

TOWARDS A TAXONOMY OF MANAGEMENT IN CONSTRUCTION: EXPLORING THE STRUCTURE OF MANAGEMENT

Christian T Lindfors¹

Department of Construction Management and Economics, The Royal Institute of Technology, Drottning Kristinas väg 30, SE-100 44 Stockholm, Sweden

Managing the complexity of construction, in terms of handling, controlling and directing organizations and projects to achieve success, forms part of the current work in the research project 'Value chain management in construction', being undertaken in collaboration with a major construction company.

Some of the early work has pinpointed deficiencies in current management thinking and practice within the subject company. One hypothesis is that organizational and project success is linked to the extent to which a company or other organization is able to understand all the issues of management, independent of the fact that one manages a small project or manages a large company. In order to be in a position to understand the true extent of management, linguistic breakdowns have been performed to try to establish consistency in the various meanings² implied by the word 'management' and how these measure up to current thinking and practice. To produce the taxonomy, an established methodology was used to give a more structured approach and to enhance the validity of the research.

As a step towards the development of this taxonomy, a preliminary structure to define the subject of management is presented. This first pass through the linguistic landscape has produced a rough taxonomic representation for understanding management in construction.

Keywords: construction management, management innovation, ontology, taxonomy.

INTRODUCTION

Management is an important factor in construction, which determine company success and company survival. That is why many construction companies keep jumping on new management fads³ even though the last ones failed. In Sweden construction companies and managers are overflowed by management innovations and so called three-letter-acronyms on a daily basis, which all promise gold and great fortunes. But, when attempting to implement them, most of the time, problems occur. And when problems occur, a new three-letter-acronym is there to replace the old, and so on. This is where many companies and managers find themselves today, navigating between management innovations trying to catch up with the latest trends in management.

¹ lindfors@recm.kth.se

² In Swedish, and indeed several other languages, there is no direct equivalent of the English word 'management'. Tradition assumes the use of a number of words that apply in specific contexts. This means that cross-cultural communication can become problematic at various levels between organizations.

³ Unsuccessful or incomplete management innovations, riding on the charm of novelty

In the 1950's Drucker (1954) makes the statement that "management is a multi-purpose organ that manages a business, manages managers and manages workers and work." Nonetheless, no unified approach has been taken to explain what measures a management innovation should comprise of, in order to serve as complete management support for construction companies. Evaluating the impact of management innovations will require that systematic and reliable information be available at multiple levels of analysis. (Bennett and Yadrick, 1996)

Establishing a single taxonomic representation of management issues would help comparative studies in the efforts to understand the impacts of management innovations. "Without some framework of study it would be like trying to catch water in a sieve" (Mullins, 1996). By creating a taxonomy and a common nomenclature, expectations are that managers and scientists will be able to overcome the terminological confusion in the area of construction management, which they are exposed to on a daily basis. Such an approach should preferably be as generic and abstract as possible to generate a highly flexible and adaptable representation to support the need to categorize management innovations and their methods.

The reason of trying to dissect the word management is an attempt to understand the basic meaning of it. In Swedish⁴, and indeed several other languages, there is no direct equivalent of the English word 'management'. Tradition assumes the use of a number of words that apply in specific contexts. This means that cross-cultural communication can become problematic at various levels between organizations. Many new management innovations pop up with names and substance, which are very difficult (hard) to interpret, e.g. knowledge management, process management and customer relation management. Using the word management does not imply that all aspects of management science are covered.

The hypothesis that organizational and project success is linked to the extent to which a company or organization is able to understand all the issues of management, independent of the fact that one manages a project, a business a government or country is based on above mentioned statements. By only using the Webster's New World dictionary, the perspective has been limited to the American use of the word. The choice of using only one source of reference, for the definition of management, can be explained by the difficulty of using multiple perspectives when solving a problem.

