CITY OF DALLAS TECHNOLOGY REFERENCE ARCHITECTURE – HANDBOOK

Version 2.01

Abstract

Guiding technology selection and deployments to meet City Strategic Objectives

Enterprise Architecture

Communications and Information Services

Attribution Notice:

This document draws heavily upon the document set noted in the references section of this document. The DoD Reference Architecture Description provided a large foundation for this document. The Cloud Security Alliance (CSA) reference architecture documentation also provides a large amount of guidance and foundational material to the City Enterprise Reference Architecture described in this document.

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1 Introduction

The term Reference Architecture, within the Information Technology community, has various meanings, multiple purposes and uses, varying levels of detail and abstraction, and very little common guidance. The Chief Technology Architect for Innovation and Information Management (IIM) within the Department of Communication and Information Services (CIS) for the City of Dallas requested a position on – and strategy for – Reference Architecture use in the department. This Reference Architecture handbook is the response to the Chief Architect's request.

Purpose

The objective is to provide useful guidance and direction on the development and use of Reference Architecture as a tool to guide and constrain architecture and solution development. This document provides guidance for the development and use of Reference Architecture in the form of a City definition for Reference Architecture and a description for City-wide Reference Architecture. The definition is applicable to all City Reference Architectures, while the description focuses on a unique set of City Reference Architectures that provide guidance to the department (CIS), hereafter referred to as City-wide Reference Architectures. This description establishes standard criteria for City-wide Reference Architectures.

How to Use This Document

Individuals and organizations looking to implement solutions for the City of Dallas are expected to use and comply with the City's approach to Reference Architecture as outlined in this document, the current version of the City's Technical Reference Architecture (TRA) Version 3.01, and the Technical Reference Architecture Checklist Version 3.01. These guiding documents should be used by vendors during creation of a Solution Reference Architecture. The goal of a Solution Reference Architecture is to identify and describe compliance with the City Enterprise Reference Architecture, competently and completely describe the architecture of a solution, and to communicate solution value relative to the guiding principles outlined in Section Three of this document.

Vendors should be prepared to:

- Align Solution Reference Architectures with the approach defined by the City of Dallas,
- utilize the language defined by the City's TRA definition and description where applicable,
- comply with the common standards, specifications, and patterns as defined by the City's TRA,
- and be prepared to validate the proposed solution against the City's Reference Architecture.

Document Structure

This document is structured to provide a logical progression of information about Reference Architecture at the City. It consists of five sections and a set of appendices.

- Section 1: Provides an introduction that describes the purpose, background, approach, and structure for this document.
- Section 2: Provides the City definition for Reference Architecture.

- Section 3: Provides a description for the City-wide Reference Architecture. This section describes and discusses the five elements of a City-wide Reference Architecture.
- Section 4: Provides a sample of City Architecture Framework views and models that could be used in describing the five Reference Architecture elements.
- Section 5: Provides a summary of the key points and positions described in this document.
- Appendices A-D: Appendix A provides a sample Reference Architecture outline for Solution Architecture based upon the City Enterprise Reference Architecture. Appendix B provides examples of existing Reference Architectures. Appendix C provides a list of references in this document. Appendix D provides pertinent definitions for use with the Technology Reference Architecture.

Background

Reference Architectures have been used in Industry to provide information, guidance, and direction for focused subject areas. These Reference Architectures have wide-ranging purposes, uses, levels of detail, and levels of abstraction. The term itself has multiple definitions and meanings and seems to be relative to the context of the environment in which it is used. A Google search for Reference Architecture returned more than 523,000 results. [DoD Reference Architecture]

Reference Architecture literature can be found throughout Industry addressing various subject areas. Due to current interests in Service Oriented Architecture (SOA), a good amount of existing Reference Architecture literature is focused on this area. Most notable are the efforts by the Organization for the Advancement of Structured Information Standards (OASIS), The Open Group Architecture Forum (TOGAF), and the Object Management Group (OMG). [DoD Reference Architecture]

As information, services, and infrastructure requirements and solutions continue to evolve, the need for Reference Architecture increases. Reference Architecture serves as a tool for providing common information, guidance, and direction to guide and constrain architecture and solutions. A City definition is needed to establish this broader perspective of Reference Architecture as the common position across the City. While Reference Architectures with varying purposes, uses, and content could exist at many levels throughout the City, a standard set of criteria needs to be established for City-wide Reference Architecture. A standard set of criteria for City-wide Reference Architecture enables consistent development, use and assessment of these architectures. It also establishes a common City expectation of the content provided by a City-wide Reference Architecture. This document focuses on describing the standard criteria. [DoD Reference Architecture]

To support Reference Architecture efforts at the City, Enterprise Architecture has adopted the Cloud Security Alliance (CSA) Reference Architecture as a baseline – or foundation – for constructing and communicating Reference Architecture (both Enterprise-level and Solution-level). The CSA Reference Architecture has strengths that other offerings do not. Though Service Oriented Architectures (SOA) are a common way to communicate, reference architectures based upon SOA are generally software focused and fail to account for data and information, infrastructure and various operational aspects needed in a reference architecture. As the CSA Reference Architecture attempts to describe and communicate additional layers of architecture not noted in SOA architectures and models, it was decided that the CSA Reference Architecture provided the City with the opportunity to communicate

needs and desires more completely that a SOA-only reference architecture. Hence, the CSA Reference Architecture description may be referenced as collateral material when inspecting the City Enterprise Reference Architecture. [DoD Reference Architecture]

Approach

The approach for developing this document involved three steps:

a. The first step was to research and gather existing Reference Architecture documents and information from commercial and government sectors. The intent is to pull together the broadest, representative sample of Reference Architecture materiel as possible.

b. The second step was to examine and analyze the Reference Architecture material to better understand existing concepts of Reference Architecture, what it is used for, its goals, objectives, characteristics, and key elements. The intent was to discover common threads for defining best practices for developing Reference Architectures.

c. The third step was to develop a City definition for Reference Architecture and a description for City-wide Reference Architecture based on the analysis of Reference Architecture material and the intent of the Chief Technology Architect.

City and CIS Strategic Plan Guidance to Reference Architecture Development

The reference architecture presented in this document facilitates the achievement of City of Dallas goals relative to technology usage.

The City Strategic Goals are:

1. Public Safety
2. Mobility Solutions, Infrastructure and Sustainability
3. Economic and Neighborhood Vitality
4. Human and Social Needs
5. Quality of Life
6. Government Performance and Financial Management

The Key Goals identified in the City's Technology+ Strategic Plan are:

1. Citizen-Centric
2. Data-Centric
3. Smart City
4. Security and Privacy

Attribution

Enterprise Architecture (EA) and its supporting reference architectures are heavily dependent upon perspective. In the case of the reference architecture described in this document, guidance towards a Cloud First strategy is provided. This guidance is developed from current understandings of major cloud reference architectures – that provided by the Cloud Security Alliance (CSA). The guidance in this handbook also draws heavily upon process-oriented reference architectures provided by Industry and government. The goal here is to provide this document's audience with an understanding that foresight

benefits the selection, implementation, deployment, operation, maintenance, management and final decommissioning of any solution.

This document draws heavily upon the document set noted in the references section of this document. The DoD Reference Architecture Description provided a large foundation for this document. The Cloud Security Alliance (CSA) reference architecture documentation also provides a large amount of guidance and foundational material to the City Enterprise Reference Architecture described in this document.

