set of domains that comprise data governance. Review of these domains is a first step in understanding the IBM maturity model. The 11 domains reside within four major groupings: *Outcomes, Enablers, Core Disciplines, and Supporting Disciplines*. Interactions among these groupings are depicted in the diagram above (Figure 4).

Business *outcomes* require *enablers*. *Enablers* are supported through core and supporting *disciplines*. Each of the domains or disciplines depicted can be further broken down into multiple components. This paper won't fully explore this model in depth but will present the definitions of each domain. The *maturity* of each domain is evaluated and assessed individually on a scale from 1 to 5. The intent is not to score—rather to determine the AS IS and manage progress through the various maturity levels (Table 5).

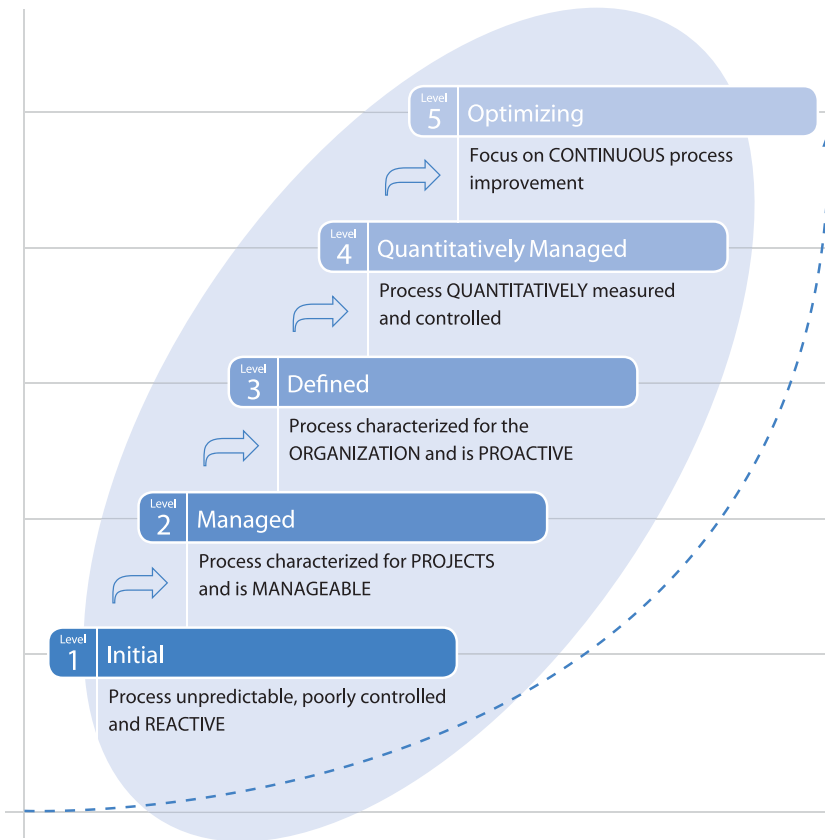
In concert with this framework, IBM developed the maturity model presented in Figure 5.

The maturity model is the “yardstick” for assessing and measuring progress within each of the 11 domains. The referenced report that presents this maturity model was published in October of 2007. In July

TABLE 5: IBM Data Governance Council – DATA GOVERNANCE DOMAIN DEFINITIONS

| Domain | Description |
|--|---|
| Data Risk Management & Compliance | The methodology by which risks are identified, qualified, and quantified, avoided, accepted, mitigated or transferred out. |
| Value Creation | The process by which data assets are qualified and quantified to enable the business to maximize the value created by data assets. |
| Organizational Structures & Awareness | Description of the level of mutual responsibility between the business and IT, and the recognition of the fiduciary responsibility to govern data at different levels of management. |
| Policy | A description of the desired organizational behavior(s). |
| Stewardship | A quality control discipline designed to ensure custodial care of data for asset enhancement, risk management, and organizational control. |
| Data Quality Management | Methods to measure, improve and certify the quality and integrity of production, test and archival data. |
| Information Lifecycle Management | A systematic policy-based approach to information collection, use, retention, and deletion. |
| Information Security & Privacy | The policies, practices and controls used by the organization to mitigate risk and protect data assets. |
| Data Architecture | The architectural design of structured and unstructured data systems and applications that enable data availability and distribution to appropriate users. |
| Classification & Metadata | The methods and tools used to create common semantic definitions for business and IT terms, data models, data types, and repositories. Metadata that bridge human and computer understanding. |
| Audit Information, Logging & Reporting | The organizational processes for monitoring and measuring the data value, risks, and efficacy of governance. |

FIGURE 5: IBM Data Governance Council MATURITY MODEL



- Up to 75% of information workers have made decisions that turned out to be wrong due to flawed data.
- As much as 30% of the work week is spent verifying the accuracy and quality of data.
- Only 10% of knowledge workers believe they always have all the information needed to confidently make effective business decisions.¹⁷

of 2008, the Council announced its plans to develop a data governance framework based on this maturity model.

