The Enterprise Ontology

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Abstract

This document presents the Enterprise Ontology, a collection of terms and definitions relevant to business enterprises. It was developed as part of the Enterprise Project, a collaborative effort to provide a framework for enterprise modelling. The Enterprise Ontology will serve as a basis for this framework which includes methods and a computer toolset for enterprise modelling.

We give an overview of the Enterprise Project, elaborate on the intended use of the Ontology, and discuss the process we went through to build it. The scope of the Enterprise Ontology is limited to those core concepts required for the project, however it is expected that it will appeal to a wider audience. It should not be considered static; during the course of the project, the Enterprise Ontology will be further refined and extended.

Keywords – Enterprise modelling, enterprise integration, ontology.

Preface to Version 1.1

Version 1.0 was used as an informal specification for coding the Enterprise Ontology. This version (1.1) reflects the relatively minor changes that were identified during the coding process. It remains essentially informal, and is intended to serve as accurate documentation for the code, suitable for non-technical readers. Version 1.1 of this document is consistent with version 0.1 of the code available from the World-Wide Web: *http://www.aiai.ed.ac.uk/~entprise/enterprise/ontology.html*. As further changes are made to the code, this document may become partially out of date.

Overall, there have been many minor changes and some significant ones. Though given in a less formal style, considerable effort has been made to ensure that the material here is consistent with the natural language documentation in the code. Details of the main changes are given in § 8.

In summary, the main differences between versions 1.1 and 1.0 are:

- Many terms and definitions were rationalised during the coding process. Some terms have been removed; some new ones have been introduced, some have been moved to different sections, or to different places in the same sections.

  A major exception to this is the Time section, which has not been updated.

- There is a major new section (§ 8) reporting on the process of coding the ontology and giving details of

  - how the Meta-Ontology was coded
  - what the relationship is between the code and the natural language version in this document.

- There is a new appendix which indicates what formal terms in the code correspond to the terms presented here.

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1 Introduction

This document presents the Enterprise Ontology, a collection of terms and definitions relevant to business enterprises. It was developed as part of the Enterprise Project, a collaborative effort to provide a method and a computer toolset for enterprise modelling.

Version 1.0 of this document served as a specification for the subsequent coding of the Enterprise Ontology in the formal language: Ontolingua. This version reflects the relatively small number of changes to the Enterprise Ontology identified while coding.

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1.1 Context: the Enterprise Project

The overall objective of the Enterprise Project is to improve and where necessary replace existing modelling methods with a framework for integrating methods and tools which are appropriate to enterprise modelling and the management of change. This framework is based on an ontology for enterprise modelling.

A goal of the Enterprise Project is to provide a computer-based toolset which will help capture aspects of a business and analyse these to identify and compare options for the meeting the business requirements. The toolset will provide task management support to users by helping them perform enterprise modelling activities and guiding them through the toolset facilities. These facilities will enable:

- capture and description of an enterprise (e.g. its processes, strategy, organisational structure, resources, goals, constraints and environment);
- specifications of business problems/requirements, consistent with the ontology;
- identification and evaluation of solution options and alternative design and implementation paths at strategic, tactical and operational levels;
- representations for the definition of relevant metrics and advanced simulation support.

The Enterprise Project is led by AIAI at the University of Edinburgh and the partners are IBM UK, Lloyd's Register, Logica and Unilever. The project is supported by the Department of Trade and Industry. Further information is available on the World Wide Web at: *http://www.aiai.ed.ac.uk/~entprise/enterprise/*.

1.2 The Role of the Ontology

The major role of the Enterprise Ontology is to act as a communication medium; in particular, between:

- different people, including users and developers, across different enterprises;
- people and implemented computational systems;
- different implemented computational systems (including modules of the Enterprise toolset, DBMS, spreadsheet etc.)

Also, and very importantly, the Ontology is intended to assist:

- acquisition, representation, and manipulation of enterprise knowledge; such assistance is via the provision of a consistent core of basic concepts and language constructs;
- structuring and organising libraries of knowledge;
- the explanation of the rationale, inputs and outputs of the Enterprise toolset modules.

The following are potential future uses of the Enterprise Ontology that are outside the scope of this project:

- the transition of research knowledge and systems into operational prototypes;
- the analysis of the internal structures, algorithms, and inputs and outputs of implemented systems, in theoretical and conceptual terms.

The Enterprise Ontology should not be considered static; it is an evolving definition of terms. It will be further refined and extended as the Enterprise Project progresses.

Ontologies can be thought of as codified knowledge on a library shelf. As we expect that the Enterprise Ontology will be of interest to a wider audience, it may itself be put on a library shelf in the future for use by others. However, this potential for wider use has not influenced the development of the Ontology directly.

1.3 Development of the Ontology

Here we briefly describe the process we went through in developing the Enterprise Ontology. Further details may be found in the paper: "Towards a Methodology for Building Ontologies", available from the World-Wide Web:
http://www.aiai.ed.ac.uk/~entprise/enterprise/ontology.html.

1.3.1 Scope

Considerable time and effort has been devoted to deciding the scope and boundaries for the Ontology. We began by brainstorming to identify as many potentially important concepts as possible. This produced a totally unstructured list of words and phrases corresponding

to a wide variety of concepts relevant to Enterprises. These were then grouped into various more or less distinct work areas such that there was more similarity in meaning and a need to refer to terms within an area than between different areas (*e.g.* Activity, Marketing, Organisation). Within each work area, the terms were assigned priorities indicating the importance of including them in the Ontology. At this point many terms were discarded and duplicates (*i.e.* nearly synonymous terms) were removed.

These work areas were dealt with one by one. For each concept, terms were chosen, and definitions given. The original work areas evolved somewhat, as new terms were added, and others removed or moved to other areas. Eventually, these work areas became the major structuring element for the Ontology and is reflected in the major sections of this document.

Within each work area, various important questions were addressed. What basic or core concepts are required? What mix of terms having a wide or general meaning and terms having a narrow or specific meaning are required?

Many factors influenced the choice of terms in the Ontology. The ultimate criterion is the judgement of what concepts are likely to be sufficiently important to the Enterprise Project and be capable of a common agreement on their meaning. Many words in common use in enterprise management have been judged to have no sufficiently widely recognised or acceptable meaning to be included in the Ontology. This does not mean they cannot be used in the project. It does mean that the meaning of such words in the context of their use will have to be related to the terms in the Ontology all of whose meanings are shared. This document attempts to give guidance on how this can be done where a potential need for this has been recognised.

1.3.2 Choosing Terms

The terms in the Enterprise Ontology have been chosen as far as possible to match the natural use of English words by people managing enterprises. This is often difficult. For a term to be used in an ontology, it should ideally have one meaning precisely defined. Real people managing enterprises often use words very flexibly (*i.e.* with varying meanings). Much of the time the particular meaning of such a word used in a particular context is correctly interpreted without the hearer realising the word is potentially ambiguous. On other occasions mis-understanding may occur, but even then, will often be corrected by common sense very quickly.

Therefore some of the terms used in the Enterprise Ontology may not be the natural choice for a particular concept for a particular reader. For example, a widely used word may be given a more limited meaning, a surprisingly wide meaning, or even specifically excluded from the Ontology in favour of some other word. Sometimes important concepts are identified for which there is no obvious name; in such cases unusual words or phrases may be introduced and frequently referred to.

However, the choices for terms, far from being arbitrary, were reached only after much consideration. The main criteria for deciding were to conform to common usage and to avoid ambiguity. Ultimately there are no absolutely correct choices; they can only be the

result of careful judgement.

1.3.3 Definitions

The purpose of the definitions in an ontology are very different from that of dictionary definitions. The latter report how words are used; ontology definitions have a normative role. They define how a limited set of terms are to be used in relation to each other. Each definition in an ontology requires careful understanding in relationship to the other definitions in the ontology. Therefore, to understand the Enterprise Ontology requires a willingness to suspend preconceptions based on the dictionary meaning and/or other common usage of terms.

Within each work area, the Ontology has been developed by trying to identify a small number of concepts central to the subject of the section (this is called 'basic' in categorisation theory). For example, 'person' is basic, whereas 'teenager' is more specific, and 'living organism' is more general. A basic term is defined first and then the related terms are defined as far as possible using the basic terms already defined. These other terms may be more general or more specific. The degree to which the definition of a term depends on other terms, and whether they themselves are dependent on more basic ones, provides an indication of how far a term is from the 'core' of the Ontology. The basic terms have been defined with the minimum possible reliance on other terms, however some dependence has been unavoidable.

Very importantly, the definitions themselves, which capture the many concepts, need to be expressed in as precise a language as possible. Such precision was gained through the identification and use of a small number of building blocks including such notions as: an Entity, a Relationship, a State Of Affairs and a Role. Insofar as such terms are the language primitives used for expressing the definitions in an ontology, they are collectively referred to as a 'meta-ontology'.

The Enterprise Meta-Ontology has been kept as small as possible. Frequently, the definition of an Ontology term will be given using the meta-ontological terms: *e.g.* an Activity is an Entity; Legal Ownership is a Relationship between a Legal Entity (owner) and an Entity (owned). However, sometimes the technical precision of this approach was sacrificed for readability and the relevant meta-ontological categories are implicit.

The natural language definitions in version 1.0 of this document served as a specification for the subsequent coding of the Ontology in a formal language. In the code, all terms are defined using the concepts in the Meta-Ontology. The coding effort identified a relatively small number of changes to the Ontology which are reflected in this version (1.1).

1.4 Document Structure

The central content of this document is in the sections containing definitions of terms forming the Ontology. As noted above, the structure corresponds directly to the work areas. Within each section, the terms have been grouped so that terms closely related to each other appear close together as far as possible. This is largely a pragmatic judgement. The relationships are

a complex web and there is no perfect way to organise the terms to avoid references between sections. However, the groupings were first chosen by experience and common sense and have continued to appear valid and useful with minor modification as the Ontology has developed. These sections exist only for convenience of exposition; no meaning is to be inferred from the fact that a particular term appears in one section rather than another. The major sections in this document describing the content of the Enterprise Ontology are as follows:

§ **2:** *Meta-Ontology* – terms used to define the terms of the Ontology
e.g. Entity, Relationship, Role;

§ **3:** *Activity, Plan, Capability and Resource* – terms related to processes and planning
e.g. Activity, Planning, Authority, Resource Allocation;

§ **4:** *Organisation* – Terms related to how Organisations are structured
e.g. Person, Legal Entity, Organisational Unit, Manage, Ownership;

§ **5:** *Strategy* – Terms related to high level planning for an enterprise
e.g. Purpose, Mission, Decision, Critical Success Factor;

§ **6:** *Marketing* – Terms related to marketing and selling goods and services
Sale; Customer; Price; Brand; Promotion

§ **7:** *Time* – Terms related to time
e.g. Time Point, Duration, Date, After, Earliest Start Time.

In § 8 we summarise our experiences in converting the natural language description of the Ontology in this document into the formal language: Ontolingua. We also clarify the relationship between this natural language description and the formal version.

A preliminary version of the Ontolingua code is now available for browsing via the Enterprise Ontology page on the World-Wide Web:
http://www.aiai.ed.ac.uk/~entprise/enterprise/ontology.html. Eventually we intend for it to be placed in the Library of Ontologies in the Ontology Editor provided by Stanford University's Knowledge Systems Lab (KSL).

1.5 Presentation

In the main sections presenting the Ontology, each term is introduced with a definition. Within each section, we proceed by defining the terms that we regard as most basic first, and then define other terms using these basic ones.

The definitions are written in carefully chosen English with other Ontology terms in UPPER case. A term is defined using a base word, however for convenience of exposition, we use grammatical variations also in upper case as if they were themselves officially defined (*e.g.* ACHIEVE, ACHIEVEMENT).

In general, any officially defined term will be presented in upper case throughout the document. However, in § 2, which describes the Meta-Ontology, terms defined in the main Ontology sections are Capitalised rather than being in full upper case (*e.g.* 'Activity' not 'ACTIVITY'). Conversely, terms defined in the Meta-Ontology are capitalised when used in the main Ontology definitions (*e.g.* 'Role' not 'ROLE').

Occasionally, we will use a word informally that is also used as an official term in the Ontology. The general rule is that official terms that appear in lower case, and all other words, should be interpreted in their dictionary sense in the light of their context.

The definition of each term is intended to be necessary and sufficient as far as this is possible in natural language. However, in many cases it is felt essential to provide clarification or additional information. This is done as notes following the definition.

