Schmitt
Effective Model Building for Strategic Planning

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Heinz-Ulrich Schmitt

Effective Model Building for Strategic Planning

A Knowledge-based System for Enhanced Model and Knowledge Management

Mit Geleitworten von
Prof. Dr. Markus Lusti und
Prof. Dr. Bruno Bircher

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Geleitwort

In seiner langjährigen Praxis als Unternehmensberater hat Ulrich Schmitt einen Mangel an computergestützten Werkzeugen zur strategischen Metaplanung festgestellt. Er hat sich deshalb zum Ziel gesetzt, mit *Meta-Planner* ein Werkzeug zu entwickeln, das den Unternehmensplaner bei der Erstellung quantitativer strategischer Planungsmodelle unterstützt.

Meta-Planner stellt auf der Basis etablierter strategischer Konzepte Gliederungsvorschläge und Heuristiken zur Verfügung, welche die Verwaltung von Planungsobjekten erleichtern. Planungsobjekte sind zum Beispiel Märkte, Produkte, organisatorische Einheiten, Aktivitäten und Kennziffern. Ihre Abhängigkeiten sind in der Regel so komplex, dass die Vielfalt der Entwurfsmöglichkeiten nicht mehr manuell oder algorithmisch bewältigt werden kann.

Auf der Grundlage eines relationalen Datenbanksystems und einer Expertensystem-Schale kontrolliert *Meta-Planner* heuristisch die kombinatorische Explosion der Planungsdaten und die Bewertung individueller Konfigurationsentscheide.

Herr Schmitt vergleicht die manuelle Modellkonfiguration mit jener von *Meta-Planner*: Sein System fördert die Transparenz und verringert die Komplexität des Planungsprozesses. Vor allem bei diversifizierten Unternehmungen mit Aktivitäten in zahlreichen heterogenen Märkten kann es die Nachteile standardisierter Vorgehensmodelle verringern.

Ulrich Schmitt integriert seine Praxiserfahrung als Unternehmensberater mit sachlogischen, methodischen und implementationstechnischen Ansätzen der Betriebswirtschaftslehre und der Informatik zu einer lauffähigen und praxisrelevanten Anwendung. Wir wünschen der Arbeit eine weite Verbreitung.

Prof. Dr. Markus Lusti

Institut für Informatik, Universität Basel

Geleitwort

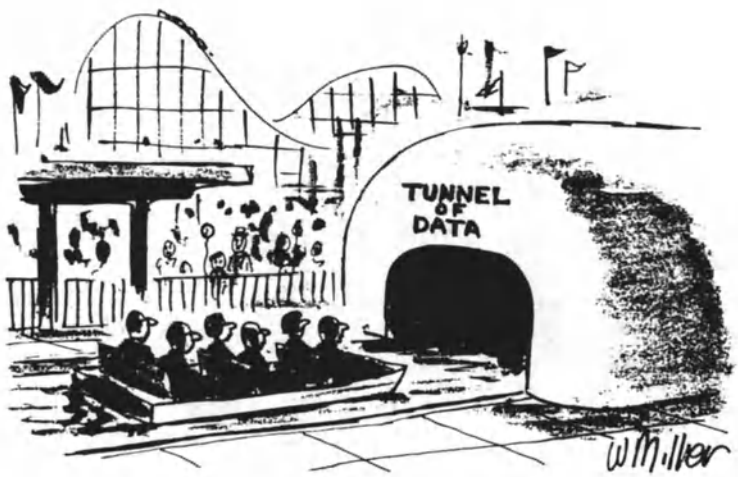
Heinz-Ulrich Schmitt legt eine Arbeit vor, welche auf einer ehrgeizigen Zielsetzung basiert: In grösseren und komplexen Unternehmen sollen Entscheidungen über die zu erstellenden Pläne, über den Informationsbedarf und über die Informationsquellen rascher und zuverlässiger getroffen werden. Solche Entscheide werden in der Praxis oft intuitiv und wenig bewusst getroffen.

Die Lösung der Aufgabe setzt Grundlagen aus verschiedenen Wissenschaftsbereichen voraus. Die Kenntnis wissensbasierter Systeme und der Computer-Wissenschaften ist ebenso erforderlich wie die Uebersicht über Unternehmungsplanung. Aufbauend auf diesen Grundlagen, gelingt es dem Autor, im Wechselspiel von theoretischer Modellformulierung und praktischer Verdeutlichung den Leser anschaulich in sein Modell einzuführen. Der Umstand, dass neben dem gedruckten Werk auch eine Software vorliegt, verleiht der Arbeit einen besonderen Wert.

Dem aufgeklärten Praktiker und Studierenden der Unternehmungsplanung bringt die vorliegende Arbeit ein Instrument, welches sich bei der Entwicklung neuer und beim Audit bestehender Planungssysteme sinnvoll einsetzen lässt. Die Umsetzung strategischer Planungen wird wirkungsvoll unterstützt. Der interessierte Theoretiker findet eine neuartige Anwendung wissensbasierter Konzepte auf qualitative Prozesse im Unternehmen. Schmitt leistet damit einen wesentlichen Beitrag zur Entwicklung jener Ansätze, die unter dem Begriff des "Knowledge Management" gegenwärtig eine vielversprechende Erneuerung verschiedener Disziplinen versprechen.

Bruno Bircher, Prof. Dr. oec. HSG

Professeur de management à l'Université de Neuchâtel



from: Harvard Business Review, Nr.5, 1989, Page 84

Preface

Does the picture above resemble the view taken by many of your business friends or colleagues in regard to their organisation's planning systems implemented?

The combined expertise of highly paid managers taken off their operative duties, faced with the task of quantifying their strategic considerations to shape the future of the company but waiting to be subdued on a rollercoaster ride in a maze of data. Their motivation is challenged by a restrictive system whose tracks do not match up to the prospective paths required and which fails to provide interconnection between crucial areas, thus impeding successfully to reach the destination desired:

- by forcing the supply of data conforming to the common denominator of heterogeneous planning areas in a format not compatible to the provider's way of thinking
- by failing to respond to the detail of the particular strategic objectives under review and by ignoring the easy consideration of alternatives and scenarios
- by, in short, providing inadequate benefits for substantial efforts and resource consumption.

New managers, planners and consultants are often faced with frustrated participants in the strategic planning rounds in a company. However, stating the problem, diagnosing the causes and creating the solution does not resemble the usual sequence of events. Incomplete information, poor documentation, divergent opinions and organisational sensitivities often only leave the choice between further 'muddling through' or the disbandment of planning systems.

As a consequence of field experience gained, the idea developed to lighten the burden of people charged with the responsibility of designing a quantitative strategic planning system which fits the particular needs of the company. As a result, a methodology evolved and was implemented as a knowledge-based prototype system which will be described in the later chapters.

However, this publication which represent my PhD-thesis at the Institute of Computer Science (Institut für Informatik - IFI) of the University Basle could not have been established without the multiple personal, academic and occupational support and sponsorships gained. In particular, I would like to thank my referents Prof. Dr. Markus Lusti who gave me the opportunity to emphasise the methodological research aspects by using high-level implementation tools and who guided me through the area of knowledge-based application development, and Prof. Dr. Bruno Bircher who as an expert in strategic management extended the valuable support already given during my professional career to my academic field of research.

I am grateful to my colleagues and the staff of IFI, and gratefully acknowledge a research grant from the 'Förderverein des Wirtschaftswissenschaftlichen Zentrum' of the Basle University and, especially, would like to thank its Director Dipl.-Ing. Michael Braune-Krickau and the sponsoring members of the Basel business community.

Last but not least thanks to my family and, above all, to my wife Barbara.

Heinz-Ulrich Schmitt

Summary

The use of *quantitative strategic planning models* links the domain of strategic management with the domain of business forecasting by using decision support systems for the model execution. The application of models requires their prior construction, a complex process which has led to a growing body of research in the domain of model management.

Since quantifying strategies represents a central element in the planning concept of a company, the configuration of a planning model has to be planned as well. The *lack of capable tools* to support the associated *meta-planning activities* has led to the inadequacy and failure of quantitative planning systems, but also motivated the development of a methodology and its subsequent implementation as a knowledge-based prototype system.

Meta-Planner provides a conceptual framework to handle case-specific planning objects on the basis of established strategic concepts. It allows easy recording of the planning model currently used as well as the present or conceivable level of differentiation of the company's actuals which forms the basis for the envisaged model design. Entities to be considered include, for example, market, products, organisational units, activities, variables and information sources.

Since their various interdependencies result in a complex network, the *solution space of design options* is immense and can be handled neither by a manually-operated system nor by a single algorithm. Based on the expert system shell Nexpert Object and the relational database Access, *Meta-Planner* incorporates an object-oriented, domain-specific knowledge base. Using heuristic reasoning it manages the potential *combinatorial explosion* of data needs and the *intangible benefits and expenditures* of individual design decisions.

Rule-based mechanisms for decoding the user's concise specifications, dynamic generation of objects and inheritance methods take the edge off the number of *user interactions* required for defining the multitude of relevant planning entities and their relationships. Object-specific *strategic relevances* and automatically estimated *data requirements* are inferenced by expert system modules to deduce which of the segments and variables under review to include or not include in the model and the subsequent planning process.

In utilising heuristic rules, scoring methods, Pareto- and what-if-analyses, the underlying *methodology* prepares the ground for generating *design proposals* and facilitates the step-by-step improvement of the model configuration. As a result, the planner is relieved from manually scanning the vast number of planning alternatives and can rely on the documentation and *integrity* of the data and his decisions.

Due to these thorough computer-aided meta-planning activities, a quantitative model is likely to become a much more integrated and accepted part of the overall *planning concept*. Moreover, subsequent shifts in the environment or in the way to view it, modifications of internal conditions, adjusted priorities and the need to correct previous imperfections can be systematically considered in order to maintain the *effectiveness and efficiency* of the planning model.

The *expertise* used is based on the literature relevant to the subject, but also on the author's consulting experience in strategy planning and modelling and other experts' know-how. The data and experience gained from one of the *strategic planning projects* handled in the past, consequently, supported the development of the methodology and the testing of the prototype.

This project also enabled the author to compare the process of the former manually conducted model configuration exercise with the additional benefits gained from the computer-aided construction process. The results demonstrate that transparency is enhanced and complexity diminishes. Especially in the case of diversified businesses with activities in numerous heterogeneous markets, a standardised *'one suit fits all'* model design can be avoided which usually bears the danger of stifling inflexibility and upcoming frustrations on part of the planning participants.

The complexity of *strategic modelling* is often stressed, but respective publications still circle around the use, benefits or failures of already established definitional models, whereas expert systems to support *strategic management* concentrate on particular, predominantly qualitative, aspects of the analysis, choice, implementation or controlling phase. The relatively few existing systems to support the configuration process in model management have been specialised to other problem domains. None of the knowledge-based systems which have come to the author's attention is specialised for the same type of modelling and domain as *Meta-Planner*.

Summary (in German)

Quantitative strategische Planungsmodelle verknüpfen das strategische Management mit der Geschäftsentwicklungsprognose. Ihre Anwendung in Entscheidungsunterstützungssystemen setzt die vorherige Konstruktion voraus. Die damit verbundenen Fragestellungen haben zu einer wachsenden Anzahl von Arbeiten auf dem Gebiet des Modell-Managements geführt.

Eine Quantifizierung von Strategien stellt ein zentrales Element der Planungskonzeption eines Unternehmens dar. Daher bedarf die Konfiguration des Planungsmodelles ebenfalls einer sorgfältigen Planung. Der *Mangel an qualifizierten Werkzeugen*, die diese *Meta-Planungsaktivitäten* unterstützen, hat zu unbefriedigenden und gescheiterten Anwendungssystemen geführt und motivierte dazu, die vorgestellte Vorgehensweise zu entwickeln und zu implementieren.

Meta-Planner stellt auf der Basis etablierter strategischer Konzepte ein Gliederungsschema zur Verfügung, welches die Handhabung fallspezifischer Planungsobjekte ermöglicht. Aktuell benutzte Planungsmodelle können ebenso dokumentiert werden wie die gegenwärtig oder vorstellbare Differenzierung der Ist-Daten, die die Ausgangsbasis für das zu erarbeitende zukünftige Modell bildet. Die zu berücksichtigenden Dimensionen beinhalten beispielsweise Märkte, Produkte, Organisatorische Einheiten, Aktivitäten, Kennziffern und Informationsquellen.

Infolge ihrer vielfältigen Abhängigkeiten entsteht ein komplexes Netzwerk, so dass der sehr grosse *Lösungsraum der Designoptionen* weder manuell noch mit einem Algorithmus zu bewältigen ist. Basierend auf der Expertensystem-Schale Nexpert Object und der relationalen Datenbank Microsoft Access beinhaltet *Meta-Planner* daher eine objekt-orientierte domänen-spezifische Wissensbasis. Mittels heuristischer Regeln kontrolliert das System die potentielle kombinatorische Explosion des *Datenbedarfs* sowie den schwer einschätzbaren *Aufwand und Nutzen* individueller Konfigurationsentscheidungen.

Die regelbasierte Dekodierung verdichteter Eingaben, Vererbungsmethoden sowie die dynamische Erzeugung von Objekten verringern dabei die erforderlichen Benutzeraktionen zur Definition der Entitäten und ihrer Beziehungen. Expertensystem-Module bewerten objekt-spezifische Relevanzen und Datenbedarfsabschätzungen, um die modell-relevanten Segmente und Variablen zu bestimmen.

Unter Einsatz von Heuristiken, Scoring-Methoden, Pareto- und What-If-Analysen schafft die zugrundeliegende Methodik die Voraussetzungen, um Designvorschläge herzuleiten und ermöglicht so eine schrittweise Verbesserung der Modellkonfiguration. Der Planer wird verschont, das Problem der unzähligen Planungsalternativen manuell zu lösen und kann sich auf die Dokumentation und Schlüssigkeit der Daten und seiner Entscheidungen verlassen.

Der umfängliche computer-gestützte Meta-Planungsprozess stellt die stärkere Integration und Akzeptanz eines quantitativen Modelles im Planungskonzept sicher. Darüberhinaus erlaubt er, Änderungen der internen und externen Bedingungen oder ihrer Einschätzung, Anpassungen der strategischen Prioritäten und die notwendige Korrektur festgestellter Mängel systematisch zu verfolgen, um die Effektivität und Effizienz der Modelle zu erhalten.

Das genutzte *Expertenwissen* basiert einerseits auf der relevanten Literatur, andererseits auf den Erfahrungen des Verfassers in der strategischen Managementberatung und Modellierung sowie auf dem Know-How weiterer Experten. Die Daten und Kenntnisse aus einem der früheren *strategischen Projekte* unterstützte daher auch die Entwicklung der Methodik und den Test des Prototypen.

Dieses Projekt gestattete auch, den Prozess der früher manuell durchgeführten Modellkonfiguration mit den Auswirkungen eines computer-gestützten Konstruktionsprozesses zu vergleichen. Das Ergebnis zeigt, dass die Transparenz gefördert wird und die Komplexität abnimmt. Speziell im Fall von diversifizierten Unternehmen mit vielfältigen Aktivitäten in zahlreichen heterogenen Märkten können standardisierte *'einer für alle'*-Modelle vermieden werden, die zumeist zu einer lähmenden Inflexibilität und zu Frustationen auf Seiten der Planungsbeteiligten führen.

Auf die Schwierigkeiten der Erstellung von *strategischen Planungsmodellen* wird oft verwiesen, die entsprechende Publikationen konzentrieren sich jedoch immer noch auf den Einsatz, die Erfolge und Misserfolge bereits erstellter definitorischer Modelle. Wissensbasierte Systeme, die das *strategische Management* unterstützen, befassen sich wiederum in erster Linie mit spezifischen qualitativen Aspekten der Analyse-, Auswahl-, Umsetzungs- oder Controlling-Phase. Die wenigen Systeme, die im Modell-Management der Konfiguration zugerechnet werden können, sind auf andere Problemdomänen spezialisiert. Keine der dem Verfasser bekannt gewordenen Anwendungen unterstützt den gleichen Modell-Typ und die gleiche Domäne wie *Meta-Planner*.

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Abbreviations

ABC	Activity-based Costing
AI	Artificial Intelligence
API	Application Programming Interface
BCG	Boston Consulting Group
DDE	Dynamic Data Exchange
DFD	Data Flow Diagram
DLL	Dynamic Link Libraries
DSS	Decision Support System
EIS	Executive Information System
ERD	Entity-Relationship Diagram
ES	Expert System
KBS	Knowledge-based System
LRP	Long Range Planning
MbO	Management by Objectives
MCDM	Multiple Criteria Decision Making
MIS	Management Information Systems
OLE	Object Linking and Embedding
PLC	Product Life Cycle
QBE	Query-by-Example
SADT	Structured Analysis and Design Techniques
SBA	Strategic Business Area
SBU	Strategic Business Unit
SM	Structured Modeling
SQL	Structured Query Language
SWOT	Strengths Weakness, Opportunity, Threat- Analysis
TPS	Transactions Processing Systems

Format Conventions

Serif Text in Italics	highlights the main topics of the paragraph e.g. *Combinatorial Explosion*
Sans Serif Text	denotes classes or their respective objects e.g. Market, Product, Public Authorities
'Sans Serif Text in Quotes'	denotes attributes or respective input values e.g. 'Strategic Relevance', 'Off'

Part I

Domain-oriented Topics

1 Introduction

1.1 Domain and Objectives

The advances of the last decade in *hardware and software technology* have furnished management with the means to plan and control corporate activities more effectively. Powerful spreadsheets, decision support and executive information systems have provided the technical opportunity to segment company and environment multi-dimensionally, to model the impact of alternative scenarios by using what-if, sensitivity and risk analyses and to access results via efficient drill-down techniques.

Nevertheless, not all of these capabilities have been adopted to their full extent in *strategic management*. Although the concepts by Abell, Ansoff, Porter, to name but a few, have laid the groundwork for an extensive qualitative differentiation of company strategies, their translation into the prospective quantitative representations has often been prevented by the resulting organisational consequences and the costly provision of data.

The success in using *long term profit and loss and balance sheet projections* to quantify the effects of corporate, business and functional strategies greatly depends on an appropriate balance between simplification and representation of a real world situation. Thus, the *underlying model* and its degree of detail control the effectiveness of any quantitative strategic planning exercise and the efficient use of company resources employed to carry them out. They also determine the acceptance by management and participants who, ultimately, will judge the planning system by the value of additional information made available and the expenditures necessary.

The *configuration of a long range planning model* is a complex task. Because of heterogeneous views and expectations, incomplete historical data and the uncertainty of forecasts, a time consuming, stepwise approach is needed to identify the objects to be planned and their refinement. Not only the initial design of an adequate model requires careful thoughts by the corporate planners or external consultants, but also the further maintenance and development of the system in the light of a company ever adjusting due to its changing environment.

Faced already with the *complexity* of scanning a multitude of variables and ratios for portraying the logical interrelationships of a company's production, marketing and financial background in a concise way, the subsequent need for further differentiation across organisational levels and units (e.g. markets, products, activities, subsidiaries) triggers a *combinatorial explosion* with potential modelling demands of several thousand data items even for small enterprises.

Because of the *lack of capable tools*, the diversified factors governing a successful model design can not be considered completely and comprehensively. Hence, existing long range planning efforts have led to historically grown systems exposing a lack of transparency in regard to the design decisions taken and suboptimal solutions due to ill-considered subsequent shifts in strategic priorities.

Research concerning the critical factors of model application [SHIM87 51], consequently, lists as some of the main reasons for *discontinuated use* the excessive amounts of input data required, the unsatisfactory compliance with expectations, the lack of user interest and insufficient flexibility.

Based on successfully applied methodologies and the author's consulting experience in strategy planning and modelling, the objective was set to research and develop the *knowledge based system Meta-Planner* in order to support a corporate planner or management consultant in the configuration phases of quantitative strategic planning models.

Rather than building a company-specific advisor, the aim was to design a *generally applicable system* to act as a companion during the lengthy configuration process, by keeping track of the numerous potential planning objects and their assessments, by giving recommendations based on the analysis of the stored data and by visualising consequences of design changes.

As a result, a *methodology* had to be developed which provides a conceptual framework to flexibly formulate and document an efficient model structure and to determine data needs, sources and productiveness. The *prototype system* implemented is based on an expert system shell and a relational database system and operates through an object-oriented, domain-specific knowledge base using inheritance methods and heuristic reasoning.

As a consequence, the system is expected to play an elementary role in the development of a sound quantitative planning system which also incorporates the flexibility required to maintain the underlying model in the case of subsequent shifts of strategic priorities.

1.2 Research Topics and Structure of Thesis

The use of quantitative strategic planning models links the domain of *Strategic Management* with the domain of *Business Forecasting* by using *Decision Support Systems* for the model execution (figure 1.a). The application of models requires their prior construction. In order to support this process, a growing body of research has been carried out in the domain of *Model Management*.

Since *Modelling and Simulation* efforts for strategic purposes are critical tasks of a company's planning concept, the model development has to be planned as well. The planning of planning activities has been researched in the domain of *Meta-Planning*. Typically, meta-planning exercises for strategic modelling are process-oriented, time-consuming and require the systematical use and *Management of Knowledge* from various know-how and power bro kers.

Since the *solution space* of design options in modelling is immense, a thorough procedure needs to assess a multitude of company-specific planning objects and their relationships in respect to their specific relevance for model inclusion and the data needs associated with it. Because of the complexities involved, such an approach can neither be supported by a manually-operated system nor by a single algorithm.

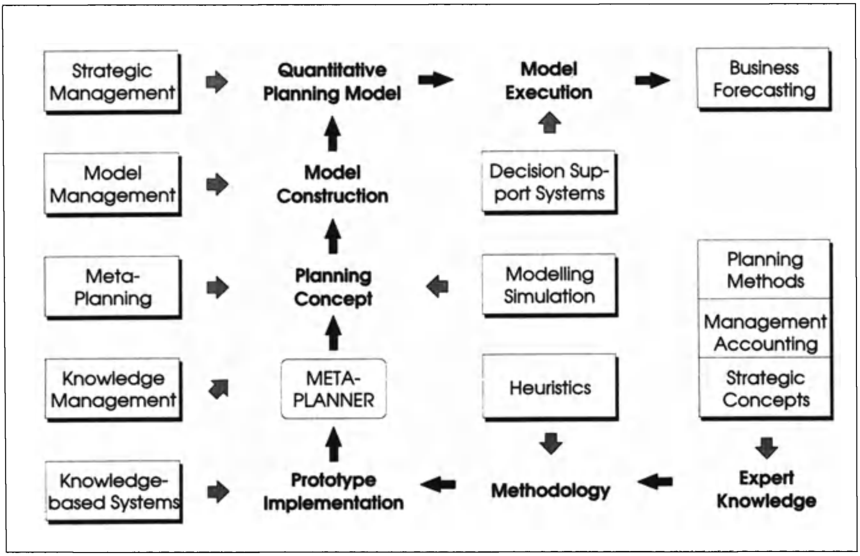


Figure 1.a: Research Topics and Academic Contributions

Thus, developing an adequate methodology has to be based on *Heuristics,* and requires the drawing of further expert knowledge from the domains of *Planning Methods, Management Accounting* and *Strategic Concepts.* To handle the expertise and the related reasoning and decision-making processes, *Knowledge-based System Technology* provides the adequate means for the implementation. The *objective of the research* can, consequently, be defined as follows:

- to develop a *heuristic methodology* based on the relevant *expert knowledge* and
- to implement the *knowledge-based prototype system 'Meta-Planner'*
- as a tool for defining *planning models* for *quantitative strategic management.*

The need to incorporate the many different domains detailed above, which either contributed to the problem definition or influenced the solution, have led to the adoption of a *terminology,* which, hopefully, will be understood by planners, managers, system analysts and knowledge engineers alike. It also induced this *structure* to the thesis:

■ Domain-oriented Topics

Chapter 2: Strategic Management. The particular role of strategic management within corporate planning is discussed (2.1), followed by the concepts, phases and objectives of the strategic management process (2.2), and a critical assessment which also covers the demands for and the advantages of strategic modelling (2.3).

Chapter 3: Modelling. After introducing the model-based planning process (3.1), the importance and aspects of a systematic meta-planning process are stressed (3.2). The basic components of the model design are discussed (3.3), followed by an overview of selected decision support models to demonstrate advanced topics and the application history (3.4).

Chapter 4: Information Technology. To execute a model, information technology is needed. A brief definition of the different types of business information systems is followed by the aspects of decision support system generation which also includes references to the relevant research in model management (4.1). Since the development of *Meta-Planner* required knowledge-based system technology, its characteristics and suitability for the project is outlined (4.2), and selected knowledge-based applications in project-related areas are introduced (4.3).

■ Application-oriented Topics

Chapter 5: Requirements Statement. After recapitulating the domain (5.1), a general problem statement is given including the introduction to the case study used during development, testing and documentation. (5.2). Subsequently, specific needs are detailed together with the preliminary design decisions which had to be taken in order to satisfy them (5.3).

Chapter 6: Methodology. Following a short introduction, the different classes of planning objects and their relationships are discussed and the references to the underlying planning concepts are presented (6.1, 6.2, 6.3). Then the respective attributes are detailed (6.4), and the methods explicitly used are explained (6.5). The chapter concentrates on the conceptual level without giving detailed processing specifications.

Chapter 7: System Design. After showing the general architecture of *Meta-Planner* (7.1), the conceptual framework applied is presented (7.2), followed by the modular decomposition of the activities involved, featuring especially the applied knowledge-based techniques (7.3). The chapter concentrates on higher level specifications of the processes and knowledge-based methods to provide information independent of the actual implementation tools used.

Chapter 8: Prototype System. After showing the system architecture (8.1) and the overall system control (8.2), the structure and functionality of the database management system is described (8.3), followed by the organisation and knowledge representation of the knowledge-based components (8.4). The chapter concentrates on the development tools used and on selected implementation issues which had to be faced to build the prototype.

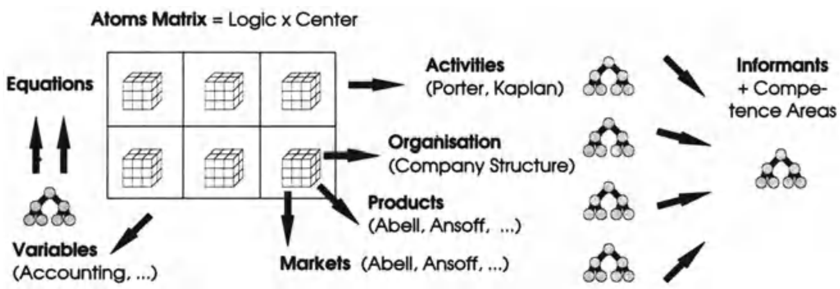
Chapter 9: Results and Perspectives. After assessing the limitations and benefits of qualitative and quantitative strategic analysis (9.1), additional statistics and results concerning the prototype and case study are provided (9.2). The further potential for development is discussed (9.3), and a competitive analysis compares *Meta-Planner* with knowledge-based systems introduced in chapter 4.3 (9.4).

However, before these domain-oriented and application-oriented topics are discussed, an outline of a user session provides a brief overview of the prototype system.

1.3 Walk through a User Session

Faced with the task of *developing a quantitative planning model* to support the analysis, selection, implementation and controlling of strategies at different levels of a company, an internal planner or external consultant inevitably has to bring together multiple views and structures, histories and experiences, expectations and objectives. By seeking information from varied documented and undocumented sources, the emerging conclusions and their consequences have to be discussed with others, so that knowledge gained from success or failure at some point can be fed back and searching, relearning and reappraisal can facilitate the evolution of better solutions. The resulting *iterative process* usually stretches out over an extended period of time.

In order to classify potential multi-period planning inputs, *Meta-Planner's* conceptual framework is composed of five dimensions: Variables, Activities, Markets, Products, and Organisation (figure 1.b). The structure supports established concepts (e.g. Abell, Ansoff, Porter, Bircher, Kaplan) as well as case-specific organisational and segmental set-ups. The individual entities of each dimension and their relationships have to be defined by the user. To provide for multiple paths of consolidation each dimension can be hierarchically structured.



Early Stages
Definition of:
State and Flow Variables,
Special Ratios,
Markets and Products,
Organisation and Activities,
Informants

Advanced Stages
Creation of Relations:
Logic Objects
Script Specification
Center (optional)
Equations
Competence Areas

Final Stages
Creation of Atoms and Center,
Analysis of Relevances and
Data Requirements,
Rule-based Generation
of Proposals to enhance
the envisaged Model Design

Figure 1.b: Features of Meta-Planner

A sixth dimension Informants allows characterising sources of information which can be linked to individual entities. Additionally, equations can be defined by combining Variables. Object attributes enable describing and evaluating entities and their relations and to store the decision to include them in the planning system.

Since the information to be handled and to be brought up-to-date is immense, *Meta-Planner* needs to address particular requirements:

- extensive data management capabilities to enter, store and modify case-specific planning objects and their relationships in order to represent the current and the envisaged planning models
- knowledge-based capabilities to provide concise data entry, systematic analyses, and rule-based proposals for the further streamlining of the model layout at any stage of the configuration process.

Due to the amount of data, the process iterations and the time needed, the different system menus and features are predominantly used at different times of the meta-planning process, subsequently specified as the early, advanced and final stages.

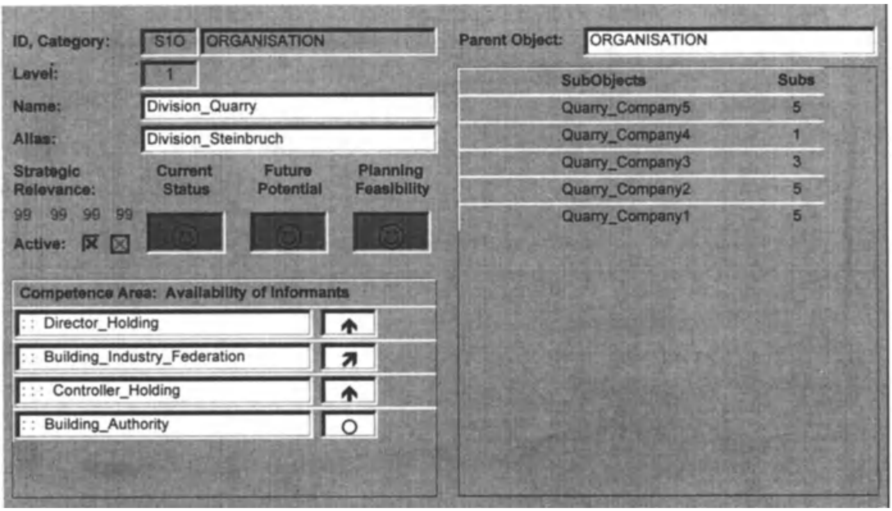


Figure 1.c: Data Entry Form of an Object belonging to the Class Organisation

■ The Early Stages

In the early stages of the configuration process, the planner is trying to identify the *business areas of particular strategic interest* to the company and the means to clearly define and adequately describe them. Corporate, business and functional strategic statements are a good starting point for this exercise, as are the current information systems used for accounting, budgeting and operative control.

However, the systematics currently applied to structure the companies' data might not benefit the strategic propositions to be verified, implemented and controlled. Crucial additional *information* might have to be represented in unaccustomed *perspectives* giving more detailed or aggregated insights for newly established success factors and areas of responsibility or monitoring.

Armed with the results of his daily analytical work, the planner starts *Meta-Planner* and enters the *markets, products, activities, organisational units and variables* relevant to the company. He links each new entry to a former entry. In gradually building up hierarchical representations, he covers the whole spectrum of the companies' commercial interests. Important points of consideration are directly attached to the respective entries, as are information sources to contact for further advice or which are available to provide data when the model is applied during the planning cycle.

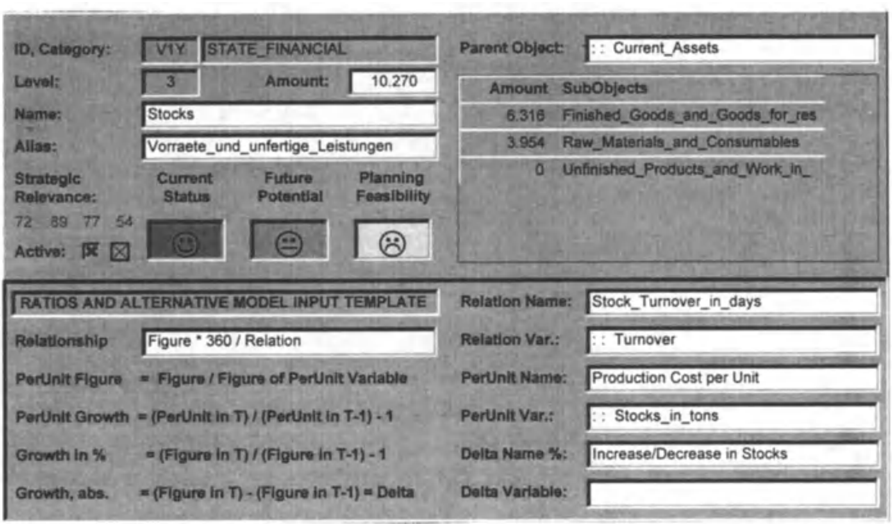


Figure 1.d: Data Entry Form of an Object belonging to the Class Variables

Whenever appropriate, he updates objects, relationships or current figures. In using a scoring method, he also evaluates the entries and assesses their current and anticipated *strategic relevance* and their *data availability*.

Figure 1.c shows the entry form for Activities, Markets, Products, and Organisation. The input object is the 'Division Quarry' which is linked via a drop-down list box (a list showing the options permitted) to the top object 'Organisation'. It is an instance of the first hierarchical level of the class 'S1O: Organisation'. Already further differentiated, the right list shows dependent organisational entities, whereas the lower left list depicts competence areas by naming the information sources specified and their availability/importance (arrows). Additional inputs allow *activating* the entry (cross) and *evaluating* its relevance (smileys); not shown is the field for adding *notes* for further descriptions.

Likewise, figure 1.d presents the form used to enter Variables. The entry depicts the variable 'Stocks' with a current value of DM 10.270 mio., which is a subvariable of 'Current Assets' and belongs to the group of 'Financial State Variables'. Since variables do not have to be linked to informants, the lower part of the screen is used to define Ratios by linking the respective entry to other variables already specified. Since both forms are also used for editing and viewing, the planner is always provided with the full local environment of the entries under review.

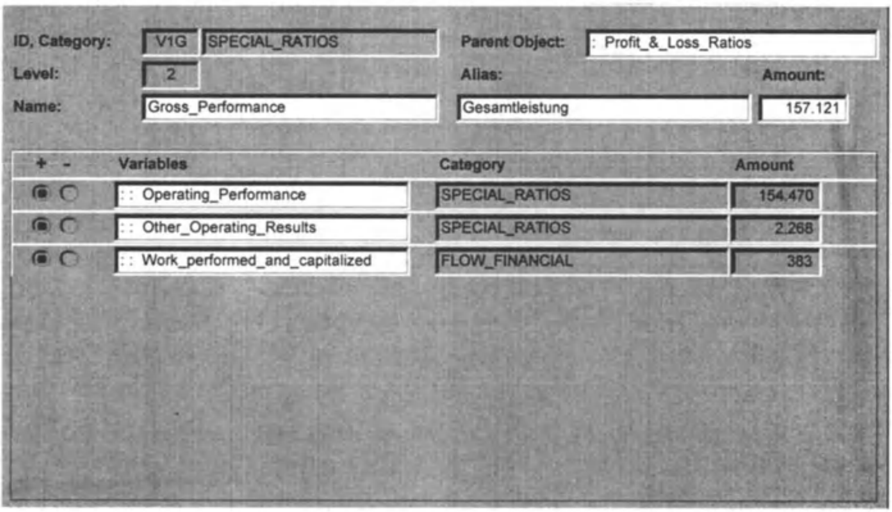


Figure 1.e: Data Entry Form of an Object belonging to the Class Special Ratios

Additive equations are defined implicitly with the hierarchical linking of Variables during data entry. Further equations can be defined explicitly by the entry of objects for the class Special Ratios. These ratios are derived from the inputs supplied by the planning participants and can, because of their more complex method of calculation, not be integrated within the state and flow variables. Consequently, each entry has to reference the respective subvariables which are part of the equation (e.g. 'Gross Performance' = 'Operating Performance' + 'Other operating Results' + 'Work performed/capitalised', figure 1.e).

■ The Advanced Stages

Although the divisions of the stages are fluid, at a certain time of the configuration process the planner has detailed most of the company's commercial features and is absorbed with defining their relations. One of these relationships, namely Ratios, have already been discussed above.

Another is concerned with representing the *planning model currently in use* and and the potential means for extensions. To document the latter, the *present or conceivable level of differentiation* in respect to the company's data structures has to be detailed and stored in the format of the Atom class.

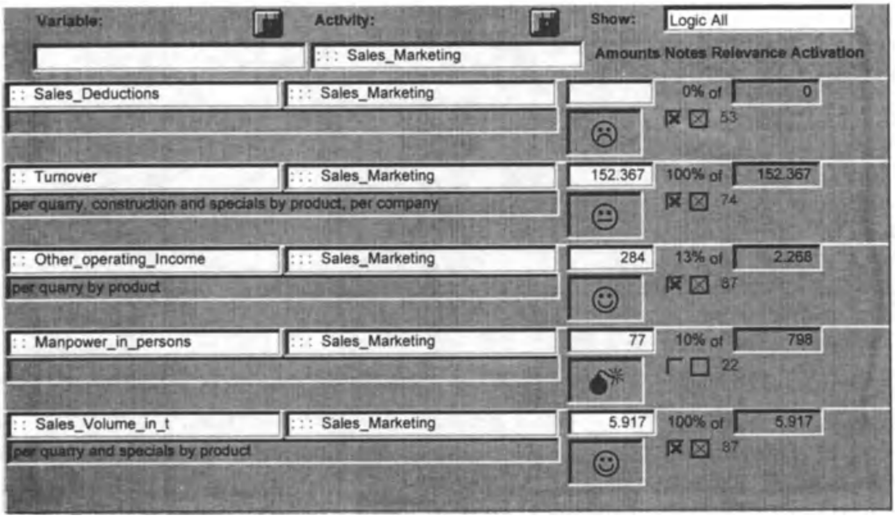


Figure 1.f: Relation Entry Form of an Object belonging to the Class Logic

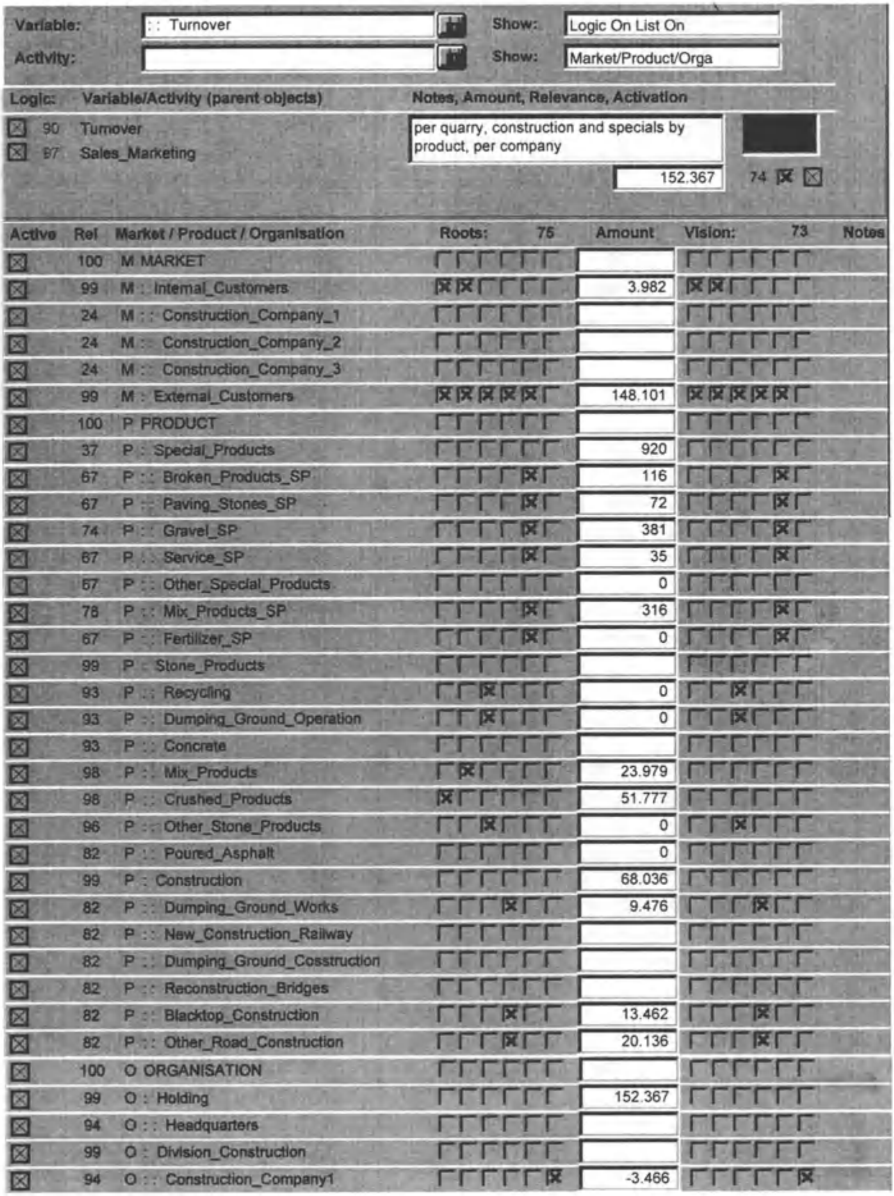
Atom objects represent potential input variables in a planning system and, thus, constitute the smallest building blocks of the model design. Each Atom, if activated, triggers a multi-period planning input during the later planning cycle, and their collective states of (de-)activation determine the data requirements of the final model.

It is defined as an element in the extensive five-dimensional matrix of Market-Product-Organisation-Activity-Variable-combinations. To define an Atom, its five constituent objects have to be selected. However, this method signifies an enormous workload for the planner and, hence, is not feasible. In order not to become defeated by the amount of data to be logged, *Meta-Planner* offers specially designed forms for the data entry.

Figure 1.f shows the first step in detailing Atoms by linking Variables to Activities. As a result Logic objects are created which act as intermediaries. In the example, five variables have been assigned to the activity 'Sales and Marketing'. As an activity can be described by numerous variables, so a variable can influence more than one activity. 'Personnel costs', for example, could be divided according to 'Production', 'Marketing' and 'Management' activities.

Figure 1.g exemplifies the second step for detailing Atoms. The layout consists of two list boxes at the top left for selecting the Variables and Activities objects of interest. The upper table shows the list of the corresponding Logic objects according to the options selected (upper right list boxes). Depending on the record chosen in this table, the lower table displays a list of the Markets, Products and Organisation objects currently available. The table allows detailing a *Script* of the current model layout as well as the potential design elements of the envisaged system.

Two times six ticking boxes (for current and envisaged model inclusion) allow defining the Atom objects indirectly. Later, this one-dimensional list has to be decoded. It is one of the tasks of the knowledge base to translate the condensed *Script*-specifications by identifying the selected Market, Product and Organisation objects of each of the twelve columns and by establishing their cross product. The results are three-dimensional submatrices (market-product-organisation) sharing the same Logic object, either currently, in the future, or both. Instead of defining each individual Atom relationship directly, the user specifies the numerous links in a much less input-sensitive way. In addition, the relevant Centers of responsibility which characterise individual Market-Product-Organisation combinations can also be automatically deduced.



Variable:	: : Turnover	Show:	Logic On List On
Activity:		Show:	Market/Product/Orga

Logic:	Variable/Activity (parent objects)	Notes, Amount, Relevance, Activation
☒ 90	Turnover	per quarry, construction and specials by product, per company
☒ 97	Sales_Marketing	152.367 — 74 ☒ ☒

Active	Rel	Market / Product / Organisation	Roots: 75	Amount	Vision: 73	Notes
☒	100	M MARKET	☐☐☐☐☐☐		☐☐☐☐☐☐	
☒	99	M : Internal_Customers	☒☒☐☐☐☐	3.982	☒☒☐☐☐☐	
☒	24	M : : Construction_Company_1	☐☐☐☐☐☐		☐☐☐☐☐☐	
☒	24	M : : Construction_Company_2	☐☐☐☐☐☐		☐☐☐☐☐☐	
☒	24	M : : Construction_Company_3	☐☐☐☐☐☐		☐☐☐☐☐☐	
☒	99	M : External_Customers	☒☒☒☒☒☐	148.101	☒☒☒☒☒☐	
☒	100	P PRODUCT	☐☐☐☐☐☐		☐☐☐☐☐☐	
☒	37	P : Special_Products	☐☐☐☐☐☐	920	☐☐☐☐☐☐	
☒	67	P : : Broken_Products_SP	☐☐☐☐☒☐	116	☐☐☐☐☒☐	
☒	67	P : : Paving_Stones_SP	☐☐☐☐☒☐	72	☐☐☐☐☒☐	
☒	74	P : : Gravel_SP	☐☐☐☐☒☐	381	☐☐☐☐☒☐	
☒	67	P : : Service_SP	☐☐☐☐☒☐	35	☐☐☐☐☒☐	
☒	67	P : : Other_Special_Products	☐☐☐☐☐☐	0	☐☐☐☐☐☐	
☒	78	P : : Mix_Products_SP	☐☐☐☐☒☐	316	☐☐☐☐☒☐	
☒	67	P : : Fertilizer_SP	☐☐☐☐☒☐	0	☐☐☐☐☒☐	
☒	99	P : Stone_Products	☐☐☐☐☐☐		☐☐☐☐☐☐	
☒	93	P : : Recycling	☐☐☒☐☐☐	0	☐☐☒☐☐☐	
☒	93	P : : Dumping_Ground_Operation	☐☐☒☐☐☐	0	☐☐☒☐☐☐	
☒	93	P : : Concrete	☐☐☐☐☐☐		☐☐☐☐☐☐	
☒	98	P : : Mix_Products	☐☒☐☐☐☐	23.979	☐☐☐☐☐☐	
☒	98	P : : Crushed_Products	☒☐☐☐☐☐	51.777	☐☐☐☐☐☐	
☒	96	P : : Other_Stone_Products	☐☐☒☐☐☐	0	☐☐☒☐☐☐	
☒	82	P : : Poured_Asphalt	☐☐☐☐☐☐	0	☐☐☐☐☐☐	
☒	99	P : Construction	☐☐☐☐☐☐	68.036	☐☐☐☐☐☐	
☒	82	P : : Dumping_Ground_Works	☐☐☐☒☐☐	9.476	☐☐☐☒☐☐	
☒	82	P : : New_Construction_Railway	☐☐☐☐☐☐		☐☐☐☐☐☐	
☒	82	P : : Dumping_Ground_Cosstruction	☐☐☐☐☐☐		☐☐☐☐☐☐	
☒	82	P : : Reconstruction_Bridges	☐☐☐☐☐☐		☐☐☐☐☐☐	
☒	82	P : : Blacktop_Construction	☐☐☐☒☐☐	13.462	☐☐☐☒☐☐	
☒	82	P : : Other_Road_Construction	☐☐☐☒☐☐	20.136	☐☐☐☒☐☐	
☒	100	O ORGANISATION	☐☐☐☐☐☐		☐☐☐☐☐☐	
☒	99	O : Holding	☐☐☐☐☐☐	152.367	☐☐☐☐☐☐	
☒	94	O : : Headquarters	☐☐☐☐☐☐		☐☐☐☐☐☐	
☒	99	O : Division_Construction	☐☐☐☐☐☐		☐☐☐☐☐☐	
☒	94	O : : Construction_Company1	☐☐☐☐☐☒	-3.466	☐☐☐☐☐☒	

Figure 1.g: Relation Entry Form of an Object belonging to the Class Script

The entry form shown in figure 1.h, therefore, is optional. A Center can be explicitly defined by selecting the respective Market, Product or Organisation objects if further information (e.g. sales or cost figures) has to be added before the inference process has been carried out. However, in using the three list boxes at the top, any explicitly defined or automatically deduced Center can also be accessed later to add this data or to view and compare results.

