The Economic Structures of Exchanges vs. Conversions in the REA Enterprise Ontology

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Introduction
The REA accounting model was first published (McCarthy 1982) as a meta-description of a business process, wherein two economic resources were exchanged via two linked economic events between two economic agents. The model was illustrated in that 1982 paper initially at the M2\(^2\) level (Figure 5, p. 564) and that metamodel is recreated here as Figure 1. The 1982 paper also illustrated an M1 level model of an acquisition process (Figure 6, p. 566), and that REA acquisition process is also illustrated here as a UML class diagram in the southeast corner of Figure 2 of the present paper. The rest of Figure 2 illustrates REA granularity extensions done over the years:

- **Value chains** (Geerts and McCarthy 1997a 1999) following the ideas of Porter (1985) in the northeast corner;
- **Value networks** (McCarthy, Geerts, and Gal 2016) following the ideas of again Porter (1985), Haugen and McCarthy (2001a), and Dunn (2012) in the northwest corner; and
- **Workflow** (Geerts and McCarthy 1997a, 2001) in the southwest corner.

Figure 3 illustrates the REA temporal extensions developed in Geerts and McCarthy (2000b, 2002, 2006), ISO (2007, 2015), and McCarthy, Geerts, and Gal (2016). At the bottom of that figure is the **accountability layer** with the original REA metamodel which portrays what has occurred in a business process. In the middle, we have the **scheduling layer** which portrays what is specified or reserved. And finally on top, we have the **policy level** that shows what could be or should be.\(^3\) We consider this metamodel as a frame (Minsky 1975; McCarthy 1987) for a business process (Hammer and Champy 1993).

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\(^1\) Most of the text in this article and all of its embedded figures have been adopted from a research monograph in progress by William McCarthy, Guido Geerts and Graham Gal (2016): *The REA Accounting Model as an Enterprise Ontology.*

\(^2\) MOF (Meta Object Facility) is an OMG (2012) standard that describes model abstraction levels: M2 describes metamodels; M1 describes actual applications of the metamodel; and M0 describes actual instances of modeled concepts.

\(^3\) Granularity extensions are explained in chapter 2 of McCarthy, Geerts, and Gal (2016); while temporal extensions are explained in chapter 3.
Figure 4 illustrates how linkages between the REA value chain level and the REA business process level are documented. Figure 4(a) illustrates with classes that a value chain is an aggregation (Smith and Smith 1977) of business processes and that a business process is an aggregation of at least two economic events connected by a duality association. Figure 4(b) is a notation developed by Geerts and McCarthy (1999) for showing overall value chain composition, and readers should understand how 4(b) is a shorthand notation for 4(a) with the additional depiction of input/output resources.

**Accommodation of the two basic Coase process prototypes: market transfers (exchanges) and within-firm transformations (conversions)**

In this section, we analyze the overall nature of business processes with a mind toward classifying them into two categories: exchanges and conversions.

For REA, a value chain is considered an entrepreneur script for creating a final product with a portfolio of attributes of value to a customer (Geerts and McCarthy, 1997a 1999; Lancaster 1966; Dunn and McCarthy 1992). In assembling each part of that portfolio, the entrepreneur must decide whether to "buy" that component or to "make" that component (see Figure 5). This involves the classical entrepreneurial analysis pioneered by Coase (1937) and explained in more detail by Kroszner and Putterman (2009). The result of that analysis is that each node in the value chain becomes either (1) an arm's length market exchange using the price mechanism as a coordinating device between internal and external agents, or (2) an internal conversion coordinated by internal agents arranged in a multitier responsibility hierarchy (Kroszner and Putterman 2009).

As shown at the bottom of Figure 5 and expanded in Figure 6, this make/buy choice leads to slightly different REA models with two different types of dualities: transfer duality and transformation duality (Fisher 1906). Transfers create value in a market transaction with outside parties, while transformations create value through changes in form or substance (Geerts and McCarthy 2000b, 6). Each of these variations is explained in a separate section next.

