Using the Business Ontology to Develop Enterprise Standards

Mark von Rosing, Global University Alliance, Chateau Du Grand Perray, La Bruere-Loir, France

Henrik von Scheel, LEADing Practice, Ottawa, Canada

ABSTRACT

The Business Ontology presented in this publication has taken the Global University Alliance's members over a decade to research and develop, spending hundreds of 'man years' to create. One of the major challenges facing practitioners and their interactions with academia is overcoming a presently fragmented way of thinking, working and modelling around enterprise concepts. Business frameworks, methods, approaches and concepts currently have their own vocabulary. Each of these vocabularies has its own definition of terms, including conflicting visual representations. (Moody, 2009) This paper therefore elaborates on how the academics have created a rich business taxonomy, defined enterprise meta objects, semantics, enterprise layers as well as the related artefacts. These artefacts have been constructed rigorously to meet up to academic standards and need to be relevant for practitioners as well. (Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011) The objectives are therefore to share the business ontology and elaborate on its research and development journey, and how the business ontology helps to remedy the inconsistent use of business relevant terms and the semantic relations between them to create the basis for enterprise relevant models and meta-models. In addition to that, it provides practitioners with the ability to map them to their various ways of thinking, working and modelling. The business ontology will be introduced as a domain ontology and the paper shows how it can be used to develop enterprise standards and industry standards.

KEYWORDS

Business Ontology, Enterprise Layers, Enterprise Standards, Folksonomy, Industry Standards, Meta-Objects, Structured Way of Working, Taxonomy

INTRODUCTION

Standards bodies (e.g., ISO, CEN, LEADing Practice, OMG) and other practitioner organisations have documented vast amounts of business knowledge as frameworks (e.g., TOGAF, ITIL, and COBIT), methods and or approaches (e.g. LEAN, Six Sigma, BPR, TQM, Zero Defect, BPMN, BPMS). Each of these standards, frameworks, methods and approaches have their own vocabulary and concepts, and hence definition of terms like business process, process step, process activity, events, role, owner, measure or even rule. This semantic heterogeneity clearly hampers mutual understanding, communication and artefact integration between the various frameworks, methods and approaches, even within and across the standards bodies and organizations applying their standards. (Jung, 2009) What is needed is a unified ontology and vocabulary for business that is rigorously built according to academic and industry standards and at the same time sufficiently detailed to be immediately applicable by practitioners.

This paper introduces a business domain ontology which from now on will be referred to as the 'business ontology', and incorporates all constructs that can be found in the most popular business standards and frameworks. It builds on the paper entitled "An Introduction to the Business Ontology" (von Rosing & Laurier, 2015) as well as the paper "Using a Business Ontology for Structuring Artefacts: Example - Northern Health" (von Rosing, Urquhart & Zachman, 2015). Both published in the June 2015, IJCSSA publication. This publication should therefore be seen as a more detailed specification of the business ontology. The content will be presented in the following way; Firstly, this publication will discuss the enterprise layers. Then we discuss how the most common identified meta-objects used within business concepts fits to the discussed enterprise layers, followed by a clear set of definitions of the mentioned meta-objects. We will also discuss how semantic concepts were used to capture and define the most common structure and relationships within artefacts i.e. maps, matrices and models. This includes the illustration where the objects and the specific relations appear in various artefacts. This is seen as a major benefit as the business ontology concepts can then be applied back to various enterprise modelling concepts such as business model, process modelling, value modelling, risk modelling as well as enterprise architecture concepts such as business architecture, information architecture and technology architecture.

THE IMPORTANCE OF UNDERSTANDING THE STRUCTURES OF THE ENTERPRISE LAYERS

An *ontology* is an intentional semantic structure that encodes the set of objects and terms that are presumed to exist in some area of interest (i.e. the universe of discourse or semantic domain), the relationships that is between them and the implicit rules constraining the structure of this (piece of) reality.(Genesereth & Nilsson, 1987; Nicola Guarino & Giaretta, 1995) In this definition, intentional refers to a structure describing various possible states of affairs, as opposed to extensional, which would refer to a structure describing a particular state of affairs. The word semantic indicates that the structure has meaning, which is defined as the relationship between (a structure of) symbols and a mental model of the intentional structure in the mind of the observer. This mental model is often called a conceptualization (Gruber, 1993). Semantics are an aspect of semiotics, like syntax, which distinguishes valid from invalid symbol structures, and like pragmatics, which relates symbols to their meaning within a context (e.g., the community in which they are shared). (Cordeiro & Filipe, 2004) The structures and context in the organizations should be considered as a whole (von Rosing, Zachman, von Scheel, 2015) which subsequently includes the views and models that capture the:

- **Business Perspective:** Such as the purpose and goal, competencies, processes, and services aspects;
- **Information Perspective:** Such as the application systems, as well as the data components;
- **Technology Perspective:** Such as the platform and infrastructure components

The mentioned layers are an abstraction that represents and considers the enterprise as a whole. (von Rosing, Zachman, von Scheel, 2015) For example, a policy, act, regulation or even a strategy is a part of the business layer, while the application systems and data aspects is a part of the Information layer. From the research and analysis done by the Global University Alliance (GUA), the most common identified structures and context in the organizations were spread across the business, information and technology layers.

For the research method of identifying the most common enterprise structure and context, we refer to the section "Academia Industry Design: A collaborative process between research and industry" in the paper entitled "An Introduction to the Business Ontology". (von Rosing & Laurier, 2015) In the next section we will cover the most common identified objects across the enterprise layers.

Objects Involved within the Enterprise Layers

All ontologies have a controlled vocabulary as a foundation. (Lassila & McGuinness, 2001) As the Business Ontology is an extensive ontology that has the ambition to cover the various aspects of an organization (as opposed to academic ontologies), its terms are organized in multiple intersecting relevant objects. In table 2 are listed the most common identified objects across the enterprise layers. These meta objects are entities that manipulate, create, describe, or implements other objects. Below is a list of these meta objects and their description.

The 87 objects represented in table 2 are all included in the business ontology as the object class types with each of them having stereotypes, types and subtypes. For example, if we would decompose the class type "data object" which has the unique ID of #62, we would find the following stereotypes that categorizes them according to their nature (see table 3). The data object stereotypes would be structured and unstructured data. Each of them has specific types, for example within the stereotype structured data the following types would be found: meta data, master data, transactional/ operational data as well as analytic data. Within the types, we identified the most common subtypes. For example, within the 'meta data' type there are the following common subtypes: Services Directory, Data Directory, Content Directory, Metadata Indexing, Translation, Retrieval, Navigation, Metadata Bridges, Metadata Tools Interface and Metadata Models. All of them have clearly defined descriptions as part of the overall Business Ontology Taxonomy. (von Rosing & Laurier, 2015) Table 3 illustrates with an example breakdown of the class type "data object" into some of its stereotypes, types and subtypes.

As a part of the overall Business Taxonomy, each of the mentioned class types shown in table 2 also has subtypes with clear definitions. While all of them represent the most common identified objects and descriptions used by the organizations, they are not the only possible stereotypes or the only possible subtypes. (von Rosing & Laurier, 2015) Therefore this enables organizations, concept developers and standard bodies alike to use these researched and validated objects and definitions to develop something where the ontology part is not 'self- or homemade'. One of the major challenges facing the market today, is overcoming a presently fragmented way of thinking, working and modelling around enterprise concepts that currently exists. Business frameworks, methods, approaches and concepts like TOGAF, ITIL, BPMN, CMMN etc. all have their own defined objects and vocabulary. Each of these vocabularies have their own definition of terms, like "strategy" or "process", including conflicting visual representations. (Moody, 2009) Even standards bodies like ISO, CEN, OMG have not only across the standards bodies duplicate and even conflicting terms, they also have within their own standards, vocabulary and concepts, and hence their own definition of terms. Many of them has different notations, descriptions and semantic relations for the same object. For example, in the case of the OMG software standards BPMN, CMMN, VDML, etc., they all have a process/activity, but different notation shapes, descriptions and semantic relations for the object. This heterogeneity clearly hampers mutual understanding, communication and the ability to model across the various software standards. As a matter of fact, our study in the Global University Alliance indicated that as more standards are used by standards bodies that allow such a heterogeneity, the lower the maturity of standardization actually becomes, thus being counter-productive to the user. Who pays the prize of this heterogeneity? The organizations applying the siloed way of thinking, working and modelling. It creates silos where they shouldn't exist, enforcing repetition, duplication and replication, all adding to the cost model and to the complexity of the organizations. While adding to the cost model hurts the revenue model, the fact that it adds complexity to an organization where it should not hamper and obstructs the value model, performance model as well as the operating model of the organization.