The compactness of the forms and formats provides easy and quick access to the data, avoids extensive manual handling by the user and facilitates the discussions with the other planning participants during the meta-planning process. By using list and ticking boxes, the planner can comfortably indicate which combinations are relevant in the current model or beneficial for the envisaged design.

However, in determining the *level of vertical and horizontal differentiation* of the future planning model, one critical success factor always has to be remembered: Quantitative strategic planning efforts should only concentrate on issues if the *actuals* can be subsequently particularised in the same manner and an effective *strategic controlling* is assured.

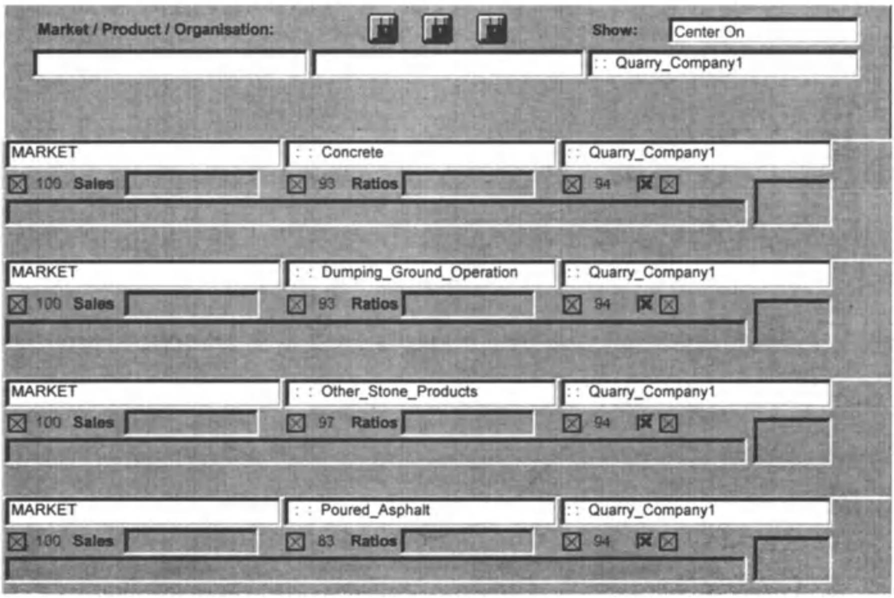


Figure 1.h: Relation Entry Form of Objects belonging to the Class Center

■ The Final Stages

In the previous stages, *Meta-Planner* offered a detailed but flexible framework. The planner was supported in documenting and actualising the relevant planning objects, their related meta-information and relationships. He also defined and assessed current and potential model structures by using the concise *Script* format.

During the iterative model configuration process, the planner's focus of attention will gradually shift to the question of which of the entries specified to include in the envisaged model design and which not. By summoning the *expert modules of Meta-Planner's knowledge base,* rules process the actual database as follows:

- The *Script* is transformed to establish the complete set of potential input variables differentiated according to *markets, products, organisational units, and activities.*
- *Centers of Responsibility* not explicitly defined are generated dynamically.
- *Evaluations* specified determine the *strategic relevance* of all entities according to their dependencies by using inheritance methods and defaults for missing scores.

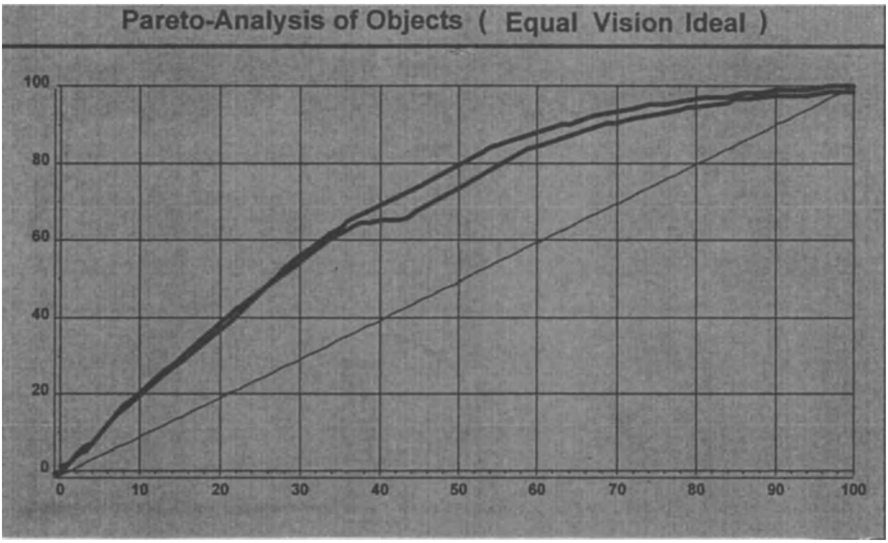


Figure 1.i: Chart showing the Results of the Pareto-Analysis

- *De-activations* specified are inherited according to the parent-child relationships defined and determine the entities to be included in the envisaged model design.
- *De-activated input variables* representing the conceivable level of differentiation of the company's data are automatically substituted by higher aggregated variables.
- *Data requirements* which greatly influence acceptance of any planning model are estimated as well as consequences of including or excluding further entities.
- Multiple *analyses* compare the current and envisaged system and identify mismatches between entity-specific strategic relevances and activation states. The results can be graphically illustrated by the use of Pareto-Charts (figure 1.i).
- *Statistics* are transferred to the database for user inspection together with any dynamically generated entity and the actualised data of the hierarchical network.

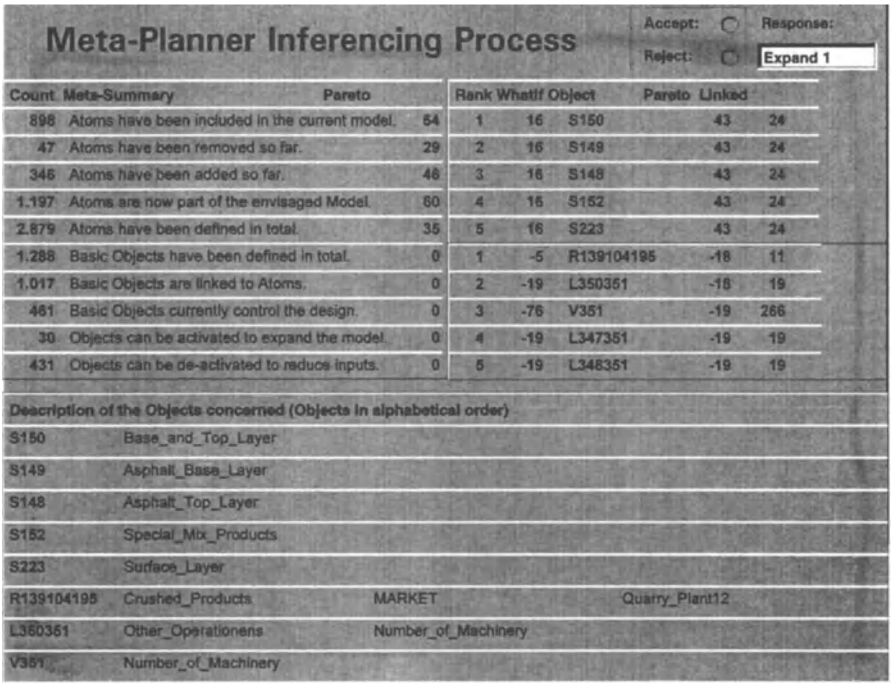
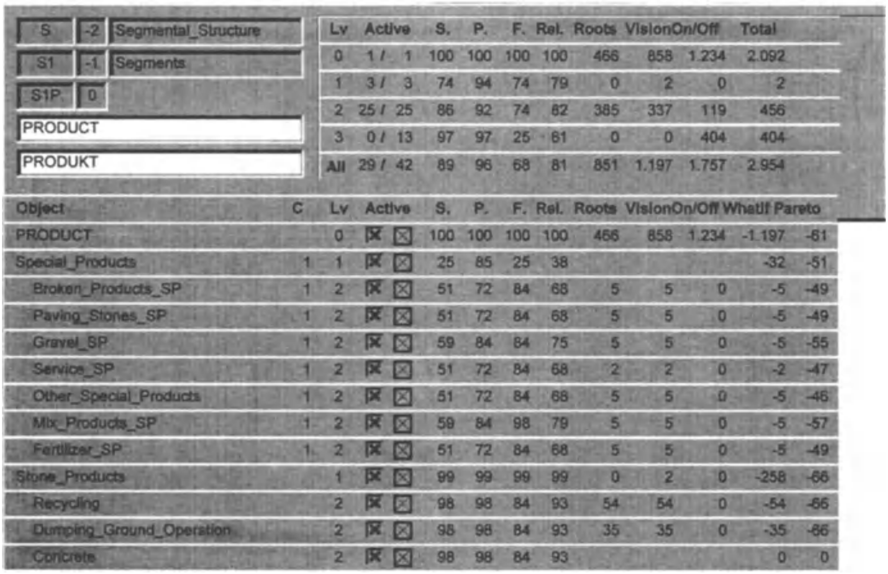


Figure 1.j: Proposals to the User

Above all, the planner is relieved from manually scanning the vast number of potential model design rectifications by being given transparent and explicit *proposals* for improvement (figure 1.j). In accordance with the *planner's acceptance or rejection* of these recommendations, *Meta-Planner* rectifies the mismatches encountered by updating the respective activation and evaluation parameter. After actualising the overall network as described above, the system turns to the next proposals. The relevant chapters 7.3.3 to 7.3.8 further explain the tasks of the knowledge based components and the rules used to generate the recommendations.

Figure 1.k presents a form reporting the results of the knowledge based analysis concerning the products of a company. The lower list structures the individual entries, while the upper right list displays summaries of the hierarchical levels and totals. Both tables cover the hierarchical level and the state or number of activations *(Lv Active)*, the evaluations of current Status, future Potential and planning Feasibility of objects together with their resulting strategic Relevance *(S P F Rel)*, the specific data needs of the current and envisaged model (*Roots VisionOn*), the number of inputs or data needs currently de-activated (*VisionOff*), the consequences of design changes in numbers of inputs *(What-If)* and the average strategic relevance of the inputs affected (*Pareto*).



S | -2 | Segmental_Structure
S1 | -1 | Segments
S1P | 0
PRODUCT
PRODUKT

Lv	Active	S.	P.	F.	Rel.	Roots	VisionOn/Off		Total
0	1 / 1	100	100	100	100	466	858	1.234	2.092
1	3 / 3	74	94	74	79	0	2	0	2
2	25 / 25	86	92	74	82	385	337	119	456
3	0 / 13	97	97	25	61	0	0	404	404
All	29 / 42	89	96	68	81	851	1.197	1.757	2.954

Object	C	Lv	Active	S.	P.	F.	Rel.	Roots	VisionOn/Off		WhatIf	Pareto
PRODUCT		0	☒ ☒	100	100	100	100	466	858	1.234	-1.197	-61
Special_Products	1	1	☒ ☒	25	85	25	38				-32	-51
Broken_Products_SP	1	2	☒ ☒	51	72	84	68	5	5	0	-5	-49
Paving_Stones_SP	1	2	☒ ☒	51	72	84	68	5	5	0	-5	-49
Gravel_SP	1	2	☒ ☒	59	84	84	75	5	5	0	-5	-55
Service_SP	1	2	☒ ☒	51	72	84	68	2	2	0	-2	-47
Other_Special_Products	1	2	☒ ☒	51	72	84	68	5	5	0	-5	-46
Mix_Products_SP	1	2	☒ ☒	59	84	98	79	5	5	0	-5	-57
Fertilizer_SP	1	2	☒ ☒	51	72	84	68	5	5	0	-5	-49
Stone_Products		1	☒ ☒	99	99	99	99	0	2	0	-258	-66
Recycling		2	☒ ☒	98	98	84	93	54	54	0	-54	-66
Dumping_Ground_Operation		2	☒ ☒	98	98	84	93	35	35	0	-35	-66
Concrete		2	☒ ☒	98	98	84	93				0	0

Figure 1.k: Report Form showing the Data Requirements of Entities

2 Strategic Management

2.1 Corporate Planning

Planning is a *systematic-methodical approach* for understanding and solving prospective problems. The main characteristics are its concern about information and future constellations, the rational rather than intuitive manner, the intention to structure and design and its process-orientation. Motivated by the ambition to secure effectiveness or efficiency of courses of actions, it also is intended to identify and minimise risks, to enlarge the degrees of freedom, to reduce complexity or to benefit from synergies [WILD81 12ff].

In the context of business policy, planning can be subdivided according to the time scale under consideration. Given the ultimate corporate objective to secure the company's long term survival and viability, different issues are addressed at various stages on the time horizon (figure 2.a).

To run the *day-to-day-business*, managerial tasks of dispositive nature have to be carried out involving mainly volume and time-related data. The emphasis is on operational control, scheduling and dispatching, and to ensure effectiveness, especially quality and productivity, by using production planning and control systems.

Short-range planning activities result in a projection of these dispositive figures as current sales and production forecasts. Additionally, value-oriented information is taken into account to supply data for the projected efficiency of the company. Typical reports cover the area of liquidity analyses or cost and income budgets.

Still based on the present business and conditions but operating on a wider time horizon (one to three years), *medium-range planning* activities concentrate on assets, liabilities, costs and returns and result in the projection of financial statements, capital budgets and quantitative management-by-objectives targets.

To emphasise future-related issues, *long-range planning* (*LRP*) activities focus more closely on the long term resource allocation and environmental factors by using economic and technological tools such as forecasting techniques and quantitative simulation models. In long-range planning the future is expected to be predictable through extrapolation of the historical growth [ANSO84 15] and results are elaborated into investment and action programs, budgets and profit plans.

Strategic planning is also concerned with the long-run nature of the company and its activities. Its objective is to sustain and create competitive advantage in a dynamic environment, and the emphasis is to guide and implement discontinuous strategic change. In order to anticipate and consider breaks in historical trends, the focus shifts from detailed numerical projections to verbal descriptions of analytical results and anticipated actions.

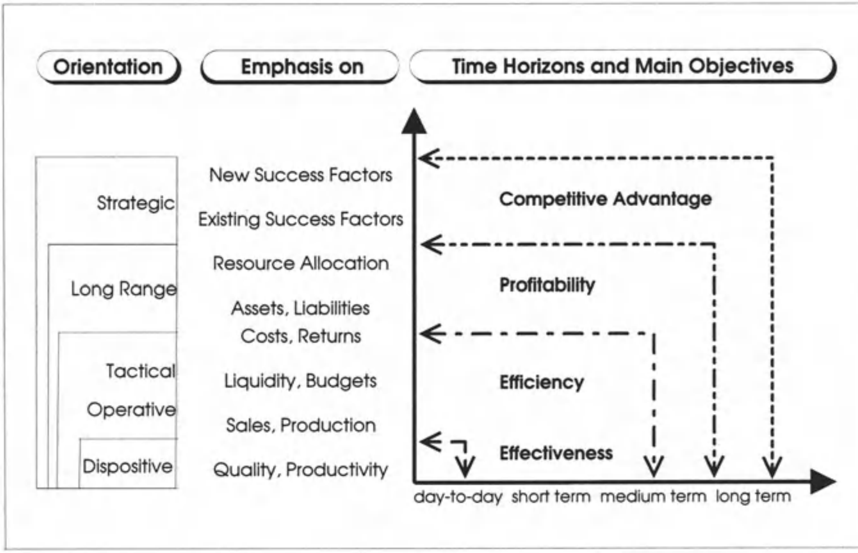


Figure 2.a: Time Horizons of Corporate Planning

2.2 Strategic Planning

2.2.1 Overview

An organisation exists in the context of a complex political, economic, commercial, technological, ethical and social environment. The achievement of its objectives depends on a number of *historical and present factors* and the fulfilment of *expected changes*. But in an ever less predictable world of dynamic markets, global competition, complex technology and shortening product cycles, the sole extrapolation of past trends is doomed to failure.

Starting in the sixties, when the saturation of markets led to the decline of companies' growth, a new approach capable of overcoming the shortcomings associated with long range planning was needed. Contrary to long-range planning, which was the companies' response to the „pressures of rapid growth, size and complexity in the 1950's" [ANSO84 187], strategic planning has been developed to *determine and anticipate change*. To be successful, it requires an early involvement of the divisional and functional management, partly to benefit from their experience but mainly to safeguard the timely initiation and implementation of ensuing organisational adjustments throughout the company.

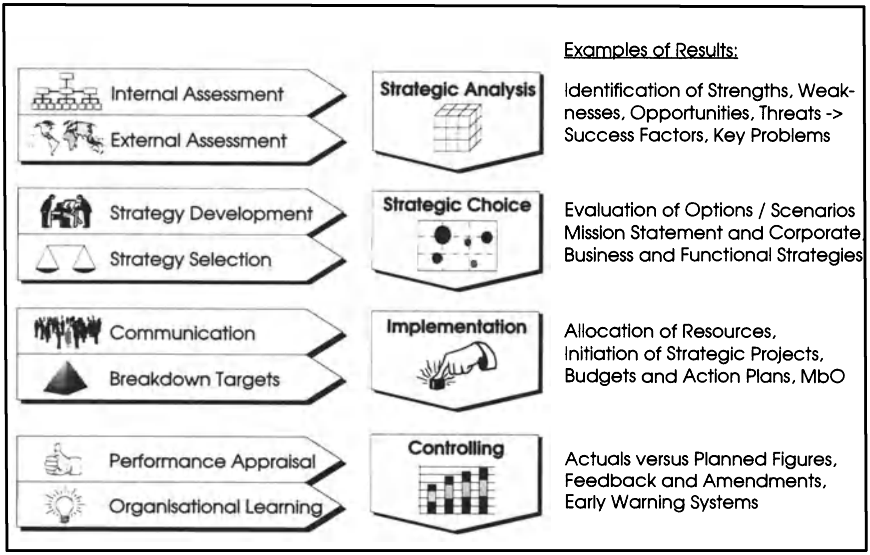


Figure 2.b: The Strategy Planning Process

The strategic planning process is highly participative and time-consuming, and requires a series of *continuous and interdependent activities* to define and maintain a sound strategy which is a „unified, comprehensive, and integrated plan that relates the strategic advantages of the firm to the challenges of the environment and that is designed to ensure that the basic objectives of the enterprise are achieved through proper execution by the organisation" [GLUE86 8]. Figure 2.b depicts the four major phases of this process.

In an initial phase, a detailed *analysis* of the factors influencing the competitive position provide an information base for the evaluation of the key issues which have to be addressed. In a second stage, potential reactions have to be considered to generate alternative options and render strategic *choice*. After the appropriate strategies have been selected, the *implementation* of the plans and actions and, finally, the *controlling* of the achievements constitute the third and fourth phases of the strategy planning process.

2.2.2 Fundamental Concepts

To achieve an effective strategic management a company has to develop a planning system which must closely match its *individual structure* and *specific needs*. Ranging from unwritten verbal guidelines of small enterprises to detailed planning volumes of multi-national corporations, the design of the appropriate system employed can vary extensively. A number of fundamental concepts, however, establish a common ground for development and have to be presented beforehand, without delving into a comprehensive discussion of features and criticisms.

■ Top-down versus Bottom-up Process

To establish realistic and rewarding strategic plans it is vital to secure the support of all those involved in implementing them. Approaches to be taken into consideration are the *top-down process* in which targets are passed down the line to be accomplished and the *bottom-up process* which requires that operational management submits plans, budgets and targets to higher authorities for approval. The strategic planning process has to incorporate both to deliver consistent plans. In an *iterative process*, to-and-from movements on the same level (horizontal co-ordination) and between different levels (vertical co-ordination) have to take place until a consensus in respect to the overall mission, objectives, priorities and measures is reached (figure 2.g).

■ Corporate, Business and Functional Level

Large diversified companies were among the first to engage in strategic planning. Their divisional organisation requires structuring strategies hierarchically and conducting planning activities at three levels.

At medium level, the *business strategies* represent the areas of commercial engagement and their individual objectives, characteristics and infrastructure. To put them into effect, subordinate *functional strategies* have to be implemented by the respective functional departments (e.g. finance, marketing, production). At top level, the *corporate strategy* has to concentrate on measures to ensure a balanced portfolio of businesses and to provide an adequate support from corporate services. The hierarchical nature of the strategy process also applies to holding and matrix organisations and small companies.

■ Strategic Business Units (SBU)

Competitive advantage is planned at the business level but implemented at the functional level. Hence, the definition of a business has to be clearly focused in order to direct and concentrate efforts, allocate resources and measure performance. Because an organisation is usually structured to suit internal conditions (e.g. production, location) a new organisational entity had to be created: A *strategic business unit* (SBU) is „an operating division of a firm which serves a distinct product/market segment or a well-defined set of customers or a geographic area" [GLUE86 5].

■ Critical Success Factors

To explain the long term financial performance of companies, another notion was devised: *Critical Success Factors* are capabilities of a company to achieve above average long term profitability in relation to its competition.

To research these 'laws' of the market place, in 1975 the PIMS-program (Profit Impact on Market Strategies) was established [ABEL80 271-371]. Based on the data of by now more than 3000 strategic business units from around 500 companies, the statistical results have shown that out of a number of factors analysed the *capital/sales-ratio* and the *market share* exercise the most significant influence on long-range success [BUZZ89; BARZ90; HILD90]. However, effects vary across branches and enterprises, and the results aimed for are not inevitably linked to the criteria researched [references to discussions in DANN90 24-29].

■ Experience Curve

The dominant role of market share was also supported by the *experience curve concept* (figure 2.c) introduced in 1966 by the Boston Consulting Group (BCG). As a rule of thumb, it states that „costs of value added net of inflation will characteristically decline 25 to 30 per cent each time the total accumulated experience has doubled" [HEND84]. This effect is based on learning, specialisation and standardisation of labour as well as on product and process improvements. As the highest potential benefit can be utilised by the market leader, the SBU-management has to place a considerable importance on its relative market share and the market growth [DUNS79 68ff].

■ Portfolio Analysis

In the financial context a portfolio represents the entire collection of investments held by an investor; in the strategic sense each business unit stands for an investment and the resulting portfolio portrays the organisation as a whole. Based on *relative market share* and the *market growth,* the Boston Consulting Group introduced the growth/share matrix (figure 2.c) to support corporate strategists in analysing and maximising their business portfolio performance.

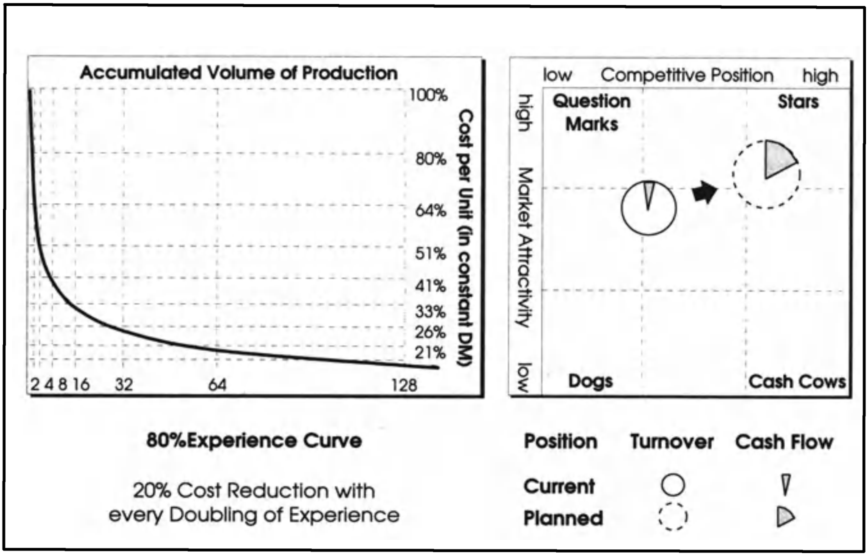


Figure 2.c: Experience Curve [following ABEL80 122] and Portfolio Diagram

Whereas *market growth* is seen as an external factor which cannot be influenced, the *relative market share* (own sales divided by sales of largest competitor) is regarded as under the control of management. For visualisation, business units have to be positioned according to their ratios and drawn as a circle with a diameter proportionate to their *revenues*, optionally showing a pie to indicate the percentage of *contribution*.

The high growth/high share-sector of the *portfolio-matrix* hosts the *stars*, already financially viable but in need of further cash to finance the rapid growth. These cash requirements have to be provided by *Cash Cows* which represent dominant products in mature markets. They may also finance *Question Marks*, characterised by a low share in a growing market, in an effort to create the future stars. The low share products in slow-growth or declining markets called *Dogs* have to be further analysed to decide on the appropriate future actions (e.g. invest, hold, divest).

Additional types of portfolios have been developed and proven their usefulness. To overcome the limitations of the growth-share-matrix, McKinsey's Portfolio substituted market growth with *market attractivity* and relative market share with *competitive position*. The differentiation between external and internal factors still applies but instead of ratios, a set of criteria is used and evaluated via a scoring method. [for further information, examples and limitations in ABEL80 173ff, DUNS79 107ff, HINT89b 122ff].

The *philosophy* underlying these concepts, however, is similar. At a given point in time, each business unit occupies a specific position in the portfolio according to its short-term and long-term commercial potential. *Portfolio Analysis*, thus, enables a company to view and analyse its business units in their entirety or against the competition, to determine the allocation of funds amongst them and to deduce potential strategies from the units' relative positions.

■ Product Life Cycle

As a strategic business unit moves between question mark, star, cash cow and dog, another underlying concept becomes apparent: the *product life cycle (PLC)*. It covers the life span of a product and is composed of four distinct phases (figure 2.d).

Because there is no universal shape, predictions about the current and future position of markets and products are highly speculative. Although it does not offer guidance in strategic positioning, the method provides a valuable aid for historical analysis. It also presents a useful theoretical vehicle for understanding the implications of product life phases in respect to resource requirements and performance expectations (figure 2.d).

Phase:	**Development**	**Growth**	**Maturity**	**Decline**
Strategy				
Market Growth	rising slowly	accelerating	levelling	declining
Strategy	invest	invest	hold	divest
Risk	very high	decreasing	low	low
Entry Barriers	technology	competitors	competitors	overcapacity
Pricing	cost-plus	penetration	competitive	cut
Finance				
Liquidity	low	improving	improving	high
Profitability	losses	greatest	decreasing	decr./loss
Cash Flow	negative	improving	improving	large-negatv.
Leverage	high	high	decreasing	low
Dividends	none	small-increase	increasing	large-none
Production				
Volume	low	increasing	stable	declining
Costs	high	falling	falling	stable-low
Development	continuing	slowing	minimal	none
Technology	new	new	established	obsolete
Personnel	increasing	increasing	fewer	fewer
Skills	being develp.	developed	developed	developed
Marketing				
No.Competitors	few	increasing	decreasing	fewer
Expenses	high	high	falling	low
Research	intense	reducing	minimal	none
Sales	low	rising	peak	declining
Advertising priorities	awareness + education	mass-market awareness	differentiation segmentation	reduced spending

Figure 2.d: Strategic/functional Implications of the Life Cycle [MCNA92 36; HIAM90 351]

2.2.3 Strategic Analysis

Competitive positions are built on *relative advantage* - out-performing one's competitors in ways that are commercially acknowledged by the customer. The source of advantage in any industry is manifold, ranging from product-related leads in price, quality, image or services to the access to critical resources or know-how, from superior research or infrastructure to efficiency in development, production or distribution. Understanding how these factors can contribute to the company's success is the objective of strategic analysis.

One of the initial duties is to identify the relevant external influences, to evaluate them and to recognise the major *opportunities and threats* facing the company currently and in future. This environmental assessment covers the markets and competition, customers and suppliers, infrastructure and technology, products and services. Another responsibility is to critically examine the internal *strengths and weaknesses* of the company. It concentrates on the cultural and political framework, structure and management, know-how and resources, technology and processes. Several guides and check lists have been devised to give planner and management the opportunity to complete these two tasks thoroughly [e.g. BARA90 105ff; PÜMP88, HINT89b 85ff]. Figure 2.e shows external (left) and internal (right) key areas and some of their dependencies which have to be addressed during the stage of analysis.

After remedying information deficiencies encountered, the pooling of internal capabilities and external forces establish the basis for identifying the company's *success factors and key problems* and to devise potential strategies for expansion, improvement, consolidation, counteraction or withdrawal.

In order to develop the strategic perspectives, a *holistic view* of the overall situation has to be adopted by taking into account a vast variety and range of data inputs. Subject to the scope of activities and the research facilities available, this data is scattered over a multitude of planners, executives and experts inside and outside the company. Bearing in mind the expenses necessary, their know-how and views need to be utilised. To do so, extensive interpersonal communication has to take place in order to gather the data required and to reach a common understanding in regard to the final analytical results.

Verbal descriptions of results and anticipated actions typically form the basis for the subsequent stages. If planning models are employed, detailed numerical projections are required. *Meta-Planner* helps to identify the model variables to be included by taking into account their relevance and data needs. It provides the means to keep increasing modelling expenditures at bay.

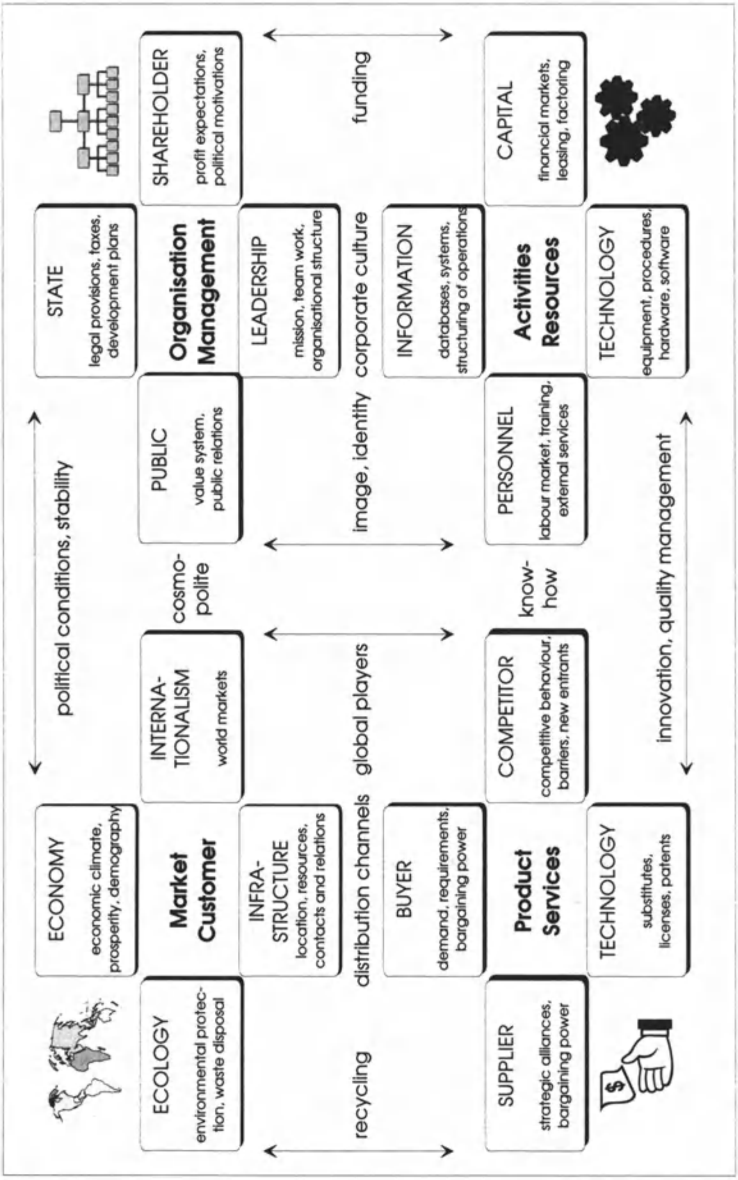


Figure 2.e: Some Key Areas of Strategic Analysis

2.2.4 Strategic Choice

The purpose of strategic choice is to identify the various strategic *options* that an organisation might pursue in the light of the analytical results and potential scenarios. It is a process of deciding which *opportunities* and *risks* to undertake and which to avoid. It also determines how and where the organisation should direct its limited *resources*.

■ Strategy Development

The development of strategies should fully cover the *scope* of possible courses of action to enable corporate choice in the ensuing strategy selection process. They have to be clearly stated in terms of their objective, direction and method of deployment.

The definition of the *general objective* can be guided by prescriptive approaches based on product life cycle and portfolio analysis (chapter 2.2.2) and expressed in relation to the *norm strategies* (e.g. invest, hold, divest) associated with the positioning of strategic business units [HINT89c 141-142].

According to Porter, a company wishing to compete successfully has to avoid getting „stuck in the middle", and has, therefore, the choice of only three *generic strategies* [PORT85 11ff]:

- *overall cost leadership;* objective: production at the lowest cost in the industry by maintaining the average industry standard of product or service quality
- *differentiation;* objective: offering a product or service which is perceived industrywide as being unique (e.g. design, image, technology, service)
- *focus on selling to a market niche;* objective: targeting of special buyer groups, geographic markets or product line segments instead of industrywide competition.

To define the *strategic direction,* the revised Ansoff-Matrix offers three „dimensions": market need (e.g. infrastructure), product/service technology (e.g. motorways) and market geography (area of intended business) [ANSO88 82ff]. Depending on the current business, strategies can be positioned by using these dimensions and by differentiating between present, related or new areas of activities.

Present need/present product/present geography strategies offer the options of withdrawal, consolidation, penetration or 'do nothing', whereas moves in *new areas* trigger the addressing of different customers, needs and regions, the development of new products, employment of new technologies, use of other distribution channels and design of novel marketing and service concepts.

New need/new product/new geography-strategies are called unrelated diversifications [JOHN89 161] and are the most expensive and risky options which can be taken. Related diversifications look for potential synergies in respect to present operations and know-how of a company (e.g. manufacturer), and cover the backward (supply activities), forward (transport activities) or horizontal integration (complementary products) of activities previously not undertaken.

The *methods of deployment* detail the means by which any direction of development is intended to be achieved. They can be rooted in internal development, acquisition or joint development and can range from the liquidation, sell-out or outsourcing of present activities to the creation of new profit centers, purchase of companies or strategic alliances with suppliers or competitors. To decide on the method suitable their characteristic features have to be taken into account (e.g. speed, costs, risk).

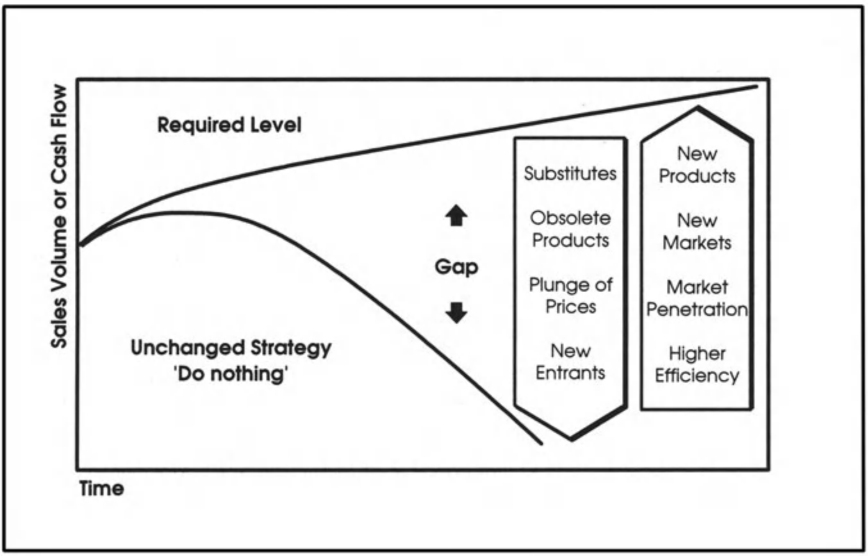


Figure 2.f: Gap-Analysis with Causes and Strategic Remedies (examples)

Gap Analysis, devised by Argenti, supports the *development of individual* strategies and the *evaluation of their impact*. It helps to indicate the extent to which a current strategy fails to meet the future objectives, and it establishes the need for strategic change. Based on the expected environmental conditions and a 'do nothing' option, the current performance is extrapolated.

The result is a projection of the existing strategy which has to be compared with the objectives set. The resulting *gap* between the two lines (figure 2.f) represents the incentive for strategic adjustments. To gain maximum *benefit* from the gap-analysis, the planner has to:

- Identify the *factors* responsible for the non-performance (white arrows)
- Search for *adequate adjustments / new strategies* to fill the gap (black arrows)
- Cater for *competitive responses or potential failures* by overfulfilling the gap
- Consider the *time sequence* of strategic decision-making and implementation
- Examine *various targets* to understand the consequences (cash flow, profit).

■ Strategy Selection

The selection process requires the *evaluation* of the alternatives against predefined criteria. It also includes the search for an appropriate *combination* of individual strategies to shape a *portfolio* which is expected to assure a balanced distribution of risk and cash flow and to achieve the companies' long-term objectives. Selection criteria fall into three categories:

- *Suitability* assesses the contribution of particular strategies in respect to the initial SWOT-analysis(*s*trength, *w*eakness, *o*pportunity, *t*hreat) and the overall company objectives
- *Feasibility* judges the potential of implementation, taking into account the capabilities of the organisations (e.g. know-how, quality), conceivable competitive reactions (e.g. dumping prices), availability of resources (e.g. funds, material, technology, skills) and matters of timing
- *Acceptability* includes the appraisal of costs, benefits, financial risk (e.g. liquidity), the extent of organisational change required and the respective level of consent with workforce and management. Environmental considerations, views of the public, the relationships to stakeholders (e.g. customers, share holders, unions) or cultural fit may have to be considered likewise. Risks associated with uncertain projections can be estimated by the use of *pessimistic and optimistic scenarios*.

The evaluation of strategies has to incorporate multiple objectives, differing opinions, uncertainty and unknown consequences. It is a complex undertaking, especially in respect to the formation of the *corporate strategy portfolio*. The search space generated by the individual options grows at an exponential rate with every additional alternative. Even the use of sophisticated multiple criteria decision making techniques does not eliminate the problem of *combinatorial explosion*, particularly in those cases where strategies are not mutually independent.

Although the theory desires that strategic business units should represent organisational building blocks as autonomous as possible, in practice internal supplier-customer-relations and the sharing of technology, resources and channels demonstrate the opposite. In fact, *synergy*, the commonly quoted advantage concerning diversification issues, depends on two or more activities or processes complementing each other to achieve a combined effect which is greater than the 'sum of the parts'.

Due to these conditions, the final portfolio chosen can provide only a satisfactory rather than the 'best' solution. Consequently, strategy selection does not represent an exact science but appears in the character of a more heuristic approach which has the aim of finding good enough results in a systematic way.

The use of quantitative *planning models* can considerably enhance the quality of these results. The consolidation of numerical projections allows the otherwise difficult assessment of multiple portfolios and, consequently, allows the consideration of more varied alternatives and scenarios.

However, since different organisational units do not share the same objective, direction, method of deployment and implications of the life cycle phase (chapter 2.2.2), their critical success factors and their adequate model representation also differ. In ignoring these *distinctions*, the model design is usually governed by the *'common denominator'*. This approach results in the gathering and analysis of over-detailed data causing increased data expenditures in terms of time, manpower and money.

Meta-Planner supports the building of tailor-made models for distinctive organisational units. Consequently, the resulting data needs are not exaggerated, and planning participants do not need to be concerned with a level of detail which defies the inherent uncertainty of the data required and undermines their motivation to provide the information.

2.2.5 Implementation

Following the agreement on a suitable portfolio of strategies, the interdependencies can be determined to clearly formulate the dependent business and functional strategies. If necessary, the corporate *mission* statement has to be modified to reflect any changes in respect to former company objectives or activities. Subsequently, the new *business policy* can be communicated to the internal and external stakeholders.

To implement the policy, adequate *budgets, projects and action plans* have to be defined. By breaking down strategic objectives, shorter-range and more operative planning figures (e.g. one-year budgets differentiated by division, area, function) provide a yardstick which allows management to measure day-to-day performance.

In order to delegate responsibility and to enable control, the cash-remitting and cash-receiving organisational units have to be defined as narrowly as possible. In this way, the respective managers can be given clear *targets, funds and milestones*. This information empowers and qualifies them to carry out the tasks required and, if necessary, adjust structures and systems, modify processes and technology, manage people, monitor progress and supply feedback.

In the same way, targets of individuals (*management-by-objectives MbO*) can be developed top-down from the company's and superiors' objectives and plans. By identifying the key tasks, setting the specific due dates and quantifying the results, the standard of individual performances can be appraised to review the progress of implementation.

The level of individual or group achievements can be linked to *incentive systems* to motivate both workforce and management and to embed the company's strategic policy thoroughly within the organisation. However, individual targets should not be generated and rewarded by considering the subordinate's activities in isolation but should be linked to the overall performance of the concerned teams to avoid individual or departmental egoisms.

Thus, the corporate strategy is implemented in a *hierarchical fashion*. Strategic plans at the top level are progressively refined and transformed into operational plans as they cascade downwards to the business units and functional levels. Figure 2.g shows the relationships of planning cycles and management levels [ABEL79 247]. It details the processes taking place to transform long range corporate guidelines into short range budgets or MbO-targets for operative management.

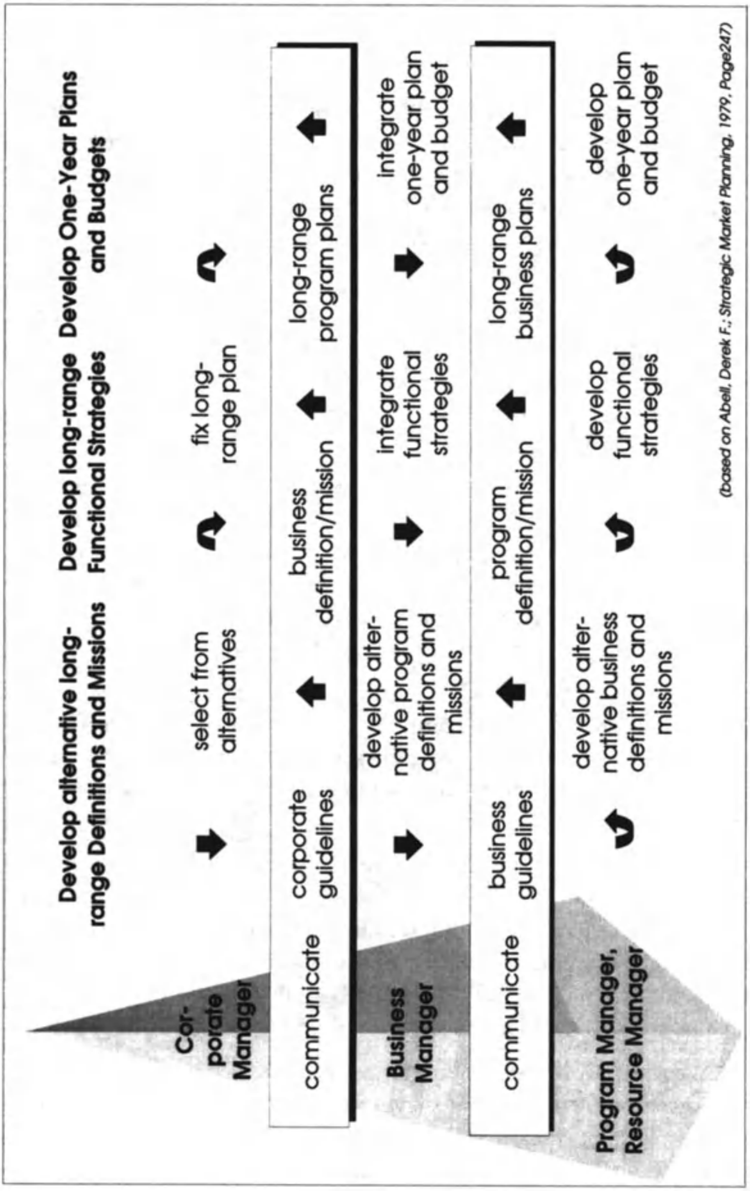


Figure 2.g: Relationship between Planning Cycles and Management Levels [ABEL79 247]

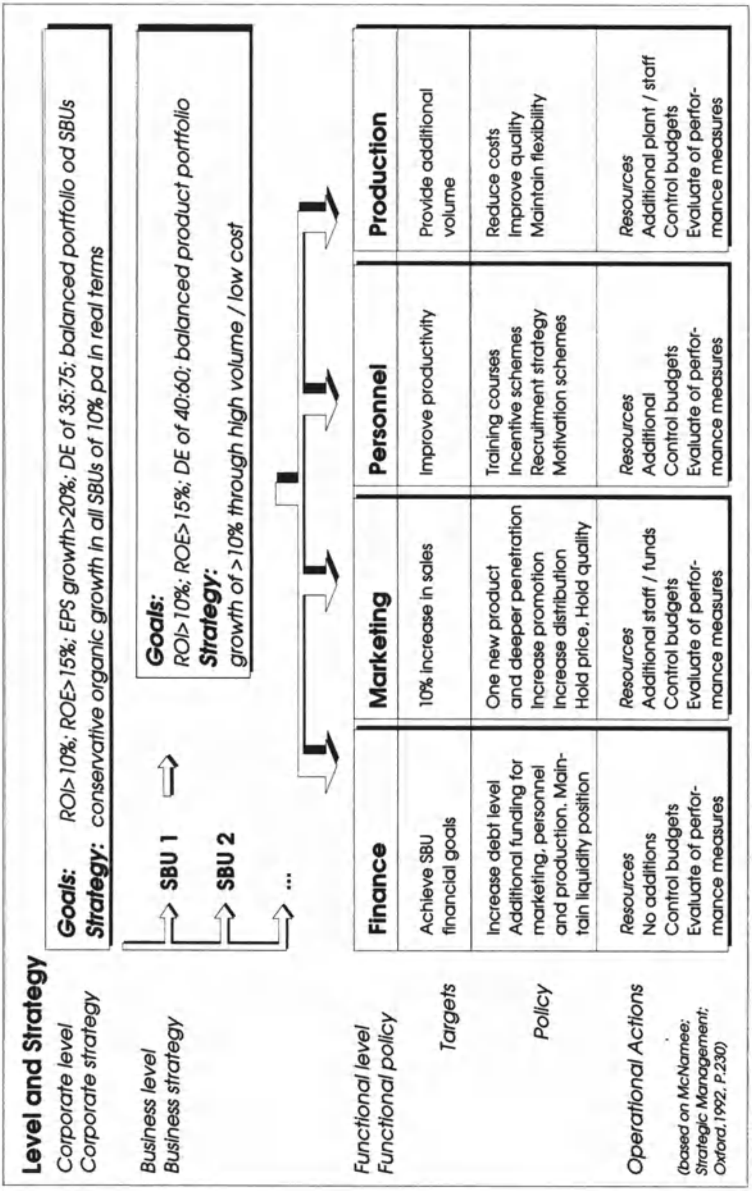


Figure 2.h: The Flow of the Strategic Implementation Process [McNA92 230]

In addition, figure 2.h exemplifies a schematic representation of an organisational structure in which implementation is assumed to take place and gives examples of breakdown targets.