2 Reference Architecture Definition

An examination and analysis of numerous existing Reference Architecture definitions within Industry revealed common points among them. A common theme among the definitions is that the primary purpose of a Reference Architecture is to guide and constrain the instantiations of solution architectures as depicted in Figure 2. Based on this, a Reference Architecture is considered an organizational asset in:

- Providing common language for the various stakeholders
- Providing consistency of implementation of technology to solve problems
- Supporting the validation of solutions against proven Reference Architecture
- Encouraging adherence to common standards, specifications, and patterns

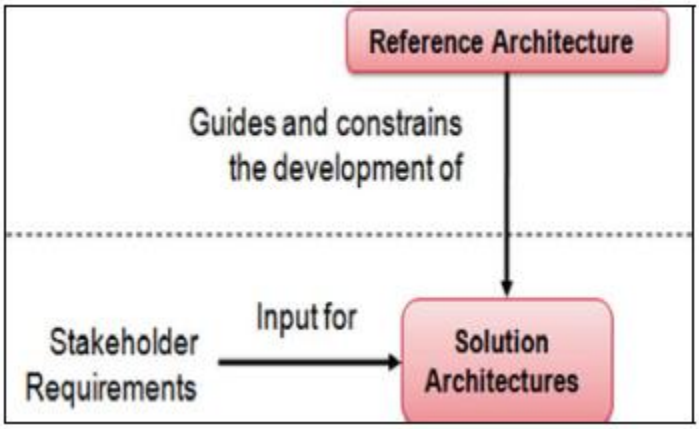

Figure 1 Reference Architecture Purpose / DoD Reference Architecture

Other relevant terms used in the definitions include “patterns” and “solution architectures”. Patterns are models of architecture representations at a level of generality that provides some degree of reuse. The City Architecture Framework defines Solution Architecture as a framework or structure that portrays the relationships among all the elements of something that answers a problem. It describes the fundamental organization of a system, embodied in its components, their relationships with each other and the environment, and the principles governing its design and evolution. Solution architecture instantiations are guided and constrained by all or part of a Reference Architecture where the generalized and logical abstract elements of the Reference Architecture are replaced by real world, physical elements according to the specified rules, principles, standards and specifications. [DoD Reference Architecture]

From all of this, a derived Citywide definition for Reference Architecture is [DoD Reference Architecture]:

> Reference Architecture is an authoritative source of information about a specific subject area that guides and constrains the instantiations of multiple architectures and solutions. [DoD Reference Architecture]

Reference Architecture serve as a reference foundation for architectures and solutions and may also be used for comparison and alignment purposes. There may be multiple Reference Architectures within a

subject area where each represents a different emphasis or viewpoint of that area as depicted in Figure 3. For each Reference Architecture, there may be any number of architectures and solutions corresponding to different aspects of the subject area viewpoint. [DoD Reference Architecture]

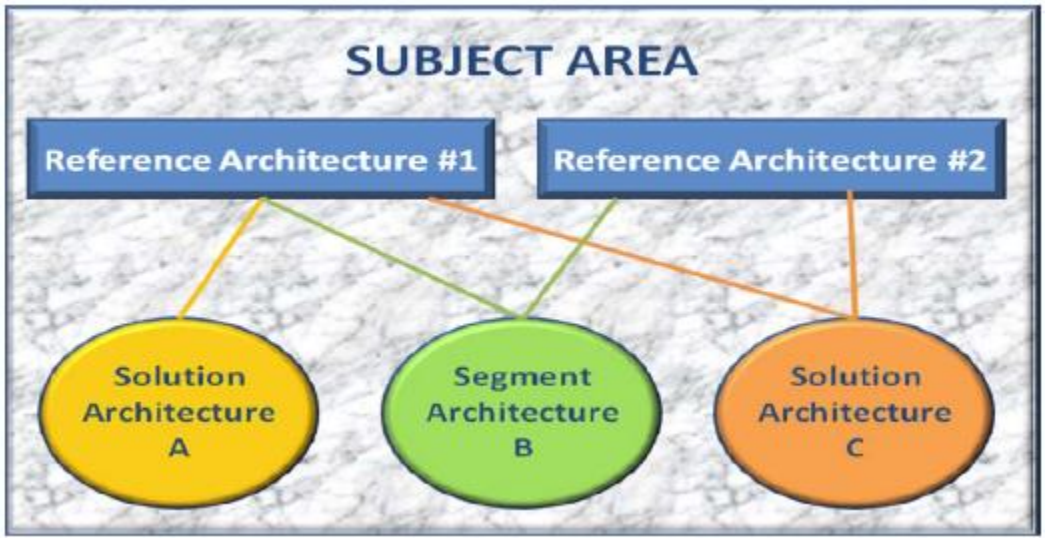

Figure 2 Reference Architecture Relationships / DoD Reference Architecture

Reference Architectures may be defined at many levels of detail and abstraction (from specific to generalized) and for many different purposes. In fact, a Reference Architecture for one subject area can be a specialization of a more general Reference Architecture in another subject area. The level of abstraction provided in a Reference Architecture is a function of its intended usage. Where solution architectures are to be developed based on a specific Reference Architecture, the level of detail provided as a reference may have to be greater than if a Reference Architecture is intended to be used for alignment purposes only. [DoD Reference Architecture]

Reference architectures may also be complimentary in guiding architectures and solutions. Figure 3 also shows that Reference Architecture may guide and constrain various types and instantiations of architecture depending on the purpose and scope. City-wide Reference Architecture, due to its broader purpose and scope, may guide and constrain Enterprise, Segment, Capability, and Solution Architectures. [DoD Reference Architecture]

3 City of Dallas Technology Reference Architecture

The City of Dallas Technology Reference Architecture is part of the City Enterprise Architecture (EA). Figure 4, City of Dallas Technology Reference Architecture, shows the construct of the Technology Reference Architecture depicting its components and their general relationships.

