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A Study of Business Structure Modeling Based on Structure Matrix

Takayuki Toyama

Department of Management and Systems Engineering,

Graduate School of Decision Science and Technology

Tokyo Institute of Technology

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1. Introduction

This thesis stands on our acknowledgments of unoccupied area in Management Information System (MIS). Though long years after the emergence of the word: MIS, essential solutions supporting the decision making based on Business Structure Models (BSM) which must reflect the complicated business activities, were laid almost vacant. The aim of this thesis is to show the concrete direction of approaches to BSM with supporting technologies developed with long compilation of ideas and experiences.

The essential aims of BSM would be to provide *Visibility with Transparency* realizing following benefits.

- Expansion of comprehensible span of cooperating people
- To provide common foundation as far as possible to understand each other and to participate though having different background.
- Shorten the time to reach the agreement, if possible

For realizing the solution, our efforts have been paid for following two sides.

- To provide modeling methodologies:

  Commonly business activities consist of those represented non-monetary and monetary values. Non-monetary quantities, unit costs and total amounts of these products must be handled in the same domain as reflecting models of management phenomena. Our efforts were to extend bi-linear modeling method originated in Germany to be able to handle these values in a same domain involving non-linear modeling and Input-Process-Output relations.

  Also effective methodologies for expressing mutual relations like cross-organizations, time series, inside out of hierarchy etc., and mutual relation as group versus group were studied.

- To provide methodologies for expression:

  To express the contents of models into organized table or group of tables would be the direction to provide Visibility with Transparency of BSM in which processing logic and data are coupled. The idea of structure matrix was extended as organized technologies of table processing as interactive packages. Plenty of ideas as concrete table technologies around these directions like dynamic chaining models, recombining of models, type symbols for generalizing application logic, were developed.

In this thesis as part of MIS, we will discuss the needs of BSM, BSM technologies as coupled methodologies of above mentioned and applied cases as BSM.

In this chapter as introduction, following themes would be discussed.

- BSM and around BSM

  The definition of BSM and positioning in MIS will be discussed.

- History of BSM technology

  The developments in Germany then in Japan would be introduced in brief.

- The rudiments of structure matrix in brief as supplementary note

  The essentials of structure matrix will bring you smoother understandings of later chapters.

- The structure of this thesis.

1-1. BSM and around BSM

Business is sounding about structure of business administration based on new idea toward new century. The traditional type of structure in business administration was designed to start from the setting of their business goals, and it was designed how to realize these goals rationally and effectively.

On the contrary, business administration responding new era based on organizational intelligence, should have structure of business administration focused on organizational competence and should be able to draw out various business goals and strategies induced from the organizational competence.

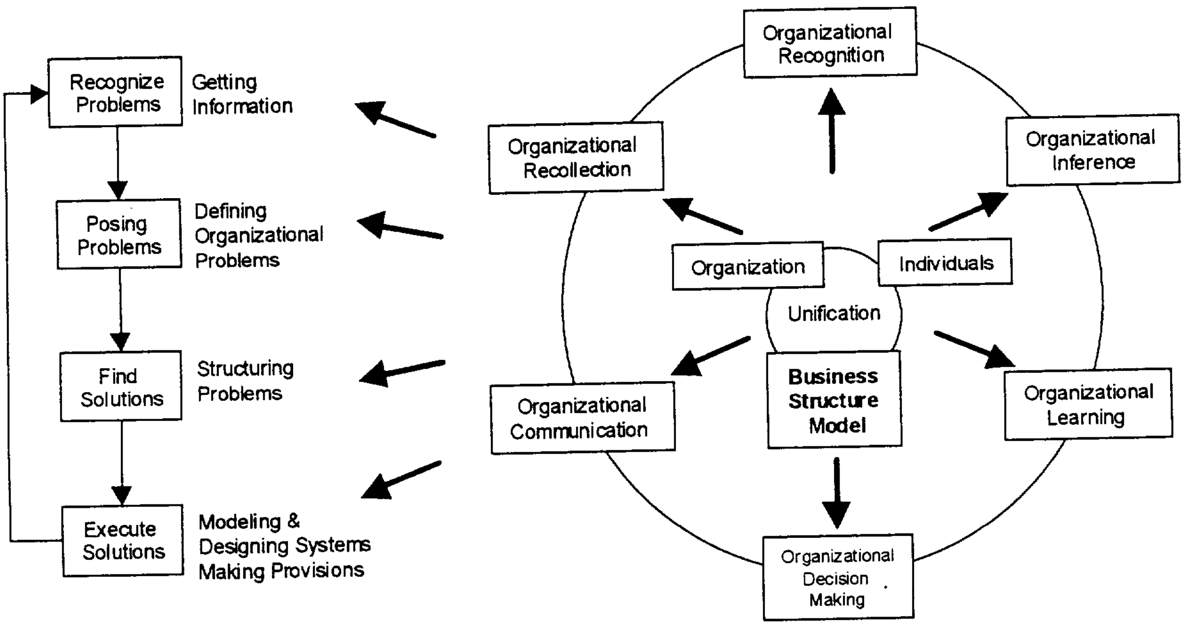


Figure 1-1 Unification of BSM with Organizational Intelligence
(Modified, referencing "Problem Solving Cycle" (Closed) lectured by Prof. Dr. Takehiko Matsuda)

The organizational intelligence is the potential energy to produce strategy and tactics, and is composed of two kinds of intelligence.

One of them is *Business System* whose mechanism has capability to produce commodities and services provided for customers by the business.

Another one is the capability called *Business Cycle* to manage the business systematically and efficiently as corporate widely (improving and revolving the business systems) when the business faces management problems.

Thus organizational intelligence stands up on both structural side and process side. BSM is an abbreviation for Business Structure Model or Business Structure Modeling. As a matter of course, Business Systems Model is a result developed by the work of Business Structure Modeling.

BSM must be in bedded in the business cycle shown in Figure 1-1 and contribute to the sophistication of *Organizational Intelligence*. (We are sure you may find our proposing BSM will surely heighten the possibilities of organizational intelligence in the side of numerically treatable world in business after understanding this thesis.)

Business Structure Modeling must provide methodologies to analyze and investigate better steering conditions near future, by

- Expressing the elements of business components and their causal relations in line with reality
- Reflecting the present status of business involving rearrangement of the assumptions and accompanying their recombination.

Naturally as coverage of BSM, it must be covered that all the activities of objective business and their measuring system reflect the needs with desired minuteness. Therefore, followings must be provided.

- Mechanism capable to handle the following three elements consistently
  - Non-monetary values which are the main constituents of front activities of the business.
  - Unit cost which are the used for evaluations of activities and bases of replacing of values among organizations.
  - Total cost as products of above two elements and accounting amounts as pure monetary values.
- Mechanism capable to express the integration of business activity toward consolidated statements, which are the important evaluation from the side of the business.

For realizing these needs, new central concept: "**Visibility with Transparency**" supported by practical methodology must be discussed.

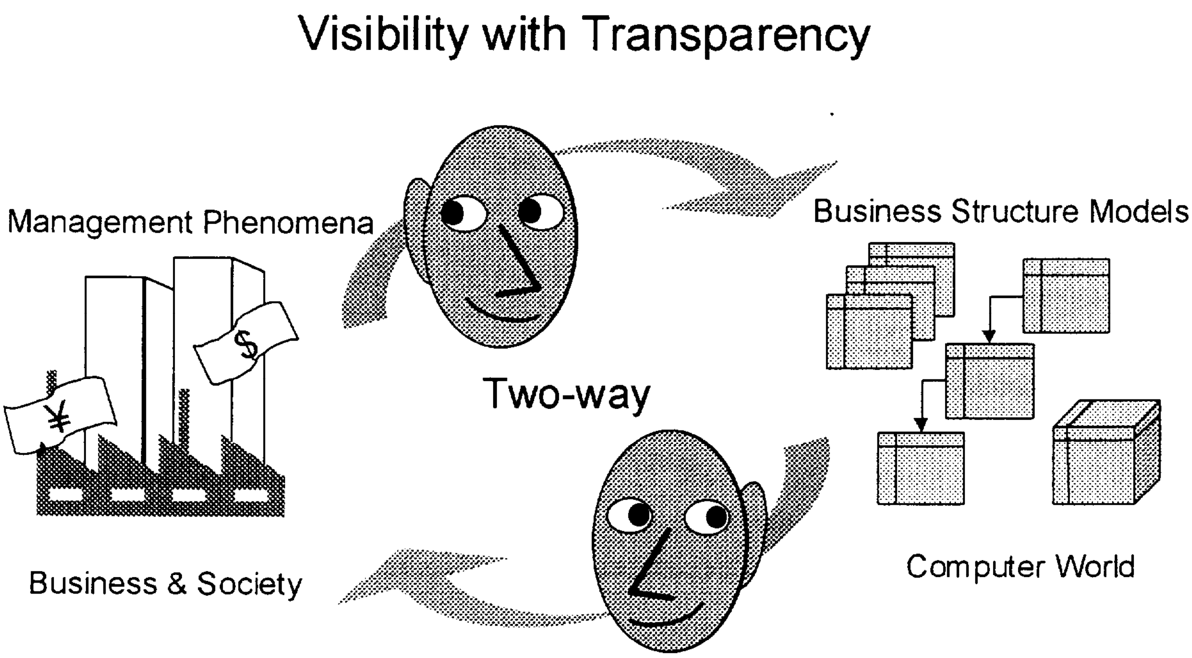


Figure 1-2. Two-way Visibility with Transparency

Business Structure Models (BSM) should be used to be active embedded in business activities. The Essentially of BSM is to provide "**Visibility with Transparency**" in making models and operating them. The "Visibility with Transparency" which the writer proposes has following meanings as shown in Figure 1-2.

- We should build and operate BSM to reflect the management phenomena into it keeping "Visibility with Transparency".
- In addition, by looking the developed BSM, we should be possible to imagine the management phenomena from the BSM.

Under these reasons, "**Visibility with Transparency**" should be said "**Two-way Visibility with Transparency**" in exact meaning. In this thesis, we simply use "Visibility with Transparency" including the meaning two-way understandings.

By this two-directional "Visibility with Transparency", it is possible with speed and stability to change the models, to combine the models and to recombine the models, then to succeed the models and to collaborate in modeling. How to realize and provide "Visibility with Transparency" is the main purpose of this thesis.

In addition, it is indispensable to respond the needs like analyzing of the differences between plan and actual, comparison of plans and investigation of better operating condition on the entire models. For this purpose, it must be possible to grasp the entire business mechanism into certain details through represented models, combining the knowledge and views of participants in their professional areas.

At present for taking the above aims, numerical data might take the lead of modeling by the reason that it is easy for objectively handling their mutual relations for implementations.

Parallel handling for individual evaluation

It should be strengthened to avoid handling of a representative value by intensively clustering the components into simple value (like a case of product-mix expressed xxx-mix). Principally, these components should be handled in parallel as they are, if they should be handled substantially in parallel for differentiating the business advantages in products and services. Also, this approach is necessary for pursuing the cost drivers.

Versatile handling modes of relations

Furthermore, elements of the models located deeply in the bottom of the organization are likely to be neglected, being prevented by the umbrella of hierarchy. In BSM, such elements must be systematically relieved crossing over the boundaries of hierarchy. If describing of causal relations among arbitrary elements are required, the setting of these relations must be easily realized in the models. (*Network* concept on the *Two-dimensional Round Robin Table* among all elements which can support *Hierarchy, Cross Organization, Bottom up* and *Inside-Out* concept)

As a vehicle to support these ideas, we need the support of new technology. Once these causal relations are projected into tables as models, we can easily approach them into the detailed part and manipulate them with *Visibility with Transparency.*

The writer's approach is *Structure Matrix* that started as expression method of models using two tiered tables, and it is possible to project the BSM structures containing logic and data visibly to a set of tables.

Positioning in DSS

Sometimes, a question comes from system users or people in planning functions.

"Where do locate BSM in DSS (Decision Support System) applications?"

We have been answering them for more than ten years about the positioning in DSS using Figure 1-3 by defining three areas as follows..

- Presentation DSS

  At the environments all the data are prepared, then "how to visibly present for smoother understanding toward *Decision Making*." is the subject of this area.

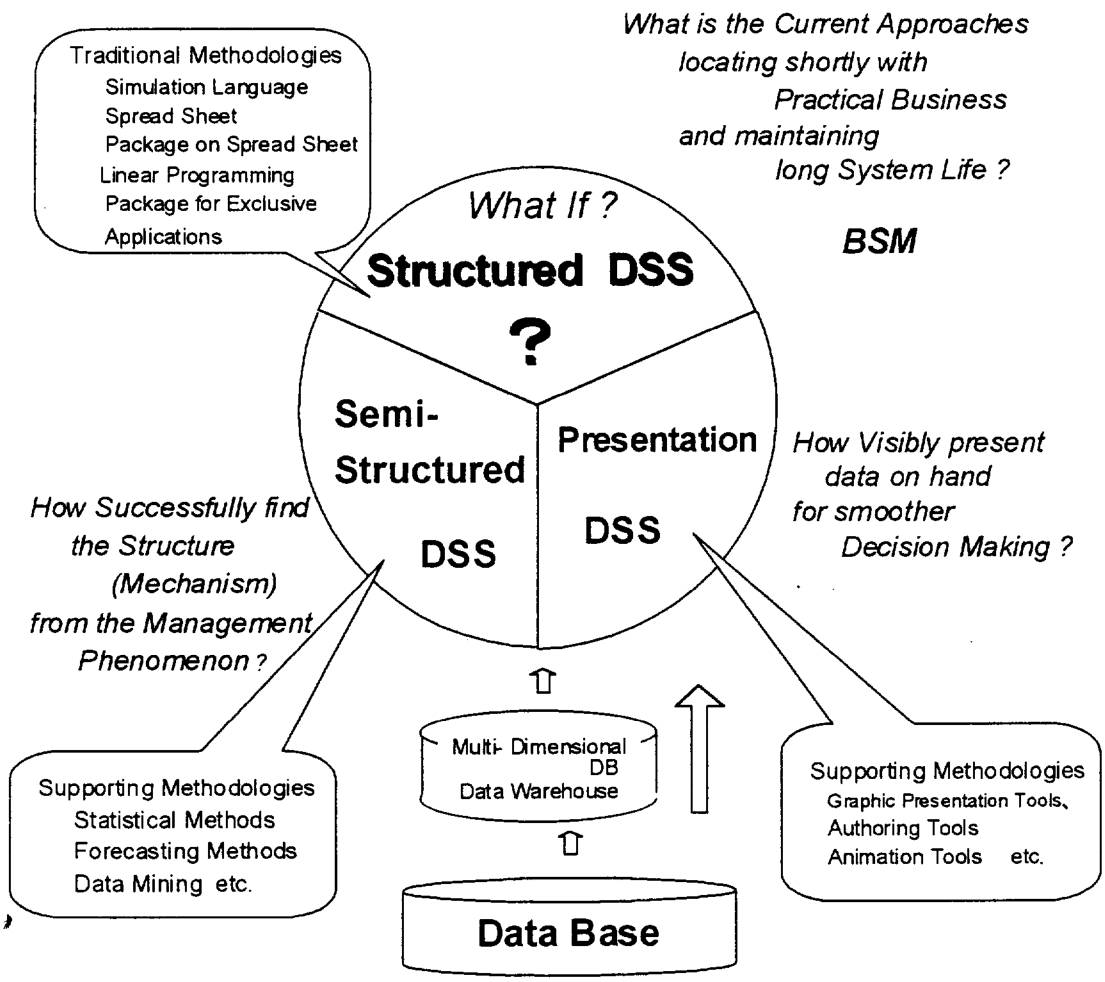


Figure 1-3. Business Structure Modeling in DSS

- Semi-Structured DSS

  We gave this word opposite for the Structured DSS. This area of problem is how to find the structure (mechanism of causal relations) within vague management phenomenon like such problems, "Why this product is not well received in the market?", "What is the reason of low quality?" and "How the sales forecast next quarter would be?"