Implementing strategies always consumes *resources* and their *allocation* between business opportunities is the most fundamental decision to be taken during the strategy development phase. Allocations can materialise in the form of investments (e.g. manpower, know-how, materials, technology, acquisitions), divestments (e.g. sale of subsidiaries or machinery) or temporary acceptance of financial losses. Over time, such series of cash infusions or withdrawals can dramatically change the character and value of a company, and, thus, have to be carefully controlled.

The *quantification* of strategies comfortably enables the breakdown into numerical subgoals for the appropriate organisational units and operative managers. In addition, the consistent modelling representations also allow the carrying out of further what-if or sensitivity analyses at whatever level of responsibility, which help better to understand the implications of implementation issues.

2.2.6 Strategic Controlling

To ensure that the implemented strategy will meet the objectives envisaged, the subsequent *performance* of the businesses and activities has to be monitored and assessed. By comparing the actuals to the plans, the analysis of confirmations and contradictions enables the operation of effective strategic controlling systems. Depending on the variances encountered, either a *feedback* can be triggered which leads to corrective reaction, or the plans need *amendments* to reflect the learning experience and to show new feasible projections.

This process commands the presence of *planned and actual figures* which are up-to-date, sound and significant. By discussing some of the main concerns of strategic control, Asch [ASCH92 105] enumerates three important elements:

- *Actual processes and results* must be capable of being measured in a reasonably objective and consistent manner focusing on the most significant factors
- *Standards of performance* need to be established representing detailed expressions of strategic objectives and measures of acceptable results
- *Actions* must be taken to correct *deviations* where actuals deviate from standards.

Kaplan proposed the *Balanced Scoreboard* [KAPL92] for performance measurement and strategic controlling. By displaying a balanced presentation of both financial and operative yardsticks, its aim is to deliver correct signals for continuous improvement and to guard against sub-optimisation by putting management more fully into the picture.

The approach requires the designation of the most important strategic goals and the translation into their respective critical indicators. The actual figures of these indicators have to be reported on a timely and periodic basis. Kaplan's method addresses four *basic perspectives* (examples of indicators):

- *Customer Perspective* focuses on cost, time, quality, performance and service (lead time, defect level, on-time delivery, mean-time response to calls)
- *Internal Business Perspective* focuses on processes, competencies, technology (cycle time, break down time, order time, productivity, development time)
- *Learning Perspective* focuses on innovation, product and process efficiency (new product introductions, percentage of new product sales, scrap rate)
- *Financial Perspective* focuses on profitability, growth and shareholder value (return on sales, sales growth, cash flow, market share, return on equity).

In order to take appropriate corrective actions, the success of this method also relies on a *responsive information system.* To identify a source of trouble, a quick disaggregation of the compounded figures is needed, which can only be achieved via efficient drill-down-queries and hierarchically structured, timely and accurate data.

But, although the scoreboard concentrates on *strategy and vision,* success is not guaranteed: „Not all long-term strategies are profitable strategies. A failure to convert improved operational performance, as measured in the scoreboard, into improved financial performance should send executives back to their drawing boards to rethink the company's strategy or its implementation plans" [KAPL92 77,78].

Being in this politically sensitive position, the *strategic controller* has to decide when corrective action is necessary or contingency plans have to be triggered. In correspondence to the specific turbulences encountered in the different markets, these actions have to be fine-tuned ranging from incremental adjustments to strategic leaps. In this complex field of responsibilities, the following common problem areas have been identified [HREB84 114-123] :

- *Poor objectives* which do not provide suitable standards of performances for comparison with the actual results, caused by an inadequate planning and implementation process
- *Insufficient information* to monitor the actual situation due to inaccurate and incomplete data, caused by slow or faulty discovery, gathering, scanning, reporting, classification, and interpretation processes
- *Poor performance controlling* due to inadequate formal appraisal and review processes, caused by missing or incomplete systems or know-how
- *Management by negative exception* which deprives planning participants of the strategic learning experience resulting from positive plan-actuals deviations
- *Obstructive organisational culture* as an effect of too strict control activities, which lead to a tendency of strict error avoidance deterring innovation and risk-taking.

Compared to operational control, strategic controlling systems have to perform on data with a much higher level of aggregation. Due to their nature and time frame, they have to analyse the external conditions and the initial assumptions upon which the plans were based. More data, supplied from a variety of, often external, sources, might be less precise or need to be processed to fit the chosen strategic segmentation.

Based on only qualitative information, the strategic controlling process has to adapt to the subjective nature of the data and the results might be disputed due to non-uniform opinions and interpretations. *Quantitative planning models,* in this respect, allow a more objective analysis of the actual situation.

However, since models in strategic management operate at a higher aggregation, the actual data of the cost and accounting systems has to be adequately processed and consolidated. The resulting database of *Meta-Planner* provides a thorough documentation of the equations and procedures to carry out these calculations. Relationships are clearly defined, so that strategic controlling figures can be easily matched by the functional managers to the operative actuals of the other management information systems.

2.3 Critical Assessment

The objective of strategic analysis is to match external opportunities (what *might* be done) with corporate capabilities (what *can* be done). Subsequently, strategic choice requires the consideration of the corporate objectives (what do we *want* to do) and ethical values (what *should* we do). In dealing with these four components of strategy, Andrews [ANDR87] takes the view that strategic management „is, and will remain, more an art than science".

But in the absence of „logically established principles or scientifically grounded laws, there is an even greater need for *intellectual effort* because of the compulsion to understand - in order to manage - complex organisations striving to make their way in an increasingly complicated world" [MOOR92 6]. Thus, strategic management has been a favoured area for both scholars and practitioners.

Although critiques concerning the multiple business methods introduced often use the phrase of „old wine in new bottles", a number of concepts and tools (chapter 2.2.2) have caught the attention and fancy of planners and academics alike, and contributed to the ever-growing domain of strategic management. Based on empirical research, common sense or the ingenuity of brilliant presentation, *useful techniques and heuristics* have been developed and applied, sometimes out of context, over-simplified and lacking the thorough evaluation needed.

But this impressive analytical arsenal is, due to its rigid application by corporate planning departments, also the source of *major criticisms* [e.g. MINT92, STAR93]. To identify the need for strategic change and find appropriate solutions, creativity and an unbiased perceptivity ought to be promoted. However, the high degree of *formalisation* often stifles the flexibility required and causes unexpected opportunities to be overlooked.

The strong *consensus and commitments* established in companies' management due to a too formal strategic planning process blur the ability to recognise unrealistic assumptions and, consequently, fail to correct non-performing strategies in time. The *inaccuracy* of long-range predictions and the widespread *misperception* of too many managers concerning their company and its environment add further to these points of critique, which are reinforced by an often prevailing *inadequate teamwork* between planners and managers.

These concerns have also been confirmed by *empirical studies* in Germany and the United States [KREI92, MINT92 85]. Besides formalisation and teamwork issues, the findings indicated an insufficient dedication of top-management and a lacking technical and inter-personal expertise of corporate planners as the factors contributing to the abstinence from more sophisticated strategic planning systems in companies.

To steer clear of these imperilments, Mintzberg and Starbuck plead for a strategic management which allows for *contingencies* to counteract uncertainty, and furthers the *close co-operation* between planners and operative management to couple action and reflection, soft and hard data, intuition and analysis. „Planners have the time and technique to engage in the necessary analysis; they have the inclination to find the important messages in the hard data and to apply the systematic models. Such inputs increase the managers' knowledge bases and extend the amount of material they can consider in strategy making. More importantly, the analyst can provide managers with new concepts and alternate ways to look at problems, sometimes freeing them from mind-sets imposed by years of experience" [MINT92 330].

But these recommendations do not go far enough. As a response to additional drawbacks encountered, Hanssmann [HANS90 332-337] has formulated six *demands* in order to avoid methodical misconceptions:

- To warrant corporate choice, the planning system must enable the selection of *alternatives* which ideally should cover the full range of options available
- To minimise data requirements, the alternatives should be represented with the least *detail* possible
- Uncertainty of the environment has to be considered explicitly via *scenarios*
- Primarily, the first steps of strategic actions have to be justified by sufficiently precise *forecasts*
- Based on the defined scenarios, *risk analyses* have to be carried out to reflect on uncertainty; strategic options have to be developed to enable further *revision* during the subsequent planning cycles
- To develop effective *risk policies,* the strategy portfolio has to include those options which promise an appropriate trade-off between benefit and risk.

In order to assess strategies and contingencies and to determine the managers' freedom of action, the sole consideration of qualitative data is not sufficient any more. The focus, which at the introduction of strategic planning had shifted from detailed numerical projections to verbal descriptions, has to be broadened to cover the quantification of analytical results and anticipated actions by *strategic modelling*.

To strengthen the evolutionary character of strategies, *financial and non-financial consequences* have to be quantified, discussed and accepted. Hinterhuber points out [HINT89a 32], that the transition from verbal to mathematical models reduces the uncertainty of decisions and increases the objectivity of controls. It gives operative management an understanding of the reality aspired to, which is uniquely defined, and clarifies the individual manager's scope for direction.

Only the quantification of strategies enables the *projection of long range financial statements*, which in turn provide management with the means

- to *review* the strategic policy in its entirety
- to set the appropriate *targets* for their operational units
- to *control* the *execution* successfully and
- to timely determine *corrective actions*.

Additionally, it supplies appropriate data to be used in a number of *techniques and heuristics* mentioned before (chapter 2.2.2) or to be introduced subsequently.

2.4 Summary

Strategic management was devised to recognise *discontinuous strategic change* and to create *competitive advantage* in a dynamic environment. It can be subdivided into the phases *analysis* (internal and external assessment), *choice* (strategy development and selection), *implementation* and *controlling*.

Although it focuses on the scanning, structuring and appraisal of predominantly *qualitative data*, it has been shown that a considerable amount of *quantitative figures* are also needed, in particular to supply hard data for established strategic tools (e.g. portfolio or gap analysis), to provide the basis for breakdown targets for implementation and controlling, and to link the strategic plans to the medium and short range planning systems.

The use of quantitative *planning models* can substantially enhance the quality of strategic management and provides a better basis for the decisions to be taken. However, the *organisational segments* differ in their points of strategic emphasis. Individual success factors, strategy type selected, field of activity, life cycle phase and so on, trigger specific qualitative as well as quantitative data requirements and, consequently, demand *particular model representations* to keep data expenditures at bay.

As excessive data needs have been the major cause for preventing the use of quantitative planning models in strategic management, *Meta-Planner* considers the strategic relevances of planning objects as well as the resulting data requirements of their model inclusions. Its main objective is to act as a *helpful companion* for the planner in his ambition to establish an *effective and efficient model design*.

3 Strategic Modelling

The *lack of capable tools* to support the configuration of quantitative planning models for strategic management has motivated the development of *Meta-Planner*. The following chapter discusses the quantitative planning process and the importance of the underlying model design. It presents a methodology to guide the meta-planning activities of the model building process and presents the principles of quantitative model building as a lead into the modelling issues supported by the system.

3.1 Model-based Planning Process

To support management in the planning process, the *qualitative assumptions* of the strategies selected have to be quantified, consolidated and converted into prospective financial statements. The results enable the review of the strategic policy in its entirety and facilitate the subsequent setting of appropriate targets for the various organisational units. However, before the *interpretation* of expected profit and loss accounts and balance sheets can benefit strategic management, a number of preliminary steps (figure 3.a) have to be taken.

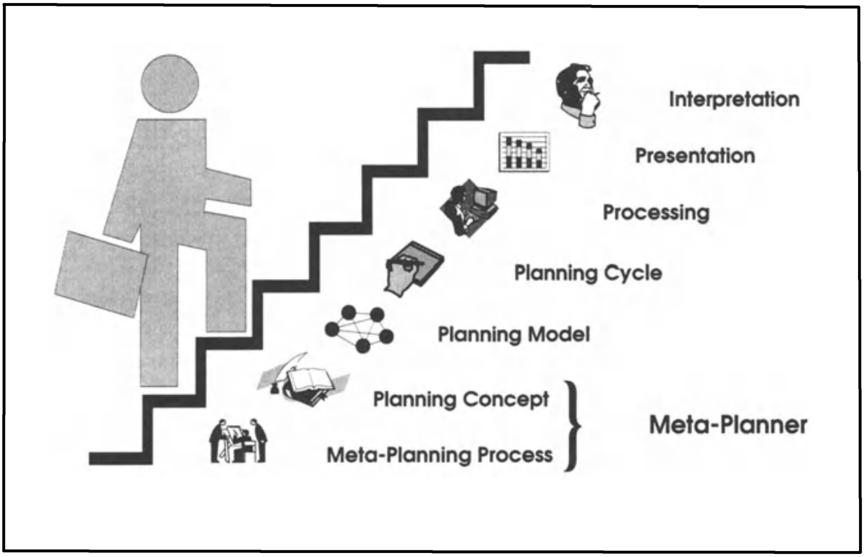


Figure 3.a: Preconditions to benefit from quantitative Strategic Planning Models

To be able to present and interpret projections, the underlying input data has to be collected and evaluated. Due to the data quantity involved, the calculation of ratios and further analytical needs, the *processing* has to be carried out by spreadsheets or other specialised software applications.

The *planning cycle* requires the study of written material and the communication with a number of informants. The persons participating have to be briefed about their role and the information expected, and provided with suitable documentation and input forms. The more people who are involved, the more time and manpower is needed for administration, training, support, collection, checking and control.

The efficient use of the resources employed, necessitates a sound *planning system* which ensures the timely co-ordination between people, data, technology and documentation. To guide the planning cycle, the implementing statutes of the system should be documented in a *planning handbook*, which also details the company-specific glossary of planning terms and summarises the underlying planning concept.

The *planning concept* includes the aim and the design of the planning system. It represents the *organisational and technological framework* in which a company performs and controls its planning activities. It can consist of only few, 'historically grown' not even paper-documented guidelines or extensive manuals with in-depth detail of policies and directives to be followed.

But independent of its level of documentation, a planning concept is expected to ensure the quality of the planning results, the effectiveness of the planning process and the efficient use of resources. These *objectives* can only be achieved, if the concept is closely tailored to the specific needs of the company - in particular, if a *quantitative model* is part of the planning concept.

The *building of a model* is a central element in the *decision making process*. Preceded by the establishment of an unambiguous objective and the consideration of various solutions, a model, whether mental or physical, provides the means to evaluate and rank the alternatives and, thus, the basis for the succeeding selection, implementation and monitoring activities. The *advantages* of modelling, compared to experimentation in reality, are easier manipulation, calculation of alternatives and risks, compression of time, lower cost associated with operation and trial-and-error, and increased benefits in regard to the learning experience [TURB90 37].

In the context of decision support a model is *an abstraction of reality applied to problem solving* [KLEI86 94]. Its construction involves the *simplification of a real world situation* [TURB90 683] and its ingredients are *data, statements,* or *subroutines* [SPRA82]. A model can help a company to define its objectives, develop sound decision rules, communicate between functional groups and, more importantly, furnish more information from which to make decisions. Its intrinsic value depends on the sufficient confidence of decision makers in the quality of the underlying data, the correct execution and the benefits associated with the additional insights gained.

Strategy making relies to a large extent on *soft information.* Hence, models used are of verbal or qualitative nature. However, „qualitative concepts alone are not sufficient to evaluate strategies. Quantitative projections have to be taken into account despite the uncertainty associated with it“ [HANS90 299]. These projections can be either isolated subjective forecasts to cover specific issues and action plans or quantitative models which allow to incorporate wider areas of strategic concern, for example:

- *extrapolative methods* to project specific variables based on that variable's past history (e.g. trend curves, exponential smoothing)
- *financial methods* to calculate specific resource and time-dependent ratios for management (e.g. depreciation, net present value, internal rate of return)
- *mathematical methods* to optimise a specified objective by obeying a defined set of restrictions (e.g. linear programming, inventory models)
- *scoring methods* to evaluate alternative problem solutions with objectives which are usually conflicting or measured by different units and criteria
- *simulation methods* to survey larger numbers of variables and their interrelationships with exogenous factors.

This study concentrates on the application of quantitative simulation models. Their benefits for the *strategic management process,* were publicised as early as 1973 by Hamilton and Moses: „Planners are able to consider a far greater number of alternatives in more detail and with greater confidence than was possible using traditional planning methods“ [HAMI73 323].

However, to achieve these aims, the configuration of a model has to be carefully planned and its objectives and components should be stated in the planning concept prior to its implementation within the decision support system selected.

3.2 Meta-Planning for Modelling

3.2.1 Quantitative Planning Concept

Several *methodologies* have been suggested and evaluated [KÜHN85; GRÜN90 101ff] to guide planners and management in defining their individual planning concept. For this project with its emphasis on strategic modelling issues, an approach in accordance with Wild [WILD81 153ff] has proven useful. In his opinion a planning system consists of eight subsystems (figure 3.b):

- *Segments / Planner* cover the organisational areas and information sources (documents and people) which take an active part in the planning process.
- *Functions* assign the managerial and job responsibilities to the participants. Depending on the degree of specialisation and decentralisation, they also determine the necessary communication and co-ordination activities.
- *Processes* describe the job responsibilities and outline the managerial, planning and control activities.
- *Information* list the required data and document its sources and receivers as well as its quality and availability.

1.a **Segments** ← *are represented by*	***Which*** organisational areas are covered?
1.b **Planner** *has*	***Who*** takes part in the planning process?
2. **Functions** *initiate*	***Which*** responsibilities have been assigned?
3. **Processes** *require*	***How*** do these responsibilities have to be performed?
4. **Information** *are processed by*	***Which*** data has to be supplied and ***Who*** provides it?
5. **Instruments** *generate*	***How*** is the data reported, processed and presented?
6. **Plans** *show projections of*	***What*** output is expected and ***Who*** is the receiver?
7. **Structure** *(of 1-6)* *is controlled by*	***Which*** interdependencies require special measures?
8. **Regulations**	***How*** are these special measures implemented?

Figure 3.b: Subsystems of the Quantitative Planning System

- *Instruments* specify the methods and tools used (e.g. forms, graphs, models, programmes, computer) for processing and reporting of data and results.
- *Plans* set forth the expected output of the planning exercise.
- *Structure* comprises the relationships between the subsystems mentioned so far. It details the interdependencies, which require further organisational measures to secure the correct running of the planning system (e.g. scheduling of dependent information flows).
- *Regulations* contain the guidelines ruling the execution of the planning cycle (e.g. harmonisation of input data between planners, method instructions).

In applying these subsystems to the quantification of strategies, the planning concept has to answer the questions given (figure 3.b). After evaluating the findings and determining any trade-offs against expenditure, the documented results produce a *blueprint* for the simulation model and the data survey. To *successfully* design a practicable concept for a company, the efforts have to concentrate on the important specific characteristics without overemphasising the detail, thus allowing the detection of significant results based on acceptable data procurement expenditures.

But, as Kreikebaum observed: „The set-up of a strategic planning system represents a typical process of organisational change, which itself needs planning. As our research indicates, this is done rather in an evolutionary than in a projected fashion, which points to underdeveloped meta-planning activities in a great many companies" [KREI92 680]. However, the activities necessary can likewise be described in terms of the subsystems (figure 3.c).

The relevant *variables and ratios* have to be defined,	⇨	**Information**
as well as their *scope, limits and way of input.*	⇨	**Processes**
To provide the *input* and to *implement* underlying plans	⇨	**Functions**
for the specified *organisational areas,* qualified	⇨	**Segments**
information sources and decision makers have to be identified	⇨	**Planners**
and designated. Depending on the *results* desired, a	⇨	**Plans**
computer-based *model* has to be devised and implemented.	⇨	**Instruments**
Based on the *relations* between ratios, segments and sources,	⇨	**Structure**
the information *flows* and consolidation *methods*	⇨	**Regulations**
have to be specified.		

Figure 3.c: Conceptualising the Quantification of Strategies

3.2.2 Meta-Planning Issues

A model can offer *substantial help* in decision making, if properly implemented. Hence, the aim is to define an appropriate model structure, which asks for *specific know-how* on the part of the model builders. However, to get the approval of the users, the models need to be simple to use and understand, and, moreover, they have to solve the 'right' problem.

To develop the structure, Hammond [HAMM74] proposes dividing the modelling process into *ten phases of activities*. Instead of a rigid step-by-step instruction, he recommends a *guideline* which requires several iterations to allow for trial-and-error:

1. Determine which processes can be modelled effectively
2. Decide whether to use a model
3. Formalise the specifications of the model (e.g. inputs/outputs, structure)
4. Prepare a proposal
5. Conduct modelling and data gathering concurrently
6. Debug the model
7. Educate the prospective users
8. Users validate the model
9. Put model into use
10. Update/modify the model as needed.

The first three phases in particular, convey an immense influence on all subsequent phases and, hence, constitute the most important but also most complex part of the modelling process. In order to experience the successful implementation of the final model, Hammond identified several *prerequisites and control factors* which are detailed in figure 3.d.

However, as advances in information technology have rocketed and powerful software tools are easily accessible, the *technical capability* to build large planning models has also been placed in the hands of 'mathematically unsophisticated' users. As Dembo [DEMB84, 157] has pointed out, „this development can create problems since the construction of a mathematical model is an endeavour that requires highly skilled, creative personnel. It requires a particular combination of art and science and very few organisations possess the in-house expertise to either build models themselves or to properly evaluate models supplied by outside consultants.

This difficulty is due in part to the inherently technical nature of model building. A large part of the blame, however, can be attributed to the way models and the results that are obtained from them are communicated, the logistic difficulties associated with implementing changes, and the lack of a theoretical framework to guide the use of models within an organisation. Planning models are by their very nature ill defined, and planning scenarios require much testing and modification during the decision process".

Since these remarks were made, even more dramatic advances have taken place in information technology. Consequently, Hogg compares the availability of sophisticated spreadsheets with certain brands of fast sports cars, which are „highly dangerous in the hands of the uninitiated". He states, that ease of use and rapid feedback positively encourages ever greater complexities and nuances to be incorporated into models, and concludes, that by dashing the hope of providing more business insight, the result is more frequently hopeless confusion [HOGG94 4].

Uncontrollable Prerequisites
Operations understood, data plentiful
Relevant data accessible
Budgets, plans and control systems are well-defined, understood
Modellers have management's support
Management scientists accept responsibility for implementation
Similar innovative techniques used in the past
Manager and modeller share status and background

Controllable Factors
Involve potential users in development process
Define model's goal explicitly
Input and output are in familiar formats
Company procedures modified little, at first
Look for common management problems to model
Start simple and keep it simple
Allow for ample judgmental inputs
Be realistic about planning time and expected results
Put a manager (not a modeller) in charge
Define roles clearly
Demonstrate part of model early on
Build model within users' organisation
Develop expertise to manage and update model
Provide ample documentation

Figure 3.d: Success Factors in Modelling [HAMM74] [SHIM87 53]

Technological capabilities are of course an important issue, but foremost the responsible planner has to concentrate on the underlying contents and the *company's needs and benefits.*

In the centre of his interest resides the model which has to serve a dual purpose to support strategic management effectively. It has to represent the company's reality and envisaged future and to provide a transparent framework for its quantitative planning activities. Thus, its function is to depict the one *system 'Company'* in order to design the other *system 'Quantitative Planning'*, whereby real as well as abstract issues have to be considered. Due to the future-orientation and environmental interdependencies, these systems can be classified as open, complex, dynamic and probabilistic [BIRC76 26].

To provide effective solutions, strategic modelling has to be concerned with the functional and the institutional particularities of a company. It requires the merging of the *structure of variables* with the *segmental structure* of the organisation and, consequently, implies the danger of the combinatorial explosion of data needs with additional levels of differentiation. Thus, expenditures involved, information available, time required, accuracy needed, and benefits expected are vital aspects when considering the utilisation of such models in the strategic management process.

To provide efficient solutions, these aspects have to be further analysed. Not only the quality of the *data* (chapter 3.3.1) has to be considered, but also the subsequent provision of *actuals* and the availability of information *sources.* Moreover, potential entities to be covered differ in their *strategic importance.* Model configuration efforts should therefore attend to the particular trade-offs of organisational units or variables. The meta-data relevant for such an assessment, has to come from the qualitative information and strategic directions already established, and the data quantities required for the planning cycle.

A successful configuration process has to target the important *entities* and to appropriately represent their *relationships* - not every factor of the real world situation can be reflected. Due to the dynamic interdependencies between understanding the business and deciding what to model and forecast, a *close co-operation between planners and decision-makers* is a vital precondition for the correct choices. However, „*hidden assumptions* in different parts of the organisation will influence what variables are considered crucial and what modifications take place" [FILD82 86].

In recognising the need to adopt a *structured approach* [KAPP82 493-495], Kappauf and Talbot recommend to differentiate between variables with low and high leverage, whereby the concentration on the latter yields the highest payoff in respect to the subsequent planning exercise.

Their *proposed methods* include the discussion with senior analysts and senior management, the survey of the users or of comparable organisations, and the application of analysis techniques (influence diagrams, decision trees, what-if or sensitivity analyses). To determine the right level of leverage the authors also furnish interviewers with a number of questions by supplying a *go - no go forecast checklist*:

- Does the forecast lead to an *identifiable decision*?
- Is the decision outcome *significant* (in terms of reward/absence of penalty)?
- Is it possible for the decision to be impacted by *alternative actions*?
- Is the decision within the firm's *planning horizon*?
- Will the forecast be *used/believed* (does the decision maker want it)?
- Can the forecast be *ready in time* for the decision?
- Is the forecast *feasible* concerning input and methods?
- Do you have the *option to refuse* to provide the forecast?

3.2.3 Continuous Improvement

Based on thorough *meta-planning activities*, a quantitative model is likely to become a much more integrated and accepted part of the overall planning concept. However, apart from first-time conceptualisations, meta-planning also has to deal with the further *improvement and development* of existing systems. Strategic planning is keyed to change. Consequently, shifts in the environment or in the way to view it, modifications of internal conditions, adjusted priorities and the need to correct previous imperfections have to be reflected in a planning model in order to maintain effectiveness and efficiency.

The aim of using models in strategic management is to reason out and simulate the current and expected reality. Consequently, the planning process can be viewed as a dialogue of the planner with the different mental and physical models available to him. In *controlling* their quality, costs and benefits, the planner will *refine* the models, and *adapt* them to the changing internal requirements and external conditions. These efforts result either in an improvement of the performance or in the worsening of the problems encountered.

Feedbacks with lasting positive effects will enable organisational learning and produce a higher yield and acceptance of the planning system. To qualify planners to systematically locate potential areas of improvement, Bircher provides checklists to estimate the current performance and to determine prospective requirements [BIRC76 384-392]. He also distinguishes between seven control and learning processes which are described below. Figure 3.d illustrates these processes and how they interact with the different levels of planning activities in a company whose subsystems and dependencies are also shown.

- *1. Learning by improving the environmental information and understanding*
  more exact formulation of data needs; better use of available information including procurement, aggregation, dissemination, accessibility, permeability
- *2. Learning by controlling the progress and execution of plans*
  stricter analysis of the variances between actuals and allowances to identify character, measurements and causes of influences, better use of information as in 1
- *3. Learning by evaluating shorter-range projections*
  closer analysis of derived short-range projections to enable instant feedback for strategy adjustments and to furnish deeper insights in the economic mechanisms
- *4. Learning by harmonising and interlocking mental and physical models*
  better exchange of information and ideas amongst all participants to facilitate a common understanding and effective further development of the system
- *5. Learning by simulation*
  better utilisation of the models by considering more alternatives or by employing, for example, what-if, sensitivity, target, risk, and monte-carlo-analyses
- *6. Learning by training*
  education of all participants in the planning cycle to support them in their respective role (e.g. model builder, informant, decision maker, moderator)
- *7. Learning by considering the meta-level*
  improvement of the overall planning concept and its documentation, observation of the planning process, and the behaviour and performance of the participants.

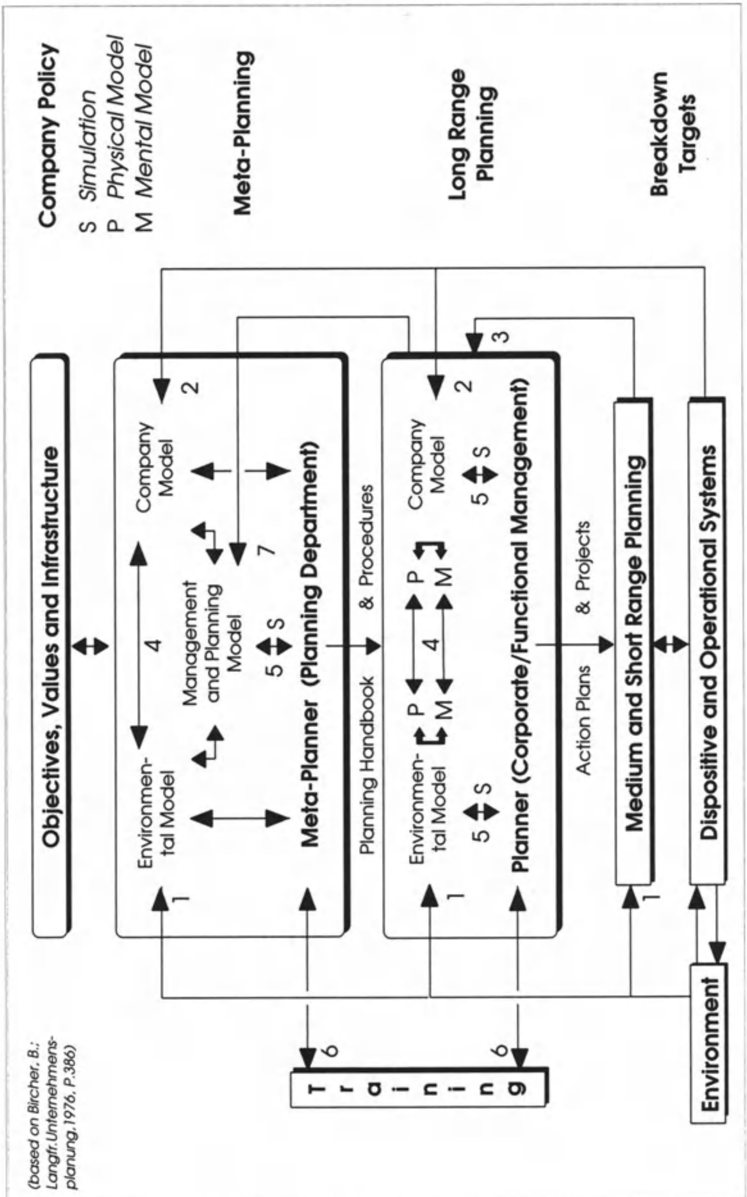


Figure 3.e: Organisational Learning and Long-Range Planning [following BIRC76 386]

3.3 Model Components

3.3.1 Data, Information, Knowledge

The *data* collected for strategic analysis is predominantly future-related, of qualitative and quantitative nature, from external and internal sources, without boundaries but multidimensional and often informal. To draw useful conclusions, the analysis process has to structure it in order to increase its level of productiveness. It has to be mustered to identify crucial gaps, to be put into context with already established facts and to verify prevailing opinions.

The result of these data gathering, scanning, classification and interpretation activities is the understanding of the data, at which stage it becomes *information*. To guide decision making processes, Rowley [ROWL92 16-17] identifies ten criteria which can be taken into consideration to determine the quality and value of the information under review:

- *Relevance* in regard to its purpose and to the problem under consideration
- *Accuracy* to secure its correctness, which may be raised at a certain cost
- *Reliability* to estimate its truth (linked to the confidence in the source)
- *Timeliness* to ensure adequate response times and the periodicity of reports
- *Level of Detail* concerning the use of ratios and right levels of summarisation
- *Completeness* to assure that the full set of factors is known for analysis
- *Consistency* in regard to its steady structure to allow comparisons over time
- *Direction* to deliver the right information to the right recipients
- *Communication* refers to appropriate channels between sender and receiver
- *Understanding* relating to presentation, user's knowledge and preferences.

Like the organisation (chapter 2.2.2), the *intelligence processing* to conduct strategic management has to be structured hierarchically. Data and information which define strategies at the functional and business level, have to be aggregated to provide a more and more global picture when viewed further and further up the organisational pyramid. The *level of aggregation* allows corporate management to participate in and control the planning process without getting lost in detail.

The planning model has to ensure that the aggregated results at each level are calculated in a *consistent and systematic* manner, thus defining a 'bottom-up' relationship which enables subsequent drill-down views, if the need arises. The formulas used in the aggregation process also equip planning participants with the briefing of how the aggregate data is obtained and what assumptions are involved.

However, this documentation usually offers only leads in respect to *the variables and relationships* which have been explicitly used in the model. As strategic models represent a much more aggregated approach than the detailed structure of the operative production and accounting systems, additional links exist which have to be documented.

Business and functional managers are familiar with the periodic reports provided by the accounting and controlling department. Hence, names of variables and ratios should have a distinct meaning, so that *homonyms and synonyms* are avoided. Unfortunately, this consistency is not always guaranteed which renders it extremely unlikely to assure a rigid specification of the strategic modelling system.

It is the meta-planner's difficult choice to add unfamiliar new names or to apply accustomed labels to strategic variables which also include additional figures in comparison with their operative counterparts. In any case, his indispensable obligation is to provide a *thorough but easy-to-understand documentation* of the dependencies between operative and strategic systems.

Deficiencies concerning these duties result in the misconception of the planning requirements, the provision of inadequate data and the subsequent misinterpretation of results. But false impressions and misjudgements cannot lead to the establishment of a sound corporate strategy, and heterogeneous opinions among participants about what has to be done during the planning exercise can quickly culminate in the organisational rejection of the strategic planning system.

In an *enriched form,* the information becomes *knowledge*. Whereas data and information can be mass-produced resulting in incredible amounts of facts and figures, knowledge has to be created by individual minds, drawing on individual experience, separating the significant from the irrelevant. It covers the „understanding, awareness, or familiarity acquired through education or experience. Anything that has been learned, perceived, discovered, inferred, or understood. The ability to use information." [TURB90 836].

Knowledge may be collected from documented (e.g. books, maps) and undocumented *sources* (people). It consists of „(1) symbolic descriptions of *definitions*, (2) symbolic descriptions of *relationships*, and (3) *procedures* to manipulate both types of descriptions" [MCGR89 13]. In the strategic management domain, it is often expressed as tasks, concepts, methods, heuristics, checklists, diagrams, relationships, assumptions, facts, rules, and so on.

The effective *acquisition of knowledge* is not only important for the development of expert systems (chapter 4.2), but is also vital in strategic management and the meta-planning stage of model design. Thus, the acquisition techniques (figure 3.f) suggested and discussed by McGraw [MCGR87] provide valuable help as well for knowledge engineers as for planners.

Knowledge	**Activity: Identification of**	**Suggested Technique**
Declarative	general heuristics (conscious)	Interviews
Procedural	routine procedures / tasks	Structured Interview, Process Tracing, Simulations
Semantic	mayor concepts / vocabulary	Repertory Grid, Concept Sorting
Semantic	decision making procedures and heuristics (unconscious)	Task Analysis, Process Tracing
Episodic	analogical problem solving heuristics	Simulations

Figure 3.f: Correlation of Knowledge Types and Acquisition Techniques [MCGR87 23]

„*Declarative knowledge* represents surface-level information that experts can easily verbalise. *Procedural knowledge* includes the skills an individual knows how to perform. It involves an automatic response to a stimuli, may be reactionary in nature, and not that easy to convey. *Semantic knowledge* reflects cognitive structure, organisation, and representation. *Episodic knowledge* is autobiographical, experiential information that the expert has grouped or chunked in episodes" [MCGR87 22-23].

Yet, someone's knowledge cannot directly be observed; one has to observe and learn to identify *expertise*, which McGraw defines as a demonstration of the application of knowledge. But even though, the quotation of Michel de Montaigne (French philosopher, 1533-1592) still indicates a further barrier: „We can be knowledgeable with other men's knowledge, but we cannot be wise with other men's *wisdom*."

3.3.2 Segmental Structure

„Any market with two or more buyers is capable of being segmented ... Each buyer is potentially a separate market because of *unique needs and desires*" and „*flexibility* refers to the effectiveness with which resources can be re-arranged and redeployed to meet new situations" [GORE92 167,183].

Both statements highlight *areas of primary concern and potential failure* in the model building for strategic management. The determination of an appropriate degree of differentiation and flexibility is vital for the success of the planning exercise. Due to the necessary co-operation with numerous know-how and power brokers, heterogeneous views and expectations have to be taken into account. Incomplete historical data and the uncertainty of forecasts add further complexities. If the concluding model design does not provide the value of useful additional information or ends up in unacceptable data requirements and expenditures, the meta-planning efforts will be wasted.

Each planning participant has a *different mental concept* of the problem which also generally differs from that of the meta-planner. Additionally, *the number of elements and interrelationships* of the real-world situation are so manifold that „all of its structure cannot be safely perceived or observed at the same time." [YADA89 31] Hence, sophisticated tools are needed to understand the integration of the organisation and processes, to discuss the design implications with users, and to communicate the progress of the analysis.

Due to the *lack of capable tools*, the diversified factors governing a successful model design cannot be considered completely and comprehensively. In particular, the relative relevance of planning objects and the resulting data requirements are in general a *black box* with unknown quantities and a considerable *trap for disaster*.

To reduce this complexity, *'one suit fits all' submodels* are institutionalised which require even higher human engineering efforts to counterbalance stifling inflexibility and upcoming frustrations on part of the planning participants. Especially in the case of diversified businesses with activities in numerous heterogeneous markets, the *standardisation of models* often leads to a reduction to the least common denominator, where the individual strategic importance and subsequent shifts are insufficiently considered. Figure 3.g shows such a *diversified enterprise* and details three of its business units together with their particular success factors.

Activities and special Features	Success Factors
SBU 1:	
Trade with variety of low-cost-products, spot delivery	On-time-Delivery
Sales budgets based on value only, no production costs	Stock Turnover
SBU 2:	
Mass-production of perishable goods,	Market Share, Quality
Sales budgets based on value and quantities	Supply Management
SBU 3:	
Consultancy for research and development	Utilisation, Innovation
Budgets depends on the availability of qualified staff	Know-How, References

Figure 3.g: Example of heterogeneous Strategic Business Units of a diversified Company

The example presents the argument that an adequate quantitative strategic planning model should be based on the *specific characteristics* and provide tailored submodels to suit the different types of organisational units.

The discussion of the product life cycle (figure 2.d) has already demonstrated that even business units with similar product ranges and markets can substantially differ in respect to the competitive priorities to pursue. Hence, not only the *segmentation* according to products and markets has to be considered, but also the *organisational structure* of the company whereby the legal framework might depict only one facet of several.

Organisational entities, like the segments discussed, pursue a specific purpose and consume company resources. Instead of selling to earn income, they acquire input and produce outputs, either goods or services including information. Depending on their distinctive attributes, each entity should also be defined by an appropriate set of variables to suit its particular needs. Kaplan identifies five principal types of responsibility centers [KAPL89 529ff]:

- *Standard Cost Centers* are responsible for the efficient repetitive transformation of known input factors (material, labour, energy) into the physical amount of output needed (products and services)
- *Discretionary Expense Centers* are characterised by outputs which cannot be easily measured in financial terms, for example administrative or research departments
- *Revenue Centers* are responsible for the selling and distribution of finished goods acquired from manufacturing divisions
- *Profit Centers* are units whose management holds almost complete operational decision-making responsibility and authority, covering production and sales

- *Investment Centers* include, in addition to profit centers, the responsibility for the working capital and the physical assets, so that the performance appraisal of the management can be based upon the return on investment.

To obtain *corporate aggregates*, the data has to be consolidated bottom-up as in the traditional accounting system. If center or segments are interdependent, the consolidation will be additive, but if dependencies exist, co-ordination activities are required and eventual transfer payments between organisational units have to be eliminated at the top-level.

If the segmentation was also structured hierarchically and/or multi-dimensionally, further *strategic consolidations* can be carried out. In addition, *top-down consolidations* may be required to allocate overhead back-down to cost centers.

As with the variables and relationships, not every center or segment imaginable should be reflected, if an efficient system is intended. But it is important, to identify and include those ones which best represent the *organisation and its commercial environment* and allow the most valuable *strategic insights* into the business. In this respect it has to closely reflect the structures applied to conduct the qualitative strategic analysis, instead of copying the, in strategic respect, often restrictive layouts of the operative and accounting system.

However, planned levels of detail which can not be adequately controlled are of little or no use. Either they have to be combined into more appropriate totals or the subsequent *controlling systems* have to be based on more differentiated actuals.

In meeting the different types of requirements discussed, tailored submodels add to the benefit of planning participants and decision makers, but also increase the complexity for the model designer. *Meta-Planner* and its conceptual framework support distinctions in the assignment of variables to planning units. By estimating the resulting data requirements, the planner is also given the means to adequately control these distinctions as well as subsequent model design changes.

3.3.3 Variable Structure

To use a model in an efficient way, not every factor of the real world situation can be reflected. But it is crucial, to identify and include the important *variables* and to appropriately represent their *relationships*. Areas of strategic concern might cover:

- sources and sizes of costs, revenues and cash flows
- status of assets, liabilities and capacities, and the investment policy
- resources available for investment or needed for strategy deployment
- strategic and financial ratios to assess the meeting of targets incl. the opportunity costs incurred and the risks associated with particular strategies
- an appropriate time horizon, representing historical periods as a base for comparison, planning periods to consider explicit strategic projections, and a post-planning period to reflect long-term profit implications of strategies.

These key components and their mathematical relations form the *logic* of the model can be further differentiated at the meta-level:

■ by Degree of Influence

- *Inputs* are imposed on the system from outside (exogenous) and are variables to which the system must respond correctly. They are time-dependent, uncertain, have to be estimated as accurately as possible and can be subdivided into:
  External or Environmental Variables depend on the scenario under review. Their behaviour affects the company but not vice versa, and, consequently, cannot be influenced by the decision maker (e.g. market growth, inflation).
  Decision or Policy Variables describe the alternative courses of action, are strategy-dependent, and the decision maker is able to exercise some degree of control over them (e.g. product price, marketing expenses).
- *Parameters* are 'reasonably' certain and can be constant for the planning period (e.g. corporate tax rate). Like environmental variables they are uncontrollable and represent *constraints* which might limit the choices of the decision maker.
- *Result or Dependent Variables* are defined in terms of parameter, input or other result variables. They are generated when the model runs (endogenous) and cover aggregates, ratios and intermediate variables (e.g. profit, return on equity).

■ by Method of Calculation

- *State variables* have to be calculated for each time step in the simulation by incrementing/decrementing the value from the previous iteration. They represent the line items of the balance sheet and other stock-type financial and non-financial variables. They are responsible for the dynamic character of the model, since changes in one period influence all subsequent periods. If increment and decrements are represented in the model, they only require a starting value:

	NEW STATE	= PREVIOUS STATE + INCREMENT - DECREMENT
e.g.	Finished Goods	= Previous Stock Level + Production - Sales - Waste

- *Rate Variables* represent the positive/negative rate of change of state variables. They represent, for example, investment and depreciation (controls assets), production and sales volume (controls stocks), turnover and costs (controls cash). They are input variables or can be derived by calculation:

  e.g. DECREMENT OF ASSETS = DEPRECIATION + DIVESTMENTS

- *Flow Variables* represent variables with no direct influence on state variables. Although most financial variables will ultimately influence cash and equity, not all are explicitly included in the state variable equation, but only as part of an aggregate. They are input variables, can be derived by calculation, or may also be dynamic, so that time-lag dependencies have to be represented in the model:

  e.g. DEPRECIATION = SUM (VALUE OF ASSET * DEPRECIATION RATE)
  SERVICE TURNOVER = f (PRODUCT SALES OF PREVIOUS 5 YEARS)

- *Ratios* are an effective way of obtaining insights into a company's operations and performance, and of drawing parallels to other time periods or competitors. They are expressed as a proportion between quantities, and can be grouped into categories according to the field of employment (liquidity, profitability, etc.). Primarily calculated by the model, they can also be used to provide user-friendly input alternatives (e.g. growth or cost-of-sales percentages).

■ by Type of Relationships

Mathematical expressions are used in a model to define the relationships between the variables. The resulting equations can be subdivided as follows [NAYL79 30]:

- *Definitional Equations* represent the definitions used in the company's management and cost accounting systems, and include the procedures to summarise variables and calculate ratios. Some equations are determined by government relations such as tax laws and depreciation rates.
- *Behavioural Equations* are hypotheses which reflect management's understanding of certain internal and external relationships affecting the company. One example was already given before in the calculation of the 'SERVICE TURNOVER'. Other ways to enhance the model with theoretical premises are, for example, the use of tables to represent sales-price-dependencies or the specification of proportional relationships between variables by allowing %-share figures as method of input.
- *Projection Equations* represent definitions which are not based on a explicitly stated behavioural relationship, but which are believed to be relatively stable in respect to time. They are based on specific forecasting techniques (e.g. trend analysis) which are supported by most modern planning software packages.

As the time horizon lengthens, the need increases to re-examine those variables that can reasonably be expected as constant in the short term. In particular for strategic purposes, a number of parameters may become sensitive and have to be viewed as variable (e.g. relative cost structures, stock ratios).

The modification of model designs also leads to fundamental *re-assignments* of variables in respect to the categories enumerated above. Further differentiation changes an input to a result variable by introducing a number of new inputs to the model and, at least, one more equation. Aggregations, on the other hand, change a former result variable into an input.

The inclusion of additional state variables demands the input of starting values. These are figures associated with a period which precedes the first model period by at least one. The use of behavioural equations or projections might trigger the need to provide even more *pre-model-periodical data,* to cater for the defined time-lag dependencies, or satisfy the historical data needs of the chosen forecasting technique.

	Variable		Model Logic / Periods:	1993	1994	1995
A	Inflation Rate	(%)				
B	Strat. Price Factor	(%)				
C	Price	($ / ton)	<Input>	9.25	9.50	9.90
D	Sales Volume	(mio t)	Trend (base: 5 historic values)	1.65	1.95	2.19
E	Turnover	(mio.$)	Sales Volume x Price	15.3	18.5	21.7
F	Fixed Cost	(mio.$)	<Input>	10.0	10.4	11.0
G	Variable Cost in %	(% sales)	<Input>	45%	43%	42%
H	Variable Cost	(mio.$)	Turnover x Var.Cost in %	6.9	8.0	9.1
I	Total Costs	(mio.$)	Fixed Costs + Variable Costs	16.9	18.4	20.1
J	Profit	(mio.$)	Turnover - Total Costs	- 1.6	0.1	+1.6
K	Owner's Equity	(mio.$)	<Input for Period 1992>	6.6		
			Prev.Owner's Equity + Profit	5.0	5.1	6.7
L	Return on Sales	(%)	Profit % Turnover	-11%	1%	7%
M	Return on Equity	(%)	Profit % Owner's Equity (t-1)	-24%	2%	31%

Figure 3.h: Logic and Results of a simple Planning Model

In order to estimate the *data requirements* of a particular model design, these dependencies have to be analysed during the configuration process. The difficulties of such an undertaking especially for large complex models can be immense. To illustrate the consequences of a design change, figure 3.h uses a small model which shows the remarkable turnaround of a company and can be classified as follows:

Flow Variables:	c d e f h i j	Definitional Equations:	e i j k l m
State Variables:	k	Behavioural Equations:	h
Ratios:	g l m	Projection Equation:	d
Input Variables:	c f g k d	Result Variables:	d e h i j k l m

The model demands the input of 15 data items. The variables c f g require values for 1993 until 1995, the state variable k needs an initial value for 1992, and the trend projection of d implies five historical figures. To differentiate the model, the inputs 'inflation rate' (a) and 'strategic price factor' (b) are added. The price, once input, becomes a result and state variable, calculated by a further definitional equation:

PRICE = PREVIOUS PRICE * (100 + INFLATION RATE) * (100 + PRICE FACTOR)

The modified model requires three more input data items, but allows the separate consideration of external (inflation rate) and decision variables (strategic price factor) in respect to the pricing policy.

