Business Process Modeling Approaches in the Context of Process Level Audit Risk

Assessment: An Analysis and Comparison

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Abstract

Current auditing standards emphasize the importance of auditors gaining a broader understanding of an organization’s operations to perform risk assessment (i.e. assess the risks of material misstatement). Auditors’ ability to effectively analyze operations in the form of business processes is by definition a key determinant of their ability to appropriately plan and conduct the audit. However, to date there has been little consideration of how best to represent or organize the information required about business processes for audit risk assessment purposes. This paper identifies a number of commonly used business process modeling conventions, and characterizes them relative to the needs of auditors in performing risk assessments at the business process level.

To provide a context for the process modeling conventions examined, international standards on enterprise modeling are outlined, and the constructs they identify are compared to those identified as needed for process level risk assessment. This comparison helps provide some assurance that the knowledge needed for audit risk assessment at the process level is similar to that needed for management understanding and control of business processes more generally.

A number of commonly used business process modeling conventions are identified based on a literature review, including data flow diagrams, system flowcharts, REA models, event process chains, IDEF0 and IDEF3, UML diagrams, and business process diagrams. The constructs represented in each of these models are compared to those identified as needed for process level audit risk assessment. Summary comments on the modeling conventions are then provided. The paper concludes by noting particular areas where additional research is needed before more definitive answers regarding which process modeling conventions are most appropriate for auditor use are possible.

Key Words: Business process models, diagrams, audit, risk assessment
1. Introduction

Current auditing standards emphasize the importance of auditors gaining a broader understanding of an organization, as well as its environment, in order to perform risk assessment (i.e. assess the risks of material misstatement). At least part of this understanding requires consideration of what Knechel (2001) refers to as "audit sensitive processes", which he describes as those processes expected to be the major determinants of residual risk. Auditors’ ability to effectively analyze such processes is by definition a key determinant of their ability to appropriately plan and conduct the audit. However, to date there has been little consideration of how best to represent or organize the information required about business processes for audit risk assessment purposes.

A business process model, defined as a simplified depiction of a business process, is the term typically used to describe a particular representation of business process information. Simplification is achieved by including only the important aspects of the business process (Eriksson and Penker 2000). Obviously what is considered important depends on the purposes the model was created to serve, and thus an understanding of those purposes is required to create an effective model. While an emerging literature does provides a variety of possible business process modeling conventions, this literature is focused on the needs of information system designers, and it is not clear whether the information captured or how it is represented is appropriate for use by auditors.

The purpose of this paper is to begin to address this gap by identifying and comparing the constructs incorporated in major business process modeling conventions to assess their potential utility for audit risk assessment. Since the modeling conventions for
supporting human understanding and analysis are largely diagrammatic, this paper will also discuss specific diagram characteristics that might be important to improve a diagram’s usefulness for decision making. The business process modeling conventions that will be discussed were identified through literature and web searches, with the paper then focusing on the ones that appear to have a broad-based consensus behind them (e.g. IDEF0) or that appear to be de facto standards (e.g. data flow diagrams).

The first step in the analysis was to identify the business process constructs and concepts that appear to be needed for audit risk assessment by examining existing standards, audit textbooks, and related material on audit approaches. These constructs and concepts are then compared to those applied in international standards related to business processes to determine what differences exist and to try and identify business process constructs that might be missing from those identified from the audit literature. A number of business process modeling conventions are then compared to the identified constructs to determine the relative completeness of each approach for audit risk assessment. Additional issues that need to be considered in choosing a modeling convention to support audit risk assessment at the business process level are then discussed, based on the conceptual modeling literature as well as empirical research. Some suggestions for future research are then provided.

This paper contributes to existing research in several ways. First, it identifies and compares identified business process constructs for audit risk assessment to those specified in international standards. This comparison can help determine whether the two can converge. Second, it evaluates the potential utility of a variety of common business
process modeling approaches for audit risk assessment purposes, which has not previously been done. Third, it summarizes some of the findings of the theoretical and empirical literature on the use of diagrams in reasoning and problem solving to lay a foundation for future research in this area.

The remainder of this paper is organized as follows: The next section provides some background on the need for business process understanding in performing audit risk assessment, concepts from related international standards that can be used to characterize business process modeling conventions, and components of a business process modeling convention. Section 3 identifies a number of relatively well established business process modeling conventions, and characterizes them in terms of both the international standards and those constructs identified as needed for audit risk assessment. Section 4 then concludes the paper by discussing some concepts from the conceptual modeling literature as well as empirical research that provide guidance on additional important characteristics of diagrammatic models, and by suggesting directions for future research on business process representation and audit risk assessment.
2. Related literature on audit risk assessment and business process models

2.1 The audit need for business process models

Auditing standards typically require that the auditor understand the entity’s business processes. For example, the International Standard of Auditing (ISA) 315 states that obtaining an understanding of the entity, and its environment, is "... an essential aspect of performing an audit in accordance with ISAs" (IFAC 2005, paragraph 4). Canadian standards (which are harmonized with international standards), and U.S. standards make similar statements. Paragraph .025 of Standard 514.1 in the CICA Assurance Handbook (2005) further specifies that an understanding of the nature of an audit entity includes an understanding of the entity’s operations.

Understanding of an organization’s operations is required to both fully understand business risk (the risk that an organization may not achieve its objectives, or set inappropriate objectives or strategies) that may result in material misstatement, and business process level internal controls intended to address business risks. Thus, although the standards leave decisions on which specific processes to focus on to the auditor’s judgement, there is agreement that an understanding of business processes is a necessary component of an effective audit.

A key assumption underlying much of the subsequent analysis in this paper is that business operations can be usefully decomposed into business processes, defined for purposes of this paper as ... a structured set of activities within the entity that are

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1 Issues related to auditing to determine an organization’s compliance with Section 404 of the Sarbanes-Oxley Act of 2002 are not explicitly included within the scope of this paper, except to the extent that the same issues arise in the course of conducting a conventional audit of an organization’s financial statements.
designated to produce a specific output in accordance with the business strategy".
(Smieliauskas and Robertson 2004, 478). Jackowski (2003, 4) describes a business
process as "... an abstraction... that describes how the work is performed in the business
environment". More conventional auditing approaches decompose business operations
into transaction cycles, (e.g. Arens et al 2003), but each cycle can be viewed as including
multiple business processes relevant to the cycle objectives. For example, Arens et al
describe the sales and collection cycle as including processes such as processing customer
orders, granting credit, shipping goods, and processing sales returns, as well as the
activities necessary to record the transactions associated with these processes.