  In this area, finding of structure is not necessarily successful. If structure of causal relation is recognized or exact enough, activity of DSS would be said a lucky matter.

- Structured DSS

This area can be defined as follows.

Using data and logic for expressing causal relation, business models can be made. Accordingly, "**What-if** calculation" can be executed after the search of the relevant cases.

For this area, many kinds of tools are available now. However, if the objective sizes exceed certain practical ranges, common solutions with practical reality are not provided. The aim of BSM is to provide powerful solutions in this area.

This classification is well accepted by business people and they easily understood that there are empty spaces abandoned at the BSM part.

Note: BSM is used not only for DSS. In many cases, the naming: BSM can be used for processing of GAAP as monthly cost system linked with calculation of consolidated statements. In such cases, models for plan are executed as extension of performance-linked monthly calculations.

1-2. The History of BSM and its Technology

The first origination of the idea as structure matrix for expressing management phenomena by Pichler Otto may trace back to the 1930s. The history can be roughly classified to five stages.

- German development
- Origin of writer's idea
- Encounter with German development and its introduction
- Developments of interactive packages
- Theoretical progress: T-H theory

Let us review the history of BSM briefly according to the circled numbers in Figure 1-4.

- German developments: ①②③

Before my encounter with German documents, there were profound studies about cost structures and opportunity to interdisciplinary studies of implementation in business as shown schematically in 1-5.

As an Engineer in E. G. Farben (German Chemical Company), Otto Pichler was stimulated from the W. Leontief's Input-Output-Table, by the story on to Prof. Dr. R. Wartmann. Then he reached the idea of structure matrix in 1930s, facing the problem to express production factors and cost relation as communicating method between engineers and business administration people. On the other hand, HOESCH A. G. (iron and steel maker) faced the problem to get precise models reflecting their important production factors. This was caused by Japanese inroads to German market and the company must have more precise models responding the shift to higher processing products in which variation of the processing cost was large.

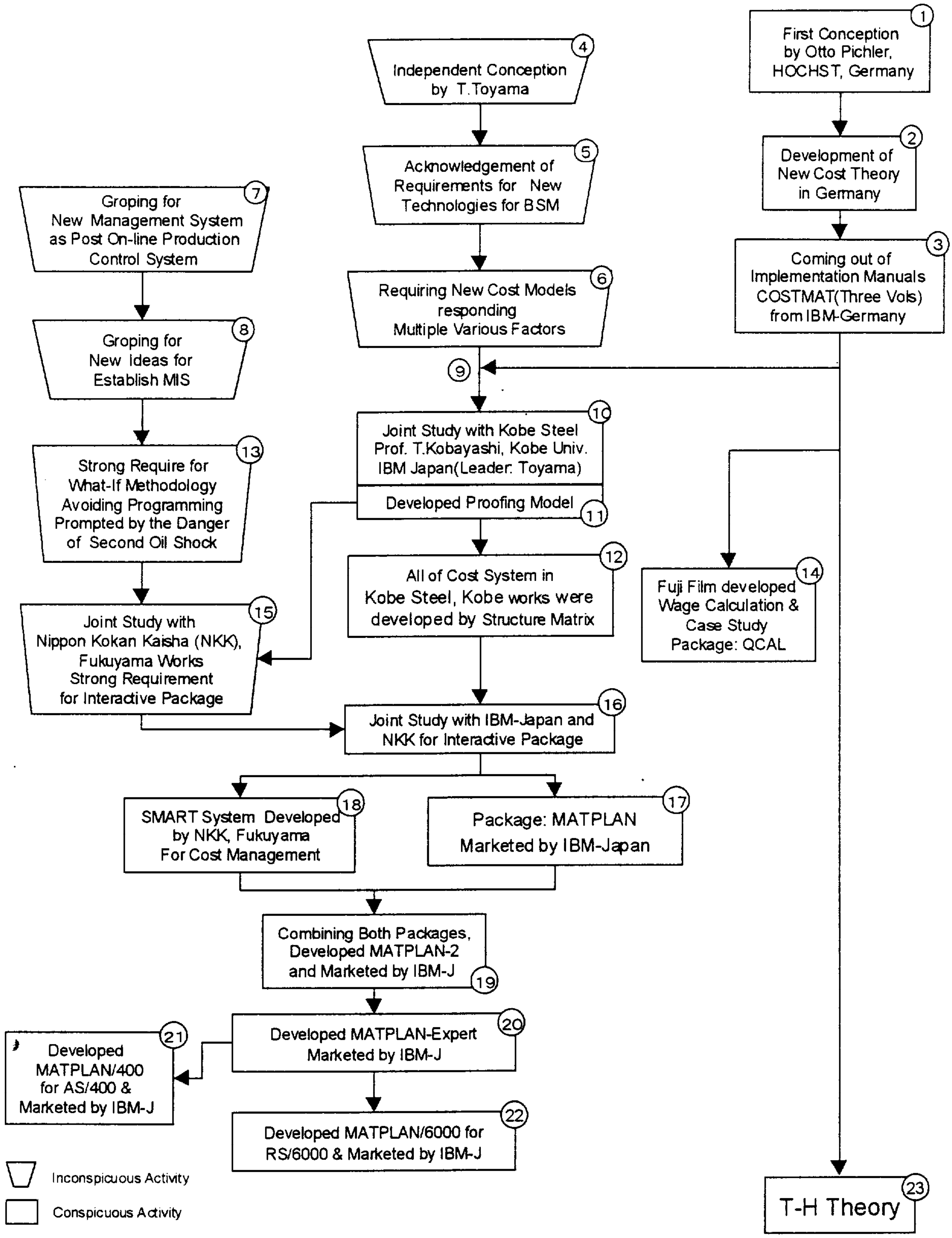


Figure 1-4 Development Flow of BSM and the packages

For solving these problems, Operations research group in HOESCH had a contact with academic society and Pichler made effort to build models. With thirties of modeling to various plants in integrated steel works, they reached a standardized model common to all type of process plant. Astonishingly, German people finally arranged their fruit in the Management Accounting Standard. These were issued from German Iron and Steel Federation as ARBESt and BR.[Betriebsw..., 1987]

Also, the fruit of HOESCH as the implemented case was also published as three volumes of manuals: COSTMAT (COST MATtrix system) from IBM-Germany.(Vol. I and Vol. II were translated to English and Japanese, Vol. III was to Japanese.)[IBM Deutc.., 1977] For more details, please refer technical books and papers.[Kobe Daigaku..., 1977]

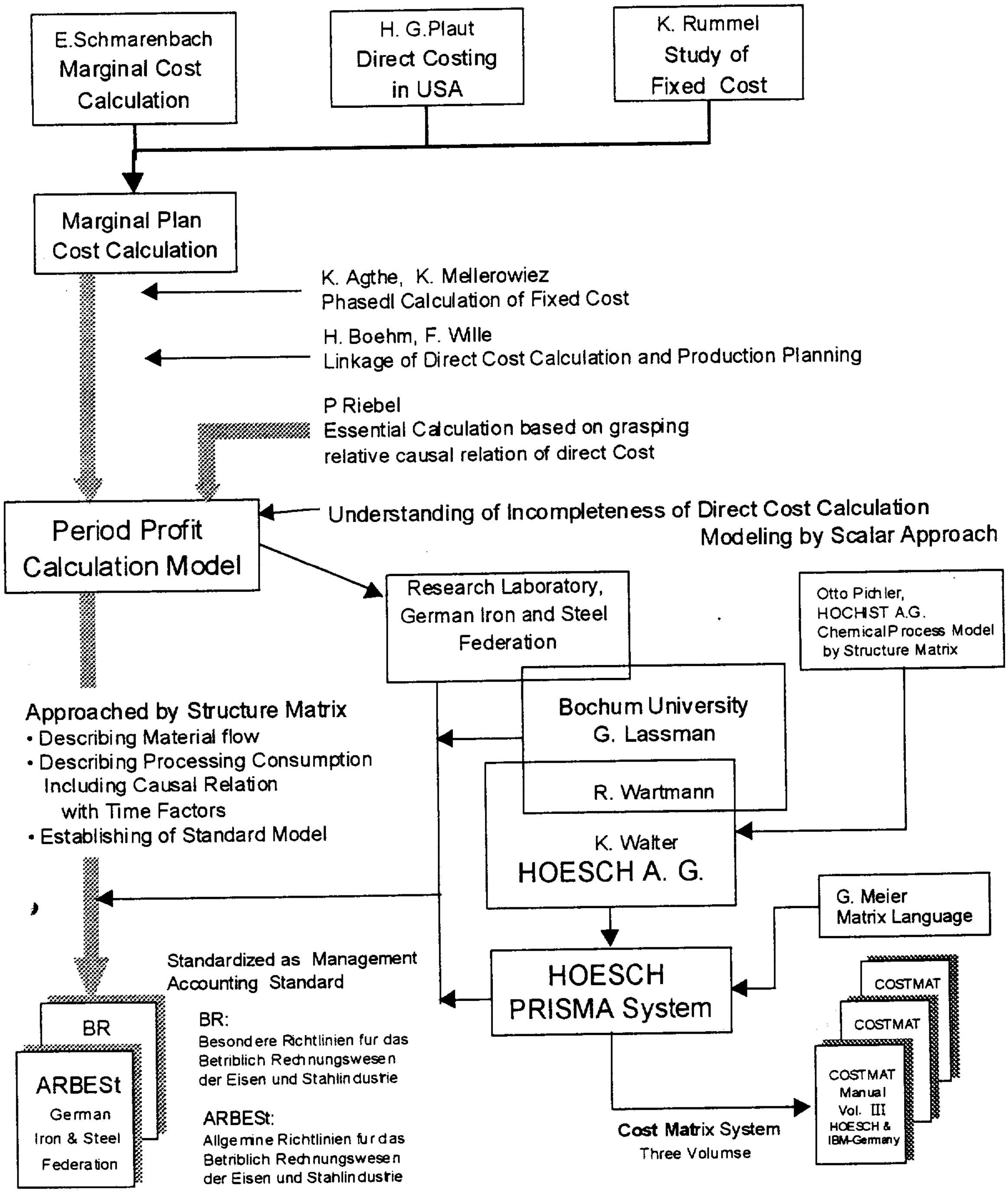


Figure 1-5. German Developments of Management Accounting on Structure Matrix (Modified, referencing the lectured material (Closed) by Professor Dr. Tetsuo Kobayashi)

- Independent idea and activities from German idea ④⑤⑥

There is an independent history around writer starting from the same conditions in Japan. How did the writer have the idea, recognize the needs and encounter the German documents were written in Appendix I.

- Independent activities prior to the encounter with German Developments

Groping for New Management System as post online production system ⑦ ⑧ ⑬

In 1964, The writer moved to IBM Japan and engaged in expansion of computer applications in metals industry. The writer spent busy days to propagate on-line system for production control. In the middle of 1970s, the propagation of on-line system in steel industry seemed to be passing its peak. User interest was in making of management system as post on-line production system. As an event of 1970s, K. Tuboi and T. Furuya, who were staffs of Ohogishima Works Project, in Nippon Kokan Kaisha (NKK), visited us in IBM-Japan for getting the idea of establishing management system of new works. Their requirement was to build a tough system that is enough capable to trace the status and change of plant operating condition for managing the new works. Their aim was in building production control system tightly linked with cost system in which clear box approach should be applied avoiding the black box compiled by programming work. For their requirements, I proposed the structure matrix method. However, I could not give concrete answer where from they should start but abandoned after few years.

The confusion caused by the oil shock happened in 1973, stood out the necessity of built in tough simulation system in the Management Information Systems (MIS) in steel works.

- Encounter with German developments and its introduction ⑨ ⑩ ⑪ ⑫

As written in the beginning of this chapter, I faced the information of German development and gradually detailed documents in Germany became obtainable in Japan. Their documents were very difficult because cost theory was explained upon highly organized theory with dignified style and with matrix oriented concept for handling multiple item concepts. (XXX-mix, like products-mix, influence factors -mix, etc.)

In the mean time, an inquiry of idea to make cost system renewal reached me from Kobe Steel Co., Kobe Works. I introduced the staff member the outline of German developments, above all about HOESCH case. By the strong interest with similar needs, Kobe Steel formed a study team including me, and making out of German document started. Because of the difficulties of the German documents, the study became idle for yeas or so.