3.3.4 Reporting

As money is the universal measurement in the business world, it is appropriate for any quantitative strategic planning system to contain financial analyses which should cover the following historic and projected statements, although on an appropriate level of aggregation:

- A *balance sheet* (figure 3.i) presents a *'snapshot'* of an organisation at a given date, and shows the composition of assets (deployment of funds) and liabilities (sources of funds). As all funds deployed have to be sourced, the balance sheet inevitably balances.
- An *income statement* or *profit and loss account* (figure 3.i) details the structure of the retained profit in the balance sheet. It shows the turnover, the costs of activities, resources and taxes, and as the summary of all items, the profit or loss incurred.

Assets	***147,7***	***Liabilities***	***147,7***
Fixed assets	60,4	Shareholders' equity	53,2
Property, plant, equipment	57,0	Capital stock	28,0
Intangible assets	0,2	Open reserves	14,5
Financial assets	3,2	Spec. item with accrual char.	0,4
Current assets	87,1	Profit/loss for the financial year	10,3
Inventories	20,5	Creditors' equity	94,5
Raw Materials and supplies	7,9	Valuation reserves	0,0
Finished goods	12,6	Accrued liabilities	31,9
Other current assets	66,6	Accounts payable	20,0
Accounts receivable	40,4	Short-term liabilities	1,7
Cash	6,9	Due to banks (long term)	3,2
Due from affiliated comp.	15,6	Due to affiliated comp. (long trm)	26,8
Other assets	3,7	Other liabilities (long term)	10,9
Prepaid expenses, def. charge	0,2	Deferred income	0,0
Sales revenues	***304,7***	Gross Profit	161,8
+ - Inventory changes	4,2	- Staff costs	88,6
Production output	308,9	- Depreciations, writedowns	22,9
+ Capital. self-construct.assets	0,8	- Other operating charges	31,2
+ Other operating income	4,5	Operating result	19,1
Total operating performance	314,2	+ - Financial result	- 0,1
- Materials & ext. charges	152,4	Total result	19,0
Gross yield	161,8	- Taxes	8,4
+ - Non-operating result	0,0	- Dividends	0,3
Gross Profit	161,8	***Profit/loss for the financial year***	***10,3***

Figure 3.i: Balance Sheet and Income Projection from Case Study (chapter 5.2.2)

- A *funds flow statement* (figure 3.j) shows the movements in the balance sheet in any time interval. Increases/decreases in the value of assets can be set against the funds to analyse how they have been financed (e.g. massive purchasing due to favourable terms leads to an increase of stock and creditors, sale of a plant to repay a loan leads to a decrease of fixed assets and debts).

  In strategic terms, the financial needs have to be matched against the resources available to identify the timing of additional finance, and to avoid excessive deficits that cannot be financed by normal means. Especially in growth phases, insufficient liquidity can seriously hamper and even threaten business operations, since increasing production quantities and stock levels have to be pre-financed [MCNE87].

- *Key Strategic Ratios*(figure 3.j) are an effective way of obtaining insights into a company's operations and performance and of drawing parallels to other time periods or competitors. The objective is to reveal factors and trends affecting performance so that actions can be taken.

Profit/loss for the financial year	10,3	Cash and accounts receivable	(9,8)
+ Taxes income, net worth	7,3	Inventories	0,5
+ Dividends	0,3	Investment fixed assets	(25,1)
Pre-Tax Profit	17,9	Financial assets	0,2
+ Depreciations, writedowns	22,9	Other assets	0,1
+ Change in accrued liabilities	1,4	Shareholders' equity	(7,7)
Cash Flow, gross	42,2	Creditors	1,3
- Taxes income, net worth	7,4	Short-term debts	1,5
- Dividends	0,3	Long-term debts	4,5
Cash Flow, net	***34,5***	***Sources and (Uses)***	***(34,5)***

Profitability		***Capital Structure***	
Return on investment	13.7 %	Gearing ratio	113 %
Return on equity	35.5 %	Equity ratio	36 %
Performance		***Financial Risk***	
Return on sales	6.3 %	Cash flow on sales	11 %
Asset turnover ratio	2.0	Interest cover	14.7 times
Costs		***Efficiency***	
Personnel cost ratio	28.2 %	Stock turnover period	0.8 months
Material cost ratio	48.5 %	Creditor turnover period	1.6 months
Liquidity		***Productivity***	
Working Capital Ratio	92.2 %	Sales per employee	199,000 DM
Non-financial Market Ratios		***Non-financial Capacity Ratios***	
Market Share Poured Asphalt	25.0 %	Manpower Requirements	1,600 persons

Figure 3.j: Funds Flow and Ratios Projections from Case Study (chapter 5.2.2)

- *Flexible budgeting* or *direct costing*. Due to the hierarchical structure of a company, multiple organisational levels add their share to the variable and fixed costs. Compared to the output-independent fixed costs, variable costs vary with output and are regarded as marginal costs. Comprising direct material, labour, administration and selling expenses, they are subtracted from the sales revenue to result in the *contribution*. The ratio indicates which part of the revenue is still available to cover the fixed costs of the particular unit under review.

  In separating these costs at each level and by consolidating the revenues being left to cover the costs of the superior units, the multi-stage fixed cost accounting procedure allows to assign costs of gradually wider areas according to the principle of causation.

  Articles, for example, might be combined to product groups, these to lines of business and then to divisions. The same applies to markets or lines of management. Each level causes costs which cannot be further differentiated, so that dependent units cannot be charged appropriately, e.g. advertising for a whole product range or image campaigns for public relations.

  In regard to *strategic management*, the approach provides an easy means of setting more focused strategic objectives for the units, each contributing to their own and their superior units' success.

  Figure 3.k shows the results of one of the construction companies with its five strategic business units. Although the total contribution of the SBUs has risen in line with the total operating performance, no higher operating result on the company level is generated. As the analysis of information not shown revealed, this was due to higher personnel costs and depreciations which could not be allocated to specific strategic business units.

Level	**Contribution** **Periods:**	**1**	**2**	**3**
Holding	Total operating performance	57,160 [1]	66,630 [1]	70,614 [1]
Company	Operating result	1,042 [2]	1,172 [2]	1,016 [2]
Company	Sum of SBU's contribution	8,302	8,938	10,284
SBU	Road Building, Motorways	3,932	2,478	1,386
SBU	Road Building, Others	306	1,076	2,322
SBU	Canalisation and Drainage	644	1,360	1,244
SBU	Joint Ventures	2,626	3,218	2,790
SBU	Other Activities	794	706	2,542

[1] including 9 other companies [2] company-specific costs deducted

Figure 3.k: Break-down Projections from Case Study (chapter 5.2.2)

3.4 Application History

Quantitative models for strategic management generally are larger-scale, complex and data-hungry applications which make use of most of the basic components introduced. In an overview of the subject, Dannenberg discusses the state of the art [DANN90 117-208, annex A]. Depending on the level of implementation, the documentation available and the strategic relevance, three categories detail theoretical concepts and prototypes as well as commercially available systems.

In regard to the latter, Dannenberg concludes that none of the systems available is able to support all aspects of the strategic management cycle [DANN90 180]. Whereas some act solely as a management information system by providing database functionalities and limited analytical tools, others focus on specific methods such as portfolio or scoring models. Due to the individuality of strategic modelling, comprehensive and generally applicable *standard packages* do not exist. Fourth-generation planning languages and decision support system generators merely offer effective software environments to run models which none the less have to be generated according to the company-specific requirements at great expenditure.

Since these findings still apply, this chapter concentrates on *selected issues and difficulties* which have been addressed or solved in strategic models publicised and which exemplify the basic components and advanced topics in strategic modelling.

■ Integrated Long Range Planning Model by Bucher

In an early contribution to the subject Bucher published a comprehensive model which was closely related to the *principles of accounting* [BUCH72, HANS90 372ff, ZWIC82]. Based on the entry formulaes of record keeping, he deduced the relevant movements in the accounting matrix, aggregated the respective state and flow variables and assigned them to the functional submodels procurement, production, sales, investment, tax and finance.

Aimed at an industrial enterprise, the *quarter* was chosen to determine the length of each planning period. Due to the longer manufacturing cycle, the model uses time-lag factors (t), material distribution coefficients m (in %) and period of storage p (in % of 90 days) to simulate the production process, work in progress, stock levels of finished goods and sales volumes, e.g.:

Material Consumption	=	(100-m) x Material Need Factor x Production started in t
		+ m x Material Need Factor x Production started in t-1
Finished Goods	=	Production started in t-1
Sales Volume	=	p x Finished Goods in t + (100-p) x Finished Goods in t-1

In regard to the capital structure, the planner is able to define fixed amounts for the raising of capital, borrowing or debt repayments, financial investments or divestments and rescheduling. Additionally, the use of a *marginal debt equity ratio* (e) was suggested. Based on this decision variable, eventual financial requirements can be automatically funded by e% owner's equity and (100-e)% creditor's equity. The use of this ratio enables the formulation of strategic policies to gradually shift the overall debt equity ratio to the level desired.

■ PuK-Simulation Model by Hahn, Hölter, Steinmetz

By providing a comprehensive concept to integrate strategic, operative and corporate planning [Hahn92], the model also incorporates a specialised finance module. After profit and balance sheet items have been calculated an imbalance between assets and liabilities eventuates in a *residual figure* which indicates the periodical surplus or need of cash resources. Resulting actions as, for example, financial investments and the expansion or repayment of credits influence the amount of interest received or paid which, in turn, influences the residual figure.

Whereas simple models charge an average interest rate on the residual figure and credits or debits it in the next period, sophisticated models such as the PuK finance submodel [Hahn92 397] use differentiated *interest rates* for loans and investments and mathematical techniques to solve the implied set of *simultaneous equations*.

■ STRATPORT - STRATegic PORTfolio-planning by Larréché/Srinivasan

In extending the scope of business portfolio analysis approaches, Larréché's and Srinivasan's model [LARR81] takes into account marketing, capacity and working capital investments, potential new business units, cash flows, profits, external financial resources, and financial risks. The *decentralised planning approach* focusses on the support of multiple business units and requires their subsequent consolidation to enable the planning of the centralised functions in the headquarter.

To solve the highly dynamic problem of how a given amount of total cash resources should be allocated among business units, a *planning period* explicitly considers future investments and cash constraints. A *post-planning period* allows the evaluation of any further long-term profit implications of actions taken. By using discounted cash flows, the model calculates a common financial ratio for the allocation decision and, thus, supports the maximisation of the *net present value*. Following the capital asset pricing model, different discounting rates can be specified for business units to correspond to their individual *level of risk* associated with projected figures.

■ Strategy Matrix by Naylor

The decentralised modelling approach presented by Naylor [NAYL84], also supports businesses characterised by joint products which share *common production facilities* and products which are either *complements or substitutes* in the marketplace. Used by large corporations at the time, the strategy matrix recognises the economic interdependence of businesses, products and markets. In preparing five-year strategic plans, each individual business center manager has to compete for the company's *strategic resources* which are managed by different managers. In case of bottlenecks, a computer-based modelling system which uses linear programming allocates the scarce resources according to the basis of the business-specific contribution to net cash flow.

■ Fichtel & Sachs Model by Felzmann

It has been emphasised that management is preparing strategic plans against the background of a complex and uncertain external environment. As discussed earlier (chapter 3.3.3), input variables can thus be subdivided into *external or environmental variables* and *decision or policy variables.*

In co-operation with the German automotive company Fichtel & Sachs, Felzmann [FELZ82] developed a planning model which rigorously differentiates between strategy-dependent (S) and independent environmental (E) input variables, e.g.:

Sales Volume	= Market Share x Market Volume
Market Share	= Market Share Planned (S) x Competition Factor (E)
Market Volume	= Previous Value x Market Growth (E) x Influence Factor (S)

or

Variable Unit Costs = Material Unit Costs + Personnel Unit Costs
Material Unit Costs = Prev. Value x Inflation Rate (E) x Efficiency Factor (S)
Personnel Unit Costs = Prev. Value x Wage Increase (E) x Productivity Factor (S)

The examples indicate that Felzmann's approach inevitably results in an increase of *data requirements*. On the other hand, it offers the ability to use distinct input data modules representing *strategic alternatives or scenarios* at whatever organisational level appropriate. As a consequence, management is able better to select and evaluate the appropriate portfolio of strategies and test the results anticipated against optimistic or pessimistic environmental conditions.

■ STRAPLA by Schmitt

In following and extending Felzmann's model, Schmitt developed a system which automated the combination of alternative strategies and scenarios [CORN84 45-81]. Autonomous models which represent market segments, strategic business units and the corporate headquarter are executed consecutively by incorporating the different strategic and environmental options defined. Since three potential strategies for each of twelve business units already result in more than half a million alternatives, an automatic cross-calculation also has to include the means for pre-selection.

Based on *pre-defined targets* (profitability, self-financing ratio, labour fluctuation) and *value-benefit-tables*, the system, hence, evaluates the resulting ratios of the alternatives and accumulates the weighted benefits using a *scoring-method*. In listing the the most promising strategic portfolios in an decreasing order of goal performance it enables a quick access and eases the analysis of the findings.

Additional partial and full-scale *quantitative planning models* for strategic management have been published [e.g. MEYE83, FLOR88, SCHO88, LUET89, DANN90, KNEU90, HANS90, HOGG94] and the domain still attracts researchers, consultants and company planners alike. The diversity of approaches and solutions confirms the difficulty of creating standardised packages which would be capable of suiting many enterprises. The company-specific requirements dominate and complicate the design process as well as the subsequent model application.

A common characteristic of the models published is the hardcoding of the model equations. The fixed definition of the equations clearly defines the input and result variables within the model, but also forces many planning participants to sit down with their calculators in order to supply the data needs. An inflexible model logic applied to a decentralised planning system with heterogeneous business units and markets is not able to support all the particular ways of thinking required.

A projected sales increase of 10% in year 1 and 20% in year 2 which has to be expressed in total sales might require the supply of the following planning data:

	current	year 1	year 2
Sales Volume planned	100.000	110.000	132.000
Sales Volume actual	100.000	105.000	126.000

In this case, the strategic controlling system will diagnose an over-optimistic projection of sales in both years. If the percentage had been known it could have been deduced that, although the envisaged year-1-increase was delayed by half a year, the envisaged growth in year 2 has been as strong as anticipated.

	current	year 1	year 2
Sales Growth actual		5%	20%
Sales Growth envisaged initially		10%	20%

Additionally, by providing the percentage-based assumptions the sales forecast provider could have confirmed his initial projection of 20% for year 2 after receiving the actuals for year 1. However, the inflexible model layout forces him to sit down again with his calculator to recalculate the figures.

To combat resulting frustrations, the flexible use and integration of models is a growing area of research in the domain of *model management* (chapter 4.2 and 4.3). However, respective improvements can also be implemented directly in decision support models. The author's experience in numerous projects has shown that flexible input formats enhances the motivation of planning participants and the quality of results and interpretations. Chapter 6.3.2 discusses the use of built-in relationships of state and flow variables further and provides examples.

3.5 Summary

To benefit from quantitative model results, a number of preliminary activities have to be carried out. Data has to be gathered, processed, presented, and interpreted. At the centre of these tasks resides the model, a central element in a *decision making process*.

Because of its vital importance for the efficient execution of the planning process, the model's *configuration* should be addressed in a thorough and systematic manner. Using the expertise of the participants in the subsequent planning cycle early on, can notably enhance the *quality* and *acceptance* of the planning model which constitutes an integral part of the overall planning concept. To structure the related *meta-planning process,* distinct subsystems can be identified which help to define objectives and actions necessary. Yet, changing internal and external factors require the *continuous improvement* of strategic modelling applications.

The use of simulation in strategic management, requires identifying and mathematically representing relevant *variables* and their *relationships*. To consider the multi-dimensional impact of strategies, the model has to be structured *vertically* (differentiating variables) and *horizontally* (assigning variables across segments). However, not every factor of the real world situation can be reflected. To safeguard efficiency, the configuration process has to target the important *entities* and *relationships* by taking into account the benefits and expenditures of the respective *data.*

Basic reports needed in order to assess the portfolio of selected strategies cover projected balance sheets, income and funds flow statements, key strategic ratios and flexible budgeting methods. These results are based on the consolidation of the individual strategic segments planned, which, on their part, determine the overall *data requirements* of the planning system.

A number of *planning models* have been published in the last more than 20 years. Most have been applied to specialised areas of decision making like investment analysis or sales forecasting. However, *quantitative models for strategic management* generally are larger-scale and complex applications which defy standardisation. Company-specific requirements dominate their implementation and, as exemplified by the application history, the many ways to solve associated design problems further add to the complexity of the modelling process.

4 Information Systems

An *information system* is an arrangement of components (people, activities, data, networks, technology) that are integrated for the purpose of supporting and improving the day-to-day operations in a business, as well as fulfilling the problem-solving and decision-making information needs of business managers [WHIT94 39]. They provide different levels of support for the various business functions in order to effectively accommodate the users and their individual responsibilities (figure 4.a).

- *Transactions or Data Processing Systems (TPS)* cover applications which capture and process data for all relevant business events including input (e.g. purchase orders), output (e.g. customer invoices) and maintenance transactions (e.g. price changes). Usually performed by and for clerical workers and controlled by their supervisors, the systems document every pertinent detail and serve as the base for further analysis.
- *Management Information Systems (MIS)* generate management-oriented reports based on accepted management (e.g. cost accounting) or mathematical models (e.g. statistics). They structure the transactions according to type, time and organisational units, and produce detailed, summary and exception reports, usually on a periodic basis in a predetermined, fixed format.
- *Decision Support Systems (DSS)* support managers in their decision-making to solve semistructured and unstructured problems (which feature non-standardised procedures, unclear objectives or ill-specified input and output). They incorporate both data and models, and allow the user to control the solution process by providing various statistical and analytical methods (e.g. what-if, risk and sensitivity analysis, goal seeking).
- *Executive Information Systems (EIS)* provide flexible access to business information for high-level executives. Data from multiple files and in-house and external databases are gathered and assembled to provide the views necessary. Statistical methods, conditional high-lights and graphical presentation allow an user-friendly scanning of information which is further enhanced by exception tracking which opens the path to the level of detail required via efficient consolidation and drill-down-techniques.
- *Expert Systems (ES)* are decision-making and/or problem-solving tools which attempt to replicate intelligent activities of specific human experts. By focusing on a usually narrow problem area, the objective is to match or exceed the level of performance of the human specialists.

Transactions Processing Systems (TPS)	Management Information Systems (MIS)	Executive Information Systems (EIS)	Decision Support Systems (DSS)	Expert Systems (ES)
Applications				
Payroll, inventory, record keeping, production and sales information	Production control, sales forecasting, monitoring	Support to top management decision, environmental scanning	Long-range strategic planning, complex integrated problem areas	Diagnosis, strategic planning, internal control planning, maintenance strategies. Narrow domain
Focus				
Data Transactions	Information	Tracking, control 'drill-down'	Decisions, flexibility, user-friendliness	Inferencing, Transfer of expertise
Database				
Unique to each application, batch update	Interactive access by programmers	External (on-line) and corporate	Database management systems, interactive access, factual knowledge	Procedural and factual knowledge; knowledge base (e.g. facts, rules)
Decision Capabilities				
No decision, or simple decision models	Structured routine problems using conventional operations research tools	None	Semistructured problems, integrated OR models, blend of judgement and structured support capabilities	The system makes complex decisions, unstructured; use of heuristics
Manipulation				
Numerical	Numerical	Numerical some symbolic	Numerical	Symbolic
Type of information				
Summary reports, operational	Scheduled and demand reports, structured flow, exception reporting	Status access, exception reporting, key indicators	Information to support specific decisions	Advice and Explanations
Highest organizational level served				
Submanagerial, low management	Middle management	Senior executives (only)	Top management	Top management and specialists
Impetus				
Expediency	Efficiency	Timeliness	Effectiveness	Effectiveness and expediency

Figure 4.a: Attributes of Computerised Systems [TURB90 18]

4.1 Decision Support Systems

The *distinctive features* of a DSS, as summarised by Turban [TURB90 20], are to address ad hoc, unexpected problems, to provide a valid representation of the real world system, to offer decision support within a short time frame, to evolve as the decision maker learns more about the problem and to be able to be developed by non-DP professionals.

The extent of the benefit from these features is largely determined by the underlying DSS-generator. It provides the technical means for the implementation and running of a DSS and its *main components*: data management, model management and communication system [TURB90 111].

As DSS and quantitative modelling have evolved simultaneously with the technological advances in hardware and software, the first systems were based on *procedural programming languages* (e.g. Fortran [BUCH72] [FELZ82]; Basic [MCNA85]). Models had to be buried in subroutines and all components for input, processing and output had be hardcoded. The flexibility was severely limited and most of the features stated above were null and void.

The introduction of *simulation languages* eased the troubles associated with modelling by allowing the user-friendly input of algebraic relations and data for dynamic, multi-year models and by providing built-in analytical tools and easy-to-customise reports and graphs (e.g. Dynamo [ZWIC82], [MEYE83]). Complex models with startling results boosted modelling activities in academia and business even further (Meadow's study 'Limits of Growth' for the Club of Rome [MEAD72] was based on Forrester's *Systems Dynamics Concept* [FORR72] and Dynamo).

The next phase was dominated by *specialised packages*. Adding more functionality to support model design (financial, statistical, forecasting functions, multi-dimensional consolidation), analysis (what-if, risk, sensitivity, goal seeking) and input/output needs (reports, graphs, user interface), they were available on mainframes and personal computers alike and provided the means for a widespread penetration of accounting, controlling and planning departments (e.g. IFPS and FCS/EPS [CORN84], [TURB90 265-301]).

With the technological advance of personal computing and the introduction of graphic-oriented interfaces, the development of complex quantitative models shifted more and more towards powerful *spreadsheets* (e.g. Lotus 1-2-3, MS-Excel), which nowadays also offer the advantage of dynamic links to database, graphics, word processing and communication packages.

Whereas specialised packages like FCS/EPS provided a *rigid framework* for model design (separated specifications of program control, model logic, data, reports and graphs), spreadsheets render *ease of use* and virtually unlimited ways to structure one's applications. Hogg's remarks (chapter 3.2.2) that these sophisticated tools can be „highly dangerous in the hands of the uninitiated" have to be seen against the background of complicated but, potentially erroneous, inadequately structured and poorly documented models which, instead of facilitating continuous organisational learning may end up in hopeless confusion.

„Financial modelling is effectively now a discipline of its own, building on skills in accountancy, economics, finance, computing and mathematics/statistics. Despite this there are few texts and little training that cover all the required skills in the modelling context" [HOGG94 11].

Consequently, to increase the productivity of modellers and decision makers alike, a growing body of work is focusing on the discipline of *model management*, which is concerned with the computer-based means for representing and processing models [BLAN93 9-18; CHAN93 19-37].

In an overview of the subject, Blanning examines, among others, the central topic of model base processing. This field of study features model sequencing and the relationship between model components, and can be subdivided into the following tasks [BLAN93 11; TURB90 683ff; TURB93 10-11]:

- *Interfacing* concerns the communication between models, data and users, and the development of effective front-ends
- *Interpretation* can provide information and explanations concerning the models used or the results derived
- *Use* and *Integration* of models cover the identification and proper combination of models and other components to act appropriately to a specific query
- *Construction* of models is occupied with the development of simplified representations of reality and includes the development of new and the selection of pre-specified models. The correct choice between these two alternatives depends on the appropriate diagnosis of the problem area and requires the decision to build a model, to use a ready-made one, or to modify existing ones.

4.2 Knowledge based Systems

4.2.1 Characteristics

Knowledge-based systems are a subfield of *artificial intelligence* (AI). As computer programs that contain both *declarative knowledge* (facts about objects, events, and situations; e.g. a is true, b is a type of c) and *procedural knowledge* (information about courses of action; e.g. if x then do y else do z), their aim is to emulate the reasoning processes and decision-making abilities of human experts in a particular domain or area of expertise.

Expertise is the extensive, task-specific knowledge acquired from training, reading, and experience [TURB90 427]. It covers facts, concepts, theories, rules, heuristics about the special and wider problem area, and includes strategies for problem solving and meta-knowledge (knowledge about knowledge).

In comparison to *databases* knowledge-based systems are not merely limited to the access and management of data, but are also capable of inferencing new information from an existing knowledge base [LUST90 9].

In contrast *to conventional procedural programs*, the programmer is not forced to closely link the description of the results desired with the detailed specification of how the problem is to be solved [LUST90 9]. Instead, the *declarative formulation* allows extending programs just by adding further facts and rules which are then processed by already existing and autonomous problem-solving components.

An practical application of knowledge-based system are *expert systems*, which represent the *knowledge* of a narrowly defined domain in a problem-oriented, easy-to-maintain and efficient-to-process manner. An expert system draws *conclusions* from the knowledge by using algorithms or heuristics and provides *explanations* for its reasoning in dialogue with the user by referring to the case-specific data [LUST90 153]. The benefits associated with its application can be manifold:

- *enhanced availability of expertise*
  The application and multiplication of an expert system enable an easy and fast access of the expertise independent of time, location and environment; it also allows the securing of scarce know-how which might be lost by retirement or job fluctuation

- *better quality of expertise*
  The knowledge base ensures a steady, unemotional and complete response and can integrate the expertise of several experts resulting in an increased reliability of results; it can solve problems whose complexity (e.g. quantity of data to be scanned or inherent dependencies) exceeds human ability
- *reduced costs and enhanced productivity*
  An expert system can be used to act as a tutor resulting in educational benefits; it can be designed to explain its findings or to check and interpret results creating better output or avoiding mistakes; consequently, it may result in lower personnel costs or might enable the use of less expensive equipment.

The accumulation of the relevant expertise and its subsequent structuring and transfer to the *knowledge base* establish the computerised foundation for the understanding, formulation and solving of the problems at hand.

However, expertise is not always available or difficult to extract from human experts. Their experiences and judgements may differ or might be difficult to express since they are also frequently based on 'gut feelings'. Additionally, an expert's motivation to participate in the lengthy and cumbersome *knowledge acquisition and engineering* is often limited.

Other problems areas in the development cycle of a knowledge-based system include the loss and misunderstanding of the acquired expertise by passing from one participant of the *analysis and design process* to the other (expert - knowledge engineer - system analyst). To add expertise to the knowledge base, it has to be restructured which further contributes to the danger of inaccurate representation.

In this respect, it is vital to select an appropriate development tool which enables the *implementation* of an effective and transparent system structure based on code which is easy to understand, debug, extend, and maintain. The options cover AI programming languages which offer the highest level of flexibility (e.g. PROLOG, LISP) and expert system shells which provide a fixed set of capabilities to build systems quickly, easily, and at low cost (e.g. KEE, NEXPERT OBJECT).

To use a system, problem-related information has to be entered into a case-specific knowledge base. This data is then analysed by the problem-solving components of the inference engine, which controls how the facts and rules in the generic knowledge base are used and processed to draw the appropriate conclusions.

Category	Problem Addressed	Types of Systems
Diagnosis	Infers system malfunctions from observations	Medical, electronic, financial analysis, auditing, machine repair
Monitoring	Compares observations in order to plan vulnerabilities	Management control, nuclear power plant regulation
Debugging	Prescribes remedies for malfunctions	Computer software
Repair	Executes a plan to administer a prescribed remedy	Automobile, computer, telephone
Instruction	Diagnoses, debugs, and corrects student behaviour	Tutorial, remedial
Control	Interprets. predicts, repairs and monitors system behaviours	Air traffic control, battle mgmt., manufacturing process control
Prediction	Infers likely consequences of given situations	Weather forecasting, crop estimation, financial forecasting
Interpretation	Infers situation descriptions from sensor data	Speech understanding, image analysis, surveillance, mapping
Design	Configures objects within situation constraints	Circuit layout, budgeting, automatic program generation
Planning	Develops guidelines for action	Strategic planning, process scheduling, military planning

Figure 4.b: Generic categories of expert system applications [MOCK89 102]

Figure 4.b details the problem areas of expert system applications. *Meta-Planner* fits into the generic category of *design*, specifically into the problem-solving type *construction* which can be further subdivided [PUPP90 128ff; PUPP93 207ff]:

- *Assignment* is the provision of an ordering plan between disjunct sets which takes into consideration preferences, short resources and other restrictions
- *Planning* is the transformation of a given initial state into a desired final state
- *Configuration* includes problems in which basic elements are selected from a given set, parametrised and assembled to form a solution object which fulfils the desired requirements.

However, the configuration of technical installations (e.g. computer) is often based on an already fixed construction plan and requires the selection of adequate components to satisfy the specific needs. *Meta-Planner*, in comparison, has to generate the layout of the planning model as well.

4.2.2 Suitability

To *assess problem areas and applications* suitable for knowledge-based technology, a number of studies have been carried out and resulted in the compilation of check lists which detail major aspects favouring the utilisation of a knowledge-based system. The following statements summarise the results of an assessment which was based on one of these lists [MERT93 17-19] and which was conducted to estimate the suitability (see notes shown in brackets) of a KBS for the meta-planning of quantitative strategic modelling.

■ Methodological Suitability

- The problem domain can be closely defined and delimited, the knowledge is stable (quantitative strategic modelling)
- The solution is complex due to the number of interdependent factors to be considered (number of potential planning objects, level of differentiation required)
- The problem solution requires heuristic knowledge and cognitive abilities (due to the combinatorial explosion of object relations an algorithm cannot be applied)
- Adequate methods have been devised in theory and successfully applied in practice (segmentation methods to derive a firm's relevant organisational structure)
- Decisions are based as well on hard facts as on soft evaluations (the inclusion of planning objects in the model is determined by objective and subjective data).

■ Availability of Expert Knowledge

- Theory of the domain is well publicised and established (strategic management, long range planning, meta-planning)
- Quantitative approaches to decision making in management science are proven (simulation, modelling, Pareto-Analysis, sensitivity and what-if analysis)
- Author has considerable professional experience in the domain (strategy consulting, financial modelling, decision support)

- Personal knowledge of potential problem areas and success factors is available (based on various respective projects in different companies/industrial sectors)
- Former manually conducted projects can be used for reference and testing (see chapter 5.2.2: case study of QuarryCon Ltd.); additional experts can be consulted.

■ Domain Related Benefits

- The methodology developed guides the meta-planning process of model design
- The system use is not restricted to particular company sizes, branches, etc.
- A complex network of interdependent planning objects can be analysed
- Current planning systems and the present or conceivable differentiation of actuals are used as the starting point of the exercise and provide the initial set of data
- The acceptance of participants in the subsequent planning cycle can be furthered by an early consideration of their views and wishes in the model design stage
- Divergent views of know-how and power brokers in a company can be easier detected, demonstrated, discussed and focused
- The design decisions can be based on objects' strategic relevance and data needs
- The consequences of intended design changes can be estimated and visualised
- Individual model design decisions are transparent and can be surveyed
- The resulting planning model is fully documented to facilitate easy comprehension and maintenance.

4.3 Project-related Application Areas

Due to the interrelated multiple domains (figure 1.a), a considerable number of knowledge-based applications in the commercial and technical field exist where parallels to *Meta-Planner* could be drawn. Consequently, the following outline of project-related application areas had to be focused.

In particular, *technical-oriented systems* in design and construction have been left out. Like Digital Equipment's expert system XCON [SVIO90 126ff] which configures customer orders for computers, these applications usually process a well-defined set of requirements and deduce the solution from an also fairly fixed set of components fully specified. In case of *Meta-Planner* the number of components is not limited and not all of them are initially known but evolve during the prolonged meta-planning exercise together with additional and modified requirements. Furthermore, there are initially no discriminations against any constellations.

Applications covered have been chosen because of their resemblance to *Meta-Planner's objectives, workings, or further potential of development* (chapter 9.3). Hence, the following references concentrate on the domains of strategic management and model management, whereby some of the systems introduced are also closely linked to decision support or knowledge management.

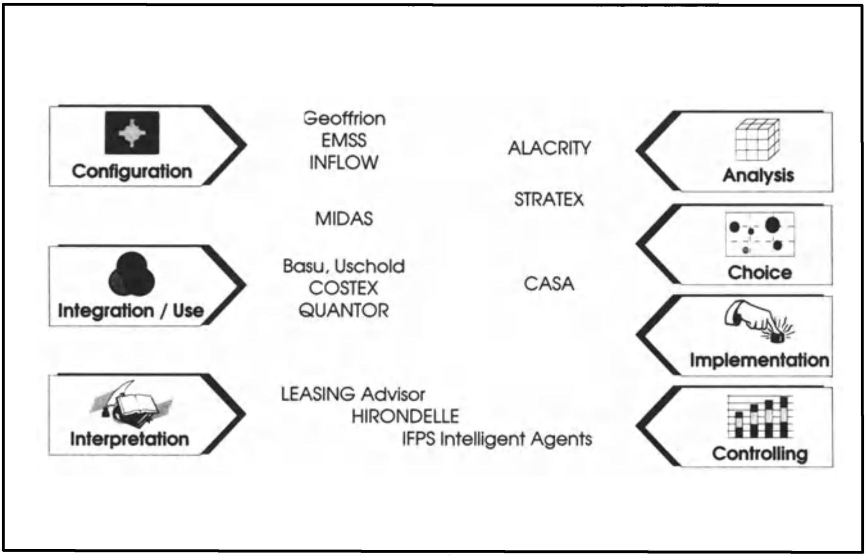


Figure 4.c: Project-related Domains and typical Applications

Figure 4.c details the areas and lists related applications. The systems shown are described below by name, purpose or objective and references to more detailed discussions. After the introduction of *Meta-Planner*, chapter 9.4 provides a competitive analysis which takes up selected areas and systems, draws parallels and presents differences and critique.

4.3.1 Strategic Management Domain

In strategic terms, the use of knowledge-based technology can benefit an organisation in two ways. It can increase the *competitiveness* by improving products, services, customer relations, processes and access to know-how, and, secondly, it is able to support the *strategic management* phases of analysis, choice, implementation and controlling. This study concentrates on the latter.

However, since innovation and creativity are closely associated with the *development of strategies* and *methods* used are often based on intuition and not exactly defined, the applicability of expert system in strategic management is sometimes questioned. Mockler also concedes that „*strategic planning* is one of the least defined and most general of the management decision areas", but maintains that applications „are feasible because:

- expert decision skills are needed to do the strategic planning job
- there are recognised experts in the field
- the job requires informed judgements
- a number of specific company strategy development tasks, especially where small companies or strategic business units are involved, involve management tasks that can be defined with sufficient precision to enable knowledge-based systems development" [MOCK89 213].

Hence, applications so far focus on narrowly defined areas and cover primarily the qualitative aspects of strategic management (chapter 2.2). They give guidance for the analysis phase by supplying respective check-lists, conduct situational analysis based on heuristic rules and established concepts, and generate ideas or recommendations for potential actions.

Their aim is, consequently, not to replace the expert but to apply and use specific methodologies of business planning more efficiently [WAND92 73]. Figure 4.d shows a selection of applications developed whereby three of them are exemplified in a little more detail.

Name	Field of Application	Author	Summary
Alacrity	strategic evaluation of business units - see above -	(COOK89)	
CASA	Computer Aided Strategy Audit - see below -	(MÜLL91)	D M S W
Business Insight	supports small businesses in strategic analysis and project team members to achieve conformity	(LEWI91)	D
Decidex	strategic analysis and evaluation of alternative scenarios for launching of products and services	(LEVI86)	M S
ESP	Expert Strategic Planner assists with the process of setting strategic objectives and related policies	(ARUN92)	D
EXMAR	assists companies with developing long-term marketing strategies by supporting several techniques	(EXMA90)	D
ICS	Integrated Consulting System for competitive market analysis	(SYED88)	S M
MA	Management Advisor assesses the value of strategic business proposals as new plants or products	(REIT90)	D
MSA	Marketing Strategy Assistant simulation of a participant in a management game	(CROS86)	S
Operation Advisor	allows developing, testing, evaluating production or operation strategies through a simulation process	(REIT90)	D
SAES	Situation Assessment Expert System support to assess a company's strategic position	(GOUL85)	M S W
SAM	Sales Mix decision support system determination of an optimal product mix	(LEE87)	S
SCAI	Strategy Checking by Artificial Intelligence information access and evaluation of strategies	(RUHL87)	S M
SESBV	Sourcenet Expert / decision support System for Business Venturing, information access	(DEAN88)	S
SIS	Strategic Intelligence System, development of a meta-system to link dedicated expert systems	(HUMP88)	S
SMARTD	Strategic Management for Analysis and Research in Technology Diffusion to support innovation decisions	(GOTT87)	D
Strat-Assist	strategy recommendations based on a strategic analysis and Porter's „Competitive Strategy"	(GREN88)	S
Strategic Planner	development of enterprise-wide strategic objectives, based on Porter and Hamermesh	(MOCK89)	M
Strategist	business strategy advisor supports portfolio planning to device strategies for marketing products	(SCHU90)	D
Stratex(B)	market and competitive analysis for the Norwegian fish industry	(BORC91)	M
Stratex(P)	support of portfolio-concepts and norm strategies - see above -	(PLAT88)	M S W
Success	assists top managers of strategic business units in strategic business formulation	(SEGE89)	D

Legend of Summary: D=(DURK93) M=(MÜLL91) S=(SCHM89) W=(WAND92)

Figure 4.d: Knowledge-based Systems in the domain of Strategic Management

- *Alacrity Strategy* [ALAC88, COOK89]
  By impersonating a strategic expert, *Alacrity's* diagnostics component questions the user to conduct a qualitative analysis of the company (26 questions), market (39) and competition (32). Based on some 3000 rules, this commercial package produces a written summary of the strategic issues of the business concerned and generates ideas for potential actions.
  The system serves as a good starting point for strategic analysis and reporting in large diversified organisations especially since a development version allows the adaptation of the knowledge base to company-specific requirements. The structured reports facilitate an instant feedback, provide a skeleton for the strategy paper to be submitted to corporate management, and due to the standardised expressions used enable a better comparison between different business segments.
- *Stratex* [PLAT88, MERT93 233ff]
  The system assists the phases of qualitative analysis and strategy development. In contrast to *Alacrity*, it explicitly supports portfolio-concepts. Company-specific components can be integrated to tailor the criteria used or to enhance the standard knowledge base.
  A portfolio is usually divided up in 3x3 areas (figure 2.c) which each define a distinct set of potential norm strategies. *Stratex* enables the combination of two portfolio analyses, for example the market and technology portfolio. By featuring the 9+9 basic strategies, it additionally provides more elaborated proposals of action on the basis of 81 (9x9) detailed strategies. With more than 500 rules, 200 frames and 300 text modules, the system is based on *Prolog* and the expert system tool *Hexe*.
- *Casa - Computer Aided Strategy Audit* [MÜLL91]
  In order to benefit from an enhanced productivity during the strategic analysis of medium-sized companies, *Casa* is an expert system tool used by a management consultancy. It supports the definition of strategic business units, analyses the corporate culture, assesses market and competition, and evaluates the strategic cost situation.
  The system implementation is based on the *Knowledge Engineering System KES II*, the database system *Clipper*, and the spreadsheet *Excel*. It includes 5 MB code and help texts, 2000 rules in 44 knowledge bases and 200 pages of automatically generated reports and up to 100 business charts.

The *attributes of strategic decision making* are innovation, complexity, an open-end process, and the initially undeveloped comprehension of causes, effects, expectations, potential solutions and alternatives. Concerning computerised systems, all these features are difficult to model.

However, experience so far shows that knowledge-based systems can ease the first steps for an organisation to conduct strategic management. The main benefits are associated with the *support of experts* in their function as data provider, analyst, or moderator of a group-dynamic process. Yet, the universal application of existing systems is limited.

Due to the multiple ways of combining the individual criteria and ratings during qualitative assessment, the knowledge bases, like in the examples given, have to incorporate a considerable number of rules for subsequent interpretation and proposals; even if, in case a more intensive use is intended in a company's particular environment, the *need for specific adaptations or extensions* soon becomes evident. Hence, an effective utilisation of such an application is closely linked to the capability and skills to properly maintain and further develop it.

Furthermore, a user still needs to know the *limitations of the underlying methodologies*. Anyone who has conducted portfolio analysis in a strategic workshop, has experienced that the ratings of individual participants concerning the same business unit can differ considerably. The need to establish definite figures for further processing, obliterates these differences. The compromised scores, however, cause a specific set of rules to fire and trigger precise interpretations and recommendations. Blinded by management science, technology and detailed output, the users more than often by-pass any common sense and critical distance required and run into in serious flaws.

As the main advantages of knowledge-based systems, chapter 4.2.1 listed the *increased availability and quality of expertise* as well as the *improvements in costs and productivity*. Analysis, design and implementation, on the other side, require considerable investments in time and manpower which sometimes have to be compromised due to commercial pressures.

In his critical assessment of *Casa*, Müller-Wünsch covers some of the problems related to the development of such complex systems by discussing the dangers of suboptimal development environments and of neglecting certain aspects of transparency, consistency, tolerance and user acceptance [MÜLL91 104-108, 158-162]. Insights in the problematic nature of introducing strategic expert systems in a consultancy environment are given in an article of a German business magazine [BIAL90] which emphasises the substantial role of commercial pressures and the user skills needed for operation and further adaptation.

4.3.2 Model Management Domain

A major goal of *decision support systems research* is the provision of flexible, dynamic modelling environments for users who are not modelling specialists [ELAM87]. In his survey of recent works [BLAN93], Blanning emphasises the contributions of *artificial intelligence* to this area and references systems which have sometimes been called *'expert modelbase systems'*. As discussed in chapter 4.1, this growing field of research can be further subdivided, whereby the contributions made in *construction, use, integration* and *interpretation* are those most relevant in respect to *Meta-Planner*.

However, these contributions are not limited to applications. Due to the fact that it is a relatively new area of research and to the speed of technological advances, new ideas and concepts are publicised which help to structure the areas and to enhance the scope of potential applications. Works relevant to this study include:

- *Geoffrion*'s approach *'Structured Modelling'* (SM) provides a formal mathematical framework to define basic model entities and their relationships by applying three levels of differentiation: the *elemental structure* documenting the definitional detail of specific model instances, the *generic structure* which partitions all elements of a given type into sets, and the *modular structure* to organise these sets hierarchically according to commonality or semantic relatedness [GEOF87]
- *Uschold*'s notion to separate domain models from executable model in model configuration to facilitate *model comprehension*, (re)use, or modification, as exemplified by an implementation in the domain of ecological modelling [USCH91]
- *Basu's and Blanning's* proposal to support enterprise modelling by *Metagraphs* which provide the means to represent both data and model relationships and, hence, a foundation for a flexible data-driven *model configuration* [BASU92].

The applications developed so far, primarily concentrate on the analysis and interpretation of data, or focus on the flexible use and integration of already established models and model components. The complexities and difficulties concerning model configuration are often stressed but relatively few systems exist and also specialise on certain problem domains, e.g. linear programming or semantic nets [see references in BLAN93 11]. The following examples provide an overview of model management and describe some typical system developments:

- *EMSS Expert Modelling Support System* [YADA89]
  The computer-aided tool is based upon an extension of the *Structured Analysis and Design Techniques (SADT).* It supports the process of system analysis which starts with the understanding of an organisation and ends with the formal specification of its *information system requirements.*
  The approach proposes a formal notation for describing basic building blocks which, subject to *control* elements, need informational *input* for the managerial *function* to arrive at a *decision.* The interactive system incorporates three subsystems: user interface, model handling and knowledge handling. It prompts the user for appropriate responses while describing a model or asking for reports. In breaking down abstract into primitive objects, a stepwise refinement process aims at linking well-defined single data elements to all more complex input, output and control entities.
- *Inflow* [KREB89]
  The system finds all the *information flows within an organisation,* thereby building an information model of a company. It is rule-based and based on PROLOG. From its derived models one can interpret how the organisation functions and where its communications problems are. It provides an *'information inventory'* that can be queried like any database [DURK93 35].
- *Costex* [WALK91]
  The system assists MIS managers in the *selection of appropriate techniques* of analysis for a given set of economic analysis contingencies. It examines the utilities of present value analysis, discounted payback analysis, uniform annual cost, benefit-cost ratio, savings investment ratio, internal rate of return, and break even analysis, as economic analysis techniques. After assessing the costs and benefits, the findings are summarised in a matrix that scores the category of utility for each technique [DURK93 25].
- *MIDAS - Manager's Intelligent Debt Advisory System* [DEMP91]
  The system's aim is to support treasurers in corporate debt decisions, namely in developing and implementing borrowing plans to meet forecast cash requirements over a rolling planning horizon. It integrates *stochastic linear programming and simulation modelling and heuristic reasoning* and covers automatic model formulation, solution, modification, sensitivity analysis, and presentation of results.
  The models and rule-based extensions support a hierarchical planning process which include the *problem definition,* the generation of an *initial borrowing plan,* the inferencing of refined *candidate plans* according to the borrowing needs stated, and, finally, the *testing* of these plans via simulation. *Midas* facilitates the direct use of sophisticated techniques by non-expert users and, thus, lessens the need for scarce intermediaries. Implemented in KEE and LISP on a workstation, the system design uses a combined frame- and rule-based diagnostic approach.

- *Quantor* [SCHO93]
  The system supports the *flexible building and execution of planning models*. It operates with parameters, ratios, flow and state variables, their definitional relationships and projected figures. Its main feature is the incorporation of confidence intervals which mark the boundaries of a 90% normal distribution and can be defined for any variable.

  During run-time the knowledge-based components process the definitional relations provided. The aim is to inference the *model configuration* for calculating the variables not specified on the basis of statistical methods and filters, whereby *over-specification* (parent and child values are given) is used either to increase the confidence levels of results or to communicate inconsistencies to the user and *under-specification* (database insufficient for complete calculation) is solved by automatically providing values with wide confidence intervals for missing data.

  Quantor provides a data-driven approach of *what-if, target and risk analyses* and offers various functionalities of a spreadsheet. Models can be easily extended since relations do not have to be specified sequentially. The input of confidence intervals, however, increases the model's data requirements considerably.

- *Leasing Advisor* [NEUH94]
  The system supports investors in their choice of financing a particular investment by *loan or leasing*. Based on a user-defined set of objectives, the knowledge-based components process the contractual data specified and deduce recommendations and explanations.

  In addition to the qualitative assessment of accounting, risk, liquidity and legal issues, it incorporates a *quantitative model*. Any ratio can be linked to objectives by stating numerical targets and related levels of satisfaction. After the projected balance sheet and profit statements have taken into account the alternative ways of financing the investment, the values of the selected ratios are evaluated and their scores complement the rule-based proposal and interpretation process.

- *IFPS - Intelligent Agents in Decision Support Systems* [KING93]
  The prototype *Smart Spreadsheet* is designed to help executives automatically monitor data patterns and carry out prescribed plans of analysis based on the patterns. Rather than incorporating large stores of expert knowledge, the notion of intelligent agents focuses on very specific tasks, e.g. *scanning and monitoring*.

  Used as an add-on within the modelling software *IFPS*, it enhances the *dialogue* with the user by automatically high-lighting reported data items. In selecting figures of interest and *analysis-options* of the menu, explanatory texts are provided as for example: 'Why did corporate revenues go down in actual? Corporate Revenues went down in actual because East Revenues decreased.' Additionally, the equations, sub-variables and related figures are reported. The *main benefits* for the users are more efficient ways to identify, trace and analyse variances. The work of the application builder, on the other hand, can be often eased, by using adequate script languages instead of the more complex languages and shells for expert system development.