The purpose of this paper is to address some theoretical issues about the basics behind construction management and to suggest a generic taxonomy of management in construction. Also how companies and managers in construction could use this new taxonomy to improve their internal and external management, based on the understanding that it will improve effectiveness and performance in the construction management area. The second and third sections of this paper will explain the concepts of taxonomic and ontological structuring and describe the methodology used in the construct of the taxonomy. In the penultimate section the conceptual taxonomy of management in construction is described and discussed. The final section presents the conclusions and discusses future uses of the taxonomy.

⁴ North Germanic language spoken in Sweden and a part of Finland

TAXONOMIC AND ONTOLOGICAL STRUCTURING

The need for a common language and structure is of importance when trying to compare and evaluate management innovations and their methods. This could be made easier with the help of a taxonomic or ontological representation of the management area. By studying literature in the above-mentioned areas, many similarities have been discovered. (Jansson, 1986; Fox and Gruninger, 1994; Chandrasekaran and Josephson, 1997; Uschold, 1996) Similarities in the three areas make work undertaken in one area applicable in another. To strengthen this statement, a comparative study was performed to show similarities in their definitions. The definitions of taxonomy and ontology are quite similar, making a clear distinction from one another difficult to achieve. To display some of the similarities a number of definitions of the expressions are listed down below:

Taxonomy The science of *classification*; laws and principles covering the *classifying of objects* (Webster's New World, 1997)

"Is partial ordering on a set of *categories*, based on the subset *relation* of the categories." (Jansson, 1986)

"Taxonomy: 1828. *Classification*, especially in *relation* to its general laws or principles; that department of science, or of a particular science or subject, which consists of or relates to *classification*; 1960. The systematic classification of anything" (Oxford English Dictionary, 1989).

Ontology "The branch of metaphysics dealing with the nature of being, reality, or ultimate substance" (Webster's New World, 1997).

"Is a formal *description of entities and their properties*; it forms a shared terminology for the objects of interests in the domain, along with definitions for the meaning for each of the terms" (Fox and Gruninger, 1994).

"In the [artificial intelligence community] (AI)- a *representation* of vocabulary, typically specialized to some domain or subject matter" (Chandrasekaran and Josephson, 1997).

Ontology: 1721. The science or study of being; that department of metaphysics which relates to the being or essence of things, or to being in the abstract" (Oxford English Dictionary, 1989).

In the definitions above a number of expressions are frequently used, e.g. *categorizing, representation and classification of objects/entities and their properties*. Thus, there are very big similarities between the scientific areas. Based on this assertion, the taxonomy produced in this paper has been produced with knowledge acquired from both taxonomic and ontological research.

Taxonomic structuring

A taxonomy provides a guiding structure for a classification system. It shows the user the clusters and relationships and the combined use of categorization and decomposition is of fundamental importance for taxonomic representation, which can appear from information in many patterns. "The user can, for instance, either zoom down to fine-grained levels to pin down exact items, or [one] can scan and highlight different parts of a system, enabling the potential creation of knowledge through open associations of relevant material" (Roberts-Witt, 1999).

"Taxonomic structuring starts with a set of samples, which are then grouped into taxa. Taxa may further be grouped into supertaxa. The resulting taxonomy is generally a tree or forest of taxon trees with samples at the leaves. Problems arise in taxonomic work when taxa or samples are differently presented and/or named by different researchers" (Nürnberg *et al.*, 1997). The simpler and more functional a taxonomy is the more useful it becomes. Broad, flat taxonomies are more effective than deep vertical ones (Uschold, 1996; Roberts-Witt, 1999). Two commonly used approaches for developing taxonomies are the priori categorization and the free categorization. The priori categorization approach simply pre-defines the categories and terms, and

the free categorization approach means mining the information and knowledge and then seeing what categories 'bubble up' (Roberts-Witt, 1999).

