# Defining the Quality Business Process Reference Models

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## Abstract

*This paper presents an empirical contribution to the quality of business process reference models, a tool used within enterprises for knowledge management and business process management. Quality in this case is defined as the existence of user desired attributes. The primary goal of the case studies was to examine user opinions of the quality attributes of reference models. The paper concludes that consistency and completeness of the model and access to feedback mechanisms are amongst the most critical attributes of reference model quality. New concepts such as a terminology-matching-dictionary and the dimension of economic efficiency of use are also introduced.*

### Key words

Reference models, Process models, Quality, Knowledge Management, Business Process

## INTRODUCTION

Knowledge management has become a leading paradigm in organisations. More and more businesses are striving to understand and deploy new techniques for increased knowledge management capabilities. A large part of knowledge management is being able to depict knowledge in a form that is re-useable in a different time or place. One method of depicting knowledge for re-use is in through reference models (Mertins & Bernus, 1998).

Frank (1999) defines a 'generic' reference model as a representation of "a class of domains" (Frank, 1999 p.656) and that a reference model is "motivated by the search for general structures that can be applied to numerous instances". Bernus adds: "[Reference Models] capture characteristics common to many enterprises within or across one or more industrial sectors." (Bernus, 1998 p.6). They are "the standard decomposition of a known problem domain" (Misic & Zhao, 2000) p 484. They can also provide a common meaning, understanding and standard terminology (Mertins & Bernus, 1998; US Department of Defense, 2001) Reference models can be "normative" and implicitly suggestive in their content, shaping domains as well as describing them (Biemans, 1990).

The definition used in this paper is:

*A Reference Model is an abstracted depiction of reality that serves as a standardised or suggestive conceptual basis for the design of enterprise specific models, usually within a like domain.*

Reference models that deal specifically with business processes are called 'business process reference models'. Business process reference models can be used for process improvement by helping design new, or re-design old, processes to improve efficiency (Mertins & Bernus, 1998) and have been applied for a variety of purposes within organisations. Some prominent applications include:

- Describing the processes supported by small and large IS packages
- Providing guidance or a starting template for modelling efforts
- Communicating "best/common/accepted" practices
- Describing a performance measurement framework
- Facilitating the classification, evolution and comparability of models by creating a standard terminology
- Facilitating Knowledge Management
- Guiding Business Process Re-design or Improvement
- Facilitating Process Benchmarking

(Bernus, Mertins, & Schmidt, 1998; Curran, Keller, & Ladd, 1998; IFIP-IFAC Task Force, 1998; Kaplic & Bernus, 2001; Lowe & Webby, 1999; Misic & Zhao, 2000; Supply-Chain Council Inc).

Despite the wide acceptance and use of business process reference models, little literature exists on them, and very few specifically address the quality aspects of business process reference models. This paper is aimed at contributing to filling this gap. Firstly, it presents an overview of the research design and then describes the derivation of a quality framework from an extensive literature review. The paper then proceeds to discuss the findings from to case studies. Finally the paper concludes with a summary of the research contributions, limitations and an outlook to the next proposed steps of the study.

## RESEARCH DESIGN

A brief review of the marketplace for reference models, suggests that producers, particularly commercial producers, are offering not only the reference model, but also a range of other services and products related to the reference model (e.g. training, case studies, feedback mechanisms) which we refer to as '*model support*'. The overall package offered by the producer, i.e. the model and the model support, is referred to as the '*reference material*' in this study. Thus, while the main focus of this study was on the reference models, the whole package (i.e. the reference material) was analysed in order to achieve a more complete view.

The primary goal of this study was to address "*What are the user-perceived attributes of the quality in business process reference material?*".

This research is designed to offer a pragmatic contribution by providing reference model producers guidance on the factors that are important to the perceived quality of their overall product. 'Quality' is a complex, multi dimensional, multi perspective phenomenon and warrants a clear definition In this research we define quality as: *the degree of existence of user desired attributes* [adopted from (Ivancevich, Lorenzi, Skinner, & Crosby, 1997 p.10)following the well established research on product quality]. We have limited the scope of this study only to the 'user perspective', where 'users' are defined as *those who would be directly using the reference material for their designated tasks*.

The scope was defined in this manner; (a) in order to manage the complexity of the study (thus, only one perspective was selected) and (b) we believed the user perspective to be the most important perspective considering the study objectives, as they (the users) are effectively the customers of the reference material producers.