Fortunately, we knew that Professor Tetsuo Kobayashi, Administration School, Kobe University, had been studying the same area after his study abroad in Germany. We formed a tripartite joint study group and the study was remarkably progressed.

Against concrete introducing plan to Kobe works after the understanding the German concept, strong opposition was issued from the accounting director of the works. The reason was as follows.

- The model may calculate strange cost and *principle of consistency* will be invoked.
- Matrix concepts don't harmonize with their business life.(No objection from front staffs)

For solving such conditions, my plan to verify the equality of total cost by comparing traditional way and new way was accepted. Two thousands of actual data taken from 10 yeas ago, were opened by the reason that the processes were already obsolete and the data was of no use.(They are shown in chapter 6 as case 1 and Appendix IV)[IBM Japan, 1978] The calculation came out exactly right. In addition, I recommended using of the word in stead of traditional mathematical words as follows.

Inner Product	→	Vertically Multiply and Horizontally Add
Transposed then Inner Product	→	Horizontally Multiply and Vertically Add

Note: Currently, these twos were unified *Multiply & Add* by unifying them into one directional calculation using the method written in chapter 2, 4 and 5 adopting a type symbol: T for the later calculation.

There was no objection after it was renamed.

New cost system based on structure matrix was implemented one by one, starting from rather easy facilities of blast furnace area and finally covered whole works.

Cost center models were standardized for a unified pattern that could cover all the different process and were written on the thesis. The implementation was progressed by four steps. First, total plant process was written in around thirty sheets. Secondly, programmer read out program steps from the sheets rather mechanically. Third, these program steps were programmed using matrix language (IBM MATSYS, Compiler language like FORTRAN). Finally, the program was executed after the compilation.

- Different Idea of Structure Matrix ⑭

In the meantime of Kobe-Kobe project, I received the request of consultation for new method from Fuji Film Co. HQ. in developing Wage Calculation System. They developed a different type of simple architecture of structure matrix, in which single person's data entered and calculated one by one. Afterwards, this system was packaged and sold as QCAL (Q means wage in Japanese) [Fuji Film, 1984]

- Developments of interactive packages and wider marketing ⑮ ~ ㉒

For responding the inquiry for post on-line production system from Fukuyama Works (Worldly largest integrated iron and steel plant at that times), Nippon Kokan Kaisha, we had been proposing the planning system coupled with cost system based on German way. In addition, the study had been continued among them. Unexpectedly, the second oil shock seemed to be happening. With high priority, their top management required plant people to develop planning system to be able to minimize the confusion that they had experienced in the first oil shock and project group was organized including production and cost management group.

By the group's request, structure matrix models were explained by concrete data getting the permission of Kobe Steel. With the same professionals, we had consent of new method by understanding the mechanism as table method having special characteristics. Nevertheless they requested providing of interactive package for quick response and for trial and errors seeking the better conditions.

It was the start of our thorny path to define functions to strengthen the specifications. While our developing with the name code: MATPLAN thinking the wider use, the oil shock seemed to be settling and NKK people became impatient for waiting the packaging. They developed their own package directed for their purpose referring our progress. After the completion, we jointed the good functions under the name code:

MATPLAN-2 and marketed from IBM-Japan.

Gradually the package was spread in many fields of different applications in different industries. Functions were reexamined through the several chances of developments toward general use from the substantial basement. The major events of essential innovation from the first idea were as follows.

- Two types of calculating directions were unified for a single calculating direction. Consequently, the processing of Input-Process-Output that includes non-linear calculations became possible.
- Handling of blocks in upper and left parts was extended to the complete two-dimensional processing. It was realized by extending the data block as two-dimensional tables, being associated with two Item Blocks.[IBM Japan, 1993] We can introduce two-dimensional matching by the type symbol: **M.** Then we can easily handle inter-tables-processing.
- We established the mechanism for chaining structures with flexibility and then the collaboration in modeling was realized.
- Procedure function was developed for more practical fixed operations
- Nested functions as type symbols like **V**, **@**, **C**, **Q** etc. were developed.

- Theoretical progress: T-H theory

Recently, Higashihara and I reviewed the past progress of modeling and found more generalities in applying bilinear relations covering the area where modeling technologies were neglected to be difficult to handle with unified method. We found the rule: "Where the consumption of resources exists, we can have chances to find bilinear relation with monetary values." Established methodologies and sample models for ABC extension and shared services are introduced in chapter 6. The development of management idea based on this theory is expected.

1-3. The Rudiments of Structure Matrix in brief ----The Supplementary Note----

This briefing of structure matrix was made to be understood smoothly whole of this thesis, because each chapter of this thesis is arranged for deeper discussion.

New Expression of Inner Product

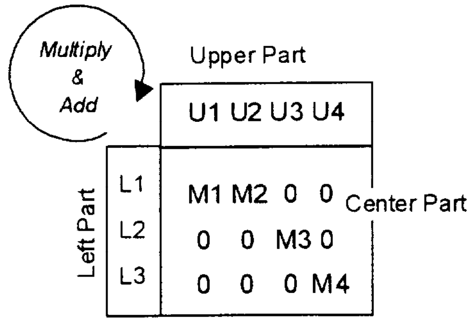
Traditional expression of inner product between matrix and vector shown in Figure 1-6 can be rewritten in a special table composed of three areas as in Figure 1-7, in which inner product can be renamed as *Vertically Multiply and Horizontal Add.* This can be abbreviated *Multiply & Add.*

Here, U1, , , U4, M1, , , M4, L1, , L3 are scalar variables.

$$\begin{bmatrix} L1 \\ L2 \\ L3 \end{bmatrix} = \begin{bmatrix} M1 & M2 & 0 & 0 \\ 0 & 0 & M3 & 0 \\ 0 & 0 & 0 & M4 \end{bmatrix} \times \begin{bmatrix} U1 \\ U2 \\ U3 \\ U4 \end{bmatrix}$$

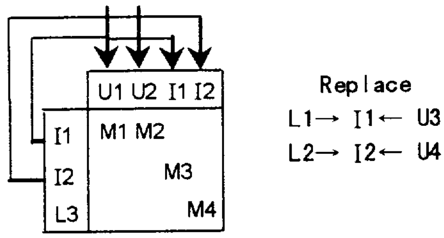
Figure 1-6 Traditional Expression

Figure 1-7 New Expression



Then, replace some elements in upper and left variables to common variables as in Figure 1-8.

Figure 1-8
Relating Left Elements to Upper Elements



Accordingly, we can recognize that this expression describes the calculating flow and following expression can be read out thus.

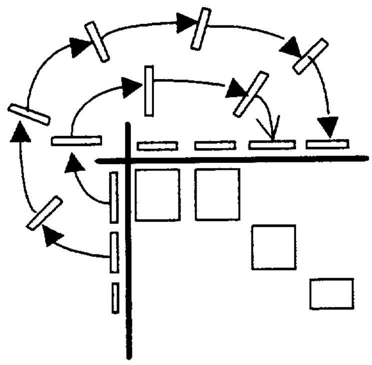
I1 = M1 * U1 + M2 * U2

I2= M3 * I1

L3 = M4 * I2

, where U1, U2 are pre-determinant variables, I1, I2 intermediate variables, and L3 a post variable.
At this stage, we can think U1, , , U4, I1, I2, L3 as flat or vertical vectors depending the located places.
And M1, , , M4 as matrices having consistent size responding the elements in upper and left part.
In the identical way, we can think U1, , , U4, I1, I2, L3 as matrices.
These are shown in Figure 1-9 and Figure 1-10.

Figure 1-9
Extending Elements to Vectors and Matrices



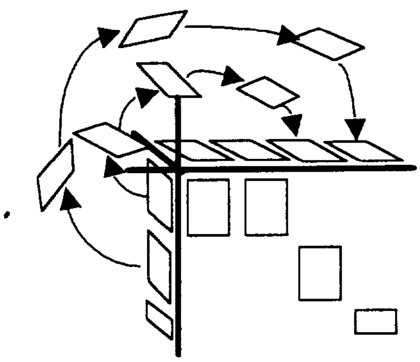


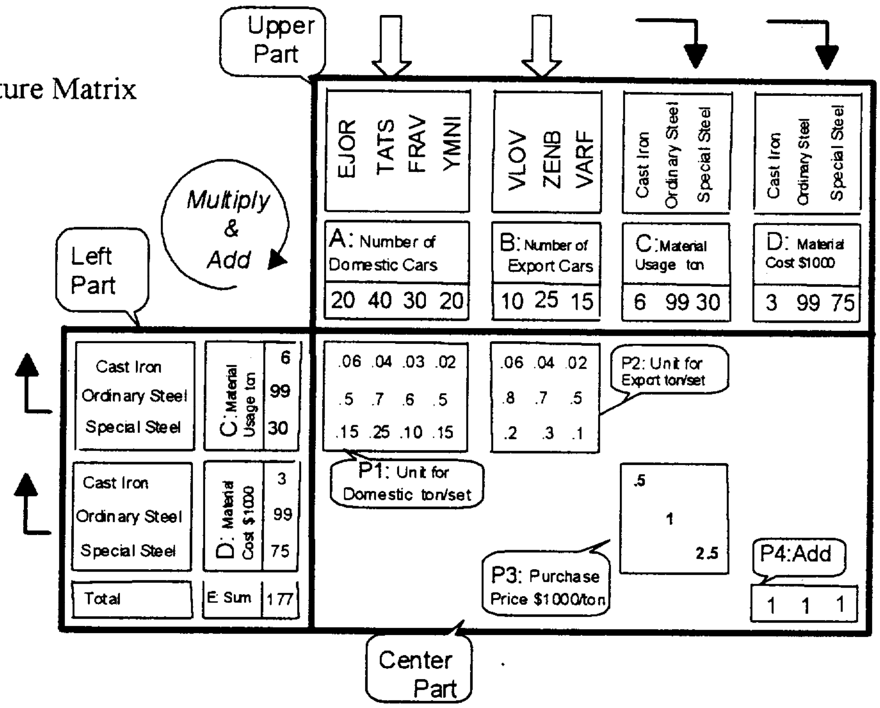
Figure 1-10
Extending Elements to Tarices

At this stage, we can recognize these tables as tables of spreadsheet and structure matrix as a new organizing technology to handle a set of tables. Furthermore, *Multiply & Add* can be extended *Input-Process-Output* relation absorbing non-linear relations

Schematic Illustration

For exact understanding, a sample model of structure matrix is shown in Figure 1-11 as flat expression.

Figure 1-11
Flatly Expressed Structure Matrix



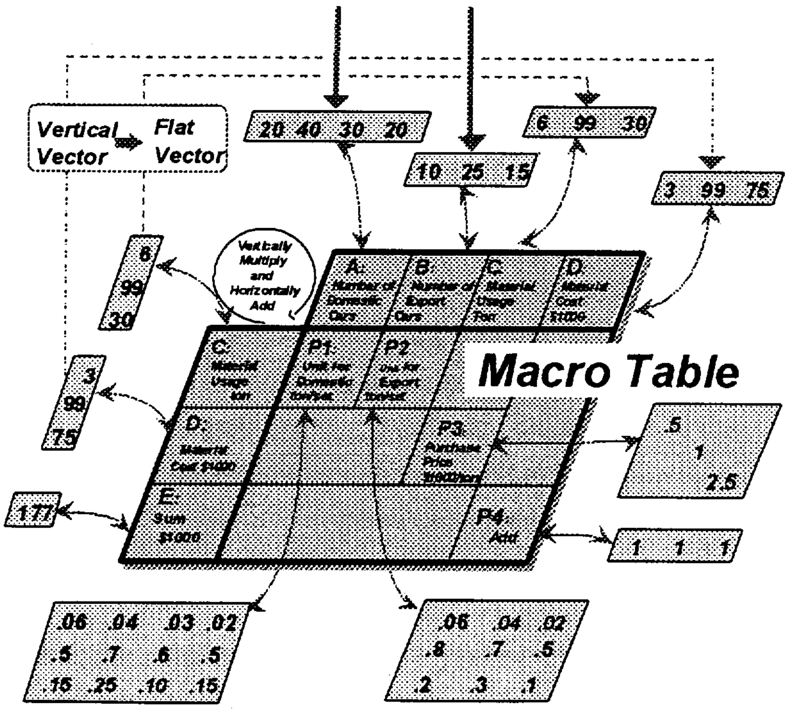


Figure 1-12 Relation between Macro Table and Micro Tables

The calculation goes on finding the unfinished blocks in upper part one after another and terminates when all left blocks are calculated.

If numbers of kinds for the car and number of materials are far large, such flat expression is too large and inconvenient to be handled. For the solution supported by interactive use of computer, two tiered expressions composed of Macro level table and Micro level tables as sketched in Figure 1-12 can be applied. Relation among a Macro Table and Micro Tables are traceable within computer by cursor handling. The model is for calculating each kind of material consumption (C) and their material costs (D) and total cost (E) by giving number of cars for domestic market (A) and for export (B). In the center blocks, material consumption rates per a car for each kind of cars are given in P1 and P2. Also, unit costs of materials are given in P3 diagonally and in P4 value 1 is placed for addition. The calculation starts from the pre - dominant blocks in the upper part, which are not in the left part.

The above mentioned is only a briefing of principle of single structure matrix. The actual architecture of structure matrix is developed enough to fit further applying. In addition, chaining of structure matrix is available, and type symbols are provided for close coverage of applications.

For more details, please refer later chapters.

About naming

Following two reasons about the naming of *structure matrix* by Otto Pichler were handed down to us through German successors.

- Structure matrix reflects the structure of business
- Structure matrix has a nested structure composed of matrix.

The originator: Otto Pichler gave this name and used this words in his paper.[Pichler,1953] Esteeming his intention, *structure matrix* is adopted throughout this thesis.

1-4. The Structure of this Thesis

This thesis is structured as follows and Figure 1-13.

- Chapter 1. Introduction

  As we have already introduced, this chapter is started from the definition of Business Structure Model (BSM) with positioning, then the history is briefed along the development of structure model and package developments. For transparent understanding of this thesis, the brief explanation of structure matrix is attached.

- Chapter 2. Essential Problems and Solving Directions in BSM

  This chapter is prepared for stating "What is the essential problems in BSM that we encounter?" and "What are the problems by traditional approach?" For fixing problems, fundamental characteristics of the objective areas from various viewpoints are discussed. The recognizing of the strategies approaching for new paradigm and images required for new methodologies are discussed.