Taxonomic representations are important for the design of knowledge and information processing systems. Jansson (1986) indicated that only the surface had been scratched, within the research community of linguistics, "in the present representation schemes and current system designs with regard to the potential of this kind of representation". In the creation of this taxonomy, work is concentrating on linguistics, which has resulted in trees of languages, in many ways similar to taxonomic structures, but even more complex. "Furthermore, unlike most taxonomies, it is common for languages in linguistic taxonomies to have multiple parents" (Nürnberg *et al.*, 1997). Very generic taxonomies are occasionally referred to as upper-level models and are used for categorizing considerable fractions of human knowledge, e.g. for natural understanding. Important uses of taxonomies are (Jansson, 1986):

Network of contexts: access structures for contexts are often designed in a way similar to the specialization of concepts. There exists interplay between taxonomic structures and such access structures.

Viewpoints of concepts: a frequently used style of expressing views or schematic characterization of concepts, is the use of multiple generalization and classification.

Explicitly similarity measures: taxonomies may be used as a simple form of similarity measure for concepts. Either directly by establishing a metric based on the taxonomy or indirectly by comparing objects and concepts based on a taxonomy of attributes.

Specialization of procedures: an important possibility is to relate procedures in taxonomies. The current most frequent cases are one level structures.

What seems to be missing is a comprehensive taxonomy of management in construction, which will help capture the diversity of management innovations and their methods, which can be used as a basis for further understanding and future developments in the construction management area.

Taxonomy and ontology = theory?

Ontologies and taxonomies are often referred to as equals of theories. Many statements suggest that they meet the criteria for theories (Chandrasekaran and Josephson, 1997; Jansson, 1986). Jansson (1986) mentions "that a taxonomic representation is such a general useful technique ... that it may be connected to a diversity of research areas like, system development methods, *and formal theory of information systems.*" Chandrasekaran and Josephson (1997) confirm this statement by suggesting that "ontologies are quintessentially content theories

One criterion for considering an ontological structure as a theory is the identification of a construct. Either epistemological or empirical methods of theorizing ontologies are common for building an ontological theory. Another criterion implies that the predictions associated with an ontology must be testable and subject to dis-corroboration. However, in order for a formal theory to be useful it must be preceded by a clear informal understanding of all aspects that it includes (Jansson, 1986).

The purpose of this taxonomy is not essentially to create a new management theory; it is rather an attempt to organize the concept of management by producing a single representation of the area.

METHODOLOGY

“Very little can be said with certainty about the structure and formation of taxonomies” (Jansson, 1986). A taxonomy may take a variety of forms, but it will always include a vocabulary of terms, and a classification of their relationships. This includes a purpose and unambiguous definitions of the language used. When creating a taxonomy one should always determine the need for one, by settling on the problem that needs to be addressed. It is always important to be clear why the taxonomy is being built and what its intended uses are. Once this has been done the hard work of actually developing the classification system can finally begin. The methodology used to develop the ‘taxonomy of management in construction’ is the methodology developed by (Uschold and King, 1995; Uschold, 1996). “This methodology is based on the experience of developing the enterprise ontology and the TOVE (Toronto Virtual Enterprise) ontology. This methodology provides guidelines for developing ontologies” (López, 1999). The methodology developed by Uschold (1996) consists of five steps: *Purpose; Level of formality; Scope: subject matter; Building; and Evaluation /revision cycle.*

Purpose

The intended users of this taxonomy are managers and scientists in the construction management area. The taxonomy is intended to assist the process of identify measures to be included in a management system, serving as an index or a base structure for developments of such. Also, bring interoperability among management innovations and their methods, achieved by translation between different management dialects and expressions and generate greater understanding of the management area among practitioners and scientists (see motivating scenario).

Motivating scenario: A manager is wondering what measures he/she should take when managing an organization. He/She has recently taken a course were he/she has encountered a management innovation which he/she is thinking of applying on an all-embracing level to his/her operations. The one thing he/she does not know is if this new management innovation covers all his/her needs for managing his/her organization. This example could actually have been taken from a real life scenario from the construction company involved in this research project.