As described earlier, maturity models and frameworks are necessary members of the data governance toolbox. The *maturity model* describes the milestones in the journey. The *framework* presents concepts and the most prominent of the relationships among the concepts. A *methodology* will describe how to navigate the framework in order to travel up the maturity model.

One of the values of maturity models is that in describing the characteristics of each stage, they describe enterprise characteristics sought, independent of any maturity model. State government does not have to follow a linear path through these stages. A foundational concept that was used in the NASCIO Enterprise Architecture Maturity Model was that the

various domains of enterprise architecture will naturally, and most likely be at different levels of maturity. That brings up a differentiating property of the IBM maturity model. It is used to assess the individual maturity of 11 separate domains.

Knowledge Logistics

The Commonwealth of Kentucky has initiated a data governance initiative using a maturity model designed by Knowledge Logistics (Table 6). This model also follows closely with the CMM levels of maturity. As with the other maturity models presented, characteristics change or evolve from reactive, independent activities to very sophisticated leverage of information assets not only for historical analysis but predictive activities.

TABLE 6: Knowledge Logistics DATA GOVERNANCE MATURITY LEVELS

| | Level of Maturity | Characteristics |
|---|-------------------|---|
| 1 | Initial | <ul style="list-style-type: none"> ▪ Entrepreneurial ▪ Individual ▪ Fragmented ▪ Chaotic ▪ Idiosyncratic ▪ Few Users ▪ Rules Unknown ▪ Variable Quality ▪ Costly |
| 2 | Repeatable | <ul style="list-style-type: none"> ▪ Departmental ▪ Consolidation ▪ Reconciliation ▪ Internally Defined ▪ Reactive ▪ Local Standards ▪ Internal Data Quality ▪ Specialist Users ▪ Local Process ▪ Costly |
| 3 | Defined | <ul style="list-style-type: none"> ▪ Integration ▪ Enterprise View ▪ Data Accountability ▪ Strategic Alignment ▪ Standards ▪ Sharing & Reuse ▪ Centralized Data Quality ▪ Planned & Tracked ▪ Wide Data Usage ▪ Metadata Management ▪ Common Technology ▪ Efficient |
| 4 | Managed | <ul style="list-style-type: none"> ▪ Quantitative Control ▪ Closed Loop ▪ Low Latency ▪ Interactive ▪ Unstructured Data ▪ Collaborative ▪ Process Efficiency & Effectiveness ▪ Built-in Quality ▪ Extended Value Chains ▪ High Availability |
| 5 | Optimized | <ul style="list-style-type: none"> ▪ Improvement & Innovation ▪ Real-time ▪ Extensive Data Mining ▪ Knowledgeable ▪ Competitive Intelligence ▪ Data Assets Valued ▪ Self-managing |

TABLE 7: MDM Institute DATA GOVERNANCE MATURITY LEVELS

| | Level of Maturity | Characteristics |
|----------|---|--|
| 1 | Basic <i>("anarchy")</i> | Application-centric approach; meets business needs only on project-specific basis. |
| 2 | Foundational <i>("IT monarchy")</i> | Policy-driven standardization on technology and methods; common usage of tools and procedures across projects. |
| 3 | Advanced <i>("business monarchy")</i> | Rationalized data, with data and metadata actively shared in production across sources. |
| 4 | Distinctive <i>("Federalist")</i> | Based on service-oriented architecture (SOA) with modular components, integrated view of compliance requirements, formalized organization with defined roles and responsibilities, clearly defined metrics, and an iterative learning cycle. |

When organizations articulate a desire to "manage information as an enterprise asset," they often don't know how to begin. - Gartner¹⁹