**REA exchanges**

The REA accountability pattern for a market exchange is shown in Figure 7, and it mirrors the REA model (M2) previously shown in Figure 1. An example M1 model of an exchange (a raw material acquisition process) was illustrated at the bottom right (southeast corner) of Figure 2. The exchange and the ultimate value accrued in the process is coordinated by the price mechanism as it operates between two independent parties (one inside the firm; one outside).

In Geerts and McCarthy (2001), we illustrated that an REA business process could actually be conceived as an aggregation of multiple smaller activities which are

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4 This choice between exchanges and conversion is discussed extensively in accounting textbooks, most commonly under the topic of "make or buy" decisions." See Horngren et al. (2015) for accounting treatments of this topic.
termed *business events*\(^5\) arranged in a particular order called a *workflow*. In Figure 8, we introduce the additional REA concept of *business process phases*, an innovation adopted directly from the Open-edi standard of ISO 15944-1 (2001). This expands our aggregation hierarchy slightly as it now illustrates that a *business process* is an aggregation of *business process phases* which themselves in turn are aggregations of *business events* arranged in a workflow. As illustrated in Figure 9, our five process phases will be termed: planning, identification, negotiation, actualization, and post-actualization.

As explained in ISO 15944-1, the editors of this standard\(^6\) derived these five phases from an exhaustive examination and compilation of the management literature dealing with business process engineering (see Annex F of ISO 15944-1 (2001)). Their analysis was then adopted into part 4 of the Open-edi standard series (ISO 2007 2015) which relies heavily on the REA ontology. The ISO description of the phases is quoted exactly in Figure 10. With regard to REA, *buyer* and *seller* are obviously roles that inside/outside *economic agents* can play, and an Open-edi *business transaction*\(^7\) is a term synonymous with the REA concept of *business process*.

Introducing phases as an REA component allow us to be more specific about the detailed nature of business events, and the use of these phases is also extremely useful in crafting easier explanations of very complicated business processes. The exact delineation and ordering of the phases is slightly arbitrary at the margin, but they can be usefully exercised to order very complex and very long sequences of workflow events. For REA, we will assume for the most part that they occur in the order shown and that they categorize business events well. These assumptions will make the phases useful for state machine mechanics\(^8\), an REA advance described by Horiuchi and McCarthy (2011).

In Figure 11, we illustrate how the business process phases correspond (in very loose fashion) to components of the REA ontology:

- In planning and identification phases, the two agents engage in activities (REA business events) to **determine** the types of resources they plan to acquire in typed exchanges. They then determine the types of trading partners they need and ultimately zero in on one particular partner to identify.
- In negotiation, the trading partners use additional business events to **specify** the typed conditions for scheduled commitments and contracts.
- In actualization and post-actualization, the inside and outside agents engage in business events (workflow activities) that **fulfill** the exchange specifications.

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\(^5\) In Geerts and McCarthy (2001), these business events were originally termed tasks. In using the term business event, we adopt the name suggested by David (1997) and Denna et al. (1993). *Business Event* was the term used by ISO 15944-4 (2007).

\(^6\) Two advanced IT practitioners from Canada: Jake Knoppers and David Clemis

\(^7\) *Business transaction* is a fundamental construct of the Open-edi Reference Model (International Standards Organization 2010)

\(^8\) REA state machine mechanics were first described by McCarthy (2003b) and then incorporated in ISO 15944-4 (2007).
When a business event completes a transfer from one party to another, an economic event is registered\(^9\).

In Figure 12, we illustrate a business process phase example at the M1 level with 14 business events\(^{10}\). Again, this particular example is based on the acquisition example from Figure 2, with the actualization business events corresponding exactly to the workflow shown in the southwest corner of that figure. The exchanged electronic messages (shown in italics in Figure 12) have actually been adopted from EDI (Electronic Data Interchange) standards like X12 or EDIFACT\(^{11}\), but readers may imagine that the same determine-specify-fulfill dialogue could have been accomplished by paper documents or by speech acts in a less technically advanced environment (such as a buyer and seller negotiating across a table).

These explanations of REA market exchanges are now complete. In the next section, we move on to analysis of REA internal conversions (see Figure 13).