Alternative approaches to audit, often referred to as strategic systems approaches
(e.g. Bell et al 1997), explicitly require consideration of business processes. The
assumption in these approaches is that "... if the business process produces the output in
the way that the strategy intended it to do, it is more likely that the business will achieve
its objectives and not fall prey to the various [business] risks." (Smieliauskas and
support for the assertion that business processes are a useful way of organizing
information for risk assessment purposes. They found that audit seniors were better able
to identify risks when using audit evidence organized according to business processes
relative to seniors making the same judgements using audit evidence organized by
transaction cycle.
2.2 Frameworks and standards related to business process modeling

The need to understand business processes is not unique to auditors. The range of professions and problems which require a similar understanding (e.g. software engineering, business process reengineering, integrated manufacturing, and supply chain management) has led to the development of a large number of modeling conventions and related tools. However, these conventions often do not agree either on what needs to be modeled nor the representations to use. Vernadat (2001) refers to the current situation as a "Tower of Babel" with users constantly having to learn new conventions (and related tools) which can not readily be translated into other forms. It thus seems important to be aware of current efforts towards standardization so that any approaches considered for audit risk assessment can also be assessed against the standards that appear to be developing.

The term commonly used in current standardization efforts aimed at creating a means of representing an enterprise over its life cycle is "enterprise modeling". Organizational aspects to be modeled are organizational functions, behavior, information, resources, structure, and economics (Vernadat 2001). Given that enterprise modeling is intended to support the design, automation, management, and understanding of business organizations and their operations, and is also business process centred (Vernadat 2001), developments in this area are potentially very relevant to the business process modeling needs of auditors. A number of standards bodies and industry groups are working on, or have developed, frameworks and standards for enterprise modeling. A full description of the many taskforces, standards and inter-relationships among the standards and
organizations related to enterprise modeling is beyond the scope of this paper\textsuperscript{2}, but some key developments relevant to business process modeling will be discussed.

Perhaps the most comprehensive of the frameworks is the Generalized Enterprise Reference Architecture and Methodology (GERAM), which was developed under the direction of the International Federation of Automatic Control (IFAC) and International Federation for Information Processing (IFIP) joint Taskforce on Architectures for Enterprise Integration (IFIP/IFAC 2002). It provides a means of organizing existing enterprise integration knowledge, so that existing architectures can be mapped to and characterized using GERAM. GERAM is process oriented, and specifies the need for modeling service, production, management and control processes and their relationships to the resources, products, and structures of the organization. It is intended to encompass the modeling of the transformation of information (e.g. orders, receipts), and materials (e.g. raw materials, products). GERAM is a generalization and consolidation of three pre-existing frameworks: the European CIM-systems-architecture framework for modeling (CIMOSA), the Purdue Enterprise Reference Architecture (PERA), and the European GRAI Integrated Methodology (GIM) (IFIP/IFAC 2002).

GERAM provides several important concepts that will be used throughout this paper. First, it defines a need for generic enterprise modeling concepts (e.g. ontological theories about what enterprise aspects should be modeled, as well as glossaries and metamodels, to define the meaning for enterprise modeling constructs. Second, GERAM defines the need for enterprise modeling languages (referred to in this paper as

\textsuperscript{2}Chen and Vernadat provide a discussion of the bodies and standards related to enterprise modeling, and
conventions) to provide a syntax for capturing enterprise model aspects. Third, GERAM specifies the need for views, which simplify model presentation by including only a subset of enterprise constructs needed for a particular purpose. GERAM defines several categories of views, including content oriented views (at a minimum function, information, resource, and organization) and purpose views (in particular, customer service/product, management, and control).

GERAM version 1.6.2 has influenced several adopted or proposed standards, including ISO 15704: "Requirements for Enterprise-Reference Architectures and Methodologies" (IFIP/IFAC 2002), ISO 14258 "Industrial Automation Systems—Concepts and Rules for Enterprise Models", and ISO/FDIS 19439 "Enterprise Integration — Framework for Enterprise Modeling" which provide additional guidance on developing enterprise modeling methodologies and constructs. ISO/DIS 19440 "Enterprise Integration — Constructs for Enterprise Modelling" specifies and defines the components needed to create the constructs identified in ISO 15704. Table One provides a list of the constructs included in the business process template specified in ISO/DIS 19440, along with some related points from GERAM.

ISO/DIS 19440 describes a business process as being constructed from other business processes or more atomistic enterprise activities. It provides a template for business process constructs that includes the information and material inputs and outputs of the process, the sequence of constituent processes or activities, the rules governing the process and sequencing of the component parts, and the responsible and authorizing

the major results achieved to date.
organizational units. When enterprise activities are specified, the related resources are
also indicated. Thus, the complete description of a business process meets the GARAM
requirement of relating the business process to the products, resources, and organizational
structures affected. It should be noted that the view of what constitutes acceptable
outcomes of a business process is quite broad in ISO/DIS 19440. The standard indicates
that while the end result of a business process must be observable or quantifiable, it may
be material or information entities, or new processes, or the achievement of specified
objectives.

While all of these efforts are leading to improved consensus on business process
modeling concepts and constructs, Kosanke (2004) concludes that standardization for
business process modeling is "...not yet applicable at the operational level." Nonetheless,
the frameworks and standards are helpful in characterizing what a comprehensive
business process modeling convention might need to capture, and a number of existing
business process modeling conventions are related to specific frameworks.

3.0 An analysis of existing business process modeling conventions

3.1 Identification of business process model constructs for audit risk assessment

There are no standards and little research on what auditors need to understand
about a business process to link it effectively to audit risk. Bell et al (1997) and Knechel
(2001) list a number of business process constructs that should be documented for audit
risk assessment purposes. Table 2 shows the constructs identified in these two sources,
along with a comparison to the constructs identified in ISO/DIS 19440. While the Bell et al (1997) and Knechel (2001) descriptions of what should be documented for a business process are broadly similar, there are some differences. For example, Knechel suggests only the information inputs and outputs of each process be specified, while Bell et al suggest that material and information inputs and outputs should also be documented. The suggested documentation approach provided by Knechel shows the controls and business measures related to each risk for a particular process, while Bell et al link controls and performance measures only to the given process. The views proposed by each source are also somewhat different. Bell et al combine risks, controls and measures with the rest of the process description within one document, but distinguish core business processes (described as those that are customer facing) from resource management processes. Knechel suggests one view that comprises the process description, while another document is used to describe the risks for each process, and the related controls and measures for each risk.