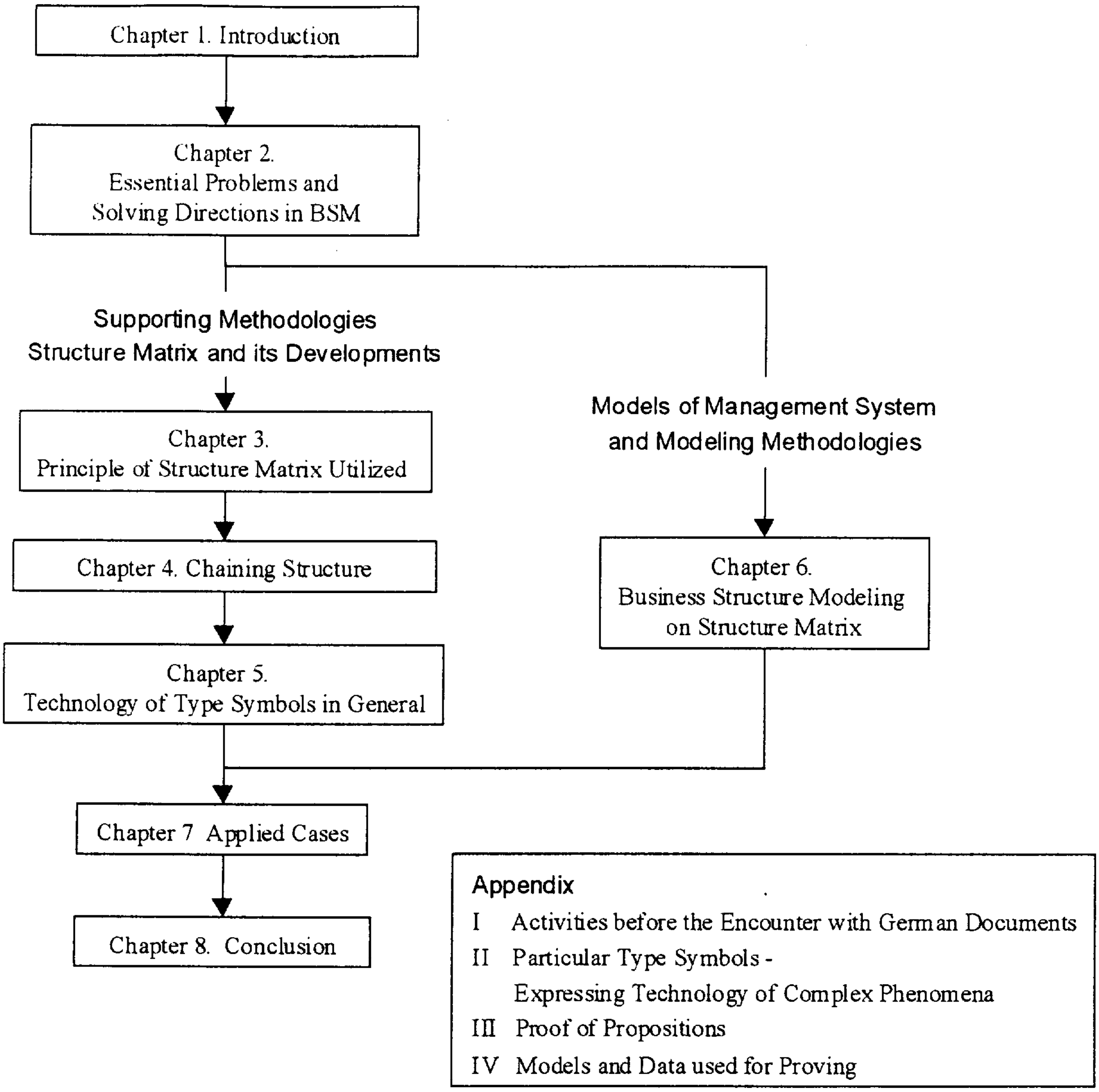


Figure 1-13. The structure of this Thesis

- Chapter 3. Principle of Structure Matrix Utilized

  Many people are easily premature about fundamental characteristics of structure matrix by personal opinion. Characteristics of structure matrix and its architecture projected onto computer are explained in detail, and extended architecture aiming practical computer usage are introduced.
  Sincere understanding of Item Block (Originated as KOL: Komponent List in Germany.) and its effectiveness are important from the point of management concept in application, model building and architecture development.

- Chapter 4. Chaining Structure

  Chaining structure is the methodology to broaden the world of structure matrix and we can serve various concepts of model management as collaboration work and enlargement of modeling activities with flexibility. We hope you find essential matters on realizing collaborations in BSM.

- Chapter 5. Technology of Type Symbols in General

  Type symbols around twenties are the technology prepared for standardizing application oriented part in models. This chapter describes only general introduction showing the idea and why simple type symbols are established superior to functions as in simulation tool from the side of application representation as simplified model expression and quick understanding. The individual peculiarities are detailed in Appendix I. For deeper investigation of BSM, please look individual explanations in Appendix I.

- Chapter 6. Business Structure Modeling on Structure Matrix

  Previous three chapters have been prepared as vehicle of this chapter.

  Taking the typical examples of profit planning models, needs of BSM technology that can integrate all the business functions are discussed first. The important discussion is in combining non-monetary and monetary values in BSM paradigm. Then discussion of concrete BSM is developed.

  According the historical progress, production and cost models combining facilities are discussed in details in which transfer cost and bilinear relations are handled. Practical improvements of architecture in structure matrix for combining production, unit cost and total cost domains are discussed. For expansion of bilinear cost theory to more generalized support covering different types of activities like service area and common resources consumption, T-H Theory that was developed getting Toyama and Higashihara's idea in shape is introduced. As concrete examples, two types of model for shared services: Engineering Center Services, Bank's HQ Staff Services to the business of mainline organizations and ABC are discussed. In addition, BSMs in pure monetary world like consolidated statements is discussed. As auxiliary modeling method well used, but not classified in the above, is supplemented.

- Chapter 7 Applied Cases

  In this chapter, tendencies of applied cases are reviewed briefly, then three cases are described. The first case is a cost management system introduced for steel works. The models were made on the sheets and the steps of calculating logic were read out by handwork rather by rote. They were programmed by matrix language then compiled for execution.

  This was the first case in which structure matrix was introduced as nucleus of application system in Japan. Prior to the full-scale introduction, validation study of new method was performed using actual data. Details of these data were attached in Appendix IV.

  The second case treated the aggregation model based on the production and cost system composed of structure matrix in the integrated iron and steel works. The principle of the aggregation is shown in the 3-2-7 Advanced Functions of this thesis. With this method, we can manage big organization with simple procedure if structure matrix models were established.

  The third case was a case implemented as Feed-Forward Management system in which performance-linked system covering production and cost management system were integrated. And as extension of these systems future activities are studied by trial on the computer system.

  By this system, top management became possible to ascertain the materialization of cost target facing the setting of cost down goals. The efforts paid by top management and front people could be linked above the same domain of structure matrix.

2. Essential Problems and Solving Directions in BSM

The aims of this chapter are three folds. First we make the current problems clear in BSM area. Second, we analyze the essential characteristics. Finally, we propose the solving the solving directions. Therefore, the contents are composed with following themes.

At first, common problems currently we often came across, are discussed with rather simpler, but straightforward expressions from the three sides.

- Voices of top management's requirements
- Cost management oriented requirements
- Requirements from the side of modeling

Next step, changes happened in the computer world are reviewed to make these problems in the current environments.

Then the problems and the boundaries approached by traditional methods: simulation language, spreadsheet and ERP (Enterprise Resources Planning) will be discussed.

Before defining how to solve directions, characteristics observed in management phenomena which BSM should defend, will be discussed and common key idea: *Visibility with Transparency* that must be placed in the bottom of arranging the solution, will be discussed.

Upon these preparations, three hypotheses adopted for defending to overcome these problems will be discussed. Then, needs of four major technical categories will be discussed for challenging BSM.

As a final discussion of this chapter, design strategies for providing tools for BSM will be enumerated.

2-1. Current Problems Common in BSM

In the management information system, BSM area is left unoccupied with effective method. Currently, we know that many able business staffs are complaining the status that there is no effective remedy to establish management accounting system, covering the business size of three thousand employees. A paper pointed out the lack of idea to establish relevant budget system in 1987 but we had not heard of any effective solution except our approaches.[Itoh, H. 1987] Surely, hurdles are very high to provide solutions overcoming problems and some breakthrough ideas must be necessary.

In BSM area, indignant voices like famous words "Shacho-sho no kuinige syndrome (eat the president's award and run syndrome)" is full in the people engaged in systematization of BSM, as a course of applying current methodologies. It is not our aim to explain this situation in details. However, the lack of relevant insight to this area and lack of abilities to evaluate methodologies proposed by consultants, package vendor or system integrator cause these tragedies.

Though my style in this sub-chapter might not harmonize this thesis, we would like to enumerate current problems with straightforward style, which we really come across in the customer sites for sincere understanding of problems. The problems will be introduced in the following three sides as sub-sub-chapters

- Voices of top management's requirements

- Cost management oriented requirements
- Requirements from the side of modeling

2-1-1. Problems from Top Management

The generalized solution how to organize the planning oriented Management Information Systems efficiently and flexibly, has been remained yet as an unsolved vacant space on the sketched layout of Enterprise Resource Planning. We should have started from recognizing problems we met in discussing fairy large-scale MIS capped by the words, planing oriented, future projecting, feed-forward management, What-if, etc.

Followings are simpler and unsophisticated questions, we would like to show in this thesis, an idea to solve them

Problem 1-1. *Aren't you loosing the timing?*

We often come across such scenes.

While working for planning,

- Competitive product appears.
- Exchange rate, interest, selling prices, etc., changes.

Intense change of external environments during the work drives sometimes their planning work essentially valueless.

Problem 1- 2. *Aren't you giving up the systematization?*

We often watch such scenes.

Planning staffs can not respond to the intense asking of planning bases after another, issued by top management or top planner.

Then,

- Talented people are giving resignation to them, taking the planning as it is.
- Requesters are keeping frustrations.

Aren't there such phenomena in your business?

Problem 1-3. *Aren't you tired?*

In planning work of Profit Planning, Consolidation of Budgeting or Production Planning,

We often come across such a compliment from the executives.

- We can't go on the *re-* or *re-re-organization phases* because of time limit.
- Then, top management is loosing their chance to reflect their intentions to them.

Even for responding the simpler changes, prodigious labor and time must be consumed and their productivity is kept worse. People are thinking strangely for such status in which planning methodologies are fallen behind in the age of computer.

Problem 1-4. *Are you getting sufficient realistic images from the planning?*

In some business simulation starting from status quo, it is required to provide the exact realistic images of near future and succeed the status given by an actual operation.

- My company is using computer heavily, but it doesn't exactly support me in making strategies.
- We can't get the realistic images in projecting near future by simulation.
- If results of simulation are given, we can't break down them to realistic operations.
- Planned items are so aggregated that we can't breakdown them into detailed realistic plans.

Though trustworthy results are given by aggregated calculation using average values or some representing values, we can't break down them well as de-aggregation toward discrimination of products..

Problem 1-5. *Are there any new methodologies?*

There are many planning jobs and management jobs accompanying allocation work like selling target or assigning common cost assignment. For example, it is very difficult to respond dynamically to the following subjects.

- If organizational change or reorganization is proposed, considering the counter-plan is very difficult!
- The causal relations of services that provided by staff organization to the mainline of business are too complex. These phenomena prevent easier and relevant evaluations of staff organizations. In some cases, the maintaining of high professionals in the business is advisable like engineering centers. However, staff organizations are sometimes separated as outsourcing jobs driven by the difficulties to manage them.

This is caused by the lack of relevant management system to support such organizations.

Are there any responding methods to be easily understandable and efficient?

Problem 1-6. *Is everything going crisscross?*

It is hard to cooperate the planning work taken over a portion of work by many staffs.

- Categories of calculated results don't fit together with their departments, like Marketing, Production, Accounting, Finance, etc.
- The systematization with integrity is thought to be so difficult, then reduced to be a handwork.

Most of the businesses are dependent on the collaboration of professionals and integration of different functions. Are there any solutions to conquer these problems?

Problem 1- 7. *Can you communicate each other?*

If the planning and analysis of systems are developed under especially talented people such as personal jobs, only the specified persons can understand.

Is there any easily understandable and communicable method for a person in charge of jobs and for other staffs as group-ware?

Are there any methods to be able to develop and maintain pacing the needs of requiring organizations?

We are often snapped by those simple and frank problems. We must go behind the outward form to grasp the inner meaning of the problems.

2-1-2. Cost Management Oriented Problems

n some complicated business, costs are key factors to be managed. In major cases, costs mediate financial value factors and the non-monetary factors and by them they operate many activities in the business front. We are expected to bring some breakthrough at the age of giving importance to the cost. By this reason, we would like to highlight the problem of BSM in some more details from the side of cost system.

Followings are the problems we come across at the reconstruction of a cost system, because of mismatch with current needs.

Problem 2-1. *Relevant methods to link the costs for multiple products to the non-monetary factors with clarified cost structures are not well proposed.*

Examples of non-monetary factors are, Parts, Material, Product group, Time consumption, Tools' consumption, Man-hours, Energy consumption, water consumption, etc.

These links do not simply mean the coverage of the above activity factors. Most of these factors should be grasped as chained structure of primary factors, secondary factors and so on.

There is a need to investigate the sensitivity of these factors, to link them cost reduction movements using this established causal relation and to hang the cost drivers and their chained relations. With more relevant and accurate cost by product base, it is required readjustments of the product line-ups for more profitable products. These requirements are especially typical in fully matured market.

Problem 2-2. *Flexible production and cost planning system, which can be developed as planning system covering global activities like purchasing, exporting and taxing, are required.*

These planning systems should be further extended to the global consolidated planning system covering the following functions.

Marketing, Research and Development, Purchasing, Production, Costing, Distribution, Service, Life cycle management, etc.