Also artefact integration between the various frameworks, methods, and approaches, even within and across the standards bodies and organizations applying their standards is not guaranteed (Jung, 2009), thereby increasing the modelling and architecture burden of the organizations. Again, this adds unnecessary cost and complexity. All in all, we identified this to be the source of high cost and low value creation in most organizations that we analyzed and worked with, making this a huge unknown factor of inefficiencies and ineffectiveness.

What is needed is a unified ontology and vocabulary for business that is rigorously built according to academic and industry standards and at the same time sufficiently detailed to be immediately applicable by practitioners. The table 2 and 3 meta objects have therefore been constructed rigorously to meet up to academic standards and need to be relevant for practitioners as well. (Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011) Something that is useable and immediately can be put to practice. In the succeeding section we will elaborate on how the discussed meta objects relates to the enterprise layers illustrated in table 1.

How the Meta Objects Relate to the Enterprise Layers

The meta objects and their class types, stereotypes, types and subtypes all have according to their context a very precise affiliation to a specific layer. The affiliation to a specific layer and sub-layer is based on the objects purpose, goal, aim, target, objective and context. While the meta object have multiple semantic relations across the layers, based on their context, they have an explicit affiliation to a specific layer. This affiliation is a set association which doesn't change with time or the semantic relationships the object has with other objects, within or across the layers. Therefor one of the findings of the GUA research was the identification of both the objects (table 2), their semantic relationship between them, which lead to the development of meta models and meta meta models. (von Rosing & Laurier, 2015) In addition also the fixed association to a layer and a sublayer (table 2). In Figure 1, is an overview of the enterprise layers, the affiliated meta objects as well as their specific notation shapes.

The categorization of the class type objects according to their relevant layers and subjects enables practitioners to use them in their direct context, but also enables enterprise modelling, engineering and architecture principles appropriate for handling the different tasks, correlations, relationships and connections. Especially since the mentioned meta objects not only have one relationship, but multiple interaction points within one layer and across the layers. In the next section we will elaborate on the association and correlation of the objects within and across the layers.

Table 1. Overview of the the most common enterprise context and structure

Business	**Purpose & Goal** – Captures ideas about the vision, mission, strategy policy, act and regulations as well as all the value the organizations seek to create.
	Business Competency – Identifies those parts of the organization that identify the essential organizational structures, roles, and capabilities needed to fulfil the scope and purpose.
	Business Service – Captures the details of how the organization can realize or achieve the desired behavior.
	Business Process - Contains the description about the activities and processes of the organization.
Information	**Application** – Captures the details of the structure and behavior of the application components, modules, system tasks, and application services.
	Data - Contains the data components, data objects, entities, data service and data media resources within the organization.
Technology	**Platform** – is based on the platform components, platform devices and the services necessary to provide the right storage and access to the data or to allow applications to operate and execute.
	Infrastructure – comprises of the infrastructure components, devices and services that are necessary to provide the environment for the assets within the platform to function or constrain their operation.

Table 2. Overview of the most common enterprise meta object class types

#	Meta Object Class type	Description
1	Force (external/ internal)	An external or internal factor that forces or pushes some aspect of an enterprise in a specific direction.
2	Driver	An external or internal factor that drives, establishes motivation for or influences the direction of an enterprise.
3	Expectation	The anticipated benefits that are of worth, importance, and significance to a specific stakeholder.
4	Value Proposition	The merit and benefit that a customer, added value partner or the market itself can obtain from their perspective and point of view.
5	Vision	The desired future state of the enterprise. An imagination of the future aspirational state of how the enterprise could or should be like without regard as to how this will be achieved.
6	Mission	The purpose and nature of the enterprise.
7	Strategy (Strategic Objective)	The direction and ends to which the enterprise seeks as well as the means and methods by which the ends will be attained.
8	Goal	A desired result considered a part of the organizational direction, aims, targets, and aspirations.
9	Objective (Critical Success Factor)	The purpose or target of one's efforts or actions.
10	Plan	The notion of thinking about and organizing the tasks required to achieve a desired output.
11	Quality	A state of excellence or worth specifying the essential and distinguishing individual nature and the attributes based on the intended use.
12	Risk	The combined impact of any conditions or events, including those caused by uncertainty, change, hazards or other factors that can affect the potential for achieving objectives.
13	Security	The objects or tools that secure, make safe and protect through measures to prevent exposure to danger or risk.
14	Measure	Any type of measurement used to gauge some quantifiable component of an enterprise's performance.
15	Time	A plan, schedule, arrangement or measure for when something should initiate, take place, be completed or the amount of time consumed.
16	Monitor	To be aware of the state, through observation or measuring. To supervise and to continually check and critically observe. It means to determine the current status and to assess whether or not required or expected performance levels are actually being achieved.
17	Control	The exercise of restraining or directing influence. It includes decision making aspects with accompanying decision logic necessary to ensure compliance.
18	Report	The exposure, description, and portrayal of information about the status, direction or execution of work within the functions, services, processes, and resources of the enterprise.
19	Organization	An arrangement or formation of resources that has a set of collective goals
20	Enterprise Capability	An enterprise capability is an abstraction that represents the ability to perform a particular skillset i.e. organizational competencies, personal competencies, business function, processes, services, and technology.
21	Organizational Competency	An integrated and holistic set of related knowledge, skills, and abilities related to a specific set of resources (including persons and organizations) that - once combined - enables the enterprise to do something well.
22	Resource	A specific person, expertise, data, information, material, machine, land, capital or organization that is required to accomplish an activity or as a means to act on behalf of the enterprise to achieve a desired outcome.
23	Actor	Any person, organization, or system that many be assigned one or more roles. Actors may be internal or external to an organization.
24	Role	A part that something or someone has the rights, rules, competencies, and capabilities to perform. A resource and/ or actor may have a number of roles i.e. process role, service role or application role and many actors may be assigned the same role.
25	Organizational Function	A cluster of tasks performing a specific class of jobs.
26	Business Object	A real world thing which relate to the enterprise's means to act.
27	Product	A result and output generated by the enterprise. It has a combination of tangible and intangible attributes (i.e. features, functions, usage).

Table 2. Continued

#	Meta Object Class type	Description
28	Contract	An agreement between two or more parties that establishes conditions for interaction.
29	Organizational Rule	A statement that defines or constrains some aspect of behavior within the enterprise and always resolves to either true or false.
30	Business Compliance	The process or tools for verifying adherence to rules and decisions.
31	Location	A point, facility, place or geographic position that may be referred to physically or logically.
32	Business Channel	A means of access or otherwise interacting within an enterprise or between an enterprise and its external partners (i.e. customers, vendors, suppliers, etc.).
33	Business Media	The material or matter used to store information (i.e. printed page, digital tape, CD, disk as well as non-volatile storage, screen, or memory).
34	Business Workflow	A flow, stream, sequence, course, succession, series or progression of as well as order for the movement of information or material from one enterprise function, service or activity (work site) to another.
35	Service Construct (setup and delivery)	The setup and arrangement which creates, organizes, and delivers business services.
36	Business Service	The externally visible [logical] deed or effort performed to satisfy a need or to fulfill a demand that is meaningful to the [business] environment.
37	Service Flow (incl. output/input)	A set of one or more service input or output states where each service state defines a step in the service flow that - when entered - executes a certain behavior.
38	Service Rule	A statement that defines or constrains some aspect of the creation of value within the enterprise.
39	Service Channel	A logical or physical communication path used to requisition provision or deliver outputs to or by business services.
40	Process	A set of structured activities or tasks with logical behavior that produce a specific service or product.
41	Event	Something that happens, this may include a planned occasion or a state change that recognizes the triggering or termination of processing.
42	Gateway	Determines forking and merging of paths depending on the conditions expressed.
43	Process Flow (incl. Input/output)	A flow, stream, sequence, course, succession, series or progression that are based on the process input or output states where each process input or output defines the process flow that together executes a behavior.
44	Process Rule	A statement that defines or constrains some aspect of work and always resolves to either true or false.
45	Application Component	An encapsulation of application functionality that is independent of a particular implementation.
46	Application Module	A single executable part - which is part of a larger application - that provides identifiable functions and exists within a specific application component.
47	Application Feature	A notable property or characteristic of an application that can include a trait or design constraint.
48	Application Function	The specification of a significant aspect of the internal behavior of the application which acts as a broader description of a set of application features.
49	Application Task	The automated behavior of a process activity performed by an application.
50	Application Service	An externally visible unit of functionality, provided by one or more components, exposed through well-defined interfaces, and meaningful to the environment.
51	Information Object	Information about real world objects that can be in any medium or form.
52	Application/System Flow	The specification of the sequence in which two application tasks processes, or an application task and an application event or gateway are executed, one of which provides an output which is an input to the other.
53	System Measurement	Measures that are defined and implementable within an application.
54	Application/System Report	Reports that are defined and implementable or implemented within or by an application.
55	Application/System	A collection of software adding capability to the enterprise through its ability to enable work.
55	Application Role	A part recognized within an application, providing behavior to automate or enable some parts of a business function, service or process task.