- *Hirondelle* [TEUL93]
  The system supports the *Bank of France* in the preparation of a *Monthly Business Outlook Survey* which provides an analysis of the economic activities in France. Sent to 25000 subscribers, it deals with the short term business activity of firms on around 60 economic sectors. Twelve experts have three days to write up the findings of the survey in around fifty pages.

  The system's objective is to preserve the *style of the verbal reports* in a homogeneous, precise and controlled way across sectors and time. It interprets the key indicators of firms surveyed by using recorded sentences with variable parts. The texts are stored in a database and can be formed according to the style and knowledge of the experts through a friendly user interface. The expert system part is based on Nexpert Object and defines the text structure by characterising the values, selecting the inclinations (e.g. rise), and choosing adequate skeletons for the evolution, current situation and prediction.

The examples cited above demonstrate the scope of applications with model management capabilities and the different approaches taken to satisfy the specific system requirements and motivations.

EMSS and *Inflow* support the analysis phase of the configuration process. *Costex* enables the selection of the most appropriate model-based techniques for economic analyses. *Midas* allows non-experts to use sophisticated models for their problem solution. *Quantor* flexibly supports the specification and running of definitional models by the user. *Leasing Advisor, IFPS,* and *Hirondelle* interpret data and information, either to support their decisions, to provide drill-down explanations, or to establish comparable verbal reports.

Concepts and systems shown engage in formalisms to support the generation of clearly defined working systems (*Geoffrion, Uschold, Basu, Blanning, EMSS, Inflow*). They provide generalised modelling support for a certain problem class like linear programming or analytical techniques (*Costex, Midas*), or solve specific model management issues by adding respective knowledge-based components to existing decision support or spreadsheet applications (*Leasing Advisor, Quantor, IFPS*).

4.4 Summary

As strategic management is embedded in corporate planning, decision support (DSS) and knowledge-based systems (KBS) also have to be seen in a *wider historical and practical context.* Based on the data of transactions processing, management and executive information systems, a DSS provides *analytical and modelling facilities* to solve semistructured and unstructured problems.

The technological means to generate DSS have changed considerably over time with the advances in hardware and software. *Modern spreadsheets* render ease of use and allow application development virtually free of any of the rigid structures imposed by former tools. But this flexibility has also led to *warnings,* since it also encourages inexperienced users to incorporate ever greater complexities into their models.

A growing body of research in *model management* addresses these aspects by also focusing on *model construction.* To increase the productivity of modellers and decision makers in this area, artificial intelligence has made beneficial contributions. Knowledge-based technology, which offers distinct advantages in the processing of expertise, has likewise been employed in the development of *Meta-Planner.*

Rooted in the KBS-category of *design/construction/configuration,* the *suitability* of this technology regarding the meta-planning of strategic modelling can be also demonstrated by an initial assessment using a complying *check list,* and by providing *examples of applications in related areas.*

For a reference of, in respect to this study less relevant, *other planning-related expert systems,* Mertens details applications in the commercial areas of logistics and production, marketing and services, human resources, research and development, finance and accounting, controlling, planning and management by also focusing on the business, banking, insurance and consultancy environment [MERT93]. By not further classifying the business systems but by including 22 additional application areas, Durkin references approximately 2500 systems which he reckons represent 20% of the total population at the time of print [DURK93].

Part II

Application-oriented Topics

5 Requirements Statement

5.1 Recapitulation of the Domain

The *aim of strategic management* is to create and sustain competitive advantage. Based on a thorough investigation of company and environment, internal strengths and weaknesses, external opportunities and threats have to be identified. The subsequent evaluation determines the key success factors and problem areas.

To cover the scope of potential actions or to provide solutions for different scenarios, strategic options are elaborated, which are the basis for the ensuing strategy selection process. Suitability, feasibility and acceptability are the prime criteria for shaping a *portfolio of strategies,* which is expected to assure a balanced distribution of risk and cash flow and the achievement of the desired long-term objectives.

In order to meet these requirements the sole consideration of qualitative data is not sufficient. To determine the *financial and non-financial consequences* of the alternative strategies of a number of more or less interdependent company units, quantitative estimates of the relevant ratios should be established, calculated, consolidated, reported and interpreted.

By exceeding but integrating often isolated capital and costs budgets, the objective has to be to provide a bird eye's view of alternative strategy portfolios and drill-down capabilities to seize underlying strategic assumptions at the grass-roots level. The quantification of strategies and the resulting *projection* of long range financial statements provide management with the means to review and shape its strategic policy in its entirety, to set the appropriate targets for operational units, to control the successful execution, and to timely determine corrective actions.

However, the *development of decision support systems* to extend the scope of strategic planning in quantifying the effects of business strategies is a complex task. To gain acceptance by management and participants, the planner has to find a balance between the detailed structure of the operative production and accounting systems and the need for a higher aggregated model due to the uncertainty of forecasts and the efficient use of company resources. He also has to allow for new strategic views of the data which might not yet have been represented at all.

Besides, the subsequent running of the model demands the set-up of *organisational structures* involving administrative, training, assistance, data collection, checking and control activities. These supporting activities together with the mobilisation of the participants in the planning cycle require the *timely coordination* between people, data, technology and documentation.

A favourable cost-benefit ratio for such an exercise necessitates a sound *planning concept* which lays out the organisational procedures and technological requirements including the structure of the quantitative planning model. Its development calls for an elaborated preparation phase characterised by *metaplanning activities.*

To ensure the quality and efficiency of subsequent planning cycles and results, the concept has to be closely tailored to the *specific needs* of the company which have to be established and subsequently updated by the planner. This process requires the specification of numerous ratios, planning units, and information sources and the decision to include or not include them into the planning process. However, the various interdependencies between these planning objects result in a *complex network* with unknown benefits and expenditures for the individual selections.

Although the *technical capability* to build large planning models increased considerably with advances in information technology, the construction of a mathematical model is still an endeavour that requires highly skilled, creative personnel. Model management systems, whose aim is to support the development and use of models, are by now an established and still growing field of study. But not all aspects have been exhaustively researched, so that the reasons for model failures [NAYL79 273-278] still apply:

- *Prerequisites:* insufficient data, inadequate political support
- *Development:* ill-defined problems, failed deadlines, inaccurate results
- *Specification:* excessive use of technical jargon, inadequate documentation
- *Effectiveness:* failure to produce useful results, unfulfilled expectations
- *Efficiency:* unfavourable cost-benefit ratio
- *Acceptance:* inadequate human engineering, dependence on one person.

5.2 Problem Statement

5.2.1 General Description

The *configuration of a long range planning model* able to represent individual business and functional strategies and to consolidate them on corporate level is a complex task. Because of heterogeneous views and expectations, incomplete historical data and the uncertainty of forecasts, a time consuming, stepwise approach is needed to identify the objects to be planned and their level of refinement.

Faced already with the *complexity* of scanning a multitude of variables and ratios for portraying the logical interrelationships of a company's production, marketing and financial background in a concise way, the subsequent need for further differentiation across organisational levels and units (e.g. markets, products, activities, subsidiaries) triggers a *combinatorial explosion* with potential modelling demands of several thousand input data items even for small enterprises.

Because of the *lack of capable tools*, the diversified factors governing a successful model design can not be considered completely and comprehensively. Hence, existing long range planning efforts have led to historically grown systems exposing a *lack of transparency* in regard to the design decisions taken and suboptimal solutions due to ill-considered subsequent shifts in strategic priorities.

The *objective* is to formulate a *methodology* which supports the corporate planner or consultant during the time consuming meta-planning phase, and to develop the corresponding *prototype system*. Methodology and prototype have to support the configuration of a crucial part of the planning concept, the quantitative model. The aim of the model is:

- based on the company's current strategic policy and potential alternatives
- to identify appropriate financial and non-financial ratios and relationships and to link them to the organisational segments considered to be relevant
- in order to represent individual strategies at business, functional and corporate level which enable the projection of long range financial statements via consolidation
- by establishing those levels of differentiation for variables and units which conform to strategic relevance and adequate sources of information
- and result in a transparent model layout and acceptable data expenditures.

The system has to be applicable to a variety of companies and branches in order to act as a *general and effective companion* for the planner by keeping track of the numerous potential planning objects and their assessments, by giving recommendations based on the analysis of the stored meta-data and by visualising consequences of design changes. In particular, the following questions have to be addressed:

- Which are the relevant *segments?* What degree of *differentiation* is needed?
- Which are the *ratios* of interest? *Where and how* do they have to be planned?
- Which *information sources* are important? Which *data needs* are covered?
- Which is the most promising *planning-mix?* Are the *expenditures* justified?

Both the development and subsequent use of the envisaged model can be characterised by the need for interaction with a number of distinctive *know-how and power brokers* in a company. Consequently, *acceptance* of system and results by these participants is a vital precondition for success. The system, therefore, has to facilitate the dialogue between the persons concerned in illustrating the consequences of model design changes and in recommending further improvements.

In directing the design stages, the proposed system is expected to overcome the intransparency of the model configuration process and to limit the uncertainty of the resulting data requirements. As a consequence, a sounder planning concept evolves which represents all relevant characteristics specific to the company without overemphasising the detail, thus *producing significant results and acceptable data procurement expenditures.* This leads to a high benefit/effort ratio and avoids the risk of a subsequent organisational rejection of the quantitative planning exercise.

The transparency of the design decisions taken and the resulting model structure is further enhanced by an *all-inclusive documentation,* which also provides the basis for the know-how transfer to developers, training of planning participants and the further maintenance and improvement of the planning model.

Further applications of the approach presented could be conceived for performing planning *audits.* In an age when lean management reduces hierarchies, the necessity for the efficient use of time and management resources becomes vital and *lean planning concepts* can promote this aim considerably.

5.2.2 Case Study

As mentioned in chapter 4.3.2 (availability of expert knowledge) former manually conducted projects were used to support the development of the methodology and the testing of the prototype. One of these projects, which was successfully completed by the author in 1990 for an organisation operating in different markets and areas, also furnishes the data used in screen shots and examples throughout the documentation of this study.

To keep the anonymity, the alias of *QuarryCon Ltd.* has been adopted for future reference. Additionally, financial data and names of subsidiaries and locations have been changed. The following statements offer an introduction as well to the company as to the motivation of the project and briefly outline the results and main benefits.

■ Company and Strategic Planning Project

QuarryCon Ltd. consists of several legally independent companies with a total turnover in excess of 200 mio.German Marks. The area of business it operates in is the *extraction, refinement and distribution of building material* as well as the completion of *road-building and other construction projects*. To enhance organisational efficiency, the group had been restructured and decentralised five years prior to the project with only a small headcount remaining at the holding.

In 1989 the *overall strategic direction* had to be re-evaluated and newly defined in order to sustain the excellent performance of the group and to establish the base for further development. To provide know-how and the necessary man-hours, a management consultancy was selected. In addition to the strategic analysis and the moderation of the strategic planning process, it was also part of the mandate to estimate the *financial implications* of the new strategy and to present projections of the respective statements up to the year 2000.

The *meta-planning activities* to build the model included the analysis of former planning documents, current management reports and audits, involved the discussion with the firm's decision makers and controllers, and required the re-segmentation of the organisation to incorporate new products and markets. Historical data had to be restructured to fit the new levels of differentiation/aggregation and was used to verify the model and to provide a basis for the planning participants and their task of projecting future performances.

The bottom-up approach of the subsequent *planning cycle* required detailed discussions with the functional heads and the management of each of the associated companies. After pinpointing objectives and courses of action, the expected consequences were estimated and quantified by the respective business and functional managers. Additionally, branch-specific particularities concerning cost accounting and ratios (e.g. quality of material, availability of deposits, radius of distribution) had to be taken into account.

■ Results and Benefits

Based on the *case-specific model design* and using a decision support system, the elaborated quantitative inputs of the holding, its associated companies and their subsidiaries were calculated and aggregated. Additionally, economic premises and the policies concerning dividends and investments had to be contemplated, to determine the cash flow reserves available for and to model the financial impact of further acquisitions.

By defining the corporate strategy and outlining the capital expenditures and dividends intended, it was possible to set forth the corridor for future growth. The presentation of these commercial potentialities also convinced the shareholders of the enterprise and, thus, provided a solid foundation for the further activities of the corporate management. In the following five years (1990-1994), the company has doubled its turnover and expanded successfully into new regions and markets by internal growth and acquisitions.

5.2.3 Computer-aided Meta-Planning

Compared to manually conducted meta-planning activities (as briefly described in the case study), the methodology of the prototype system, called *Meta-Planner,* provides a conceptual framework to define and assess planning objects and relationships, and to determine the resulting model data needs and productiveness.

In aiming to become a planner's close *companion* during the *configuration process of quantitative models* in the limited but complex strategic management domain, it flexibly documents the outline of the planning model through an object-oriented, domain-specific knowledge base using inheritance methods and heuristic reasoning.

A typical application of the system stretches from the gradual build-up and assessment of the case-specific planning objects, to the definition of their relationships and to the continuous modification of the model layout until a satisfying design is accomplished. Because of its evolutionary nature, the process is iterative. Thus, it usually extends over a prolonged period of time, in particular, since the interaction of the user with other *know-how and power brokers* is strongly recommended and encouraged.

Figure 5.a shows the subjects of primary interest, which govern the computer-aided meta-planning process. By focusing on the distinctive features of the company, a system session has to provide the following functionalities:

During the initiation phase the user has to define the *segmentation* of the business. Markets, products, organisational units, and activities are specified and hierarchically structured. To document the *data availability*, competence areas are set up by linking the segments to the information sources available. This feature allows the detection of information *gaps* and the determination of individual *burdens* of participants in the anticipated planning cycle (figure 1.c).

Additionally, *variables* of the accounting system and of the desired projections are detailed and, likewise, hierarchically structured. The linking of these variables defines their relationships and results in the *vertical structure* (equations and consolidation) of the model logic (screenshot in figure 1.d and 1.e).

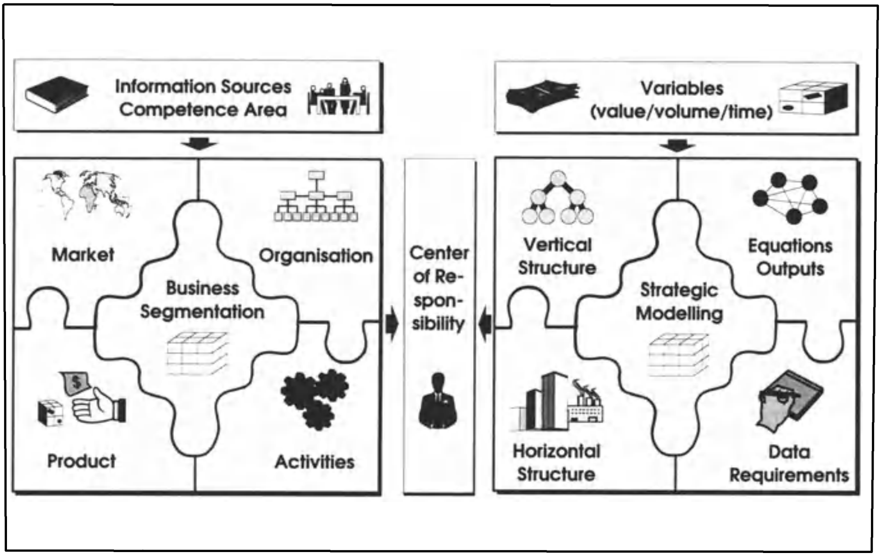


Figure 5.a: Main Elements of the Meta-Planning Process

The *horizontal structure* of the model is defined by assigning variables to specific *centers of responsibility* (market-product-organisation-activity-combinations). These links define the present or conceivable level of differentiation of the companies' data and represent the starting point for the configuration process. The input forms used (screenshot in figure 1.f, 1.g and 1.h) also allow the portrayal of the current model layout to provide an additional measure of comparison for the estimation and analysis of *data requirements*.

Using the same input forms, the present and future *strategic relevance* of the segments and variables and the *availability and quality* of the respective data needs is evaluated by the planner. Additional comments can be used to further describe any object; variables can be characterised by input of their current figures.

The settings of *activation parameters* control the inclusion of particular planning objects and their relationships in the projected planning system and document the progress of the meta-planning activities.

By calling the inference engine from a sub-menu, the objects and relationships are processed by the knowledge base. Based on the defined parent-child relationships, *rules and inheritance methods* determine the activated planning objects and their evaluation values. This feature considerably reduces the number of user interactions since object-specific data not yet provided by the user is 'inherited' from superior objects. These data can later be selectively updated if the need arises.

Additional rules analyse the verified evaluation and activation states and estimate the *relevance* of each object in respect to the other planning objects as well as the *volume* of the current and prospective input data. A heuristic, called *Pareto-Analysis,* particularises relative relevances and data requirements of individual objects. According to detected *imbalances,* the knowledge base recommends the (de-)activation, differentiation or further aggregation of selected objects (screenshot in figure 1.i and 1.j).

The *acceptance or rejection* of these *proposals* by the user results in an improved Pareto-distribution or leads to a revision of the underlying data, and, finally, to the specification of a fully documented *model design*.

5.3 Specific Needs and Constraints

To increase the workability of the proposed system, some problem areas in particular have to be addressed. The following paragraphs detail these specific needs and constraints as well as the preliminary design decisions taken to a accommodate them (marked by a bullet). These requirements have exercised a significant influence on the subsequent design of both the methodology and the prototype system.

5.3.1 Established Strategic Planning Concepts

The concepts established by Abell, Ansoff and Porter have laid the groundwork for an extensive differentiation of company strategies (chapter 6.1). However, the organisational consequences and the costly provision of data often prevent their translation into prospective quantitative representations. Yet to enable a close linkage between strategic management and quantification, the *segmentation structures* used in strategic analysis have also to be applied to the quantitative model layouts.

- To incorporate the established *strategic planning concepts* the planning model has to be structured in respect to the dimensions applied during the strategic analysis stage (markets, products, activities, etc.). Each of these dimensions is an abstraction that describes a set of individual planning objects sharing the same purpose and attributes.
- This construction corresponds to the notion of *classification*, a characteristic of object-oriented design (OOD), which means „that objects with the same data structure and behaviour are grouped into a class" [RUMB91 2]. Each planning object assigned to a class during the meta-planning phase (e.g. objects Europe, Asia, ... to the class markets) is a discrete, distinguishable entity which can be uniquely referenced. This corresponds to another notion: *identity* [RUMB91 2].

5.3.2 Company-specific Characteristics

In order to achieve maximum benefits, the layout of planning models has to be closely tailored to the company's specific characteristics. Depending on the industrial sector and the firm's size and scope, the model design is likely to be unique in its features. The state of the current systems in use, the (non-)availability of historical and prospective data and the organisation's level of planning experience add to this uniqueness. To accommodate these individual requirements the proposed system has to provide a *high-level general structure* which can be universally applied to different organisations and branches.

- The individual nature of *companies' characteristics* does not lend itself to a catalogue of pre-defined elements. *Meta-Planner*, therefore, consists of two separate databases. The *generic part* provides a high-level conceptual framework, which is universally applicable and controls the definition and processing of any assigned object. The second, *case-specific part* is generated at the time of application and holds all case-dependent planning objects and their related information.

5.3.3 Multitude of Planning Objects

Although the layout of the envisaged planning model will be considerably less detailed than the structure of the operative production and accounting systems, the latter form an important starting point for the subsequent meta-planning process. Additionally, the multi-dimensional segmentation of the company and its environment furthers the need for an *extensive management* of a multitude of company specific planning objects and their inherent dependencies and relations.

- The *multitude of objects* encountered even in small business planning exercises requires a coherent knowledge management. Inherent dependencies between classes add to the complexity of the data administration, which has to control the input, deletion, editing and linking of objects and their relations. It is of vital importance that the *integrity* of the case-specific database is secured at all times. To add the required functionalities to the proposed system, a *relational database management system* was chosen, which enables the storing of hierarchically structured object lists and many-to-many relationships and, additionally, supports the design of the forms and charts required for the user interface.

5.3.4 Combinatorial Explosion of Data Needs

An input variable constitutes the smallest element (model atom) of the planning model. An important aspect of the meta-planning process is to determine the *level of vertical and horizontal differentiation* which is needed to plan any particular variable.

Vertically differentiated	Examples of resulting Subvariables	Multiples
by further cost categories :	direct and indirect labour costs	2
Horizontally differentiated	**Examples of resulting Subvariables**	
by employees :	blue-collar and white-collar staff	2
by type of work :	labour costs of sales, marketing, production	3
by cost objectives :	labour costs of product X, group Y, article Z	3
by recipient of goods/service:	labour costs attributable to country, customer	2
by cost center :	labour costs department, subsidiary, holding	3

Figure 5.b: Differentiation of the Input Variable 'Labour Costs'

Differentiation can improve the quality of the subsequent planning exercise, but also increases the data requirements. Instead of planning, for example, the labour costs as a whole, figure 5.b enumerates levels of detail which are conceivable. However, the use of multiple segmentation levels can result in a combinatorial explosion of data needs (in the labour cost example of figure 5.b to maximal 216 input data items [=2x2x3x3x2x3]). The uncertainty of these effects is the biggest disadvantage of a manually conducted meta-planning exercise and has to be overcome by *thorough estimates*. To combat potentially high data needs further, *distinctions* must be able to be made in the assignment of variables to the different planning units.

- To consider the impact of *combinatorial explosion* the subsequent (de-) selection of any particular planning object has to be analysed in regard to the resulting difference in data requirements. To gain this information a great number of what-if analyses (chapter 6.5.4) have to be carried out causing a substantial overhead of processing time. Therefore, a different, rule-based, approach had to be developed and implemented.

5.3.5 Traceable Model Design Decisions

The decision for or against the inclusion of a particular planning object in the subsequent planning process has to be taken on a *traceable base of information*. In a manually conducted analysis the design issues are typically solved in a step-by-step fashion with the underlying information, if filed at all, usually hidden in numerous memorandums.

The motivations concerning the detail of these historically grown planning models are generally difficult to survey. It has, therefore, to be the aim of the proposed system to enable a conscious selection of planning objects based on a *transparent evaluation scheme* and descriptive comments. Additionally, the potential *sources of information* for the data supply and examples of current figures should be documented to facilitate judgement of the data availability and data expenditure.

- Apart from the data needs caused, each planning object has to be rated according to its strategic relevance to review its inclusion in the model. An evaluation scheme had to be developed for the selection process (chapter 6.5.1). The results are stored in a model information base which enables the subsequent *tracing of design decisions.*
- Additionally, potential *informants and data sources* are assigned to their respective objects of expertise and their individual contribution is estimated (chapter 6.3).

5.3.6 Model Design Rectification

Evaluation results and data requirements have to be set against each other, taking into account the interdependencies between the various planning objects. Based on these data an adequate methodology has to be adopted to report individual outcomes and respective *trade-offs of planning object (non-) inclusions*. Rules have to be established to detect imbalances in respect to the applied selection option in order to enable the proposed system to automatically suggest model design rectifications.

- The potentially extensive maze resulting from the dependencies and relations of the many planning objects can not be controlled manually by the user. The assistance given by the system has to incorporate the ability to *suggest model design rectifications.* Evaluation results and data needs have to induce these proposals.
- A ratio common to all objects under scrutiny has to be devised, computed and sorted to reflect the need for changing an object's selection status (chapter 6.4). The operation to obtain this value depends on the class of the object and, thus, corresponds to a third object-oriented design notion: *polymorphism*[RUMB91 2].
- To support the rule-based selection process, a heuristic is employed which is successfully used in other management areas (chapter 6.5.3).

5.3.7 User Interactions

As the final planning model requires the acceptance of management and participants in the subsequent planning process, the proposed system needs the acceptance of the planner or consultant handling it. To furnish a *smooth operation* in the light of the large number of planning objects, it is necessary to incorporate features to take the edge off the number of user interactions for supplying data during the meta-planning process.

- In view of the multitude of objects, their description, evaluation and selection, the *number of user interactions* required from first input to first results is an important consideration for the acceptance of the system by the user. Given the subclass-class-structure and the tree-like organisation of the planning objects, another characteristic of object-oriented design becomes important, namely *inheritance* (chapter 6.5.2), which is the sharing of attributes and operations among classes based on their relationship [RUMB91 3].
- User interactions can greatly be reduced by inherited data for selection and evaluation parameters which later can be selectively updated if the user does not agree with the reported outcome. Based on their parents' information some type of objects, rather than introduced explicitly, can be created dynamically. Since certain objects have multiple parents further rules are required to solve conflicts (chapter 6.5.2).

5.3.8 Documentation and Maintenance

A *comprehensive information system* is required in order to document the resulting quantitative part of the planning concept. It also has to act as the basis for future maintenance requirements, since prospective changes in strategy have to reflect upon the concept in order to maintain effectiveness and efficiency of the underlying model. To enable the auditing of existing planning systems, models currently in use must be able to be represented as a measure point for the configuration process. The handling of subsequent modifications to reflect the changed priorities, has to ensure the comparability between the current and the envisaged system.

- The *documentation and maintenance* requirements add to the need to adopt an established database management system which offers easy access to the stored information via queries, reporting and import/export capabilities. To accommodate comparisons, the parameters of the individual planning objects reflect the selection states for both - the current and the envisaged model (chapter 6.4).

5.4 Summary

Designing long range planning models to support the strategic management process in quantifying the financial and non-financial consequences of business strategies is a complex task. The solution demands the quest for an appropriate balance between simplification and representation of a real world situation and its accomplishment is judged by the value of the information gathered and the expenditures necessary. However, the difficulty in estimating the relevance of planning objects and data requirements is a major drawback in designing an adequate model.

To assist planners in this process, a methodology and its implementation as a prototype system is proposed. Its objectives are stated and further requirements are resolved into preliminary design decisions which includes the employment of an object-oriented software development methodology, the application of a relational database management system and the use of rules and heuristics.

Chapter 9.2 includes a table which references the requirements stated above to the topics of the methodology, system design, and prototype system to be presented in the following chapters.

6 Methodology

„Problem solving has to be supported by as many useful methods as possible, even if they originate from far-removed disciplines and do not correspond to the traditional way of thinking" [HUER81 8]. To fill this statement with substance, Hürlimann published a systematic inventory of more than 3000 *problem solving methods.*

Since then hundreds more tools and techniques have been put to press either in publications especially dedicated to decision-making [e.g. ANDE85, HIAM90] or by concentrating on the field of research and application [e.g. RADK85, ARMS93]. Strategic management in particular has been very successful in adding new methods or modifications to this ever-growing list.

In developing a *methodology* to support the configuration of quantitative models for strategic planning, a number of proven problem solving methods have shown the way to the results of this project. Apart from the efforts spared to 're-invent the wheel', these inclusions mainly benefit the system user by adding familiarity. They enable an easy and thorough understanding of the underlying mechanisms and provide the means to build up on already established tools and analytical results.

However, the combination of these methods requires a careful fine-tuning and interfacing. The following chapters will introduce the *building blocks* of the methodology and the *philosophy* behind them. Wherever appropriate, the references to established methods will precede the description of its actual application.

Since the solution space regarding the design options in modelling is immense, a heuristic approach had to be adopted. Whereas an algorithm is a step-wise method which always gives a precise answer, a *heuristic* is a rule of thumb, a *general principle* used in reasoning processes. Whereas the former are expected to be incapable of error and therefore infallible, the latter are able to provide good, sometimes even optimal solutions.

Heuristics are increasingly being used for *complex problems* especially where variables are interdependent, problems are ill-defined and they have politically determined goals. Their *aim* is to reduce the expenditure associated with the construction and use of an algorithm by taking into account that alternatives which have been ruled out as of minor relevance are disregarded during the solution process.

6.1 Segmentation

The significance of differentiating between internal and external strategic analysis has been discussed in chapter 2.2. By applying an additional criterion, the *success profile* [BIRC88 20-24] identifies four distinctive areas of strategic concern:

- *Market, Customer, Competition* (external factors, people-oriented)
- *Product, Services* (external factors, technically-oriented)
- *Activities, Processes, Systems* (internal factors, technically-oriented)
- *Organisation, Management, Personnel* (internal factors, people-oriented).

This structure has been successfully used in strategic projects, and is based on the assumption that the good performance of an organisation is linked to a number of *distinct factors* which are commercially appreciated by the customer or which contribute towards an unique professional standing in the market place. Each area covers qualities which are of potential importance within the company and industry. By asking planning participants to evaluate the criteria in respect to their company's competitive position, the resulting *current and future success profile* indicates primary needs for further development or points out divergent views across functions or management levels.

Importance (in points)	**current/future**		**current/future**
Market, Customer		***Product, Services***	
good market contacts	70 / 100	complete product range	20 / 15
good image	35 / 26	niche products	5 / 12
commercial awareness	12 / 5	*good product quality*	60 / 42
favour. competitive behaviour	18 / 15	for-/backward integration	- / -
adequate pricing policy	25 / -	highly innovative	5 / 8
high regional market share	22 / 5	short idea-to-market cycles	- / 4
Organisation, Management		***Activities, Processes***	
good management systems	25 / 45	flexibility regarding capacity	5 / 8
efficient administration	- / -	strong financial basis	33 / 20
high staff motivation	48 / 52	*cost-effective production*	44 / 53
strong leadership	33 / 28	availability of resources	12 / 46
decentralised organisation	40 / 15	qualified personnel	26 / 24
use of synergies	3 / 22	adequate technology	12 / 10

Figure 6.a: Strategic Success Profile: Criteria of QuarryCon Ltd

Figure 6.a shows the criteria used in the case of QuarryCon Ltd. Assessed by top managers the success factors were seen in good market contacts, cost-effective production, product quality and staff motivation. Based on their successful standing in the market, the common understanding was to pursue these competencies further.

Due to its effective support in the analysis stage, the four areas have also been adopted to host the four classes which are used for the company's segmentation, namely Market, Product, Organisation, and Activity [1)] (see also figure 5.a). Each class represents a strict hierarchy of user-defined planning objects with the respective class name also acting as the top object.

6.1.1 Basic Objects

or: Which are the relevant Planning Segments?

■ Organisation

Describing the legal and organisational layout of an individual company, the class Organisation represents the holding and its stakes, divisions and subsidiaries, locations, plants and important outlets. All objects are distinct areas of responsibility within a company, usually shown in an organisational chart and considered in the actual structure of the information and reporting system (example in figure 6.e). However, all organisations are different and the actual layout seldom reflects the level of differentiation needed to conduct fruitful strategic analysis or development. To overcome this problem, other segmentation techniques have been suggested and are the foundation for creating the three classes Activity, Market and Product.

■ Activities

To further structure a company by concentrating on its activities, Porter introduced the *value chain analysis* [PORT85]. This technique helps to identify the competitive performance and the company's capabilities. It concentrates on the *value* which a customer is prepared to pay for the product or service.

1) Sans Serif Text denotes classes or their objects, e.g. Market, Public Authorities
'Sans Serif in Quotes' denotes attributes or their input values, e.g. 'Relevance', 'Off'

The objective of a strategy is to create a value which leaves, after deduction of the costs incurred, a satisfactory *margin*. The costs embody all value-adding activities absorbed so far and the *value system*, as a result, reflects success and failure of the past strategy, and the current and potential sources of *differentiation* in relation to the competitive offerings. *Value activities* are performed inside and outside the organisation. Therefore, the intrinsic value system has to be seen in a wider context, and the analysis has to incorporate activities carried out by suppliers, contractors, channels or customers as well.

In assisting these process, Porter provides a conceptual framework, the *value chain* (Figure 6.b), to segment a company's value system according to two broad types: primary and support. Using this framework, value analysis identifies where and how a company adds value, how competitors differ and where additional, commercially viable, value could be created. The *primary activities* are subdivided into five generic categories:

- *Inbound Logistics*: reception, storage, distributing of inputs to the product
- *Operations*: the transformation of those inputs into the final product
- *Outbound Logistics*: collection, storage, distribution of products to customers
- *Marketing/Sales*: persuasion of customers to buy, the infrastructure to do so
- *Service*: the efforts to enhance or maintain the value of the product.

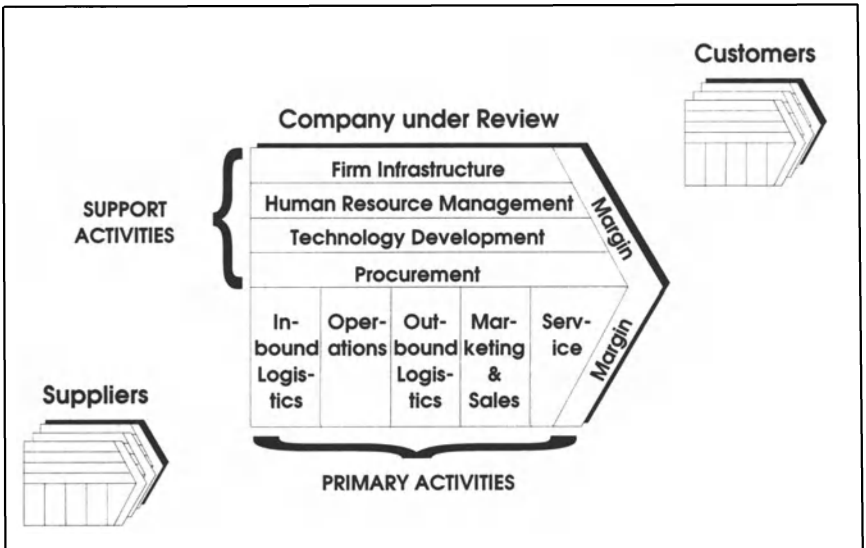


Figure 6.b: The Generic Value Chain [PORT85 37]

The *support activities* are subdivided into four generic categories:

- *Procurement*: processes to acquire various resource inputs for the activities
- *Technology Development*: the know-how and equipment applied to products, processes and resources in order to perform the activities
- *Human Resource Management*: finding, training and keeping of personnel
- *Firm Infrastructure*: the systems employed for planning, designing, financing, performing, documenting, controlling and improving the activities including general, quality and relation management.

The *pinpointing and classification process* has to concentrate on those value activities which are quite distinct, having different economies and representing significant cost centers within the business unit. In strategic terms it is important to distinguish between necessary and discretionary activities. While the former establish the basic functionalities of the product, the latter are responsible for the specific features of the product in the market and may offer the opportunities for differentiation.

Value activities can be direct (e.g. assembly), indirect (e.g. scheduling) or quality-related (e.g. testing, reworking). To carry out the *cost analysis*, the respective operating costs and the appropriate charges for the assets utilised should be assigned to them. Figure 6.c shows an example of a resulting cost distribution.

„One of the key aspects of value chain analysis is the recognition that organisations are much more than a random collection of machines, money and people" [JOHN89 89]. Hence, it is important to investigate the *linkages* between interdependent activities to ensure the proper co-ordination and optimisation of the resources utilised.

By comparing an organisation's linkages, primary and support activities with those of the competition, *differences* become apparent even between enterprises serving the same market with the same range of products. The information gained will indicate different approaches to meet the customers' needs and differing proportions of emphasis and costs spent. Reviewing these variations in light of their market success will help to identify areas of strengths and weaknesses and to exploit opportunities by strategy adjustments.

Value chain analysis can also play a valuable role in designing the *organisational structure* which balances the benefits of separation and integration. Since departmental boundaries are often not drawn around the most suitable clusters of activities, the analytical efforts are impeded and time and money might be wasted.

However, as the last paragraph implies, existing organisational structures and accounting systems are usually not structured according to value activities. Consequently, the corresponding analyses are not easily to obtain and require considerable expenditures, even when carried out on an ad hoc basis.

By considering activities, *Meta-Planner* offers the chance to systematically incorporate these analytical technique not only based on the historical (strategically structured) data but also in respect to future targets to be set.

The class Activity can include as a starting point the generic primary and support activities as defined by Porter (example in figure 6.e), but has to be further refined. „The appropriate level of *disaggregation* depends on the economics of the activities and the purposes for which the value chain is being analysed." However, value activity labels are „arbitrary, and should be chosen to provide the best insight into the business" [PORT85 45,48].

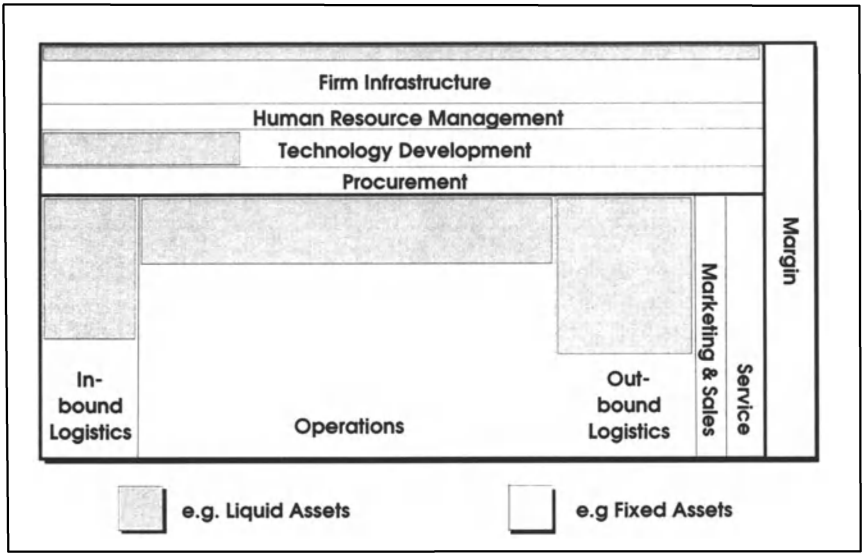


Figure 6.c: Value Analysis for the Distribution of Operating Costs or Assets [PORT85 69]

■ Market and Products

The concept of the *strategic business units* (*SBU*) has been briefly discussed in chapter 2.2.2. As an *core element* of strategic management, it is „an operating division of a firm which serves a distinct product/market segment or a well-defined set of customers or a geographic area." [GLUE86 5]. Because existing structures usually do not correspond to the this concept, the organisation has to be creatively segmented to provide the basis for strategic analysis and development.

Because strategic business units describe businesses the company is already in, Ansoff introduced the term *strategic business area* (SBA) which additionally covers businesses it could be in [ANSO84 37]. The latter are the origins of opportunities to grow and diversify and not to be left out during strategy analysis, development and, consequently, modelling.

But defining what markets, products, customers, responsibilities, etceteras, constitute a *strategic business area* can still be a difficult task. According to Abell, a *product* should be considered as a „physical manifestation of the application of a particular technology to the satisfaction of a particular function for a particular customer group" [ABEL79 170]. Accordingly, the *scope* of a business may be defined in the following three dimensions:

- Who or where is the addressee? (*customer groups, market geography*)
  To pinpoint the relevant consumers or industrial customers, it is necessary to establish their identity, which can be linked to geography, demography, socio-economic class, industrial segment, size, ownership, distribution channel, and so on.

- What demands are being served? (*customer functions, market needs*)
  Products and services perform certain functions and satisfy specific needs in the customers' view. Consequently, they may be described by their distinctive attributes or benefits offered.
  e.g. transport by taxi, bus, ship, ... is a function of speed, price, comfort, etc.

- How are these needs being satisfied? (*product/service technology*)
  A function can be performed by different problem solutions. Some of the alternatives might only become important if environmental factors change (oil price for energy consumption) or might become obsolete and are substituted by others (wet or electric shavers instead of razor blades).

By adding the competitors' businesses to the resulting three-dimensional grid (figure 6.d), the focus of the current or potential activities can be analysed and defined. Depending on the required level of fine-tuning, the dimensions can be differentiated by further subdivision. Thus, each element of the matrix can be characterised by its own set of *market attributes* (e.g. competitors, growth rates, market share, profitability, entry barriers) and, ideally, by distinctive *success factors* (e.g. buying or cost behaviour, access to information).

To evaluate and visualise the particular findings, portfolio-diagrams, success or SWOT-profiles can be applied as for strategic business units. In fact, in order to ensure strategic learning and evolution, the *responsibility* for the selection and monitoring of strategic business areas, the development of competitive products and marketing strategies is usually assigned to the respective business unit.

In answering the question of the *segmentation detail* advisable, Ansoff offers the recommendation that „the segmentation process must identify a large enough number of significantly different combinations [of business attributes] to permit management to make meaningful competitive and strategic resource allocation decisions. On the other hand, the number of strategic business areas must be small enough to keep strategic decisions comprehensible and manageable" [ANSO84 44].

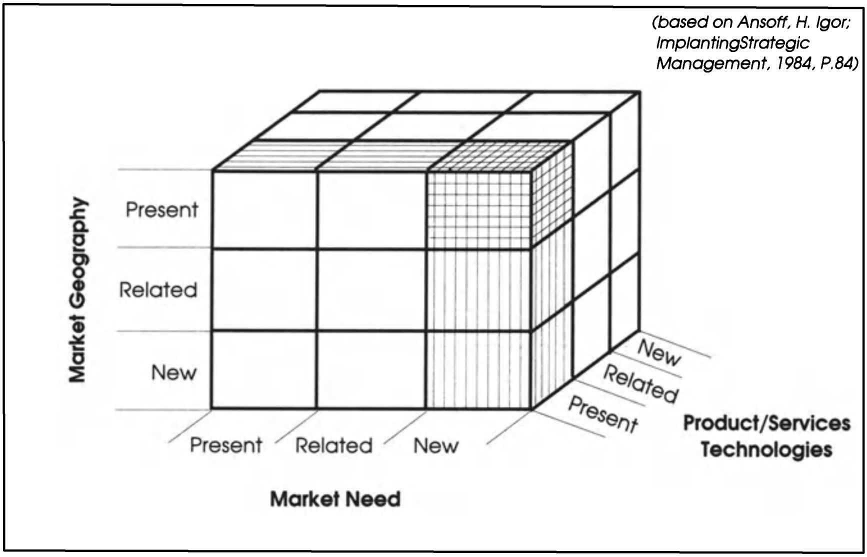


Figure 6.d: Segmentation [ANSO88 84]

Meta-Planner makes use of two classes to represent the above segmentation criteria. The class Market allows the specification of planning objects representing customer groups, regions or distribution channels. The class Product serves to define product functions, customer needs or product/service technology. Figure 6.e exemplifies the application of the hierarchical segmentation structures using an excerpt from the QuarryCon Ltd case study.

The design and running of a planning model requires a considerable amount of input data. In particular in respect to the market-product-segmentation, it has to be said, that not all of these data constitutes *additional data requirements*. A large fraction has to be gathered and processed anyway to provide the data for the methods and tools used to support the qualitative strategic analysis. The discussion of strategic management concepts (chapter 2.2.2) has shown that even the *qualitative assessment* of business units, experience curves, portfolios, or life cycles requires quantitative historic figures and planned estimates, including market share and growth rates, revenues or cash flows.

Organisation	**Activities**	**Market**	**Product**
Holding	Primary Activities	Public Authorities	Quarry
Sub Quarry 1	Inbound Logistics	Federal Authorities	Crushed Products
Plant A	Operations	Regional Authorities	Unbroken Material
Plant B	Outbound Logistics	Communities	Rubble Products
...	Marketing, Sales	Public Sector	Broken Products
Sub Quarry 2	Service	Federal Railways	Gravel
...	Support Activities	Federal Post Office	Mixed Products
Sub Construction 1	Procurement	Others	Bitumen
Sub Construction 2	Human Resources	Private Sector	Concrete
...	Techn. Developmt.	Civil Engineering	Construction
Sub Spec.Products	Quality Managemt.	Own Enterprises	Merchandise
	Firm Infrastructure	Other Enterprises	Others
	External Resources	Building Constructn.	Recycling
	Transport Services	Industry	Services
Sub = Subsidiary		Other Customers	...

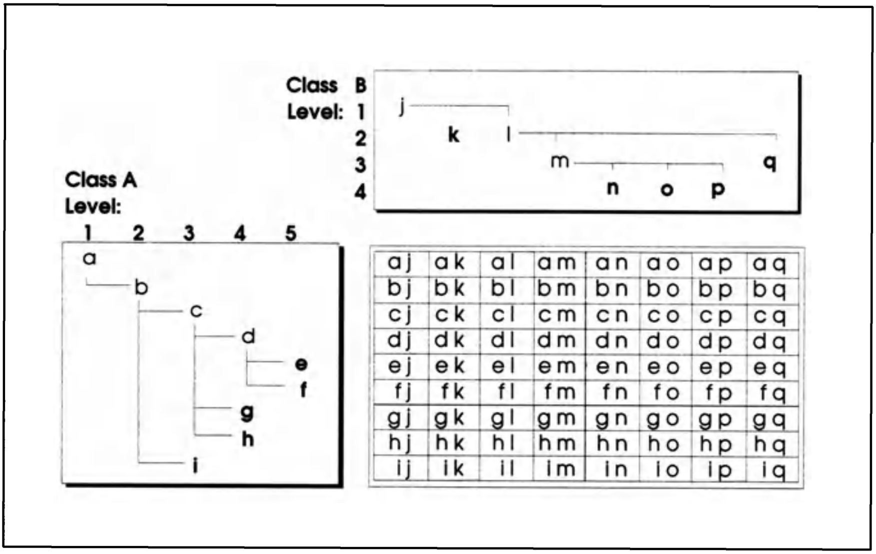
Figure 6.e: Segmentation Structure of QuarryCon Ltd (excerpt)

6.1.2 Relationships

or: What Degree of Differentiation is needed?

The objective of segmentation is to determine *areas of accountability*. Based on the object classes discussed, ancillary objects can be established which account for the processes and their resource consumption as described by the model variables. Each object denotes a specific *Market-Product-Organisation-Activity-combination* and is assigned to a specific class called Center (of responsibility). Thus, all potentially relevant centers are elements of a four-dimensional matrix, whose axes represent the defined objects of the classes Market, Product, Organisation, and Activity. Since the matrix can be derived from the input already given, the elements do not need to be explicitly specified.

Figure 6.f demonstrates the basic principle by using only two dimensions. The combination (cross product) of 5level-9object-class A with 4level-8object-class B results in 9x8=72 potentially important responsibility centers. As can be seen from the numeration, the existing parent-child-relationships of the dimensions (*strict hierarchy*) is also handed down to the dependent matrix-elements, which now have n predecessors (*multiple hierarchy*, where n is the number of dimensions).



aj	ak	al	am	an	ao	ap	aq
bj	bk	bl	bm	bn	bo	bp	bq
cj	ck	cl	cm	cn	co	cp	cq
dj	dk	dl	dm	dn	do	dp	dq
ej	ek	el	em	en	eo	ep	eq
fj	fk	fl	fm	fn	fo	fp	fq
gj	gk	gl	gm	gn	go	gp	gq
hj	hk	hl	hm	hn	ho	hp	hq
ij	ik	il	im	in	io	ip	iq

Figure 6.f: Responsibility Center (abstract example with only 2 dimensions)

6.2 Information Sources

6.2.1 Basic Objects

or: Who or what are the important Sources of Information?

Both the development and subsequent use of the envisaged model demand interaction with distinctive know-how and power brokers in a company. Yet, data may be collected not only from *undocumented* (people in and outside the company) but also from *documented sources* (market study, publications, databases, maps, organisation charts, cost reports, etc.). In order to execute the planning cycle, the documentation of the planning concept has to detail the participants and sources responsible for the provision of specific data requirements. Available information sources should therefore be considered and documented during the meta-planning stage. *Meta-Planner* takes this need into account by providing the autonomous class Informants to specify the relevant planning objects.

6.2.2 Relationships

or: Which Data Needs are covered by them?

In order to assure the timely and correct running of the model as early as possible, the significance of these informants concerning the *availability of data* has to be taken into account. Since the detection of *information gaps* and *individual burdens* (of participants in the planning cycle) can be a very important factor in the design decisions to be taken, *Meta-Planner* provides the means of linking Informants to individual objects of the *segmentation structure* (Market, Product, Organisation, Activity).