Two years ago, the subject company decided upon applying a management innovation as their new management system on an all-embracing level. The innovation was applied in a top-down manner as specified. After a year’s execution, they started to understand that the system did not satisfy their intended needs. Thoughts were raised concerning implementation issues. Had it been implemented the wrong way or was it just lacking in its usability? After a closer investigation it was revealed that the innovation was just not behaving as it was intended to do, it was also lacking some vital measures in the managerial areas. The case in itself motivates the need of a taxonomy describing the basics of management. The subject company mentioned in the case would absolutely have benefited by a ‘taxonomy of management in construction.’ This in order to detect that some important measures were missing and that the innovation had to be complemented, or replaced, by another management innovation. By building the taxonomy, hopes are put on the fact that managers and scientists in the construction management area will be able to overcome the terminological confusion in the area of management innovations.

Competency questions: What measures have to be taken into consideration when creating a holistic management innovation? What management innovations and tools can complement each other to cover all measures necessary to perform to be successful in managing operations? What management innovations and methods should I use to cover my need of construction management requirements?

Level of formality

If formality can be divided into four hypothetical positions along a scale of formality: 1) highly informal; 2) structured-informal; 3) semi formal; and 4) rigorously formal, the taxonomy of management in construction is structured informal. By structured informal meaning that it is expressed in a restricted and structured form of natural language, greatly increasing clarity by reducing ambiguity by well-used definitions. (Uschold, 1996; Uschold and Jasper, 1999)

Scope and subject matter

The scope of the taxonomy is limited to management and management innovations in the construction management field. However, it is generic enough to serve a wide variety of users and fields of research. The subject matter is the basics of construction management. Thus, what measures to take into consideration when improving the organizational management system by applying management innovations.

Taxonomy building

The main activity is to produce the definitions, but some decisions must also be made as to how and whether to arrange the definitions in any particular way, thus structuring the taxonomy. (Uschold, 1996) Produce a complete intermediate document, an informal taxonomy consisting of terms and definitions in a structured form of natural language. (Uschold, 1996) The general criteria for taxonomy building described by Uschold (1996), states that a taxonomy shall meet the following criteria: *Clarity* - Definitions should be maximally clear and unambiguous; *Consistency and Coherence* - One should avoid introducing new terms, instead, consult dictionaries, thesauri, and technical glossaries; and *Extensibility and Reusability*: One should design a taxonomy in such a way as to maximize subsequent reuse and extensibility.

The axiom of this study can be represented by the quote “Management is management, whether it is applied to a project, business, government or country”. The taxonomy was produced of precise and unambiguous language definitions for the concept of management and its relationships. More about the taxonomy creation is described in the ‘A conceptual taxonomy of management in construction’- section.

Evaluation / revision cycle

When the taxonomy has been properly structured and defined an evaluation/revise cycle will be performed before the informal taxonomy is deemed to be complete. This is yet to be performed. One should make a judgement of the taxonomy with respect to the frame of reference, which may be requirement specifications, competency questions, and or the real world to deem if it fulfils the overall goal. Specifically, the taxonomy must be able to answer all the formal competency questions, as well as contain only terms, definitions and axioms that are required to answer at least one competency question. (Uschold, 1996)

A CONCEPTUAL TAXONOMY OF MANAGEMENT IN CONSTRUCTION

Structure

The taxonomy described in this article was built “top down” by examining the word management from a linguistic perspective, and attempting to organize and categorize the deduced words in a way that might be useful and helpful when trying to examine management innovations and their methods. A deductive approach was taken moving from the general to the particular. The purpose here was to highlight the wide variety of options open to managers and management scientists. The methodology used when developing the taxonomy is described earlier in the methodology section. The development of the taxonomy started with the definition of management, which was derived from the ‘Webster’s New World’ dictionary an American dictionary guide to current American usage. The limitation of using only one source could be explained by the difficulty of applying more than one perspective to a problem. By only using the Webster’s New World dictionary, the perspective was limited to the American use of the word. From these definitions a number of words were derived: Direct, Control, and Handle. These were then defined and decomposed exactly like the word ‘management’. By defining the word and then decompose it into to a higher degree of precision, a highly structured model started to appear (see the ‘Definition’ section down below).