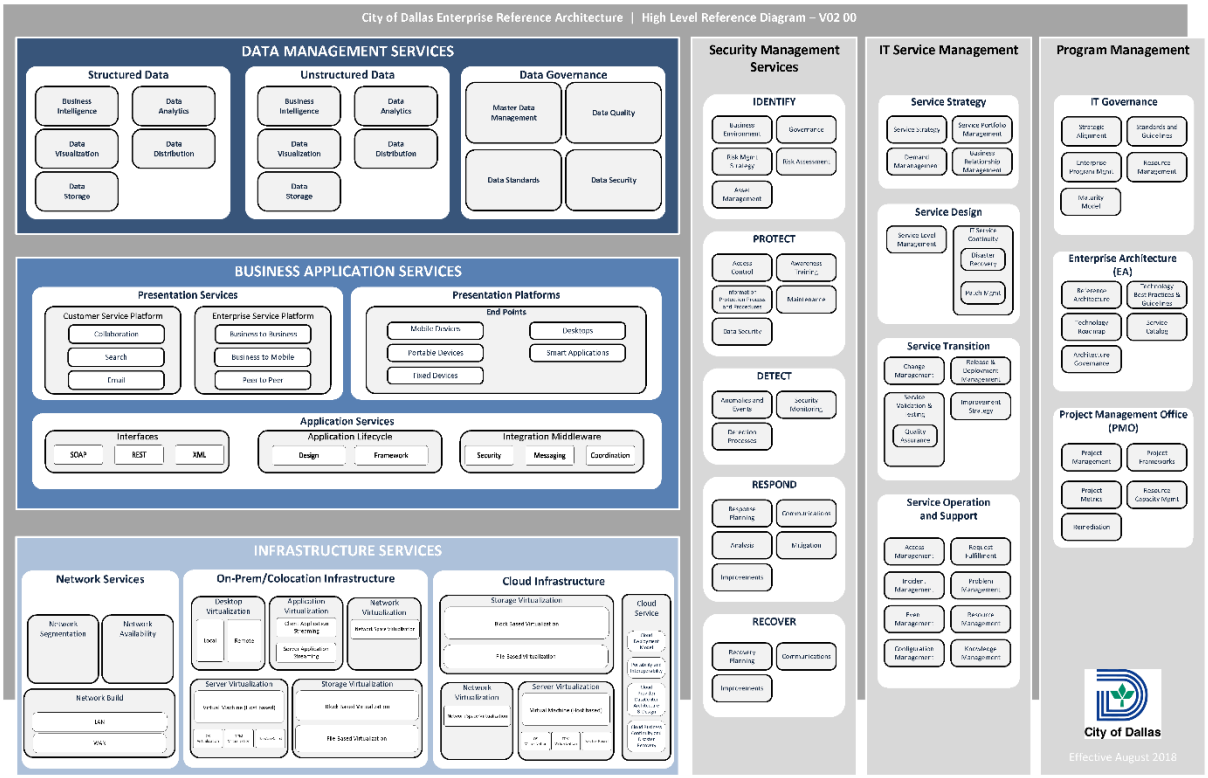

Figure 3 City of Dallas Technology Reference Architecture

The Technology Reference Architecture provides information, guidance, and direction that is applicable across the City. This information, guidance, and direction are provided in the five (5) elements that comprise a Citywide Reference Architecture. [DoD Reference Architecture]

a. Strategic Purpose – Identifies goals and objectives of the Reference Architecture and describes the specific purpose of and the problem(s) to be addressed by the Reference Architecture. [DoD Reference Architecture]

b. Principles – Sufficient high-level foundational statements of rules, culture, and values that drive technical positions and patterns. [DoD Reference Architecture]

c. Technical Positions– Technical guidance and standards, based on specified principles that need to be followed and implemented as part of the solution. [DoD Reference Architecture]

d. Patterns (Templates) – Generalized architecture representations (viewpoints, graphical/textual models, diagrams, etc.) that show relationships between elements and artifacts specified by the technical positions. [DoD Reference Architecture]

e. Vocabulary – Acronyms, terms, and definitions that are used in the Reference Architecture and relevant to architectures and solutions that are guided and constrained by the Reference Architecture. [DoD Reference Architecture]

Strategic Purpose

The strategic purpose describes the context for the Reference Architecture and provides the basis for the principles, technical positions, patterns, and vocabulary in the Reference Architecture. The context includes descriptions of the scope, goals, and purpose of the Reference Architecture, why it is needed, and when and how it should be used. The key authoritative sources used in the development of the Reference Architecture, as well as the intended audience (to whom the architecture is directed), should also be included in this section. The strategic purpose should explicitly identify the primary producing stakeholder (owner) organizations that will develop and implement related architectures and solutions. It should also explicitly describe the issue(s) and stakeholder concern(s) that will be addressed by the Reference Architecture. Understanding and consensus on the strategic purpose of the Reference Architecture will enable end-to-end traceability between organizational context and an eventual solution implementation. [DoD Reference Architecture]

The Strategic Purpose for the City of Dallas' Technology Reference Architecture is to facilitate the achievement of City of Dallas goals relative to technology usage as described previously in City and CIS Strategic Plan Guidance to Reference Architecture Development. The Technology Reference Architecture is intended for use both by City departments and vendors when creating Solution Reference Architecture. The Technology Reference Architecture should be used for all Technology acquisition, upgrade, and evolution activities conducted with the City of Dallas.

Principles

Principles are high-level statements that apply to the subject area and tie back to business requirements. They incorporate values and organizational culture and drive technical positions and patterns in defining how an organization fulfills its mission. The identification of assumptions and constraints can assist in gaining an understanding of the context of the Reference Architecture, which can provide a helpful perspective on the guiding principles. [DoD Reference Architecture]

Principles are general rules and guidelines that should be understandable, robust, complete, independent, and are not intended to state the obvious. They inform and support the way in which an organization sets about fulfilling its mission and are intended to be enduring and seldom amended. In the Citywide Reference Architectures (either Enterprise or Solution), principles without any additional information should be enough to clearly convey the general intent of the Reference Architecture. In some cases, principles may be extracted from relevant subject area policy. In other cases, they may be created because of the development and analysis of the Reference Architecture. [DoD Reference Architecture] The following are principles supporting the City's Reference Architecture:

- Appropriate Business Value must be present
- Focus on Desired Business Outcomes
- Citywide Scope
- Standards Based
- Simple
- Scalable

- Strategic
- Reliable
- Sustainable
- Secure
- Service Oriented
- Cloud Driven

Technical Positions

Technical positions describe the technical guidance and standards established for a subject area. Due to rapidly evolving technology, technical positions are likely to change often to keep up with industry. Required services, standards, agreements, security model, communication protocols, web services, XML namespaces, data quality, etc. are all technical positions that must be described and addressed in a Citywide or Solution Reference Architecture. [DoD Reference Architecture]

Defining technical positions forces an organization to identify relevant technical guidance and standards and justify their choices and tradeoffs. For example, a SOA Reference Architecture would include descriptions of the services and standards to assist architects in understanding and incorporating them in solution architectures for the subject area. [DoD Reference Architecture]

An effective way for conveying technical positions is via a table that contains information relevant to a standard, but technical positions may be described in various ways. [DoD Reference Architecture]

Patterns

Patterns show how artifacts may be organized and related for repeated use. They are typically low to mid-level tabular, structural, behavioral, or graphical model abstractions that focus on interaction of the artifacts. Patterns undergo change most often as new pattern concepts are discovered and emerge from solution architectures. [DoD Reference Architecture]

Patterns may be conveyed through various means such as Activity Models, Process Models, and Behavioral Models. It is important to identify the pattern and describe it with enough detail for it to be clearly understood and used appropriately. [DoD Reference Architecture]

Three potential benefits of architecture patterns are: 1) they enable improved communication between stakeholders; 2) they facilitate application of sound architectural concepts and implementations; and 3) they can become standardized through multiple implementations. An effective way to develop a foundation to provide patterns of operational behavior is to leverage the activities of an Activity Node Tree with an Activity Event sequence diagram. This combination of viewpoints exploits the relationship between the process model and the operational activities, while supporting the concept of integrated architectural viewpoints. [DoD Reference Architecture]

Vocabulary

The vocabulary provides the acronyms, terms, and definitions that are pertinent to a Reference Architecture (Enterprise or Solution). It enables a common understanding of terms and consistency of definitions across the subject area. This highlights the importance of a common vocabulary of terms as key content of a Reference Architecture. As well, the authoritative nature of a Reference Architecture can be reinforced through the practice of documenting the sources of all activities, process steps and performers within the vocabulary (e.g., an Integrated Dictionary). [DoD Reference Architecture]

4 City of Dallas Technology Reference Architecture Description

The following sections identify and describe the major elements and components of the City of Dallas Technology Reference Architecture. Furthermore, relevant Technical Positions, Patterns and Vocabulary are interspersed throughout these sections as appropriate.