Figure 1 depicts the high-level research method applied for this study. First, a comprehensive review of the relevant literature was conducted drawing upon related fields namely reference models, conceptual model quality and business process modelling. A quality framework was derived from this phase. This framework provided the basis from which to draw questions about specific attributes of quality for use in the case studies. User perceptions and reactions to the proposed quality attributes were then tested within a case study method, with case sites in which business process reference models were extensively used.

The following sections will first describe the derivation of the quality framework and will then discuss the case studies in detail.
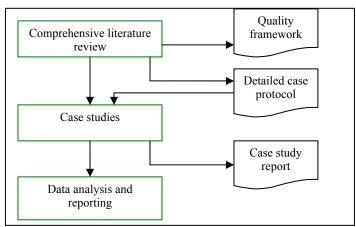


*Figure 1: The high level Research Design*

## LITERATURE REVIEW: DERIVING THE QUALITY FRAMEWORK

A comprehensive literature review was conducted to derive a quality framework. The *quality framework* included the *quality dimensions*, which were high level constructs or the goals of quality. The quality dimensions are at a conceptual level and serve mainly as a categorisation for the quality attributes. The *quality attributes* are the sub constructs of the dimensions. As Figure 2 depicts, the quality attributes can be seen as the practical means of achieving these high level theoretical quality dimensions. It is important to restate that the goal of this study was not to theoretically test the framework, but instead to use it as a guideline in the conduct of the case studies, to identify quality attributes.
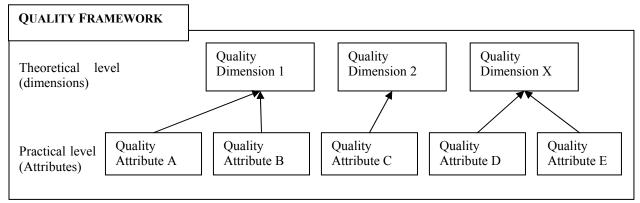
**QUALITY FRAMEWORK**

| | | | |
|---|---|---|---|
| Theoretical level (dimensions) | Quality Dimension 1 | Quality Dimension 2 | Quality Dimension X |
| Practical level (Attributes) | Quality Attribute A — Quality Attribute B | Quality Attribute C | Quality Attribute D — Quality Attribute E |

*Figure 2: Terminology used within the study's quality framework*

The literature review resulted in 3 quality dimensions for business process reference models; Syntactic, Semantic and pragmatic (see Figure 3). This may seem to be a direct replication of the Lindland et al. (1994) framework, where they explain quality in terms of how the model relates with other elements of Language (all the possible statements that would be possible given a particular set of language rules or meta-model), Domain (all possible statements that are correct and relevant to a particular problem), and Audience Interpretation (the set of interpretations that the audience has made based on the model).

However, the definitions of the quality dimensions used in this research were expanded from the original to include influences from other quality frameworks including the Guidelines of Business Process Modelling (Becker, Rosemann, & von Uthmann, 2000), Semiotic framework (Shanks, 1999) and the revisions to Lindland et al's (1994) original work in (Krogstie, Lindland, & Sindre, 1995) and other papers. The following sections describe the quality dimensions as used within this study.
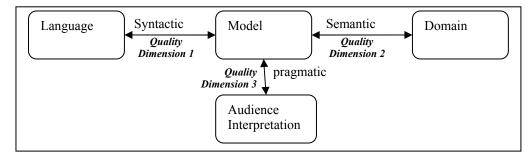
| Language | Syntactic *Quality Dimension 1* | Model | Semantic *Quality Dimension 2* | Domain |
|---|---|---|---|---|
| | | *Quality Dimension 3* pragmatic | | |
| | | Audience Interpretation | | |

*Figure 3: Quality framework for this paper*

### Syntactic Quality

The languages often used in business process reference models are not languages with strict, formally defined rules. Therefore there is no mathematical test exists for compliance or non-compliance as suggested by Lindland et al. (1994). Rather the syntactic correctness is more to do with the properties that describe the structure and organisation of the model itself as in Misic & Zhao (2000). Reference models often do not have a defined meta-model or accompanying modelling conventions document, hence judgements must be made about the *implied* meta-model and

conventions. Using this thinking we define language in a reference model as the implied meta-model *as well as* the layout, overall design and underlying concepts that have been applied to depict the content of a model.