1.5.1 Terms

The central purpose of the Enterprise Ontology is to achieve effective sharing of meaning. The Enterprise Ontology consists mainly of:

Defined Terms: Terms explicitly included in the Enterprise Ontology. In addition to the natural language definition provided here, there is also a formally coded definition.

Related Terms To better understand the Enterprise Ontology, it is helpful to know how its terms and concepts relate to the terms and concepts widely used in other contexts (*e.g.* other ontologies). Therefore, at the end of each section we list a number of related terms that are fairly commonly used but are *not* defined in the Enterprise Ontology. Where possible, we specify the relationship between these terms and those in the Enterprise Ontology. These related terms fall into three categories:

1. *Synonyms*: Terms recognised as widely used in enterprises that are not defined in the Ontology, but which are considered the same or very close in meaning to defined terms.
2. *Borderline Terms*: Terms for which we make an attempt to show how they might be defined using Ontology terms. However, because they are deemed insufficiently important for sharing, are not formally included in the Ontology.
3. *Other Commonly Used Terms*: A list of commonly used terms that were not defined.

1.6 Conforming to the Enterprise Ontology

Defined Terms Conforming to the Enterprise Ontology requires conforming with the definitions of the main terms comprising the Enterprise Ontology.

Synonyms Ideally, for a given concept for which there is already a formally defined term, users should use that term. This ensures maximum ease of sharing. There may be a strong preference for using another term (*e.g.* one listed as a synonym in the Enterprise Ontology) – in which case the Enterprise Ontology needs to be extended to include the new term. Given a convenient mechanism in the formal language, the new term should be formally defined as a synonym of the existing defined term. Alternatively, the new term can be created as a sub-class of the existing defined term. If there is nothing different about the sub-class, then it is de facto the same class, and effectively a synonym.

To increase sharing possibilities, users should avoid using one of the synonyms listed in the Enterprise Ontology and giving it a *different* meaning from that of the defined term it is synonymous with.

Borderline Terms The user may choose to use any of these terms, but must explicitly adopt a definition. Conforming with the Enterprise ontology does not require this to be the provided definition, but this is recommended to increase potential sharability.

1.7 Ontology Overview

As already mentioned, the sections are as follows:

- Meta Ontology
- Activity, Plan, Capability, and Resource
- Organisation
- Strategy
- Marketing
- Time

See figure 1 for a table listing of all the concepts defined in the Enterprise Ontology organised by major section.

For initial understanding, the Meta-Ontology will be dealt with last in this overview. The main concepts of each section and the main relationships between them are given in the following sections. Some readers may prefer to go directly to the main sections, and read this section as a summary.

1.7.1 Activities and Processes

The central term is ACTIVITY. This is intended to capture the notion of anything that involves actual doing, in particular including action. An ACTIVITY can have happened in

ACTIVITY etc.	*ORGANISATION*	*STRATEGY*	*MARKETING*	*TIME*
Activity	Person	Purpose	Sale	Time Line
Activity Specification	Machine	Hold Purpose	Potential Sale	Time Point
Execute	Corporation	Intended Purpose	For Sale	Calendar Date
Executed Activity Specification	Partnership	Purpose-Holder	Sale Offer	Relative Time Point
T-Begin	Partner	Strategic Purpose	Vendor	Duration
T-End	Legal Entity	Objective	Actual Customer	Duration Bounds
Pre-Condition	Organisational Unit	Vision	Potential Customer	Time Interval
Effect	Manage	Mission	Customer	Before
Doer	Delegate	Goal	Reseller	Same or Before
Sub-Activity	Management Link	Help Achieve	Product	After
Authority	Legal Ownership	Strategy	Asking Price	Same or After
Activity Owner	Non-Legal Ownership	Strategic Planning	Sale Price	Distance
Event	Ownership	Strategic Action	Market	Earliest Start Time
Plan	Owner	Decision	Segmentation Variable	Latest Start Time
Sub-Plan	Asset	Assumption	Market Segment	Earliest End Time
Planning	Stakeholder	Critical Assumption	Market Research	Latest End Time
Process Specification	Employment Contract	Non-Critical Assumption	Brand	Interval Before
Capability	Share	Influence Factor	Image	Interval During
Skill	Shareholder	Critical Influence Factor	Feature	Interval Overlaps
Resource		Non-Critical Influence Factor	Need	Interval Disjoint
Resource Allocation		Critical Success Factor	Market Need	
Resource Substitute		Risk	Promotion	
			Competitor	

This table contains all terms formally defined in the Enterprise Ontology. Within each column, the terms are listed in the same order as they appear in the main sections of this document. There is no relationship between terms that happen to be in the same row.

Figure 1: Overview of Enterprise Ontology

the past and may be happening in the present. The term can also be used to refer to a hypothetical future ACTIVITY. However, there is a need to refer explicitly to specifications or plans for ACTIVITIES. This is called an ACTIVITY SPECIFICATION. Like a recipe, it specifies at some level of detail one or more possible ACTIVITIES. An EXECUTED ACTIVITY SPECIFICATION must have a corresponding ACTIVITY, the thing done.

The concept of ACTIVITY is closely linked with the idea of the DOER, which EXECUTES an ACTIVITY SPECIFICATION by performing the specified ACTIVITIES. A DOER may be a PERSON, ORGANISATIONAL UNIT or MACHINE. These terms are defined in the Organisation section and may collectively be referred to as [POTENTIAL] ACTORS (see § 1.7.6).

The ability of a POTENTIAL ACTOR to be the DOER of an ACTIVITY is denoted by CAPABILITY (or SKILL if the DOER is a PERSON). ACTORS may have other Roles in respect of an ACTIVITY such as ACTIVITY OWNER.

Also closely related to ACTIVITY is RESOURCE, which is something that can be used or consumed in an ACTIVITY. An ACTIVITY can also have outputs or EFFECTS. An ACTIVITY is linked to a TIME INTERVAL, which is defined in the Time section (§ 7). An ACTIVITY may take a short or a long time, and may be simple or complex. Complex ACTIVITIES may be de-composed into many SUB-ACTIVITIES.

An ACTIVITY SPECIFICATION with an INTENDED PURPOSE (defined in § 5 on Strategy), is called a PLAN. The concept of being able to repeatedly EXECUTE the same PLAN is captured in the term PROCESS SPECIFICATION.

Control of doing of ACTIVITIES is important to enterprises. For this, we define AUTHORITY to be the right (of an Actor) to perform one or more ACTIVITIES (*e.g.* as specified in a PLAN).

1.7.2 Organisation

Central to the Organisation section are concepts of LEGAL ENTITY and ORGANISATIONAL UNIT (abbreviated as OU). Both of these refer to things which have a "gestalt" whether they are individual or composite. They differ in that a LEGAL ENTITY is recognised as having rights and responsibilities in the world at large and by legal jurisdictions in particular, whereas ORGANISATION UNIT need only have full recognition within an organisation.

LEGAL ENTITY includes PERSON and CORPORATION. Larger LEGAL ENTITIES may wholly own other smaller LEGAL ENTITIES. ORGANISATION UNITS may be large and complex, even transcending LEGAL ENTITIES. Large OUs will normally be seen as being made up from smaller ones. The smallest may correspond to a single PERSON, in fact a particular PERSON could be seen as corresponding with more than one small OU.

A MACHINE is a non-human, non-legal ENTITY that may play certain Roles otherwise played by a PERSON or OU (*e.g.* perform an ACTIVITY).

The OWNERSHIP of rights and responsibilities may only, from the legal point of view, lie with a LEGAL ENTITY. Within an organisation, rights and responsibilities for RESOURCES may be allocated to OUs. Therefore OWNERSHIP is defined to include this, with LEGAL and NON-LEGAL OWNERSHIP defined to enable the distinction where needed. OUs may be responsible for ACTIVITIES.

Within an organisation the management structure is represented by MANAGEMENT LINKS. The term MANAGE represents assigning PURPOSES to OUs. A pattern of MANAGEMENT LINKS between OUs determines an organisational structure. This can include multiple MANAGEMENT LINKS into any one OU with constraints on the different kinds of PURPOSES assigned through each link.

1.7.3 Strategy

The central concept of the Strategy section is PURPOSE. PURPOSE captures two related notions. One, is the intended reason for EXECUTING an ACTIVITY SPECIFICATION, *i.e.* what a PLAN is for. The other is something that an ORGANISATION UNIT can be responsible for (defined in the Organisation section). A STRATEGIC PURPOSE is one declared to be of 'strategic' importance. STRATEGIC PURPOSES tend to be on a relatively high level on long time scale. Other PURPOSES may be detailed and short term, or anything in between.

Like an OU, a PURPOSE can be composed or decomposed. That is, one statement of PURPOSE may relate to something which can also be seen to HELP ACHIEVE some grander PURPOSE. By this means, a spectrum of widely used terms like VISION, MISSION, GOAL, and OBJECTIVE can be represented without there being shared agreement on precisely how these terms are used.

STRATEGY is defined as a PLAN to ACHIEVE a STRATEGIC PURPOSE. Based on the concept of PLAN from the Activity section, the concepts key to STRATEGIC PLANNING can be represented with the terms DECISION, ASSUMPTION, RISK, and various kinds of FACTOR.

1.7.4 Marketing

The central concept of the Marketing section is SALE. A SALE is an agreement between two LEGAL ENTITIES for the exchange of a PRODUCT for a SALE PRICE. Normally the PRODUCT is a good or service and the SALE PRICE is monetary, however other possibilities are included. The LEGAL ENTITIES play the (usually distinct) Roles of VENDOR and CUSTOMER. A SALE can have been agreed in the past, and a future POTENTIAL SALE can be envisaged, whether or not the actual PRODUCT can be identified, or even exists. A PRODUCT targeted at a specific CUSTOMER is referred to as a SALE OFFER, otherwise it is just FOR SALE.

The MARKET is all SALES and POTENTIAL SALES within a scope of interest. The

MARKET may include SALES by COMPETITORS. The MARKET may be decomposed into MARKET SEGMENTS in many ways in many levels of detail. This can be done by any properties of the PRODUCT, VENDOR, CUSTOMER, SALE PRICE or of anything else associated with a SALE. These properties are SEGMENTATION VARIABLES.

Analysis of a MARKET may involve understanding of FEATURES of PRODUCTS, NEEDS of CUSTOMERS, and IMAGES of BRANDS, PRODUCTS, or VENDORS. PROMOTIONS are ACTIVITIES whose PURPOSES relate to the IMAGE in a MARKET.

1.7.5 Time

The basic concepts of the Time section are TIME LINE and TIME POINT. From these are derived DURATION, TIME INTERVAL, CALENDAR DATE, and other concepts which may be required to relate to the other terms of the Ontology. The important notions of before and after are represented as Relationships between TIME POINTS; the notions of disjoint, during, overlaps are represented as Relationships between TIME INTERVALS.

1.7.6 Meta-Ontology

The basic concept of the Meta-Ontology is ENTITY. This is in a sense the catch-all for all other concepts. In creating the Ontology, some concepts will be seen as standing in their own right independent of others (e.g. PERSON). These will be directly classed as ENTITIES. Other concepts will more naturally be seen as a RELATIONSHIP between two or more other ENTITIES (e.g. SALE). Thus though SALE could legitimately be described as an ENTITY, it is more precisely characterised by being described as RELATIONSHIP.

Within a RELATIONSHIP, an ENTITY may have a ROLE (e.g. a Person may be Customer in a Sale). Alternatively, an ENTITY may be seen as an ATTRIBUTE of another ENTITY (e.g. Date of birth of a Person).

Certain ROLES in RELATIONSHIPS are special in that the playing of these ROLES entails some notion of doing or cognition (*e.g.* performing an Activity, or holding an Assumption). Only certain ENTITIES can play such ROLES; currently this includes Persons, OUs and in some cases Machines. We refer an ENTITY playing such a ROLE as a ACTOR (roughly synonymous with 'agent' in other ontology work). A ROLE played by an ACTOR is an ACTOR ROLE.

To accommodate the needs of a multiplicity of users and viewpoints now and in the future, new ACTOR ROLES may commonly arise, as new RELATIONSHIPS are introduced into or used in conjunction with the Ontology. New major kinds of ACTOR ENTITIES may also arise, though perhaps less frequently.

Collectively, the fact that one or more ENTITIES are participating in one or more RELATIONSHIPS with one or more other ENTITIES, describes a situation, which we call a STATE OF AFFAIRS. A STATE OF AFFAIRS may be said to hold or not to hold (*i.e.* to

be true or false).