Data Management Services

Data Management Services provide needed frameworks and methods to ensure the security of data and information. One of the most common pain points across organizations is the amount of data generated across the company, sometimes including redundant data (different perspectives for the same threat or gap). All this data needs to be transformed into useful information that business asset owners can use to prioritize, strategize, and manage the risk portfolio they own. [Cloud Security Alliance] [DAMA DMBOK]

Data Management Services manages the extraction, transformation, cleansing, and loading of information into a common data model either for analytical or operational goals. [Cloud Security Alliance] [DAMA DMBOK]

Typical Extract, Transform, and Load (ETL) data normalization, data mining, balance scorecard, among other capabilities will reside here. [Cloud Security Alliance] [DAMA DMBOK]

This domain simplifies all these sources of data by having a data management approach. All data containers are allocated on this domain, where eventually they can be extracted, transformed, and loaded into the following: [Cloud Security Alliance] [DAMA DMBOK]

- Operational data store: All day-to-day and transactional information will be allocated here, using a 360 degrees perspective around information assets (i.e. application and infrastructure vulnerabilities, patching gaps, penetration test results, audit findings, and controls per asset). [Cloud Security Alliance]
- Data Warehouse: All historical transactions will be used to develop a data warehouse or data mart that can measure the success obtained with the risk management program. Also, this model can be used to identify behavior patterns, trends, tendencies, and systemic gaps across the organization. [Cloud Security Alliance]

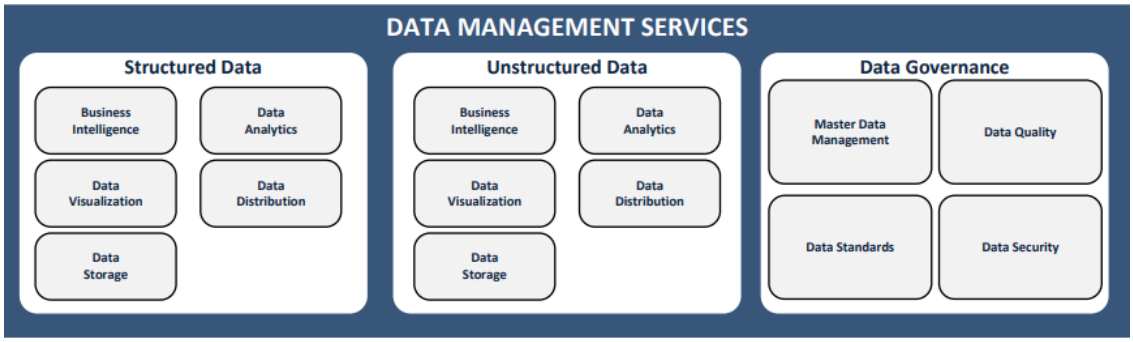

Figure 4 Data Management Services

Currently, Data Management Services focuses on three main areas of interest which include:

- Structured Data
- Unstructured Data

- Data Governance

Structured Data

Structured data refers to information with a high degree of organization, such that inclusion in a relational database is seamless and readily searchable by simple, straightforward search engine algorithms or other search operations. A structured data is an abstract model that organizes elements of data and standardizes how they relate to one another and to properties of the real world. For instance, structured data may specify that a data element representing a car comprise a number of other elements which in turn represent the color, size and owner of the car [Cloud Security Alliance] [DAMA DMBOK] [Wikipedia, .

Five areas are of current interest within Structured Data include:

- Business Intelligence
- Data Analytics
- Data Visualization
- Data Distribution
- Data Storage

Unstructured Data

Unstructured data (or unstructured information) refers to information that either does not have a pre-defined data model or is not organized in a pre-defined manner. Unstructured information is typically text-heavy, but may contain data such as dates, numbers, and facts as well. This results in irregularities and ambiguities that make it difficult to understand using traditional programs as compared to data stored in fielded form in databases or annotated (semantically tagged) in documents. [Wikipedia, Unstructured Data]

Five areas are of current interest within unstructured data include:

- Business Intelligence
- Data Analytics
- Data Visualization
- Data Distribution
- Data Storage

Data Governance

Data governance embodies a convergence of data quality, data management, data policies, business process management, and risk management surrounding the handling of data in an organization.

As the organization manages data between Applications, Services, and Enterprise Information Integration activities, the need to have a well define governance model that outlines and looks for compliance on how data is massaged, transformed, and stored throughout the IT infrastructure including internal and external services (i.e. SaaS, PaaS, IaaS, ASP, or others).

Processes included as data governance include data ownership, how data should be classified, and responsibilities that data/asset owners have for their applications and services, as well the necessary controls for data throughout the lifecycle.

Four areas of current interest under Data Governance include:

- Master Data Management
- Data Standards
- Data Quality
- Data Security

Business Application Services

Business Application Services provide needed software or business applications a set of meaningful resources that are used by business users to perform various business functions. Business Application Service aligns IT assets with the City's KFAs supporting business goals, facilitating the ability of the City to be profitable.

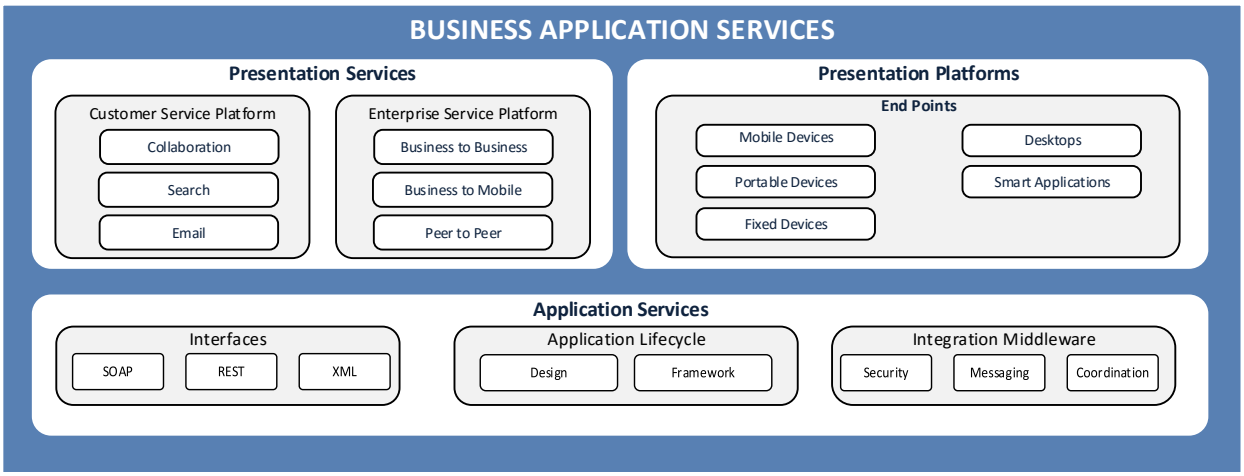

Figure 5 Business Application Services

Currently, Business Application Services focuses on three main areas of interest include:

- Presentation Services
- Presentation Platforms
- Application Services

Presentation Services

Presentation Services domain is where the end-user interacts with an IT solution. Presentation Services are currently comprised of two main areas of focus which include:

- Presentation Modality
- Presentation Platform

Presentation Platforms

The Presentation Platform Services focus on the different types of End-Points that end-users utilize to interact with a solution such as Desktops, Mobile Devices (smart phones, tablets), Portable Devices (laptops) or special purposes devices such as medical devices or smart appliances. Presentation Services are currently comprised of End Points topics which include:

- Mobile Devices
- Portable Devices
- Fixed Devices
- Desktops
- Smart Applications

Application Services

Application services are the rules and processes behind the user interface that manipulate the data and perform transactions for the user. In addition to the application services of an IT solution, the Application Services domain also represents the development processes that programmers go through when creating applications. Application Services are currently comprised of three main areas of focus which include:

- Interfaces
- Application Lifecycle
- Integration Middleware

Infrastructure Services

Infrastructure Services provide the basic core capabilities that support higher-level capabilities in other areas of the architecture. This is the service layer that support applications that are visible to most users (whether cloud, internal or external). This level is comprised of the virtual machines, physical machines, applications, databases and both internal and external (3rd party) cloud services. Often, Infrastructure Services will be deployed centrally and will run standard machine images, with all necessary service preconfigured to support ease of integration and reliable connectivity and access. Infrastructure Services can also include cloud services that can be provided from an internal or external service provider.