Table 2. Continued

#	Meta Object Class type	Description
57	Application Rule	A business rule that is implemented within and executed by an application.
58	Application Compliance (incl. Security)	Behavior or ability within an application whereby it can certify the integrity of application rules.
59	Application Channel	A physical communication path used by one or more applications to requisition, provision, or deliver outputs.
60	Application Media	Material or matter used by an application as the source or method of accepting or providing inputs and outputs.
61	Data Component	A cohesive collection of data that is part of an application.
62	Data Object	A logical cluster of all sets of related data representing the data object view of a business or information object.
63	Data Entity	An encapsulation of data where logical data entities are a specification of the organization of information to store data as a physical persistence structure e.g. data tied to applications, repositories, and services.
64	Data Table	A physical specification of the means of arranging data in rows and columns while being stored in a physical persistence structure e.g. data tied to applications, repositories, and services.
65	Data Service	A standardized and uniform way of accessing information in a form that is useful to enterprise applications without requiring knowledge of its physical persistence structure.
66	Data Flow	The specification of the sequence in which data moves from one state to another.
67	Data Rule	Criteria used in the process of determining or verifying values of data or generalizing certain features of data.
68	Data Compliance (incl. Security)	The means of adhering to and verifying adherence to policies and decisions about the data.
69	Data Media	The matter or material used to store physical persistent data.
70	Data Channel	A physical communication path used to requisition, provision or deliver data.
71	Platform Component	An abstract description of the features of the existing environment that the application software is expected to have to allow it to execute.
72	Platform Device	A set of platform components configured to act as a modular part of a platform.
73	Platform Function	The specification of a significant job and/or task of the internal behavior of the platform.
74	Platform Service	A technical delivery task required to provide platform enablement mechanisms to support the delivery of one or more parts of an application.
75	Platform Rule	Criteria used in the process of determining the behavior of the platform.
76	Platform Compliance (incl. Security)	The means of adhering to and verifying adherence to policies and decisions about the platform.
77	Platform Media	The matter or material provided by a platform as the source or method for storing data.
78	Platform Channel	A physical path used by a platform to host an application software.
79	Infrastructure Component	An abstract description of the features of the existing environment that the platform requires to operate.
80	Infrastructure Device	A set of infrastructure components configured to act as a modular part of the infrastructure.
81	Infrastructure Function	The specification of a significant aspect of the internal behavior of the infrastructure which acts as a broader description of a set of infrastructure features.
82	Infrastructure Feature	A notable property or characteristic of the infrastructure that can include a trait or design constraint.
83	Infrastructure Service	A technical delivery task required to provide infrastructure enablement mechanisms to support the delivery of one or more parts of a platform.
84	Infrastructure Rule	Criteria used in the process of determining the behavior of the infrastructure.
85	Infrastructure Compliance (incl. Security)	The means of adhering to and verifying adherence to policies and decisions about the infrastructure.
86	Infrastructure Media	The matter or material provided by an infrastructure as the source or method for transmitting data.

Table 2. Continued

#	Meta Object Class type	Description
87	Infrastructure Channel	A physical communication path used by an infrastructure component to provide the resources needed by a platform.

Association and Correlation of the Meta Objects Across the Enterprise Layers

As we have discussed in this paper, the categorization and thereby the association of the class type objects according to the relevant enterprise layer enables the practitioner to use them in their direct context. Thereby having identified the meta objects across the layers, which are an abstraction that represents and considers the enterprise as a whole (von Rosing, Zachman, von Scheel, 2015), it is vital not only to understand the context of the meta object to the layer, but also to understand the relationships of the objects within and across the layers. In the following examples we will discuss general relationships of objects within and across the enterprise layers. Please note that the (#) symbol is a reference to the meta object numbers found in figure 1.

- Strategies (#7), objectives (#8) and goals (#9) define the direction of the organization (#19) and thereby the specific organizational functions (#25).
- The organizational functions create and work with resources (#22) and actors (#24) to execute the defined strategies, objectives and goals.
- Value or performance expectations (#3) influence plans (#10) around organizational functions.
- Organizational Functions create business services (#36).
- Organizational Functions are executed as a task within a Business Process (#40).
- The organizational functions can partly or fully be automated as application functions within application components (#45) and application modules (#46).
- The business services can partly or fully be automated as application services (#50).
- The business processes can partly or fully be automated as application tasks (#49).
- The organizational functions and processes have business roles (#24).
- When automating an organizational function, process or service within application/systems (#55), there will be application roles (#55).
- The business roles as well as the application roles work with both business objects (#26) as well as information objects (#51).
- Control (#17) of organizational functions, roles, processes and services can be ensured through rules (#29) i.e. policies, acts, regulations, procedures and standards.
- Organizational rules are also set in place to ensure quality (#11), lower risk (#12) and ensure security (#13).
- Organizations (#19) relate the organizational rules (#29) throughout the enterprise. For example, when applying it to the business processes and business services, these would become specific process rules (#44) and service rules (#38). All the rules can also be related to the information and data objects (#62) and can be automated into application rules (#57), platform rules (#75) and/or Infrastructure rules ((#84).
- Platform Devices (#72) i.e. smart phones, tablets, scanners etc. are used by Roles to support the functions, processes and services.
- Organizational functions, processes, services and thereby also the resources as well as the execution of the defined rules can be measured (#14) e.g. Performance Indicators.
- Data Objects (#62) are within Measurements.
- Information Objects and Data Object enables creation of Report (#18).

Table 3. Example of the of the overall Business Ontology Taxonomy with a breakdown of the class type "data object" into some of its stereotypes, types and subtypes

Class type	Description	Stereotype (Nature of Object)	Description	Type	Subtype
Data Object	A logical cluster of all sets of related data representing the data object view of a business or information object.	Structured Data	Has been or can be placed in fields	Meta Data	Services Directory
					Data Directory
					Content Directory
					Metadata Indexing
					Translation
					Retrieval
					Navigation
					Metadata Bridges
					Metadata Tools Interface
					Metadata Models
				Master Data	Interface Services
					Lifecycle Management Services
					Hierarchy & Relationship Management Services
					Master Data Event Management Services
					Authoring Services
					Data Quality Management Services
					Base Services
				Transactional/Operational Data	Management
					Query
					Continuous Query
					Storage Model
					Performance Optimization
					Connector
					Data Indexing
					In Memory DB
					Calculation Engine
				Analytic Data	Operational Intelligence
					Query, Report, Scorecard
					Exploration & Analytics
					Data Warehouse
					Identity Analytics
					Unstructured/Text Analytics
					Discovery Mining
					Predictive Analytics
					Cubing Services
		Unstructured Data	Is not relational and doesn't fit into pre-defined data models	Character Data	Document Management Services
					Digital Asset Management Services
					Compliance Management Services
					Reporting & Monitoring Services
					Content Capture & Indexing Services
					Content Storage & Retrieval Services
					Content Business Process Services
					Base Services

Table 3. Continued

| Class type	Description	Stereotype (Nature of Object)	Description	Type	Subtype
				Audio Data	Document Management Services
					Digital Asset Management Services
					Compliance Management Services
					Reporting & Monitoring Services
					Content Capture & Indexing Services
					Content Storage & Retrieval Services
					Content Business Process Services
					Base Services
				Video Data	Document Management Services
					Digital Asset Management Services
					Compliance Management Services
					Reporting & Monitoring Services
					Content Capture & Indexing Services
					Content Storage & Retrieval Services
					Content Business Process Services
					Base Services

- Business measurements as well as system measurements (#53) are found within reports. Reports which also can be automated within application/system reports (#54).
- Information Objects as well as Data Object are sequenced by Application/System Flow (#52)
- An Application/System Flow partially or fully automates a Business Workflow (#34)
- A Business Workflow is made up of Application Tasks
- …and so on, and so forth.