As has previously been mentioned, the terms in the Ontology have not been explicitly defined in terms of this Meta-Ontology unless this has seemed the most natural choice for a particular term. However, the Meta-Ontology has been implicit in much of the work leading to the choice of terms and definitions. When the Ontology is coded in a formal language, it is expected that the relationship between the terms and the Meta-Ontology will become more explicit.

2 Meta Ontology

In this section, we present the main terms and concepts used to define the Enterprise Ontology itself. In § 2.1, we introduce the main concepts and building blocks: ENTITIES, RELATIONSHIPS, and STATE of AFFAIRS. In § 2.2 we discuss special ACTOR ROLES in some RELATIONSHIPS which entail some notion of doing or cognition. They are played by ACTORS.

2.1 Entities, Relationships and States of Affairs

The Enterprise Ontology is composed of a set of ENTITIES and a set of RELATIONSHIPS between ENTITIES. ENTITIES can play ROLES in RELATIONSHIPS. An ATTRIBUTE is a special kind of RELATIONSHIP. A STATE OF AFFAIRS is a situation characterised by any combination of ENTITIES being in any number of RELATIONSHIPS with one another.

ENTITY: a fundamental thing in the domain being modelled.

Examples:

- a human being is an ENTITY
- a plan is an ENTITY

Notes:

1. An ENTITY may participate in RELATIONSHIPS with other ENTITIES.
2. We intentionally avoid distinguishing between a *type* of ENTITY, and a *particular* ENTITY of a certain type. In the main, we use the word ENTITY with explicit reference to a particular thing; however, most references to ENTITY in this Ontology implicitly define a category or type of ENTITY.

RELATIONSHIP: the way that two or more ENTITIES can be associated with each other.

Examples:

- Have-Capability is a relationship between a Person and an Activity denoting that the Person is able to perform the Activity.

- a Sale is a relationship constituting an agreement between two Legal Entities to exchange a Product for a Sale Price.

Notes:

1. A RELATIONSHIP is itself an ENTITY that can participate in further RELATIONSHIPS.
2. In natural language the word 'relationship' has many meanings. The following are important but logically distinct concepts that 'relationship' commonly refers to:
   - the kind of relationship (closest to above definition);
   - a name given to the kind of relationship (e.g. 'Marriage', 'Have-Capability');
   - a particular relationship between particular ENTITIES.
     Examples:
     - Bill and Hillary Clinton are in a Marriage relationship.
     - Einstein was in a Have-Capability relationship with the Activity of thinking.

   Further distinctions can be made reflecting the use of the mathematical concept of a tuple. For example, in mathematics, the set of all tuples related in a certain way is a useful concept (e.g. the set of all married couples).

   In this document, these distinctions are ignored; in particular, we will use the word 'Relationship' fairly loosely, including various of the above meanings. It should be clear from context what we mean, and thus no problems of ambiguity. In § 8 we explain how these concepts are formalised.

ROLE: the way in which an ENTITY participates in a RELATIONSHIP.

Examples:

- Vendor is a ROLE played by an ENTITY in a Sale RELATIONSHIP (see § 6).

Notes:

1. A participating ENTITY is said to be *playing* the ROLE.
2. Strictly speaking, the correct way to refer to an Entity playing a particular ROLE, is to use a phrase like 'the Entity playing the Vendor ROLE'. This is awkward, and instead, we will often use the shorter phrase 'the Vendor'.

ATTRIBUTE: a RELATIONSHIP between two ENTITIES (referred to as the 'attributed' and 'value' ENTITIES) with the following property:

- within the scope of interest of the model, for any particular attributed ENTITY the RELATIONSHIP may exist with only one value ENTITY.

Examples:

- Date of Birth is an ATTRIBUTE associating only one Date with a given Person.

Notes:

- From a mathematical perspective, an ATTRIBUTE is a function.

STATE OF AFFAIRS: a situation; the following is necessarily true of a STATE OF AFFAIRS:

- it consists of a set of RELATIONSHIPS between particular ENTITIES; *E.g.* 'Joe Bloggs can lay bricks' (*i.e.* is in the Have-Capability RELATIONSHIP with the Activity: bricklaying.')
- it can be said to hold, or be true (and conversely to not hold or to be false)

ACHIEVE: the realisation of a State Of Affairs; *i.e.* being made true;

Notes:

1. When the State Of Affairs is a PURPOSE, one would frequently say it is being 'accomplished'.

2.2 Actors

Certain ROLES in RELATIONSHIPS are special in that the playing of these ROLES entails doing or cognition. These are called ACTOR ROLES; ENTITIES playing such roles are called ACTORS.

ACTOR ROLE: A kind of ROLE in a RELATIONSHIP whereby the playing of the ROLE entails some notion of doing or cognition.

Notes:

1. Some of the important RELATIONSHIPS in the Enterprise Ontology that have ACTOR ROLES are:

RELATIONSHIPS:	*ACTOR ROLES:*
Perform-Activity	performer
Have-Capability	haver
Hold-Authority	holder
Delegate	delegator
	delegatee
Hold Purpose	holder
Hold-Assumption	holder
Ownership	owner

2. Users of the Ontology who define RELATIONSHIPS should indicate which ROLES are ACTOR ROLES.

ACTOR: an ENTITY that *actually plays* an ACTOR ROLE in a RELATIONSHIP.

Notes:

1. Whether or not a given ENTITY is an ACTOR or not depends on what RELATIONSHIPS it is participating in at a given point in time. The same ENTITY might be an ACTOR at one time but not at another time.

POTENTIAL ACTOR: an ENTITY that *can play* an ACTOR ROLE in a RELATIONSHIP, *i.e.* an ENTITY for which some notion of doing or cognition is possible.

Notes:

1. An ENTITY is either always a POTENTIAL ACTOR, or never one. It does not depend on what RELATIONSHIPS it is participating in (unlike ACTOR).
2. The set of POTENTIAL ACTORS currently includes, but is not necessarily limited to the following:
   - Person
   - Organisational Unit
   - Machine
3. If users of the Ontology require other ENTITIES to be ACTORS, they should review the Ontology RELATIONSHIPS using the ACTOR ROLE to ensure the addition is valid for them. If it is, then the new kind of ENTITY must be added to the above list of POTENTIAL ACTORS.
4. A more elaborate classification of POTENTIAL ACTORS might consist of two main types: *Natural* and *Artificial*, the latter being synonymous with Machines. *Animals*, of which Person could be a special type would come under the former category as would *Gravity* which is rather different, and might be classified separately as *In-Animate*. *Artificial* POTENTIAL ACTORS might be further classified, *e.g.* into physical and conceptual Machines.
5. Some ACTOR ROLES can be played by only *some* of the above POTENTIAL ACTORS. For example, it may not be allowed for a MACHINE to own something. Where agreement exists, such restrictions may be specified in the Ontology itself; alternatively they may be specified later by individual users.

2.3 Related Terms

2.3.1 Synonyms

- *Class* (in Object-Oriented systems *e.g.*: Ontolingua) &
  Concept (in Description Logics): a kind or type of ENTITY
- *Instance, Individual*: ENTITY
- *Relation, Predicate*: RELATIONSHIP
- *State*: STATE OF AFFAIRS
- *Slot* (in Object-Oriented systems): ATTRIBUTE;
- *Role* (in Description Logics): similar to ATTRIBUTE; Roles in Description Logics may have more than one value.
- *Agent*: ACTOR

2.3.2 Borderline Terms

1. (mathematical) *Function*: an ATTRIBUTE is a function, though not all functions need to be ATTRIBUTES.

3 Activity, Plan, Capability and Resource

In this section, we present the central concepts of an ACTIVITY, which is something actually done, and an ACTIVITY SPECIFICATION, which is like a recipe describing something to do. Most activity/planning/process ontologies only have a representation for the latter. To allow convenient modelling of process enactment and/or keeping of historical records of past activities, it is helpful to represent instances of the actual doing, *i.e.* the carrying out of the 'recipes'; this is what ACTIVITY is for.

We also present various important Relationships between ACTIVITIES and other ENTITIES. Important related concepts are: PLAN, which is an ACTIVITY SPECIFICATION with an INTENDED PURPOSE; CAPABILITY to perform ACTIVITIES, and RESOURCE which is something that can be used or consumed during an ACTIVITY.

3.1 Activities

ACTIVITY: something done over a particular TIME INTERVAL. The following may pertain to an ACTIVITY:

- has PRE-CONDITION(S);
- has EFFECT(S);
- is performed by one or more DOERS;
- is decomposed into more detailed SUB-ACTIVITIES
- entails use and/or consumption of RESOURCES
- has AUTHORITY requirements
- is associated with an [ACTIVITY] OWNER
- has a measured efficiency

Notes

1. an ACTIVITY can have happened in the past, may be happening in the present, and a hypothetical future ACTIVITY may be envisaged;
2. The word 'something' in the above definition is deliberately general; we mean to include mental activities, for example.
3. We wish to allow PURPOSE-free ACTIVITY, such as water flowing down a hill. An association between an ACTIVITY and a PURPOSE can be made by matching the INTENDED PURPOSE of a PLAN to the EFFECT(S) of ACTIVITIES specified in the PLAN.

4. ACTIVITIES may be informally classified as 'strategic', 'tactical' or 'operational' depending on the 'level' of an associated PURPOSE as characterised by the HELP ACHIEVE Relationship between PURPOSES.

ACTIVITY SPECIFICATION: a characterisation of something to do; a specification of activity.

Notes:

1. an ACTIVITY SPECIFICATION can be thought of as a constraint functioning as a selector identifying a restricted range of ACTIVITIES in the universe;
2. insofar as an ACTIVITY SPECIFICATION will be built up from various components (statements in some language), each constraining the specification in different ways, an ACTIVITY SPECIFICATION can be thought of a collection of constraints.
3. The language for expressing ACTIVITY SPECIFICATIONS will include statements about how ACTIVITIES are decomposed into SUB-ACTIVITIES; temporal ordering of (SUB-)ACTIVITIES; RESOURCE usage, and much more.
4. An ACTIVITY SPECIFICATION is deliberately intended to include any degree of specification of ACTIVITIES; for example:
   - a trivial level of specification: 'go to Edinburgh'
   - comprehensive and detailed set of instructions involving many ACTIVITIES.
5. An ACTIVITY SPECIFICATION need not be EXECUTABLE; possible reasons are:
   - it contains constraints that cannot be met (*e.g.* regarding RESOURCE usage or timing)
   - it is underspecified and/or ambiguous, so the DOER has insufficient information to proceed with execution;

EXECUTE: a Relationship between one or more Potential Actors and an ACTIVITY SPECIFICATION whereby the one or more Potential Actors perform the specified ACTIVITIES.

Notes:

1. Because a PLAN is an ACTIVITY SPECIFICATION, it is also correct to speak of EXECUTION of a PLAN.
2. The EXECUTION of a PLAN should result in the ACHIEVEMENT of its INTENDED PURPOSE.

EXECUTED ACTIVITY SPECIFICATION: A Relationship between an ACTIVITY SPECIFICATION and an ACTIVITY whereby the ACTIVITY is the result of [one] EXECUTION of the ACTIVITY SPECIFICATION.

Notes:

1. An ACTIVITY SPECIFICATION has been executed when all the specified ACTIVITIES have been performed; if the ACTIVITY SPECIFICATION is a PLAN, then execution should result in the ACHIEVEMENT of the PLAN'S INTENDED PURPOSE.

2. This is a one-to-many Relationship because an ACTIVITY SPECIFICATION may in general be executed many times.

T-BEGIN and T-END: the two TIME POINTS that define the TIME INTERVAL over which an ACTIVITY is done;

PRE-CONDITION: a State Of Affairs required to be true in order for the ACTIVITY to be performed.

Notes:

1. The requirement may be specified to hold immediately before T-BEGIN, immediately before T-END, or throughout the whole TIME INTERVAL.

EFFECT: State Of Affairs that is brought about [i.e. made true] by the ACTIVITY.

Notes:

1. The EFFECT may be specified to hold immediately after T-BEGIN, immediately after T-END, or throughout the whole TIME INTERVAL.
   For example, ringing a door buzzer has EFFECT of producing noise during but not before or after the TIME INTERVAL of the ACTIVITY.

DOER: the Role of an Actor in a Relationship with an ACTIVITY whereby the Actor performs (all or part of) the ACTIVITY.