MDM Institute

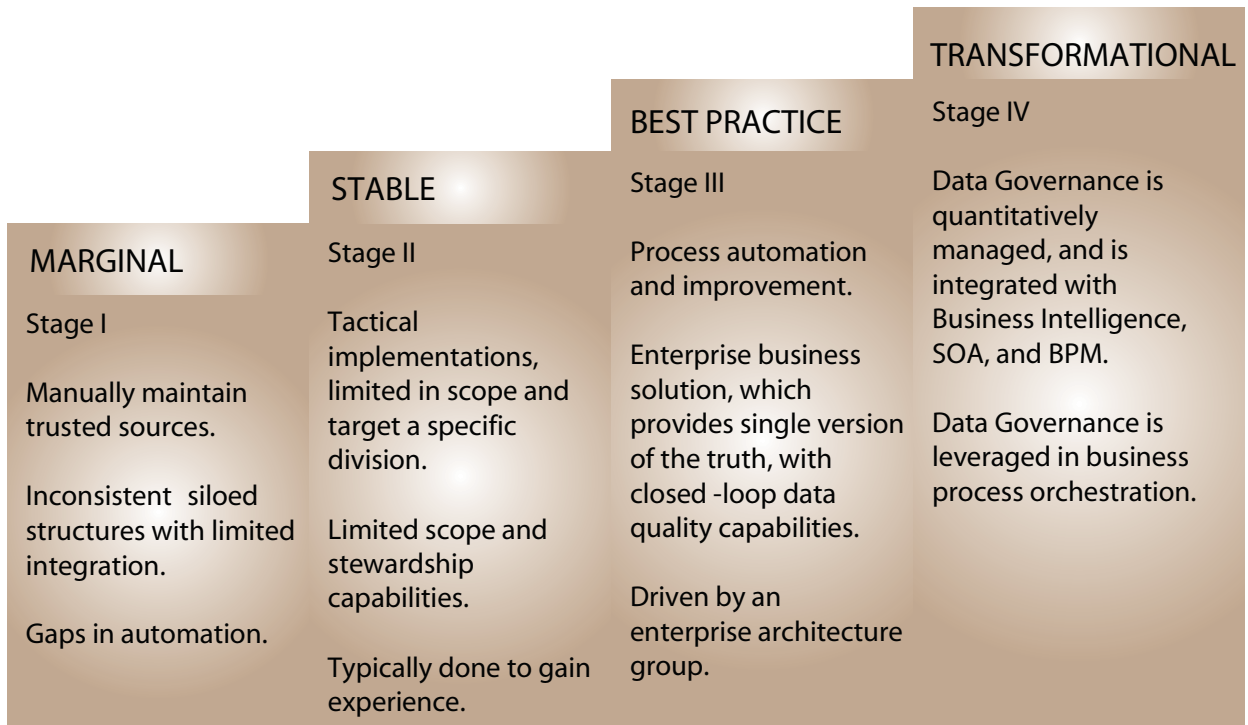
The MDM Institute (formerly known as the CDI Institute) presents the data governance maturity model¹⁸ shown in Table 7. This model provides an excellent starting point for initiating the conversation about data governance. The essence of this model is a migration from the initial state which is described as reactive, no control, application and project driven to a formalized approach. The MDM Institute emphasizes leveraging service oriented architecture (SOA) as a foundational approach for planning, designing and implementing enterprise services including data and information services. The MDM Institute's definition of data governance also has a Master Data Management (MDM) focus in level 3 and an SOA flavor to distribute the governed master data across the enterprise in step 4.

"The formal orchestration of people, processes, and technology to enable an organization to leverage data as an enterprise asset."

—The MDM Institute definition of data governance

This model is phased with fewer steps, but is based on the same concept of an evolving maturity. At the higher levels the business side of the organization is playing an active role.

FIGURE 6: Oracle DATA GOVERNANCE MATURITY MODEL



Oracle Corporation

Oracle is well known for its emphasis on a well designed underlying data architecture. Oracle Corporation maintains an expertise in data governance consistent with the definitions for data governance presented in NASCIO’s Data Governance Part I issue brief. Effective data governance must correctly align people, processes, and technology to convert data into strategic information and knowledge assets for the state government enterprise.

It is important to understand that the data that needs governing resides across a wide variety of heterogeneous applications and business intelligence systems. Most data quality problems begin in these fragmented applications. The very nature of this data makes it difficult to manage and creates challenges for data governance.

Becoming an organization that fully controls and leverages its key data assets is an evolutionary process. Oracle’s Data Governance Maturity Model is intended to

be used to determine what steps an enterprise will need to make to improve its data governance capabilities. That intention is in direct support of the rationale and intended outcome of this research brief and provides validation of our approach.