The business process constructs Bell et al and Knechel identify for audit risk assessment are broadly similar to those from ISO/DIS 19440 and GERAM, with three important exceptions. First, there is no explicit construct in ISO/DIS 19440 to document the risks that threaten attainment of a process’s objectives. Accordingly, there is also no link between risks and a particular control to address those risks. Second, while Bell et al (1997) and Knechel refer to "controls" as a generic construct, ISO/DIS 19440 has no one equivalent. While controls for a particular process may be partially captured under behavioral rules that determine the sequence of events, they may also be reflected in the
form of inputs (control information), constraints, and declarative rules. A more detailed specification of the meaning of these constructs than currently provided in the ISO standards, with a subsequent comparison to control types in the audit literature, would be needed to clarify the relationships between the two sets of constructs. Third, there is no separate construct in ISO/DIS 19440 for related classes of accounting transactions, but transaction class could be captured as another type of output information. The routine/non-routine or accounting estimate distinction could be captured as an attribute of the output.

The ISO/DIS 19440 business process constructs include several items not mentioned in Bell et al (1997) or Knechel (2001), such as operational responsibility and authority for the process, duration, description, and priority. While an understanding of operational responsibility versus authority might well be useful in better understanding segregation of duties where needed, the other items at a face value level can not be readily linked to the needs of an auditor when performing risk assessment at the process level.
3.2 Identification and selection of business process modeling conventions

Identification of major business process modeling conventions was done through a literature review that included systems analysis and design and accounting information system textbooks, relevant databases such as the Association for Computing Machinery (ACM) Digital Library, ABI-Inform and CiteSeer, and by using Google to search websites for relevant terms. To keep the analysis manageable, several additional constraints were imposed in choosing conventions to investigate further.

First, only the conventions that appeared to be backed by an industry or international consortium, or that seem to have been adopted by a number of users as evidenced by multiple references to the particular convention were retained. This was helpful in ensuring that there was sufficient information available to explain the convention, and also helped in identifying conventions that were reasonably well established.

Second, the comparison of the constructs needed for business process analysis for audit risk assessment versus those needed more generally for business process modeling suggests a fairly good correspondence between the two sets of constructs. Within the GERAM and related standards, the business process modeling constructs seem to most closely correspond with what is referred to as the functional/behavioral view of the organization, in other words those conventions intended to represent what is being done by the organization to achieve some purpose, and the sequence of activities involved. To understand what modeling conventions are most appropriate for capturing what is needed by auditors, it thus seemed appropriate to focus on those conventions that claimed to
capture the functional and behavioral aspects of an organization, as opposed to the information, organizational, or resource structures. It should be noted, however, that the functional structure does capture these other aspects, but only to the extent that a particular information, organization, or resource construct interacts with a process.

Third, the focus was also limited to what Vernadat (2001) refers to as "descriptive models", which are intended to support communications and understanding, rather than modeling conventions intended to support the development of software programs or assist in systems optimization. This restriction seemed appropriate given the purpose of suggesting possible modeling conventions for use by auditors to understand business processes so as to identify related audit risks.

Finally, many conventions form part of a larger methodology or architecture. In discussing each convention, the parts of the overall methodology or architecture chosen for analysis was restricted to those that the methodology or architecture described as being relevant to capturing the functional/behavioral perspective of an organization.

3.3 Analysis of existing business process modeling conventions

The above criteria led to identification of the following business process modeling conventions: data flow diagrams, system flowcharts, resource-event-agent diagrams, IDEF0/IDEF3, event process chains, UML activity diagrams, and business process diagrams from Business Process Modeling Notation. Table Three shows a characterization of each convention based on the italicized constructs identified in Table Two, with discussion below of the reasons for the particular characterization given. It
should be noted that while all of the following conventions are described as being useful for business process modeling, many of the conventions were created for some other purpose. For example, systems flow charts were originally created to support the development of computer programs and information systems, as were data flow diagrams. REA models were created to support the development of organizational databases. The comments below are thus not intended to be criticisms of the modeling convention in question, but rather an assessment of their suitability for a purpose (business process risk assessment) which is in many cases quite different from what the convention was first created to support.

3.3.1 Data flow diagram (DFD)

The DFD is traditionally viewed as part of the Structured Systems Analysis methodology (Gane and Sarson 1979; Demarco 1979) which was originally developed for use in creating information systems requirements. Later textbooks and tutorials have also described the DFD as a tool for business process modeling (e.g. Dennis and Wixom 2003), although in some cases it appears that "business process" is being used as a synonym for "business information system". DFDs focus on depicting data flows among processes that in some way change the data, the sources and destinations of data that are external to the process being modeled (external entities), and data stores.

A key principle in the creation of DFDs is that of functional decomposition, meaning that each process can be subdivided into subprocesses, which can be further subdivided, etc. DFDs thus provide a "context" view (the information system as a whole
and the entities external to the system that either provide or receive data from the
system), and a more detailed view depicting either the processes comprising the system,
or the activities comprising each process. DFDs are also usually created either to provide
a logical view of a process (emphasizing what processes are occurring and the data flows),
or a physical view of a process (emphasizing the organizational units performing a
process and the form the data are in, such as paper or electronic).

A strength of the DFD is its simplicity, due to the small number of constructs
required to be learned to read and create these diagrams. The functional decomposition of
DFDs also enables the diagrams to be used to represent both more abstract and more
detailed representations of the same process, and to relate these representations to one
another.

A weakness of DFDs as a business process modeling convention is that they do
not show flow of control (Powers et al 1984), relying on additional tools within
structured analysis such as decision tables to indicate what determines the sequence of
activities. While controls that occur as processes can be captured like any other process
(e.g. "verify purchase order authorization" would be acceptable as a process), and control
data can be shown like any other data flow, there is no separate construct to represent
"controls" as a concept. As would be expected from a convention focused on modeling
data flows and their transformations, there are also no structures to capture resources,
objectives, or risks. DFDs also do not capture linkages to organizational structures,
except as they provide or receive data, although the organizational structures performing
the process are captured in the "physical view" of a DFD for a particular process (e.g. a
process could be labeled "Purchasing" in a physical view, versus a label of "create purchase order" in the logical view).