Notes:

1. There may be more than one DOER for a given ACTIVITY.
2. Not all ACTIVITIES need have an explicit DOER; *e.g.* flowing water; In such cases, it may be more natural to think of the DOER as the supplier of force behind an ACTIVITY (*e.g.* the environment, gravity).

SUB-ACTIVITY: The Role of an ACTIVITY in a Relationship with another ACTIVITY such that performance of the first ACTIVITY is considered to be part of the performance of the other ACTIVITY.

Examples:

- performing each of the following SUB-ACTIVITIES may be considered to be part of performing the ACTIVITY "go to Edinburgh"
  - go to Heathrow
  - fly to Edinburgh airport
  - go to Edinburgh city centre

Notes:

1. Typically an ACTIVITY is decomposed into SUB-ACTIVITIES to provide more detail.
2. There is much more structure in an activity decomposition than a simple the set of SUB-ACTIVITIES; *e.g.* temporal constraints may define a partial order.

AUTHORITY: the right of an Actor to EXECUTE an ACTIVITY SPECIFICATION. Informally, this is equivalent to the right to perform one or more ACTIVITIES.

Notes:

1. The holder of AUTHORITY need not have the CAPABILITY to perform the ACTIVITIES;
2. The ACTIVITY that the Actor has the right to perform may itself be the granting of such a right, normally to another Actor – this is a kind of DELEGATION.
3. The holder of AUTHORITY may be self-authorised;
4. This definition allows for the case of a MACHINE having AUTHORITY.
5. The idea of CAPABILITY vs AUTHORITY is analogous to that of 'can' vs 'may'.

ACTIVITY OWNER: Actor responsible for an ACTIVITY.

Notes:

1. May be identified indirectly via Role (e.g. project manager) or directly as a named PERSON.
2. This will normally be NON-LEGAL OWNERSHIP

Depending on their requirements, users of the Ontology may find the need to define a variety of specific kind of ACTIVITIES. We introduce EVENT as one kind of ACTIVITY, but give no details. This allows users of the Ontology to distinguish EVENT from an arbitrary ACTIVITY, while ensuring that it inherits all the properties of ACTIVITY as defined in the Ontology.

EVENT: a kind of ACTIVITY

Notes:

1. One common distinction between EVENT and ACTIVITY is that the former is seen as outside the scope of interest of the model apart from its EFFECTS. In particular, the model will not recognise the DOER, the DURATION, or choice or control over its occurrence (*e.g.* a hurricane which is performed by the 'environment').
2. Another common distinction between EVENT and ACTIVITY is that the former is seen as instantaneous and the later as having duration. In fact, it is arguable that any event has some duration even if it is not measured, and the duration of ACTIVITY can be made arbitrarily small. Therefore, this is not considered a valid distinction to include in the Ontology.

3.2 Plans

PLAN: an ACTIVITY SPECIFICATION with an INTENDED PURPOSE.

Notes:

1. See notes under ACTIVITY SPECIFICATION.

SUB-PLAN: a PLAN whose INTENDED PURPOSE HELPS ACHIEVE the INTENDED PURPOSE of another PLAN.

PLANNING: an ACTIVITY whose INTENDED PURPOSE is to produce a PLAN.

PROCESS SPECIFICATION: a PLAN that is intended to be or is capable of being EXECUTED more than once.

Notes:

1. We intentionally do not define the term 'process', as it means so many things to so many people. The terms in this Ontology should be sufficient to define whatever specific notion of 'process' is required.
2. Typically, a PROCESS SPECIFICATION will be parameterised to enable reusability in various forms at different times. As such, it may be viewed as a PLAN schema.

3.3 Capabilities

CAPABILITY: a Relationship between a Potential Actor and an ACTIVITY SPECIFICATION denoting the ability of the Potential Actor to perform the specified ACTIVITIES.

Notes:

1. The idea of CAPABILITY vs AUTHORITY is analogous to that of 'can' vs 'may'.

SKILL: a CAPABILITY such that:

- the Potential Actor is a PERSON;
- the ability must be practised/demonstrated to some measurable degree.

3.4 Resources

RESOURCE: the Role of an Entity in a Relationship with an ACTIVITY or ACTIVITY SPECIFICATION whereby the Entity is or can be used or consumed during the performance of the ACTIVITY or the ACTIVITIES as specified in the ACTIVITY SPECIFICATION.

Notes:

1. a RESOURCE may have a quantifiable measure denoting how much is available for use in ACTIVITIES
   e.g. amount of fuel; number of typewriters
   - If the RESOURCE is used but not consumed, the quantity available will decrease at the beginning and return to the original level at the end of the TIME INTERVAL of the ACTIVITY.
   - If the RESOURCE is consumed, the quantity available will decrease over the TIME INTERVAL of the ACTIVITY.
2. a RESOURCE may be shared by more than one ACTIVITY
3. An Entity produced by an ACTIVITY may be viewed as a RESOURCE in that *other* ACTIVITIES may use/consume it; however such outputs are not RESOURCES with respect to the producing ACTIVITY.

RESOURCE ALLOCATION: the allocation of RESOURCES to ACTIVITIES.

Notes:

1. RESOURCE ALLOCATION is itself an ACTIVITY, though it may not be necessary to model it explicitly as such. Indeed, the ACTIVITY of RESOURCE ALLOCATION itself may have RESOURCES allocated to it (e.g. personnel).
2. RESOURCE ALLOCATION is the responsibility of OUs
3. an OU responsible for RESOURCE ALLOCATION may DELEGATE it to another OU.

RESOURCE SUBSTITUTE: a RESOURCE that can be used or consumed in an ACTIVITY instead of another RESOURCE.

3.5 Related Terms

3.5.1 Synonyms

- *Behaviour*: ACTIVITY
- *Task*: ACTIVITY
- *Action*: ACTIVITY

3.5.2 Borderline Terms

1. *Personal Skill*: the degree of SKILL recognised for a PERSON

3.5.3 Other Commonly Used Terms

1. *Process:* see note 1 under definition of PROCESS SPECIFICATION.

4 Organisation

The central concept in this section is that of an ORGANISATIONAL UNIT, the main structural element of an organisation. Complex ORGANISATIONAL STRUCTURE is captured by the various MANAGE relationships between OUs.

First, however, we define the notions of a LEGAL ENTITY (which includes a PERSON, CORPORATION etc.) and a MACHINE, all of which themselves may correspond to a single OU.

Other important concepts defined in this section are DELEGATION, OWNERSHIP, STAKEHOLDER, SHARE, SHAREHOLDER and ASSET.

4.1 Legal Entities and Machines

PERSON: a human being

Notes:

1. For the purposes of this Ontology, PERSONS are of interest for their capacity to play various Actor Roles in an enterprise (*e.g.* perform ACTIVITIES).
2. The concepts of sole trader and a registered business are included here. For most purposes, the law makes no distinction between these things and the PERSON owning/operating them.

MACHINE: a non-human Entity which has the capacity to carry out functions and/or play various roles in an enterprise.

Notes:

1. a MACHINE is similar to a PERSON in that many functions and roles may be performed by either. However, it is anticipated that some functions and roles will be exclusive to one or the other. For example, a MACHINE may not be held responsible for anything.

CORPORATION: A group of PERSONS recognised in law as having existence, rights, and duties distinct from those of the individual PERSONS who from time to time comprise the group.

Notes:

1. Historically, in law, rights and duties apply to individual humans; rights and duties of groups are inherited from this.

PARTNERSHIP: A group of PERSONS carrying on business in common.

Notes: The following is true in English law, but not necessarily in other legal systems:

1. there is a distinction between PARTNERSHIP and CORPORATION;
2. each PARTNER may have unlimited liability for the debts of the PARTNERSHIP to other LEGAL ENTITIES;
3. the PARTNERSHIP does not have a legal identity separate from its PARTNERS; e.g. if PARTNERSHIP is sued, this means all PARTNERS are sued.

PARTNER: a PERSON who forms part of a PARTNERSHIP;

LEGAL ENTITY: the union of PERSON, CORPORATION, and PARTNERSHIP

Notes:

1. For the purposes of the Ontology, this is equivalent to the more commonly used definition of a LEGAL ENTITY: 'that which can enter into a legal contract'.

4.2 The Structure of Organisations

ORGANISATIONAL UNIT (OU): an Entity [with a defined identity] for MANAGING the performance of ACTIVITIES to ACHIEVE one or more PURPOSES. An OU may be characterised by:

- the nature of its PURPOSE(S);
- one or more PERSONS working for the OU;
- RESOURCES allocated to the OU;
- other OUs that MANAGE or are MANAGED-BY the OU;
- its ASSETS;
- its STAKEHOLDERS;
- being LEGALLY OWNED;
- its MARKET (if it is a VENDOR).

Notes:

1. The term OU is deliberately defined with no constraint on its size or place within an organisation. Furthermore, no special terms for OUs of any particular size are defined (e.g. division, department). This is because no consistent use of such terms can be found across different enterprises, or even within a single enterprise over time. Therefore the existence of a very small and simple unit, even corresponding with a single PERSON, or a very large and complex structure (e.g. a multi-national CORPORATION) can equally be represented as an OU. The structure of an OU is represented by the set of as many other OUs and MANAGEMENT LINKS (see below) as required.
2. The term MANAGEMENT LINK leads to the concept of higher-level and lower-level OUs depending on which MANAGE and which are MANAGED.
3. The terms 'enterprise' and 'organisation' are not defined in the Ontology, but a user of the Ontology may wish to define one or other of them as a high-level OU, perhaps corresponding with highest OU in the scope of interest.
4. An individual PERSON may correspond to, or belong to, more than one OU, one for each different role or function.
5. An essential PURPOSE of most OUs is to maximise performance against financial and other organisational OBJECTIVES.

MANAGE: the ACTIVITY of assigning PURPOSES and monitoring their ACHIEVEMENT

Notes:

1. This includes RESOURCE ALLOCATION and the power to give AUTHORITY;
2. This includes managing of people, (*e.g.* skill base, career development), and of OUs. This is reflected by the nature of the PURPOSES that are set and monitored; e.g. time horizon, deliverables.
3. This gives rise to an asymmetric Relationship between the managing and managed entities. See MANAGEMENT LINK.

4. Although the visible activity of management in an enterprise may take place between PERSONS (or possibly MACHINES), where the PURPOSE assigned and monitored clearly relates to the activities of the OU, it will frequently be natural to model it as being between the OUs.

DELEGATE: a kind of MANAGING ACTIVITY whereby there is a transfer of something to a (normally lower-level) Actor.

Notes:

1. We do not formally characterise DELEGATION, this is left to the users. Details to be considered include what may be delegated, (*e.g.* task, authority, responsibility).

MANAGEMENT LINK: a Relationship whereby one Actor directly MANAGES another Actor.

Notes:

1. The particular arrangement of MANAGEMENT LINKS determines what is commonly referred to as Organisational Structure, Control Structure, or Management Structure.
   - Examples of common Organisational Structures are hierarchical (e.g. line management), matrix (for project/programme management) and flat.
   - Co-management is a situation where an OU is MANAGED by more than one OU.
2. A single sequence of Actors directly connected via MANAGEMENT LINKS can be thought of as a management chain. More precisely, all management chains have:
   - Only one Actor (lowest level) that does not MANAGE another Actor;
   - Only one Actor (highest level) that is not MANAGED by another Actor;
   - No branching (*i.e.* no Actor MANAGES or is MANAGED by more than one other Actor).
3. An OU at the lower end of a Management Chain may correspond directly with one PERSON. The PURPOSES of such a PERSON may be very similar to the PURPOSES of the OU and therefore the PURPOSES may not need to be separately modelled. Higher up a Management Chain, the PURPOSES of an OU are likely to be dissimilar to the PURPOSES of a PERSON.
4. By virtue of being MANAGED by an OU, an OU may informally be thought of as being 'part of' the MANAGING OU.
5. Insofar as a MACHINE can be viewed as a MANAGED and/or MANAGING Entity, it may be considered to be an OU.

LEGAL OWNERSHIP: a Relationship between a LEGAL ENTITY and an Entity whereby the LEGAL ENTITY has certain rights with respect to the Entity.

Notes:

- the Entity in such a Relationship will be said to be 'LEGALLY OWNED'

NON-LEGAL OWNERSHIP: a Relationship between an Actor and an Entity whereby the Actor is recognised within a LEGAL ENTITY as having certain rights with respect to the Entity.

Examples:

- the Relationship between an OU and the RESOURCES allocated to it.

Notes:

1. In the eyes of the law, OWNERSHIP can only be vested in a LEGAL ENTITY. For practical purposes within an organisation, rights of an Actor with respect to an Entity within the organisation will be important to model.