**REA Conversions**

The nature of conversion process modeling has developed throughout the history of REA design work. In the original REA paper (McCarthy 1982) and in follow-up proofs of concept (Fedorowicz and McCarthy 1983), conversions in general and manufacturing in particular were viewed as a series of arms-length exchanges from one department or agent in a company to another – a common transfer pricing conception. Beginning with workshop presentations by Geerts and McCarthy (1992a, 1992b), new views of REA manufacturing began to surface (Geerts and McCarthy 1994). These evolved over five years to Geerts and McCarthy (1999) and McCarthy (2000) and then further to the present work as Fisher’s (1906) distinction between multiple types of duality interactions (exchanges vs. transformations) began to be emphasized more\(^{12}\). This evolution in REA thought was aided by multiple factors:

- Consultation with industry experts like Robert Haugen in manufacturing planning systems and supply chain management (Haugen and McCarthy 2001a, 2001b)).

Especially prominent concepts advocated by Haugen were accommodation of

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\(^9\) A business event that signals the completion of an economic event is often referred to as a *critical* event. The values represented in an accounting income statements are summaries of events in the actualization and (to a far lesser extent) the post-actualization phases.

\(^{10}\) This example has been approximately adapted from ISO 15944-4 (2007).

\(^{11}\) EDIFACT is the United Nations EDI standard, while X12 is an alternative EDI standard used in the USA.

\(^{12}\) In actuality, Fisher specified a third type of dual interaction called transportation. In this present work, we consider – in accordance with the economic resource ideas of Lancaster (1966) – that transportation is a subset of transformation where the location attribute is changed. In additional work, we discuss the inclusion of business location as a component of the REA model. Our conversion models also reflect the economic thinking of Black and Black (1929).
bills-of-materials modeling with quantity-per attributes for capacity management and plant scheduling.

- Review of REA modeling papers that emphasized complex conversion process examples (see Grabski and Marsh (1994) and Denna et al. (1994)). The examples here were much more complex than those in the prior REA literature, and accommodation of this increased complexity led to basic changes in the pattern for conversions.

- Reorientation of REA manufacturing examples in teaching that utilized the increased complexity mentioned above. Examples include NicoSys (McCarthy 1999), Bismark Sausage (McCarthy 2000), Western Michigan Office Furniture (McCarthy 2005), Nantasket (McCarthy 2006), and Michigan Medical Equipment (McCarthy 2010).

All of this experience led to the following changes in our present approach to differential modeling of conversions vs. exchanges:

- Reconsideration from the theory of the firm perspective (Kroszner and Putterman 2009) that the arms-length idea of transfer pricing with two agents (inside, outside) was not as suitable from an economic theory perspective as is modeling internal agents only, as arranged in a tiered responsibility hierarchy (see Figure 1 example) where planning and coordination are less dependent on price mechanisms.

- Reconsideration of the philosophical basis for modeling the accounting concept of Work-in-Process (WIP) where Geerts and McCarthy (2000b) realized that the traditional accounting concept of a WIP balance is simply an attribute of an interrupted economic event of significant time length like a job, a batch, a manufacturing run, or a campaign. From an ontological perspective (Sowa 2000), all of these entities are best treated as processes (occurrents), not things (continuants).

- Realization that the give (use or consume) and take (produce) nature of conversion duality was meaningfully different enough to warrant differential modeling from exchange duality, most significantly in its meronymic nature (Gamallo 2011; Motschnig-Pitrik 1993).

These changes lead to the conversion process pattern illustrated in Figure 15. Readers should note how this pattern differs from the exchange pattern of Figure 7, especially with regard to its designation of one (inside) agent only and its differential naming of the stockflow labels. *Use* is an outflow that does not completely exhaust an input factor (like a machine being used in a job operation), while *consume* is an outflow that does exhaust the input (like an egg being consumed in a material issue for baking). *Produce* is an inflow that links an overall assembly process to its finished product.

In Figure 16, the meronymic nature of conversion processes is emphasized. On the left, the *parts* of a conversion process are portrayed: relatively short economic events (finer granularity) that use or consume resources like “issue an engine to an automobile in process” (an instance of a raw material issue) or “install an engine in an automobile in process” (an instance of a job operation). On the right, the *whole* conversion process is portrayed: an economic event of longer duration (coarser
granularity) that produces the expected outcome of the conversion like “make a batch of Cadillacs over the course of three days” (an instance of a manufacturing run).