Definitions (Webster’s New World dictionary, 1997)

Management is defined as the act, art or manner of managing, or controlling, or directing, or handling. The word ‘manage’ is a verbification of management, and can therefore be derived from the word management.

UNDERSTANDING THE ISSUES OF MANAGEMENT

The taxonomy indicates the major kinds of variables and measures to take into consideration, as well as the major issues to enhance understanding among practitioners and scientists. Instead of focusing on the tangle of uncertainty and complexity that troubles too many construction projects, the concept of understanding is concerned with having clarity and the absence of ambiguity. By increasing the understanding of managers who are ignorant of some of the basic thinking behind management, thought are made that the personal development level will increase from being passive to active. Instead of being over-stimulated, i.e. the surrounding environment is developing faster than the own understanding, one could use the taxonomy to understand the basics of one’s needs and then try to find the management innovations to support these needs. The structure of the taxonomy offers a valid and logical way of addressing at least the basic thinking behind management. The taxonomy was developed as a way of organizing the many different approaches of management innovations and methods.

Manage	To <u>control</u> the movement or behaviour of; <u>handle</u> To have change of; <u>direct</u>	
Taxon L1	Taxon L2	
Control	To <u>check</u> or <u>verify</u> by comparison with a duplicate register To <u>regulate</u> To <u>verify</u> by comparing with a standard or by other experiments To exercise authority over, <u>direct</u> , <u>command</u> To <u>operate</u> or <u>regulate</u> To hold back; curb; <u>restrain</u>	
Direct	To <u>manage</u> the affairs, course, or action, of; <u>guide</u> , <u>regulate</u> To order or <u>command</u> with authority To turn or <u>point</u> (a person or thing) toward an object or goal; <u>aim</u> ; head To tell (a person) the way to a place To <u>address</u> (words, remarks) to a specific person or persons To <u>plan</u> the actions and the effects and to <u>supervise</u> and <u>instruct</u> in the carrying out of such a plan To <u>give directions</u> ; make a practice of directions	
Handle	To <u>manage</u> , <u>operate</u> , or use with the hand or hands; <u>manipulate</u> To <u>manage</u> , <u>direct</u> , <u>train</u> , etc. To deal with or <u>treat</u> in a particular way To deal with successfully or appropriately To behave toward; <u>treat</u>	
Top level	Taxon L2	Taxon L4
Manage	Check	Analyse, characterize, chart, collate, diagnose, distinguish, estimate, evaluate, examine, examine resemblance or difference, grade, inspect, investigate, jot, measure, observe, record, register, study, survey, systematically inquire, test by questioning, try, view in relation to
	Verify	Allot to a particular place, analyse, compare against a standard, diagnose, establish the truth, evaluate, examine, give new assurance of the validity of, prove, observe, ratify, regard, relate, send for information and decision, show, study, survey, systematically inquire, try, validate
	Regulate	Adapt, bring in conformity with a standard, compare with standard, exercise authority, exercise control over, manipulate, rectify, resolve, restrain, settle, systematize
	Command	To have authority, To have jurisdiction
	Operate	Accomplish, cause to produce, contrive, control or guide the operation, effect, exploit, forge, keep in motion, put into operation, shape, solve
	Restrain	Assign certain limits to, curtail, hinder, hold or keep back, interpose, keep from happening or existing, keep under control, prescribe, reduce to confine without bounds, stop
	Instruct	Cause to know, communicate knowledge, connect, convey knowledge and information about, develop, give information, guide the studies of, inform, import information and knowledge, make known and accepted, provide instructions, provide schooling, share knowledge, train, transit information and knowledge
	Guide	Aim of an objective, direct the operations, drill, guide on a way, have charge of, instructions, teach as to make fit, undergo
	Regulate	Adapt, bring in conformity with a standard, compare with standard, exercise authority, exercise control over, manipulate, rectify, resolve, restrain, settle, systematize
	Order	Adjust, administratively structure, arrange by systematic planning, arrange elements, ask, bring about, integrate, orchestrate, prepare, relate, sequence, settle, set up an plan, unionize
	Command	To have authority, To have jurisdiction
	Point	Accord, allege, bestow, conduct, declare, direct attention to, exhibit, inform, instruct, observe, perform, plead, present, say, take notice of, usher
	Aim	Believe, change, conjecture, intuit, mean, opinionize, plan, signify, suppose
	Head	Be ahead, direct the operations, guide on a way, have charge of, preface, surpass in rank and dignity and importance
	Address	Administer, ask, assign, deliver, designate, devise, encounter, make ready beforehand for some purpose, meet, plan, predetermine, signal, strategize, talk
	Plan	Construct, form into or according to structure, form into a scheme or systematic arrangement, intend purpose, remember, remind
	Supervise	Examine, inspect, have or exercise the charge and oversight of, survey, watch
Operate	Accomplish, cause to produce, contrive, control or guide the operation, effect, exploit, forge, keep in motion, put into operation, shape, solve	
Train	Bring to maturity through neutering care and education, bring under control, drill, expand by a process of growth, expound, introduce, make effective in action, make ready beforehand for some purpose, modify, plan, repeat in order to strengthen or develop teach, stipulate, strategy, supervise	
Treat	Administer, behave forward, deliver, function, move forward, name or state explicitly or in detail, work	
Manipulate	Administer, behave forward, cause to produce, contrive, control or guide the operation, deliver, effect, exploit, forge, function, keep in motion, move forward, name or state explicitly or in detail, shape, solve, work	
Respond	Answer, counteract, reciprocate	
Submit	Evoke, imply, inspire, make amenable, mention, nominate, offer for consideration or as a hypothesis, predispose, propose, seduce, set forth, set before the mind, subjugate	