As described in the introduction, Oracle Corporation also believes that a data governance maturity model will assist the enterprise in determining where they are in the evolution of their data governance discipline and identifies the short-term steps necessary to get to the next level (Figure 6 & Table 8). Each step on the journey has associated measurable key performance indicators with real return on investment that justifies the cost.

A Survey of Progress in Data Governance

So where do organizations stand in their progress? A survey was conducted by Aiken, Allen, Parker, and Mattia that explored the current standing of data management practice maturity.²⁰

TABLE 8: Oracle DATA GOVERNANCE MATURITY LEVELS

| | Level of Maturity | Characteristics |
|----------|--------------------------|---|
| 1 | Marginal | Stage I reflects an organization that has started to understand the need for data governance. They will need to expand the scope of ongoing data quality initiatives, and add data stewardship capabilities. |
| 2 | Stable | Stage II is characterized by division wide data governance initiatives with data governance teams in place. Socializing the successes achieved at this level helps drive increased demand for further progress. Enterprise wide teams need to be formed and cross divisional conflicts around data ownership and access rights need to be resolved. Master Data Management solutions need to be deployed. |
| 3 | Best Practice | Stage III organizations are running best data governance practices across their enterprise. Data governance policies are executed automatically by Master Data Management execution engines, and feedback loops that report results directly back to the governance committees. |
| 4 | Transformational | Stage IV integrates the proven quality data in the applications and business intelligence tools directly into all business processes to achieve transformational status for the organization. |

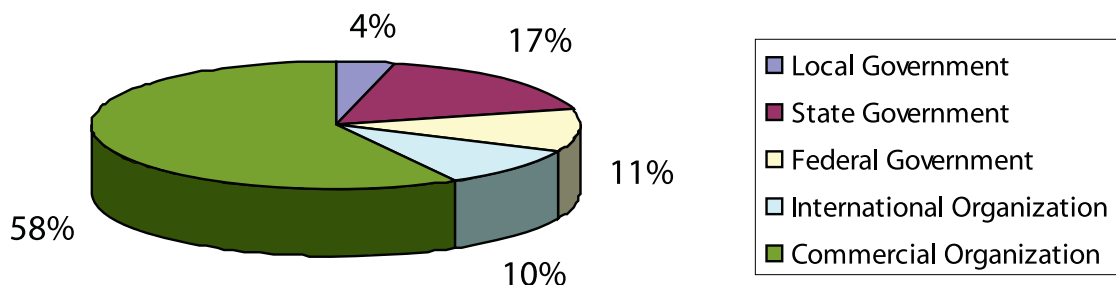
Although this research brief is focused on data governance, the research from Aiken et al. is very relevant to our discussion because of the consistency in the outcomes sought. This research brief, the research by Aiken et al., and the summary of each of the maturity models are all directed at the same outcome: managing data, information and knowledge as enterprise assets in order to achieve enterprise intent.

175 organizations were assessed during the period 2000 to 2006 with the intent of determining the maturity of data management practices. Such a study provides a general understanding of progress made in truly managing information as an enterprise asset and how carefully it is

harvested for value. This study also provides state government with assistance in determining how it stacks up against the rest of the “world” regarding its management of information assets—is state government ahead, behind, or on par with industry, federal government, etc.

The results are consistent with where states currently reside on any maturity scale. However, the point made by Aiken et al., is that armed with this information many organizations will see the opportunity for competitive advantage by deliberately directing resources and incentives to pursue higher levels of maturity in managing enterprise information assets. State government isn’t necessarily subject to competitive forces that characterize

FIGURE 7: ORGANIZATIONS IN SURVEY



most markets. However, state government is involved in an unprecedented pressure to make gains in effectiveness while facing ongoing fiscal crisis. In this way, competitive forces are turned inward—state agencies may eventually be evaluated for effectiveness and may in future compete for limited internal resources. Therefore, the pressure is still on government and even non-profit organizations to effectively manage enterprise information assets.

Figure 7 presents a profile of the organizations that participated in this survey.

The maturity model used is based primarily on the Carnegie Mellon University Software Engineering Institute’s Capability Maturity Model Integration (CMMI)²¹ and resembles maturity models presented earlier in this report. The rationale presented by Aiken et al. is the adaptation and prevalent usage of CMMI maturity levels to other areas of software engineering. The data maturity levels are presented in Table 9. This approach provides the ability to compare the maturity of data management with other domains within enterprise architecture.