3.3.2 System flowcharts

System flowcharts are one of the oldest forms of diagrams used in information systems. While they were originally used to document computer programs, they are also described in Gelinas et al (2004) a means of documenting information flows and related business processes. System flowcharts capture inputs and outputs, processing, storage, and entities. There are a large number of variants on the basic symbols, including ANSI and ISO notations, and many variants on how the symbols are combined to model a particular process. To focus the discussion, the flowcharting conventions proposed for auditors in Kaplan (2001) will be used here.

Kaplan notes that for business processes, only two symbols to show processes and decision points may be necessary. However, for more detailed flowcharts, he provides a variety of other symbols, including symbols to distinguish manual input and operations, documents, types of data storage, and displays, with lines used to connect steps together. Kaplan recommends that the organizational units performing each action should be shown (presumably either as text or by using swimlanes. The latter are shown by organizing activities into columns each of which is labelled with the name of the organizational unit performing the activities).

A strength of system flowcharts is that they do capture flow of control via decision points, and can show manual versus automated operations and inputs. However,
they do not have constructs intended to capture objectives, risks, or resources.

Accounting transactions can be reflected via standard input and output constructs, but do not have their own construct. Controls can be captured as decision points, activities, or data, but there is no separate "control" construct. Performance measures do not have any construct they can be readily mapped to, although such information could be captured by adding comment symbols with appropriate text to the diagrams.

### 3.3.3 Resource-event-agent (REA) modeling

REA modeling was introduced by McCarthy (1982), with various refinements to the approach since that time. While the REA approach was originally focused on providing a framework to model data about economic transactions within organizations, later efforts have expanded it to also include means for modeling business processes to guide the development of organizational databases. One such approach, provided by Dunn et al (2005), has been summarized below.

Unlike the concepts underlying DFDs and system flowcharts, REA concepts are explicitly founded on a particular ontology, or basis for determining what should be modeled. The key constructs are economic resources, economic events, and agents, which comprise organizational units (from the level of the individual to that of a complete organization). The REA business process diagram is part of a larger enterprise modeling convention anchored on value chain concepts, whose primary goal is to support the design of a comprehensive database for enterprise economic transactions (Dunn et al 2005).
A basic concept in REA modeling is the idea of the exchange. An exchange represents paired events, with one event in which a resource is consumed or decreased always being paired with an event in which a resource is acquired or increased (e.g. cash is decreased to acquire raw materials). Each event has associated with it at least one internal agent, and often an external agent. The modeling approach thus captures for each event an associated resource, whether that resource is increased or decreased by the event, and the organizational unit involved, as well as the associated complementary event representing the other part of the exchange and its relationship to the associated resource and organizational unit. In addition to events of the "exchange" type, other events that can be modeled include commitments to future economic events, and instigations (triggers) of events. Both of these event types are also linked to resources and agents. Relationships between instigations, commitments, and exchanges are also modeled. Inputs and outputs of events in an REA model are always resources (including cash and labour) rather than information. To provide a modeling of information, other conventions such as DFDs or system flowcharts are used to model the activities comprising each event in the REA business process model.

A key strength of the REA modeling conventions is the clarity of the underlying metamodel, which provides considerable guidance in determining what should be modeled and how it should be represented. The splitting of REA models into value chain versus business process versus workflow views also reduces complexity. Because REA modeling is explicitly focused on creating a model to support accounting systems, the patterns captured by each model typically corresponds to a class of accounting
transaction, such as sales and collections, or acquisition and payments. Similarly, the objective of a business process is inherent in its name and the economic nature of what is being modeled. For example, the acquisition/payment business process inherent objective is to acquire goods and services needed by the organization to conduct operations, in exchange for payment. There is no separate construct to explicitly indicate objectives for any given process that can then be linked to particular aspects of the REA diagram.

A key difference of REA business process models relative to others discussed in this paper is that they do not correspond to the "physical reality" of a particular business process. They capture the economic essence of transactions, and use an economic/value chain perspective to define a business process, rather than attempting to model the details related to the physical and informational inputs, outputs, and sequence of activities required to realize a particular organizational objective. As such, the definition of "resources" in REA models appears to be much more precise than that used in the ISO standards, and what is intended to be encompassed by the latter may be much broader (e.g. the machines, information systems, and humans skills required to carry out a particular activity, and which may not be consumed within that activity) than what is intended within REA by the term "resource". A more physical model of each event shown in the REA model can be created using other techniques, as mentioned earlier.

There are no constructs for modeling risks related to a particular process in REA modeling, nor the controls intended to address the risks, although controls may be represented within each event using the other modeling conventions such as DFDs and system flowcharts. REA models also are not intended to capture flow of control, although
the flow of control within a particular event may be portrayed if the modeling convention
used to decompose the event has a means of depicting flow of control, e.g. a systems
flowchart.

3.3.4 IDEF0/IDEF3 models

IDEF0 and IDEF3 are part of a larger system modeling methodology developed
by the U.S. Airforce known as Integrated Computer Aided Manufacturing Definition
(IDEF) (Kamath et al 2003). The IDEF0 convention was derived from the actigram,
which is part of Structured Analysis and Design Technique (SADT) (Knowledge Based
Systems 2004). The website http://www.idef.com provides a brief description of IDEF
conventions, along with a link to the link to the IDEF0 standard released by the American
National Institute of Standards and Technology (NIST). The following description is
largely based on these sources.

IDEF0 is used to model processes and constituent activities and their
transformation of inputs into outputs, along with the controls governing the
transformation and the resources (referred to as mechanisms in IDEF0) required for the
process. Inputs and outputs can be materials or information. Controls can be any type of
information that starts, regulates, or synchronizes the process. Arrows indicate the
direction of flow of information or materials between processes, and thus indicate
interdependencies among the processes. Functional decomposition is used with IDEF0,
with a context model at the top level showing the process as one activity with all inputs
and outputs, and then subsequent levels decomposing the process into multiple activities.
Every process must also have a stated purpose.