Please note that the purpose of this example was not to specify or detail all the semantic connections between the objects, but rather to illustrate the basic associations between the objects and thereby the layers. In figure 2, have we demonstrated an example of basic links within and across the enterprise layers. While very simplistic, the illustration epitomizes the basic link between the service-oriented objects of the layers, and therefore the need for not only thinking, working and modelling in siloed concepts, but rather to relate the concepts that fit together.

What makes the layered concept different from other, more traditional enterprise frameworks, methods and approaches, is the fact that it does not only work in domains or a specific subject, but in layers. The ability to work within and across the layers, and thus simultaneously work within multiple domains and subjects effortlessly, integrates semantically the right objects across the different silos, thereby both enabling enterprise modelling, engineering and architecture principles. (von Rosing, Zachman, von Scheel, 2015)

In the following two sections, we will discuss the repeatable patterns around the discussed meta objects and enterprise layers.

Figure 1. overview of the enterprise layers, the associated meta objects and their specific notation shapes
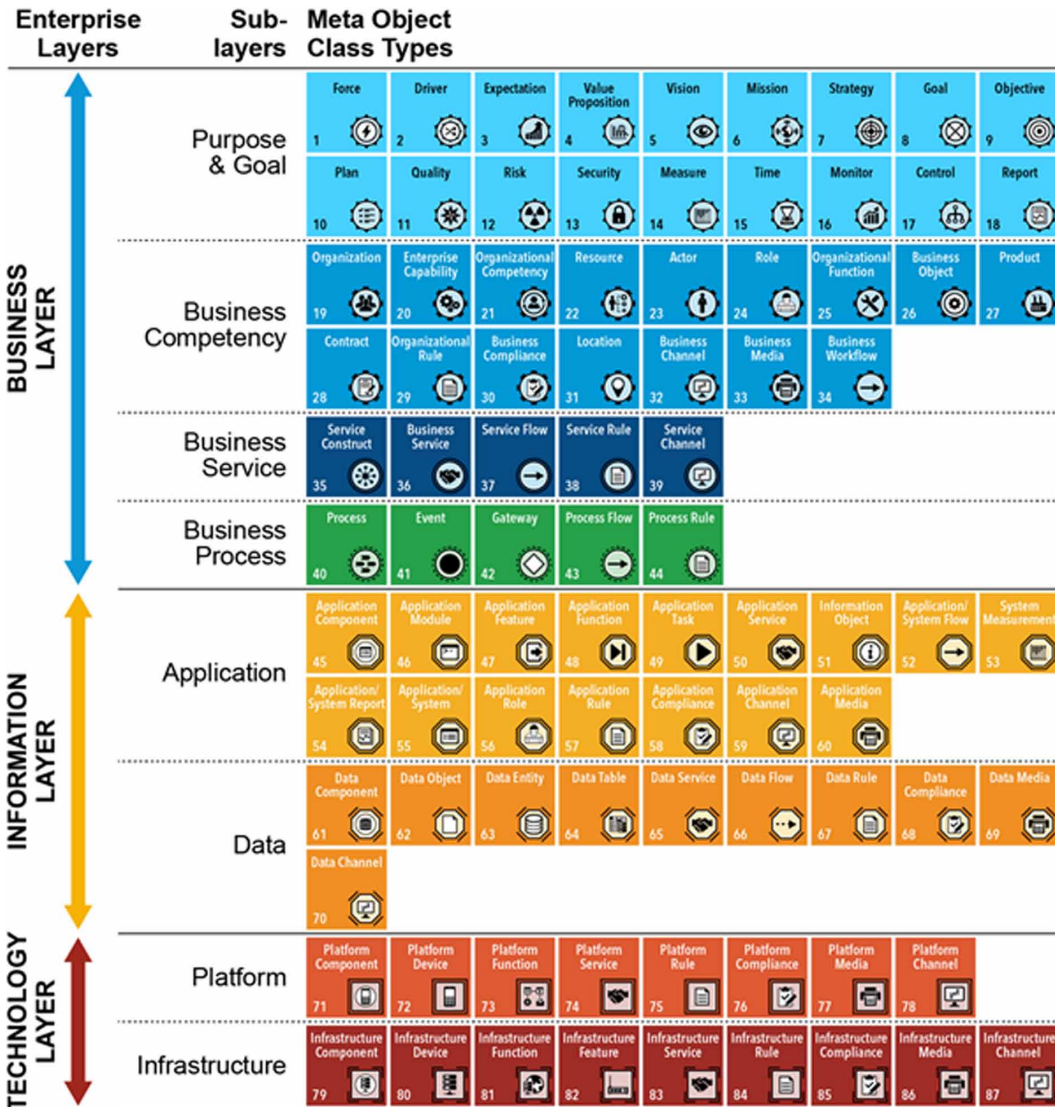
The Repeatable Enterprise Patterns

As a part of the 2004 detailed research of the Global University Alliance, which was the foundation of developing this Business Ontology, we identified the most common meta objects, stereotypes, types and subtypes with all their definitions and over 10.000 semantic relationships that were common across all organizations, business units, departments and agencies. There were plenty surprises along the way, one of them was that despite being independent of size, product or service when the objects existed within the organization, they had the same semantic relationship. It surprised us, because were these findings really true? We analyzed 10 different industry sectors, namely the Financial Services, Industrial sector, Consumer Packaged Goods, Consumer Services, Energy, Public Services, Healthcare, Utilities, Transportation, Telecommunication and the High Tech sector organizations with the same output and results. The semantic relations were the same. Even when analyzing and researching the 51 sub-industries we came to the same conclusion. While certain industries had specific meta objects