Through many consultant activities, necessary requisites in businesses are analyzed well. Astonishingly, they are not proposing materialized plan to be able to implement. Even in ERP (Enterprise Resource Planning) packages, it is out of consideration that planning systems with cost system are to be oriented to handle the changes of business structures.

Problem 2-3. *Cost for in-process inventories staying in the process flow should be evaluated by looking it objectively as possible as avoiding arbitrariness.*

In evaluating the degree of completeness as in-process inventory, we can not be free from the setters' arbitrariness, so long as adopting the method so-called equivalent coefficients. To avoid arbitrariness, methodologies to provide objective bases for calculating the processing cost are eagerly desired.

Problem 2-4. *Methodologies to assign increasing fixed common costs to the most likely relevant factors are requested.*

Some examples in production businesses are as follows.

Example 1. Relevant assignment of various types of designing cost.

Example 2. Relevant assignment of the cost by considering

the rate of automation covering the parallel facilities.

the rate of investment for facilities.

Typical requirements are:

- To make the mechanism of assignments transparent
- To provide repeating trials and errors until reach consensus
- To extract work-site efforts for cost reduction toward intentionally inclined direction set by management.

In financial and distribution businesses, one of the typical requirements is "To assign cost of head-quarters staff, by relating the control items of businesses (like trading commodities, sales amount and employees), synchronizing the organizational changes."

Problem 2-5. *Responding dynamically to the request of cost estimations at quotations.*

Quick and flexible case studies are required involving with following movements.

- Utilizing the experiences to the utmost
- Investigating the reasonable estimating values about inexperienced items
- Averting the miss of estimated items as best as we can.

What kind of technologies should be associated with these movements?

Problem 2-6. *To grasp cost variances with integrity.*

Providing mechanisms to support following the cost variances as typical cases are required in accurate discriminations of factors and with integrity.

- Cost variances between planed cost and actual cost on the cases:

  Caused by product-mix differences

  Caused by purchase prices' differences

  Caused by yields' differences

  Caused by the efficiency differences of equipment

  Caused by proficiency differences
- Accurate grasping of cost variances caused by the manipulating of standard cost which was forced by the sudden economical changes like importing cost.(like oil shocks)
- Capable mechanisms following the intermediate change considering the social upheavals.

Surely, some robust common frame to responding various cases would be necessary to respond these requirements

Problem 2-7. *Cost system should be built-in giving smoother links with not only other liaison system but liaison people.*

Traditionally, cost systems had a tendency to be developed and operated as independent application systems from other application systems. Nowadays cost system should be located as one of a core system closely linked within the following systems.

- Management Information System ------ Profit Planning System, Budgeting System
- Production Management System ----------------Synchronizing with Production Planning, and Cost Planning System and Designing
- Product Design System -------------------- Design System with Cost Planning System

Today, cost system and its mechanism are common properties of working staffs and not the exclusive possessions within the cost people as new age of management. So those systems should be located and embedded in the total integrated system.

Problem 2-8. *What would be the more sophisticated cost management system?*

Sophisticated Cost Management System realizing the following mechanisms should be supported based on reliable sound foundations.

- Mechanisms are to be able to handle both direct costing and total cost starting from the same origin of data
- Easier mechanism to realize the following condition should be provided.

Profit calculated by financial accounting = *Profit calculated by management accounting*,

What technologies should be established for realizing these mechanism?

These problems are burden for us.

2-1-3. Question from the Side of Modeling

From the viewpoint of business systems modeling, following are the current problems.

Problem 3-1. *Capability and maintainability of modeling for larger scale and complexities*

We don't experience to have large scale models covering whole business (for example, profit planning of global business activities including) and covering details of activities. According current technologies, models covering large business organization are made by two different approaches

One is built by simplifying the objects by aggregating the phenomenon partly forcibly and partly giving up. The other is built within a small region of business by setting the boundary then those models are linked by arranging the delivery condition of variables entering the each region. As far as depend on such mechanism, to make large business models is excessive expectation. A kind of breakthrough technologies is hoped for.

2-2. Changes in the Computer World and its Environments

During our 23 years of long study to enlarge the application of structure matrix, environments in computer system world were exceedingly changed. The changed prerequisites, of which the computer application system should be based, are simply pointed out as follows. The discussion based on our initial research has been already unrealistic and meaningless.

- Drastically, released from the limitation burden to the useable system capacities.

  As known well, available capacities of main memory and disk memory increased on different scales.
- Amazing increase of CPU speed

  By the same way as the above, CPU speed steeply increased and interactive processing becomes commonly available as a consequence.
- Drastically, shorten the span of time and space

  Driven by the above twos and revolution happened in communication.
- Popularized and brought low cost using of development tools for interactive screen processing

  Driven by the eminent window processing technology like MS Windows, Visual Basic, Delphi, etc., developments of interactive program becomes easy. In addition, the hurdle to develop heavy table driven programs became strikingly easy, and accordingly their periods of development became surprisingly short.
- Environmental change in providing business planning

  Supported by the popularization of PC, Data Base, cheap storage and by the providing contents by media, the available data to be used for the decision support can be held in business in any way, whatever the quality is. There was scarce data in the busines system.

2-3. Current Problems in the Traditional Systems and their Boundaries

In this sub-chapter, current problems in BSM approaches will be discussed in comparison with the following two typical methodologies:

Approach by Simulation Language

Approach by Spreadsheet

Essentially this comparison should be discussed in the later part of this thesis after the entire understandings of our approaches and technologies. It is, however, necessary to explain some assumption and general understanding, before discussion of the problems in order to clarify our standpoint.

2-3-1 Premises before the Comparison

First, we should limit the application area of discussion as follows to avoid the status at cross-purposes.

- Production planning linked with cost management having hundreds of products.
- Profit planning of listed companies having hundreds of products.

The reason is that major part of our BSM approaches is applied there.

Second, we understand the base of discussion as follows.

- Each approach has its own significance of the existence with economic and technological background. However, even the firmly established existence has sometimes no permanent guarantee to be able to keep original form as we saw in the world of information technologies. Discussions about the possibility to substitute for the BSM methods are likely to be resulting into an analogy like the discussion that all the logic of packages can be developed by machine language or by C language. We should avoid such non-sense discussion.
- Our purpose of discussion here is not in the detailed comparison of current functions. Especially, about IT functions, we had been looking violent changes. Our purpose should be in the direction of approaches to BSM.
- In approaching BSM, if the scales of the subjects are enough small, the differences of applying methods are rather small. In the evaluation, we should consider the used package, application area and its scales of the covered subjects and prepared functions at the age.

Third, one of the key aims of BSM approach is to provide **"Visibility with Transparency"**, especially **"Two-way Visibility with Transparency"** that includes the capabilities to let end-user imagine the management phenomena from the expressed models. As shown in Figure 1-2.

Management Phenomena ←→ Business Structure Models

It is insufficient to provide models reflecting management phenomena with "Visibility with Transparency" in only one-way. It is important to realize the status to provide the possibility for users to comprehend the management phenomena inversely from the once expressed models. In these cases, the expressed models can be in paper or in computer. From the side of expression of BSM, if it could not be realized, BSM approach becomes meaningless. Following points are mostly derived from this grasping capability of models, and detail discussion should be referred in the later part of this chapter.

- Versatile causal relations must be expressed as long as relations exist accordingly needs of expression exist. In addition, this includes the tight expression between non-monetary values as the measure of activities in the field and monetary values as economic activities.
- Models must be cooperated with other models that are not well understood and collaboration of modeling must be easily performed.
- Without grasping the entirety of the subjected areas, people can enter into modeling and systematize them. The reason is that people can understand their entire coverage having the sense of values to them after their implementation, even if they experienced before.
- On the basis of the on-site knowledge and experiences, the model must be formed as extension of perform-linked system. Also in near future, it must be investigated by synchronizing or preceding the current business activities.

As additional characteristics of confronted BSM, the models are formed, considering management cycles like the period, months, weeks, days, etc.

In the following sub-sections, we discuss on approaches by other methodologies.

2-3-2. Approach by Simulation Language

If we approach by simulation languages, we encounter the following problems.

- Let us consider a simulation program with large steps, e.g. more than 3,000 steps. This method can not respond effectively for the dynamic changes arisen by social and economic environments and caused by human conceptions. Thinking the profit planning of smaller listed companies in Japan, the programming steps by the simulation language may exceed millions of steps easily. Because of this boundary, programming approaches are impracticable.
- "Imaging the management phenomena from the developed program inversely" is almost impossible. We must not leave black box of end-user's calculating logic. Above all, that logic is the proprietary of active business. (Lack of Two-way Visibility with Transparency)

  Taking examples, describing mutual relations among detailed factors of production, cost, finance, etc., and amount of materials, hours, money, etc., expression is impossible and enormous programming steps are required. Also, let us imagine more than 30 equations. We can easily grasp the mutual relations. Our implemented cases have easily millions of equations.
- Dynamic chaining and recombination of each apportioned program as product of collaborated works are almost impracticable. Just imagine the chaining and recombination of the programmed paragraphs with 1,000 steps each produced by 10 people. Dynamic coinciding work of used variables and detailed understandings of the application logic by the consolidators are almost impossible.

(Those problems covering the description of complex phenomena are mostly caused by scalar oriented approach.)

2-3-3. Approach by Spreadsheet

Before comparing spreadsheet, we would like to emphasize that the start of our idea was preceded the appearance of spreadsheet as in Chapter 1 and Appendix I in this thesis.

If we approach by spreadsheet, the following problems can be counted.

- Currently, spreadsheet having the size of million rows and million columns with calculating capability in each cell is not provided. Current limitation of most popular spreadsheet: Microsoft Excel is 65,536 rows and 256 columns. (Structure matrix package like Supercel PC guaranteed the maximum size of million rows and million columns as center part of single structure matrix. Here, million means exactly 998,001 (999x999))

Our fundamental question is "Idea of spreadsheet architecture can be extended practically for the tables with million x million cells?"

The actual needs we meet are the support of table having billion rows and billion columns if expressed by spreadsheet. We are realizing the needs by the chaining architecture function of single structure matrices in package: Supercel.

- All the calculating logic must be set considering the processing sequence with each cell position. Once inputted logic healed behind value data in each cell must be read out.
- It is not practicable to insert many cells into the central part of the established spreadsheet associated with the individual logic of other people.

  For solving this problem, addition of new cells in the edge of the spreadsheet is common, and finally developer must maintain the maintenance of this system himself. This is often the well-used system easily left for the developer, and consequences, this system is abandoned to be inflexible for personnel change.
- Because spreadsheet has an architecture, we can not place plural data in a cell (Essentially cell data is limited as scalar data). Therefore, clustered handling of plural data (like vector data or matrix (accordingly, table) data) can not be applied.

  For example, such parallel data for multiple products and data for all accounting items should be treated some times by the units of cluster and some times by each.
- To transfer (with gathering and distributing) 1,000,000 cells of data among spreadsheets and to synchronize the progress of calculations, is practically impossible. In addition, frequent dynamic changes of these transferring relation are infeasible.

  Such transferring function is successfully realized by the architecture: *Chaining Structure* independent from the architecture of single structure matrix. We are sure such huge and complex transferring between tables can not be realized within the architecture of single table.

2-3-4. Concrete Comparison of Three Types of Methodologies

The common problems of above two methods are the lack of *Visibility with Transparency*, if they become large enough. By the same reason, to imagine the management phenomena from the developed system is almost impossible for larger system.

Another common problem of both methodologies is based on the scalar oriented method. Therefore, there is a certain limitation of coverage in the size of covering system.

Comparisons taking simple examples: programming, spreadsheet and structure matrix are shown in Figure 2-1 and Figure 2-2.[Toyama, T, et al. 1999] Figure 2-1 illustrates the three types of profit calculation: Case 1 via each product; Case 2 via each product and each area and lastly, Case 3 real business process. The data is comprehensive and two-dimensional and the logic is the simple calculation between tables or matrices, as follows:

$$S = Pu * V \qquad C = Cu * V \qquad P = S - C$$

Where C = total cost, Cu = unit cost, S = sales, P = profit, Pu = unit price, V = volume sold

Profit calculation - I By Product

Price Unit (Pu) 1000 $

PC	2.5
TV	1.5
Stereo	1.8

x

Sold Volume (V) 1000 $

PC	500
TV	500
Stereo	800

=

Sold Amount (S)M$

PC	1,250
TV	750
Stereo	1,440

Sold Volume (V) 1000 $ (PC 500, TV 500, Stereo 800)

x

Cost / Unit (Cu) 1000 $

PC	2
TV	1
Stereo	1.2

=

Total Cost (C)M$

PC	1,000
TV	500
Stereo	960

Sold Amount - Total Cost =

Profit (P) M$

PC	250
TV	250
Stereo	480

PC: Personal Computer

TV: Television

Profit calculation - II By Product and By Market

Price Unit (Pu) 1000 $

	USA	EU	Asia
PC	2.5	2.5	2.5
TV	1.5	1.5	1.5
Stereo	1.8	1.8	1.8

x

Sold Volume (V) 1000 Sets

	USA	EU	Asia
PC	200	100	200
TV	200	100	200
Stereo	300	200	300

=

Sold Amount (S) M$

	USA	EU	Asia
PC	500	300	540
TV	250	150	360
Stereo	500	300	540

Sold Volume (V) x Cost / Unit (Cu) =

Cost / Unit (Cu) 1000 $

	USA	EU	Asia
PC	2.0	2.0	2.0
TV	1.0	1.0	1.0
Stereo	1.2	1.2	1.2

Total Cost (C) M$

	USA	EU	Asia
PC	400	200	400
TV	200	100	240
Stereo	360	200	360

Sold Amount - Total Cost =

Profit (P) 1000 $

	USA	EU	Asia	
PC	100	50	100	(250)
TV	100	50	100	(250)
Stereo	180	120	80	(480)

Profit calculation -III Real Case

In realizing Profit planning, more than 1000 x 1000 items for product and market segments are used utilizing codes instead of named items.

Market Segment → 1000s

Product Category ↓ 1000s

	A01	A02	....	...
P01				
P02				

Figure 2-1 Comparison of Methodology - I
(Referred from Toyama, T., et al, 1999))

Methodology I *Traditional Programming* (Language C, etc.)