The assessment evaluated 5 predefined data management processes (adapted from Parker²²). (See appendix for definitions of these processes and the statistical results from this survey.) Per CMMI practice, overall ratings for participants in the self-assessment were based on the lowest rating achieved on the 5 data management processes. In other words, if an organization achieved individual

ratings of 1, 2, 2, 3, and 2; the overall rating for that organization would be 1. Assessments scores adjusted for self reporting inflation present that the participants were somewhere between “Initial” and “Repeatable” on the maturity model used. As stated by the researchers, the results may be a motivator for organizations to actively pursue the higher levels of maturity. State government is very early in terms of data governance maturity. However, this study by Aiken et al., presents that state government isn’t necessarily in “catch up” mode. However, it can be anticipated that organizations will become more prudent in their management of information assets.

The Value of Maturity Models

Better data leads to better information which will lead to better informed decision makers. Better decisions will necessarily lead to better service to citizens. Proper data governance leads to state government becoming less reactive and more predictive in its activities toward serving citizens. Proper data governance leads to state government acting as “one government” rather than a collection of independent agencies. Proper management of data, information and knowledge assets provides economic gains, and compliance with security and privacy requirements. An important tool state government can use to chart and evaluate its progress in improving the quality of its data and information are data governance maturity models.

TABLE 9: Aiken et al. – DATA GOVERNANCE MATURITY LEVELS

| Level | Name | Practice | Quality and Results Predictability |
|-------|-------------------|---|--|
| 1 | Initial | The organization lacks the necessary processes for sustaining data management practices. Data management is characterized as ad hoc or chaotic. | The organization depends on entirely on individuals, with little or no corporate visibility into cost or performance, or even awareness of data management practices. There is variable quality, low results predictability, and little to no repeatability. |
| 2 | Repeatable | The organization might know where data management expertise exists internally and has some ability to duplicate good practices and successes. | The organization exhibits variable quality with some predictability. The best individuals are assigned to critical projects to reduce risk and improve results. |
| 3 | Defined | The organization uses a set of defined processes, which are published for recommended use. | Good quality results within expected tolerances most of the time. The poorest individual performers improve toward the best performers, and the best performers achieve more leverage. |
| 4 | Managed | The organization statistically forecasts and directs data management, based on defined processes, selected cost, schedule, and customer satisfaction levels. The use of defined data management processes within the organization is required and monitored. | Reliability and predictability of results, such as the ability to determine progress or six sigma versus three sigma measurability, is significantly improved. |
| 5 | Optimizing | The organization analyzes existing data management processes to determine whether they can be improved, makes changes in a controlled fashion, and reduces operating costs by improving current process performance or by introducing innovative services to maintain their competitive edge. | The organization achieves high levels of results certainty. |

A number of maturity models have been presented. Much value is brought to the enterprise by examining these structures. The organization will understand the complexities of data governance, and begin to explore what it will take to develop a sustained, successful data governance effort. Management and technical staff will gain an appreciation of the components, scope and depth, and level of effort required to initiate a data governance program and that it will take time to achieve the higher levels of maturity. The state government enterprise can adapt its own maturity model and framework from this mix of ideas.

Common across these maturity models is the progressive maturing from strictly reactive to predictive. It is the predictive nature that is the intended long term capability sought—not only to manage risk, but to anticipate, uncover and prepare for opportunities and threats. This predictive capability will include identifying potential opportunities and threats and the impact of these vectors on state government. Understanding of impact then leads to proactive development of effective response. Because the future can not be predicted with certainty, stochastic modeling, or probability analysis, can be employed to present multiple outcome scenarios. The enterprise architect would create these scenarios based on the analysis of information assets from inside the enterprise and leveraging the information assets of its partners. The outcome sought is government that is no longer simply reacting, but is prepared for any foreseeable circumstance. At this point the enterprise is truly dynamic, agile, fluid, adaptive and spontaneous.

Managing data, information and knowledge assets in this way is not strictly an IT initiative—this is an enterprise initiative demonstrating strong collaboration across business and technology, strategists and implementers, policy makers and citizens, career government employees and elected officials. This also demonstrates government that has created successful collaboration across multiple jurisdictions

and levels of government. The citizen eventually sees “one government.” All of these behaviors and characteristics are founded on proper management of state government data, information and knowledge assets with the ultimate outcome—benefiting the citizen.