Figure 1: The preliminary taxonomy of management in construction (Taxon Level 1 and 3, has been extracted for display purposes only)

CONCLUSIONS

The purpose of this study was to establish the theoretical validity of a conceptual taxonomy of management in construction and to use this taxonomy as a possible framework for additional investigation into the nature of management innovations and their methods. In this paper, a step has been taken toward the development of a preliminary taxonomy for the assessment of management innovations.

The hypothesis of the research states that, "organizational and project success is linked to the extent to which a company or organization is able to understand all the issues of management, independent of the fact that one manages a project, a business or a government, country." In the creation of the taxonomy of management in construction, a step has been taken towards the goal of clarifying the fundamentals of management. A well-defined structure has been presented. (See figure 1 and appendix 1) A step has also been taken towards a taxonomy to clarify the ambiguities created by the numerous amounts of management innovations available on the market today. The structure of the taxonomy offers a valid and logical way of addressing at least the basic thinking behind management.

Using the methodology developed by Uschold (1996), the work has been given a more structured approach and factors of importance have been taken into consideration to create a valid taxonomy of management in construction. Such a taxonomy can be used to drive construction management research and development in a number of critical areas and provide a means of systematically extrapolating data describing a current managerial situation. Managers and management scientists can with such a taxonomy overcome the terminological confusion in the area of construction management, which they are exposed to on a daily basis. Creating and acquiring knowledge will always be hard work of business. By developing practical taxonomies, managers should not also have to struggle to find the required framework of knowledge the second time around.