In Figure 17, Figure 18, and Figure 19, we illustrate how the phases of a business process introduced earlier need to be adapted for a transformation. Those five phases – planning, identification, negotiation, actualization, and post actualization – were adopted from the world of Open-edi (ISO 15944-1) where activities with business and economic events take place primarily in the independent collaboration space between independent firms.

By contrast with exchanges, conversions occur within just one firm. As Figure 17 illustrates, this means that the identification phase of a business process (where a 1-to-1 linkage with an independent outside agent is established) is no longer needed. In Figure 18, we provide short textual descriptions of the conversion phases. Readers are reminded that these categorizations are not absolute. The categories provide useful delineation of business and economic events, and we normatively expect the conversion workflow to follow these phases. In Figure 19, we illustrate how these phases might unfold for an example company as they proceed through planning, scheduling, and actual manufacturing.

Example -- Alaskan Aircraft Expeditions (AAE) Revenue Operations

For both our exchange and conversion explanations, we intend to provide more substantive explanations by rely on an integrated example called Alaskan Aircraft Expeditions (AAE). A brief overview of this example is offered in the blocked text below.

AAE generates revenues by offering various types of expeditions to its clients. Most clients avail themselves of a standard menu of expedition choices (such as “The Glacier Bay Extravaganza” or the “Gold Rush Trek”, or the “Bear Watch.”) Expeditions contain groups of 1-30 people.

In total, AAE offers a menu of 80 expedition types, each of which has a standard capacity, a fixed number of needed employees of certain types, one standard aircraft type, and a standard itinerary of places to be visited in a certain order. However, in some cases, a majority of the scheduled clients insist on an altered itinerary of their own making. In these cases (which occur only 3% of the time), AAE simply arrange a typed schedule (with typed fees, aircraft, and people) and then lets the lead guide accede to the client wishes, as long as the intended sites to be visited are in the location database. This database contains the names of

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13 Alaskan Aircraft Expeditions is not a real enterprise, but it is an extensive example often used for REA teaching purposes. Its structure was designed from multiple observations of real Alaskan expedition enterprises.
all the "reachable" locations in Alaska, and it was populated by the company founders when they first got into the tour business.

Each client pays for his/her participation by obtaining an expedition ticket from AAE. Tickets may involve multiple passenger slots where for example there are associated slots for family members, friends, etc. An expedition ticket is issued by a booking agent to a single client for a single expedition tour, although there can be as many as 10 slots (taken passenger places) on the ticket (for a family with two parents and eight children for example).

A new scheduled expedition (identified by "expedition-number") is usually put into the database months before its time by a booking agent, and the number of slots associated with it is determined by its type. Actual expeditions are keyed on a starting timestamp, and all actual expeditions are scheduled beforehand. Individual planes and workers are assigned to expeditions on the day they start, not beforehand. Expeditions have expedition tickets associated with them, and unique ticket numbers are generated automatically as they are needed. Per-slot charges to actual clients are often lower than their undiscounted basic fee which is determined by the type of expedition. Discounts are usually given for slots that are booked ahead of time, and the actual percentage for a discount is determined by a booking agent in negotiation with a client.

Expeditions involve one aircraft, 1-4 pilots, 1-3 guides, and 0-4 expedition workers plus 1-30 client and client-slotted associates. On all tours, one of the guides serves as the lead employee, responsible for management and safety policy. All guides may serve as leads. AAE aircraft are grouped by aircraft type, and the company uses 15-17 different types, each of which has a unique name. Individual aircraft (AAE usually has 50-100 leased at any particular time) are named after famous native Alaskans, and their seating and fuel capacities are determined by their type. Pilots are company-certified to fly only a subset of the aircraft types available, and their hours in each type are tracked.

Clients are also encouraged to buy expedition supply items (like hiking boots, fur parkas, or camping paraphernalia) at the company store on the starting day of their tour. AAE has a policy of associating "recommended" supply items for types of expeditions, and they distribute flyers to clients emphasizing their recommended buying lists. All client purchases of supply items are tied directly to a client's expedition ticket#. Supply items are never purchased directly by clients because a local commercial statute prohibits AAE from direct sales without an impending participation on an expedition.