Rather than establishing precise data-participant-assignments (as required for the planning cycle), the focus is to identify useful areas of expertise within and outside the company. *Meta-Planner* provides the autonomous class Competence Area to record this *segment-related know-how* of particular *informants.* The respective links have to be explicitly specified by the user and can be further qualified by estimates of an individual's specific contribution. Together with the availability of the source, a base is established for the *systematic screening* of information sources.

6.3 Variables

6.3.1 Basic Objects

or: Which are the Ratios of Interest?

Variables and their relationships are the basic building blocks of the model, and form the *model logic*. Their elementary part has been already discussed under the topics 'Variable Structure' (chapter 3.3.3), 'Reporting' (chapter 3.3.4) and 'Application History' (chapter 3.4). Their role in the operative production and accounting systems is the:

- systematic, complete *documentation* of all numerically accountable events
- *management of operations* and *financial measures* to achieve efficiency
- provision of periodic *performance* reports for planning, controlling and disclosure.

In comparison with the detailed structure of these systems, strategic planning models have to operate at a *much more aggregated level* due to the uncertainty of forecasts and the efficient use of company resources. Additionally, they might have to facilitate *new strategic views* of the data which might not yet have been represented at all.

Some of these views can be the result of a *segmentation process* as described in chapter 6.2.1, which leads to an extended horizontal model structure (chapter 3.3.2). Another strategically relevant approach is to expand the vertical structure by adding non-financial variables in order to incorporate activity-based costing approaches.

The philosophy of *activity-based costing* (*ABC*), a heuristic developed by Johnson, Kaplan and Cooper [JOHN92, COOP91], postulates that all activities in a company exist to support the production and distribution of products and services, and should be allocated accordingly. In modern industry, direct costs often represent a relatively small proportion of the total corporate expenses. *Traditional accounting systems*, however, may still allocate the fixed overheads by burden rates which correlate with output volume. Although the bottom-line financial performance of the company is not affected, costs calculations concerning individual products can be distorted.

„By using *cost drivers* triggered by units of output (e.g. direct labour hours or machine hours) to allocate overhead triggered by batches and product lines, companies systematically *undercost* the low-volume products that have tended to cause most overhead growth in recent years, and they systematically *overcost* high-volume products that tend not to cause overhead to grow" [JOHN92 143].

In particular in the case of proliferated product lines and marketing channels, reports fall short in providing management with the proper information for strategic decisions. Case studies supplied by the authors demonstrate, that as *product diversity* increases, *overhead costs* correlate less and less with physical volume.

In regarding overhead expenses as variable and driven by something other than the number of units, the first step of the ABC-process requires the *determination of the main activities* (quality control, purchasing, despatching, etc.) and their related personnel and material costs. After *identifying their influencing cost drivers* (set-up times, number of orders, etc.), these costs can be, in proportion to the driver-specific demands, *assigned to the categories of interest* (product, customer, region, location, channel, etc.).

In introducing a new structure compared to the traditional accounting system, and in making deliberate *trade-offs between speed of analysis and cost allocation accuracy*, ABC represents a powerful heuristic, which was summarised by its creators as follows: „It is better to be basically correct with ABC, say within 5 or 10% ..., than to be precisely wrong using outdated allocation techniques" [ARMS93 302].

The example below (figure 6.g) states a result which would not have shown up in a traditional accounting system. Setting the cumulative percentage of annual profits against the percentage of customers ranked by profitability, it can be seen, that in fact a profit 2.5 times as high as the one reported (=100%) could have been achieved by not serving approximately 30% of the customers. As the analysis shows, these customers have been unprofitable for the period under review.

Apart from measuring costs, ABC also measures *consumption of resources* and seeks to establish a *linkage between demands and resource spending*. Consequently, it can assist management in determining those entities of a category which are (not) adding value in order to strengthen, transform or eliminate the respective parts of the business. In this way, ABC provides a systematic method to reveal hidden profits and losses, and to improve cost management.

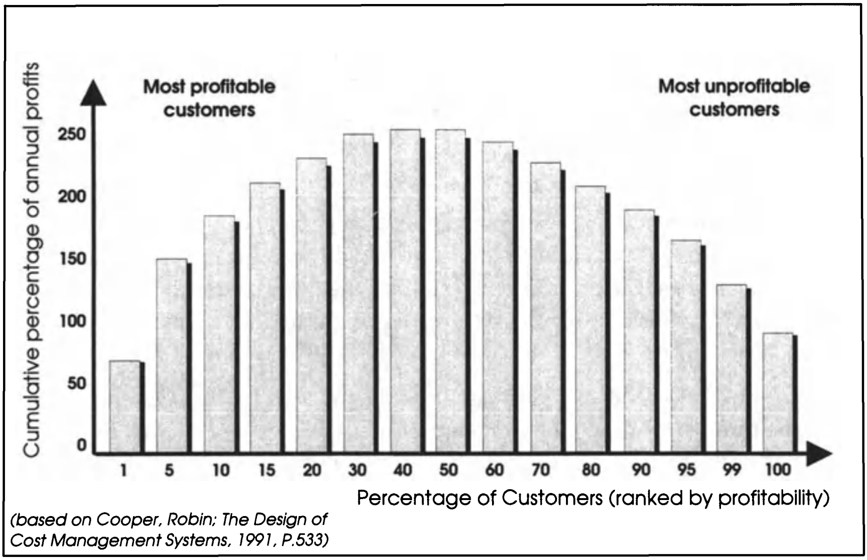


Figure 6.g: Activity-based Costing: Cumulative Profitability by Customers [COOP91 533]

In *strategic terms*, it offers support to select the most profitable business areas and to develop better structured activities. One of the remedies for improving a unsatisfactory situation is to reduce the quantity associated with particular cost drivers, another is to find ways to lessen the specific expenditure per cost driver. Hence, these ratios can become *cornerstones* in the development and controlling of strategies.

When considering the *cost behaviour of particular expenditures* during strategic modelling (categories suggested by Ames/Hlavacek are, for example, bedrock fixed, managed fixed, direct variable and shared [AMES90]), one has also to bear in mind, that all costs are variable in the long run. To support the definition of equations, the class Variable, therefore, is partitioned in a different way (examples relating to the case study are given in figure 6.h):

- Financial State Variables: assets, liabilities, etc.
- Financial Flow Variables: revenues, expenditures, etc.
- Non-financial State Variables: capacity, potential, etc.
- Non-financial Flow Variables: sales volumes, consumption, etc.
- Special Ratios: e.g. value added = sales - costs of goods/services

Financial State Var.	Financial Flow Var.	Non-fin. State Var.	Non-fin. Flow Var.
Assets	***Revenues***	***Potentials***	***Sales Volumes***
Fixed Assets	Sales, total	Duration of Deposits	Sales Volume, tons
Tangible Assets	Sales, external	Stone Deposits, tons	Recycled Volume, t
Land and Buildings	Sales, internal	Dumping Volume, m^3	Dumping Service, m^3
Plant, Machinery	Sales, other		
Intangible Assets	Work capitalised		
Financial Assets	Other Oper. Income		
Current Assets	Non-oper. Revenues		
Stocks	Financial Result		
Debtors	Interest received		
Liabilities	***Expenditures***	***Capacities***	***Consumption***
Capital and Reserves	Material Costs	Personnel	Pollution, tons
Subscribed Capital	Raw Materials	Executives	Oil-related products
Provisions	Consumables	Salary Worker	Energy used, kWatt
Creditors	Other ext. Charges	Labour Force	
Trade Creditors	Interest payable	Potential Output	
Loans	Tax on Profit or Loss		
Financing Requiremt.	Dividends		

Figure 6.h: Structure of Variable in QuarryCon Ltd Case Study (excerpt)

6.3.2 Relationships

or: How and where do the variables have to be planned?

Equations are the *mathematical representation of relationships* between the company-specific variables of interest. Whereas chapter 3.3.2 and 3.3.3 illustrated the types and differentiation of variables in a model, the concepts discussed in chapter 6.2 concentrated on the strategic issues which should expressed by them and their relationships, and defined the segmental object classes used in *Meta-Planner*. The following section focuses on the *technical aspects* of how to link the individual objects specified (financial and non-financial state and flow variables, special ratios) in order to establish the equations of the model.

■ Additive Relationships of Variables

The conceptual framework forces the input of state and flow variables in a parent-child-relationship. Due to this strict hierarchical structure, most of the additive relationships of the variables are defined simultaneously with their input by the user. To define further links or other arithmetic relations, the class Special Ratios allows the specification of objects which can be defined using any of the, by then, available Variables (including those of the class Special Ratios). These type of relationships (e.g. levels of contribution or profit and loss) cannot be defined implicitly within the tree structures, so that their calculation procedures have to be explicitly defined.

■ Complex Relationships of Variables and Time Shifts

Complex relationships cover the wide area of management ratios (figure 3.j). *Ratios* are an effective way of obtaining insights into a company's operations and performance and of drawing parallels to other time periods, units or competitors.

Instead of leaving these modelling issues fully to the planner, *Meta-Planner* provides *'templates'* to define the respective dependencies more easily. These technical aids focus on relationships which are expressed as a proportion between two quantities, since the resulting ratios can also be used as an alternative user-friendly input method (e.g. growth or cost-of-sales percentages).

Ratios expressed by three or more variables have to be defined using intermediate steps or as an addendum in form of comments. They represent additional result variables which bear no influence on the data requirements of the model (provided that the subvariables are already defined), and, therefore, need not to be considered for the model design optimisation by *Meta-Planner.*

Irrespective of the type (state or flow), the template is applicable for any variable and opens the following options for defining its particular relationships and ratios:

- *Δ Growth Rate (absolute)* is calculated as the absolute difference between two successive time periods
- *Δ Growth Rate (%)* is calculated as the percentage increase between two successive time periods
- *Relation* is calculated as a proportion in respect to another variable which has to be defined by the user
- *Value per Unit* is the result of dividing the variable under review by another variable which has to be defined by the user and represents a quantity
- *Growth per unit (%)* is calculated as the percentage increase of the *Value per Unit* ratio between two successive time periods.

	Financial Variable		Non-financial Variable	
Flow Variables				
object name	Revenues	($)	Man-hours needed	(hours)
Δ growth rate, abs.	*Δ Revenues*	($)	Δ *Man-hours needed*	(hours)
Δ growth rate, %	*Δ Revenues*	(%)	Δ *Man-hours needed*	(%)
relation	*Market Share* [1]	(%)	*Productivity* [5]	(hours/ton)
value per unit	*Price* [2]	($/ton)	*Yearly Working Time* [6]	(hours)
growth per unit, %	*Inflation Rate*	(%)	*Labour Time Variance*	(%)
State Variables				
object name	Stock	($)	Labour Force	(persons)
Δ growth rate, abs.	*Δ Stock* [X]	($)	*Δ Labour Fluctuation* [Y]	(persons)
Δ growth rate, %	*Δ Stock*	(%)	*Δ Labour Fluctuation*	(%)
relation	*Stock Turnover* [3]	(%)	*Productivity* [7]	(persons/ton)
value per unit	*Production Costs* [4]	($/ton)	*Yearly Working Time* [8]	(hours)
growth per unit, %	*Inflation Rate*	(%)	*Labour Time Variance*	(%)

Links to variables:

1) *Market Volume in $*
2) *Sales Volume in tons*
3) *Sales Volume in $*
4) *Stock in tons*
5) *Production Volume in tons*
6) *Total Man-hours needed in hours*
7) *Production Volume in tons*
8) *Total Man-hours needed in hours*

X) *+ Production in Costs*
- Sales in Costs
- Valuation Adjustments

Y) *+ Employees hired in persons*
- Terminations in persons

Δ=delta: absolute or percentage difference in comparison to previous time period
x and y: in case of state variables, absolute growth can be specified by more than one subvariable to consider individual increments and decrements

Figure 6.i: Built-in Relationships of State and Flow Variables

Whereas the first two options are always active, the *Relation* and *Value per Unit* ratios are only activated with the specification of the corresponding variable by the planner. Each active ratio has a unique name which can be customised by the user. Figure 6.i demonstrates the application of the template method by giving examples for each of the four variable types. The use of these template structures adds distinctive advantages to all phases of the modelling process:

- During *model configuration* they provide an easy way to link and document complex relationships (e.g. variable cost dependency) in a transparent way
- For *model programming* they allow specifying the model equation in a concise form. Ratios can be implemented by just attaching the respective names to their basic variables, since the standardised calculation procedures can be stored in subroutines which are generally applicable
- For *data gathering* they allow specifying alternative input values. Apart from the absolute values of the basic variable under review, all activated 'template' ratios can also be used to detail the expected projections. Participants in the planning cycle are no longer forced to sit down with their calculators in order to compute the required input formats. Since all ratios are applied prior to the planning cycle to the historic figures, additional information support the participants in making sound judgements concerning the envisaged planning periods.
- For *model execution* they allow the intelligent handling of the model. According to the input figures provided, the subroutines are able to restructure the equations. In case of multiple conflicting inputs, procedural preferences correct the data transparently to the data provider. In case of missing input values, 'zero change rate defaults' enable the status-quo projections of absolute values, relations or values per unit (depending on the valid relationships and preferences specified).

■ Horizontal Structure and Consolidation

In order to establish the horizontal structure, the planner will have to explicitly link Variables to the particular segments of interest. These segments are represented by specific cells within a market-product-organisation-activity matrix, and termed Center (chapter 6.2.2). Since each of these relationships is based on the basic planning objects, the strict hierarchies of these objects also define the additive equations needed for consolidation purposes, namely:

- consolidation of input or variables derived otherwise within a given Center e.g. executives + salary worker + labour force = personnel
- consolidation of the results in respect to the legal structure (Organisation) e.g. SUM [personnel of all organisational units] = personnel of the company
- consolidation in respect to the strategic structure (Market, Product, Activity) e.g. personnel primary activities + personnel support activities = personnel.

6.4 Attributes

The *objects* in a *class* share particular properties or *attributes*. Each attribute has a *data type* (e.g. string, boolean) which defines the format of its value. In a knowledge based system, the *value* which describes the attribute of a specific object is stored in a so-called slot. The object Fixed Assets, for example, belongs to the class Financial State Variables. The attribute 'Amount' is linked to this class and has the data type numeric. The value '60.4 mioDM' is assigned to the slot Fixed Assets. 'Amount'.

Attributes shared by all objects are the 'Name', an 'Alias' (e.g. German translation) and 'Notes'. Whereas the name of basic objects have to be defined by the user in a unique way, the names of the complex objects are derived from their parents. As in the example above, some classes/objects can be further qualified by attributes of string or numerical data type. 'Competence Factors' for Competence Areas, 'Costs' and 'Sales' for Center, and 'Amount' for Variables require the specification of current values or estimates. These figures are not needed by the inference process of the knowledge based system but force the planner timely to consider the data availability in respect to the later planning cycle.

■ Activation

An important attribute shared by all objects and classes is the *activation parameter*. Since the specification and linking of many planning objects result in numerous *interdependencies* and a *complex network*, it is vital to clearly qualify those elements which constitute the actual layout of the envisaged planning model at every step of the meta-planning process.

The data type of the activation parameter is boolean, and if set to 'On' the particular planning object is an active element within the subset of the company's envisaged model design. During meta-planning, the object-specific settings can be changed, explicitly by the user or as a consequence of accepted proposals by the inference engine of the knowledge based system. In an iterative process, objects join and leave the subset continuously until the user or system is satisfied with the resulting model layout.

However, activations have to be seen within the hierarchical context of the conceptual framework. Hence, parameters of parent objects can supersede settings of individual child objects. These dependencies are detailed in *decision tables* (figure 6.j).

Activation of Parent Objects	all On	all On	not all On	not all On
Activation Setting of Child Object	On	Off	On	Off
Resulting Activation Child Object	On	Off	Off	Off

Figure 6.j: Decision Table for the Determination of Activation Parameter

■ Evaluation

The success of strategic modelling depends on an appropriate balance between simplification and representation of a real world situation and will be judged not only by the expenditures necessary (data requirements) but also by the ability to mirror strategies at different levels and to provide additional valuable information.

In order to improve the configuration of a model layout by including (removing) the most (least) suitable elements, the planning objects have to be evaluated by the planner. The objective is to point out the most favourable or critical factors in respect to the strategies' deployment and success.

External factor analysis, for example, has to highlight the outstanding market potentials, the most competitive products, the key technologies available or aspired to, the most acknowledged customer values provided or the commercially most viable services, channels, references, etc.. Internal assessment has to emphasise those distinct activities and resources which contribute or are most likely to contribute to the companies' success in the market place. It also has to earmark potential risks or constraints, critical bottlenecks, notorious areas of under-performance, and the most promising sectors of cost or process improvements.

To allow for these considerations, another common object-specific attribute is the 'Strategic Relevance', a numerical evaluation parameter which depicts the outcome of a scoring method based on the following criteria/subattributes:

- 'Status' denotes the strategic importance of a particular basic planning object at this moment in time
- 'Potential' denotes the strategic importance of a particular basic planning object expected in the future
- 'Feasibility' denotes the availability/costs/certainty associated with satisfying the data needs of particular basic planning objects.

6.5 Methods applied

6.5.1 Multiple criteria decision making

Multiple criteria decision making (MCDM) provides methodologies to support the *evaluation of alternative problem solutions.* The area of application can be characterised by the presence of usually conflicting multiple objectives which are measured by different units and criteria. When the value of the criteria can be marked with figures, a *model-based approach* can be used which requires an explicit normalisation, the quantification of the value structure and the evaluation of the competing alternatives [KO88 35].

As discussed in the previous chapter, the evaluation of *strategic relevances* by the planner provides a measure for the system to (de-)select objects for the model configuration process. In order to comply with this objective, the *strategic relevance* has to be object-specific and to reflect a number of numerical and non-numerical aspects.

As some data underlying the evaluation process can be specified by input of current values or estimates ('Competence Factors', 'Costs/Revenues' for Market, Product, Organisation, Activity; 'Amounts' for Variable), other important information can be documented via object-specific comments, and might include the decline or rise of markets and technologies, chances for cost savings, bottlenecks or risks, and the practicability or effort to plan a particular entry.

Object:	Recycled Building Material			*(Product)* *Amount:* 0.4 mio DM (turnover)
Weight	*Attribute*	*Evaluation*	*Score*	*Notes*
(1/3)	Status:	27 points	9	high costs compared to production currently only a minor activity
(1/3)	Potential:	69 points	23	good for image, increasingly required in tenders for public sector projects
(1/3)	Feasibility:	90 points	30	share of recycled material for public road works will be approximately 40% volumes and costs are predictable
(1.0)	Strategic Relevance		62 points	

Figure 6.k: Scoring Method for estimating the Strategic Relevance of a Planning Object

In considering these aspects, the planner has to assess the basic objects according to their current 'Status', future 'Potential' and planning 'Feasibility'. Based on the resulting evaluation marks (as shown in figure 6.k on a scale from 0 to 100) and by using a scoring model with weight factors, the 'Relevance' is calculated.

Because of the combinatorial explosion caused by the multitude of potential relationships, differentiated evaluations are not carried out for complex objects which depict the relationships between basic objects (e.g. Center). Instead, the resulting criterion 'Strategic Relevance' is used directly.

However, the application of a multiple criteria decision making method to support the meta-planning process has to obey certain constraints which are caused by the hierarchical dependencies of the objects involved. A *constraint*, in knowledge based terminology, is a limitation on some concept. In this particular context, it restricts the range of values that a evaluation parameter can take during problem solving by complying to the following rules:

- the evaluation value of any particular basic planning object ('Status', 'Potential', 'Feasibility') can not be equal or higher than the *value* of its parent-object
- the evaluation value of any particular non-basic planning object ('Strategic Relevance') can not be equal or higher than the *combined value* of its parent-objects.

As a consequence, the method applied in *Meta-Planner* requires the specification of *relative evaluations instead of absolute values.* The data entry screens (figure 1.c, 1.d) provide four check boxes for the criteria permissible which allow distinctions between 'very high ++', 'high +', 'below average -' and 'low --'. By assigning numerical factors to these boxes (99%, 90%, 70%, 40%), the method selects the appropriate percentage factor and multiplies it with the respective evaluation score of its parent object. The processing, therefore, has to be conducted top-down to provide the values needed for the subordinate objects. The top objects of the basic object classes (Market, Product, Organisation, Activity, Variable) are named after their class and their non-changeable evaluation scores are set to 100.

The evaluation process has to be sufficiently detailed to reflect and document the different facets of design decisions. To maintain the model, this detail also allows following up on the subsequent changes caused by strategies ever adjusting to changing environments and organisational learning. Nevertheless, using knowledge based *inheritance* methods becomes vital for the workability of the system.

6.5.2 Inheritance

Inheritance is „the sharing of attributes and operations among classes based on a hierarchical relationship. ... The ability to factor out common properties of several classes into a common superclass and to inherit the properties from the superclass can greatly reduce repetition within designs and programs and is one of the main advantages of an object-oriented system." [RUMB91 3].

Meta-Planner greatly benefits from this design concept (chapter 8.3), but development and running of the system are differently affected by the fundamental *types of inheritance* which can occur. Whereas the first type stated below is beneficial for the user, the other three types offer advantages mainly for the application developer.

■ Values

In view of the numerous objects and their activation and evaluation, a reasonable *number of user interactions,* required from first input to first results, has to be assured. To accomplish this vital precondition for the acceptance of the system, *value inheritance* takes the edge off the bulk of input requirements.

- *Activation parameters* inherit the respective value of the parent objects.
  IF Parents are 'On' *AND Object is* 'On' *or not set THEN Object* = 'On'
  IF any Parent is 'Off' *OR Object is* 'Off' *THEN Object* = 'Off'

- *Evaluation parameters* inherit the combined value of the parent objects. If no object evaluation exists (constraint, chapter 6.5.1), the inherited value is multiplied by the factor '0.99'. This corresponds to an user evaluation of 'very high ++'.
  IF Parents are 'X' *AND Object is not set THEN Object* = 'X' * 99%
  IF Parents are 'X' *AND Object is* 'Y' *THEN Object* = 'X' * 'Y'

By initially defining only the objects and their relationships without any activation or evaluation, the user would, consequently, be confronted with a situation where all objects are activated and their evaluation criteria bear the highest scores. However, in de-activating and/or down-marking objects high up in the hierarchy, he immediately could *influence whole subsets of objects in the network* since inheritance takes place with every calculation anew. In this way, he can shape the subset for the envisaged model design with a confined number of interactions.

A consequence of this approach might be, on the other hand, that the system generates proposals which are based on inherited data which do not adequately represent the user's view and preferences. However, since the user does not have to agree with the stated recommendation, the proposal can be rejected. In this case, the activation states of the specific objects stay unchanged, but the evaluation parameters have to be modified accordingly.

This modification will, as any other selectively updated activation and evaluation parameter by the user at any time, cascade down the defined relationships and update any missing and dependent factors.

■ Attributes

Attributes are inherited from parent classes to child classes, and from classes to objects. Whenever a new subclass or object is added to a particular class, it *immediately* inherits all attributes of this class.

■ Methods

Methods are inherited when they are needed during processing and when there is no method directly attached to the object under review. Activation parameter and strategic relevance, for example, have to be calculated for all user-defined objects. Due to the either strict or multiple hierarchical relations, the procedures and decision tables differ. By linking the different methods to the appropriate classes, repetition during development is avoided, handling and documentation are eased due to uniform method names, and maintenance is developer-friendly.

■ Relationships

To estimate the data requirements of the current or envisaged model design, the model Atoms have to be analysed to determine their respective activation states. Additionally, it needs to be established, in which way the Variable under review can be planned within its local Center. Since all relevant Equations specified are inherited by the model Atoms, the system only has to check if any linked 'template' variables are also assigned and activated locally.

6.5.3 Heuristics

Activation parameter and evaluations help to classify and assess a multitude of objects. MCDM and inheritance methods provide the complete and consistent information base needed for a systematic meta-planning process. However, the immense *solution space* which is provoked by the combinatorial explosion of the numerous design options, can neither be managed by a manually-operated system nor by an algorithm. Consequently, a heuristic approach has to be adopted.

„*Heuristic thinking* does not necessarily proceed in a direct manner. It involves searching, relearning, evaluating, judging and then again searching, relearning and reappraisal as exploring and probing takes place. The knowledge gained from success or failure at some point is fed back and modifies the search process. More often than not, it is necessary to redefine either the objective or the problem, or to solve related or simplified problems before the primary can be solved" [ROWE93 111].

There is also „no universal method to develop the heuristics that may help us solve a given problem. How to develop heuristics is itself a heuristic. Typically, you may consider solving a problem by using the experience you may have gained from solving similar problems" [SHIN92 437]. In researching the subject, Rowe concludes that a logical approach [ROWE93 116] to heuristic rules incorporates:

- A classification scheme which introduces structure into a problem
- Analysis of the characteristics of the problem elements
- Rules for selecting elements from categories in order to achieve efficient search strategies
- Rules for successive selections, where required
- An objective function that is used to test the adequacy of the solution at each stage of selection or search.

„The Pareto Law provides a powerful approach to the first two steps in the development of heuristics by allowing the partitioning of problems that facilitate efficient search strategies" [ROWE93 116]. This empirical law was first used by the economist Vilfredo Pareto who showed in 1897 that the distribution of income is uneven; a large share of world income was held by a small population. Known also as the law of the trivial many and the critical few, this technique describes a common tendency for a relatively small proportion of items in a set to be really significant.

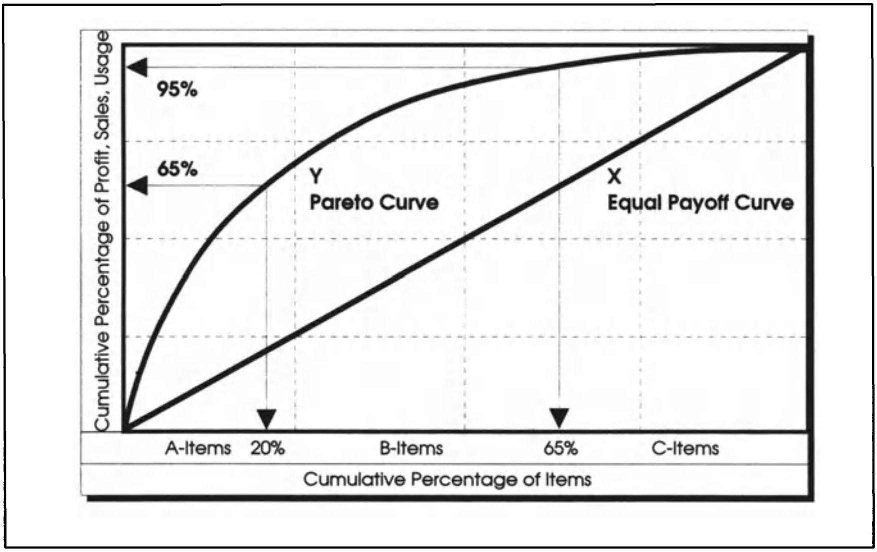


Figure 6.1: ABC Analysis for a Pareto Distribution

In management science it is also known as *ABC-Analysis* and used to identify the crucial A-area (e.g. 20%) of activities, products, customers, etc. on which management should concentrate its efforts to improve efficiency and performance. To deal with the less important entities (C-category) different policies can be adapted. Thus, efforts can be concentrated on areas where the highest returns are expected, and resources are not wasted by investing energies for insignificant benefits.

The first step of the method requires analysing the distribution of the entities according to the value of the chosen payoff they generate (e.g. benefit, cost, usage). The cumulative percentages of the payoffs are set against the cumulative percentage of the entities and can be illustrated in a *Pareto-Diagram* (figure 6.1). Curve X represents the equal payoff curve which indicates that all entities share the same payoff value; curve Y, on the other hand, shows that subsets of entities have a greater payoff than the respective remaining entities. The *Pareto distribution* can now be divided into categories (A, B, C) and different actions can be taken to deal with each category according to their relative significance.

Based on its impressive features, the Pareto analysis has also been applied to control the high number of planning objects and relationships and to help in making the right choices for the model configuration. By taking into account the strategic relevances and the different activation states, the traditional approach had to be adapted to fit the particular requirements of *Meta-Planner*, including the comparison of the different Pareto-distributions in respect to the current and envisaged planning model object sets (see chapter 7.3.5).

6.5.4 What-If Analysis

Decisions are based on predictions and assumptions. To draw the decision maker's attention to the factors which mostly influence the expected outcome, *what-if or sensitivity analyses* are used. These techniques apply alternative values for a predicted input figure and recalculate the consequences by taking each what-if? value in turn.

The changes of input values have an *impact on the results* under review. The bigger the impact, the more sensitive the input variable. Input with a high sensitivity must be accurately predicted and carefully controlled. Low sensitivity points to variables where prediction errors or insufficient control is of much less consequence. The business model (figure 6.m) exemplifies how sensitive six input variables are in respect to the discounted cash flow of a company over a five year period.

Similarly, the effects of *changing the activation parameters* in the model configuration process have to be analysed. In order to generate proposals for improving the model design, the sole consideration of strategic relevances is not sufficient. By adding or removing a given object at different times or different objects at a given time, the change in the resulting overall data requirements can vary extensively.

To take these complex dependencies into account, every iteration step in the configuration process has to be accompanied by a *what-if analysis*. Since a calculation of all alternatives is doomed to failure because of the processing time required, a *rule based approach* had to be devised which furnishes similar support (chapter 7.3.6).

In providing thorough estimates for the data needs and the consequences of design changes, *Meta-Planner* addresses the most *crucial handicap* of a manually conducted meta-planning exercise. It enables the planner to control differentiation effectively by combating high data need potentials resulting from inconsiderate global assignments of variables to planning units.

t	PERIOD	1	2	3	4	5
P	Price	1.20	1.32	1.45	1.60	1.76
M	Material Cost	0.60	0.65	0.70	0.76	0.82
C	Capital Expenditure	135.00	0.00	0.00	0.00	0.00
O	Overheads	30.00	31.80	33.71	35.73	37.87
V	Volume	150.00	154.50	159.13	163.91	168.83
W	% Working Capital	20.0%	19.8%	19.6%	19.4%	19.2%
PR	Profit	= (V*P) - V*M - O				
CF	Cash Flow	= PR - PR t-1 * 0.48 - C - (V*P*W- (V*P*W) t-1)				
IRR	Internal Rate of Return	= Discounted Cash Flow (CF)				

	Internal Rate of Return,	**=**	**27.3%**	**change abs.**	**change in %**
if	Price	+ 5% then	38.3%	+10.9	+40.0
if	Volume	+ 5% then	32.3%	+5.0	+18.2
if	Material Cost	+ 5% then	21.8%	-5.5	-20.2
if	Capital Expenditure	+ 5% then	24.3%	-3.1	-11.2
if	Overheads	+ 5% then	25.6%	-1.7	-6.2
if	% Working Capital	+ 5% then	26.2%	-1.1	-4.1

Figure 6.m: Sensitivity Analysis in Decision Support [FCS85 7.8-7.9]

6.6 Summary

Chapter 6 details the *important components* of the methodology without discussing the specific implementation issues associated. It focuses on classes, their attributes and relationships, and the methods applied to support the configuration process. In particular, it emphasises the underlying *principles of the classification system,* which support the strategic management concepts of success profile, segmentation, value chain analysis and activity-based costing. The combination of these methods for strategic modelling is often hindered by the then rapidly increasing data needs.

The *conceptual framework* of *Meta-Planner,* however, helps to set-up the company-specific conditions in a systematic way and allows assigning variables individually to specific planning units. Object hierarchies for variables, markets, products, organisational units, activities and informants enable a top-down configuration process and user-friendly definition of objects and their relationships. *Scoring models* and *inheritance methods* support the institution of a transparent and consistent database in order to control the multitude of planning objects and their activation and evaluation parameters. *Pareto and what-if analyses* provide the means to generate *proposals* by monitoring the specific strategic relevances and data requirements of the objects concerned.

7 System Design

Meta-Planner is a knowledge based system rooted in the generic category of construction. Since there is no pre-determined construction plan for the model layout and initially no discriminations against any constellations, its *objective* is to support a corporate planner or management consultant (1) to select, parametrize and assemble basic planning objects (2) from a set which has to be specified by the user (3) to result in a model layout for quantitative strategic planning (4) which fulfils the desired requirements regarding relevance and data needs.

Although the problem-solving sub-type *configuration* (chapter 4.3.1) best describes this aim, due to the heuristic approach of the problem solving process, some aspects of the related types assignment and planning also apply.

The desired solution provides an ordering plan between the set of available objects and the set of used objects in the current and the envisaged planning model. In contrast to the sub-type *assignment,* these sets are not disjunct but are formed by consideration of preferences, short resources and other restrictions. Similar to the sub-type *planning* the solution process requires the consecutive transformation of given states into desired states. But instead of taking into account scheduling options, it follows an one-step-at-a-time procedure. *Meta-Planner's* ways of handling matters, in this respect, can be compared with a *therapy process.*

Triggered by the observation of some unfavourable characteristics of a company's current planning system, the motivation is roused to streamline, enhance or newly develop a planning model. As a consequence, the *therapist* (planner) has to examine his *patient* (current planning or accounting model) to identify the *problems* (model conditions). To determine the *therapy* (meta-planning process), he has to analyse the available *remedies* (consideration of planning objects and relations) by taking into account their *effectiveness* (strategic relevance) and *side effects* (data needs).

In order to select and apply the most appropriate *therapeutical option* (potential action to change condition) he has to compare their *implications for the patient's state* (all resulting constellations of the objects = solution space). In an *iterative process,* favourable parameters are determined and incorporated into the therapy. By *monitoring* the respective new states, the process can be continued by opting for additional *medication* (configuration decision) until the therapist is satisfied with the *results* (blueprint of the envisaged planning model).

Because of this evolutionary nature of the model configuration, its meta-planning process has to be iterative and usually extends over a prolonged period of time. The tasks to be carried out are affected by

- a *problem area* which embodies the company-specific segmental, organisational, and accounting structure, whereby not all elementary and collective objects are known at the beginning of the exercise but also need to be newly determined and re-examined in collaboration with the planning participants concerned, e.g. due to additionally required or new levels of detail/abstraction
- *observations* regarding these objects, like unequivocal definition, accessibility or predictability of related data which require the participation of numerous know-how and power brokers in the company and might be controversial or time-dependent, e.g. due to personal views or mutations in the organisational structure and the company's environment
- *evaluations* of these objects regarding their relevance for the strategic planning process which are based on incomplete as well as on unreliable and changeable opinions, e.g. due to the time and cost constraints of the meta-planning phase, due to false or subjective beliefs of the numerous participants, and due to conflicting conceptions which have to be resolved in one way or another
- *consequences* of the model layout in respect to the subsequent planning cycle and strategic controlling process which require to analyse the data requirements resulting from the design decisions taken and their information sources in order to ensure the transparency, control and acceptance of the envisaged system.

How much these factors can render the design process more difficult, depends greatly on the particularities of the application environment. Company-specific characteristics like corporate culture, styles of leadership, level of decentralisation or the quality of the management systems are as influential in this respect as the planning skills within the organisation or the experience with and the prevailing belief in planners, planning and planning systems.

In the same way as the transition from verbal to mathematical models reduces the uncertainty of decisions and increases the objectivity of controls [HINT89a 32] in the area of strategic management, so the use of a tool like *Meta-Planner* furthers the transparency of model design decisions and gives planners and management an understanding of the reality aspired to and clarifies the scope for direction.

7.1 General Architecture

To serve this purpose and to facilitate the use in different organisations and branches (chapter 5.3.2), the general architecture (figure 7.a) features two types of *knowledge bases* and three components of a *control system shell*:

- *a generic knowledge base* to provide a generally applicable conceptual framework including the structure of classes and frames. It contains control knowledge (*meta-rules*), derivation knowledge (*rules, methods*) and factual knowledge (*facts*)
- *a case-specific knowledge base* to store case-dependent objects and attributes covering the user input, intermediate and final results (*factual knowledge*)
- *a knowledge acquisition component* to enter the domain-specific general expert knowledge to the generic knowledge base
- *an interactive communication component* to enable problem-oriented, user-friendly dialogues between planner and computer including the means to define and assess the case-specific planning objects and to react to the system's proposals
- *a problem solving component* which interprets the knowledge of the generic knowledge base to process the case-specific information for the model configuration.

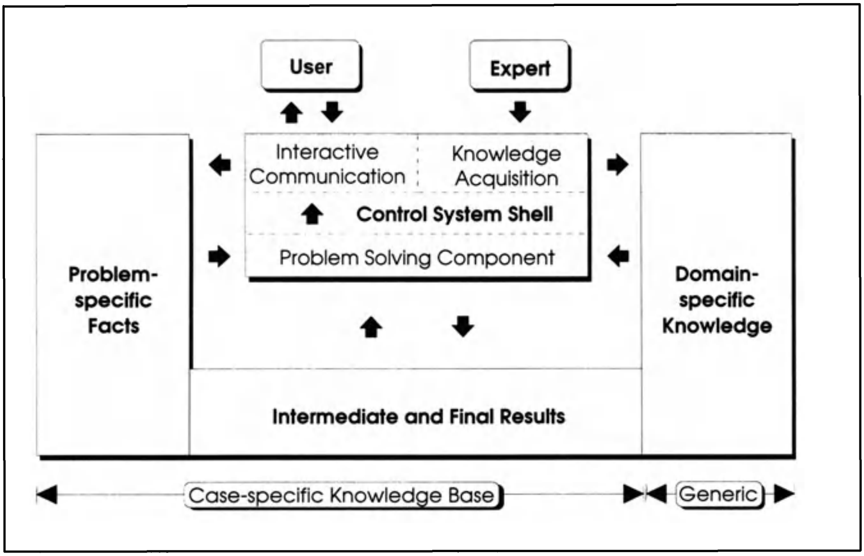


Figure 7.a: General Architecture of Meta-Planner (following Puppe [PUPP93 16])

7.2 Conceptual Framework

The *structural elements* of the conceptual framework were detailed in chapter 6. The following summary with additional definitions of some intermediate objects, details the mapping (figure 7.b) and provides a concise glossary for the subsequent, more technically oriented, explanations.

Basic planning objects are organised in strictly hierarchical tree structures where a successor has at most one predecessor. *Complex objects* are sparsely populated matrices which document the links of individual basic objects with each other or with the elements of the matrices. Due to this framework, strict and multiple hierarchies exist, where basic subobjects have exactly one parent object and individual matrix elements have two or more predecessors but no loops.

Figure 7.b shows the relationships between the basic and complex object classes. Basic objects are depicted as trees and complex objects as 2, 3, 4 or 5-dimensional cubes to represent the number of parent relationships.

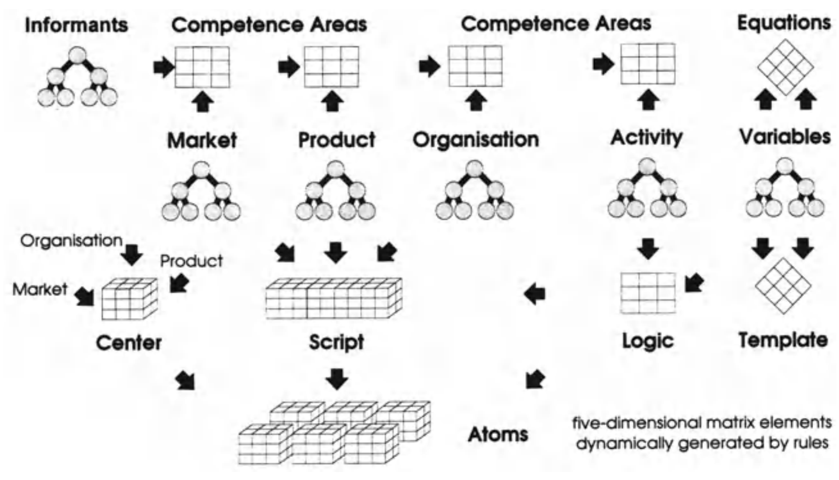


Figure 7.b: Mapping of the Conceptual Framework

■ Basic Planning Objects represented as tree structure

- Segments
  superclass of the objects Market, Product, Organisation, Activity (chapter 6.1.1)
- Market, e.g. industrial customers
  coverig customer groups or regions, distribution channels (chapter 6.1.1)
- Product, e.g. asphalt surfaces
  product function, technology, customer needs, services (chapter 6.1.1)
- Organisation, e.g. subsidiary StreetWorks
  covering headquarters, divisions, companies, locations, (chapter 6.1.1)
- Activity, e.g. sales/marketing
  primary and support activities, activities outsourced (chapter 6.1.1)
- Variable, e.g. personnel costs
  further substructured into financial/non-financial stock/flow variables and ratios: revenue, cost, assets, liabilities, sales volume, capacity (chapter 6.3.1)
- Informants, e.g. product manager S.Treet
  know-how and power broker, market studies, surveys (chapter 6.2.1).

■ Complex Planning Objects represented as matrices

- Center, e.g. asphalt surfaces for industrial customers in Company X
  three-dimensional matrix to document relevant centers of responsibility which are defined as a cross combination of Segments (chapter 6.1.2)
- Competence, e.g. market know-how of Mr. S.Treet concerning asphalt surfaces
  two-dimensional matrix to document available expertise of information sources in regard to Segments (chapter 6.2.2)
- Equation, e.g. ratio 'value added' = 'sales' - 'costs of goods'
  two-dimensional matrix to document the explicitly defined algebraic relationships between Special Ratios and Variables objects (chapter 6.3.2)
- Template, e.g. 'stock turnover' = 'sales volume' / 'stock'
  two-dimensional matrix to document the explicitly defined relationships between Variables (chapter 6.3.2)
- Logic, e.g. personnel costs attributed to the primary activity sales/marketing
  two-dimensional matrix to document the assignment of Variables to Activities as the first step to define the horizontal model structure
- Script, e.g. see chapter 8.32 and figure 8.d
  cross-reference list to define the objects of the class Atom in a concise way, represents the assignment of Logic objects to Market, Product, Organisation

- Atom, e.g. personnel costs attributed to sales and marketing of asphalt surfaces for industrial customers in subsidiary StreetWorks.

five-dimensional matrix as the result of a rule-based decoding process which is based on the user-defined Script objects and results in the specification of the relevant links between Logic and Centers (horizontal model structure).

7.3 Modular Decomposition

To particularise and computerise the iterative model configuration methodology, the problem solving process can be subdivided into distinct phases. The modular decomposition of the prototype design reflects these partitions. Figure 7.c introduces the modules and provides a visual help for the detailed explanations in the following chapters.

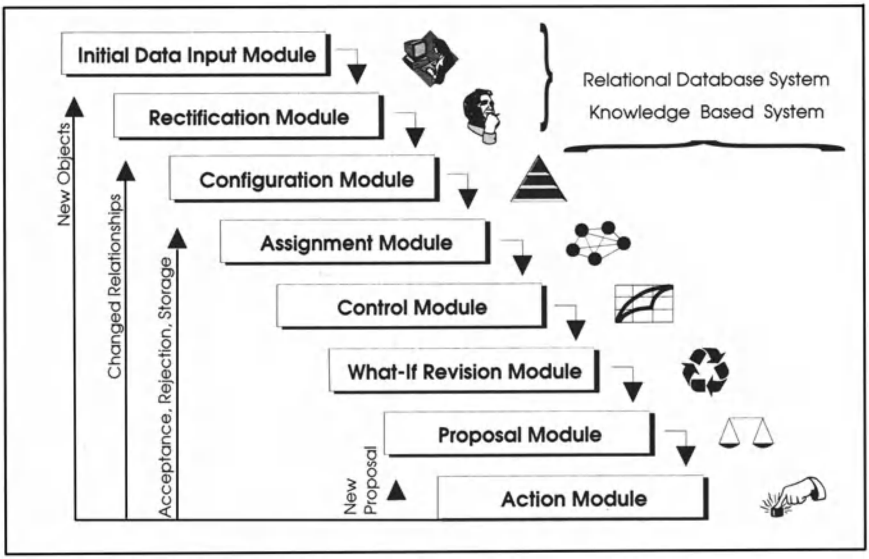


Figure 7.c: Modular Decomposition of Meta-Planner

7.3.1 Initial Data Input Module

This module controls the entry of new planning objects and their relationships by the user. Since the meta-planning of strategic modelling is a group-dynamic and time-consuming process, data input to extend the company-specific knowledge base can be a recurrent activity.

■ Specification of Basic Objects

The user is urged to systematically collect all objects which are known or suspected to be important. According to the conceptual framework (figure 7.b, chapter 6.2-6.4) he has to classify the object and link it to the parent object of the respective class Market, Product, Organisation, Activity, Variable or Informant (figure 1.c, 1.d). The input of the object adds a new member or instance to the class and, due to its strict hierarchy, simultaneously defines additive relationships needed for consolidation. For a complete definition of the object, the user has to supply further specific information by filling in the associated attributes of the object types (chapter 6.5) whereby parameters are initialised whenever possible by the system.

■ Definition of Relationships: Competence Area

To define the objects of the class Competence Area, the user has to explicitly specify the relation between Informants and the relevant objects of the class Segments. The link is established by using a subform with list boxes (lower left-hand side of figure 1.c) and can be further qualified by a 'competence availability factor' (represented as smileys in figure 1.c), which enable the detection of information gaps and determine individual burdens on information sources.

■ Definition of Relationships: Vertical Structure

Additive equations are defined implicitly with the linking of Variable objects during data entry. Further equations can be defined explicitly by the entry of objects for the class Special Ratios and the references to the respective subvariables to be added or subtracted (e.g. 'Gross Performance', figure 1.e).

To add more complex equations, every stock or flow Variable entry screen provides a template which possesses slots to link the variable to others (figure

1.d, chapter 6.3.2). Time-related ratios are automatically added representing absolute and percent growth rates. Proportional and unit-related ratios have to be uniquely named and can be activated by using drop-down list boxes to select the related Variable.

■ Definition of Relationships: Horizontal Structure

To define the horizontal model structure and the Atom objects which will be responsible for the later data requirements, the user has to specify the links between Variable and the segmental and organisational entities (chapter 6.3.2). However, the matrix of market-product-organisation-activity combinations is usually extensive. Each element would have to be identified by its four constituent objects. The direct linking to their relevant Variables, therefore, signifies an enormous workload for the planner and is not feasible (chapter 5.3.7). The approach used instead includes:

- linking of Variables and Activities to define Logic objects
- linking of Logic to Market, Product, Organisation objects to define Script.

The first step further differentiates Variables by linking them to their related Activity objects (figure 1.f). All specified Variable-Activity-combinations become objects of the class Logic, and each link, if subsequently assigned to other segmental objects, might require the input of multi-period data in the later planning cycle and the subsequent collection and analysis of the actuals to conduct strategic controlling. However, to link these Logic objects directly to the three-dimensional elements of the remaining Market-Product-Organisation-matrix still requires extensive manual handling since three constituent objects would have to be specified.

Instead of defining these links explicitly, the user is provided with a list of the individual Market, Product and Organisation objects for any Logic object (figure 1.g). By ticking the appropriate boxes, he can indicate which combinations are relevant in the current model or beneficial for the envisaged design. Each of the list entries can be further qualified by current totals and notes.

Rather than defining each individual relationship, the user specifies the numerous links in a much less input-sensitive way. It is the subsequent task of the knowledge base to decode the condensed information entered by identifying the selected objects of the different market, product and organisation columns/vectors and by establishing their cross product.

7.3.2 Rectification Module

This module allows the user to update data or to revise his beliefs. The metaplanning phase is characterised by the *co-operation* between the planner and numerous know-how and power brokers. Heterogeneous views and expectations together with the impossibility immediately to grasp the full complexity of the issues demand a process of *organisational learning and compromising*. The planner as catalyst of the process and focal point of the reached agreements has to incorporate the revised common beliefs and understandings into the model design.