The language and progressive dynamic used in maturity models facilitate conversation and understanding among technical staff, business staff and upper management, and strategic partners. Seeing the relationships among the various components of data governance helps develop the necessary understanding and prepares the organization to begin development of a delivery process to launch and sustain a data governance initiative. Frameworks and maturity models can also be used in conversation with partners to compare and contrast various approaches and sequencing in data governance.

The elements in the data governance framework and maturity model will depend most on what the enterprise is trying to accomplish and how information assets can enable that intent. State government will be most interested in data quality, properly managing citizen information, and using business intelligence and analytics to predict trends, the impact of those trends and determining state government response.

It is expected that state government will not have the resources to necessarily create a separate governance structure for managing data and information. However, some state governments have established the roles of data stewards, data architects, data analysts, and data base administrators. State government may also have existing enterprise IT governance and would be best served by incorporating data governance into this existing governance structure.

Conclusions and Observations

- In an effort to better serve the citizen through increased efficiencies and a common viewpoint, data must be managed.
- Some of the rationale for data governance is to gain the capability to respond strategically and tactically to business challenges; respond immediately in an emergency; and ensure government responses are orchestrated through collaborative information sharing. Without enterprise data governance, state government is crippled in its ability to respond to opportunities and challenges—response will be inconsistent, arbitrary and ineffective across agencies.
- Data governance encourages the measurement of successes and failures. Goals, objectives and strategies cannot be defined, understood, communicated, or measured without quality data.
- Maturity models provide a measure for the state enterprise to gauge its success in managing data and information as an enterprise asset.
- Data governance maturity models can be used as references in communication, awareness building, and the marketing of data governance.
- The states must face the challenge of stove-piped federal program funding which creates “islands of data.” Solutions developed under this funding will also be stove-piped. State government must continue to reach out to federal agencies through NASCIO, NGA, and NCSL to move the federal government toward reformation of current federal funding restrictions and reporting to actually encourage enterprise-wide solutions that touch multiple government lines of business. State government must have the ability to access, share, and analyze information from across state agencies and programs in order to effectively deliver services, identify fraud, avoid redundant investment and service delivery, and provide a “one state government” view to citizens.
- Data governance will not happen without the support of government leadership. The state CIO is in the best position organizationally and technically to initiate and champion data governance. Understand the importance of data, information and knowledge assets in achieving a vision for eDemocracy and 21st Century government.

Calls to Action for the State CIO and State Government

1. **Begin now to develop expertise and governance for managing data, information and knowledge assets.**

- Given current economic stresses, focus on those areas of data governance most relevant to enabling effective tactical and strategic response.
- Begin to develop a library of case studies that present the economics of data governance and, real outcomes and illustrative consequences that resonate with policy makers. Examples include: fraud detection and prevention; avoidance of redundant or duplicative citizen assistance; improved business processes and decision making; consequences of poor or conflicting information for decision making during a crisis; potential and real outcomes when first responders, including firefighters, law enforcement officers, and paramedics, don't have complete information when entering an emergency situation; the cost of research that becomes necessary when information from various sources is in conflict.

2. **Begin to build awareness through communications and marketing initiatives.**

- The intent of these initiatives is to move the culture and organization of state government toward understanding the necessity of managing information as a state government enterprise asset.
- Consider the cost of unreliable information or conflicting information from different sources and how that hampers state government's ability to gather and analyze state data particularly in responding to the current economic crisis.

3. **Understand the scope of data governance.**

- Identify opportunity areas for early initiatives.
- Scope management will be critical – targeted initiatives must be carefully selected.
- Begin to identify strategic partnerships that are necessary for implementing an effective, sustained effort (e.g., private industry and public entities; intergovernmental agencies; counties, cities and states).

4. **Ensure that data governance has appropriate representation from business stakeholders, i.e., the real owners of the information.**

- Data and information only has value to the extent that it enables the business units within state government and their partners.
- Any efforts to develop effective data governance must involve close collaboration between the business unit partners and IT that recognizes the decision rights associated with the various roles in state government.

5. **Implement data governance within existing enterprise and data architecture practice.**

- Data governance is not a separate activity. Rather, it is an important mechanism for managing enterprise information and knowledge assets within the scope of enterprise architecture.