Figure 2. Illustration of basic links between the service-oriented objects and the layers
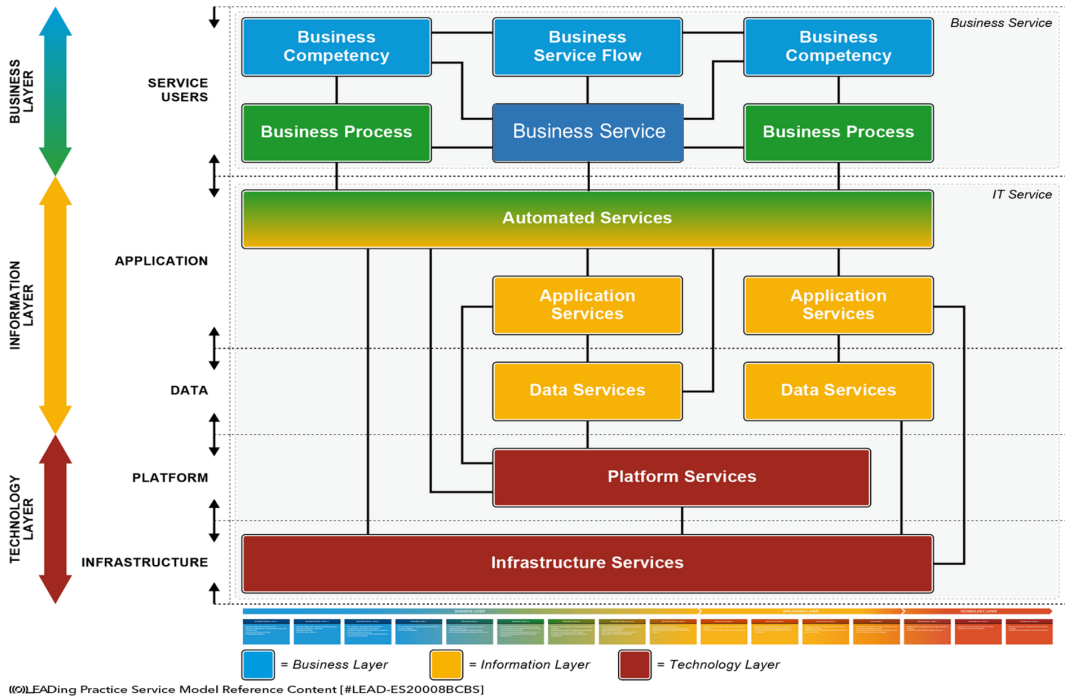
with types and subtypes relevant for their industry, all the industries had the meta objects listed in table 2. All the industries also had the same semantic relations. The findings led to a lot of questions in our research team, so we decided to analyze what differentiated the organizations in their way of working with the objects. In order to understand the behavior, we decided to examine the activities of the industry leaders (financial outperformers in each industry). In order to do that, we examined data from the Standard & Poor's archives during a period from 1994 to 2004, and later again from 2004 to 2014. As part of the GUA research, we scrutinized the differences between the responses of financial outperformers and those of underperformers over a 10-year period. For organizations with publicly available financial information, we compared revenue and profit track records with the average track records for those in the same industry. We analyzed and cross-referenced the findings to other existing research that have proven that there is a connection to organizations approaches and their overall performance (Malone, T.W., Weill, P., Lai, K, D'Urso, V., Herman, G., Apel, T., Woerner, S., 2006). MIT (Malone, 2004), Accenture Research (Accenture, 2009), IBM Institute for Business Value (IBM, 2008, 2009, 2010, 2011, 2012), Business Week Research (BW, 2006), and The Economist Intelligence Unit (Economist, 2009). Throughout the analyses, there was gathered information and conclusions, based on these top- and bottom-half groupings of the organizations that outsmarted and outcompeted their peers. The analysis confirmed that the outperformers and underperformers both had the objects shown in table 2 as well as the same semantic relations. But there was a difference between how the outperformers versus the underperformers worked with the objects. We identified that the outperformers did the following, which the underperformers consistently didn't do. They identified which objects were:

1. Important to develop the core differentiating aspect of the organization to outthink, outsmart and outcompete other organizations. The outperformers converge on the revenue model and value model to strengthen the competitive advantage with emphasis on innovation. It was less than

5% of the organization that was core differentiating in terms of adding to the value model and the revenue model. The objects relevant to the core differentiating aspects are the foundation for design thinking and innovation.
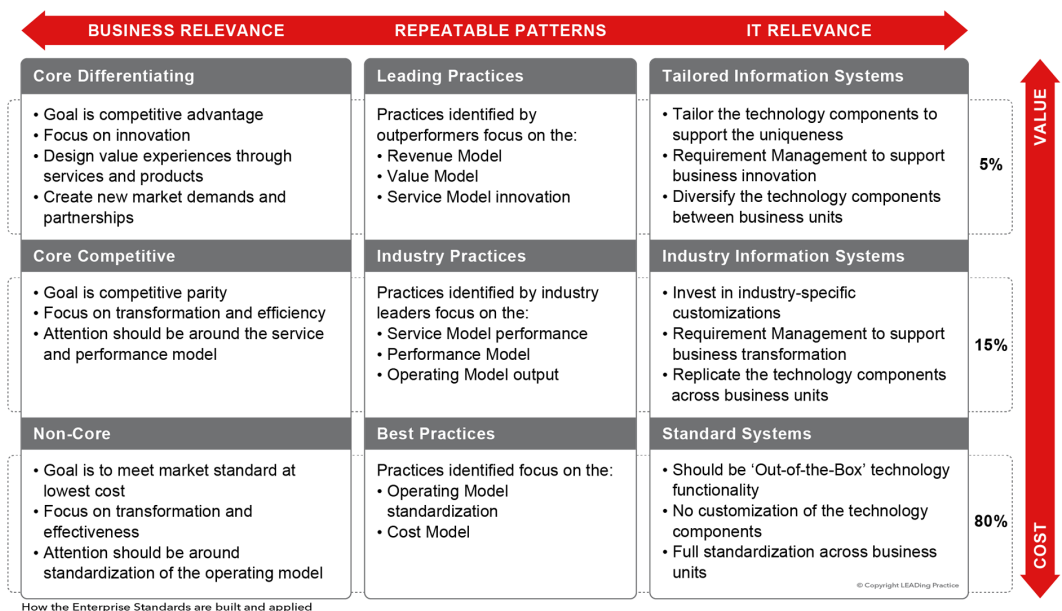
2. Relevant for core competitiveness. Contrary to general thinking, it was less than 15% of any organization's aspects that was relevant for the core competitiveness, and thereby head to head industry competition of the organization. The outperformers focused on performance model and service model to improve the competitive parity with emphasis on efficiency, innovation and transformation.

3. Significant for the non-core aspects of the organization. In the organizations analyzed, it was more than 80% of the organization that was non-core, and thereby do not add to the differentiation or competitiveness of the organization. In those areas the outperformers focused on the cost model and operating model to standardize, harmonize, align, optimize and thereby enabling cost cutting.

A notable difference was that the underperformers in general didn't identify their core differentiating, their core competitive nor their non-core aspects. So while they worked with the relevant objects, such as identifying the disruptive industry forces and trends, developed their enterprise strategy, specified their critical success factors etc., they did not realize that the concepts they applied them to needed different ways of working and modelling. In figure 3, we have illustrated the patterns that we identified. Exemplifying the connections between the business context researched and the repeatable patterns identified (i.e. best practices, industry practices and/or leading practices). Additionally, how the patterns should be automated within the technology perspective.

There were multiple repeatable patterns identified, both in the business, information and technology layer. Below are some examples of repeatable patterns identified:

Business Layer:

Figure 3. Exemplifying the connections between the researched business context and the patterns identified

BUSINESS RELEVANCE	REPEATABLE PATTERNS	IT RELEVANCE	
Core Differentiating	**Leading Practices**	**Tailored Information Systems**	**VALUE**
• Goal is competitive advantage • Focus on innovation • Design value experiences through services and products • Create new market demands and partnerships	Practices identified by outperformers focus on the: • Revenue Model • Value Model • Service Model innovation	• Tailor the technology components to support the uniqueness • Requirement Management to support business innovation • Diversify the technology components between business units	5%
Core Competitive	**Industry Practices**	**Industry Information Systems**	
• Goal is competitive parity • Focus on transformation and efficiency • Attention should be around the service and performance model	Practices identified by industry leaders focus on the: • Service Model performance • Performance Model • Operating Model output	• Invest in industry-specific customizations • Requirement Management to support business transformation • Replicate the technology components across business units	15%
Non-Core	**Best Practices**	**Standard Systems**	**COST**
• Goal is to meet market standard at lowest cost • Focus on transformation and effectiveness • Attention should be around standardization of the operating model	Practices identified focus on the: • Operating Model standardization • Cost Model	• Should be 'Out-of-the-Box' technology functionality • No customization of the technology components • Full standardization across business units	80%

© Copyright LEADing Practice

How the Enterprise Standards are built and applied

- Disruptive forces and trends that can influence the core differentiating aspects of the enterprise. The patterns are therefore Leading Practices that help to outperform, outsmart and outcompete the competition. The patterns were identified in 51 different industries.
- Benchmarks on which strategies are being used for the core differentiating, the competitive as well as the non-core aspects. The strategies were distinctive for the core differentiating aspects versus the non-core aspects.
- Most critical organizational capabilities - those that are the basis for both core differentiating and core competitiveness (across 51 different industries).
- Integrated planning (typical functions, processes, KPIs, and the flows involved as well as the continuous improvement loops).
- Most common non-core capabilities and processes across organizations, such as Finance, HR, IT, Procurement, etc. This enables organizations to reuse the content as well as to help them standardize and cut cost.
- Industry-specific processes that helps organizations develop their core competitive performance model as well as help standardize the operating model.
- Critical KPIs (across 51 different industries) that help organizations in their reporting, control and decision making activities.