OWNERSHIP: the union of LEGAL OWNERSHIP and NON-LEGAL OWNERSHIP.

Notes:

1. This is equivalent to: a Relationship between an Actor and some Entity whereby the Actor has certain rights with respect to the Entity.
2. It is *rights* that are OWNED, not the Entity itself; *e.g.* one who leases a car does not own the car, but they have legal rights with respect to it.

OWNER: the Role of the Actor in an OWNERSHIP Relationship

ASSET: an Entity LEGALLY OWNED that has MONETARY VALUE.

Examples:

- MACHINE, equipment, land, building, material,
- idea, design, patent, information.

Notes:

1. 'having monetary value' is not the same as 'can appear on a balance sheet'
2. capital asset, fixed asset and liquid asset are specialisations of ASSET but are not central to our concerns. The differences between these are determined by accounting standards.
3. An Entity may be both an ASSET and a RESOURCE but some ASSETS are not RESOURCES and some RESOURCES are not ASSETS.

STAKEHOLDER: a Role of a LEGAL ENTITY or OU in a Relationship with an OU whereby one or more PURPOSES of the OU are included in the scope of interest of the LEGAL ENTITY or OU.

Notes:

1. the STAKEHOLDER is usually one of: OWNER, PARTNER, SHAREHOLDER, EMPLOYEE.

EMPLOYMENT CONTRACT: An agreement [Relationship] between a LEGAL ENTITY in the Role of EMPLOYER and a PERSON in the Role of EMPLOYEE.

SHARE: A subdivision of the rights of OWNERSHIP of a CORPORATION recognised by law and the CORPORATION.

SHAREHOLDER: A LEGAL ENTITY OWNING one or more SHARES in a CORPORATION.

4.3 Related Terms

4.3.1 Synonyms

Party: LEGAL ENTITY

4.3.2 Borderline Terms

Company: roughly synonymous with CORPORATION; the minor legal differences between a Company and CORPORATION are ignored in this Ontology.

Registered Business that is not a CORPORATION: encompassed by PERSON

Sole Trader: encompassed by PERSON

Business: CORPORATION, or Sole Trader or Registered Business that is not a CORPORATION.

5 Strategy

The central concept in this section is PURPOSE which is either something that an Actor has, or is the main reason for executing a PLAN. PURPOSES may be decomposed into higher and lower level PURPOSES via the HELP ACHIEVE relationship. Special kinds of PURPOSE are: MISSION, VISION, GOAL, OBJECTIVE and STRATEGIC PURPOSE. A STRATEGY is a PLAN to achieve a STRATEGIC PURPOSE.

Other important concepts introduced include STRATEGIC PLANNING, STRATEGIC ACTION, DECISION, ASSUMPTION, (CRITICAL) INFLUENCE FACTOR, CRITICAL SUCCESS FACTOR and RISK.

5.1 Purpose and Strategy

PURPOSE: a Role of a State Of Affairs in one of the following Relationships:

- **HOLD PURPOSE**: a Relationship between an Actor and a State Of Affairs whereby the Actor wants, intends, or is responsible for the full or partial ACHIEVEMENT of the State Of Affairs;

  Notes:

  - The Actor will usually be a PERSON or OU, however MACHINE is not excluded.

Example:

- Some PERSON wants to be in Edinburgh on some date;

- **INTENDED PURPOSE**: a Relationship between an ACTIVITY SPECIFICATION and a State Of Affairs whereby:
  - EXECUTION of the ACTIVITY SPECIFICATION will result in fully or partially ACHIEVING the State Of Affairs;
    and
  - The State Of Affairs entails one or more of the EFFECTS of the ACTIVITY SPECIFICATION whose ACHIEVEMENT is declared to be the primary reason(s) for EXECUTING the ACTIVITY SPECIFICATION.

  Notes:

  1. An ACTIVITY SPECIFICATION with an INTENDED PURPOSE is *by definition* a PLAN.

  Example:

  - The PURPOSE of a PLAN is to be in some particular location on some date.

Notes:

1. a PURPOSE may be effectively decomposed into more detailed PURPOSES via the HELPS ACHIEVE Relationship.
2. A Responsibility may be viewed as a special kind of PURPOSE. Being responsible for implies the PURPOSE is DELEGATED by another Actor. This contrasts with the more general case where an Actor wants or intends a PURPOSE of their own volition.
3. A PURPOSE is characterised by one or more of the following:
   - *Measurability*: extent to which it is possible to objectively determine whether ACHIEVEMENT has occurred
   - *Time Horizon e.g.* short, medium, or long term
   - *Specificity*: how detailed the PURPOSE is; related to measurability in that very detailed PURPOSES will tend to be measurable.
   - *Relative Priority*: degree of desirability with respect to some Actor

PURPOSE-HOLDER: the Role of the Actor in the HOLD PURPOSE Relationship.

Kinds of Purposes

We introduce various different kinds or levels of PURPOSE: STRATEGIC PURPOSE, OBJECTIVE, GOAL, MISSION and VISION. We define the first two only, because the rest are used in many different ways. It is up to the Ontology user to specify what these may mean in a given situation.

STRATEGIC PURPOSE: A PURPOSE held by an ACTOR that is declared to be of 'Strategic' importance.

Notes:

1. Such a declaration is arbitrary; there is no way to otherwise infer whether PURPOSE is of strategic importance or not.
2. Frequently, a STRATEGIC PURPOSE will be fairly 'high-level' with respect to the HELPS ACHIEVE Relationship (*e.g.* it may correspond to a MISSION)

OBJECTIVE: a PURPOSE with a defined measure.

Notes:

1. The idea is that it is possible to detect the ACHIEVEMENT of an OBJECTIVE.

VISION, MISSION, and GOAL: kinds of PURPOSES

Notes:

1. They may or may not be OBJECTIVES.
2. Below we indicate some ways that these terms may be specialised:
   - Insofar as the HELPS ACHIEVE Relationship orders PURPOSES, the order will tend to be (from lowest-level): OBJECTIVE, GOAL, MISSION, VISION.
   - With respect to measurability, the order will tend to be (from most measurable): OBJECTIVE, GOAL, MISSION, VISION.
   - With respect to to time horizon, the the order will tend to be (from shortest time horizon): OBJECTIVE, GOAL, MISSION, VISION.

HELP ACHIEVE: a Relationship between two States Of Affairs whereby one State Of Affairs contributes to or facilitates the ACHIEVEMENT of the other State Of Affairs.

Notes:

1. The HELP ACHIEVE Relationship is particularly important when the States Of Affairs are PURPOSES. In this case, the HELP ACHIEVE Relationship may define a directed acyclic network of PURPOSES which gives rise to a notion of higher- and lower-level PURPOSES.
2. Users of the Ontology may wish to constrain the meaning of HELPS ACHIEVE more precisely, or even define more than one flavour. It is deliberate that the Ontology permits this while providing a basic structure that can be shared.

STRATEGY: a PLAN to ACHIEVE a STRATEGIC PURPOSE

STRATEGIC PLANNING: a [PLANNING] ACTIVITY whose INTENDED PURPOSE is to produce a STRATEGY

STRATEGIC ACTION: a SUB-PLAN of a STRATEGY

Notes:

1. Strictly speaking, this is a mis-nomer in that it is not an ACTIVITY, but a PLAN. It is left as such to conform with common usage.

5.2 Decisions, Factors, Assumptions

DECISION: commitment by an ACTOR to perform an ACTIVITY.

Notes:

1. this is roughly equivalent to the traditional definition: 'commitment to a course of action'. The notion of commitment appears synonymous with 'intention' as distinct from 'want/desire'

ASSUMPTION: a Role of a State Of Affairs in a Relationship with an Actor whereby the Actor takes the State Of Affairs to be true without knowing whether it is true or not.

Notes:

1. An ASSUMPTION may or may not be critical
2. ASSUMPTIONS are typically used during PLANNING and may be associated with PLANS.

CRITICAL ASSUMPTION: an ASSUMPTION that is associated with or used in STRATEGIC PLANNING.

NON-CRITICAL ASSUMPTION: an ASSUMPTION that is not associated with or used in STRATEGIC PLANNING.

INFLUENCE FACTOR: a State Of Affairs known to be true which is within the scope of interest of an Actor.

Example:

- current rate of inflation

CRITICAL INFLUENCE FACTOR: an INFLUENCE FACTOR that is associated with or used in STRATEGIC PLANNING.

NON-CRITICAL INFLUENCE FACTOR: an INFLUENCE FACTOR that is *not* associated with or used in STRATEGIC PLANNING.

CRITICAL SUCCESS FACTOR (CSF): A PURPOSE declared by an Actor to be critical to the success of one or more higher-level PURPOSES.

Notes:

1. the practical significance of this is that CSFs provide the central focus for STRATEGIC PLANNING.
2. it is important to note that the declaration is arbitrary in the sense that there is no set of Attributes that can objectively determine whether a PURPOSE is a CSF or not.

RISK: the Role of a State Of Affairs in a Relationship with an Actor whereby the Actor regards the State Of Affairs as a potential hindrance to the ACHIEVEMENT of one or more PURPOSES.

5.3 Related Terms

5.3.1 Synonyms

Threat: RISK

Programme: STRATEGY

Target: PURPOSE, GOAL

Measurable Target: OBJECTIVE

5.3.2 Borderline Terms

Contingency Plan: a PLAN which is used when a specified State Of Affairs occurs.

Notes:

1. usually associated with a RISK

6 Marketing

The central concept in this section is the SALE relationship, which is an agreement between a VENDOR and CUSTOMER to exchange a PRODUCT for a SALE PRICE. The MARKET is defined in terms of all SALES and POTENTIAL SALES, and may be subdivided into MARKET SEGMENTS using SEGMENTATION VARIABLES.

Other important concepts related to a MARKET include: BRAND, IMAGE, PROMOTION and COMPETITOR.

6.1 Sales

SALE: an agreement [Relationship] between two LEGAL ENTITIES to exchange one good, service or quantity of money for another good, service or quantity of money.

Notes:

1. The exchange in a SALE entails transfer of OWNERSHIP
2. A SALE may have as associated TIME-POINT indicating when the agreement was made.
3. A SALE may be characterised by a number of things, including: sales type, volume, value

POTENTIAL SALE: a possible future SALE.

FOR SALE: a situation whereby one LEGAL ENTITY offers to enter into a SALE. Associated with every such situation is a PRODUCT (being offered FOR SALE) and an ASKING PRICE.

Notes:

1. The definition for FOR SALE entails a necessary distinction between the seller (VENDOR) and the buyer (POTENTIAL CUSTOMER), in that only the former is offering something.
2. It is correct to say that the PRODUCT (the item being offered for exchange) is FOR SALE;
3. Informally, we may refer to the FOR SALE situation as a Relationship between the various parties and things exchanged.

SALE OFFER: A FOR SALE situation where a particular LEGAL ENTITY is being offered the PRODUCT.

6.1.1 Roles in Sales Relationships

The notions of customer, vendor, product and price are usually associated with sales. They are essentially roles that distinguish between the entities exchanged and the LEGAL ENTITIES involved. We reflect this in the Ontology by formally defining ACTUAL CUSTOMER, VENDOR, PRODUCT, ASKING PRICE, and SALE PRICE as Roles in the SALE and FOR SALE Relationships.

The Ontology caters for exceptional cases, where both things are goods (barter) or both money (currency exchange). However, in these cases the SALES Relationship is symmetric and there is no obvious way to distinguish between the Roles. Because of this, special care may be required in defining such SALES Relationships.

VENDOR: the Role of the LEGAL ENTITY who

- offers a PRODUCT, FOR SALE for an ASKING PRICE –or–
- agrees to exchange a PRODUCT for a SALE PRICE in a SALE.

Notes:

1. From the VENDOR's perspective, the exchange is referred to as 'selling'.

ACTUAL CUSTOMER: the Role of the LEGAL ENTITY agreeing to exchange a SALE PRICE for a PRODUCT in a SALE.

Notes:

1. From the ACTUAL CUSTOMER's perspective, the exchange is referred to as 'buying'.

POTENTIAL CUSTOMER: any LEGAL ENTITY who may become an ACTUAL CUSTOMER.