Rectification covers the re-defining of existing objects and relationships. Situations in which current data and conclusions become invalid, might include:

- a mistake has been made (*correction or organisational learning*)
- time-dependent data have changed (*reorganisations, different responsibilities*)
- emerging new data (*acquisitions, emerging markets, innovations)*
- users' preferences have changed (*consensus of know-how and power brokers*)
- contradictions must be resolved (*relative relevances do not mirror reality)* (*further details / aggregates are required*)

But apart from explicit modifications by the user, changes of object attributes can also be triggered by accepted or rejected proposals (chapter 7.3.8), in particular in respect to evaluation and activation parameter. However, complex object structures, many interdependencies, and extensive use of inheritance methods can considerably boost the impact of rectifications. Thus, even the single change of an object, a relationship or a data attribute may trigger substantial modifications and noticeable additional data expenditures.

In order to maintain consistent data, a revision process has to take all consequences of the rectification into account, either by „brute force" (recalculation of all conclusions) or, more appropriate for processing-intensive applications, by updating only affected conclusions.

The update procedures concerning the knowledge base are detailed in chapter 7.3.3 and 7.3.4. The rectification module specifically ensures the consistency of the database system to enable the correct guidance of user inputs (e.g. updates of object statistics after changes in the hierarchical structure have been specified).

7.3.3 Configuration Module

This module represents the *interface between the relational data base and the knowledge base* of the expert system. Its objective is to synchronise the information in both environments and to tailor it according to the specific structural needs. The tasks include:

- *transfer of input data* from the relational database to the knowledge base by ensuing the correspondence of information stored in the records, fields and cells of the database in respect to the objects, properties and slots of the knowledge base
- *configuration of dynamic objects* by decoding the indirect Script specifications
- *transfer of conclusions* from the knowledge base to the database by ensuing the correspondence of the different storing concepts as detailed above.

Responsible for the execution of these tasks are rules in the generic knowledge base. To secure efficient transfer operations, standard interface facilities should be adapted and, hence, require the compatibility between the relational database and the knowledge base structure.

As detailed in chapter 7.2, links between Center and Variables define the horizontal model structure and the Atom objects. In order to detail these relations in an efficient manner, a two-step approach enables commencing with an indirect representation by creating Logic objects and linking them to the list of Market, Product, and Organisation.

Stored in the relational database, this information needs not only to be transferred to the knowledge base, but also to be decoded. Designated configuration rules dynamically generate the relevant Atom objects as well as the so far not explicitly specified Center by identifying the populated matrix-elements of all market-product-organisation-activity combinations. A matrix-element is populated, if at least one Variable object is assigned to it.

Each of these assignments is an object in its own right and part of the class Atom. It represents an input model variable, which, during the planning cycle, might trigger an individual multi-period data need. The class Atom represents the many-to-many-relationships between the variable and segmental structure of the model, and provides the conceptual basis for an analysis of the data requirements.

7.3.4 Assignment Module

This module is responsible for updating the relationship network of the knowledge base by taking into account up-to-date user input, and rectifications triggered by accepted or rejected system proposals (chapter 7.2.8). It consists of special *assignment rules* which use

- *inheritance methods* to hand down input and derived knowledge to dependent objects in order to provide values in case of parameters not yet defined
- *formulae and decision tables* to calculate ratios and determine states which depend on input and derived values, or multiple parents
- *statistical functions* to provide information for the system control
- *schedules* to process values in a favourable and efficient order.

In particular, the following data initialisations and updates are necessary:

- controlling activation of segments and variables for the envisaged model design using a decision table (chapter 6.4, 6.5.2)
- controlling activation states of all complex objects by considering multiple parents using a decision table (chapter 6.4, 6.5.2)
- dynamic generation of higher-aggregated Atom objects and associated links to provide (input) substitutes for de-activated subordinate Atom objects
- evaluating status, potential, feasibility of segments and variables (chapter 6.4)
- estimating strategic relevance of segments and variables based on their evaluations using a scoring-method (chapter 6.5.1)
- estimating strategic relevance of all complex objects by considering multiple parents using formulae and weightings (chapter 6.5.2).

The aim is to analyse the overall network in order to designate the two presently activated subsets of objects which represent the *current* and the *envisaged model layout*. The different object sets and their characteristics provide the numerical basis for further analysis. It allows comparing both models in light of the changed strategic relevances and their specific data requirements, and enables the appraisal of selection criteria in order to improve the model design.

7.3.5 Control Module

This module is responsible for the controlling of a multitude of planning objects (more than 3000 in the case study) and their attributes. Its objective is to evaluate the *effectiveness of the envisaged model layout*. In order to enable such an assessment, the following heuristic is applied:

'Include the objects with the highest strategic relevance in the envisaged model'.

This *rule of thumb* provides a *constraint*, which can be activated to identify the most suitable set of objects to be considered. In a perfect world with complete and genuine information, the Atom objects as decoded from the Script specification would only have to be sorted according to their strategic relevances. The least important objects would be dropped until the reduced level of data needs is satisfactory.

However, as indicated under the topic of rectification (chapter 7.2.2), *perfect conditions* never prevail. Complex dependencies, soft data and subjective views are met by limited resources and a legacy of historic planning systems, which might have been recognised as inadequate but nevertheless demand gradual modifications and careful changeover procedures.

Hence, the initial set of Atom objects can only be used as an *ideal yardstick* and the *starting point* of the exercise. Whereas the object set portraying the current planning or accounting system will stay unchanged during the meta-planning process, an analysis of the envisaged model set will generally show that some low-relevance objects are members, while other high-relevance objects have not been included. To allow for gradual modifications, the heuristic rule has to be extended:

'Eliminate the activated object with the lowest relevance from the model.'
'Incorporate the inactivated objects with the highest strategic relevance.'

The application of the modified rules will change the structure of the selected object set until a satisfactory configuration for the envisaged model is accomplished. In order to detect possible contradictions in an efficient manner, control rules carry out a Pareto-Analysis (chapter 6.5.3), which structures the data accordingly. To provide the user with an at-a-glance-overview concerning the task at hand, each model (current, envisaged, ideal) is analysed, and can be visually presented using a Pareto-Diagram (figure 1.i and 7.d). The methodical steps required are:

- analyse *ideal model*: sort all objects according to their strategic relevance in descending order
- analyse *current model*: sort all Atoms according to their application in the current system (Yes, No), then according to their descending relevance
- analyse *envisaged model*: sort all objects according to their activation status (On, Off), then according to their descending strategic relevance
- calculate cumulative percentage figures for each resulting table, by, starting at the top, consecutively dividing the *cumulative relevance* by its total
- repeat the last step by taking into account the *cumulative number of objects*.

Figure 7.d exemplifies *Pareto distributions* for all three models. The *ideal model curve* considers the Atom objects starting from the left as the most relevant. Assuming an adequate evaluation, the more important objects should be considered for model inclusion. However, by analysing the *current model curve* (objects included on the left, neglected on the right) the potential for improvement becomes apparent. Since some modifications have already been carried out, the *envisaged model curve* is located between the two, and will, with every further betterment, move more and more towards an 'ideal' distribution.

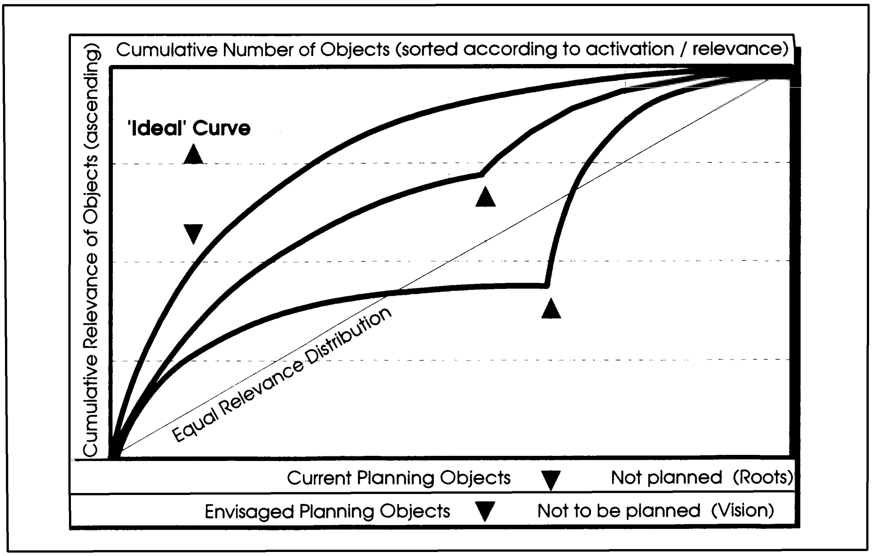


Figure 7.d: Pareto-Analysis of Ideal, Current and Envisaged Planning Model Object Sets

7.3.6 What-If Revision Module

The modules represented so far mimic the *approach taken by experts* in the field of model design. Although their mental meta-planning framework is generally far less detailed (no explicit structure) and exact (no numerical evaluations), it also strives to gather all relevant objects and information (module 7.3.1), to constantly update the findings (module 7.2.2), to define and assess the evolving vertical and horizontal model structure (module 7.3.3 and 7.3.4), and to decide upon model improvements by looking at the strategic relevance of objects and relations (module 7.3.5).

The what-if revision module enables the consideration of a further dimension which, in a manually conducted process, usually cannot be contemplated in the manner which reflects its true importance.

The quantity of *data requirements* and the associated *expenditures* greatly effect the success and acceptance of any planning model, and can be profoundly affected by any single design decision taken. Their thorough calculation, in particular in case of large models with complex vertical and horizontal structures, cannot be carried out manually, but the building and cumbersome maintenance of a computerised input estimation program is, due to the additional work involved, not practical either.

The *Meta-Planner* knowledge base contains all information for carrying out this calculation. Each design decisions can be based not only on the strategic relevance associated with any object but also on its specific data requirements. Consequently, the module contains *revision rules,* which perform a *what-if analysis* (chapter 6.6.4) by switching the activation parameter for each object (from 'On' to 'Off' or vice versa) and by recording the specific impact on the overall data needs.

However, since a full recalculation after each modelling decision would require excessive processing resources, a *rule-based approach* had to be developed which achieves equivalent results. Checks to be performed include :

- Scanning of all Atom objects to determine their activation and evaluation settings within in their particular Center submodel by taking into account the multi-inherited activation states from their direct predecessors
- Analysis of complex objects in respect to multiple 'Off'-activation inheritances
- Bottom-up consolidation of all objects by checking their activation states to determine the impact of an 'On'-'Off'-switch for the consolidating object.

7.3.7 Proposal Module

This module is responsible for the *generation of proposals and their recommendation to the user.* Based on the Pareto-distributions and the what-if analyses, *proposal rules* detect the most significant imbalances and determine the most appropriate revision action, which include:

- *activation* of currently de-activated objects with high strategic relevance and an acceptable demand for additional data requirements
- *de-activation* of currently activated objects with low strategic relevance, but considerable data requirements
- pointing-out of currently activated objects with high strategic relevance but low data requirements as potential candidates for *further differentiation.*

In entering into a kind of *bargaining process* with the knowledge base, the user responds to proposals with an *acceptance* or *rejection.* Figure 1.j shows a screenshot generated during the inferencing process. The upper left table gives information of the actual state of the meta-planning process. 898 multi-period input data have been included in the current model. After de-activating 47 and adding 346, the envisaged model actually contains 1197 Atoms. 2879 Atoms have been specified in total.

Of the 1298 Basic Objects defined, 1017 are currently linked to and, thus, are parent objects of Atoms. By changing the activation states of 461 of those Basic Objects, the number of Atoms in the envisaged system can be influenced. The activation of 30 (431) Basic Objects expands (reduces) the model inputs.

The upper right list recommends the respective best five options to expand or reduce the model. It depicts the rank, the number (WhatIf) of Atoms affected by the (de-)activation, the Object code which is referenced in the bottom list, the average strategic relevance ratio (Pareto), and the total of the dependent Atoms (Linked) including those which stay or are already de-activated. By selecting the appropriate proposal from a list box in the upper right corner and ticking the acceptance or rejection button.

Thus, the planner is relieved of the necessity to scan a legion of planning alternatives manually, and can rely on the *documentation and integrity* of the data and his decisions.

7.3.8 Action Module

This module is responsible for *triggering the consequences* of the user's responses. Depending on the appropriate action, which is selected by *action rules*, the system focus has to be referred back to one of the foregoing modules (figure 7.c).

■ Acceptance

The *acceptance* of proposals results in the switching of object-specific activation parameters. Objects with low relevance join the subset not to be planned and are superseded by higher-aggregated objects; objects with high relevance extend the subset for the envisaged model design.

As a result of continuously accepted proposals, the Pareto-distribution is steadily improving (figure 7.d: envisaged object curve). To reflect these changes, the system focus is referred back to the configuration module. The tasks to be performed include re-processing dependent objects, updating their activation states and data needs, and to actualising the Pareto-distribution, what-if analysis and database.

■ Rejection

The *rejection* of proposals indicates, that the strategic relevances of the objects under review do not adequately reflect the user's preferences. Objects earmarked for de-activation (activation) had been underrated (overrated), due to inherited relevances or due to initial mis-evaluations by the user.

To rectify these inadequacies, the relevances have to be modified. Since no activation state has changed, the objects under review stay in their subsets of planned or not planned objects, but, due to their updated relevances, these affiliations are now verified. As a result, the Pareto-distribution improves. To reflect these changes, the system focus is referred back to the configuration module. The tasks required include re-processing the dependent objects' evaluation, and updating the Pareto-distribution and database.

■ Structural Changes

The *addition or modification of objects and relationships* always require the application of one of the first two modules. This need for structural changes can be triggered by an accepted proposal rule (recommendation regarding further differentiation of an object) or is a result of the organisational learning curve which demands more or less detail. As a result, the network has to be fully updated, and the Pareto-distribution and the data requirements can change considerably, for the positive, but also for the negative.

7.4 Summary

As a knowledge-based system rooted in the generic category of configuration, *Meta-Planner* has to incorporate features which establish a close similarity to a *therapy process*. These special characteristics naturally reflect as well on the general architecture as on the modular decomposition of the system design.

To assist the documentation of the modules, the conceptual framework and its constituents (whose underlying principles have been discussed in chapter 6) are summarised and extended to reflect required intermediate structures (figure 7.b). Eight designated modules are presented which cover the following responsibilities:

- entry of new planning objects and relationships (*Initial Data Input Module*)
- change of existing structures (*Rectification Module*)
- synchronisation between database and knowledge base, and generation of dynamic objects and structures required (*Configuration Module*)
- updating data dependencies of the relation network (*Assignment Module*)
- controlling of a multitude of objects via Pareto-analyses (*Control Module*)
- consideration of data needs via what-if analyses (*What-If Revision Module*)
- generation of recommendations (*Proposal Module*)
- triggering of appropriate actions according to the acceptance or rejection of proposals (*Action Module*).

8 Prototype System

The technical requirements of the methodology introduced can be summarised as follows:

- In supplying a conceptual framework to handle case-specific segments, variables and informants by incorporating established strategic segmentation concepts, the prototype has to offer reliable *database management facilities* and a *comfortable user interface* for the input, editing and viewing of objects and data.
- In detailing the object relationships for the vertical and horizontal structure of the current and envisaged model, the configuration process is exposed to the effects of combinatorial explosion. Since templates and scripts provide the user with smart ways for concise object linking, the prototype has to incorporate *rule-based mechanisms for decoding* the user information and for the *dynamic generation of the objects and relations* necessary for the analysis.
- For determining the envisaged model configuration, the methodology requires the evaluation of planning objects and competencies via *qualitative assessments and scoring methods.* However, to secure acceptable levels of user inputs the prototype needs to support *inheritance methods* which adequately consider the single and multiple dependencies within the object hierarchies.
- To analyse objects for model inclusion, their individual *data requirements* have to be estimated and set against their specific activation and evaluation states. The prototype has to *consolidate* the input quantities and related data, and carry out *Pareto-analyses* which should also been shown as *charts.*
- In selecting the most suitable object set for the envisaged planning model, mismatches between object-specific activation and evaluation states have to be detected. By taking into account the consequences of design changes, the prototype has to perform *what-if analyses* and to use *heuristic rules to generate proposals* for the step-by-step improvement of the model configuration.

This chapter concentrates on the development tools used to satisfy these technological requirements and focuses on the prototype's architecture and implementation issues.

8.1 System Architecture

The technological environment for the development of the prototype system includes the relational database management system *ACCESS 2.0* from Microsoft and the expert system shell *NEXPERT OBJECT 3.0* from Neuron Data, now marketed under *Smart Elements*. Both development tools run under *MS WINDOWS* on a Personal Computer. In order to transfer data between the systems, Nexpert Object's Database Bridge is used. Additionally, the Access tool *GRAPH* provides the facility to draw analytical charts to visualise the results of the Pareto-analysis.

Figure 8.a demonstrates the division of tasks in respect to the design's modular decomposition discussed in chapter 7.3. The initial data input and the subsequent rectification and analysis is based on the relational database management system and is characterised by the sharing of code and forms, while the processing is carried out within the expert system and utilises a number of dedicated knowledge bases which are symbolised by nine smaller rectangles on the right-hand side.

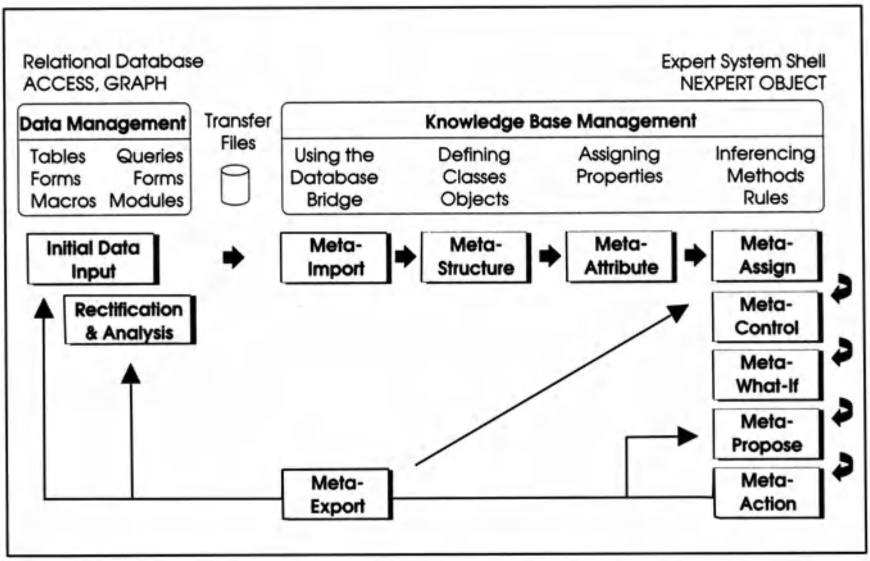


Figure 8.a: Technical Architecture

8.2 Overall Control Structure

Since *Meta-Planner*'s technological environment consists of two Windows applications which perform the interdependent functions of data management and processing, the issue of the overall system control structure had to be solved. To control the interactions between these environments, *Dynamic Data Exchange (DDE)*, a Microsoft Windows communication protocol and Application Programming Interface (API), is employed. Using this protocol, a Windows application (*client*) starts up a second Windows application (*server*), passes information, uses the server's functionalities, and calls for results.

In *Meta-Planner* the inference process of the knowledge based modules is initiated by the user via a pull-down menu from the database environment (chapter 8.2.3). The case-specific objects and relationships are passed to the knowledge-base where they are decoded and processed as detailed in chapter 8.3. Subsequently, dynamically generated objects and modified information is sent back to update the database tables. Hence, *Access* acts as a client with *Nexpert Object* as a server.

When the DDE Initiate() function succeeds in connecting the client *Access* to the server *Nexpert*, Windows creates a channel between them. In the subsequent conversation taking place, *Nexpert* will respond to messages (*EXE_xxx calls*), which allow clearing all knowledge bases (*EXE_clear*), loading one (*EXE_load*), launching (*EXE_run*) or re-starting (*EXE_restart*) the inference process, and providing information to initiate backward chaining (*EXE_suggest [hypothesis]*) or forward chaining (*EXE_volunteer [atomname, value]*).

Based on these messages which are used in conjunction with the DDE functions in *Access Basic*, the database environment is able to fully control the tasks to be carried out within the knowledge based subsystem. The actual transfer of data between the relational tables and the knowledge base is carried out by the action side of *Nexpert's* rules which make use of *Retrieve and Write* statements and the functionality provided by the *Nexpert Object Data Bridge* (figure 8.a).

8.3 Database Management Functionality

ACCESS is a relational database management system, which provides primarily a non-procedural environment, although it also contains a powerful procedural language (Access Basic). Based on tables, queries and forms, it allows the development of complex applications by using its flexible report generator and external presentation software, for example Microsoft Graph, via object linking and embedding (OLE). Application building and control makes use of macros or BASIC routines and is further supported by query-by-example (QBE), structured query language (SQL) and dynamic link libraries (DLL).

8.3.1 User Interface

Meta-Planner particularly demands the ability of ACCESS to provide effective relational *database management* capabilities for the input, editing and analysis of the case-specific data, to secure its *referential integrity*, and to establish an efficient and user-friendly interactive *communication* between planner and system.

■ Input, Editing, Viewing

Figure 8.b details the requirements for the user interface in order to define, evaluate and structure the various objects to be processed (chapter 7.2, figure 7.b). Since different types of objects share the same properties, standardised input forms with minor alterations have been used to enable a *swift familiarisation* with the system. To assure a compact menu tree, the same forms are also used for editing and viewing. By including any parent or dependent object of a particular entity shown, a form always conveys the full local structure and environment. The resulting *high information density* guarantees that all relevant information is at hand whenever relationships or evaluations have to be modified.

- The objects of Market, Product, Organisation and Activity (figure 1.c) share a form which also covers the set-up of the Competence Areas
- As Competence Areas are linked to particular sources of information, they are also included in the form representing the Informants (not shown)
- Stock and Flow Variables share a form (figure 1.d) which also provide the opportunity to link variable to create Template ratios

- Special Ratios (figure 1.e) are defined by selecting the relevant Variables and defining their algebraic relationship
- Further forms (figure 1.f, 1.h) define Logic and Center objects
- To link the Logic objects to the respective Market, Product, Organisation objects, a form (figure 1.g) is used to specify Script objects in an indirect way which will later have to be decoded by the knowledge-based modules to create Atoms.

Classes	**Definition**			**Evaluation**			**Structure**
	Name	Notes	Amount	A	SPF	R	Links to
Basic Objects							
Informant	x	x	-	-	-	-	Parent, Segments
Market	x	x	-	x	x	c	Parent, Informant
Product	x	x	-	x	x	c	Parent, Informant
Organisation	x	x	-	x	x	c	Parent, Informant
Activity	x	x	-	x	x	c	Parent, Informant, Variable
Stock/Flow Variable	x	x	x	x	x	c	Parent, Activities
Special Ratios	x	x	x	-	-	-	Parent, Variable
Complex Objects					CF		
Competence Area	c	-	-	x	x	-	-
Center	c	x	x	x	-	x	Segments
Logic	c	x	x	x	-	x	Market, Product, Organisation
Script	c	x	x	x	-	-	-

Legend:

	A	*Activation Parameter for the envisaged model layout*
	SPF	*Status, Potential, Feasibility to evaluate individual objects*
x Input / Edit	*R*	*Factor to determine strategic relevances of planning objects*
c calculated	*CF*	*competence factor to evaluate informant-segment know-how*
- not applicable	*Segments - objects of classes Market, Product, Organisation, Activity*	

Figure 8.b: Object-specific Input Features of the User Interface

■ Analysis of Results

Based on the information of the database, the inference process dynamically generates Atom objects, estimates data requirements and actualises activation and evaluation values. By updating the database accordingly, consistency between the two technological environments and within the overall object network is attained. Furthermore, the effects of the meta-planning process can be visualised by Pareto-charts (figure 1.i and 7.d). To compute the required cumulative ratios in an efficient manner, aggregate queries have to reduce the potentially thousands of objects to a number which can be easily accessed by the graphic software.

8.3.2 Relational Database Design

To document the structure and contents of the relational database, figure 8.c summarises the attributes of the tables *Objects, Relations, Center, Script* and *Atoms*. Since attributes are shared, the condensed representation shown avoids redundant repetition, but has to reference the database tables concerned within the fifth column „tables" by indicating the first letter of the table names: o, r, c, s, and a. Properties might be repeated, if the way of input or calculation differs between the tables.

■ Basic Objects

All basic objects (Informants, Segments, Variables) share a strictly hierarchical structure and differ only marginally in respect to their properties. To collect them all in the one table *Objects*, a number of fixed records store the basic object categories and mirror in detail the classification system in the static knowledge base.

Figure 8.c details their properties. The unique identifier 'PrimaryKey' consists of a counter column. MS Access increases the value of this counter automatically for each new record by one, deleted record numbers are not re-used. To define the hierarchical relationships, the property 'SubObjectOf' is a reference and contains the counter value of the parent object, which has to be assigned via a drop-down list box by the user. The properties 'Name' and 'Alias' allow uniquely terming an object, and 'Amount' and 'Notes' help to store further relevant information to support the activation and/or evaluation process or to document reasons for the design decisions taken.

Activation and evaluation parameters exist as input fields ('Status?', 'Potential?', 'Feasibility?', 'Activation?') as well as calculated fields ('Status', 'Potential', 'Feasibility', 'Activation'). This separation is necessary, since not all inputs have to be initially defined by the user and because actual settings depend as well on inherited values from parent objects. To ensure that any subsequent modification cascades downwards correctly, any input data fields not yet explicitly defined have to be identified, which is only possible if they have not been previously overwritten by a calculated or inherited value. Based on these evaluations, the 'Relevance' of the basic objects is calculated.

Identification	Type	Source	Example	Tables	Description
PrimaryKey	Number	System	(counter)	o r - - -	primary key
Name, Alias	Text	Input	Profit	o - - - -	unique identifier and additional ID to support second language
Notes	Text	Input		o r c s -	object-specific comments
Amount	Integer	Input	100.000	o r c - -	current figures for variables, logic, center; competence factors
Amount	Integer	Input	100.000	- - - s -	current figures for logic object in respect to selected basic object
Relationships					
SubObjectOf	Number	Input	(counter)	c r c s a	one or more candidate keys to point to the parents' PrimaryKey
ClassKey	Number	calc.	(counter)	o r c s a	pointer to PrimaryKey of the object category respective class
Level	Integer	calc. 2		o - - - -	hierarchical level within the object tree
Evaluation					
Status?	Integer	Input	1= very high	o - - - -	evaluation of the current strategic importance
Potential?	Integer	Input	2= high	o - - - -	evaluation of the expected strategic importance
Feasibility?	Integer	Input	3= average	o - - - -	evaluation of availability, costs, certainty of the data
Status	Percent	calc.	90%	o - - - -	= f (Status?, Parent.Status)
Potential	Percent	calc.	80%	o - - - -	= f (Potential?, Parent.Potential)
Feasibility	Percent	calc.	70%	o - - - -	= f (Feasibility?, Parent.Feasibility)
Relevance?	Integer	Input	4= low	- - c s -	evaluation of the expected strategic importance
Relevance	Percent	calc.	80%	o - - - -	= f (Status, Potential, Feasibility)
Relevance	Percent	calc.	80%	- r c - a	= f (Relevance?, Parents.Relevance); Relevance? not for Atoms
Activation					
Activation?	Boolean	Input	on/off	o r c - -	activation in envisaged system
Activation	Boolean	calc.	on/off	o r c - a	= f (Activation?, Parents.Activation); Activation? not for Atoms
Roots(1-6)	Boolean	Input	on/off	- - - s -	activation of script relations for current model configuration
Vision(1-6)	Boolean	Input	on/off	- - - s -	activation of script relations for envisaged model configuration
Roots	Boolean	calc.	on/off	- - - - a	activation of atom objects for current model configuration
Vision	Boolean	calc.	on/off	- - - - a	activation of atom objects for envisaged model configuration
Results					
RootsOn	Number	calc.		o r c - -	number of dependent activated atoms for current model config.
VisionOn	Number	calc.		o r c - -	number of dependent activated atoms for envisaged model config.
VisionOff	Number	calc.		o r c - -	number of dependent de-activated atoms for envisaged model cfg.
What-If	Number	calc.		o r c - -	number of affected atoms in case of changing activation state
Pareto	Number	calc.		o r c - -	average relevance of affected atom objects by activation change

Figure 8.c: Data Dictionary of the tables Objects (o), Relations (r), Center (c), Script (s), and Atoms (a)

■ Complex Objects

All complex objects can be described as elements of a *multi*-dimensional matrix. Two-dimensional relationships involving two basic objects are stored in the table *Relations* (Logic, Competence Areas, Equations, Template).

Figure 8.c shows that each record has a unique 'PrimaryKey' based on a counter value. Two 'SubObjectOf' properties point to the immediate parents which are basic objects stored in the table *Objects*. The field 'ClassKey' is assigned automatically during data entry and depicts the class name also stored in table *Objects*. 'Notes', 'Amount', input 'Activation?' and computed 'Activation' are used as described above, but the strategic 'Relevance' is now evaluated directly, so that the input field 'Relevance?' substitutes the attributes 'Status?', 'Potential?' and 'Feasibility?'.

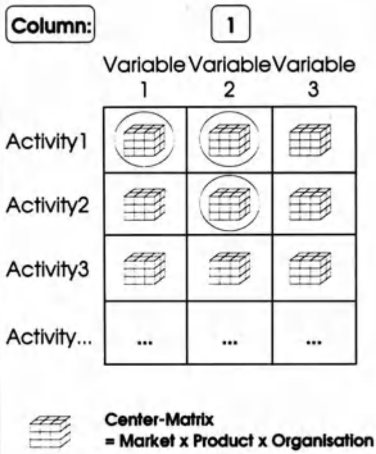
Three-dimensional relationships which represent the Center objects are stored in the table *Center*. The record structure is similar to the table *Relations*, with the exception that an additional 'SubObjectOf' reference is used to provide sufficient pointers to the parent object in the classes Market, Product, and Organisation.

■ Script

The meta-planning exercise resembles a thorough investigation of the potential planning objects and their relationships and is based on their specific strategic relevances and data expenditures. The objective is a blue-print of the model design to guide the system developer in the implementation process.

Hence, all possible links between variables and segmental structures have to be defined, evaluated and examined. Each link, if defined and activated, requires the input of a multi-period value during the subsequent planning cycle. It can be depicted as an element of a five-dimensional matrix and is defined by the respective objects of the five categories Market, Product, Organisation, Activity, and Variable.

Figure 8.d. column 1 exemplifies the five-dimensional matrix. The circles indicate relevant relationships between Variables and Activities already defined by the user as Logic objects in the table *Relations*. To define the model layout, further links have to point out the remaining Segments (Product-Market-Organisation-combinations) where these Logic objects (e.g. personnel costs marketing) are applicable or are likely to become relevant. The number of links to be established can run into thousands, and it is, hence, not feasible/acceptable to define them explicitly.



Column:	2	3		4
Product1	on	on	-	(on)
Product2	on	on	on	-
Product3	on	-	on	-
Product4	on	-	on	-
Market1	on	on	-	on
Market2	on	on	-	on
Market3	on	-	on	on
Market4	on	-	on	on
Orga.1	on	-	on	(on)
Orga.2	on	-	on	-
Orga.3	on	on	-	-
User Interactions	11	5	7	4
Centers	4x4x3	2x2x1	3x3x2	1x4x1
affected	48	4	12	4
		16		

Figure 8.d: Definition of the Model Script

Rather than linking each respective Center to the Logic object, the Products, Markets and Organisation objects are displayed in an one-dimensional list. By selecting every list object, the Variable-Activity-combination is assigned to all Segment combinations (figure 8.d column 2). In case not all objects listed are chosen, it is linked only to a subset which is determined by fully combining the selected subsets of the three Segment categories, their so-called *cross product* (figure 8.d column 3).

If Logic objects are only assigned to objects of one or two different categories, the system automatically links it to the top object of the categories omitted (figure 8.d column 4). Certain market development investments, for example, might not be attributable to specific products or organisational units. If not specified explicitly, the top objects of Product and Organisation are assigned by default to indicate that the investment is allocated to the full product range and the company as a whole.

The list-oriented set-up (figure 1.g) supports all aspects of strategic sales, cost and resource allocations. It reduces the number of necessary user interactions with a growing number of objects at an exponential rate. Using Script specifications, the user is able to define the model currently used as well as the potential design elements of the envisaged model. The latter should be construed by examining the companies' data and its present or conceivable level of differentiation. However, to secure effective *strategic controlling*, objects should only be planned in certain detail if the actuals can be subsequently particularised in the same manner.

'SubObjectOf' properties point to the immediate parents which are Logic objects stored in the table *Relations* and the respective Market, Product, or Organisation objects stored in the table *Objects*. 'Notes' and 'Amount' store further information, and the parameter 'Roots(1-6)' and 'Vision(1-6)' are used to enumerate the elements of the current and for the envisaged planning model.

■ Results

The data stored in the tables and properties discussed so far can be modified by user-defined additional objects and relationships or the alteration of existing data. It also can be updated by results of the *inference process*, including actualised activation and evaluation values or dynamically generated Center and Logic objects.

The consolidation carried out in the knowledge base estimates the *data requirements* for the current and envisaged model configuration: 'RootsOn', 'VisionOn' and 'VisionOff' (figure 8.c). As a result of the *what-if analyses*, the 'What-If' parameter shows how many Atom objects are affected in case the respective object's activation is changed. The 'Pareto' parameter indicates the average strategic relevance of these Atom objects concerned.

However, to present the results of the Pareto-analysis as a chart, all Atom objects which have been dynamically generated during inferencing have also to be stored in a table. Each Atom record has a set of five 'SubObjectOf' references which point to the immediate parents stored in the table *Objects*. These keys uniquely define the respective element in the five-dimensional matrix (figure 8.d column 1) and link the basic objects of the classes Market, Product, Organisation, Activity, and Variable.

As shown in figure 8.c, 'Activation' and 'Relevance' parameter are derived solely by multiple inheritance from the parent objects and, hence, require no input values by the user. The activation parameter 'Roots' depicts the current model layout and is solely derived from the Script specifications. The parameter 'Vision' for the envisaged model configuration additionally incorporates the inherited activation settings of all parent objects. Since Atoms as the smallest objects always require the input of <u>one</u> multi-period value during the subsequent planning cycle, the data expenditure does not have to be recorded.

■ Entity Relationship Diagram

An *entity-relationship-diagram* (ERD) is a data modelling tool which depicts the associations between different *entities* in an information system. An *entity type* (e.g. Markets) shares the same set of attributes and its *instances* (e.g. overseas customers) are stored as *records* in the same *table*. In a relational database each record has to have a unique *identifier*, the *primary key*, which can be made up of one or more data *fields*. The *primary key* is used to establish links between different records and, used as a reference to the unique record, becomes a *candidate key* of the related table.

Figure 8.e lists the four main tables of *Meta-Planner* introduced earlier and shows the relationships which are drawn in crow's-foot notation [MART85 297ff]. All basic objects share the same attributes and, hence, can be stored in the one table *Objects*. They all represent strictly hierarchical structures as symbolised by the one-to-many self reference. However, they enter into different types of many-to-many-relationships with each other.

Many-to-many-relationships depict the complex objects discussed previously as defined by the user or dynamically generated by the inference process. By introducing the tables *Script*, *Center*, and *Relations*, the candidate keys and associated data can be stored and the links can be split into one-to-many relations.

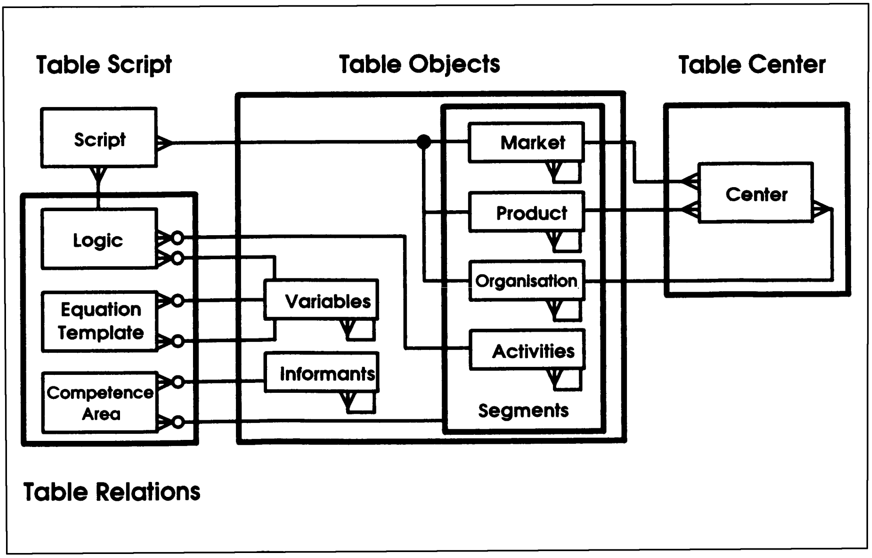


Figure 8.e: Entity-Relationship-Diagram

8.3.3 Menu Structure

Figure 8.f shows the contents of *Meta-Planner's* menu bars. Implemented as pull-down menus, the lower three menus provide the familiar functionalities of Windows and database applications in supporting editing, searching, sorting, filtering, and navigating, whereas the upper ones access the different forms, statistics, charts, and processes:

- The menu *File* allows the printing of reports, the updating of the database, and the launching of the inference process which is executed by the knowledge-based modules.
- The menu *Definition* enables the specification and modification of all basic and complex objects.
- The menu *Analysis* menu provides statistics concerning the different object categories and the options for drawing relevance charts and Pareto-Diagrams. The model Atoms assigned can be accessed from different viewpoints (by ...).

Menu File	**Menu Definition**	**Menu Analysis**
Print Setup	Informants	Basic Objects
Print Preview	Market	Atoms by Logic
Print	Product	Atoms by Center
Update Database	Organisation	Relevance Chart
Inference Process	Activity	Pareto Diagram
Exit	Flow Variable	Statistics
	State Variable	
	Special Ratios	
	Logic/Center	
	Data Atoms (Script)	
Menu Edit	**Menu Records**	**SubMenu Goto**
Undo	Data Entry	First
Undo Current Record	Goto... (SubMenu)	Last
Cut	Refresh	Next
Copy	Ascending	Previous
Paste	Descending	New
Paste Append	Edit Filter/Sort	
Delete	Apply Filter/Sort	
Select Record	Show All Records	
Find...	Allow Editing	
Replace...		

Figure 8.f: Menu Structure

8.4 Knowledge-based Functionality

In supporting reasoning and object-oriented structures, *NEXPERT OBJECT* is a *hybrid expert system shell.* It can be embedded within current hardware and software standards and offers compatibility across all development and delivery platforms for the knowledge bases built. Its aim is to reduce development time and costs by providing an easy-to-use graphical interface for interactive development, thus, opening up artificial intelligence systems to a wide range of non-AI specialists.

To represent reasoning, Nexpert uses rules. A *rule* is a knowledge structure which is expressed in the format *'if ... then ... do ... else do ...'* and lets the system backward or forward chain along reasoning paths. The one or more if-clauses comprising the left-hand side of the rule are called *conditions.* The right-hand side consists of the result of their evaluation, called *hypothesis* (true, false, unknown), and *actions* that are triggered in case of true or false conditions.

To order knowledge, Nexpert uses hierarchies of both *classes and objects.* The latter represent the members of a class. The *properties* of these structures describe their characteristics, whereby a class acts as a template which defines the properties its objects must possess (like those of frames and instances). To determine unknown values for object properties, called *slots,* the order of sources, such as users or databases, to be investigated can be defined by *system methods.*

Based on the hierarchical relationships, property values can be inherited between classes and subclasses, classes and objects, or objects and subobjects. Depending on the options and priorities set, downward, upward and multiple *inheritance* is supported and can be altered dynamically during run-time. However, not only the overall system can be influenced but also individual property slots by setting their so-called *meta-slots.* Moreover, *if-change system methods* or *demons* allow the definition of functions to be performed whenever the value of a property is changed.

Nexpert offers powerful mechanisms to define the subsets and structures needed for processing and inferencing, including the establishment of *dynamic objects and relationships* during run-time. One of these means is *pattern matching* whereby class and object names can be used as a pointer to object sets. Another are *interpretations* which allow dynamically creating required class, object, and property names via string manipulation. Built-in functions, pre-defined external routines, and user-defined methods which can be triggered by *message passing* add further flexibility.

The sum of these features allows the efficient coding of reasoning and structural requirements and, consequently, has led to the selection of Nexpert Object as the development environment for this project, in particular, since the *shell's open architecture* and the availability of *run-time versions* would also benefit further development efforts towards a commercially viable system.

Besides, an expert system shell also provides the *knowledge acquisition component* and the *problem solving component*. Whereas the former enables entering domain-specific expert knowledge in the generic knowledge base, the latter controls its correct interpretation for inferencing and the processing of the case-specific information. Hence, development efforts could concentrate on the interactive communication between planner and computer and the domain- and case-related structural aspects of the knowledge bases (figure 7.a).

8.4.1 Knowledge Design

Whenever a knowledge base is saved, the respective *code* is generated and stored in a special Nexpert-format as an ASCII text file, compatible with Nexpert running on all platforms (figure 8.g). A knowledge base, which can also be saved in a compiled version compatible with the development platform only, may contain any number of classes, objects, properties, rules and methods. By providing functions for loading and unloading, an application can be modularised in order to further *structure* the knowledge and to occupy *memory* only for pertinent representations. Depending on the actual inferencing requirements, the appropriate knowledge bases are loaded and can be processed at the same or different times.

Meta-Planner's knowledge design also makes use of this *modular architecture*. Although memory and performance considerations can become increasingly important with a growing number of objects, the prime reason for using multiple knowledge bases was to match them with the particular functions of the modular decomposition as detailed in figure 8.a (see also chapter 7.3 and figure 7.c).

To avoid *redundancies* within these knowledge bases, all information common to the functional modules (like class, object, property and some control structures) are stored in two knowledge bases which are loaded on a permanent basis during initialisation of the system. The following chapters detail the tasks of the different knowledge bases and discuss some of the implementation issues involved.

```
(@CLASS=      Planning_Object
              (@SUBCLASSES= Structure  KnowHow  Variable))

(@PROPERTY=Relevance  @TYPE=Float;)

(@META=       Relevance      @FORMAT="k,0.000";)

(@OBJECT=     zControl
              (@PROPERTIES= Value  @TYPE=Boolean;  zChildren))

(@METHOD=     OrderOfSources
              (@ATOMID=P00.Pareto;@TYPE=SLOT;)
              (@FLAGS=PUBLIC;)
              (@LHS=    (> (SELF.WhatIf) (0))
                        (> (SELF.WhatIf) (0)))
              (@RHS=    (Assign (SELF.WhatIf/SELF.WhatIf) (SELF.Pareto)))
              (@EHS=    (Assign (0) (SELF.Pareto))))

(@RULE=       Script_Decoding_2
              @COMMENTS="Decoding of Script to create Atom Relationships 2";
              (@LHS=    (SendMessage ("zLogStart") (@TO=hA40b;))
                        (Assign (1) (hA40b.hR01))
                        (SendMessage ("A40_PM") (@TO=<|V3Bp|>;)))
              (@HYPO= hA40b)
              (@RHS=    (DeleteObject (<|V3Bp|>))
                        (SendMessage ("zLogEnd") (@TO=hA40b;))))
```

Figure 8.g: Nexpert's ASCII File Knowledge Structures (excerpts from Meta-Planner)

8.4.2 Object Model

The knowledge bases *Meta-Structure* and *Meta-Attributes* contain the *object model* which identifies the objects in the system, their relationships and properties. It incorporates the conceptual framework as detailed in chapter 7.2 (figure 7.b) and mirrors its relational database representation discussed in chapter 8.2.2 (figure 8.e).

Meta-Structure includes the properties which are subdivided and exclusively assigned to abstract classes. *Meta-Attributes* contains the classes needed for the inference process as detailed in the structured list below (figure 8.h). Links referring to abstract classes assure the relevant attributes are passed on by *attribute inheritance*. The division into two knowledge bases cuts the size of the underlying Nexpert text files because attributes are only stored once and not for every class inclusion.

Since these considerations are solely tool-related in order to ease development and maintenance, the abstract class structure is not further discussed. The concrete classes of *Meta-Attributes* on the other hand consist of superclasses and leaf classes. Whereas the former possess no direct objects and are used only for initial assignments during data import or for pattern matching, the latter have direct objects assigned to them.

Figure 8.h shows the superclasses and leaf classes and documents their hierarchical relationships. The right column further describes the leaf class as a basic or complex object category, references the name of the relational database tables which store the imported objects, and defines any parent classes, if applicable.

Superclasses	Leaf Classes	Data Source and Parent Classes
Structure		
Segments	Product	basic objects from table *Object*
	Market	basic objects from table *Object*
	Organisation	basic objects from table *Object*
	Activity	basic objects from table *Object*
Responsibility	Center	complex objects from table *Center* = *Product x Market x Organisation*
Know-How		
Info Sources	Informants	basic objects from table *Object*
Competence	Competence Area	complex objects from table *Relations* = *Informants x Segments*
Variable		
Input	Flow Financial	basic objects from table *Object*
	Flow NonFinancial	basic objects from table *Object*
	Stock Financial	basic objects from table *Object*
	Stock NonFinancial	basic objects from table *Object*
Ratios	Special Ratios	basic objects from table *Object*
Relations	Logic	complex objects from table *Relations* = *Input x Activity*
	Template	complex objects from table *Relations* = *Input x Input*
	Equation	complex objects from table *Relations* = *Special Ratios x Input*
DataNeeds	Script	complex objects from table *Script*
	Script1, 2, 3, 4	for decoding script to atoms
Atoms	Atoms Roots	model atoms used in current system = *Logic x Center*
	Atoms Vision	model atoms for envisaged system = *Logic x Center*

Figure 8.h: Class Structure of the Knowledge Base

Figure 8.i uses Rumbaugh's graphical notation [RUMB91] to illustrate the object model. An Atom consists (*small diamond*) of one Logic object linked to one Center. A Logic object couples one input Variable with an Activity, while a Center represents a Product-Market-Organisation combination. Product, Market, Organisation and Activity objects are summarised (*small triangle*) in the abstract class Segments. Any Segment object attached to an Informant constitutes a Competence Area.

Variables can be of financial and non-financial nature and of type flow or stock. Two Variables linked define a Template relationship (figure 6.i). Additional Equations define Special Ratios by assigning input Variables and/or Special Ratios and by defining the arithmetic relationships.

Classes shown on the bottom line are instantiable. Each contains at least one instance which represents the top object. Other instances are case-specific objects defined by the user. Product, Market and Organisation form a list whose items can be linked to Logic objects to define the Script (within the database environment) which has to be decoded by the inference process to dynamically generate the model Atoms.