1-1. Profit Calculation By Product

```
Int I. Pu[3], V[3], Cu[3], C[3], P[3] ;   <Declare>
< Input data or Read from File >
Pu[1]=2.5; ;;; Cu[3]=1.2                 <Data Insert>
for (il=1; ;;; i<=3) {                   <Calculation>
  S[I]=Pu[I] * V[I];
  C[I]=Cu[I] * V[I];
  P[I]=S[I]-C[I];
        }
< Output Data or Write into File >
```

1-2. Profit Calculation By Product and By Market

```
Int I. Pu[3], V[3], Cu[3], C[3], P[3] ;   <Declare>
< Input data or Read from File >
Pu[1][1]=2.5; ;;; Cu[3][3]=1.2
for (I=1; ;;; i<=3) {
   for (j=1; ;;; j<=3
       S[I][j]=Pu[I][j] * V[I][j];
       C[I][j]=Cu[I][j] * V[I][j];
       P[I][j]=S[I][j]-C[I][j];
          }
        }
< Output Data or Write into File >
```

In implementation, computer operations for compiling, link and test are involved facing the change of I, J limits, These require end users' operations with high computer skills.

Methodology II *Traditional Spreadsheet* (*Excel, Lotus, etc.*)

II-I. Profit calculation By Product

	A	B	C	D
1	Product	PC	TV	Stereo
2	P	2.5	1.5	1.8
3	Volume-V	500	500	800
4	@Cost-Cu	2.0	1.0	1.2
5	Sale	1,250	750	1,440
6	Cost-C	1,000	500	960
7	Profit-P	250	250	480

Following Calculations are **hidden behind** each cell of this Sheet

B5=B2 * B3
B6=B3 * B4
B7=B5 - B6

C5=C2 * C3
C6=C3 * C4
C7=C5 - C6

D5=D2 * D3
D6=D3 * D4
D7=D5 - C6

II-I. Profit calculation By Product and By Market

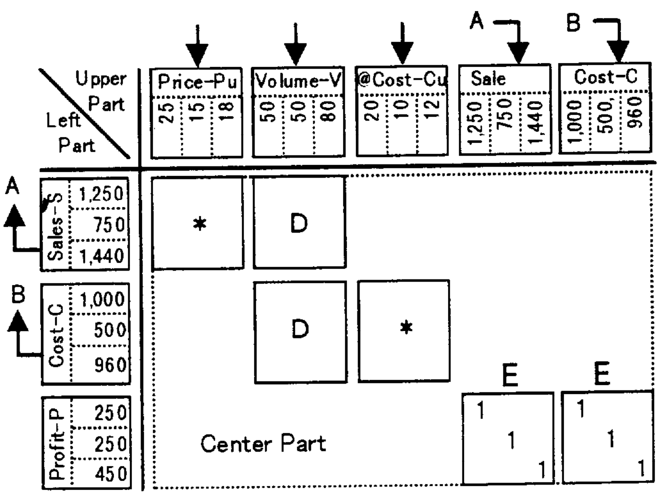
	A	B	C	D	E	F	G	H	I	J
1	Market	USA			EU			Asia		
2	Product	PC	TV	Stereo	PC	TV	Stereo	PC	TV	Stereo
3	P	2.5	1.5	1.8	2.5	1.5	1.8	2.5	1.5	1.8
4	Volume-V	200	200	300	100	100	200	200	200	300
5	@Cost-Cu	2.0	1.0	1.2	2.0	1.2	2.0	1.0	1.0	1.2
6	Sale	500	300	540	250	150	360	500	300	540
7	Cost-C	400	200	360	200	100	240	400	200	360
8	Profit-P	100	100	180	50	50	120	100	100	180

Followings are **hidden** B6=B3 * B4 C6=C3 * C4
B7=B4 * B5 C7=C4 * C5
B8=B6 - B7 C8=C6 - C7

Continued for D, E, F, G, H, I, J

When those products and market segments are given by codes, to understand the calculating logic hidden behind the cells becomes very difficult. By data size limitations in the sheet, calculation, for example exceeding 1000 x 1000 data is also difficult. Sometimes MACRO programming must be employed to overcome these limitations.

Methodology III Structure Matrix



This shows logic structure and blocks with one dimensional data. Two dimensional data (as table) can also be handled in these blocks with the same logic.
In the upper part Input blocks are located and in the left part Output blocks are located.
In the center part processing type symbols can be arranged. Some of them bear data behind them as tables for processing. Inner matrix products for the center blocks with upper blocks are prepared as default calculations.
With combination of * (Multiply) and D (Dummy), upper blocks, directly located in the upper part, are mutually multiplied and the result goes to the left part. Type Symbol: E represents the diagonal matrix.

Merit of Structure matrix for end users
- Easy developing of models
- Easy and quick response for changes
- High productivity in modeling, development and maintenance during the system life

Figure 2-2 Comparison of Methodology -II
(Referred from Toyama, T., et al, 1999))

Tables relating to *S*, *Pu*, *V*, *Cu* and *P* are of one dimension in Case 1, and two-dimensional in both Cases 2 and 3. The structure of the table -logic and table-data can, therefore, be systematically and easily illustrated by using structure matrix technology.

Figure 2-2 illustrates that the traditional methodologies, programming and spreadsheet approaches are complex but can usually be modified, though they may incur a limitation of data size. Structure matrix technology can communicate in the same logic-structure with a considerable amount of the data and multi-dimensional structures.

As stated in the beginning of this thesis, from the aim of BSM it is necessary to establish the organizational intelligence by keeping the two-way Visibility with Transparency. For ordinary human, it may be restricted within around ten or so of screens to let him grasp entire management phenomena from the once expressed models in computer and to be able to manipulate the detailed parts for case studies. Consequently, approaches to the fairy large models by these traditional methodologies are beyond the boundaries of our knowledge.

****

Note:: Some unsuccessful tries of Structure Matrix Packages

The writer has never had a chance to meet the real alternative of BSM packages, which provide essential functions as we are providing. Therefore, the writer will introduce some cases of experiences as substitution methods and the replaced project by other methods.

Case 1. Education tool of structure matrix

In 1988, the writer visited German scholars in Administration School of Business, Bochum University. There, they demonstrated a package developed for the student's education to exercise principle of structure matrix and BSM logic under the pressure of necessities as academic Mecca of structure matrix. The package building in the fundamental architecture of structure matrix was developed based on the early stage of spreadsheet: VISICALC. However, the table was flatly structured without having hierarchical structure with insufficient performance. By their entreaty, we modified MATPLAN to English use and sent them as education tool of the school, Bochum University.

Case 2. Switched to the approach by Programming

Some few systems were reluctantly switched to COBOL programs from MATPLAN which were developed on the interactive language APL. The proto-typing of material flow was very successful, but the realizing by the package was unsuccessful.

Case 3. Switched to the approach by spreadsheet

By the appearance of remarkable efficient spreadsheet like EXCEL and by delayed providing of efficient structure matrix package written by compiler languages, some systems (mostly profit planing system) were switched to spread sheet though admitting the merit of spreadsheet.

Case 4. Switched to the program development

In a steel company, expression of material flow exceeded the limit size of macro table (at that time, 500 x 500 blocks9 though partial model was successfully developed. Therefore, user reluctantly switched to programming method by compiler languages, though the problems of Visibility were remained unsolved.

As writer's comments, the switching program to other method will be ceased by the appearance of newly developed program by compiler language like Supercel. As a nature of application by structure matrix, the performance is always a top problem in our history because next target for larger size application appears when we reached.

****

2-4. Characteristics Observed in Describing the Management Phenomena

Following typical characteristics are observed in modeling management phenomena like Profit Planing, Cost management, Production balancing, etc., through the long experiences.

- Describing method having clear passage is the important subject.

  Involving input and output relations and monetary values linked with mutual causal relations, describing the factors of products, materials, parts, tools, labor hours, energy consumption, etc., requires essential method having clear passage.

- A categorizing of model concepts in business phenomena

  Management phenomena related to monetary values are categorized largely into two groups.

  A. Transitive types

  There are phenomena being understood *Transitive phenomena* along time series sectioned by week, month, quarter, year. As writer's feeling, 70~80 percentages of businesses are categorized in this group. In these phenomena, input comes simultaneously in the same time duration and transactions happened in a same time duration and the results are transferred to the different time duration

  B Project types

  Understood as Project type phenomena in which all the factors are time axis oriented.

  Businesses like Construction, Ship Building, Plant Engineering, merchant ship, are categorized to this group

- A type of causal relations

  In business modeling there are two viewpoints.

  C Flow type

  Mainly in expressing material flow, the block diagram linking material Input, processing function, and output describe flow. Thus, usual business activities are tending to be grasped by flow. In addition, profit of business is mostly grasped in a flow of money.

  D Stock type

  Assets and inventories are evaluated for stock. The concept of organization itself has been based on the idea of stock.

  Many cases of actual business activities are composed mixing these viewpoints.

  These two must be treated in the same domain.

- Reflecting multiple factors

  In most of manufacturing companies, multiple products are sold to multiple customers and multiple materials and parts are bought. For making plans to reflect strategies, neglecting variety or using averaged values are not afforded only in small range of organization or highly concentrated area of business. At present, discrimination of products and services is the main theme to servive in business world. (Exceptions are energy companies particularly electric power and gas suppliers.) These industries have simple product lines and simple yardsticks.) Also the same ones are in coal mining, metals mining and fuel companies.

However, in most companies, multiple cost factors are combined in mix with other factors making hierarchical layer one by one.

For taking examples, cost system reflecting cost drivers, or sales target setting reflecting target drivers. The business staff in those complex substances must grasp the entire of those.

How to approach the entire structure covering the jungle of complex substances is the problem.

- Major job flow

  In major companies having common job functions, there exist sequenced patterns that start from R&D or Marketing, through many job functions like manufacturing, staff functions and multiple divisions... and finally, reaches consolidated report of B/S, P/L, C/F.

- Major part of calculations in management information system

  Looking these areas of calculation from the side of bottom as end-user, calculation logic is composed of very simple logic like four arithmetic calculations (+ - x ÷) and conditions.

  Logic that requires very higher education in understanding is very rarely used and if used, the area is kept as sanctuary especially for skilled person.

  The problems are that the links of causal relations are composing very long chains and these causal factors are co-related in complex. So staff can not easily understand the influence of factor to other related factors intuitively.

  The providing of deterministic modeling method with clear passage is a confronted subject.

- Mutual relations among the bottom level

  The front level information in the organizational structure, are frequently depend on important mutual causal relation across the hierarchical boundaries.

  For example, a kind of product has a strong relation with the bottom function of plant facilities if organized by the unit of sales models and plant models. As another sample, environmental contaminants handled in each plant, are often to be neglected because they are too small to handle in the consolidate business models though summarizing them is large enough from the side of business. There exist many such matters to be handled by traditional methodologies.

  So called ***Inside Out*** or ***Cross Organizational*** methodology must be associated with planning tool as new IT.

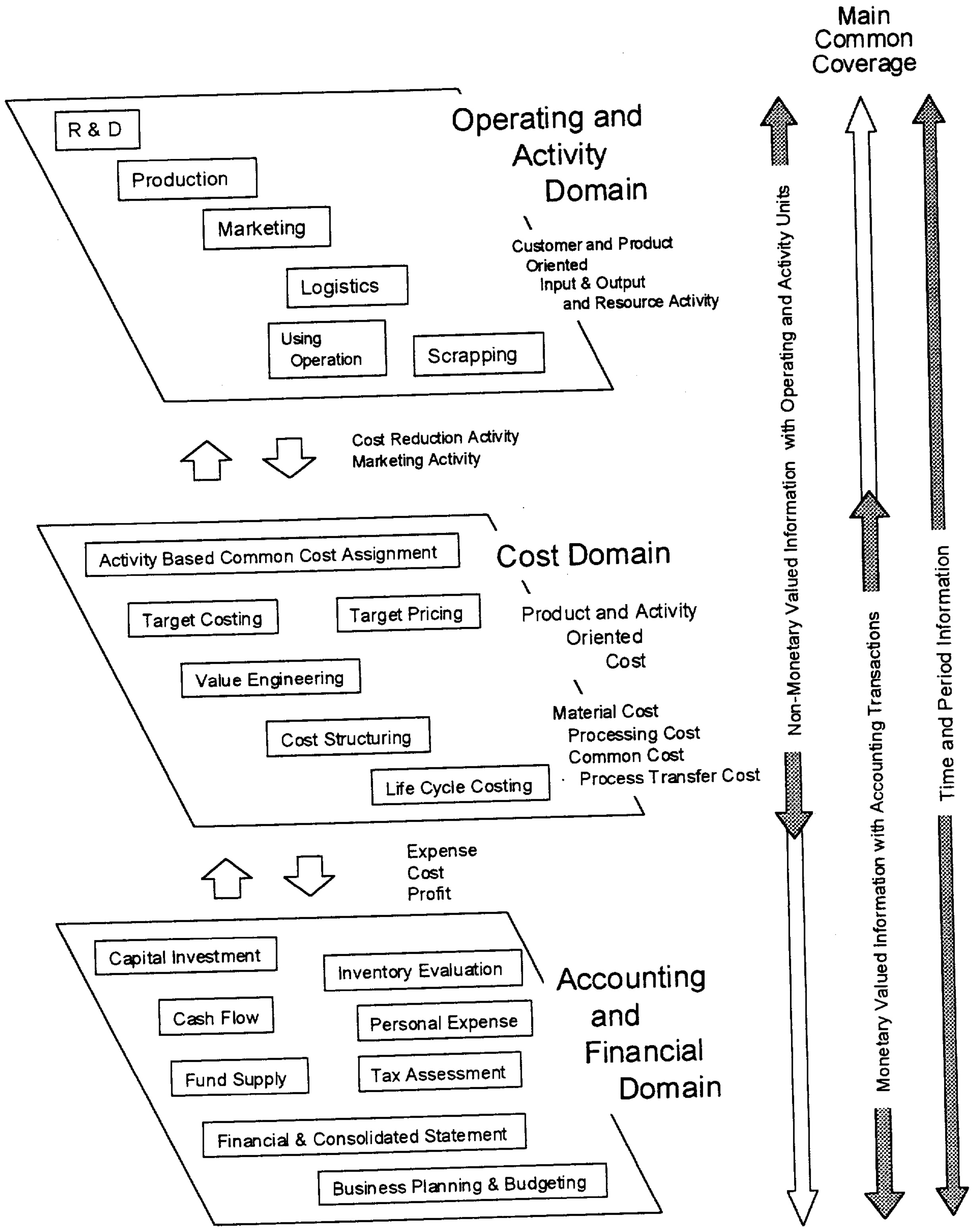


Figure 2-5 Typical Domains of Business Operations and Activities on Consolidated MIS

- Needs of Collaboration

  The more it approaches to entire business planning increase the more collaboration is necessary. The large scale planning covering whole business with realistic accuracy must involve staff represent their organizations and their specialties and skills.