Using this definition of language we see that syntactic quality is not only the strict applications of the grammar and symbols, but also how these are used in terms of consistency, especially with respect to aspects such as layouts, naming conventions etc. It also includes the mapping of the language and constructs used to depict the real world entities as can be explained in glossaries for example (i.e. ontological aspects). This definition of syntactic quality covers Becker et al's (2000) "(Syntactic) Correctness", "Comparability" and parts of the "Systematic design". Our definition maps to the Semiotic frameworks "syntactic" layer.

### Semantic Quality

Semantic quality reflects how well the model captures what it was supposed to capture as defined by the model scope statement or implied scope statement. An ideal fit in this case is that the model correctly captures everything of relevance and nothing of irrelevance. This is essentially Lindland's et al. (1994) original definition of "completeness". This quality is similar to Becker et al's (2000) "(Semantic) Correctness", and "Relevance". Our definition also subsumes Zamperoni and Lohr-Richter's "consistency" where no model statement contradicts another model statement (Zamperoni & Lohr-Richter, 1993). Semantic consistency is also mentioned as important in semantic quality in (Misic & Zhao, 2000). Our Semantic quality maps to the semantic layer of the semiotic framework.

### Pragmatic Quality

Again expanding from Lindland et al's (1994) definition, the pragmatic quality is defined here as how well the model is understood, which includes the quality of the model itself and the quality of the support material e.g. training, explanations etc. Perfect pragmatic quality would mean that every part of the model was correctly interpreted by the relevant audience. This quality also corresponds to Becker et al's "Clarity". As a means to this understanding, the distribution of the model is also important, hence our pragmatic quality also includes attributes of the Semiotic framework's physical layer, our reasoning being that an audience cannot interpret that which it cannot access. It also includes attributes from social quality from Lindland et al. (1994) and the Semiotic framework. This social quality was included in the pragmatic quality because, assuming the model has only one correct interpretation, any inconsistencies in individuals interpretations, which is a lack of Lindland et al's social quality, must be due to at least one incorrect interpretation. This incorrect interpretation is therefore an expression of poor pragmatic quality of the model; hence social quality is dependant on pragmatic quality and will be included within it for this discussion.

### Quality Dimensions Excluded

One aspect that was left out of our framework that has been repeatedly mentioned in literature is the concept of "feasibility" (Lindland, Sindre, & Solvberg, 1994) or "economic efficiency" (Becker et al., 2000). This type of quality weighs the cost/benefit of further improvements, while designing the model, and asks the question "does the cost of incrementally improving the model out-weigh the benefits gained from such an improvement?". At the point the cost is higher, the literature suggests that the optimum economy efficiency has been achieved. This concept is solely focused on the creation of a model. From the user requirements point of view however, the reference model producer's effort is irrelevant and probably unknown and as such we excluded it from the case study questions.

## THE CASE STUDIES: EXAMINING USER PERCEPTIONS OF QUALITY

"The case study method refers to a group of methods which emphasise qualitative analysis" (Gable, 1991 p.31). It is defined as an "empirical inquiry that investigates a contemporary phenomenon within its real-life context" (R. Yin, K., 1994) and can be conducted for exploratory, explanatory or descriptive purposes (Tellis, 1997; R. Yin, K., 1994). Case studies are applied to serve an exploratory function in this research. The main goal of the case studies was to identify the quality attributes that should exist in a reference model.

Yin (1994) states the relevance of multiple case studies, when the intent of the researcher is to build and test a theory (Yin, 1994; Gable 1994). Thus a multiple case study approach has been incorporated in to the overall case design of this study. A detailed case study protocol was derived, carefully documenting all procedures relating to the data collection and analysis of the case studies. The protocol defines the structure of the overall case study effort and is specially advantageous for exploratory studies as this, for (1) they force the researcher to consider the objectives and goals of the study in advance, (2) to help avoid redundant effort, and any potential omissions of the data collection

and finally (3) to support the communication and documentation efforts (Gable 1991; Yin, 1994).

The primary objective of the case studies was to identify those attributes that were perceived as important for reference model quality.

## Introducing the case sites

The reported study was conducted in two organisations: Queensland Rail (QR) and Telstra – Australia.