Clients may pay for expedition tickets in cash taken directly by the booking agent. Clients may also pay by credit card, and they may keep multiple cards in their file. All cash receipts are keyed on a remittance timestamp, even when money is taken directly. It is often the case that clients pay for their initial expedition ticket fee right away, then pay for their remaining balance due to supply items a month or two later, because no money or credit cards can be used in the company supply store (items purchased are charged to a ticket). Clients often do buy
multiple expedition tickets at one time (if for example, they want to go on two different expeditions on consecutive days). When clients buy multiple tickets, they may settle with a single remittance. For AAE, 90% of cash receipts occur in the revenue cycle.

Supply items are manufactured directly by AAE on the grounds of their own facility. Each supply item has a predetermined bill of materials and operations list, where the amount of materials, machine time, and typed labor minutes are itemized on a “quantity-per” basis. Manufacturing scheduling is done on a “push” basis by a manufacturing supervisor who is notified when store supplies of supply items need replenishment. However, a series of scheduled raw material issues can trigger a new purchase-order for new materials on a “pull” basis. In addition to scheduling the production order, the manufacturing supervisor oversees the entire WIP job and the actual labor operations of the machinists and line workers.

AAE uses debt financing, and it does most of its acquisitions on credit where terms vary by vendors. The company leases its aircraft, and it also leases its structures (an office building, a small factory, and an aircraft facility). Advertising costs are tied to expedition types and and/or customer segments, and structure costs are tied to temporal/sectional groupings of company activities.

A preliminary value chain for AAE is shown in Figure 20. We have labeled each business process at this top level with the common cycle description normally used in accounting. The starred business processes -- revenue and conversion -- are exemplars of REA exchanges and REA conversions, so we illustrate those with class diagrams in the subsequent illustrations of Figure 21 and Figure 22.

In Figure 21, we illustrate in some degree of detail what the M1 model of the AAE revenue process might look like. We show the stereotypes for the REA-based classes (in brackets at the top of each class), but for economy of space purposes, we do not show the stereotypes for associations. Instead, we label the associations with variants of their stereotyped names. Readers should note the parallels between the full REA metamodel in Figure 3 (an M2 model which provides the stereotypes) and the business process in Figure 21 (an M1 model which represents AAE’s revenue activities). The color coding in both figures is deliberately aligned and should be informative. Yellow represents the REA policy layer, red represents the REA scheduling layer, and green represents the REA accountability layer. This detailed exchange example illustrates many of the REA-based principles we have described in the first section of the paper.

In Figures 22(a) we again illustrate in some degree of detail what an M1 model of an AAE process might look like, this time for its manufacturing. Again, we show the

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14 This value chain has been deliberately simplified for explanation purposes.
15 We have chosen the amount of detail carefully in an effort not to make the figure lettering too small. Obviously, a real data model would have much more detail.
stereotypes for the REA-based classes but only label the associations with variants of their stereotyped names.

This UML class diagram possesses ample detail for a reader to peruse, but these features might be especially notable:

- The three REA temporal levels – policy-scheduling-accountability – are discernible from top to middle to bottom of the figure. This is an M1 model of a particular REA application, and readers should note its correspondence to the M2 REA metamodel portrayed in Figure 3.
- Some attributes exist at all three temporal levels. As an illustration, there is a standard sequence for operations, a scheduled sequence, and then an actual sequence. Under certain circumstances, these could all differ for good business reasons. It should be noted also that these three levels of temporal delineation supply a conceptual framework for the attributes needed to calculate normal cost accounting manufacturing variances (as outlined in a text like Horngren, Datar and Rajan (2015).
- The diagram is somewhat incomplete in that it doesn’t account for machines as an input (as shown on the value chain). This is due to space considerations, so we illustrate in Figure 22(b) (with much larger fonts and boxes) the additional classes and associations.
- To illustrate trigger associations, we include the PurchaseOrder commitment from the acquisitions cycle.
- A traditional Bill of Materials is illustrated with the SupplyItem-IssueType-RawMaterial constellation.
- Because the commitment constellation of ScheduledOperation-ProductionOrder-ScheduledIssue is inserted all together, there is only one promise association needed.