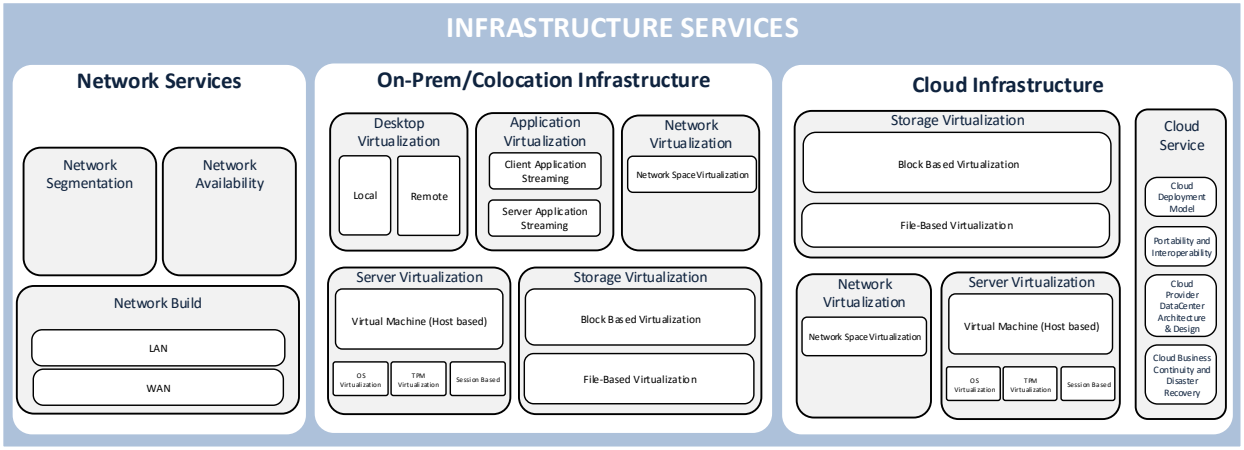

Figure 6 Infrastructure Services

Currently, Infrastructure Services focuses on three main areas of interest which include:

- Network Services
- On-Prem/Co-Location Infrastructure
- Cloud Infrastructure

Network Services

The Network Services are mainly concerned with the physical assets used by the organization to support the On-Premise or Co-Located services that are consumed by users (internal, external or cloud). These services are the lowest level and least visible to the end user, although they are the foundation that underlies reliable and secure operation of the IT services that are provided to the end user.

Three current areas of interest pertaining to Network Services which include:

- Network Build
- Network Availability Services
- Network Segmentation Services

On-Prem/Co-Location Infrastructure

The Virtual Infrastructure inherits some of the same services that are present in the internal/physical infrastructure. These include the software images that must be securely built and managed for the virtual servers that are hosted on the virtualization platform provided on the physical server. However, there are also unique requirements for the virtualized infrastructure itself. In addition, the Co-Location infrastructure needs to be accounted for. In a sense, the co-located and internal/physical infrastructure is the same with the exception that a 3rd party owns the facility and would be responsible for physical maintenance of the facility, general utilities associated with the facility and the physical security in terms of access and preventative measures or controls. The City of Dallas still owns and manages the actual hardware and connections between the hardware in the co-location application.

There are five current areas of interest pertaining to Virtual Infrastructure which include:

- Desktop "Client" Virtualization
- Server Virtualization
- Storage Virtualization
- Application Virtualization
- Network Virtualization

Cloud Infrastructure

The Cloud Infrastructure inherits some of the same services that are present in the virtual infrastructure, but also considers deployment models, portability and interoperability of data and services, Service Provider's data center architecture and operations and Data Center operations for Business Continuity.

Security Management Services

Security Management Services provide needed frameworks and methods of operation to ensure the security of information. Security Management Services approaches information and cyber-security from a principles-based approach. The principles used by Security Management Services were adopted from the NIST Cybersecurity Framework published in February 2014. In all, that framework posits five principles, or functional areas, that define and guide information security efforts. Though discussed elsewhere, the five principles driving Security Management Services are: Identify, Protect, Detect, Respond and Recover.

Security Management Services are responsible for the development of standards pertaining to information and cyber security. The standards developed by this service bundle are targeted at ensuring that information and information processing systems and network have enough security mechanisms to ensure the confidentiality, integrity and availability of City data and systems.

Security Management Services are responsible for ensuring that information and systems comply with the security criteria listed in appropriate standards documents. Whether a standard is a customized City standard or a federal or industry security standard, Security Management Services can evaluate information and their supporting system to provide an assessment of how well the information and systems are meeting the goals and objectives of one or more standards.

Currently, Security Management Services defines its activities based upon the five principles or function areas for Security Management Services, which include:

- Identity
- Protect
- Detect
- Respond
- Recover

Figure 9, on the next page, illustrates the relationship of interest areas within Standards and Compliance Services

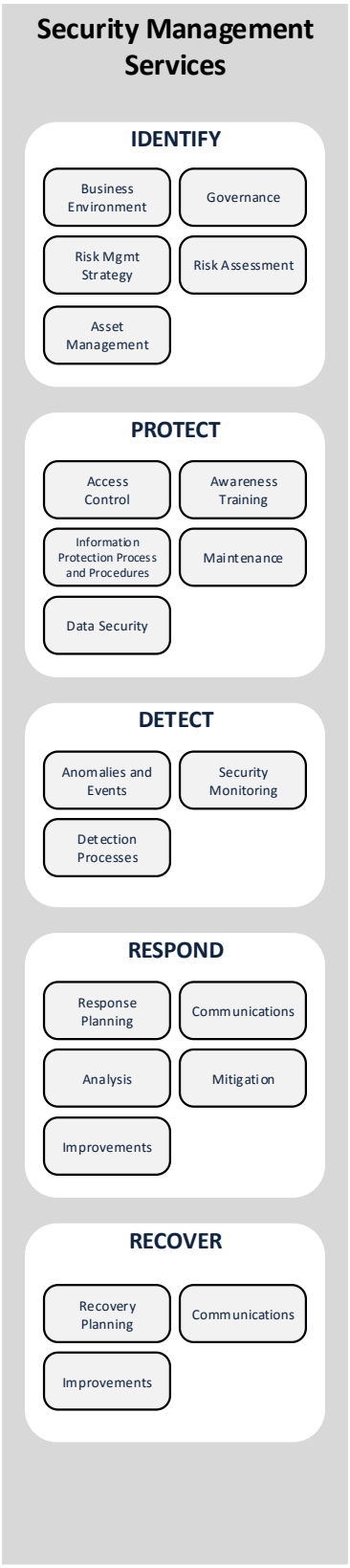

Figure 7 Security Management Services

Identify

Identify – Develop the organizational understanding to manage cybersecurity risk to systems, assets, data, and capabilities.

The activities in the Identify Function are foundational for effective use of the Framework. Understanding the business context, the resources that support critical functions, and the related cybersecurity risks enables an organization to focus and prioritize its efforts, consistent with its risk management strategy and business needs. Examples of outcome Categories within this Function include: Asset Management; Business Environment; Governance; Risk Assessment; and Risk Management Strategy.

Five current areas of interest pertaining to the Identify functional area include:

- Business Environment
- Governance
- Risk Assessment
- Risk Management Strategy
- Asset Management

Protect

Protect – Develop and implement the appropriate safeguards to ensure delivery of critical infrastructure services.

The Protect Function supports the ability to limit or contain the impact of a potential cybersecurity event. Examples of outcome Categories within this Function include: Access Control; Awareness and Training; Data Security; Information Protection Processes and Procedures; Maintenance; and Protective Technology.

Five current areas of interest pertaining to the Protect functional area include:

- Access Control
- Awareness Training
- Information Protection Process and Procedures
- Maintenance
- Data Security

Detect

Detect – Develop and implement the appropriate activities to identify the occurrence of a cybersecurity event.