*Queensland Rail* (QR) is a Queensland state Government owned corporation that provides transport and logistics business solutions to a diverse range of customers throughout the State, Australia and overseas. With annual operating revenue of over $2 billion, 9500km of narrow gauge track, and around 14,000 staff, QR is one of Australia's largest and most modern rail networks. Today, modelling is extensively used within QR within different projects, for multiple purposes. The Supply Chain Operations Reference Model (SCOR – see appendix A) was extensively applied within one of QR's process improvement research projects; the Rail supply chain optimisation project. Process modelling was used within this project as standardised way to exchange information, within a wide variety of stakeholders of a supply chain; different functional specialists could talk to each other in some common language.

*Telstra* is majority owed by the Commonwealth Government of Australia after going through partial privatisation in 1997, and provides information and telecommunications services, throughout Australia and the Asia-Pacific. Telstra's revenue in 2002 was over $10 billion with over 17 million voice and data services in operation employing over 40,000 staff. Telstra is heavily involved with the development of the extended Telecommunications Operations Map (eTOM - see Appendix A) and is working on using the framework to develop standards both within the company and in its interactions with others. Telstra's adapted version of eTOM is named teTOM. Telstra uses teTOM for several purposes, including the modelling of the internal processes and as a method of identifying duplication of processes, or resources to support these processes. Telstra is also currently investigating into using the reference model for process improvement projects.

## Data collection

A comprehensive case study protocol was derived, carefully documenting all procedures relating to the data collection and analysis phases of the study. Data was collected from a total of 5 respondents (2 from QR and 3 from Telstra) from the case sites in the form of semi-structured interviews. All interviewees had extensive experience in using business process reference models and were model users. The questions were drawn from the literature using the framework discussed in the first part of this paper. General questions about the identified quality dimensions were followed by a series of questions testing the individual attributes of quality. After the interviewees had responded to each question, they were prompted to comment on the importance of these attributes based on their experience.

## Data Analysis

Analysing case study evidence has been a noted challenge by most case study experts (Yin, 1994, p.102). Only a few case data analysis techniques and supplementary tools for data analysis have been discussed in literature (Miles & Huberman, 1984; R. K. Yin, 1994). We will first briefly discuss the method we applied to analyse the case data. The next section will present the findings with evidences

"Codes are tags or labels for assigning units of meaning to the descriptive or inferential information compiled during a study" (Miles & Huberman, 1984 p. 55). A comprehensive data analysis tool, Nvivo 2.0, was used for the data analysis of this study. The data was coded within the tool to elicit meaning and present summaries of the phenomena investigated. A tree like node structure was initially created to capture the quality factors of the a priori model; namely syntactic, semantic and pragmatic quality. Whenever a quality attribute was mentioned, it was coded with the relevant node(s).The data coded under each code was re-analysed to make sure that they did belong to the coded quality construct. In the final phase of data coding, In-vivo (coding bottom-up, by using the key words from the data) coding was conducted to derive a list of sub constructs that described each quality attribute. The codings were then validated by a second coder.

## Results and discussion

All questions from the case protocol were based on the framework that was derived in the first part of this paper. In

order to justify that the framework we used was appropriate for this purpose, we conducted some preliminary analysis at the quality dimension level. An intersection search was conducted through NVivo, to test any potential overlaps between the three quality constructs and the results depicted no overlaps at all, indicating that the quality constructs identified in the framework were mutually exclusive in terms of describing the overall quality of business process reference models.

The main purpose of this research was to identify the quality attributes pertaining to the quality dimensions, not to provide a relative ranking. However, some indication to the relative importance of the quality attributes can be obtained by comparing the number of citations for each individual quality attribute across the different case studies. 'Numbers', usually get ignored in qualitative research, however a lot of counting actually does take place in qualitative studies when judgements are made. For example we "identify themes or patterns that happened a number of times and that consistently happens a specific way" (Miles & Huberman, 1984 p.215). Table 1 presents the primary findings of this study. It contains the different attributes pertaining to each quality dimension as perceived by the user interviewed in the case studies and depicts the number of times that the quality attributes were mentioned as across the case studies. The case study results were combined because there was no significant difference between the results.