As was the case with our AAE revenue exchange example shown in Figure 21, readers are reminded that this M1 UML example is much simplified. A real manufacturing process would have considerably more detail.

On a last note with regard to the AAE example, readers should consult Figure 23 which illustrates a simple stark fact with regard to value chain modeling in a dependent-demand situation: resources at the accountability layer in REA flow forward in the value chain while commitments for resources at the scheduling layer flow backward. The output of the acquisition cycle (raw materials) is the input to the conversion cycle, but the commitment for raw material consumption (the scheduled issue) “triggers” the commitment for raw material acquisition (the purchase order).

Conversion Prototypes

The basic accountability pattern shown in Figure 15 can actually be applied to a wide variety of “making” activities. We can usefully think of three major prototypes for conversion modeling, but there are more to be designed as the study of REA
conversion continues. Looking at these three prototypes should help readers understand the essential nature of REA conversion modeling.

1. **The Finished Product prototype** (see Figure 24) – The output here is normally a finished good, such as a manufacturing run of cars or a batch of cookies. However, useful management artifacts such as designs or schedules also fit. A value conclusion may be materialized about these artifacts if such a judgement is possible (e.g., if an outside market exists) or they can be simply seen as the aggregate of their used or consumed factors of production. The output of a design process is a resource that can be used to direct subsequent production or managerial action. For example, the design of a car model “X4J” can then be used to direct the production of the X4Js. Each completed car of this particular model embodies some of the design resource.

2. **The Enduring Occurrent prototype** (see Figure 25) – These occurrents use or consume many resources to fulfill the agreed upon contract. The completed large-grained “produce” process actually becomes a resource to be exchanged or used/consumed downstream in the value chain, and the degree to which the consumed resources match what was scheduled can lead to cost under/over specification. Examples are a consulting job or an advertising campaign.

3. **The Carrier Resource prototype** (see Figure 26) – For this type of conversion, the resource may have values for certain attributes enhanced or new values assigned. AAE actually outsources its aircraft maintenance (see AAE value chain), but if it were done internally, the aircraft would be the carrier resource in a conversion. For a logistics example, a sold product may now have a “true” value for its “delivered” attribute or its location attribute may be changed. The economic rationale (i.e., why do this?) for the carrier conversion is that the downstream production functions that use augmented resources now become more efficient.

As mentioned above, we expect more prototypes to materialize in the future as REA conversion is studied more extensively. Indeed, the entire concept of developing design patterns for such prototypes is an area of intense study in the object-oriented community (Hruby 2007) (Hruby and Kiehn 2006). Some initial design pattern work for REA exchanges was started but not finished by Geerts and McCarthy (1997b), and it needs to be developed further for both exchanges and conversions. Such exchange patterns are most important to the notion of full REA modeling, a concept that enables intensional reasoning (Geerts and McCarthy 2000a).

**Conclusion**

This paper has summarized the different REA modeling approaches used for market exchanges and internal conversions. The original REA model (McCarthy 1982) did not differentiate these two cases in as detailed a fashion as we did here, and the differentiated structures developed here should prove useful in future REA conversion work. This future work is certainly envisioned as *design science* REA work (Geerts, Graham, Mauldin, McCarthy, and Richardson 2013; McCarthy 2012) where better
manufacturing models are configured to represent more complex conversion environments.

References


Figure 1 -- The REA Metamodel
The POLICY layer

The SCHEDULING layer

The ACCOUNTABILITY layer

The POLICY layer — “What is available or available to” — Economic Types, typify, policy

The SCHEDULING layer — “What has been specified or reserved” — Economic Commitments, Economic Contracts, fulfill, specify, reserve, reciprocal, trigger, promise (inside, outside)

The ACCOUNTABILITY layer — “What has occurred” — Economic Resources, Events, and Agents; duality, stockFlow, participate (inside, outside), responsible
(a) Class Diagram of REA granularity levels 2-3

(b) Business Process Notation for Value Chains

Figure 4

Value Chain of Object Enterprise (a script for creating value for the customer)