- Needs of studying the cases

  The more it approaches to entire business planning, the more it increases needs of case study or re-planning.

  For responding the environmental changes, resource arrangements and changed conception given by higher management over and over, needs of re-planning, re-re-planning for entire arrangements and seeking of business chances become strong.

Visibility with Transparency

For investigating the background needs derived from the above characteristics, we can find the common and essential need as characteristics of BSM. This paragraph as a short discussion is prepared for characterizing BSM by a concept: *Visibility with Transparency.* This phrase would be the key phrase throughout this thesis. Of course, *Visibility with Transparency* in this thesis means the *Two-way Visibility with Transparency* as written in Chapter 1 and shown in Figure 1-2.

Today, requirements of *Visibility with Transparency* are directed not only for MIS, but also for activities in businesses and societies as observed in many movements: like in the rationalization of current Japanese financial industry, in the current eco-activity and in the enact basement of ISO9000 and ISO14000. By the rapid progress of globalization in these areas, accountabilities explained only by data become to be thought insufficient. Among many approach directions in designing Management Information Systems (MIS), *Visibility with Transparency* becomes one of essential requirements now. However, we understand that requirements discussed in this chapter are almost originated from one point that how we can grasp the benefit brought by *Visibility with Transparency.* Generally, accountability should be supported by data and by the persuasive logic having transparency.

Looking at the phrase: *Visibility with Transparency* from the perspective of time span, we have been treating the two important words independently from the spot of systematization. Surely, there is a duplicated area in the coverage of these words as in 2-6. Roughly speaking the direction of these words is different. *Visibility* would be directed mainly for smoother human interface. *Transparency* might be directed for satisfactory explanation how the objective phenomena would be complex. For example, graphic presentation can be a method providing *Visibility.* However, entering the detailed graphs from a part of displayed graph may require logic to support the transparent structure in the behind.

In this chapter, various kinds of viewpoints will be introduced. However, essential requirements are how to provide *Visibility with Transparency* as management technology and information technology (IT).

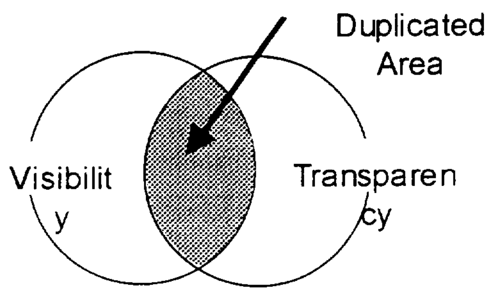


Figure 2-2 Relation between Visibility and Transparency

2-5. Hypotheses Overcoming the Problems

For overcoming the pre-mentioned problems, some breakthrough technologies must be established apart from traditional methods or from these extensions. We had a confidence of insight into the management phenomena from the long experience into computer applications. Finally we reached three hypotheses as follows. However, proving of these hypotheses is a matter to be expected not by theoretical approach, but by popularizing.

Hypothesis 1. Characteristics of calculation in BSM

The characteristics of calculation logic in major part of BSM are composed of accumulation of very simple logic if looked element-wisely from end-users. However, mutual relations are extremely complex and their linkages are extremely long forming great chains.

Major part of calculating logic is composed of simpler calculation: the four basic operations of arithmetic (Plus, Minus, Multiply and Divide), Condition calculation and calculation about interest. High level calculations like partial differential equation, dynamic programming, etc., are rarely involved from our long-term experiences.

However, relations among elements are very highly compiled and most cases, major parts of complicated relations are neglected by giving the dogmatic excuses that these have small influences. In addition, the causal relations are linked together forming extremely long chains and network.

These relations can be easily found in the profit planning of businesses covering the marketing of products to consolidated financial statements.

Honestly, thinking the expression of these complexities, two-dimensional round-robin table (In Japanese: sou-atari-table) must be necessary to representing these phenomena exactly. In this idea, empty positions are fortunate places where mutual relations don't exist.

Hypothesis 2. Technology to provide *Visibility with Transparency*

Table is one of the fundamental technology to give familiarity to end users without making them put logic into black boxes. If all the business structures with their logic and data can be reflected in a table or group of tables, we can provide applications by end users with *Visibility with Transparency*.

In decision making, using the causal relation models, which are the businesses proprietary themselves that must be kept by employee staff: end user. Accountability is a subject that should be well supported by the system's *Visibility with Transparency*.

Also, there are three domains (or better say paradigms).

- non-monetary values
- monetary values (unit cost)

- multiplicand of these non-monetary values and these monetary values (as total cost = non-monetary consumption x unit cost, and financial values transformed from these),

We foresaw that these technologies could support these paradigms keeping *Visibility with Transparency* in the same table world.

Hypothesis 3. Technology of structure matrix and its extensions

We understand that the structure matrix and its extensions is the only one that can respond technically above two hypotheses, because we couldn't find better solution. And then, we could have following insight. If program packages are developed along the structure matrix and its extensions,

- we can attain *Visibility with Transparency*
- business models having large scales can be represented
- bringing out detailed technical knowledge along structure matrix in packaging

Based upon above hypothesis, we proceeded the development of series of packages: MATPLAN (Matrix system for PLanning and ANalysis) in IBM Japan and some followers:

Rough evaluations of above three hypothesizes at this time are as follows.

Hypothesis 1. Its later half about complexity is correct, but is former half is rather reckless. We prepared much of functions with inventions for covering this Hypothesis. Detail is in the following chapters and the Appendix I.

Hypothesis 2. This was correct and along the trend of times, and this becomes certain more and more.

Hypothesis 3. We are convincing our inspiration that structure matrix is the best solution though improvements are necessary with continuing efforts.

2-6. Four Major Technologies to be established

Considering the above three hypotheses, our efforts were concentrated in establishing technologies of following four major areas.

- Technologies around the frame for handling structure matrix
- Technologies around chaining of structure matrices
- Technologies around type symbols
- Consistent technologies for describing BSM

Among above four technologies, first two are purely architectural solutions realizing structure matrix. The major part of the third (type symbols) and the last are for applications. These four seem to be quite different responding to business modeling.

Outlines of these technologies are explained as follows.

- Technologies around the frame for handling structure matrix

The frame realizing structure matrix is a base to provide tough architecture of elementary changes and calculating sequence as interactive use including activate type symbols. Also, this includes providing the function to reach structure tables, scrolling of large tables with two or three dimensional extents. Details of these technologies are written in chapter 3.

- Technologies around chaining of structure matrices

  On the basis of the establishment of structure matrices, to build up larger models by chaining of these are required. For realizing flexible chaining, some profound insight to the needs and characteristics had been necessary. Compared with other three technologies, there was no hints or succeeded ideas to establish this area of technologies. There was only the necessity to respond needs of recombination, needs of multiple data to be transferred to the multiple destination, and needs of collaboration in building up and operating large models. Details of these technologies are written in chapter 4.

- Technologies around type symbols

  Type symbol is a technology that simply represents application logic block by block. This gives users simple out look insight of models with easy understandings, with small number of type symbols around twenty. Type symbols are used by locating in the center part of single structure matrix (sometimes with single structure, and sometimes with successive string specifying particular names and parameters). In addition, type symbols work as standardizing application logic in the bottom of system. Type symbols are the keys to project business phenomena in computer world. Details about general functions are written in chapter 5 and details of individual functions are written in Appendix I.

- Consistent technologies for describing value chains

  In the modeling oriented for business structure, to establish consistent causal relation as value chain within the given range of modeling where non-monetary and monetary relations are included, is an important key. Take example of flows in the profit planning in most businesses. Models start from marketing or R&D managed by non-monetary yard sticks in the actual working site, then unit cost models are linked, and multiplication of those non-monetary values and unit cost reach financially linked area like consolidated reports. Aiming the reality of model, these items must be handled, as far as possible, by paralleled elements like product-mix, activity-mix, processing-mixed, energy-mixed, accounting item-mixed, contamination-mixed.
  Details of these technologies established along structure matrix are written in chapter 6.
  Many technologies about proportional cost and fixed cost will be discussed.

However, the consistent common aim of these four is how to attain *Visibility with Transparency*.

2-7. Strategic Approach toward BSM Technologies

Our efforts for business structure modeling are gradually concentrated toward establishing four core technologies, starting three tacit hypotheses. Through joint studies with the university and customers, and through the experiences in various customers with versatile application areas, we gradually reached the conclusion that our approach should be summarized to more general and sophisticated items, which what-if simulation in business structure modeling should realize. Those items are simply introduced in the followings

- Provide *Visibility with Transparency* for end-users

  As already said, *Visibility with Transparency* is a key phrase of these technologies. Avoiding to make black boxes, non-programming approach is crucially important for maintaining application system.

  Also this will provide end-users common base of communication each other. In addition, smooth reach of designated part of model must be guaranteed. This concept is, in some extent, duplicated with other concepts.

- Realize enough scalable object oriented architecture as table objects from the side of end-users

  Set of tables will be organized as architecture and each table will be defined and must be handled as a unit that users can handle as end-users oriented object. (So, this object implies processing way, calculation logic and data.)

- Make possible to represent heavy complex causal relations, even in the case of large scale modeling

  In the traditional approach, less important relations are tending to be neglected avoiding the complexity and explosion of programming steps. Two-dimensional *round-robin* table (This table means that all the elements are placed in the upper edge and the left edge, and in the cross points causal relation should be placed.) would be the architecture as final solution if the neglecting of less important relation should not be afforded. For coming severity of modeling like environmental problems, energy saving and this kind of requirement can not be neglected.

- Provide quick and efficient response to the change of logic and data as online

  Responding the needs of changes by end-users, without involving modification of programs or reprogramming, it is required to project influential part before the change and to guarantee the change of the necessary parts by end-users.

  Changing of logic should be performed interactively only thinking local changes without involving the investigation of the programs.

- Pursuit collaboration in modeling and succeeding of the models made by others

  In the large business structure modeling, collaboration work having different back ground and different mission is mandatory. To be collaborative, the outline of each model should be understandable by consolidator and easy interfacing conditions among models should be provided by common rules with flexibility.

- Provide two directions of extending path:

  Upward integration of models

  Downward integration of models

  As ideal approaches to the system, we can not expect modeling staff having complete experience to the business. After compiling some experiences as a part of modeling in business, model approach should be extended toward upward or downward. (The words: drill down and integration, would be adequate in some cases.) Ideally modeling mesh should be prepared for both upward direction and downward integration synchronizing the growth of modeling worker's confidence.

- Provide clustering of models and simultaneously *inside out* capabilities

  For easier handling of models driven by collaboration, models should be clustered reflecting the easier handling and extent of business boundary. On the contrary, elements located in the bottom of model are likely to be remained without linkage to other clusters. In other words, elements linked together with these in the grass roots that we can not be easily observed are not to be neglected. We would like to give a phrase: *inside out and link together*. In the age of network, such concept should be highly evaluated.

- Support proportional cost models based on bilinear relations and multiple fixed cost models

  There are cost theories for proportional cost based on bilinear relation of material and cost, established in Germany and progressed in Japan, should be fully absorbed in the architecture. Also for the modeling of common fixed cost, ABC (Activity Based Costing) and some other methodologies we developed should be represented in the architecture.

- Support parallelism in items like product-mix, parts-mix, accounting item-mix, etc.

  Nowadays being driven by the intense development of computers, representing the phenomena by using scalar values inserting the average values, become nonsense in many application areas. The same is in modeling, we predicted. Users show keen interest to grasp the influence by product-mix, material-mix, parts-mix, facilities' efficiency mix, ...etc. We must provide mechanisms to represent parallel handling of those indexes in modeling.

- Provide architecture giving both *linear structure image* as a whole and partially support *non-linear relations* for easier understanding.

  From the macro-scopic view, linear structure is easy to understand. Really, econometric models and energy balancing models are sometimes formulated as linear models as macro model. However, non-linear relations are occupying most of business phenomena. Taking the example in cost structure, relation of *total cost* is given by the product (multiplication) of *materials' quantity* and *unit cost*. These familiar three items not only limit the phenomena into technical mechanisms, but form non-linear relation. Consequently, the architecture is required to combine linear image as macroscopic views and to represent non-linear mechanisms in the bottom of modeling.

- Direct the processing logic toward *Input-Process-Output* as inter-table processing

  Concept of system analysis: Input-Process-Output in model analysis is easy to understand and its results can be the basic elements to be handled by end-users. Combining their results as models would be a straightforward way to approach the business structure modeling.

For utilizing the easier representing of *Input-Process-Output* relations, three areas (Input area, Process area and Output area) should be provided distinctively by the function. The Output to other set of *Input-process-Output* should be linked by the system tacitly in the behind.