| Syntactic quality | | Semantic quality | | pragmatic quality | |
|---|---|---|---|---|---|
| *attributes* | **# citations** | *attributes* | **# citations** | *attributes* | **# citations** |
| Language must be clearly defined | 14 | Clearly define the scope of the model and its limitations | 10 | Provide extended documentation to guide the use of the models (e.g. implementation guides, case studies) | 14 |
| Language must be used consistently | 14 | Prior validate the models | 5 | Model users must be educated about the reference model | 10 |
| The language must be simple to understand | 7 | Models must be semantically consistent | 4 | Provide tool support | 6 |
| Have a glossary to define the key terms | 7 | Avoid unnecessary repetitions | 4 | Obtain feedback from stakeholders | 5 |
| Provide Vendor training; explaining the terminology | 5 | Try to capture the entire domain as a whole | 4 | The model must be easily accessible | 3 |
| All levels of the reference model must be defined adequately | 3 | Provide supplementary material to support user understanding of the content | 3 | User should be able to maintain contacts with the vendors for clarifications | 3 |
| Create a meta model | 3 | Arrange for vendor feedback and continuos support | 3 | Model should be tailor-able to specific needs | 2 |
| Avoid the use of unfamiliar terms | 2 | Conduct vendor training on the conceptual aspects of the model | 1 | | |
| Models must be laid out properly | 2 | Have realistic and feasible content (I.e. recommendations) | 1 | | |
| | | Only have relevant statements | 1 | | |

*Table 1: Frequency of attributes within each quality dimension*

The need for a clearly defined and consistently applied language was repeatedly mentioned. This point was raised often, and sometimes in response to questions not dealing with the language. Interviewees consistently expressed strong opinions on the importance of consistent clear language, e.g. "extremely important". In the words of one respondent, the lack of consistency "discredits the … quality" of the model. The respondents often mentioned the importance of the consistency of language use. This finding fits neatly with the emphasis placed on consistency in literature.

Guidance on the terminology used and the actual meaning of the model was also essential for users. All the respondents indicated that the ability to ask questions and receive answers about the model was an essential part of using a reference model. These question and answer sessions, delivered in a training situation or a simple email

conversation, were variously described as "very important" and "extremely important" and saved users "a tremendous amount of time".

A deviation from past literature is found on the issue of relevance. Most existing model quality frameworks indicate that a model is of low quality if they contain irrelevant material. The results from the case studies indicate that having material that is not relevant to the audience does not negatively impact on the model's perceived quality. Most respondents indicated that at least part of the models they were using were not applicable to their situation, however this was not identified as a quality problem. This may be an important distinguishing feature between quality of specific models and reference models. From our findings we conclude that a reference model should contain more information than a specific model and this "overly-complete" model is of higher quality. Again the issue of clarity in the definition and use of the model language, especially process naming, is essential. It allows users to identify irrelevant parts of the model, evidenced by comments such as "having the definitions for the bits that weren't relevant to us was essential".

Linked to this issue of completeness was the result that users desired a reference model to capture an entire domain, in one case an entire telecommunications service provider as a commercial entity and in the other a complete supply chain. A reason for this could be that a reference model provides standardised terminology in what can be large and complex domains, as is the case in these case studies. Sacrificing conciseness for completeness appears to have a positive effect on user perceptions of quality of the model, by ensuring that the complete large and complex domain has been mapped in its entirety, even if it is not used in such a widely scoped modelling project.

One interesting concept that was canvassed in the interviews was the use of pragmatic variation in the models. The idea that the same underlying model would be presented to different stakeholder groups, but with the terminology changed to suit the intended audience, was raised during the case studies. This idea has not been expressed previously in the literature, and is an important new concept that could increase the pragmatic quality of a reference model.

A terminology matching dictionary or functionality could be developed by reference model providers for various expected audiences, especially with respect to terminology that is common in other reference models or for different perspectives. This could be as simple as a table, listing the terminology matches between the model, other common models or common terms for various stakeholder groups, e.g. technicians, managers etc. An interesting example from the QR case was the initial confusion about the Americanised terms as opposed to Australian terms used in the model; another example of where a terminology dictionary would be advantageous. However, feedback from the case studies is that the use of terminology customisation could defeat the standardising effect of a reference model and is an example of Gulla and Brasethvik's (2000) comment that pragmatic variation of models complicates the formation of a common understanding of the domain. Depending on how broad the scope of the standardisation of terms is designed to be, the overuse of the terminology matching dictionary could still be of great use. For example the use of terminology variation might not be appropriate if the major aim of the model is to align a whole industry, but may well be useful to match the terms to that of a single organisation that is using the model.