Appendix A

Data Management Processes defined by B. Parker.²³ The five data management processes evaluated by Aiken et al., were as follows and are further described in the article cited.

| Process | Description | Focus | Data Type | Research Results Maturity Level Range / Average <i>Unadjusted for Self-²⁴ Reporting Inflation</i> |
|---------------------------------|---|------------------------------|---|---|
| Data Program Coordination | Provide appropriate data management processes and technological infrastructure. | Direction | Program data: Descriptive propositions or observations needed to establish, document, sustain, control, and improve organizational data-oriented activities such as vision, goals, policies and metrics. | 2.06 to 3.31 / 2.71 |
| Organizational Data Integration | Achieve organizational sharing of appropriate data. | Direction | Development data: Descriptive facts, propositions, or observations used to develop and document the structures and interrelationships of data – for example, data models, database designs, and specifications. | 2.18 to 2.66 / 2.44 |
| Data Stewardship | Achieve business-entity subject area data integration. | Direction and Implementation | Stewardship data: Descriptive facts about data documenting semantics and syntax – such as name, definition, and format. | 1.96 to 2.40 / 2.18 |
| Data Development | Achieve data sharing within a business area. | Implementation | Business data: Facts and their constructs used to accomplish enterprise business activities – such as data elements, records and files. | 1.57 to 2.46 / 2.12 |
| Data Support Operations | Provide reliable access to data. | Implementation | | 2.04 to 2.66 / 2.38 |
| Data Asset Use | Leverage data in business activities. | Implementation | | (no data) |

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Chuck Tyger, Associate Director Enterprise Architecture, The Commonwealth of Virginia

Chris Walls, Senior Website & Publications Coordinator, AMR Management Services

Tom Walters, Division of Data Architecture, The Commonwealth of Kentucky

Appendix C: Resources

NASCIO www.nascio.org

IT Governance and Business Outcomes – A Shared Responsibility between IT and Business Leadership
<http://www.nascio.org/committees/EA/download.cfm?id=98>

Data Governance – Managing Information As An Enterprise Asset Part I – An Introduction
<http://www.nascio.org/committees/EA/download.cfm?id=100>

Enterprise Architecture: The Path to Government Transformation
<http://www.nascio.org/committees/EA/>

Call for Action, A Blueprint for Better Government: The Information Sharing Imperative
<http://www.nascio.org/advocacy/dcFlyIn/callForAction05.pdf>

PERSPECTIVES: Government Information Sharing Calls to Action
<http://www.nascio.org/publications/index.cfm#19>

In Hot Pursuit: Achieving Interoperability Through XML
<http://www.nascio.org/publications/index.cfm#21>

We Need to Talk: Governance Models to Advance Communications Interoperability
<http://www.nascio.org/publications/index.cfm#50>

A National Framework for Collaborative Information Exchange: What is NIEM?
<http://www.nascio.org/publications/index.cfm#47>

List of NASCIO Corporate Partners
<http://www.nascio.org/aboutNascio/corpProfiles/>

List of NASCIO Publications
<http://www.nascio.org/publications>

List of NASCIO Committees
<http://www.nascio.org/committees>

The Data Administration Newsletter

<http://www.tdan.com/index.php>

Presents 8 chapters that describe how to implement data governance

The Data Governance Institute

<http://datagovernance.com/>

DGI created a poster on data governance that can be downloaded, or ordered in hardcopy online.

The Data Management Association

International – DAMA – www.dama.org

The Data Management Body of Knowledge (DMBOK) including a framework of data management functions and environmental elements.

<http://www.dama.org/i4a/pages/index.cfm?pageid=3364>

The IT Governance Institute (ITGI)

<http://www.itgi.org/>

Information Systems Audit and Control Association (ISACA)

<http://www.isaca.org/>

Certification in Governance of Enterprise IT (CGEIT) from ISACA

<http://www.isaca.org/Template.cfm?Section=Certification&Template=/TaggedPage/TaggedPageDisplay.cfm&TPLID=16&ContentID=36129>

The Center for Information Systems Research (CISR)

<http://mitsloan.mit.edu/cisr/>

The National Information Exchange Model (NIEM) www.niem.gov

**Global Justice Reference Architecture
for SOA**

http://www.it.ojp.gov/topic.jsp?topic_id=242

Global Justice Reference
Architecture (JRA) Specification:
Version 1.7

[http://www.it.ojp.gov/documents/
JRA_Specification_1-7.doc](http://www.it.ojp.gov/documents/JRA_Specification_1-7.doc)

The Global Justice Reference
Architecture (JRA) Web Services
Service Interaction Profile Version
1.1