IDEF0 does a good job of showing the resources, inputs, outputs, and controls of each process. It also depicts control data separately from input data required to perform the process. However, as Kamath et al (2003) note, the flow of control between functions is not directly captured within the convention, meaning that temporal precedence is not shown, nor what causes a process to start or stop. However, a modeler can choose to arrange activities in an appropriate order on a page to represent their proper sequence. Vernadat (1996) also notes that there is also little guidance on how to do the functional decomposition, and that exceptions are not depicted. There are also no distinct constructs for accounting transactions, performance measures, or for linking to the responsible organizational units, although operational responsibility may be reflected by capturing the organizational unit as a resource needed to operate the function.

To capture flow of control, IDEF3 provides a process description diagram showing precedence and causality of activities within a process (Kamath et al 2003). The process description diagram shows only the activities within a process and the flow of control among activities — inputs, outputs, and controls for each activity are not shown. (e.g. while it is possible from the process description diagram to determine what activities occur in parallel, and the sequence of activities, control data such as schedules, capacity, and authorizations are not shown).

3.3.5 Extended event-driven process chain diagrams (EPC)

EPC diagrams are a component of the Architecture of Integrated Information
Systems (ARIS) framework developed by Scheer (1992), and described by Kamath et al (2003) as subsequently adapted for use in SAP AG’s R/3 reference model. EPC diagrams are used in ARIS and SAP R/3 to describe business processes, and in ARIS represent the "control view" which links functions, organizations, and data (Stefanov and List 2005).

Van der Aalst (1999) describes basic EPCs as consisting of activities, events, and connectors indicating flow of control between activities and events. The intent underlying an EPC is to model the complete chain of activities that occur in response to a business event, and thus describe a business process. Events trigger activities as well as describing the outcome after an activity has occurred, e.g. the receipt of a customer order, or the acceptance of a customer order. Van der Aalst notes the existence of an extended EPC that allows the modeling of objects, data inputs and outputs, and organizational units performing the function. Keller and Detering (1996) describe these as providing two separate views: one which emphasizes the flow of control among activities and the related events (the lean EPC), and one which shows for each activity the related data inputs and outputs and organizational units involved in the activity (the assignment/extended EPC).

A key strength of EPC diagrams is that they are easy to understand, but the absence of a clear semantics to aid in the interpretation of an EPC is a problem in their use (Van der Allst 1999). Identification of the appropriate events to be modeled (e.g. those which trigger activities) can also be challenging (Keller and Detering 1996). In addition, EPC diagrams also do not have an explicit construct to model controls, although the activity construct may be used to represent controls such as authorization or verification that can be viewed as controls, and examination of the organizational units involved may
provide some sense of segregation of duties. There is no representation for the resources required for a particular activity.

3.3.6 Unified Modeling Language (UML) activity diagrams

Unified Modeling Language (UML) is the de facto standard for the modeling of object oriented information systems (Pender 2003), and is supported by a broad-based industry consortium known as the Object Management Group. UML version 2.0 consists of 16 diagrams (Pender 2003), one of which is the activity diagram. Pender describes the activity diagram as the key means in UML of modeling logic, and claims part of its notation is based on that of system flowcharts. The activity diagram has been developed for use as a business process modeling convention by Eriksson and Penker (2000), and Jackowski (2003), among others. The description that follows is based on Pender (2003) and Eriksson and Penker (2000).

Activity diagrams capture both the activities comprising a business process and the flow of control among the activities. Activities are linked together to form a complete process. Usually, each activity starts when the activity preceding it in the sequence completes. Guard conditions can be used to indicate delays before another activity starts by providing conditions that must be satisfied before another activity can be performed. Decision points provide the primary means of indicating flow of control, determining which of a set of potential activities will occur depending on which of a set of specified conditions exist. Activities can also be shown as happening in parallel. Swimlanes can be used to partition an activity diagram to show the organizational units that contribute to
each activity. Inputs to and outputs from activities are either material or information. The use of resources by processes is not modeled. Like many of the other conventions, while controls can be shown as activities or in the form of data, there is no explicit construct to model a control that is distinct from that of a regular activity or data.

Eriksson and Penker (2000) provide a number of extensions to the basic UML diagrams to create an approach for enterprise modeling. They extend the activity diagram to create a process diagram, which shows explicitly the goals for each process, the material used and provided by the process, the resources needed for the process, and controls for the process. Eriksson and Penker also provide a business behavior

A strength of activity diagrams is the small number of symbols that must be mastered to read or create a diagram. The use of the Eriksson and Penker extensions enable activity diagrams to capture much of what is needed to understand a business process. A problem with activity diagrams (and UML more generally) is that they are intended to provide a modeling convention by providing a set of symbols that are loosely mapped to particular concepts such as activities and decision points, but the precise meaning of many of the concepts is not well defined.

3.3.7 Business process diagram (Business Process Modeling Notation)

Business Process Modeling Notation (BPMN) is intended to provide a notation that is readily understandable by all business users, from the business analysts that create the initial drafts of the processes, to the technical developers responsible for implementing the technology that will perform those processes, and finally, to the
business people who will manage and monitor those processes (White 2004). The notation was developed by an industry consortium known as the Business Process Management Initiative, with version 1.0 of the notation released in May 2004 (White 2004).

The business process diagram (BPD) is the graphical notation provided within BPMN, and is based upon flowchart techniques. The description that follows is based largely on White (2004). A BPD captures activities and the flow of control that defines the sequence in which the activities occur. Each process can include events (which affect the flow of a process, including by acting as triggers), activities, decision points, and the data inputs and outputs. Swimlanes can be used to show organizational units performing each activity. Business Process Diagrams can be decomposed to provide greater or less detail about processes. Separate connection symbols are used to show message flows between organizations from sequence flows that connect activities within an organization.

Owen and Raj (2003) suggest that a strength of the BPD is that it is closer than many other conventions in depicting how business analysts think of processes. They also note that BPD can be mapped to executable business languages, so that an automated analysis of business processes could be supported. The BPD is focused primarily on the portrayal of activities; data inputs and outputs are optional, but the sequence of activities comprising a process must be shown. The resources required by a particular activity are also not shown. Controls can be modeled as activities, data, or decision points, but there is no separate control construct.
3.4 Discussion of business process modeling conventions

The preceding discussion provides a characterization of each business process modeling convention based on its apparent ability to portray the constructs sources such as Bell et al (1997) and Knechel (2001) suggest are needed for audit risk assessment. The following points summarize the key findings from this characterization, as well as describing some related issues about the modeling conventions.