The Detect Function enables timely discovery of cybersecurity events. Examples of outcome Categories within this Function include: Anomalies and Events; Security Continuous Monitoring; and Detection Processes.

Three current areas of interest pertaining to the Detect functional area include:

- Anomalies and Events
- Detection Processes

- Security Monitoring

Respond

Respond – Develop and implement the appropriate activities to act regarding a detected cybersecurity event.

The Respond Function supports the ability to contain the impact of a potential cybersecurity event. Examples of outcome Categories within this Function include: Response Planning; Communications; Analysis; Mitigation; and Improvements.

Five current areas of interest pertaining to the Respond functional area include:

- Response Planning
- Communications
- Analysis
- Mitigation
- Improvements

Recover

Recover – Develop and implement the appropriate activities to maintain plans for resilience and to restore any capabilities or services that were impaired due to a cybersecurity event.

The Recover Function supports timely recovery to normal operations to reduce the impact from a cybersecurity event. Examples of outcome Categories within this Function include: Recovery Planning; Improvements; and Communications.

Three current areas of interest pertaining to the Recover functional area include:

- Recovery Planning
- Communications
- Improvements

IT Service Management

Information Technology Service Management (ITSM) refers to the entirety of activities – directed by policies, organized and structured in processes and supporting procedures – that are performed by an organization to plan, design, deliver, operate and control information technology (IT) services offered to customers. It is thus concerned with the implementation of IT services that meet customers' needs, and it is performed by the IT service provider through an appropriate mix of people, process and information technology. [Wikipedia, IT Service Management]

Differing from more technology-oriented IT management approaches like network management and IT systems management, IT service management is characterized by adopting a process approach towards management, focusing on customer needs and IT services for customers rather than IT systems, and stressing continual improvement. [Wikipedia, IT Service Management]

Currently, IT Service Management focuses on four main areas of interest which include:

- Service Strategy
- Service Design
- Service Transition
- Service Operation and Support

Figure 10, on the next page, illustrates the relationship of interest areas within Technology Operations and Support Services

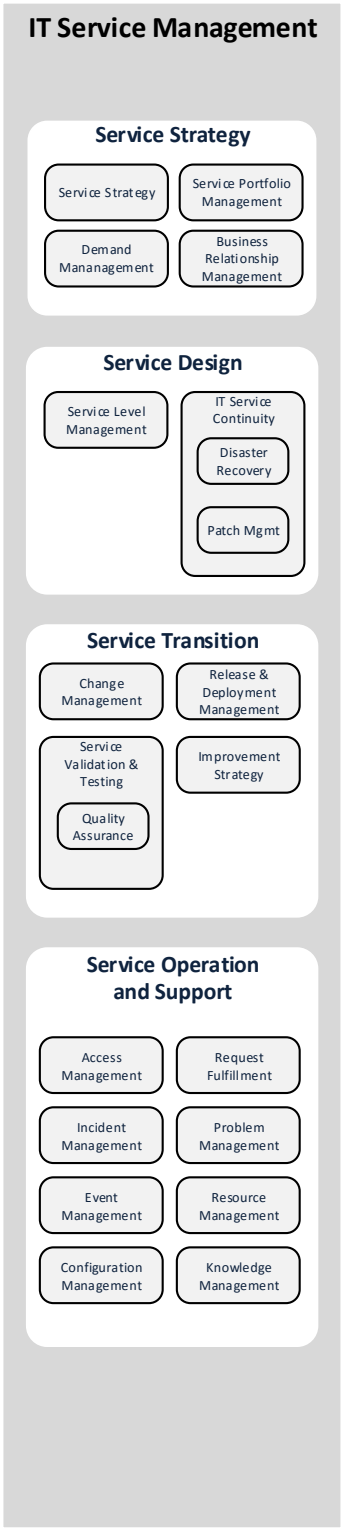

Figure 8 Standards and Compliance Services

Service Strategy

Business outcomes are produced by business processes governed by objectives, policies and constraints. The processes are supported by resources including people, knowledge, applications and infrastructure. Value is defined strictly in the context of business outcomes. [ITIL v3, Service Strategy]

Focus on business outcomes over everything else is a critical advance in outlook for many service providers. It represents a shift of emphasis from efficient utilization of resources to the effective realization of outcomes. Efficiency in operations is driven by the need for effectiveness in helping customers realize outcomes. Customers do not buy services; they buy the fulfilment of needs. This distinction explains the frequent disconnection between IT organizations and the businesses they serve. What the customer values is frequently different from what the IT organization believes it provides. [ITIL v3, Service Strategy]

Four current areas of interest pertaining to Service Strategy include:

- Service Strategy
- Service Portfolio Management
- Demand Management
- Business Relationship Management

Service Design

Service Design deals with the design of new or changed service for introduction into the live environment. [ITIL v3, Service Design]

Service Design attempts to provide a holistic approach to all aspects of design when changing or amending any of the individual elements of design. [ITIL v3, Service Design]

Two current areas of interest pertaining to Service Operation include:

- Service Level Management
- Information Technology Service Continuity Management

Service Transition

Service Transition provides a consistent and rigorous framework for evaluating the service capability and risk profile before a new or changed service is released or deployed. [ITIL v3, Service Transition]

The purpose of Service Transition is to plan and manage the capacity and resources required to package, build, test and deploy a release into production and establish the service specified in the customer and stakeholder requirements. [ITIL v3, Service Transition]

Three current areas of interest pertaining to Service Transition include:

- Change Management
- Release and Deployment Management
- Service Validation and Testing

Service Operation and Support

Service Operation and Support deals with those technologies that are essential in maintaining uninterrupted technical services and ensuring that users have access to the appropriate services required to support business functions. [ITIL v3, Service Operation]

Service Operation and Support is primarily concerned with the proactive and forward-looking services that the business requires from Information Technology to provide adequate support to the business users. It is focused on the business as the customer of the IT services. [ITIL v3, Service Operation]

To the business, customers and users Service Operation and Support is the entry point for service request. They interact with Service Operation and Support by [ITIL v3, Service Operation]:

- Asking for changes
- Needing communication, updates
- Having difficulties, queries.

The Service Help Desk is the single contact point for the customers to record their problems with Service Operation and Support. The Help Desk will try to resolve problems, if there is a direct solution or will open a Help Ticket (i.e., Incident). Incidents initiate a chain of processes: Incident Management, Problem Management, Change Management, Release Management and Configuration Management. This chain of processes is tracked using the Configuration Management Database (CMDB), which records each process, and creates output documents for traceability (future Quality Management). [ITIL v3, Service Operation] [Wikipedia, ITIL]

Eight current areas of interest pertaining to Service Operation and Support include:

- Access Management
- Request Fulfillment
- Incident Management
- Problem Management
- Event Management
- Resource Management
- Configuration Management
- Knowledge Management

Program Management

Program Management was designed based on those best practices and reference frameworks with proven success aligning the business and transforming the program management practice across organizations into a business enabler.

Most program management methodologies focus only on the delivery of technical capabilities while missing the opportunity to create a dynamic synergy with the business, transforming reactive practices into proactive areas that eventually can enable business command centers that provide relevant information about the health around information assets and business processes.

A common concern when organizations decide to integrate services with cloud providers is the level of security the provider will offer as well as the amount of exposure when data is hosted on a multi-tenant model. This domain outlines those aspects that must be considered besides the technological solutions, such as legal guidance, compliance and auditing activities, human resources, and monitoring capabilities with a focus on fraud prevention.

Currently, Program Management focuses on three main areas of interest which include:

- IT Governance
- Enterprise Architecture (EA)
- Project Management Office (PMO)

Figure 11, on the next page, illustrates the relationship of interest areas within Program Management.