Notes:

1. This definition includes both LEGAL ENTITIES to whom PRODUCTS *are* offered FOR SALE, and LEGAL ENTITIES who might purchase something which is not but could be FOR SALE.
2. Since *any* LEGAL ENTITY can potentially participate in a SALE, the set of all LEGAL ENTITIES seems identical to the set of all POTENTIAL CUSTOMERS. Thus, this term may be redundant and unnecessary.
3. Various conditions are possible any of which, singly or in combination, may or may not be true in a particular case:
   - the actual offer of a PRODUCT to the LEGAL ENTITY [i.e. a FOR SALE Relationship];
   - the ability of POTENTIAL CUSTOMERS to afford the ASKING PRICE;
   - the LEGAL ENTITY having a NEED;
   - the existence of a PRODUCT having a FEATURE capable of satisfying a NEED;
   - the existence of a marketing PROMOTION aimed at POTENTIAL CUSTOMERS.

CUSTOMER: The union of POTENTIAL CUSTOMER and ACTUAL CUSTOMER.

One special kind of CUSTOMER is described below:

RESELLER: CUSTOMER who enters into a SALE agreement for the PURPOSE of making further SALES of the PRODUCT (or a derivative of it).

Notes:

1. A RESELLER is a CUSTOMER in one SALE and a VENDOR in another.

PRODUCT: the Role of the good, service, or quantity of money that is:

- offered FOR SALE by a VENDOR –or–
- agreed to be exchanged by the VENDOR with the ACTUAL CUSTOMER in a SALE.

Notes:

1. There is possible confusion with the use of the term 'product' when referring to something produced/manufactured but which is not sold (*i.e.* an intermediate product internal to a manufacturing process). It may become necessary to introduce two terms for this, such as 'Market Product' and 'Manufactured Product'.

ASKING PRICE: the Role of the good, service, or quantity of money being asked for by a VENDOR in exchange for a PRODUCT that is FOR SALE.

SALE PRICE: the Role of the good, service or quantity of money agreed to be exchanged by the ACTUAL CUSTOMER with the VENDOR for the PRODUCT in a SALE.

Notes:

1. We specifically chose not to define the price as the 'value' of the PRODUCT, because value is relative, the price is the actual thing exchanged. (usually money).

6.2 Market

MARKET: All SALES and POTENTIAL SALES within a scope of interest.

Notes:

1. A MARKET can be characterised by any number of SEGMENTATION VARIABLES
2. A MARKET may be measured in various ways. For example: the number of SALES, the sum of the SALE PRICE of the SALES, or ratios between one set of SALES and another.

SEGMENTATION VARIABLE: Any Attribute determinable from a SALE or POTENTIAL SALE in a MARKET. Examples include:

- PRODUCT: identity, size, shape, colour, sex appeal
- VENDOR: geographical location, size
- CUSTOMER: socio-economic class, age, sex
- SALE: geographical location, TIME POINT of occurrence (e.g. date and time)

MARKET SEGMENT: All SALES and POTENTIAL SALES in a MARKET having defined values of one or more SEGMENTATION VARIABLES.

Examples:

- Geography = Asia;
- Socio-economic class of CUSTOMER = yuppie.

Notes:

1. One person's MARKET may be another person's MARKET SEGMENT

MARKET RESEARCH: An ACTIVITY whose

- PURPOSE is to better understand a MARKET
- EFFECTS includes the existence of information about a MARKET

BRAND: A name identifiable by CUSTOMERS associated with one or more PRODUCTS of a VENDOR.

IMAGE: a set of properties that a CUSTOMER believes to be true of a BRAND, PRODUCT or VENDOR.

Example:

- Rolls Royce automobiles are believed by CUSTOMERS to be reliable

FEATURE: An Attribute of a PRODUCT which may satisfy a NEED of a CUSTOMER.

NEED: A physical, psychological or sociological requirement of a CUSTOMER.

MARKET NEED: an identifiable NEED of CUSTOMERS which is not fully satisfied by PRODUCTS currently FOR SALE.

PROMOTION: An ACTIVITY whose primary PURPOSE is to improve the IMAGE [of a PRODUCT, BRAND and/or VENDOR].

Notes:

1. A PROMOTION may have additional PURPOSES, all normally related to the MARKET.

COMPETITOR: a Role of a VENDOR in a Relationship with another VENDOR whereby one offers one or more PRODUCTS FOR SALE that could limit the SALES of one or more PRODUCTS of the other VENDOR.

Notes:

1. this competition is a symmetric Relationship; *i.e.* each VENDOR is a COMPETITOR of the other in the same manner.

6.3 Related Terms

6.3.1 Synonyms

Bid, Proposal: SALE OFFER

Consideration: SALE PRICE

Reputation: IMAGE

Supplier: VENDOR

Trading Entity: VENDOR

6.3.2 Borderline Terms

Buyer: the LEGAL ENTITY approving the SALE. In many cases the Buyer will be the ACTUAL CUSTOMER; alternatively, if the ACTUAL CUSTOMER is a high-level OU, the Buyer may be a PERSON or OU within that OU.

Consumer: the LEGAL ENTITY who will use the PRODUCT in a SALE; In many cases, the Consumer will be the ACTUAL CUSTOMER; alternatively, if the ACTUAL CUSTOMER is a high-level OU, the Consumer may be a PERSON or OU within that OU.

Product Substitute: a PRODUCT that may be offered by a VENDOR in place of a PRODUCT previously offered. Planning tools may need knowledge of the FEATURES of PRODUCTS to plan or optimise substitution.

Customer Base: A group of existing CUSTOMERS. These may be segmented by geography, demographics etc. Should be considered as part of MARKET RESEARCH and/or PROMOTIONS.

6.3.3 Other Commonly Used Terms

- *Product Portfolio*
- *Target Customer*
- *Target Market Segment*

7 Time

Note: This section has not been updated to reflect the code. It is unchanged from version 1.0 and is here mainly for historical interest. Anyone interested in the details of the time portion of the Enterprise Ontology should consult the code on the World-Wide Web accessible from: http://www.aiai.ed.ac.uk/~entprise/enterprise/ontology.html. *The code for the time-related concepts was not developed as part of the Enterprise Ontology; rather it was imported directly from the Library of Ontologies on the Ontology Editor provided by the Knowledge Systems Lab (KSL) at Stanford. Details of KSL are available on the World-Wide Web at* http://www-ksl.stanford.edu/.

The concept of time is not specific to Enterprises, but is used by them. We have made no attempt to re-think existing work on representing time; instead, we merely imported it.

The central concepts are a TIME LINE and a TIME POINT, where the latter is comprised of the former. We define the concepts of DURATION, and TIME INTERVAL; we also define various relationships between TIME POINTS and TIME INTERVALS.

7.1 The Fundamentals

There are two fundamental concepts:

TIME LINE: an ordered, continuous, infinite sequence of TIME POINTS.

TIME POINT: a particular, instantaneous point in time;

Notes:

1. a TIME POINT can exist independently from knowing where it is on the TIME LINE (*e.g.* 'when the next big earthquake hits California'). You can still talk about it and perhaps constrain it to some extent.

We define two special kinds of TIME POINTS:

CALENDAR DATE: a kind of TIME POINT characterised by being represented as a specific calendar year, month, day, hour, and minute.

Examples:

- (e.g. 11:33 am 7 July 1654)

RELATIVE TIME POINT: a kind of TIME POINT characterised by being represented as a durational offset from an origin.

Examples:

- tomorrow may be represented as 'the day after today'

7.2 Durations and Intervals

Using the above two fundamental concepts, we characterise various other useful notions:

DURATION: an absolute distance between two TIME POINTS.

Notes:

1. A DURATION will typically be measured in some units (e.g. years, weeks, etc).
2. The following are special cases of a DURATION:
   - Infinity: arbitrarily large DURATION
   - Epsilon: arbitrarily small DURATION
   - Zero: DURATION of zero length

DURATION BOUNDS: a specification of an upper and lower bound on a length of time consisting of two DURATIONS.

Examples:

- the process time takes between 1 and 3 weeks

Notes:

1. A DURATION is a special case of a of a DURATION BOUND where an exact length of time is required. This can be represented by having the upper and lower bound be the same DURATION.

TIME INTERVAL: an interval of time specified as two TIME POINTS and bounds on the distance between the two time points.

Notes:

1. The bounds imply that the interval is in a sense fuzzy; you do not know how long it is or necessarily where on the TIME LINE the TIME POINTS are.
2. The following is a special case of a TIME INTERVAL:
   - Always: the interval from infinitely far into the past to infinitely far into the future.

7.3 Time Relationships

We define a number of useful Relationships between TIME POINTS:

BEFORE: a Relationship between two TIME POINTS where by one precedes the other on the TIME LINE with a minimum distance of Epsilon.

SAME-OR-BEFORE: a Relationship between two TIME POINTS where by one precedes the other on the TIME LINE with a minimum distance of Zero.

Notes:

1. If the distance is Zero, the two TIME POINTS are identical

AFTER: a Relationship between two TIME POINTS where by one succeeds the other on the TIME LINE with a minimum distance of Epsilon.

SAME OR AFTER: a Relationship between two TIME POINTS where by one succeeds the other on the TIME LINE with a minimum distance of Zero.

Notes:

1. If the distance is Zero, the two TIME POINTS are identical

SAME: a Relationship between two TIME POINTS whereby the distance between them is Zero.

DISTANCE: between two TIME POINTS specified as a DURATION

We define a number of useful Relationships defined on TIME INTERVALS:

EARLIEST START TIME: an Attribute of a TIME INTERVAL whose value is a RELATIVE TIME POINT denoting the earliest time that the TIME INTERVAL may begin.

LATEST START TIME: an Attribute of a TIME INTERVAL whose value is a RELATIVE TIME POINT denoting the latest time that the TIME INTERVAL may begin.

EARLIEST END TIME: an Attribute of a TIME INTERVAL whose value is a RELATIVE TIME POINT denoting the earliest time that the TIME INTERVAL may end.

LATEST END TIME: an Attribute of a TIME INTERVAL whose value is a RELATIVE TIME POINT denoting the latest time that the TIME INTERVAL may end.

INTERVAL-BEFORE: a Relationship between two TIME INTERVALS whereby one TIME INTERVAL is wholly before the other.

INTERVAL-DURING: a Relationship between two TIME INTERVALS whereby one TIME INTERVAL is a sub-interval of another TIME INTERVAL.

INTERVAL-OVERLAPS: a Relationship between two TIME INTERVALS whereby one TIME INTERVAL overlaps another TIME INTERVAL.

INTERVAL-DISJOINT: a Relationship between two TIME INTERVALS whereby the two TIME INTERVALS do not overlap.

7.4 Example

TIME POINTS:

- MidnightToday,
- Actual-Takeoff-Time,
- Actual-Landing-Time

RELATIVE TIME POINTS: (defined relative to MidnightToday)

- Scheduled-Takeoff-Time (= 8 hrs 10 min)
- Scheduled-Landing-Time (= 16hrs 30 min)

DURATION BOUNDS:

- Time-Delta: defined to be plus or minus 15 minutes

TIME INTERVAL:

- Flight-Time: defined by the two time points
  - Actual-Takeoff-Time
  - Actual-Landing-Time

DISTANCE: Relationships are defined stating that the time between scheduled and actual takeoff (and landing) are both limited by Time-Delta.

What this means is that the flight is scheduled to take off at 8:10am and land at 4:30 pm plus or minus 15 minutes in each case. You can then assert things like 'state of flight is in-the-air' during Flight-Time.

8 Coding the Enterprise Ontology

Readers with limited interest in technical details may wish to skip this section.

The previous sections of this document collectively comprise the informal, natural language description of the Enterprise Ontology. Version 1.0 of this document served as a specification for the subsequent encoding of the Enterprise Ontology in the formal KIF-based language: Ontolingua. There were relatively few changes to the Enterprise Ontology identified while coding. These have been reflected in this version thus sacrificing a certain amount of historical accuracy for clarity of exposition.

In this section, we describe our experiences of the coding process and clarify the relationship between the code and the natural language specification (henceforth referred to as the 'Specification' On occasion, we refer to technical details regarding Ontolingua. However, they may be safely ignored by readers unfamiliar with the language, as other material does not depend on these details. Further information about Ontolingua may be found on the World-Wide Web at *http://www-ksl.stanford.edu/*.

NB: The majority of this section was taken directly from the separate report: AIAI-TR-192, entitled: "Converting an Informal Ontology into Ontolingua: Some Experiences". It is available on the web at: "http://www.aiai.ed.ac.uk/ entprise/enterprise/ontology.html".

The Role of the Code The role of the formal representation of the Enterprise Ontology is to provide a more precise specification of the meaning of the ontology than is possible in natural language.