First, none of the business modeling conventions considered capture all the constructs that Bell et al (1997) and Knechel (2001) suggest are necessary for understanding audit risk at the business process level. The conventions generally have no means for portraying process objectives or related risks, or for linking performance measures to particular processes or activities constituting the process. While several of the conventions (e.g. system flowcharts, business process diagrams, and activity diagrams) do have means of adding comments to any diagram, there is no means to enable these comments to be explicitly linked to one another in a meaningful way. This lack of linkages of comments to the remainder of the modeling constructs means that diagrams can not show the linkages of particular risks to a given objective, nor show the linkages of process controls to the risks they are intended to address.

Second, the lack of formal definitions for a number of the modeling conventions such as would be provided by a formal ontology or semantics make comparisons of constructs across modeling conventions awkward. For example, what is intended to be meant by a "resource" in one convention may not be exactly what is intended by another convention. Similarly, some conventions use different terms that appear to refer to the
same concept.

Third, there is a distinction between conventions that attempt to model a more complete view of the physical reality of a particular process versus those that attempt only to model a particular aspect of a process. In part this distinction manifests as whether the convention attempts to model flow of control within a process, and whether information related to the flow of materials (whether products, services, or raw materials) is portrayed. UML activity diagrams, flowcharts, extended event process chains, and business process diagrams all try to model flow of control, and also attempt to model (other than event process chains) the information related to the flow of materials. In contrast, data flow diagrams model only the flow of information, and do not model flow of control. REA models portray the materials involved in each process, but do not model flow of control. The perspective provided by Bell et al (1997) suggests that understanding the sequence of events is important as well as the flow of materials is important for risk assessment, but Knechel (2001) suggests only that the flow of information needs to be considered, and does not mention the need for understanding the sequence of activities constituting a process.

Fourth, the "controls" construct is particularly difficult to link to the process modeling conventions examined. Controls at the process level fall into several categories, such as segregation of duties, input controls, processing controls, and output controls. (Smieliauskas and Robertson 2004). As suggested by Table 1, controls as viewed from an enterprise modeling perspective may appear in declarative rules, constraints, data inputs, the activities performed, behavioral rules, the organizational units involved in providing
inputs, receiving outputs, or performing the activities, or the operational authority for an activity.

None of the modeling conventions reviewed have the full range of constructs suggested in Table 1 that might be used to capture controls. At a minimum, it would appear necessary to convey control information going into and coming from a process, the flow of control within a process, the organizational units involved in all steps of a process, and the control related activities within a process to be able to capture the categories of internal control suggested by Smieliauskas and Robertson (2004). This would suggest that the IDEF0/IDEF3 diagrams, and the UML activity diagrams with the Eriksson and Penker extensions might be most promising for capturing the various types of controls needed, since they do portray organizational responsibility, the control data for each activity, flow of control, and can capture the control related activities within each process.

Finally, the IDEF0/IDEF3 and UML activity diagrams with Eriksson and Penker extensions would appear to provide the most complete coverage of the constructs needed for analyzing audit risk at the business process level, based on the results in Table 3. However, there are a number of issues which need further investigation before any substantive guidance can be provided as to the modeling convention that would be generally best for use in process level audit risk assessment. These will be discussed next.
4.0 Directions for future research and concluding comments

The preceding analysis focuses on the major business process modeling conventions in terms of the constructs that can apparently be portrayed by the convention. Existing research based on conceptual modeling as well as studies of the utility of diagrams in reasoning and problem solving suggests a number of other considerations in choosing a means of representing information for audit risk assessment.

First, there is the basic question of under what circumstances diagrams are preferable to text for information representation. Text based and diagram based modeling approaches can be thought of as forming the ends of a continuum with respect to possibilities for external representation of non-quantitative information; obviously, approaches may be taken that are combinations of text and diagrams. A basic issue in the selection of business process models is thus whether they should be more diagrammatic or more text-based. With the exception of flowcharts, audit textbooks (e.g. Knechel 2001) and anecdotal evidence suggests that audit documentation of business processes tend to be largely, although not exclusively, text based. To the extent that a diagramming notation is provided, it is typically some type of systems flowchart (e.g. Smieliauskas and Robertson 2004). In contrast, systems analysis and design research and textbooks as well as accounting information system textbooks almost always propose and present business processes in a largely diagrammatic form when they are intended for use by people rather than computers.

A literature review done by Alencar, Boritz, and Carnaghan (2004) concluded, based on a large number of theoretical and empirical papers, that diagrams can and do
often lead to better performance on a wide variety of tasks relative to information

equivalent text representations, where "better" is typically defined in terms of accuracy
and speed. There is thus reason to believe that diagram based representations are often
desirable for a variety of decision making and reasoning tasks.

However, the review findings also stress the importance of considering the user,
domain knowledge, task, task environment, and diagram characteristics in determining
when a diagrammatic representation should be superior to a text-based representation, or
to diagrammatic representation done with different modeling conventions. For example,
the theoretical literature makes it clear that diagrams without appropriate spatial
arrangements of the symbols and careful abstraction will not be superior to text, and there
are some empirical findings to support this view. This leads to the question of what
diagram characteristics might be important in improving their efficacy.

One particular diagram characteristic that Stenning and Oberlander (1995) suggest
is important is ensuring that the number of possible interpretations of a diagram be
limited, since this reduces cognitive load on the part of the user. One means of
accomplishing this may be to ensure that concepts of interest from the domain being
modeled (e.g. business processes) are each mapped to one, and only one, modelling
construct (Wand and Weber 2002). For example, if it is important to an auditor that data
flows about products and services be distinguished from data flows about documents
such as orders and receipts, these two concepts should be modeled differently within a
particular modeling convention, perhaps through the use of different types of lines.
Similarly, if controls are viewed as a single concept by auditors in analyzing business
processes, they should map to one modeling construct within the diagrammatic representation.

Another important diagram characteristic suggested in Wand and Weber (2002) is the explicitness of important relationships and concepts, along with omission of irrelevant information. Thus, if Knechel’s (2001) suggestion that it is important that each process risk be linked to the related controls and performance indicators is true, an appropriate business modeling convention should explicitly capture these relationships.