Information Layer:

- Most common SAP blueprints, both in terms of processes automated in SAP modules, application tasks as well as the SAP system measures. What is relevant is that the level of tailoring and customizing these ERP systems is mostly way too high (and often done in the wrong places). The tailoring of the information systems should only happen within the core differentiating aspects of the organization. While important, is procurement, HR or finance etc. really the core differentiating components within the organization? While it obviously depends on the industry, products and services, the most likely reason you need to standardize it is to improve the operating model and reduce cost. Consequently, huge customizations do not add value, but most likely enforces your unique way of working, where you are nonetheless not unique (and neither should be). The standardization is important in some areas, but should be done with out of the box functionality (i.e. software vendor best practice).
- Most common Oracle blueprints, both in terms of processes automated in Oracle workflows, modules, application tasks as well as the Oracle system measures.
- Most common way of calculating the information system performance measures. These findings were quite important for analytics, business intelligence, reporting and decision making
- And many others.

Having made these astonishing findings, in 2004, we decided in the GUA to both work with the existing standards bodies, such as ISO, CEN, IEEE, NATO, UN, OMG etc., as well as to create an enterprise standard body (LEADing Practice) that develops the enterprise standards and the patterns. Packaging the patterns identified according to their context and subjects into reusable "Reference Content". Consequently, the Enterprise Standards are the result of international subject matter experts and academic consensus. The Enterprise Standards has been developed in the following ways:

- Research and analyze the existing patterns in the organization.
- Identify common and repeatable patterns (the basis of the standards).
- Sort the repeatable patterns by:
  - Best practices, enabling standardization and cost cutting.
  - Industry practices, empowering performance for head to head competition.

- ◦ Leading practices, facilitating the innovation of value to develop differentiating capabilities.
- In order to increase the level of reusability and replication, package the identified patterns into Enterprise Standards.
- Build Industry accelerators within the standards, enabling organizations to adopt and reproduce the best practices, industry practices and leading practices.

Today there are 123 different subjects that have been packaged as reusable reference content. What is important is that they are both agnostic and vendor neutral, and are built on repeatable patterns that can be reused/replicated and thereby implemented by any organization, both large and small, and regardless of its products, services or activities. (von Rosing & Laurier, 2015) All together, they describe the set of procedures an organization can follow within a specified area or subject in order to replicate the ability to identify, create and realize value, performance and standardization, etc. The 123 different enterprise standards with their repeatable patterns have been categorized into 6 specific areas:

1. Enterprise Management Standards with the official ID# LEAD-ES10EMaS
2. Enterprise Modelling Standards with the official ID# LEAD-ES20EMoS
3. Enterprise Engineering Standards with the official ID# LEAD-ES30EES
4. Enterprise Architecture Standards with the official ID# LEAD-ES40EAS
5. Enterprise Information & Technology Standards with the official ID# LEAD-ES50EITS
6. Enterprise Transformation & Innovation Standards with the official ID# LEAD-ES60ETIS

In tables 4 to 9, we will provide an overview of the the 6 specific enterprise standard categories and the reference content (a total of 123 areas) that are found within them.

THE REPEATABLE INDUSTRY PATTERNS

Through the many thousands of organizations participating, there has in the past decade been a huge focus on packaging the industry specific patterns into reusable reference content. The reason that it has taken so a long time is that all of the identified industry patterns also needed to be fully integrated with the general enterprise standards and their reference content portrayed in table 4, 5, 6, 7, 8 and 9, thereby ensuring full integration and standardization when applying the reference content of a specific industry and the general applicable standards. The way this was achieved was to apply the Business Ontology concepts by using the table 2 meta class objects and adding the missing industry class types, stereo types and subtypes and use the semantic relations found in the meta models and meta meta models to establish how they relate rightfully together. For more information and the specifics on the construct of the objects to the semantic models, meta models and meta meta models we refer to the paper entitled "An Introduction to the Business Ontology". (von Rosing & Laurier, 2015)

Relating it semantically rightfully together, facilitated the ability to use the reference content from areas such as strategy to competencies, processes, services as well as to the industry specific content. All of it being able to be related, modelled, engineered and architected throughout the business, information and technology layers. Table 10 shows an overview of the existing 10 industry sectors and 51 industries where specific industry patterns have been identified. Most of the work has been done in collaboration with industry-specific organizations as well as the academic community.

CONCLUSION

When an organization decides to make use of ontology and semantics to lay the foundation of what the GUA calls the 'way of working', it is done so for a variety of reasons and purposes, but the most

Table 4. Overview of the reference content found in the Enterprise Management Standards

Name:	Reference Content #
Strategy Management	LEAD-ES10001PG
Growth: Core Differentiating & Core Competitive	LEAD-ES10002BC
Value Management	LEAD-ES10003PG
Performance Management	LEAD-ES10004PG
Executive Communication & Story Telling	LEAD-ES10005EX
Control Management incl. Evaluation & Audit	LEAD-ES10006GO
Planning Management	LEAD-ES10007BC
Procurement Management	LEAD-ES10008BC
Human Resource Management	LEAD-ES10009BC
Production Management	LEAD-ES10010BC
Product Management	LEAD-ES10011BC
Marketing Management	LEAD-ES10012BC
Sales & Customer Service Management	LEAD-ES10013BC
Call Center Management	LEAD-ES10014BC
Supply Chain & Logistics Management	LEAD-ES10015BC
Compliance Management	LEAD-ES10016GO
Risk Management	LEAD-ES10017ALL
Governance	LEAD-ES10018GO
Portfolio Management	LEAD-ES10019ALL
Program Management	LEAD-ES10020ALL
Project Management	LEAD-ES10021ALL
Financial Management	LEAD-ES10022BC
Risk Ontology	LEAD-ES10023ALL
Policy	LEAD-ES10024PG
Outsourcing	LEAD-ES10025ALL
Contract Management	LEAD-ES10026BC
Policy Management	LEAD-ES10027PGBC
Culture	LEAD-ES10028ALL
Deliver on Promise	LEAD-ES10029ALL

important thing to keep in mind is that once you have established a specific and very clear definition – for a meta object, for example – this definition will be available to all the relevant employees across organizational boundaries of the enterprise after it has been documented and published for use. This means that a common understanding and consensus – on what name a particular meta object has – will have been established within the organization for whenever a member of that organization needs to refer to that particular meta object. Simultaneously with the meta object relationships within and across the enterprise layers, it makes it a lot more practical for organizations to handle objects in a larger context. Not just for documenting tasks such as blueprinting and artefact standardization, but also for using them when modelling, engineering and architecting concepts and solutions, regardless

Table 5. Overview of the reference content found in the Enterprise Modelling Standards

Name:	Reference Content #
Ontology	LEAD-ES20000ALL
Drivers & Forces (external/internal) Modelling	LEAD-ES20001PG
Stakeholder	LEAD-ES20002EX
Requirement Modelling	LEAD-ES20003PG
Business Model	LEAD-ES20004BC
Business Process	LEAD-ES20005BP
Revenue Model	LEAD-ES20006BC
Value Model	LEAD-ES20007BCPG
Service Model	LEAD-ES20008BCBS
Performance Model	LEAD-ES20009BCPG
Operating Model	LEAD-ES20010BC
Cost Model	LEAD-ES20011BCPG
Role Modelling	LEAD-ES20012BC
Competency Modelling	LEAD-ES20013BC
Measurement	LEAD-ES20014PG
Workflow	LEAD-ES20015ALL
Channel	LEAD-ES20016ALL
Capability Modelling	LEAD-ES20017ALL
Enterprise Sustainability	LEAD-ES20018ALL
Case Management	LEAD-ES20019ALL
Meta Modelling	LEAD-ES20021ALL
Value Chain	LEAD-ES20022PGBC
Event Model	LEAD-ES20023ALL

of business unit and/or business requirement. In the sense of semantics then, it allows you to accurately describe how a particular object relates to another particular object (regardless of object type or subtype or hierarchical location). Consequently, a structured business ontology, with clearly defined semantics, can have real business value, since it allows organisations to define what (ontology) the essential business terms are, and how (semantics) they relate to each other as well as where in the enterprise layers. As we have previously illustrated, the business ontology is an empiric ontology, meaning that its roots lie in practice, as it was developed by practitioners documenting their practical knowledge of the field rather than having originating from theory and academics specialized in a restricted area of business. Similarly, it is one of the few ontologies that has the ambition to cover all aspects of business. In order to attain the desired level of completeness, the business ontology is complemented with elicitation support such as guiding principles for creating, interpreting, analyzing and using the objects within particular layers of the enterprise. The business ontology also offers a set of principles, views, artefacts/templates that have detailed meta object relations and rules that apply to them e.g. how and where can the enterprise objects be related (and where they cannot). As the business ontology has the ambition to support a large community, it is open source within its community and also vendor neutral and agnostic as it can be used with most existing frameworks,