[http://www.it.ojp.gov/documents/
WS-SIP_Aug_31_version_1_1_
FINAL\(3\).pdf](http://www.it.ojp.gov/documents/WS-SIP_Aug_31_version_1_1_FINAL(3).pdf)

The Global Justice Reference
Architecture (JRA) ebXML
Messaging Service Interaction
Profile Version 1.0

[http://www.it.ojp.gov/documents/
ebXML_SIP_v01_Final_Version_
100407.pdf](http://www.it.ojp.gov/documents/ebXML_SIP_v01_Final_Version_100407.pdf)

Appendix D: Endnotes

¹“Data Governance – Managing Information As An Enterprise Asset Part I – An Introduction,” NASCIO, April, 2008, available at www.nascio.org/publications.

²Note: this report has been liberal regarding the inclusion of maturity models. The words “data management” or “enterprise information management” may appear in the title of a specific maturity model. Nevertheless, if a maturity model captures the essence relevant to this report, then it was included.

³“Transforming Government through Change Management: The Role of the State CIO,” April 2007, NASCIO, www.nascio.org/publications.

⁴“IBM Council Predicts Data Will Become an Asset on the Balance Sheet and Data Governance a Statutory Requirement for Companies Over Next Four Years,” IBM press release, ARMONK, NY - 07 Jul 2008, see <http://www-03.ibm.com/press/us/en/pressrelease/24585.wss>.

⁵ RASIC charts present assigned roles within a project team: responsible, approving, supporting, informed, and consulting.

⁶ Gartner’s Data Quality Maturity Model, February 7, 2007, ID Number G001139742.

⁷ Newman, D., Blechar, M.J., “Putting Enterprise Information Management in Context,” Gartner, June 1, 2007, ID Number: G00148273.

⁸ The first of Dr. W. Edwards Deming’s 14 Points. Deming, W.E., *Out of The Crisis*, Massachusetts Institute of Technology, Center for Advanced Engineering Study, 1986. ISBN: 0911379010.

⁹“The Four Stages of Data Maturity,” DataFlux, Tony Fisher, retrieved on November 10, 2008, from http://www.sas.com/news/sascom/2007q4/column_tech.html.

¹⁰“The Four Stages of Data Maturity,” page 2; English, Larry. “Plain English about Information Quality: Information Quality Tipping Point.” DM Review, July 2007.

¹¹ Adapted from “The Data Governance Maturity Model,” DataFlux Corporation. This paper presents these characteristics at the various stages of data governance maturity. Retrieved on March 11, 2008, from <http://www.dataflux.com/resources/resource.asp?rid=184>.

¹² See course materials from EWSolutions, “Enterprise Data Governance and Stewardship,” available for purchase at www.EWSolutions.com.

¹³ Newman, D., Logan, D., “Gartner Introduces the EIM Maturity Model,” Gartner Research, ID Number: G00160425.

¹⁴ See IBM Data Governance Council, <http://www-01.ibm.com/software/tivoli/governance/servicemanagement/data-governance.html>.

¹⁵ See Carnegie Mellon Software Engineering Institute at www.sei.cmu.edu.

¹⁶ IBM Data Governance Council Maturity Model, October 2007, retrieved on May 12, 2008, from http://www-935.ibm.com/services/uk/cio/pdf/leverage_wp_data_gov_council_maturity_model.pdf.

¹⁷ Thomas, G.J., “Application of the DMBOK in an Enterprise Data Architecture,” presentation at 2008 DAMA Conference.

¹⁸“Corporate Data Governance Best Practices, 2006-07 Scorecards for Data Governance in the Global 5000, The CDI Institute, April 2006, www.The-CDI-Institute.com.

¹⁹ Newman, D., Blechar, M.J., page 8.

²⁰ Aiken, P., Allen, D., Parker, B., Mattia, A., "Measuring Data Management Practice Maturity: A Community's Self-Assessment," *Computer*, Vol. 40, Iss. 4, April 2007, pp. 42-53.

²¹ Carnegie Mellon University Software Engineering Institute, *Capability Maturity Model: Guidelines for Improving the Software Process*, 1st ed., Addison-Wesley Professional, 1995.

²² Parker, B., "Enterprise Data Management Process Maturity," *Handbook of Data Management*, S. Purba, ed., Auerbach Publications, CRC Press, 1999, pp. 824-843.

²³ Ibid.

²⁴ Aiken, et al., page 49.

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