It is not claimed to be totally rigorous or complete. In particular, we make no claims about how or whether the axioms will be used directly by any theorem prover or automatic language translation software. Users of the formal code may add further axioms for greater rigour or completeness depending on their requirements.

Fidelity Overall, we believe that we were successful in accurately representing the intended meaning of the terms described in the Specification. Below we discuss some of the details of the coding process and the relationship of the code to the Specification. Differences include simple name changes, removing some terms, adding new terms and shifts in perspective for a particular concept.

Choice of Language The choice of Ontolingua as a representation language has proved highly suitable from the point of view of representational adequacy. Within the Ontology development part of the Enterprise Project, suitability from other vantage points, (*e.g.* the software) remains untested.

Section Outline In the remainder of this section, we proceed by describing the details of how the Meta-Ontology presented in the Specification was manifest in the Ontolingua code. Of particular importance is how Roles and States of Affairs were handled. After this, we identify some of the main issues that arose during the coding process which gave rise to changes from the natural language Specification.

8.1 Meta-Ontology

KIF, on which Ontolingua (OL) is based, gives the full expressive power of first-order logic. As such, it comes with a standard meta-ontology, namely: objects, relations, and functions. For the most part, OL provided adequate primitives to cover what was required to represent

the Enterprise Meta-Ontology. There was little to be gained by formally defining things like 'ENTITY' and 'RELATIONSHIP' as described in the Specification. However, for clarity, we point out precisely what these correspond to in the code.

8.1.1 Entities, Classes and Instances

In the Specification, to conform to common natural language usage, we intentionally blurred the distinction between a *type* of entity, and a *particular* entity of a certain type. The majority of terms defined in the Specification correspond to *types* of entities, which, in OL are unary relations called *Classes* – *e.g.* Person, Activity, Purpose. Particular entities of a certain type are called *Instances*, in OL.

Formally, 'ENTITY' in the Specification, (taken as a type of thing rather than a particular thing of a certain type) is equivalent to the union of the OL Frame-Ontology classes: Set and Thing.

8.1.2 Relationships, Roles and Role Classes

Relationship 'RELATIONSHIP', in the Specification was also deliberately ambiguous, reflecting common usage of the term in natural language. In particular, it referred both to the set of tuples constituting a relation and a single tuple. If we restrict usage to refer to the set of tuples (*i.e.* the mathematical relation), then 'RELATIONSHIP' is equivalent to a subclass of Relation@Frame-Ontology which excludes unary-relations. We found no need to define this class explicitly in OL.

Attribute 'ATTRIBUTE' in the Specification is roughly equivalent to a Function in OL. However, in the main, what was said to be an ATTRIBUTE in the Specification is modelled in OL as a slot on some class whose slot-cardinality is set to 1.[1]

Role While it seemed useful in the Specification to introduce various terms defined specifically as ROLEs, the concept of a ROLE is not directly and explicitly represented in the formal code. Instead, a ROLE is implicitly represented as the semantics of an argument in a relation.

For example, a particularly important ROLE is RESOURCE, defined as the Role of an ENTITY in a RELATIONSHIP with an ACTIVITY whereby the ENTITY is or can be used or consumed during the ACTIVITY.

It is not obvious how or whether one might usefully represent this ROLE, per se, in formal code. However corresponding to every ROLE, is the set of all ENTITIES that play that

[1] There is a subtle distinction here. A slot with slot-cardinality set to 1 may not explicitly be a Function in OL; rather it *corresponds* to what has the defining property of a function. In particular, it corresponds to a sub-relation (i.e. a subset of tuples) of the [independently defined] Binary-Relation used in the slot. That Binary-Relation need not be a Function.

ROLE. For RESOURCE and other important ROLES, we formally represent this set and refer to it as a *Role-Class*.

We represent the RELATIONSHIP referred to in the definition of RESOURCE as a binary relation called *Can-Use-Resource*, where the first argument refers to the activity, and the second to the entity. The unary relation *Resource*, represents the class of all entities (i.e. instances) that participate in this Relationship with some activity. It is defined as follows:

$$\forall E.(Resource(E) \quad \leftrightarrow \quad \exists A.(Activity(A) \wedge Can_Use_Resource(A, E)))$$

So, the concept of a ROLE is adequately represented in OL, but from a different perspective from that in the Specification. Rather than formalise the way an Entity participates in a Relationship, instead we formalise the set of all Entities that participates in a Relationship in that certain way.

As a matter of convenience, and formal precision, we defined *Role-Class* in OL. Specifically, it is "A special kind of Class, one which is defined as the set of all Entities playing a particular Role in some Relation." Technically, *Role-Class* is a meta-class, *i.e.* the class of all classes which are defined in terms of roles. A particular role class, such as *Resource*, is an instance of the [meta-]class *Role-Class*. To the extent that updates may occur which change the particular set of tuples comprising a relation, being an instance of such a class is dynamically determined. For example, an Entity may, in principle, be a Resource at one time, but not at another.

There are many other important ROLES in the Specification that give rise to a *Role-Class* in OL; a few are noted below:

Assumption: The *State-Of-Affairs* in an *Assumed* relationship with some *Actor*;

Stake-Holder: An *Actor* that *Holds-Stake-In* some *Organisational-Unit*;

Purpose: a *State-Of-Affairs* that is either

- in a *Hold-Purpose* relationship with some *Actor*, or
- the *Intended-Purpose* of some *Plan*.

This is an interesting example Where *Purpose* is logically the union of two *Role Classes*.

8.1.3 State of Affairs

Informally, a STATE OF AFFAIRS is some kind of situation. It is something that can be thought of as holding, or being true (or conversely, as not holding, or as being false). Thus, in first-order logic, any state of affairs can be represented by a syntactically valid sentence, or formula. Note that while it may be convenient to think of a state of affairs as a set of sentences (*e.g.* $\{S_1, S_2, S_3\}$), this is equivalent to a single sentence using explicit

conjunction (*i.e.* $S_1 \wedge S_2 \wedge S_3$). Strictly speaking, then, to formally represent a state of affairs, is to formally specify the syntax of a first-order logic sentence. Fortunately, this and other meta-level things are already formalised in KIF, so there was no need to re-define this from scratch.

From a practical standpoint, the reason for having *State-Of-Affairs* in the Ontology is to clarify the meaning of certain terms (*e.g. Help-Achieve*, *Intended-Purpose*, *Pre-Condition* and *Effect*). In the code, this is done by restricting the argument types in certain relations. However, to be *any* sentence at all is a very loose, ineffective restriction. For example, Pre-Conditions and Effects relate to activities in the domain being modelled, thus we should like to further restrict the state of affairs to be only those sentences which refer to world state conditions. For example, *Home-City(John, Edinburgh)* should be allowed, but *Relconst('Intended-Purpose')* which refers to the representation language itself, should be prohibited[2].

So, the class *State-Of-Affairs* is too general because it allows sentences to be constructed referring to *any* relation at all. We require a way to define sub-classes of *State-Of-Affairs* by restricting the set of relations that can be referred to when constructing sentences representing states of affairs.

To do this, we define a meta-level binary relation: *Restricted-Sentence* whose first argument is a sentence, and whose second argument is a set of relational constants. The relation holds if and only if:

1. the first argument is a syntactically valid first-order logic sentence;
2. all relational constants referred to in the first argument are in the set comprising the second argument.

Here, the most general case is the degenerate one, where the second restriction has no effect. Formally, *S* is a *State-Of-Affairs* if and only if *Restricted-Sentence(S, AllRelconsts)* is true; where AllRelconsts is the set of all relational constants. Formally,

$$\forall S.(State_Of_Affairs(S) \quad \leftrightarrow \quad Restricted_Sentence(S, setofall(?r, relconst(?r))))$$

The more useful cases arise when one wishes to define sub-classes of State-Of-Affairs, such as *WS-Condition*, or *Authority-Condition*. Because there are likely to be a wide variety of world state relations, it would be awkward to have to explicitly list them. It is more convenient to create a separate class of world state relation constants, (*WS_Relconst*) and use the *setofall* function. Formally,

$$\forall S.(WS_Condition(S) \quad \leftrightarrow \quad Restricted_Sentence(S, setofall(?r, WS_Relconst(?r))))$$

Where, for example, *WS_Relconst('Home-City')* would be true and thus in the restricted set of relational constants.

[2] In KIF, *Relconst* is a unary relation representing relational constants; it is used in a bootstrapping fashion to define KIF syntax.

In other cases, the restriction may be to a very small number, or a single relational constant; then it is simpler to list them directly. For example,

$$\forall S.(Authority_Condition(S) \quad \leftrightarrow \quad Restricted_Sentence(S, setof('Hold_Authority')))$$

Final remarks. Strictly, to do a comprehensive job of formally defining State-Of-Affairs, we would have to essentially repeat what is defined in the KIF-Meta ontology, re-structuring it slightly to suit our purposes. We have chosen not to do this at this time.

See appendix A for a table summarising the correspondence between terms in the Meta-Ontology found in the Specification, and their encoding in Ontolingua.

8.2 Producing Formal Definitions

The Meta-Ontology as described above, is the formal foundation on which the definitions of all other terms is based. In producing formal definitions of the terms in the Meta-Ontology and of all other terms, a number of issues arose giving rise to the need to change things somewhat from how they were described in the Specification. Most of the important changes fell into the following categories, which we will address in turn:

- A number of terms were not defined at all;
- Some terms were defined from a different perspective;
- Many new terms were introduced.

For example, in the Meta-Ontology, ACHIEVE, ENTITY and RELATIONSHIP fall in the first category; ROLE is defined from a different perspective (*i.e. Role-Class*); and POTENTIAL ACTOR is a new term (not found in version 1.0 of the Specification). Below we elaborate on these issues and give further examples from the main sections of the Ontology.

8.2.1 Terms not Defined

In some cases, a term referred to a concept which there was no obvious need to define, or there was no obvious way to do so in a useful manner.

For example, ACTIVITY-DECOMPOSITION is manifest in the details of how SUB-ACTIVITIES are inter-related, and other constraints that comprise an ACTIVITY SPECIFICATION. Defining something formally corresponding to an ACTIVITY DECOMPOSITION did not seem useful.

A MANAGEMENT LINK is defined to be a specific relationship between two particular ORGANISATIONAL UNITS. In the code, we instead define the *Manages* relation which

formally represents all such links as a set of tuples. Formally, MANAGEMENT LINK refers to the class of all tuples that are in the *Manages* relation; there was no need to formally define such a class.

Similarly, in version 1.0, ORGANISATIONAL STRUCTURE was defined to be "the MANAGEMENT LINKS relating a set of OUs" which strictly speaking, can be interpreted to be identical to the set of tuples comprising the *Manages* relation, and thus is also unnecessary to define.

8.2.2 Terms Viewed from a New Perspective

In some cases, the perspective from which an entirely clear and natural definition was given in the Specification, was awkward to base the formal definition on. For example, AUTHORITY is defined as "the right of an Actor to EXECUTE an ACTIVITY SPECIFICATION". However, it was simpler to model this as a binary relation (*Hold-Authority*) denoting the *fact* that an ACTOR has the right to EXECUTE an ACTIVITY SPECIFICATION. There is no essential change in meaning, just of perspective. It would be possible to model the 'right' explicitly to retain the original perspective, but this was not deemed useful.

8.2.3 New Terms

There are rather more terms in the code than in the Specification. There are three main reasons for this.

1. to fill gaps, *i.e.* things were missing in the Specification;
2. to make explicit much that which was only implied in the Specification which required teasing out;
3. to formalise logical connections that were clearly evident, but not precisely characterised in the Specification.

Filling Gaps Examples of the first situation are SALE OFFER and ACTIVITY SPECIFICATION. The latter is a particularly important concept which was deemed to require explicit definition, so as to distinguish a set of instructions for doing something from the doing of the thing itself (*i.e.* ACTIVITY). The underlying concept was clearly evident in the original definition of PLAN (in version 1.0): "a specification of one or more ACTIVITIES for some PURPOSE". With the addition of ACTIVITY SPECIFICATION, this was changed to "an ACTIVITY SPECIFICATION with an INTENDED PURPOSE".

Making Things Explicit An example of the second situation arises where something is defined in the Specification as 'a Role in a Relationship between an X and a Y whereby ...'. For example, Assumption is defined to be "a Role of a State Of Affairs in a Relationship

with an Actor whereby the Actor takes the State Of Affairs to be true without knowing whether it is true or not". In the Specification, it is only noted that the Relationship exists but it is neither named nor defined. These Relationships are formalised as [usually binary] relations. In this case, the *Assumed* relation was defined and *Assumption* is a *Role-Class* formally defined in terms of this relation.