Business Process → Business Process → Business Process

resource with a portfolio of attributes

Coesian entrepreneur analysis

Market Exchange (buy processes)

Internal Conversion (make processes)

Figure 5 – Entrepreneur choice of exchange or conversion
Figure 6 -- REA duality types: buy (transfer) vs. make (transformation)

Figure 7 -- Accountability frame for market exchange
Figure 8 – Adding process phases to REA granularity levels

Figure 9 -- Market Exchange Process Phases
- **Planning:** In the Planning Phase, both the buyer and seller are engaged in activities to decide what action to take for acquiring or selling a good, service, and/or right.

- **Identification:** The Identification Phase pertains to all those actions or events whereby data is interchanged among potential buyers and sellers in order to establish a one-to-one linkage.

- **Negotiation:** The Negotiation Phase pertains to all those actions and events involving the exchange of information following the Identification Phase where a potential buyer and seller have (1) identified the nature of good(s) and/or service(s) to be provided; and, (2) identified each other at a level of certainty. The process of negotiation is directed at achieving an explicit, mutually understood, and agreed upon goal of a business collaboration and associated terms and conditions. This may include such things as the detailed specification of the good, service, and/or right, quantity, pricing, after sales servicing, delivery requirements, financing, use of agents and/or third parties, etc.

- **Actualization:** The Actualization Phase pertains to all activities or events necessary for the execution of the results of the negotiation for an actual business transaction. Normally the seller produces or assembles the goods, starts providing the services, prepares and completes the delivery of good, service, and/or right, etc., to the buyer as agreed according to the terms and conditions agreed upon at the termination of the Negotiation Phase. Likewise, the buyer begins the transfer of acceptable equivalent value, usually in money, to the seller providing the good, service, and/or right.

- **Post-Actualization:** The Post-Actualization Phase includes all of the activities or events and associated exchanges of information that occur between the buyer and the seller after the agreed upon good, service, and/or right is deemed to have been delivered. These can be activities pertaining to warranty coverage, service after sales, post-sales financing such as monthly payments or other financial arrangements, consumer complaint handling and redress or some general post-actualization relationships between buyer and seller.

Source: ISO 7850 1994-1 – Operational Aspects of Open-edi for Implementation

**Figure 10 -- ISO Open-edi Phases of an Exchange Business Process**

<table>
<thead>
<tr>
<th>Exchange Phases</th>
<th>REA components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Business Events with Types of Resources, Events, and Agents</td>
</tr>
<tr>
<td>Identification</td>
<td>specify</td>
</tr>
<tr>
<td>Negotiation</td>
<td>Business Events with Commitments for Types of Resources, Events, and Agents</td>
</tr>
<tr>
<td>Actualization</td>
<td>fulfill</td>
</tr>
<tr>
<td>Post-Actualization</td>
<td>Business and Economic Events with Economic Resources and Economic Agents</td>
</tr>
</tbody>
</table>

**Figure 11 -- Correspondence of exchange phases and REA components**
<table>
<thead>
<tr>
<th>Business Process Phase</th>
<th>Example Business Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Buyer sends CatalogRequest to Vendor</td>
</tr>
<tr>
<td></td>
<td>Buyer receives Catalog from Vendor</td>
</tr>
<tr>
<td>Identification</td>
<td>Buyer sends AvailabilityAndPriceRequest to Vendor</td>
</tr>
<tr>
<td></td>
<td>Buyer receives AvailabilityAndPriceResult from Vendor</td>
</tr>
<tr>
<td>Negotiation</td>
<td>Buyer sends Offer to Vendor</td>
</tr>
<tr>
<td></td>
<td>Buyer receives CounterOffer from Seller</td>
</tr>
<tr>
<td></td>
<td>Buyer accepts the details of CounterOffer on shipment and proposes PaymentSchedule to Vendor</td>
</tr>
<tr>
<td></td>
<td>Buyer accepts PaymentSchedule from Vendor, thus completing PurchaseOrder (contract) specification (alternatively, another CounterOffer would loop negotiations or a NonAcceptance would suspend or abandon the business process)</td>
</tr>
<tr>
<td>Actualization</td>
<td>Shipment Clerk receives an AdvanceShippingNotice from Vendor when shipped goods arrive</td>
</tr>
<tr>
<td></td>
<td>Shipment Clerk inspects Raw Materials</td>
</tr>
<tr>
<td></td>
<td>Buyer sends ReceivingReport to Vendor when inspected goods are accepted (Economic Event Purchase registers)</td>
</tr>
<tr>
<td></td>
<td>Cashier receives Invoice from Vendor</td>
</tr>
<tr>
<td></td>
<td>Cashier sends BankTransferNotice to Vendor with information about payment of the Invoice (Economic Event Cash Disbursement registers)</td>
</tr>
<tr>
<td>Post-Actualization</td>
<td>Buyer sends WarrantyInvocation to Vendor if materials are found to be inadequate in use</td>
</tr>
</tbody>
</table>