Ease of inference is another important diagram characteristic pointed out by Larkin and Simon (1987), and likely facilitated by the previous two characteristics. If the necessary inferences to solve the problem can be readily made from one modeling convention but not another, the first is likely to be more useful for problem solving. Cheng et al (2001) expand on this point by referring to a user’s ability to mentally "run" a diagram to make inferences. For example, if audit risk assessment at the process level requires linkage of process risks to every control that addresses the risk, a diagram that makes explicit that there is no such linkage for a particular risk (perhaps by having no connecting line between the risk and the identified controls) should be useful than one which does not make this explicit. Determination of what constructs need to be grouped together to support inference making will also be helpful in deciding what views might be needed within a particular business process modeling convention.

Ultimately, determination of whether a particular modeling convention is likely to be better at supporting audit risk assessment will require more study of what exactly an auditor needs to understand about a business process, and how the information needs to
be combined to form appropriate inferences. A better understanding of what auditors need to understand is particularly important given that Bell et al (1997) and Knechel (2001) are largely focused on one particular audit methodology at a particular point in time. A more generalized understanding of what is needed would help ensure that the task is properly understood, and any modeling convention assessment is being done within the broadest possible context. Nonetheless, the reasonable correspondence between the process concepts that are suggested for audit purposes and what international standards suggest needs to be understood about processes for management and control purposes provides some assurance that the constructs in question are at least somewhat plausible.

The issue of the mapping between the concepts in the domain of interest (in this case, business processes for audit risk assessment purposes) and the modeling constructs also requires a clearer understanding of the meaning of modeling constructs. As noted earlier, many of the modeling conventions have only a fairly informal glossary to guide the understanding of what a particular construct is supposed to represent. REA diagrams are an exception to this, and work is being done to improve the semantics of the constructs in UML in studies such as Opdahl and Henderson-Sellers (2002).

This paper takes a first step in providing a means to choose an appropriate modeling convention to support audit risk assessment at the business process level. It identifies and characterizes a number of modeling conventions based on what constructs they appear to use, versus what is claimed to be needed for the task of process level audit risk assessment. A comparison to international standards for process modeling within the larger context of enterprise modeling also helps to determine the completeness of the
conventions surveyed. Greater awareness of these alternative conventions, versus the ones traditionally used in accounting information system and audit textbooks such as data flow diagrams and system flow charts, may help accounting academics and practitioners choose modeling techniques better suited to business process analysis. In the longer term, additional research on what is needed to understand business processes for audit risk assessment and more complete semantics of the modelling constructs should be helpful in improving inferences about audit risk.
References


International Federation for Information Processing/International Federation of Automatic


Table 1: Process Relevant Concepts from Enterprise Modeling Frameworks and Standards

<table>
<thead>
<tr>
<th>Source</th>
<th>Construct/Concept</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>PrEn ISO 19440 Heading 6.3.1</td>
<td>Description</td>
<td>Textual description of process/activity</td>
</tr>
<tr>
<td>PrEn ISO 19440 Heading 6.3.1</td>
<td>Objectives</td>
<td>Preferred possible and achievable future situations that should influence choices</td>
</tr>
<tr>
<td>PrEn ISO 19440 Heading 6.3.1; 3.1.14</td>
<td>Constraints</td>
<td>Restriction or limitation or condition governing process</td>
</tr>
<tr>
<td>PrEn ISO 19440 Heading 6.3.1</td>
<td>Performance</td>
<td>Metrics by which achievement of objectives can be assessed</td>
</tr>
<tr>
<td>PrEn ISO 19440 Heading 6.3.11, 3.1.21</td>
<td>Declarative Rules</td>
<td>At process level only — objectives and constraints combined with applicability conditions</td>
</tr>
<tr>
<td>PrEn ISO 19440 Heading 6.3.1, 6.4.2</td>
<td>Inputs</td>
<td>Can be object information to be processed, control information, resources or events (which initiate a process)</td>
</tr>
<tr>
<td>PrEn ISO 19440 Heading 6.3.1, 6.4.2</td>
<td>Outputs</td>
<td>Can be object information, state of resources after process/activity completion, or events</td>
</tr>
<tr>
<td>PrEn ISO 19440 Heading 6.3.1</td>
<td>Behavioral Rules</td>
<td>At process level only; of a When...Do form, to indicate sequencing of constituent processes/activities; not necessarily deterministic</td>
</tr>
<tr>
<td>PrEn ISO 19440 Heading 6.3.1, 6.4.2</td>
<td>Priority</td>
<td>Allows for selection of which process to start first when behavioral rules trigger more than one process to start</td>
</tr>
<tr>
<td>PrEn ISO 19440 Heading 6.3.1, 6.4.2</td>
<td>Where Used</td>
<td>Relevant domain</td>
</tr>
<tr>
<td>PrEn ISO 19440 Heading 6.3.1</td>
<td>Constituent Processes/Activities</td>
<td>At process level only; business processes or enterprise activities that are directly employed to perform process</td>
</tr>
<tr>
<td>PrEn ISO 19440 Heading 6.3.1, 6.4.2</td>
<td>Operational Responsibility</td>
<td>Organizational group or person</td>
</tr>
<tr>
<td>PrEn ISO 19440 Heading 6.3.1, 6.4.2</td>
<td>Operational Authority</td>
<td>Organizational group or person</td>
</tr>
<tr>
<td>PrEn ISO 19440 Heading 6.4.2</td>
<td>Ending Status*</td>
<td>Applicable only to activities; indicates a particular status value and priority for that status value</td>
</tr>
</tbody>
</table>
Table 1 (Continued): Process Relevant Concepts from Enterprise Modeling Frameworks and Standards

<table>
<thead>
<tr>
<th>Source</th>
<th>Construct/Concept</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>PrEn ISO 19440</td>
<td>Duration</td>
<td>Defined only for activities</td>
</tr>
<tr>
<td>Heading 6.4.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PrEn ISO 19440</td>
<td>Legitimate outputs</td>
<td>End-results must be observable or quantifiable: material, information, newly designed processes, or achievement of designated objectives</td>
</tr>
<tr>
<td>Heading 6.3.1, 6.4.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GERAM 1.6.2</td>
<td>Views</td>
<td>The minimal set of views provided should be those of function, information, resource, organization</td>
</tr>
<tr>
<td>Heading 3.1.5.2.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GERAM 1.6.2</td>
<td>Business Process Purposes</td>
<td>Customer service or product, management, control</td>
</tr>
<tr>
<td>Heading 3.1.3.4</td>
<td></td>
<td></td>
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</tbody>
</table>
Table 2. Comparison of Concepts and Constructs Needed for Business Process Risk Assessment versus those identified as Business Process Constructs in Enterprise Modeling