Formalising Logical Connections As an example of the last situation, consider the following definitions from version 1.0 of this document:

PLANNING: an ACTIVITY whose major EFFECT is to produce a PLAN;

STRATEGY: a PLAN to ACHIEVE a high-level PURPOSE;

STRATEGIC PLANNING: an ACTIVITY whose PURPOSE is to produce a STRATEGY.

Problems with these definitions are:

- the idea of a 'major EFFECT' is undefined;
- 'high-level PURPOSE' has no meaning, though it appears to be a special kind of PURPOSE;
- STRATEGIC PLANNING is not defined in terms of PLANNING;
- the phrase 'to produce' is used in the definitions of STRATEGIC PLANNING and PLANNING, but is undefined.

To address this, we made the following alterations:

- We introduced a new term: *Strategic-Purpose* which is formally defined as a type of *Purpose*;
- *Strategic Planning* is formally defined as a type of *Planning*;
- 'to produce' is defined as a Relationship called *Actual-Output* between an *Activity* and an Entity where by the Entity is an output produced by the *Activity*;
- the idea of a 'major EFFECT' is formalised using *Intended-Purpose* which is linked with *Actual-Output* in the formal definition of *Planning*.

Most of these changes are reflected in the current version of this document, the major exception being *Actual-Output*, which is defined only in the code. The following definitions are as given in the code:

Planning: An *Activity* whose *Intended-Purpose* is to produce a *Plan*.

Strategic-Purpose: A *Purpose* held by an *Actor* that is declared to be of 'Strategic' importance.

Strategy: a *Plan* whose *Intended-Purpose* is a *Strategic-Purpose*

Strategic-Planning: a *Planning Activity* whose *Intended-Purpose* is to produce [an *Actual-Output* which is] a *Strategy*

Although we avoiding the use of the term 'high-level', the resulting definition of *Strategic-Purpose* has a circular aspect. The fact is, whether something is 'strategic' or not, is a fairly arbitrary declaration. It is up to users to use this is a sensible manner.

Summarising this example, by introducing two new terms: *Strategic-Purpose* and *Actual-Output* we have been able to make our definitions more precise, making various implicit connections explicit.

9 Conclusion

This document contains Version 1.1 of the Enterprise Ontology developed as part of the Enterprise Project. Its scope is limited to those core concepts required for the project, however it is expected that it will appeal to a wider audience.

The Enterprise Ontology, here described in natural language, has subsequently been coded in the formal language: Ontolingua. A prior version of this document served as a specification for this coding effort. The relatively small number of changes to the Enterprise Ontology identified while coding are reflected in this version. As such, clarity of exposition has been emphasised over historical accuracy.

9.1 Relationship with existing efforts

An important goal has been to ensure that the Enterprise Ontology is compatible with existing ontologies. Thus, the development of the Ontology has taken account of other external ontology developments whenever possible. In the early stages, considerable use was made of Collin's Business dictionary to ensure consistency of usage of terms. The Activity ontology is broadly consistent with two major external ontologies: TOVE and KRSL. The Time and Meta-Ontology both have input from external activity. For other parts, (*e.g.* Market, Organisation), it has not yet been possible to do significant benchmarking against external activities.

9.2 Further Developments

This Ontology will be further refined and extended during the lifetime of the Enterprise Project. In addition to development of this core Ontology, each user of the Enterprise

toolset may require their own specific ontological extensions.

9.3 Acknowledgements and References

The Enterprise Ontology has been developed largely from scratch; however it was inspired and influenced by many other projects and efforts, too numerous to mention. The main influences are listed below, together with references:

TOVE: TOronto Virtual Enterprise project, University of Toronto.

- Mark S. Fox, J Chionglo, Fadi George Fadel, 'The Toronto Virtual Enterprise model', Enterprise Integration Laboratory, University of Toronto, 1993
- Fadi George Fadel, Mark S. Fox and Michael Gruninger, 'A Resource Ontology for Enterprise Modelling', Submitted to Third IEEE Workshop on Enabling Technologies: Infrastructures for Collaborative Enterprises (WET ICE 1994), Morgantown, West Virginia, 1994
- Michael Gruninger and Mark S. Fox, 'An Activity Ontology for Enterprise Modelling', Submitted to Third IEEE Workshop on Enabling Technologies: Infrastructures for Collaborative Enterprises (WET ICE '94), Morgantown, West Virginia, 1994

O-Plan: Planning and Scheduling group, AIAI;

- A. Tate, "Characterising Plans as a Set of Constraints - the ⟨I-N-OVA⟩ Model - a Framework for Comparative Analysis", Special Issue on "Evaluation of Plans, Planners, and Planning Agents", ACM SIGART Bulletin Vol. 6 No. 1, January 1995.
- K.W. Currie and A. Tate, 'O-Plan: the Open Planning Architecture', Artificial Intelligence, 51(1) 1991
- A. Tate, B. Drabble and R. Kirby, 'O-Plan2: an Open Architecture for Command, Planning and Control' in M. Fox and M. Zweben (eds), Intelligent Scheduling, Morgan Kaufmann, 1994

ARPA/Rome Laboratory Planning and Scheduling Initiative:

- Knowledge Representation Specification Language (KRSL) Reference Manual – Version 2.0.2; edited by Nancy Lehrer; February 1993
- A. Tate, 'Plan Ontology' - a paper to the Workshop on Ontology development and use, San Diego, California, USA, November 1994

The Time section of the Enterprise Ontology was imported from KRSL and is largely unchanged; the Plan Ontology influenced the development of the Activity section. Both documents are available through the world-wide web:

http://isx.com/pub/ARPI/ARPI-pub/krsl/krsl-info.html

ORDIT: Esprit project No. 2301

- A.J.C.Blyth, J.Chudge, J.E.Dobson snf M.R.Strens, 'ORDIT: A new methodology to assist in the process of eliciting and modelling organisational requirements', Proceedings on the Conference on Organisational Computing Systems, Nov, San Jose, California, 1993.

People actively involved in developing and/or reviewing the natural language version of the Enterprise Ontology include: Nigel Carr, Faramarz Farhoodi, John Fraser, Ian Filby, Martin Gladwell, Ann Macintosh, Keith Mantell, Melita Saville, Jussi Stader and Austin Tate. Mark Fox provided valuable insights during a flying visit. We extend thanks also to the many others who assisted in a variety of ways but are not mentioned.

Coding the Ontology The existence of the Ontolingua language (based on KIF) in general and the Ontology Editor in particular has greatly facilitated the process of converting the natural language specification of the ontology into a formal language. We extend thanks to James Rice in particular and the team at Knowledge Systems Lab (KSL) Services in general who were extremely helpful during the coding effort showing unusual commitment to our being satisfied users. Details of KSL are available on the World-Wide Web at *http://www-ksl.stanford.edu/*.

Persons who provided useful comments and feedback on various versions of the code include: Florence Fillion, Nicola Guarino, Ian Harrison, Martin King, Chris Menzel and Austin Tate.

A Term Encodings

In this appendix, we indicate whether and how each term in the Specification of the Enterprise Ontology is formally represented in Ontolingua. This information is given in a series of tables, one for each major section of the Ontology. Within each table, terms are listed in alphabetical order. This is valid for version 0.1 of the code of the Enterprise Ontology, currently available for browsing on the World-Wide Web from:
http://www.aiai.ed.ac.uk/~entprise/enterprise/ontology.html.

ACHIEVE	*not defined*; see Help-Achieve
ACTOR	Actor
ACTOR ROLE	*not defined*; see Actor, Role-Class, Qua-Entity
ATTRIBUTE	*not defined*; meaning as: Function@Kif-Relations
ENTITY	*not defined*; equivalent in meaning to union of Set@Frame-Ontology and Thing@Frame-Ontology most similar defined term: EO-Entity
POTENTIAL ACTOR	Potential-Actor
RELATIONSHIP	*not defined*; equivalent in meaning to Relation@Frame-Ontology (excluding unary relations)
STATE OF AFFAIRS	State-Of-Affairs
ROLE	*not defined* implicit in the semantics of an argument in a Relation see Role-Class; Qua-Entity

This table indicates for each term in the Specification, which term or terms most closely correspond to it in the formal code.

Figure 2: Meta-Ontology

ACTIVITY	Activity
ACTIVITY OWNER	Activity-Owner
ACTIVITY SPECIFICATION	Activity-Spec
AUTHORITY	Hold-Authority
CAPABILITY	Have-Capability
DOER	Actual-Doer; see also Specified-Doer
EFFECT	Effect; see also Planning-Constraint
EVENT	Event
EXECUTE	Specified-To-Execute; see also Actually-Execute
EXECUTED ACTIVITY SPECIFICATION	Execution-Of-Activity-Spec
PLAN	Plan
PLANNING	Planning
PRE-CONDITION	Pre-Condition; see also Planning-Constraint
PROCESS SPECIFICATION	Process-Spec
RESOURCE	Resource; see also Can-Use-Resource
RESOURCE ALLOCATION	Resource-Allocation
RESOURCE SUBSTITUTE	Resource-Substitute
SKILL	Have-Skill
SUB-ACTIVITY	Sub-Activity; see also Sub-Activity-Spec
SUB-PLAN	Sub-Plan; see also Sub-Plan-Of

This table indicates for each term in the Specification, which term or terms most closely correspond to it in the formal code.

Figure 3: Activities and Processes

ASSET	Asset
CORPORATION	Corporation
DELEGATE	Delegate
EMPLOYMENT CONTRACT	Employment-Contract
LEGAL ENTITY	Legal-Entity
LEGAL OWNERSHIP	Legal-Ownership
MACHINE	Machine
MANAGE	Manage
MANAGEMENT LINK	*not defined*; see Manages
NON-LEGAL OWNERSHIP	Non-Legal-Ownership
ORGANISATIONAL UNIT	Organisational-Unit
OWNER	Owner
OWNERSHIP	Ownership
PARTNER	Partner; see also Partner-Of
PARTNERSHIP	Partnership
PERSON	Person
SHARE	Share
SHAREHOLDER	Shareholder; see also Shareholder-Of, Shareholding
STAKEHOLDER	Stakeholder; see also Holds-Stake-In

This table indicates for each term in the Specification, which term or terms most closely correspond to it in the formal code.

Figure 4: Organisation

ASSUMPTION	Assumption; see also Assumed
CRITICAL ASSUMPTION	Critical-Assumption
CRITICAL INFLUENCE FACTOR	Critical-Influence-Factor
CRITICAL SUCCESS FACTOR	Critical-Success-Factor
DECISION	Decision
GOAL	Goal
HELP ACHIEVE	Help-Achieve
HOLD PURPOSE	Hold-Purpose
INFLUENCE FACTOR	Influence-Factor
INTENDED PURPOSE	Intended-Purpose
MISSION	Mission
NON-CRITICAL ASSUMPTION	Non-Critical-Assumption
NON-CRITICAL INFLUENCE FACTOR	Non-Critical-Influence-Factor
OBJECTIVE	Objective
PURPOSE	Purpose
PURPOSE-HOLDER	Purpose-Holder
RISK	*not defined*; see Perceived-Risk
STRATEGIC ACTION	Strategic-Action
STRATEGIC PLANNING	Strategic-Planning
STRATEGIC PURPOSE	Strategic-Purpose
STRATEGY	Strategy
VISION	Vision

This table indicates for each term in the Specification, which term or terms most closely correspond to it in the formal code.

Figure 5: Strategy

ACTUAL CUSTOMER	Actual-Customer
ASKING PRICE	Asking-Price
BRAND	Brand
COMPETITOR	Competitor
CUSTOMER	Customer
FEATURE	Feature
FOR SALE	For-Sale
IMAGE	Image
MARKET	Market
MARKET NEED	Market-Need
MARKET RESEARCH	Market-Research
MARKET SEGMENT	Market-Segment
NEED	Need
POTENTIAL CUSTOMER	Potential-Customer
POTENTIAL SALE	Potential-Sale
PRODUCT	Product
PROMOTION	Promotion
RESELLER	Reseller
SALE	Sale
SALE OFFER	Sale-Offer
SALE PRICE	Sale-Price
SEGMENTATION VARIABLE	Segmentation-Variable
VENDOR	Vendor

This table indicates for each term in the Specification, which term or terms most closely correspond to it in the formal code.

Figure 6: Marketing

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