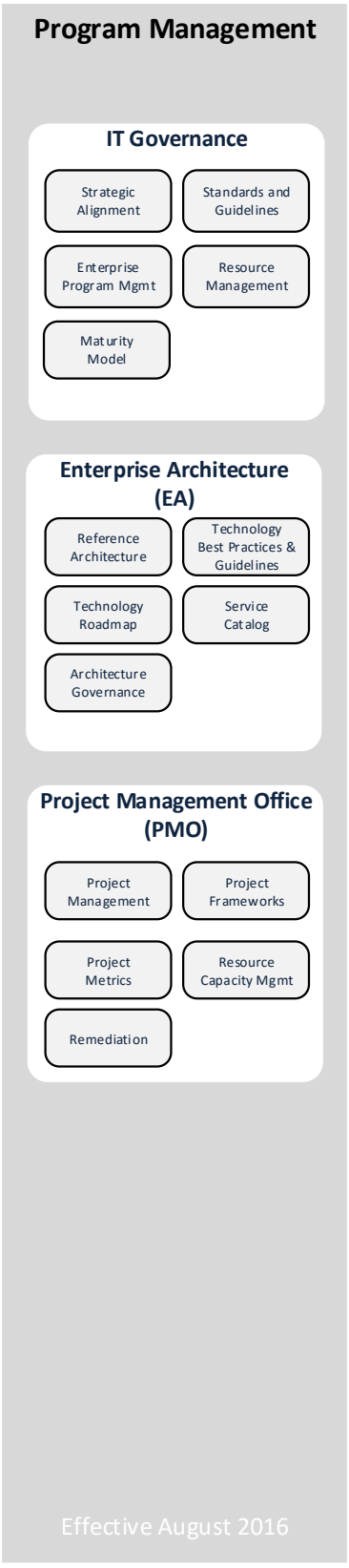

Figure 9 Program Management

IT Governance

This capability covers all processes and components oriented to establish decision rights and accountability framework to encourage desirable behavior in the lifecycle for IT services. [Cloud Security Alliance]

Five current areas of interest pertaining to IT Governance include:

- Strategic Alignment
- Standards and Guidelines
- Enterprise Program Management
- Resource Management
- Maturity Mode

Enterprise Architecture (EA)

By being inclusive with all other management frameworks, Enterprise Architecture (EA) is a discipline that helps the Enterprise define, develop and exploit the boundaryless information flow (BIF*) capabilities in order to achieve the Enterprise's Strategic Intent. [The Open Group, TOGAF 9.1]

Five current areas of interest pertaining to Enterprise Architecture include [The Open Group, TOGAF 9.1]:

- Reference Architecture
- Technology Best Practices and Guidelines
- Technology Roadmap
- Service Catalog
- Architecture Governance

Project Management Office (PMO)

The Project Management Office (PMO) is the department or group that defines and maintains the standards of process, generally related to project management within the organization. The PMO strives to standardize and introduce economies of repetition in the execution of projects. The PMO is the source of documentation, guidance and metrics on the practice of project management and execution. [Cloud Security Alliance] [PMI PMBOK]

Five current areas of interest pertaining to Project Management Office (PMO) include:

- Project Management
- Project Frameworks
- Project Metrics
- Resource Capacity Management
- Remediation

5 Summary

The purpose of this work was to provide guidance and direction to the City enterprise on the better use of Reference Architectures for guiding and constraining architecture descriptions, developments, and usages for current and future capabilities. The approach taken was to research and leverage Reference Architecture information and best practices to develop a City definition for Reference Architecture and describe the elements that compose a City-wide Reference Architecture. The key points made in this document are:

a. Reference Architecture is defined as an authoritative source of information about a specific subject area that guides and constrains the instantiations of multiple architectures and solutions. This definition is applicable to all the City.

b. Reference Architecture may be developed by various organizations throughout City for their own purposes and intended uses, but City-wide Reference Architecture must contain the five elements described in this document.

c. City-wide Reference Architecture is a specific Reference Architecture that provides information and guidance that is applicable to all of City and contains five key elements.

d. The five key elements of a City-wide Reference Architecture are:

    1. Strategic Purpose - explains context, scope, goals, purpose, and intended uses.

    2. Principles - high-level statements, general rules and guidelines that constrain how an organization fulfills its mission.

    3. Technical Positions - technical guidance and standards that need to be implemented as part of the solution.

    4. Patterns - reusable models for doing something.

    5. Vocabulary - key terms and definitions to promote common understanding and use. A City-wide Reference Architecture requires all five elements to properly guide and constrain architectures and solutions.

e. The goals and objectives of Reference Architecture are numerous. They solve a specific (recurring) problem in a problem space; explain context, goals, purpose, and problem being solved including when and how Reference Architecture should be used; and provide concepts, elements and their relationships that are used to direct/guide and constrain the instantiation of repeated concrete solutions and architectures.

f. Reference Architectures may address different levels of abstraction (from the specific to the generalized) and at different levels of coverage (from patterns to full end-to-end coverage).

Appendix A: Solution Reference Architecture Sample Outline

The following sample outline is should be used in the development of a Solution Reference Architecture that is in alignment with the City Enterprise Reference Architecture. The sample outline contains all the elements described in this document. It is not meant to be prescriptive but serves as a guide to assist in organizing the content for a Solution Reference Architecture. [DoD Reference Architecture]

To elaborate, the following sample outline should only be considered illustrative. The goal of a solution reference architecture is to identify and describe compliance with the City Enterprise Reference Architecture, competently and completely describe the architecture of a solution, and to communicate solution value relative to the guiding principles outlined in Section One of this document. [DoD Reference Architecture]

Solution Reference Architecture

1. Introduction
   a. Overview
   b. Scope Sources
   c. Key Authoritative
2. Context
   a. Guiding Principles
   b. Constraints and Assumptions
      i. Constraints
      ii. Assumptions
   c. Alignment with City Enterprise Reference Architecture
3. Service Capability Description
   a. Authentication
   b. Authorization & Access Control
   c. Activity Decomposition
4. Principles/Rules and Process Pattern(s)
   a. Solution Reference Architecture Principles and Rules
   b. Process Pattern(s)
      i. Combined Process Pattern
      ii. Authentication Process Pattern
      iii. Authorization and Access Control Process Pattern
5. Technical Position

Appendix A: Acronyms
Appendix B: Integrated Dictionary
Appendix C: Diagrams

Figure 10 Sample Solution Architecture

Appendix B: Examples of Solution Reference Architectures

OASIS SOA Reference Architecture

The OASIS Reference Architecture for Service Oriented Architecture follows from the concepts and relationships defined in the OASIS Reference Model for Service Oriented Architecture. OASIS Reference Architecture is an abstract realization of SOA, focusing on the elements and their relationships needed to enable SOA-based systems to be used, realized and owned; while avoiding reliance on specific concrete technologies. While it remains abstract in nature, the OASIS Reference Architecture describes one possible template upon which a SOA concrete architecture can be built. [DoD Reference Architecture]

The OASIS Reference Architecture goal is to show how SOA fits into the life of users and stakeholders in a SOA ecosystem, how SOA-based systems may be realized effectively, and what is involved in owning such a SOA-based system. The following diagram taken from the OASIS Reference Model depicts the overview of the OASIS SOA Reference Architecture and Reference Model space showing levels of artifacts from concrete to abstract. [DoD Reference Architecture]