<table>
<thead>
<tr>
<th>Concept/Construct Specified for Business Processes for Audit Risk Assessment</th>
<th>Concept/Construct Specified for Business Processes for Enterprise Modeling (ISO/DIS 19440 and GERAM 1.6.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objectives</strong> (related to overall business objectives) (Bell et al 1997; Knechel 2001)</td>
<td>Objectives (preferred possible and achievable future situations that should influence choices)</td>
</tr>
<tr>
<td><strong>Related Business Risks</strong> (intrinsic, threaten attainment of objectives) (Bell et al 1997; Knechel 2001)</td>
<td>No equivalent</td>
</tr>
<tr>
<td><strong>Inputs</strong> (materials, resources, or information; may not be processed) (Bell et al 1997); Inputs (information only) (Knechel 2001)</td>
<td>Can be object (material of information) information to be processed, control information (which is not processed), resources, or events (which initiate a process)</td>
</tr>
<tr>
<td><strong>Activities</strong> (including trigger for process and how it terminates) (Bell et al 1997; Knechel 2001)</td>
<td>Constituent Processes/Activities; Events specify trigger for process</td>
</tr>
<tr>
<td><strong>Linkages Between Processes, including sequence or lack thereof</strong> (Bell et al 1997)</td>
<td>Behavioral Rules describe flow of control/sequencing</td>
</tr>
<tr>
<td><strong>Outputs</strong> (product, deliverable, information, resource) (Bell et al 1997) Outputs (information only, consider reliability) Knechel 2001)</td>
<td>Can be object information (product or service, new process, achievement of objective, information), state of resources after process/activity completion, or events</td>
</tr>
<tr>
<td><strong>Systems</strong> (Collections of resources, including information systems — Bell et al 1997) — Knechel notes to include reliability (manual versus electronic)</td>
<td>Possibly maps to part of resources, which should be specifiable as carried out by people or technology according to ISO 15704.</td>
</tr>
<tr>
<td><strong>Accounting Transactions Affected and Type</strong> (Data related to the process that are used in accounting reports to management or third parties. Classify transactions as routine, not routine, or accounting estimates. (Bell et al 1997; Knechel et al 2001.)</td>
<td>Output — object information (type information)? Routine/non-routine distinction not explicitly mentioned but could be captured as object attribute.</td>
</tr>
</tbody>
</table>
Table 2 (Continued). Comparison of Concepts and Constructs Needed for Business Process Risk Assessment versus those identified as Business Process Constructs in Enterprise Modeling

<table>
<thead>
<tr>
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<th>Concept/Construct Specified for Business Processes for Enterprise Modeling (ISO/DIS 19440 and GERAM 1.6.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls to mitigate risks (Policies and Procedures — may or may not be implemented) (Bell et al 1997) Controls should be mapped to risks they related to (Knechel et al 2001)</td>
<td>Control information as inputs, behavioral rules, possibly constraints, declarative rules;</td>
</tr>
<tr>
<td>Performance Measures (related to specific processes, typically covering three dimensions of cycle time, process quality, process costs - Bell et al 1997) (related to specific risks Knechel 2001)</td>
<td>Performance measures related to objectives</td>
</tr>
<tr>
<td>Other Symptoms of Poor Performance (Bell et al 1997)</td>
<td>No direct equivalent</td>
</tr>
<tr>
<td>Views: Core Business Processes and Resource Management Processes (Bell et al 1997); Functional (process map) and risks/controls/measures (internal risk analysis) (Knechel 2001)</td>
<td>Function, information, resource, organization</td>
</tr>
<tr>
<td>No equivalent</td>
<td>Description</td>
</tr>
<tr>
<td>No equivalent</td>
<td>Priority</td>
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<td>No equivalent</td>
<td>Where Used</td>
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<td>No equivalent</td>
<td>Operational Responsibility</td>
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<td>No equivalent</td>
<td>Duration</td>
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Table 3. Comparison of Concepts and Constructs Needed for Business Process Risk Assessment versus those Provided in Major Business Process Modeling Notations

<table>
<thead>
<tr>
<th>Construct</th>
<th>DFD</th>
<th>System Flowcharts</th>
<th>REA Models</th>
<th>IDEF0/IDEF3</th>
<th>Extended EPC</th>
<th>UML Activity Diagrams</th>
<th>Business Process Diagrams (BPMN)</th>
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</thead>
<tbody>
<tr>
<td>Objectives</td>
<td>No</td>
<td>No</td>
<td>No distinct constructs</td>
<td>As narrative</td>
<td>No</td>
<td>In Eriksson and Penker extensions</td>
<td>No</td>
</tr>
<tr>
<td>Related Risks</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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</tr>
<tr>
<td>Inputs</td>
<td>Data</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Data</td>
<td>Yes</td>
</tr>
<tr>
<td>Activities</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Flow of control (sequence)</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Outputs</td>
<td>Data</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Data</td>
<td>Yes</td>
<td>Data</td>
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<td>Resources</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>In Eriksson and Penker extensions</td>
<td>No</td>
</tr>
<tr>
<td>Accounting Transactions</td>
<td>No distinct constructs</td>
<td>No distinct constructs</td>
<td>Yes</td>
<td>No distinct constructs</td>
<td>No distinct constructs</td>
<td>No distinct constructs</td>
<td>No distinct constructs</td>
</tr>
<tr>
<td>Controls</td>
<td>No distinct constructs</td>
<td>No distinct constructs</td>
<td>Possible at task level</td>
<td>Yes</td>
<td>No distinct constructs</td>
<td>In Eriksson and Penker extensions</td>
<td>No distinct constructs</td>
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<td>Performance Measures</td>
<td>No</td>
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<th>REA Models</th>
<th>IDEF0/IDEF3</th>
<th>Extended EPC</th>
<th>UML Activity Diagrams</th>
<th>Business Process Diagrams (BPMN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>In physical view</td>
<td>Possible</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Responsibility</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Views</td>
<td>Context and Decomposed; logical versus physical</td>
<td>Overview and Detailed</td>
<td>Business process, workflow</td>
<td>Function versus Flow of Control</td>
<td>Flow of control; organization al units and data input and outputs for a particular process.</td>
<td>Overview and Detailed</td>
<td>Overview and Detailed</td>
</tr>
</tbody>
</table>