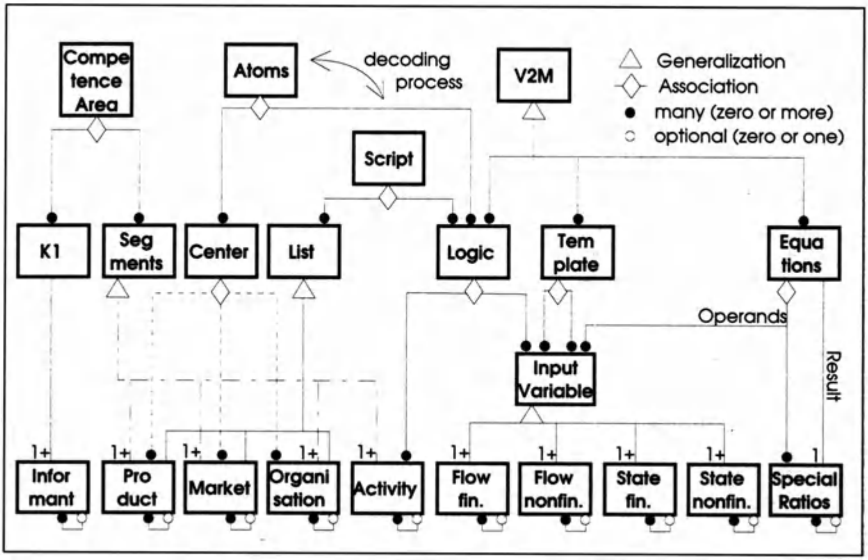


Figure 8.i: Object Model of Meta-Planner

8.4.3 Functional Model

The *functional model* shows „how output values in a computation are derived from input values, without regard for the order in which the values are computed". *Data Flow Diagrams* (DFD) are used to picture „the flow of data values from their sources in objects through processes that transform them to their destinations in other objects" [RUMB91 123,124]. This structured technique represents data flows as arrows, processes as rounded rectangles, and data stores as open rectangles.

■ Configuration, Assignment and Control

Figure 8.j exhibits the data flow diagram of the knowledge bases *Meta-Import, Meta-Assign* and *Meta-Control* (figure 8.a) which include the rules for the configuration, assignment and control modules. The data stores labelled *table 'name'* are the relational tables whose data is imported to the knowledge base. The other data stores refer to the objects and their attributes. The data flows show the data transferred from the database (dotted line) and the update of the evaluation and activation parameters by inheritance methods and initial settings (full line). The processes reference the underlying rules which are further detailed in figures 8.k and 8.l.

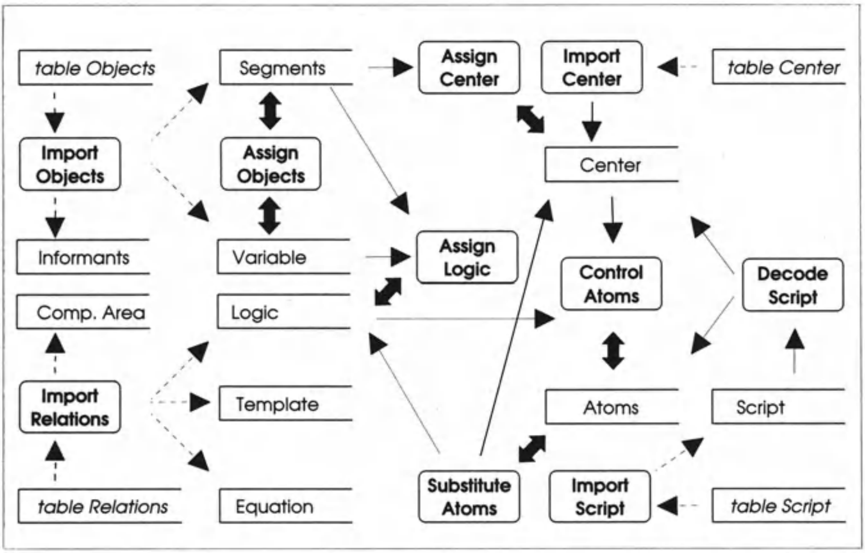


Figure 8.j: Data Flow Diagram for Configuration, Assignment and Control

Figures 8.k and 8.l summarise the rules and methods of the three knowledge bases by using structured English. After the user has triggered the inference process via pull-down menu, the data in the tables *objects, center, relations* and *script* is accessed by the database bridge of the knowledge base and, according to the value of the property 'ClassKey', assigned to the classes given in figure 8.h. After generating the links to the parent objects concerned, the activation and evaluation parameters of Segments, Input Variables, Center and Logic objects are updated by taking into account their hierarchical relationships and by using inheritance methods. Figure 8.k documents the relevant formulas by using the relational database field names as detailed previously in figure 8.c.

```
Rules Import_Objects and Assignment_Objects
Retrieve  records from database table Objects
Assign to appropriate concrete class as indicated by ClassKey (e.g. Activity)
          IF        slot Level = 1
          THEN Assign to class TopObjects
          ELSE  Link to Parent (as indicated in slot SubObjectOf)
          ENDIF
FOR ALL   objects of classes Segments and Input
          Level       = Parent.Level        + 1
          Activation  = Parent.Activation   * Activation? 1)
          Status      = Parent.Status       * Status? 2)
          Potential   = Parent.Potential    * Potential? 2)
          Feasibility = Parent.Feasibility  * Feasibility? 2)
          Relevance       = (Status * Potential * Feasibility) POWER(1/3)
ENDFOR

Rules Import_Center and Assignment_Center
Retrieve  records from database table Center and Assign to class Center
Link to   | Product | , | Market | and | Orga |
FOR ALL   objects of class Center
  Activation=( | Market | .Activ. * | Product | .Activ. * | Orga | .Activ.)*Activation? 1)
  Relevance  = ( | Market | .Rel. * | Product | .Rel. * | Orga | .Rel.) * Relevance? 2)
ENDFOR

Rule Import_Relations and Assignment_Logic
Retrieve  records from database table Relations
Assign to appropriate concrete class as indicated by ClassKey (e.g. Logic)
Link to   ParentObjects in appropriate classes   (e.g. | Activity | and | Input | )
FOR ALL objects of class Logic
  Activation   = ( | Activity | .Activation * | Input | .Activation * Activation? 1)
  Relevance    = ( | Activity | .Relevance* | Input | .Relevance* Relevance? 2)
ENDFOR
          Order of Sources - if not specified: 1) = Off ; 2) = 99%;  | x | = parent in class x
```

Figure 8.k: Configuration and Assignment for Basic Objects, Center and Relations

To establish the model Atoms and their relationships, the user's Script specifications have to be retrieved and decoded. Figure 8.1 outlines this process by summarising the rules applied. In order to compute the cross product as shown in figure 8.d, the Nexpert's multi-value feature has to be used. A *multi-value* is a slot in string format which can hold a list of individual items that can be extracted or manipulated separately. By storing the vectors of the assigned Market, Product and Organisation objects in individual slots, special execute library routines enable the stepwise refinement of the Script definitions and generate the Atoms dynamically.

```
Rules Import_Script and Decode_Script
Retrieve records from database table Script and Assign to class Script
         IF     slot Roots(1-6) = On  OR slot Vision(1-6) = On
         THEN CreateName based on |Logic| and counter (1-6)
              IF        Object with CreateName does not exist
              THEN      CreateObject and assign to class ToBeDecoded
              ENDIF
              Store |Market|, |Product|, or |Orga| of Object in multi-value list
         ENDIF
FOR ALL objects of class ToBeDecoded
    IF    defined ParentObjects exclude classes Market, Product or Organisation
    THEN add ParentObject which depicts TopObject of respective classes
    ENDIF
    Generate cross product from ParentObjects for current/envisaged model
    Store generated results as dynamic objects in class AtomsRoots/AtomsVision
    Link  each Atom to |Center| and |Logic|, create parents if not existing
ENDFOR
Rules Control_Substitution_Atoms
FOR ALL Atoms of envisaged model
    IF    slot Activation = Off
          Analyse   |Market|, |Product|, |Organisation|, |Activity|, |Variable|
          Replace   any de-activated parent with its next activated direct parent
          IF        |Center| or |Logic| with new combination does not exist
          THEN      CreateObject, Assign to class and Parents, update attributes
          ENDIF
          Create    Links between Atom, |Center|, |Logic|, update attributes
    ENDIF
ENDFOR
Rules Control_Assignment_Atoms
FOR ALL objects of class Atoms
    Relevance      = (|Center|.Rel.* |Logic|.Rel.)* POWER(1/5) * Relevance?2)
    Analyse slot |Logic|.Activ. and |Center|. Activ. and set counter slots
    LogicOnCenterOn, LogicOffCenterOn, LogicOnCenterOff, LogicOffCenterOff
ENDFOR
         Order of Sources - if not specified: 1) = Off ; 2) = 99%;  |x| = parent in class x
```

Figure 8.1: Configuration and Control for Script and Atoms

Subsequently, a rule examines all Atom objects which have been de-activated and, hence, are not part of the envisaged planning model. To adequately consider and pool their significant data within other input objects, the presence of activated higher-aggregated Atoms has to be assured whereby further Logic-Center-links might have to be created dynamically. Thus, all initially defined Atoms via Script, which detail the present or conceivable differentiation of the companies' actuals, are either used directly or are closely linked to and substituted by variables used in the envisaged model. To establish the consolidation of the Atoms, the last rule in figure 8.1 analyses and stores the state of their 'Activation' in four dedicated properties.

Figure 8.m demonstrates the application of the assignment rules. It covers a full branch of the network and shows the computation of the activation and evaluation parameters. The number stated after an activation parameter counts the input values of all parent objects in the branch set to 'Off'.

ID	Class Name	Object Name	Status	Potential	Feasibility	Relevance	Activation case A	Activation case B
	Basic Objects							
1	Organisation	StreetWorkCompany	27	62	11	26	On	On
2	Organisation	StreetWorksPlant 1	27	43	10	23	Off 1	Off 1
	input values	(parent is number 1)	99	70	90	-	Off	Off
3	Product	Asphalt Surfaces	81	63	89	77	On	On
4	Product	Recycled Material	95	89	89	91	Off 1	Off 1
5	Market	External Customers	90	90	90	90	On	On
6	Activity	Sales, Marketing	44	6	44	23	On	On
7	Variable	Personnel Costs	36	36	36	36	On	On
	Complex Objects							
8	Center	1 x 3 x 5	-	-	-	18	On	On
	input values		-	-	-	-	On	On
9	Center	1 x 4 x 5	-	-	-	22	Off 1	Off 1
	input values		-	-	-	-	On	On
10	Center	2 x 4 x 5	-	-	-	18	Off 2	Off 2
	input values		-	-	-	-	On	Off
11	Logic	6 x 7	-	-	-	8	Off 1	On
	input values		-	-	-	-	Off	On
12	Atoms	8x11 = 1x3x5x6x7	-	-	-	7	Off 1	On
13	Atoms	9x11 = 1x4x5x6x7	-	-	-	17	Off 2	Off 1
14	Atoms	10x11 = 2x4x5x6x7	-	-	-	8	Off 3	Off 2

- not applicable

Figure 8.m: Example of the hierarchical Dependencies within the Object Network

The line „input values" under Object 2 and 8 to 11 exemplifies the workings of the object-specific assignment process. The 'Activation' parameter are calculated using Boolean algebra and are based on object-specific input values and the parent objects' activation states. Not specified input default to 'On'.

Regarding the evaluation, the user is offered four choices: 99%, 90%, 70% and 40%. If an input has not been specified, a default of 99% is used. The result is the product of this input multiplied by the figures inherited from the parent objects. In this way, the 'Status', 'Potential' and 'Feasibility' of Basic Objects and the strategic 'Relevance' of Complex Objects are computed. The 'Relevance' for Basic Objects is calculated as the cubic root of the product from 'Status', 'Potential' and 'Feasibility'.

Consequently, dependent objects are always lower than their parents. Since top objects are set to 100, subobjects' values range from 99 to 0. Merely the Atoms are an exception. Since they do not have to be directly compared with their parent objects during Pareto-analysis, the fifth root (five basic parent objects) is taken from their 'Relevance' to facilitate more contrasting results.

Concerning the 'Activation' the example shows that none of the three Atoms have been considered in the case A-scenario. In case B, however, Atom 12 (personnel costs attributed to sales and marketing of asphalt surfaces for external customers in StreetWorks Company) is earmarked for inclusion in the envisaged model.

To lessen memory requirements, Atoms are not individually represented as objects but as relationships. Two subobjects for the current and the envisaged model inclusion are generated for each Logic object and can be linked to any Center of interest. Figure 8.n shows one of those subobjects by concentrating on the attributes and values of the three Atom objects depicted in the example given in figure 8.m.

Object: 'consolidated' Object of class AtomsVision for the envisaged model
I Logic I Personnel Costs attributed to Sales and Marketing regarding ...
I Center I (1) ... asphalt surfaces for external customers in StreetWorks company
(2) ... recyled material for external customers in StreetWorks company
(3) ... recyled material for external customers in StreetWorks plant 1

I x I = parent in class x	LogicOn CenterOn	LogicOff CenterOn	LogicOn CenterOff	LogicOff CenterOff
Analysis of Atoms 1-3 (case A/B):	0 / 1	1 / 0	0 / 2	2 / 0

Figure 8.n: Example of 'consolidated' Atom Objects (based on example in figure 8.m)

■ What-If Revision, Proposals and Actions

After the configuration, assignment and control tasks have been carried out, the referential integrity and the attribute values of the case-specific knowledge base are verified. Additionally, all specified potential actuals are linked to activated Atoms. However, to conform with the user's assessments, the objects activated for the envisaged model design should possess the highest strategic relevance rankings.

In case this constraint is violated, the further inference processes need to focus on the elimination of these imbalances, either by modifying the activation or the evaluation values. In figure 8.m, for example, the relevance of Atom 12 is lower than 13 and 14 but the only one activated.

Since changes cascade down the defined relationships, the effects caused within the object network by any modification vary extensively. Shifting data expenditures, in particular, have to be considered in deciding which of the detected constraint violations have to be tackled with priority. The multitude of objects, on the other hand, prohibits the carrying out of a conventional *what-if analysis* (chapter 6.5.4) due to the excessive processing time required.

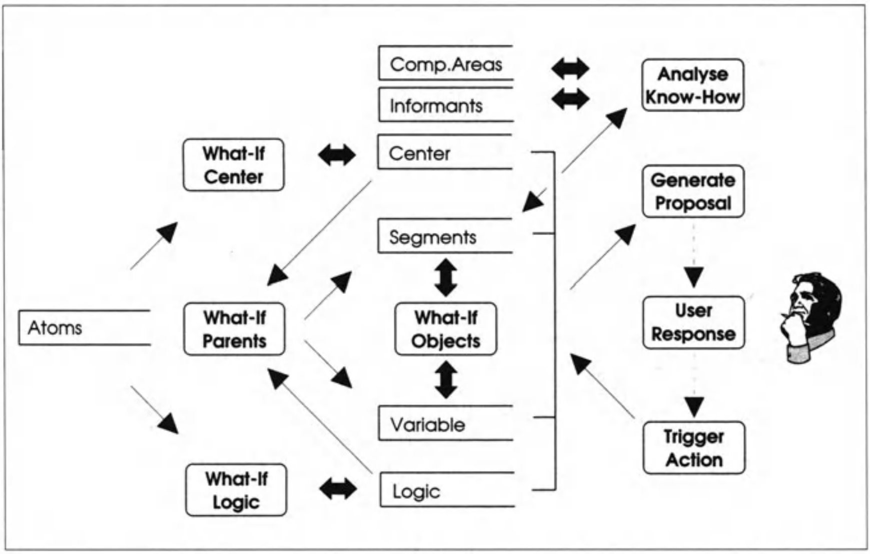


Figure 8.o: Data Flow Diagram for What-If Revision, Proposal and Action

Figure 8.o exhibits the data flow diagram of the knowledge bases *Meta-What-If*, *Meta-Propose* and *Meta-Action* (figure 8.a). In order to support the further configuration process, an alternative approach to direct the what-if revision is taken.

Based on the *'consolidated'* Atoms which summarise the Atoms assigned according to their inherited activations (figure 8.n), further bottom-up aggregations are carried out. First the 'Logic?Center?' parameter are totalled and assigned to their Logic and Center parent objects. Then these figures are added up for their parents in the classes Variable, Activity, Market, Product and Organisation. Finally, parent-child relationships within these classes are considered.

During this process, rules determine the object-specific scope for shifts in the data expenditure levels. Six distinct categories are used to tabulate activation state modifications and the resulting consequences which would be triggered by the inheritance methods applied (chapter 6.5.2):

- Activated Atoms always belong to the category AllYes. The de-activation of any parent will de-activate these Atoms and decrease the data needs accordingly.
- Atoms set to 'Off' because both parents are de-activated (Logic <u>and</u> Center) always belong to the category AllNo. No single change of a parent's activation is able to change these Atoms' states since at least one other parent will still be de-activated. Consequently, data needs will not be influenced either.
- Atoms set to 'Off' because of only one de-activated parent (Logic <u>or</u> Center) belong to and stay in the category NoYes if the <u>activated</u> parent's branch is consolidated; no de-activation of any of the superior objects can change the state of these Atoms. If the <u>de-activated</u> parent's branch is consolidated they belong to the category CanYes and have to be further analysed on each level of the consolidation process to determine their potential impact on the data needs:
    - If more than one superior parent is de-activated, the number of CanYes-Atoms is re-assigned to the category NoYes since no activation of any of these superior objects can change the state of the dependent Atoms.
    - If only one of the superior parents is de-activated, the number of CanYes-Atoms is re-assigned for this particular parent to the category MeYes since a change to 'On' will activate these Atoms and increase the data needs. For further consolidation, they are assigned to the category OneYes to point out that more superior parents are not able to change these activation states.

By systematically analysing the activation states, this *rule-based approach* allows the review of the implication of any model modification caused by adding or excluding an object. To further support design decisions, the 'Pareto' parameter is calculated, which indicates the average strategic relevance of the Atoms sensitive to object-specific activation changes. The results establish the base to estimate *data expenditures* and to generate *proposals for model improvement*. They also provide statistics for the system control, since only AllYes-Atoms and OneYes-Atoms can be influenced by particular changes of activation.

In case multiple de-activations would cause a *deadlock*, since too many Atom objects are exempted from the further design changes, additional rules could be triggered. Without changing the configuration of the existing envisaged model layout, their task would include the elimination or shifting of redundant de-activations. These rules have not yet been implemented in the current prototype.

Only the envisaged model object set is influenced by the activation parameter and needs to be subjected to the knowledge based design improvement. The current model object set acts solely as a *yardstick* for comparison and any contradictions concerning activation and relevance values only reflect the inadequacy of the former/current model in light of the actual evaluations. However, to provide the necessary statistics for benchmarking, an inventory of the respective Atom objects has to be taken as well for the current model although on a much lesser detail.

A further rule in *Meta-What-If* (figure 8.p) analyses the available know-how of the Competence Areas defined. It assigns the aggregated 'Competence Availability Factors' to the parent objects in the respective classes Segments and Informants in order to detect information gaps and individual burdens on information sources. Finally, proposal rules sort all objects according to their specific *relevances* and *data needs* to conduct a Pareto-analysis. The objective is to provide the basis for determining the most likely (object) candidates for model design rectifications.

```
Rules Competence_Consolidation
 FOR ALL objects of class Competence_Area
    IF    slot Competence Availability Factors is set
          Allocate its Value¹⁾ to | Segments |
          Allocate its Value¹⁾ to | Informants |
    ENDIF
 ENDFOR              ¹⁾ Order of Sources, if not specified: 0%     | x | = parent in class x
```

Figure 8.p: Processing of Competence Areas in structured English

As described in chapter 7.3.5, this Pareto-analysis is carried out for the *ideal, current and envisaged model.* Consequences of design changes can thus be set against the planning model currently used, and a comparison with the ideal distribution indicates the potential for further improvement.

Figure 8.o also exhibited the data flow diagram of the knowledge bases *Meta-Propose* and *Meta-Action* which include the rules for proposals and the subsequent actions to be carried out in response to the user's acceptance or rejection. The data stores shown refer to non-Atom objects only since all Atom-related computations have been carried out in the previous knowledge base modules. The data flows represent the access of the data derived from the What-If and Pareto-Analysis.

```
Rules Proposal_to:                 Streamline       Expand
IF   DataRequirements =            Too High         Not Too High
     FOR ALL                       activated        de-activated     objects (not Atoms)
     Select     object with        lowest value>0   highest value    in slot Pareto
     ENDFOR
     Propose    to                 de-activate      activate         selected object
ENDIF

Rules Proposal_Differentiation
     FOR ALL    activated basic objects which are leaf objects within their class
                with no further basic subobjects but activated dependent Atoms
          IF    slot Relevance is among the highest scores
                Propose    to further differentiate the object
          ENDIF
     ENDFOR

Rules Proposal_Terminate
     FOR ALL objects except Atoms
          Select     de-activated object with highest value in slot Pareto
          Select     activated object with lowest value in slot Pareto
     ENDFOR
     IF   slot Pareto of activated object >= Pareto of de-activated object
          Propose    to terminate configuration process (no more imbalances)
     ENDIF

Rules Action_after_User_Response_to_Streamlining_or_Expansion_Proposal
IF     Accepted      THEN Change Object.Activation; UPDATE Activation, What-If
ELSEIF Rejected      THEN Change Object.Relevance; UPDATE Evaluations, Pareto
ELSEIF Withhold      THEN Mark Object for Postponement; GENERATE New Proposal
ENDIF
```

Figure 8.q: Knowledge Base for Proposal and Action in structured English

The proposal rules which are further detailed using structured English in figure 8.q select appropriate objects to be modified and recommend these changes to the user. Depending on his reaction the activation or evaluation of the particular object under review is altered. All other changes required are data-driven, since the system control is handed back to one of the previous modules. The proposals recommended to the user cover

- the *streamlining* of the model by de-activating low relevance objects with comparatively high data requirements
- the further *expansion* of the model by activating high relevance objects with reasonable additional data needs
- the more detailed *differentiation* of the model by focusing on high relevance objects with no parent objects but activated Atoms with relatively high relevance
- the *termination* of the configuration process since no imbalances can be detected.

8.4.4 Dynamic Model

The *dynamic model* describes „those aspects of a system concerned with time and the sequencing of operations" [RUMB91 18]. By capturing the elements of control, the relations between states and events can be shown in state diagrams. A *state* is an abstraction of an object with its values and links depicted at a certain point in time, drawn as a rounded rectangle. An *event* changes states by triggering actions (instantaneous) and activities (time-consuming). The *transitions* are drawn as directed arcs.

Figure 8.r exhibits the state diagram of the *inference process*. Rather than showing the transition of individual objects (e.g. by inheritance), it focuses on the state of the case-specific knowledge base as a whole. After the user calls up the rule-based modules by selecting the 'Knowledge Inferencing' option from a pull-down menu, a number of activities are performed which have been discussed previously. Each of these processing steps alters the objects and their relationships in an unique way and results in a distinct state of the overall network as indicated by the labels within the rectangles.

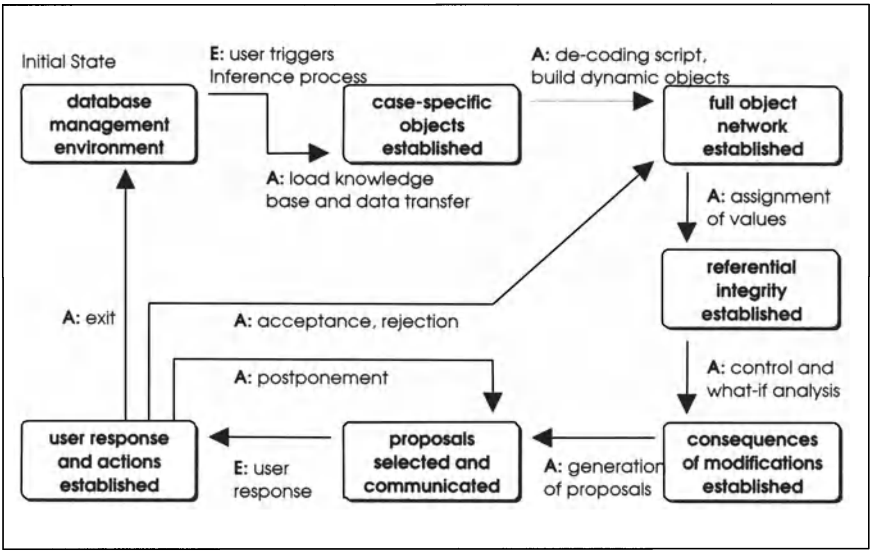


Figure 8.r: Dynamic Model of Meta-Planner

Since the inference process is data-driven and fully controlled by rules, only one further external event has to be initiated by the user: his response to the proposals submitted. As a consequence, the control is either referred back to the database for analysis and modification or to the rule-based modules in which case subsequent actions are triggered by the object-specific updates which have been taken place. In any case, the respective results of the analysis are transferred to the relational database to secure the conformity of information.

Figure 8.s shows the knowledge-based modules depicted in figure 8.a and described above. It lists the sizes of their respective ASCII-text files and the structure of their technical knowledge representation.

A feature of the expert system shell allows to specify user-defined methods. Their flexibility allows to define 'rule-based subroutines' which can be called from the main rules to work on similar tasks for different classes and objects. Together with the mechanisms referred to in chapter 8.4, they enable the multiple application of one rule where otherwise many rules would have to be used. Consequently, the actual Nexpert-rules are dedicated to general control tasks and statistical reporting, whereas the user-defined methods have to process the objects and their data.

Knowledge Base	kByte ASCII file	Number of Rules	If Change Methods	Order of Sources Methods	User defined Methods	Rule and Methods Total
Meta_Structure	4	1	-	-	-	1
Meta_Attributes	15	-	-	-	-	-
Meta_Import	18	8	15	3	5	31
Meta_Assign	19	8	-	17	10	35
Meta_Control	8	4	-	-	7	11
Meta_What-If	16	4	-	-	13	17
Meta_Proposal	6	4	-	-	4	8
Meta_Action	4	4	-	-	1	5
Meta_Export	5	5	-	-	-	5
Total System	95	38	15	20	40	113

Figure 8.s: Statistical Information related to the Knowledge Bases

8.5 Summary

The requirements regarding the implementation of the methodology, which are recapitulated at the beginning of the chapter, have resulted in the decision to support the prototyping of *Meta-Planner* by using two different *technological environments*. Based on a relational database management system and an expert system shell, an introduction to the overall *system architecture and control structure* explains the division of tasks as well as the particular tools used to carry them out and to link the processes.

Subsequently, the *database management functionality* is further detailed by focusing on the user communication services to be provided by the user interface, the database design with its table structures and relationships, and the menu structures implemented to facilitate quick and comprehensive data access.

Likewise, the *knowledge based functionality* is elaborated. By referring to the modular decomposition of the processes as discussed in chapter 7.3, the reasons for the knowledge design are clarified and its object, functional and dynamic model is particularised. Furthermore, statistical information is given to quantify file sizes and to detail the number of methods and rules used in the different knowledge bases.

A short introduction to the *features of the tools* which led to their selection precedes the respective sections.

9 Results and Perspectives

9.1 Qualitative versus Quantitative Planning

In his *critical assessment* of strategic planning, Mintzberg warns „how a bias toward the quantitative can allow the economic to displace the social and the financial to displace the creative" with the result that „hard data can seriously bias and distort any strategy making process that relies on it excessively" [MINT92 258].

Crucial data for strategy making relies to a large extent on *soft information* gained by meeting the troops, customers, suppliers, competitors, and so on. Because the scope and richness of most of this information cannot be expressed in numerical terms, it tends to be excluded if informants are forced to express their views in the restricted format of an *over-formalised numbers-driven planning system*. By demanding administrative efficiency from participants rather than ingenuity and creativity, their motivation is stifled and important perceptions gained from their informal network of contacts might be left out.

Quantitative modelling can never be a *substitute* for the qualitative aspects of strategic analysis and management. An annual ritual of producing reams of numbers cannot satisfy the organisational need to engage in strategic thinking, just as numeric controls do not suffice for an adequate setting of strategic direction [MINT92 86]. Hence, the use of models constitutes a *downstream activity* in the strategy making process which primarily should take place after an assessment of the soft and hard data available and the various views expressed has been carried out.

Moreover, *model development and maintenance* should be considered as one particular outcome of the strategic management process, namely the future intelligence policy. Its first objective is to determine if the application of an comprehensive quantitative model is likely to enhance the insight into the company's activities at all, and if the benefits justify the expenditures encountered in collecting the additional data required and in implementing the organisational processes necessary.

If the answer is NO, quantitative modelling might be confined to *localised and isolated applications* (financial analysis, investment appraisal, sales budgets, etc.), and the implementation of strategies and the further development of success factors is carried out on the basis of definite strategic projects and detailed action plans only.

However, if the answer is YES, specific and realisable demands have to govern the model building and maintenance process. *Benefits, expenditures and deficiencies* of preferably every relevant model component ought to be analysed in order to enhance the feasibility of the data procurement and to strengthen the organisational acceptance of the final system.

Most of this *meta-information* can only be gathered from those individuals who will be subsequently responsible for the data supply and its inherent strategic commitments. Hence, sources of information have to be identified and their availability and reliability need to be taken into account since time and cost-related constraints as well as organisational changes (e.g. fluctuation, transfers) can seriously affect the performance of the envisaged planning system and its underlying model.

The third part of this study has introduced a methodology which fully considers these important aspects. The implemented prototype *Meta-Planner* makes use of a relational database system to record the results of the meta-planning activities in form of object-specific comments, current figures and scorings, and provides a thorough *documentation* for the subsequent programming of the model and important organisational *requirements* of the planning cycle.

Moreover, in using knowledge-based technologies it analyses the *interdependencies* between the variables and segmental structures defined and estimates the *data needs* of envisaged model layouts in comparison with the currently used planning system. Based on the changing data requirements induced by potential modifications and the relative strategic relevance of planning objects, *Meta-Planner* proposes model enhancements and guides the iterative configuration process.

By incorporating *established methodologies* (Ansoff, Abell, Porter, Kaplan, Bircher), the conceptual framework provided closely corresponds to the structures recommended for qualitative strategic management. In supporting a know-how already familiar to the planner, the system furthers the ability to uncover those mix of segmentation concepts and alternatives which best benefits the company.

To consider the design options available in a solution space governed by the effects of combinatorial explosion, an *innovative approach* has been introduced to define, edit, combine, evaluate and choose the most suited planning objects for quantitative strategic modelling by utilising scoring methods, rule-based what-if analyses, inheritance methods, and selection heuristics based on the Pareto Law.

Meta-Planner, thus, enables the handling of a complex network characterised by a multitude of objects and relationships which can neither be adequately controlled manually nor by an algorithm, and generates the following *results*:

- transparent documentation of the meta-planning process and its findings
- assessment of current systems in respect to the actual strategic necessities
- estimation of data requirements for the current and the envisaged system
- blueprint of the model configuration for programming and maintenance
- unambiguous links between numerical strategic targets and operative actuals due to clearly defined relationships between the different levels of aggregation
- naming of qualified information sources available for data procurement
- assignment of responsibilities to establish segment-specific competence areas.

Ultimately, these outputs together with the process initiated by the employment of the methodology offers the following *benefits*:

- capability to secure and enhance organisational learning via effective knowledge management
- systematic approach to profit from the operative and corporate know-how at hand
- better understanding of the organisation and its structure and environment
- thorough foundation for more effective planning, implementation and controlling
- ability to explore alternative strategies on a transparent quantitative basis
- greater confidence in and a better quality of strategic decision-making
- an efficient way to reduce complexity and to promote the company-wide acceptance of systems, strategies and actions taken.

9.2 Prototype and Case Study

Chapter 5.3 detailed the specific needs and constraints concerning the development of the methodology and the prototype system. Figure 9.a provides a cross-reference table which points out the sections where the conceptual and implementation issues of these requirements are discussed.

Chapter 5.2.2 introduced a former strategic planning project which was completed by the author in 1990 for a company which was given the alias *QuarryCon Ltd*. The project included the configuration and application of a quantitative model to assess the *financial implications* of the business and functional strategies and to test and confirm the re-evaluated *overall strategic direction*.

The data and experience gained from this project supported the development of the methodology and the testing of the prototype. It furnished the data used in screen shots and examples throughout the documentation of this study. However, first of all it enabled the author to compare process and results of the former manually conducted model configuration exercise and to confirm the additional benefits gained from the computerised knowledge-based tool *Meta-Planner* as detailed in chapter 9.1.

To give an indication of the number of objects to be investigated and the efforts involved, figure 9.b shows a table which lists the different object classes discussed previously and which details the number of the company-specific objects in the case of *QuarryCon Ltd.*

A total of 256 Basic Objects have been included in the study. Column 1 includes the totals of the different subclasses, column 2 the number of objects activated, and the following columns labelled 'Level x' how the objects are distributed in respect to the hierarchical levels.

Below some statistics for the Complex Objects are given. Competence Areas, Equations and Templates have not been fully defined. Since they do not effect the data requirements (no additional input needed) and, therefore, the knowledge-based processing, they have only been included for demonstration purposes.

928 Script entries were based on 108 Logic objects and, after being processed by the knowledge-base, resulted in the specification of 2114 potential input parameter (Atoms) in 748 distinct Centers.

Chapter, Specific Needs and Constraints	->	Chapter, Topic of Implementation
5.3.1 Established Strategic Management Concepts		
Strategic Success Profile (Bircher)		6.1 Segmentation
Value Chain Analysis (Porter)		6.1.1 Activities
Business Segmentation (Abell, Ansoff)		6.1.1 Markets and Products
Activity-based Costing (Johnson, Kaplan)		6.3 Variables
5.3.2 Company-specific Characteristics		
Segmentation Structure, Responsibility Center		6.1 Basic Objects, Relations
Information Sources, Competence Area		6.2 Basic Objects, Relations
Variables, Model Logic and Atoms		6.3 Basic Objects, Relations
Static and Case-specific Knowledge Base		7.1 General Architecture
Basic and Complex Planning Objects		7.2 Conceptual Framework
Objects and Relationships		8.4.2 Object Model
5.3.3 Multitude of Planning Objects		
Entry of Planning Objects and Relationships		7.3.1 Initial Data Input Module
Updating of Data and Revision of User Beliefs		7.3.2 Rectification Module
Database Integrity and User Interface		8.3 Database Management
5.3.4 Combinatorial Explosion of Data Needs		
What-If Analysis		6.5.4 Sensitivity Analysis
Estimation of Data Requirements		7.3.6 What-If Revision Module
Rule-based Approach		8.4.3 Functional Model
5.3.5 Traceable Model Design Decisions		
Availability of required Input Data		6.2 Information Sources
Evaluation Parameter		6.4 Attributes
Evaluation Method		6.5.1 Multiple Criteria Decisions
5.3.6 Model Design Rectification		
Activation Parameter and Strategic Relevance		6.4 Attributes
Pareto-Analysis		6.5.3 Heuristics
Ideal, Current and Envisaged Model		7.3.5 Control Module
Suggestions of Model Design Rectifications		7.3.7 Proposal Module
5.3.7 User Interactions		
Definition of Responsibility Centers		6.1.2 Relationships
Activation and Evaluation Parameter		6.4 Attributes
Handling of missing Values		6.5.2 Inheritance
Generation of dynamic Objects		7.3.3 Configuration Module
Calculation of dependent Values		7.3.4 Assignment Module
Decoding of Model Script		8.4.3 Functional Model
System Control		8.4.4 Dynamic Model
5.3.8 Documentation and Maintenance		
Current and Envisaged Model		7.3.5 Control Module
Comprehensive Information System		8.1 System Architecture

Figure 9.a: Reference to related Implementation Issues

Object Class	**Total**	**Acti-vated**	**Top Level**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**
Organisation	38	38	1	4	10	23	-	-
Market	18	3	1	3	4	10	-	-
Product	42	42	1	3	25	13	-	-
Activity	23	23	1	3	11	6	2	-
Segments, total	121	106	4	13	40	52	2	-
Flow, financial	36	36	1	3	19	11	2	-
Flow, non-financial	6	6	1	3	2	-	-	-
State, financial	52	52	1	2	7	13	20	9
State, non-financial	9	9	1	3	2	3	-	-
Variables, total	103	103	4	11	30	27	22	9
Special Ratios	13	13	1	1	11	-	-	-
Informants	19	19	1	2	6	10	-	-
Basic Objects, total	256	241	10	27	87	89	24	9
Competence Areas	48							
Equations	22							
Template	6							
Logic	108	50						
Script	928							
Atoms	2114	1514						
Center	748	523						

Figure 9.b: Statistics concerning the Case Study of QuarryCon Ltd.

Included in the 108 Logic objects are 50 explicitly defined Variable-Activity-combinations; 58 were dynamically created during the inference process since de-activated Atoms had to be substituted by higher aggregated Atom, Logic and Center objects. As a consequence of the evaluation and selection process, 523 distinct Centers (Market-Product-Organisation-combinations) were referenced in the final future planning model layout which resembled a total of 1514 multi-period input values (Atoms).

9.3 Further Potential for Development

The areas to further enhance the features of *Meta-Planner* can be grouped into technological and methodical advances, and the automatic generation of an executable calculation model.

■ Improvement of Technical Conditions and Current Features

- The *standard database bridge* of Nexpert Object only allows to access flat file formats. Since ACCESS uses its own file manager, the data transferred from database to knowledge base and vice versa has to be duplicated and stored also as DOS-files in dbase III format.

  However, the utilisation of Nexpert's *Extended Database Access Module* enables now the direct access of relational database tables via SQL-statements which also speeds up the transfer operations.

- As discussed in chapter 8.4.3, multiple de-activations in the same line of inheritance could cause *deadlocks*. Objects affected are exempted from the next iteration of design proposals. Since any single change of activation in the network does not alter their state, the what-if and Pareto-analysis do not cover them temporarily in their set of potential recommendations.

  Further rules could be added to the generic knowledge base which would enable the inference engine to break any deadlocks if they were to become noticeable obstructions in the configuration process. These rules would shift de-activations of parent objects which have been identified as *redundant*. The overall configuration of the envisaged model layout, which depends on the activation states of the Atoms, would stay unchanged.

- The *user-defined activation of objects* for the envisaged model layout could be further differentiated by incorporating Atoms. Currently the Script specifications detail cross products whose Segment-Variable-combinations represent the current planning system and the present or conceivable differentiation of the companies' actuals. The decision regarding which of the so defined Atom objects are to be part of the envisaged planning model is entirely controlled by the inheritance of the parents' activation settings.

  The current toggles ('On', 'Off') of the Script specifications (figure 1.g) could be substituted by multiple-choice fields to cater for the additional information required. Fields not set would indicate that the combination is not relevant, positive settings would show evaluated activated Atoms; negative settings evaluated de-activated Atoms.

  Due to the extended functionality the current decoding process would have to be changed. Additionally, the Script specifications in the relational database would have to be updated if accepted or rejected proposal rules change the settings of Atoms. Menus and screens could stay unchanged.

To enable user-defined settings for each specific Atom, however, would also require extensive changes to menus and data entry screens. The current Script input method would have to be dis-continued, since individual Atom settings could not be reflected adequately in the less granulated cross-product-oriented Script definitions. As a consequence, the user would become fully aware of the dilemma of combinatorial explosion. The number of user interactions required would rocket and the transparency of the system and the case-specific data would seriously be diminished.

■ Extension of the rule-based Proposals

Meta-Planner has been devised to act as a companion for the configuration of strategic planning models irrespective of the branch, industry, size, etc. of the company under review. However, these aspects naturally play an important role in finding the model design best fitting the particular needs of an organisation. A fertile area for further development would be to add information and know-how about planning issues which address particular characteristics of the businesses concerned.

Potential sources of additional expertise would include academic and empirical research in the area of management science and model management, planning tools and methodologies successfully applied, practical and heuristic knowledge of planners, consultants and decision makers, insights and perceptions of accountants, auditors and planning participants, and so on.

In structuring the relevant data and by providing a rule-based access to this know-how, the potential services to be offered could range from training and clues for novice planners, to valuable tip-offs for planning experts or to efficiency increases if employed in professional model building or system auditing. Although the number of influencing factors which could be considered is immense, the expertise would be primarily used in the following ways:

- *Classification*
  Based on an assessment of the company under review, the resulting profile is matched to a knowledge base containing information of other firms. Depending on the similarities found, the planner is provided with material and proposals concerning the general layout of his planning system.

  Relevant topics would cover managerial aspects like the *Corporate Culture* and *Styles of Leadership*, the prevailing *Belief in Planning and Planning Systems*, the *Level of Decentralisation* encountered and the *Degree of shared Responsibilities* and *Planning Skills* within the organisation.

Additionally, different points of strategic emphasis could be analysed. A predominant orientation towards *financial, process, social* or *ecological objectives* or a prime commitment towards *customer or shareholder value* provides ample scope for special recommendations or, for instance, the introduction of class-specific weighting factors for the current implementation of *Meta-Planner*.

- *Methods*

Already discussed to some extent, a wealth of concepts and methods exists to support all phases of the strategic management process. Each of these tools, if correctly applied, provides valuable insights for the decision making process but also demands certain data. Additional rules could explain the specific benefits and data needs for their application. Moreover, they could assess the actual model design and recommend those instruments which could be employed on the basis of the defined layout or by minimal additions of objects or variables.

One important method in this respect is *comparative analysis*. Based, for example, on the company's geographic scope, industry, branch, size, activities or success factors, external *statistics and empirical studies* exist (e.g. federation of industry, market studies, country reports, PIMS-study [BUZZ89]) which can be used to measure up the own historic or planned figures to the ratios of apt benchmark organisations or to link variables to external indicators and projections available.

A second alternative are those methods which are not directly linked to data but provide concepts and checklists to carry out *environmental or organisational analysis*. Some methodologies already presented (chapter 6) fit as well into this category as, for example, Porter's *Five Forces Scheme* of competitive strategy [PORT80], Barabba's *Market Research Encyclopaedia* [BARA90], Rappaport's *Shareholder Value Analysis* [RAPP86].

A third category to be considered are *strategic management tools*. Their aim is to systematically represent and visualise strategic conditions or consequences. They depend on certain data inputs which can also be included in the model structure. Due to their self-contained character, tools can become an integrated part of the final implementation by being linked directly to the model output generated in form of profiles or charts. Examples of established tools to be covered are the different types of *Portfolios, Experience Curves, Gap-Analysis* (all discussed in chapter 2.2), *Value Analysis Charts* (figure 6.c), *Cumulative Profitability Diagrams* (figure 6.g), *Pareto-Analyses* (figure 6.1), *Break-even Analysis* [ARMS93 321].

- *Comparison*
  In building up a database of planning models in other enterprises, a company-specific model under review could be compared to those of similar organisations. Submodels for certain organisational entities could be used as an example or as a default model which could be adapted to the company-specific needs. Key information of the meta-data, for example, data requirements or differentiation, could be set against other model designs used to provide a yardstick for the configuration process.

The extension of the knowledge base to cover the issues of classification, methods, and comparison would enable an *auditing of quantitative planning systems*. Based on the current model, strategic relevances and the differentiation of actuals, the inference process would critically review the system and provide a written appraisal to point out strengths and shortcomings and to recommend potential improvement.

■ Automatic Compilation of the Decision Support System

Meta-Planner provides a blueprint of the model configuration for the system developer. In order to calculate the ratios, consolidate the segments and produce the outputs as specified during the meta-planning process, this *blueprint* has to be transformed into a program which can be executed by the decision support system or spreadsheet selected.

Since the objects to be considered, the paths of consolidation, and most of the equations are detailed already in a relational database, a potential area for further development would be the building of a *compiler* to create this executable program automatically.

Since all information relevant is stored in ACCESS tables, a calculation via EXCEL would be one of the options available. The transfer of object names or data between the database and spreadsheet does not raise any problems since the import/export-facilities provided are easy to operate. However, the crucial issue to be addressed relates to the transfer and implementation of the hierarchical relationships and the equations.

9.4 Competitive Analysis

The common feature between the expert systems used in strategic management as introduced in chapter 4.3 and *Meta-Planner* is the objective to support the strategic decision making process. Whereas the systems concentrate on particular aspects in providing direct help in the analysis, choice, implementation or controlling phase, *Meta-Planner* offers assistance indirectly by specifying *quantitative models* tailored to the specific needs of the company. The resulting model and subsequent planning cycle, however, positively affects all those phases:

- in gathering and surveying those quantitative data estimates which have been rated to be useful, strategically relevant and feasible to project (analysis)
- in applying different levels of detail to suit the distinctive features and strategic scope of the organisational entities (documentation of strategies and choice)
- in establishing a consistent basis to further detail strategic objectives in shorter-range and more operative targets, funds and milestones (implementation)
- in defining the relationships between planning variables and their respective set of actuals to facilitate indisputable variance analysis (strategic controlling).

The synergies include the sharing of the quantitative modelling results, since more estimates and increased data quality also benefit the scope and informative value of applicable qualitative methods. An extension of *Meta-Planner's* rule-based proposals as suggested in the previous chapter would increase these synergies further since the qualitative information available could be utilised more intensively too.

This inclusion of additional rules based on qualitative company data would also widen the scope for *interpretations*. While the present prototype is able to compare the envisaged planning model with the one currently used, an expanded knowledge base could provide opinions about the design by drawing conclusions related to other companies, the branch, methods applicable, and so on.

There are a number of similarities between *Meta-Planner* and *Quantor* [SCHO93]. Both allow the building of models on the basis of definitional relations (chapter 3.3.3), disapprove of the inflexibility of conventional models caused by the rigid set-up of input-output relations, and aim to enhance the usability and acceptance of quantitative models.

However, *Quantor* focuses on the *use of models*. It provides *enhanced spreadsheet functionalities*, but the decisions, which organisational entities, variables and relationships to include in the model layout have to be taken outside the system. Consequently, links between variables to be planned and actuals conceivable are only covered if they are either fully integrated or externally documented. Its *knowledge-based functionality* concentrates on deducing the model equations required by analysis of the relations and the data specified.

Meta-Planner, in comparison, specialises on the processing of *meta-information* and proposes *model improvements* based on the strategic relevance of potential planning objects and the changing data requirements. The model design process is also supported by the built-in relationships of templates to specify variables (figure 6.i). The method of calculation, however, has to be deduced by generally applicable macros in the decision support system (e.g. Excel, FCS) which executes the specified model.

Respective routines have been successfully applied to process the planning data in the case study and other projects. By allowing *alternative ways of input*, priorities to be defined determine the value to be used in case of over-specification. If data is missing, zero-growth rates are used or the appropriate 'per item', 'share' or 'turnover ratio' of the previous period is carried over to perform status quo projections.

Thus, flexible means for *data input at the grass-roots level* can also be provided without raising the data needs by the additional specification of upper and lower probability limits as requested by *Quantor*. Models used for the strategic management of multi-dimensional businesses generally are of considerable size and complexity. Hence, data needs are a crucial issue and the planner has to concentrate on getting the right data with the right level of detail for the right organisational entities from the right persons. Any what-if, target, sensitivity or risk analyses can be carried out subsequently, by limiting any additional data needs to the important areas and by using the built-in functionality offered by the decision support system used.

The *Expert Modelling Support System (EMSS)* shares the same motivation with *Meta-Planner*. As also outlined by Yadav [YADA89 31], an information system designer has to distinguish between that part of the real world which is reflected in the system and that which is not. If the number of the parts to be included and their interrelationships are so high that all of its structure cannot be safely perceived or observed at the same time, subsystem structures have to be obtained by perceivable steps of system analysis.

However, in providing a general framework for detailing objects and relationships and for defining information requirements, it supports only the documentation of the system analysis phase. The decisions which of the entities to include in the system design are left to the system engineer.

Meta-Planner, in comparison, enables the evaluation of individual entities. It actively supports the configuration process by considering trade-offs between object-specific relevances and data needs. The system generates recommendations for design improvements and its conceptual framework is geared towards the requirements and segmentation methods of strategic management.

Although the complexities and difficulties in building and operating models within this complex domain of application are often stressed, the related publications still circle around the use, benefits or failures of already established definitional models for long range planning (chapter 3.4). None of the knowledge-based systems in the area of model configuration which came to the attention of the author is specialised for the same type of modelling and domain as *Meta-Planner*.

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