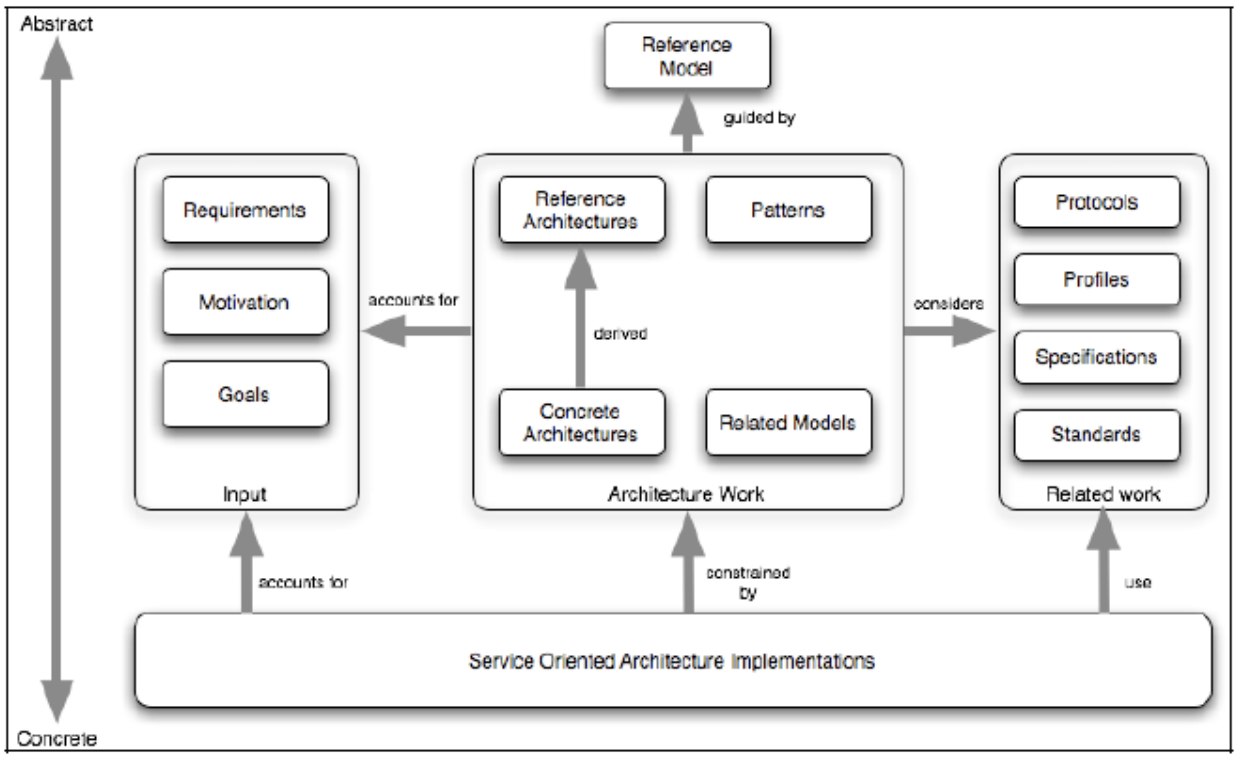

Figure 11 Sample of OASIS-Based SOA Reference Architecture and Reference Model / DoD Reference Architecture

The Open Group SOA Reference Architecture

The Open Group has published their SOA Reference Architecture. This document provides guidelines for making SOA architectural, design, and implementation decisions. It provides patterns and insights for integrating the fundamental elements of a SOA solution composed of architectural building blocks (ABB) within a nine-layer structure. Their SOA Reference Architecture serves as a blueprint that includes

templates and guidelines for architects. These will enable the process of modeling and documenting the nine architectural layers, their architectural building blocks (ABB), options for layers and ABBs, mapping of products to the ABBs and architectural and design decisions that contribute to the creation of a SOA. [DoD Reference Architecture]

The nine layers of the Open Group's SOA Reference Architecture are designed to reinforce the various perspectives of SOA business value. For each layer, there are two aspects: logical and physical. The logical aspect includes all the architectural building blocks, design decisions, options, KPIs, etc.; the physical aspect of each layer is to cover the realization of each logical aspect using technology and products and is determined by the different architectural decision points that get taken. This specification focuses on the logical aspect of the SOA Reference Architecture, while providing the model for the architectural decision points. [DoD Reference Architecture]

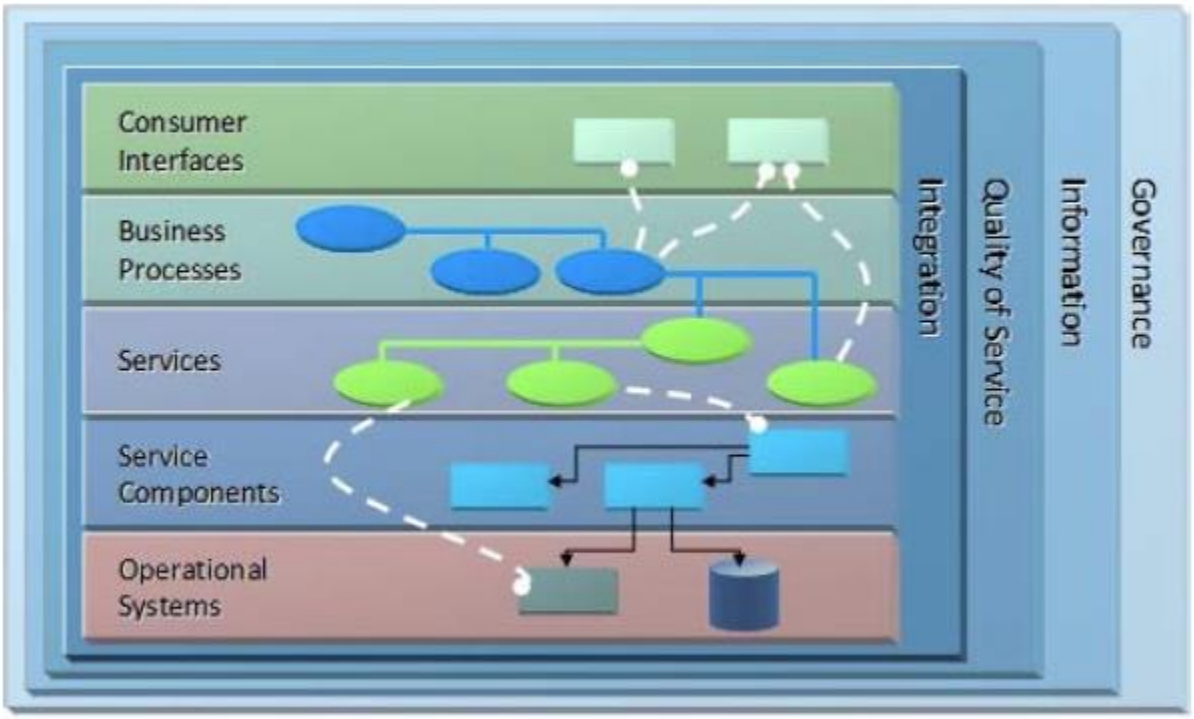

Figure 12 The Open Group SOA Reference Architecture Layers / © 2009 The Open Group / DoD Reference Architecture

Appendix C: References

To expedite the development and publication of Reference Architecture material, this document draws heavily upon the following resources:

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Appendix D: Definitions

Architecture Definitions

Solution Architecture

A framework or structure that portrays the relationships among all the elements of something that answers a problem. It describes the fundamental organization of a system, embodied in its components, their relationships with each other and the environment, and the principles governing its design and evolution.

Reference Architecture

Reference Architecture is an authoritative source of information about a specific subject area that guides and constrains the instantiations of multiple architectures and solutions. [DoD Reference Architecture]

Cloud Computing Definitions

On-demand self-service.

A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.

Broad network access.

Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).

Resource pooling.

The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacenter). Examples of resources include storage, processing, memory, and network bandwidth.

Rapid elasticity.

Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.

Measured service.

Cloud systems automatically control and optimize resource use by leveraging a metering capability1 at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service