Table 6. Overview of the reference content found in the Enterprise Engineering Standards

Name:	Reference Content #
Decomposition & Composition	LEAD-ES30001ALL
Lifecycle Management	LEAD-ES30002ALL
Testing	LEAD-ES30003SA
Enterprise Requirement	LEAD-ES30004ES
Quality	LEAD-ES30005EM
Geographical Information System (GIS)	LEAD-ES30006EM
Agile	LEAD-ES30007ES
Categorization & Classification	LEAD-ES30008ES
Enterprise Tiering	LEAD-ES30009ALL
Integrated Planning	LEAD-ES30010ALL
Performance Engineering	LEAD-ES30011ALL
Value Engineering	LEAD-ES30012PG
Service Engineering	LEAD-ES30013BS
Process Engineering	LEAD-ES30014BP
Information Engineering & Systems Engineering	LEAD-ES30015BCSAD
Enterprise Engineering & Engineering Layers	LEAD-ES30016ALL

Table 7. Overview of the reference content found in the Enterprise Architecture Standards

Name:	Reference Content #
Layered Enterprise Architecture	LEAD-ES40001ALL
Business Architecture	LEAD-ES40002PGBCPSI
Value Architecture	LEAD-ES40003PG
Process Architecture	LEAD-ES40004BP
Service Oriented Architecture	LEAD-ES40005BS
Application Architecture	LEAD-ES40006SAID
Information Architecture	LEAD-ES40007BCSAD
Data Architecture	LEAD-ES40008SAI
Platform Architecture	LEAD-ES40009PL
Infrastructure Architecture	LEAD-ES40010IL
EA Governance	LEAD-ES40011GO
Security Architecture	LEAD-ES40012CS
Cloud Architecture	LEAD-ES40013CC
Agile Enterprise Architecture	LEAD-ES40014ALL

Table 8. Overview of the reference content found in the IT Standards

Name:	Reference Content #
IT Strategy	LEAD-ES50001PG
Business Model of IT	LEAD-ES50002BC
IT Process Map	LEAD-ES50003BP
IT Center of Competency	LEAD-ES50004BC
Cloud Computing	LEAD-ES50005CC
Cyber Security	LEAD-ES50006CS
Knowledge Management	LEAD-ES50007PGIDBC
Analytic	LEAD-ES50008PGIDBC
Reporting	LEAD-ES50009PGIDBC
Application	LEAD-ES50010SAIDBCBP
Application Modernization & Optimization	LEAD-ES50011SAIDBCBP
ERP	LEAD-ES50012SADIBC
Software Testing	LEAD-ES50013SADI
Information Management	LEAD-ES50014BCIDSA
Data	LEAD-ES50015DISABC
Rule Modelling	LEAD-ES50016PGBCSADI
Service-Oriented Computing	LEAD-ES50017ES
Platform	LEAD-ES50018PLES
Infrastructure	LEAD-ES50019IL
Social Media	LEAD-ES50020ALL
Blueprinting	LEAD-ES50021ALL
Implementation	LEAD-ES50022ALL
Cloud Ontology	LEAD-ES50023ALL
Customer Relationship Management	LEAD-ES50024ALL
Supplier Relationship Management	LEAD-ES50025ALL
Supply Chain Management	LEAD-ES50026ALL

Table 9. Overview of the reference content found in the Transformation and Innovation Standards

Name:	Reference Content #
Alignment & Unity	LEAD-ES60001ALL
Change Management	LEAD-ES60002ALL
Maturity	LEAD-ES60003ALL
Continuous Improvement	LEAD-ES60004ALL
Organizational Development	LEAD-ES60005ALL
Optimization	LEAD-ES60006ALL
Effectiveness	LEAD-ES60007ALL
Efficiency	LEAD-ES60008ALL
Re-engineering	LEAD-ES60009ALL
Root Cause Analysis	LEAD-ES60010ALL
Transformation Benchmarking	LEAD-ES60011ALL
Innovation	LEAD-ES60012ALL
Alignment of Portfolio, Program & Project (PPP) Management	LEAD-ES60013ALL
Innovation & Transformation Blueprinting &Implementation Method	LEAD-ES60014ALL
Transformation	LEAD-ES60015ALL

Table 10. Overview of the 10 industry sectors and 51 industries where specific industry patterns have been identified

Financials Sector	Energy Sector	Utilities Sector
■ Central Bank ■ Banking ■ Insurance ■ Financial Markets ■ Real Estate	■ Oil & Gas ■ Alternative Energy	■ Electricity Utilities ■ Gas, Water & Multiutilities ■ Power Producers
Industrial Sector ■ Aerospace & Defense ■ Automotive ■ Chemicals ■ Forestry & Paper ■ Metal & Mining ■ Construction & Materials ■ Electronic & Electrical Equipment ■ Manufacturing & Industrial Engineering	**Public Sector** ■ Defense (Public) ■ Finance & Treasury ■ Border Services ■ Foreign Affairs & Trade ■ Health ■ Agriculture & Food ■ Labor & Social Services ■ Energy & Natural Resources ■ Education ■ Environment ■ Tourism ■ Transport & Infrastructure ■ Justice ■ Local Government	**Transportation Sector** ■ Airline ■ Railways ■ Shipping ■ Postal ■ Logistical Service Providers **Communication Sector** ■ Media & entertainment ■ Telecommunications ■ Publishing
Consumer Packaged Goods Sector ■ Food ■ Beverage ■ Tobacco ■ Fashion & Apparel Goods ■ Retail ■ Travel & Hotel	**Healthcare Sector** ■ Health Care Services & Equipment ■ Pharmaceuticals ■ Life-science & Biotechnology	**High Tech Sector** ■ Software & Services ■ Technology Hardware & Equipment

methods and approaches that have any of the meta objects mentioned in this document. The mapping can be found online. (practice, 2014) As the business ontology has been formalized in MOF, it can be considered a Platform Independent Model (PIM), which stresses its neutrality.

For more information, we refer to the following publications:

- An Introduction to the Business Ontology (von Rosing & Laurier, 2015)
- The Value of Ontology (von Rosing, Laurier and Polovina, 2015)
- Using a Business Ontology for Structuring Artefacts: Example - Northern Health" (von Rosing, Urquhart & Zachman, 2015).
- Applying Ontology and Standards for Enterprise Innovation and Transformation of three leading Organizations (von Rosing, Fullington and Walker, 2016
- Using the Business Ontology to develop a Role Ontology (von Rosing and Zachman, 2016).
- The relationship between Ontology and Modelling concepts: Example Role Oriented Modelling (Hove, von Scheel, Arzumanyan, Zachman, 2016).
- Applying Ontology and Standards for Strategy focused execution: Example SAL Heavylift. (Okpurughre, von Rosing and Grube, 2016).
- Applying Ontology and Standards to develop Smart Applications: Example Dutch Railway (Bach, von Rosing and von Scheel, 2016).

REFERENCES

W3C. (2008). Extensible Markup Language (XML) 1.0 (5th ed.). Retrieved from http://www.w3.org/TR/2008/REC-xml-20081126/

W3C. (2014). RDF Schema 1.1. Retrieved from http://www.w3.org/TR/2014/REC-rdf-schema-20140225/

W3C (Producer). (2012). OWL 2 Web Ontology Language Retrieved from http://www.w3.org/TR/2012/REC-owl2-quick-reference-20121211/

Anand, A., Fosso Wamba, S., & Gnanzou, D. (2013). A Literature Review on Business Process Management, Business Process Reengineering, and Business Process Innovation. In J. Barjis, A. Gupta, & A. Meshkat (Eds.), *Enterprise and Organizational Modeling and Simulation* (Vol. 153, pp. 1–23). Springer Berlin Heidelberg. doi:10.1007/978-3-642-41638-5_1

Armstrong, J. S., & Brodie, R. J. (1994). Effects of portfolio planning methods on decision making: Experimental results. *International Journal of Research in Marketing*, *11*(1), 73–84. doi:10.1016/0167-8116(94)90035-3

Bach, B., von Rosing, M., & von Scheel, H. (2016). Applying Ontology and Standards to develop smart applications: Example Dutch Railway. *International Journal of Conceptual Structures and Smart Applications*, *5*(Special Issue).