Figure 12 -- An Example Exchange Process with Business Events Grouped in ISO 15944-1 Phases

Figure 13 -- REA duality types: buy (transfer) vs. make (transformation)
Figure 14 – An M1 example of REA agent subtypes use

Figure 15 -- Accountability pattern for conversion
Figure 16 -- REA transformation duality (meronymic)

Figure 17 -- Conversion Process Phases
- **Planning**: In the Planning Phase, economic agents are engaged in activities to decide the types of actions to take for converting certain factors of production into a higher order bundle of economic resources—the decision to make a resource and the determination of the types of activities needed for that conversion process.

- **Negotiation**: The Negotiation Phase pertains to all those actions and events where potential economic agents have (1) selected the specified type and quantity of economic resources to be used or transformed and, (2) scheduled the detailed activities needed to produce the specified resource set. For an internal conversion, the detailed set of types and quantities of agents needed for the entire conversion process are converted from a quantity-per-basis to actual scheduled amounts and quantities.

- **Actualization**: The Actualization Phase pertains to all economic and business events necessary for the execution of the results of the scheduled business process. The firm assembles the planned combinations of materials, labor, and other services into the bundled package of a finished resource or a completed process.

- **Post-Actualization**: The Post-Actualization Phase includes all of the events and associated exchanges of information that occur after the agreed upon good, service, and/or right is deemed to have been manufactured or assembled. These can be activities pertaining to some rescheduling/adjustment of the actual or proposed standards for the conversion processes.

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**Figure 18 -- Conversion Process Phase Descriptions**

<table>
<thead>
<tr>
<th>BT Phase</th>
<th>Example Business Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Manager evaluates capacities and available sources of skilled labor (employee types), machines (machine types) and raw materials (raw material type). Production manager receives sales forecast for types of supply items (finished goods).</td>
</tr>
<tr>
<td>Negotiation</td>
<td>Using the bill of materials (FGType=issuType=RMTypetype) and the operations list (FGType=issuType=employeeType=polices), the production supervisor uses type quantity-per attributes to derive scheduled events and attributes.</td>
</tr>
<tr>
<td>Actualization</td>
<td>Supervisor schedules a production order (commitment) with reciprocal links to scheduled RM issues (commitments) and to scheduled labor operations (commitments).</td>
</tr>
<tr>
<td>Post-Actualization</td>
<td>Production manager reschedules some capacities and resources based on breakdowns/shortages/overages.</td>
</tr>
</tbody>
</table>

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**Figure 19 -- An Example Conversion Process with Phases**
Figure 23 – Backward flow of commitments and forward flow of resources

Figure 24 – REA Generic Conversion #1 – Finished Product

Example Processes:
- Manufacturing
- Baking
- Construction of a valuable artifact such as a design or a schedule
**Figure 25 -- REA Generic Conversion #2 -- Enduring Occurrent (service acquisition)**

- Labor
- Other
- Materials

**CONVERSION**

- small -
- BIG +
- small -

*Example Processes:*
- Advertising Campaign
- Consulting Job
- Audit Engagement

**Figure 26 -- REA Generic Conversion#3 -- Carrier Resource or Grouping**

- Labor
- carrier resource or grouping
- Materials

**CONVERSION**

- small -
- BIG +
- small -

*Example Processes:*
- Logistics
- Maintenance
- Training