From the coding in Table 1 and from the context in which the models were discussed, it seems that there is an aspect of economic efficiency in the quality attributes or dimensions of reference models (e.g. simple to understand language, extended documentation to guide the use of the model etc). However, this economic efficiency differs from the traditional definition, which was deliberately excluded from our case study questions. Our findings indicate that an important quality attribute of a *reference* model is the economic efficiency of the *use* of the model, not the creation of the model. The ease of modification of the reference model and advice on how to best use the model could be important for users of the model, because the reference model could form the basis for the enterprise specific model that will need to be updated and maintained throughout its life incurring a cost to the user.

## CONTRIBUTIONS AND LIMITATIONS

The study findings will benefit future research in the domain of reference models and more specifically on reference model quality. The study findings will be of value to practitioners who apply business process reference models, as the findings can be used in the selection and evaluation process. The most important outcome of this research will be to provide current and potential reference model vendors an insight into the important attributes of models as perceived by the model users, giving them practical guidance on what attributes of the models should be enhanced to improve their clients' perceptions of their reference model. The major outcome of this research is the pragmatic list of specific quality attributes from the perspective of the business process reference model user, an area that has not previously been researched.

A limitation of this research is the external validity, with only 2 case studies. This phase of the study had to limit to two case studies for a variety of reasons beyond the control of the researchers. This research is not, and is not intended to be a definitive study on the quality of business process reference models. The paper is limited to an exploration of the 'user' perceived attributes of quality, intended solely to provide a basis for further work in the area. The use of citations as an indication of the perceived importance of the various attributes can be perceived as a limitation, as they can be highly influenced b the interviewing and coding styles. Again this should be taken only as an indication and would require further quantitative validation of the relative importance and completeness of the attribute list. Furthermore, the study findings were based on perceptual values only and no other quantitative mean (for example direct comparisons) for validating these were conducted within this study. However quantitative tests as direct comparisons should be done on proven quality criteria, derived from exploratory research such as the results presented in this paper. As Krogstie et al. (1995) states, it is difficult to measure quality directly and thus perceptions are arguably a valid substitute for direct measures.

## CONCLUSION

This paper presented the empirical findings of two case studies that aimed at testing the quality of business process reference material. The paper first introduced the research background, discussed the overall research method and a quality framework, and then presented the findings from the analysis of the case data. The paper concludes with an overview of the research contributions and limitations. In conclusion, the consistent use of terminology, a simple modelling language, and a complete, accurate and ideally tested, content were identified as the primary quality attributes of reference models. Our study empirically supported the mostly theoretical claims made by past papers. Findings that were not mentioned in existing literature, or contradicted past studies, included the issue that models should be complete at the expense of being completely relevant to a particular audience, and the need for a feedback mechanism either through training or some other means. An interesting new idea expressed throughout the case studies was the idea of customisation of the terminology used in reference models. The original framework was found to be lacking in that it did not contain aspects of economy, particularly of the economic efficiency of the *use* of the reference model.

Further work in more exploratory case studies followed by a quantitative survey encompassing a larger sample would be required to further test and validate the findings of this study. However, we believe that this paper has laid the exploratory foundation for further empirical research into the area.

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## ACKNOWLEDGEMENTS

## APPENDIX A: INTRODUCING THE REFERENCE PROCESS MODELS UNDER INVESTIGATION

### eTOM

eTOM is an extension of the TOM and provides business processes for service providers (TeleManagement Forum, 2001). From a top down methodology eTOM provides an enterprise wide framework for SP processes. eTOM lacks in the level of detail provided on these processes although it does provide a structured and logical framework for development of reference models at low levels. Although eTOM is nominally aimed at the Information and Communication Services industry the generality of the model makes it applicable for other service providers in the

IT and related industries.

**SCOR (Supply chain operations reference model)**

SCOR (Supply-Chain Council Inc, 2002) contains several sections and is organised around the five primary management processes of Plan, Source, Make, Deliver, and Return. By describing supply chains using these process building blocks, the model can be used to describe supply chains that are very simple or very complex using a common set of definitions. The Model has been able to describe and provide a basis for supply chain improvement for global projects as well as site-specific projects. It does not prescribe development of systems/information flow, thus, every organisation that implements supply chain improvements using the model will need to extend the Model.

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