Braun, S., Schmidt, A., Walter, A., & Zacharias, V. (2007). The Ontology Maturing Approach for Collaborative and Work Integrated Ontology Development: Evaluation Results and Future Directions. *Paper presented at theInternational Workshop on Emergent Semantics and Ontology Evolution ESOE, ISWC '07*, Busan, Korea.

Cardoso, J. (2007). The Semantic Web Vision: Where Are We? *IEEE Intelligent Systems*, *22*(5), 84–88. doi:10.1109/MIS.2007.4338499

Carpenter, H. (2009). Accenture Survey Identifies Companies' Innovation Improvement Opportunities.

Corcho, O., Fernández-López, M., & Gómez-Pérez, A. (2003). Methodologies, tools and languages for building ontologies. Where is their meeting point? *Data & Knowledge Engineering*, *46*(1), 41–64. doi:10.1016/S0169-023X(02)00195-7

Cordeiro, J., & Filipe, J. (2004). The Semiotic Pentagram Framework -- A Perspective On the Use of Semiotics within Organisational Semiotics. *Paper presented at the7th International Workshop On Organisational Semiotics*, Setúbal, Portugal.

Dunn, C. L., & McCarthy, W. E. (1997). The REA accounting model: Intellectual heritage and prospects for progress. *Journal of Information Systems*, *11*(1), 31–51.

EDM council. (2014). Financial Industry Business Ontology. Retrieved from http://www.edmcouncil.org/financialbusiness

Fox, M. (1992). The TOVE project towards a common-sense model of the enterprise. In F. Belli & F. Radermacher (Eds.), *Industrial and Engineering Applications of Artificial Intelligence and Expert Systems* (Vol. 604, pp. 25–34). Berlin Heidelberg: Springer. doi:10.1007/BFb0024952

Geerts, G. L., & McCarthy, W. E. (2002). An ontological analysis of the economic primitives of the extended-REA enterprise information architecture. *International Journal of Accounting Information Systems*, *3*(1), 1–16. doi:10.1016/S1467-0895(01)00020-3

Genesereth, M., & Nilsson, N. (1987). *Logical foundations of artificial intelligence*. Los Altos, CA: Morgan Kaufmann.

Gordijn, J., & Akkermans, H. (2001). Designing and Evaluating E-Business Models. *IEEE Intelligent Systems*, *16*(4), 11–17. doi:10.1109/5254.941353

Gruber, T. R. (1993). A translation approach to portable ontology specifications. *Knowledge Acquisition*, *5*(2), 199–220. doi:10.1006/knac.1993.1008

Guarino, N. (1997). *Semantic Matching: Formal Ontological Distinctions for Information Organization, Extraction, and Integration* (pp. 139–170). SCIE.

Guarino, N. (1998). Formal Ontology and Information Systems. *Paper presented at theProceedings of FOIS '98*, Trento, Italy.

Guarino, N., & Giaretta, P. (1995). Ontologies and Knowledge bases: towards a terminological clarification. In N. Mars (Ed.), *Towards Very Large Knowledge Bases: Knowledge Building and Knowledge Sharing* (p. 314). IOS Press.

Hove, M., von Scheel, J., Arzumanyan, M., & Zachman, J. A. (2016). The relationship between Ontology and Modelling concepts: Example Role Oriented Modelling. *International Journal of Conceptual Structures and Smart Applications*, *5*(Special Issue).

IBM Institute for Business Value. (2007). The Enterprise of the Future and the The path to success. IBM Global CEO Study 2008-2012.

Jung, J. J. (2009). Semantic business process integration based on ontology alignment. *Expert Systems with Applications*, *36*(8), 11013–11020. doi:10.1016/j.eswa.2009.02.086

Lassila, O., & McGuinness, D. L. (2001). *The role of frame-based representation on the semantic web*. Nokia Research Center.

Leading practice. (2014). Interconnects with Existing Frameworks. Retrieved from http://www.leadingpractice.com/about-us/interconnects-with-main-existing-frameworks/

Lima, J., Amaral, C. G., & Molinaro, L. (2010). Ontology: An Analysis of the Literature. In J. Quintela Varajão, M. Cruz-Cunha, G. Putnik, & A. Trigo (Eds.), *Enterprise Information Systems* (Vol. 110, pp. 426–435). Springer Berlin Heidelberg. doi:10.1007/978-3-642-16419-4_44

Malone, T. (2004). *Do Some Business Models Perform Better than Others? A Study of the 1000 Largest US Firms*. Sloan School of Management Massachusetts Institute of Technology.

Malone, T. W., Weill, P., Lai, K., D'Urso, V., Herman, G., Apel, T., & Woerner, S. (May 2006), Do some business models perform better than others? MIT Sloan Research Paper.

Okpurughre, P., von Rosing, M., & Grube, D. (2016). Applying Ontology and Standards for Strategy focused execution: Example SAL Heavylift. *International Journal of Conceptual Structures and Smart Applications*, *5*(Special Issue).

OMG. (2006). MOF To IDL Mapping (MOF2I).

OMG. (2008). IDL To Java Language Mapping (I2JAV).

OMG. (2013a). *Business Process Model And Notation*. BPMN.

OMG. (2013b). *Semantics Of Business Vocabulary And Rules*. SBVR.

OMG. (2014a). IDL To C++11 Language Mapping.

OMG. (2014b). Interface Definition Language (IDL) 3.5.

OMG. (2014c). Ontology Definition Metamodel (ODM), Version 1.1.

OMG. (2014d). *Value Delivery Modeling Language*. VDML.

OMG. (2014e). XML Metadata Interchange (XMI) *(Also Known As MOF 2 XMI Mapping)*.

Osterwalder, A. (2004). *The Business Model Ontology - a proposition in a design science approach*. Lausanne: University of Lausanne.

Poels, G., Maes, A., Gailly, F., & Paemeleire, R. (2007). The pragmatic quality of Resources-Events-Agents diagrams: An experimental evaluation. *Information Systems Journal*. doi:10.1111/j.1365-2575.2007.00255.x

practice, L. (Producer). (2015, February 13). LEADing Practice Templates. Retrieved from http://www.leadingpractice.com/tools/templates/

The Economist. (2009, April). How to prosper in a recession.

von Rosing, M., Fullington, N., and Walker, J., Applying Ontology and Standards for Enterprise Innovation and Transformation of three leading Organizations, International Journal of Conceptual Structures and Smart Applications, Volume 4, 2016

von Rosing, M., Kemp, N., Hove, M., & Ross, J. W. (2015). Process Tagging—A Process Classification and Categorization Concept. In M. v. R.-W. S. v. Scheel (Ed.), The Business Process Management Handbook (pp. 123-171). Boston: Morgan Kaufmann.

von Rosing, M., & Laurier, W. (2015, January-June). An Introduction to the Business Ontology. *International Journal of Conceptual Structures and Smart Applications*, *3*(1), 20–42. doi:10.4018/IJCSSA.2015010102

von Rosing, M., Laurier, W., & Polovina, S. M. (2015a). The BPM Ontology. In M. v. R.-W. S. v. Scheel (Ed.), The Business Process Management Handbook (pp. 101-121). Boston: Morgan Kaufmann. doi:10.1016/B978-0-12-799959-3.00007-0

von Rosing, M., Laurier, W., & Polovina, S. M. (2015b). The Value of Ontology. In M. v. R.-W. S. v. Scheel (Ed.), The Business Process Management Handbook (pp. 91-99). Boston: Morgan Kaufmann. doi:10.1016/B978-0-12-799959-3.00006-9

von Rosing, M., & Zachman, J. A. (2015). In M. v. R.-W. S. v. Scheel (Ed.), The Business Process Management Handbook (pp. 101-121). Boston: Morgan Kaufmann.

von Rosing, M., & Zachman, J. A. (2016). Using the Business Ontology to develop a Role Ontology. *International Journal of Conceptual Structures and Smart Applications*, *5*(Special Issue).

Week, B. (2006, April 24). The World's Most Innovative Companies. *Business Week*.