Additional research and development is required to improve and evaluate the taxonomy. This work will involve further categorizing of the fourth level taxons. Ordering the taxons in a logical way for display to reach the generality of the taxonomy needed for future usability. Comparing existing management innovations against the generic categories will then test the taxonomy.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the financial support of the Foundation for Strategic Research (SSF) and NCC AB, as co-sponsor, for the project, "Value chain management in construction", which forms part of the Swedish national graduate school and research programme, Competitive Building. The author also wishes to acknowledge Brian L. Atkin, Professor in Construction Management and Economics at the Royal Institute of Technology, for the supervision of the research project.

REFERENCES

- Bennett, W. Jr. and Yadrick, R. M. (1996) Taxonomic considerations in organizational. *Assessment and process change, Proceedings of the 38th Annual Conference of the International Military Testing Association*. San Antonio, Texas, USA.
- Chandrasekaran, B. and Josephson, J. R. and Benjamins, R. V. (1997) Ontology of tasks and methods. *1997 AAAI spring symposium on ontological engineering*. Stanford, California, USA.

- Drucker, P. F. (1954) *The practice of Management*. New York and Evanston, USA: Harper and Row Publishers.
- Fox, M. S. and Gruninger, M. (1994) Ontologies for Enterprise Integration. *Proceedings of the 2nd Conference on Cooperative Information Systems*. Toronto, Ontario, Canada.
- Jansson, C. G. (1986) *Taxonomic representation*. Doctoral thesis, Royal Institute of Technology, Akademitryck, Stockholm, Sweden.
- López, F. M. (1999) Overview of Methodologies for building ontologies. *Proceedings of the IJCAI-99 workshop on ontologies and problem-solving methods (KRR5)*. August 2, Stockholm, Sweden.
- Mullins, J. L. (1996) *Management and organizational behaviour (fourth edition)*. London, U.K: Pitman Publishing.
- Nürnberg, P. J. and Leggett, J. J. and Schneider, E. R. (1997) As we should have thought. *Proceedings of the Eighth ACM Conference on Hypertext (HT 97)*. Southampton, U.K.
- Oxford English Dictionary (1989) *Oxford English Dictionary (Second Edition)*. Oxford, U.K: Oxford University Press.
- Roberts-Witt, S. L. (1999) Practical Taxonomies: Hard-won wisdom for creating a workable knowledge classification system. *Knowledge Management*, (Jan). California, USA: Curtco Freedom Group. <http://www.phys.uni.torun.pl/~duch/ref/s-search/taxonomy/featureb1.htm> (10 October 2000).
- Uschold, M. (1998) Knowledge level modelling: Concepts and terminology. *Knowledge Engineering Review*. Edinburgh, U.K. **13**(1).
- Uschold, M. (1996) Building ontologies: towards a unified methodology. *Proceedings of Expert Systems'96, the 16th Annual Conference of the British Computer society Specialist Group on Expert Systems*. Cambridge, U.K.
- Uschold, M. and Gruninger, M. (1996) Ontologies: principles, methods and applications. *Knowledge Engineering Review*. Edinburgh, U.K. **11**(2).
- Uschold, M. and Jasper, R. (1999). A framework for understanding and classifying ontology applications. *Proceedings of the IJCAI-99 workshop on ontologies and problem-solving methods (KRR5)*. August 2, Stockholm, Sweden
- Uschold, M. and King, M. (1995) Towards a methodology for building ontologies. *The Workshop on Basic Ontological Issues in Knowledge Sharing, International Joint Conference on Artificial Intelligence*. Also available as AIAI-TR-183 from AIAI, Edinburgh, U.K.
- Uschold, M. and King, M. and Moralee, S. and Zorgios, Y. (1997) *The enterprise ontology*, AIAI, Revised Completed Draft, Edinburgh, U.K.
- Webster's New World (1997) *College Dictionary (Third edition)*. Ohio, USA: Simon and Schuster, Inc