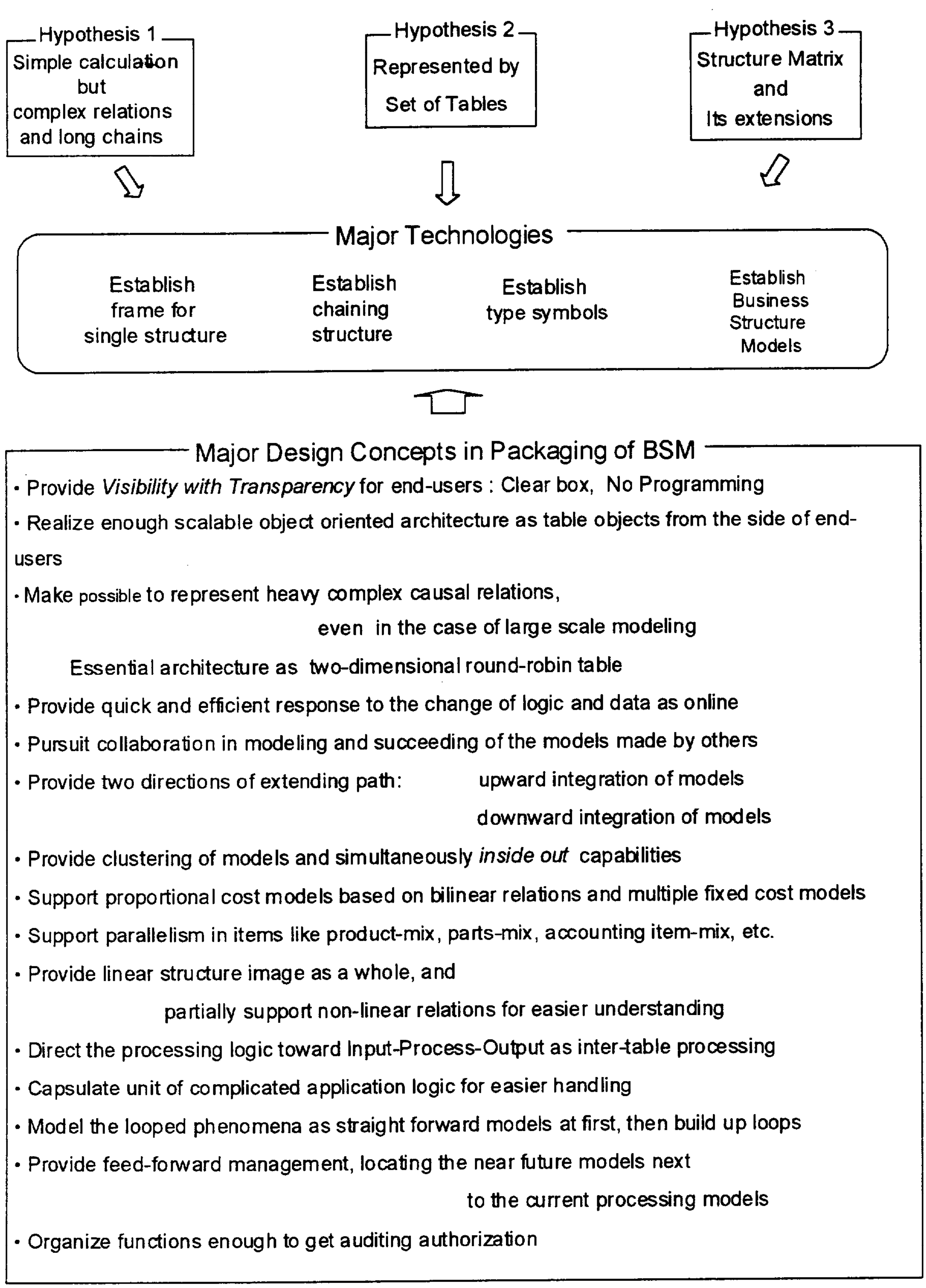


Figure 2-7 Major Design Concepts in Developing BSM Package

- Capsulate unit of complicated application logic for easier handling

  For absorbing complicated application logic should be well-defined and capsulated as type symbols. Considering the smoother modeling, those type symbols should be selected from the list. Also logic that cannot be standardized should be covered by the local programming by some sophisticated languages. Sometimes there are so-called sanctuaries in which users' own logic are developed themselves and maintained by themselves like military base in the country. For example, scheduling logic, delivery processing by their priorities, plant reaction models. This sanctuary must be well handled and maintained by lapped in the capsulated architecture.

- Model the looped phenomena as straight forward models at first, then build up loops

  Substantially, loop phenomena themselves are hard to understand. Moreover, traditional system approach required loop processing in programming that were not related to the phenomena themselves. Our strategy to support such complex modeling should be to provide simpler approaches for general users.

  One of the ways is to establish the part of straightforward first, and after confirming the completeness, loop relation should be organized step by step.

- Provide Feed-forward management

  As for business structure modeling, users require to extent of their current system by incrementing their time series. Usually integrated system for monthly statements is highly expected as an extension of these toward near future. (For example, monthly ahead, two months ahead, etc.)

  Users are eagerly expecting to have so called *feed forward management system*, by seamlessly locating the coming future models next to the present models and by getting realizable actions for future efficiency. Especially, this realization is long been hoped for from the side of management accounting.

- Organize functions enough to get auditing authorization and security protections

  Business structure models are sometimes used partially involving business performance models as GAAP (Generally Accepted Accounting Principle). In this case, technologies must be armed to pass auditing and tax audit. From the point of security in profit planning, where collaboration works are integrated, security is an essential concern for a certain organization. Taking example in the department of personnel management, planned salary structure and its concrete data are highly interested by collaborators, and must be strictly kept confidential. From the side of profit prediction, total figures are necessary on the contrary of *Visibility with Transparency*. In such cases, some cautious treatments for the ranking of security's levels would be considered. For example, manipulation, looking only, masked calculation (Possible to look only the result and logic and input data can be looked.), etc. Nevertheless of these restrictions, the value of *Visibility with Transparency* in modeling will never be lost.

From next chapter, details of four technologies are discussed individually.

3. Principle of Structure Matrix Utilized

Current architecture was attained through the long history of trial and errors, starting from the idea to describe the management phenomena with *Visibility with Transparency*. In this chapter, some principles will be introduced as bases of ideas and the basic idea of how and why we reached the current architecture will be introduced. How we reached the current architecture of structure matrix is shown in the chart of history: Figure 3-1.

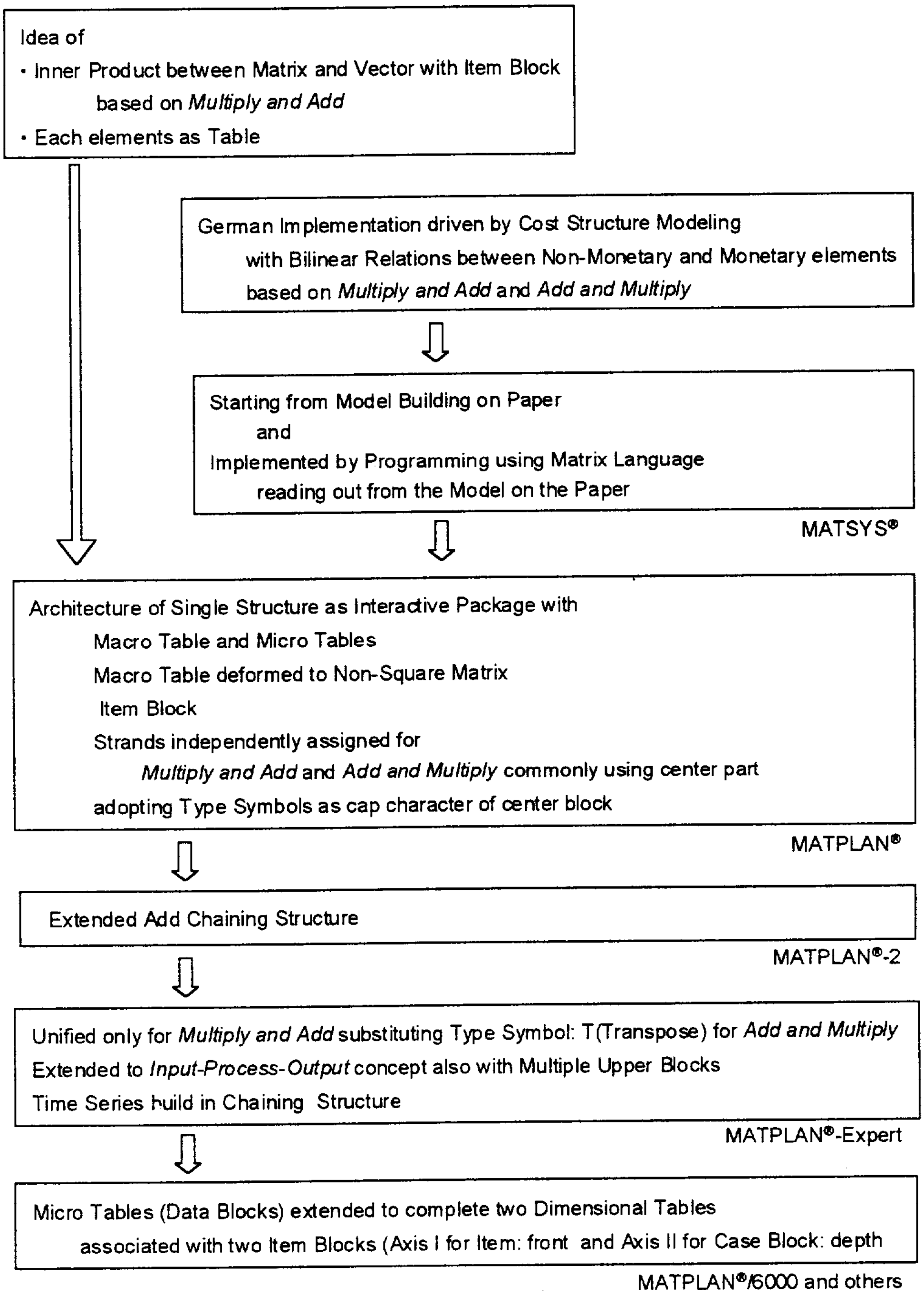


Figure 3-1. History toward Current Architecture in Structure Matrix Package

3-1 Basic Characteristics of Structure Matrix

In this chapter, basic principles necessary for further chapters are introduced.

3-1-1 Structure Matrix as Graph Matrix

As starting this expression, a graph of process flow chart (or flow diagram) of a chemical process is shown in Figure 3-2..

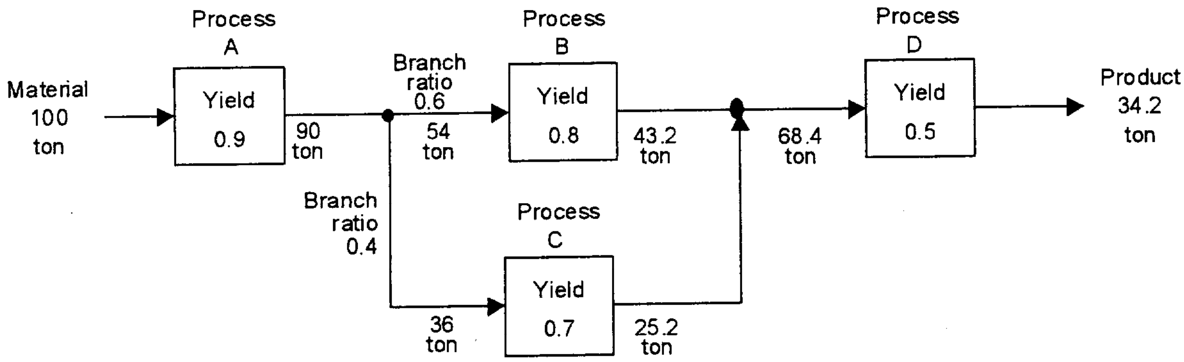


Figure 3-2. Expression of Process Flow Diagram

It can be easily converted into a matrix notation and its calculating process can be expressed as structure matrix involving the calculation of *Multiply & Add* as in Figure 3-3..

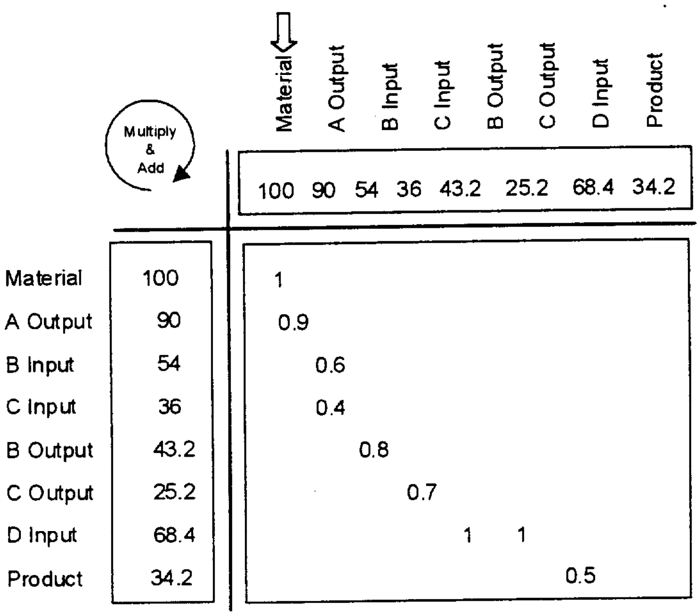


Figure 3-3. Expression of Process Flow Diagram by Structure Matrix

In this example, each figures in blocks and flows are scalar.

Figure 3-4 is an outline of material flow in wire production linking Rod Mill and Wire Mill starting from input material: billet. Commonly, a calculating problem of material requirement is performed inversely along the material flow. Figure 3-5 shows block diagram for production of multiple products (mix production), giving their yield data in the form of matrices.

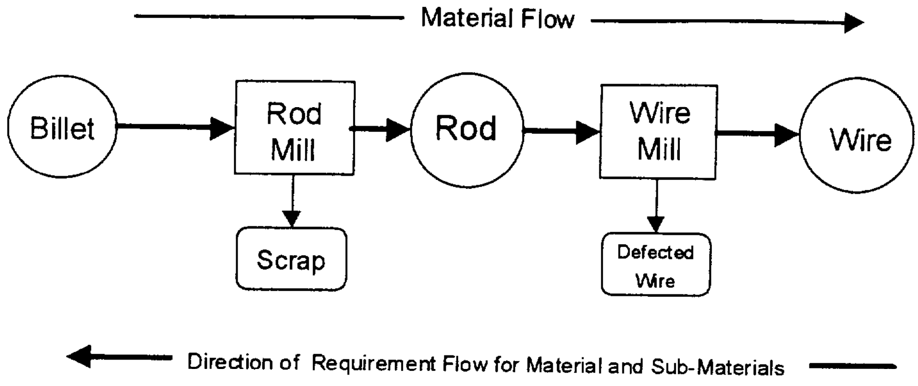


Figure 3-4 Flow of Wire Production

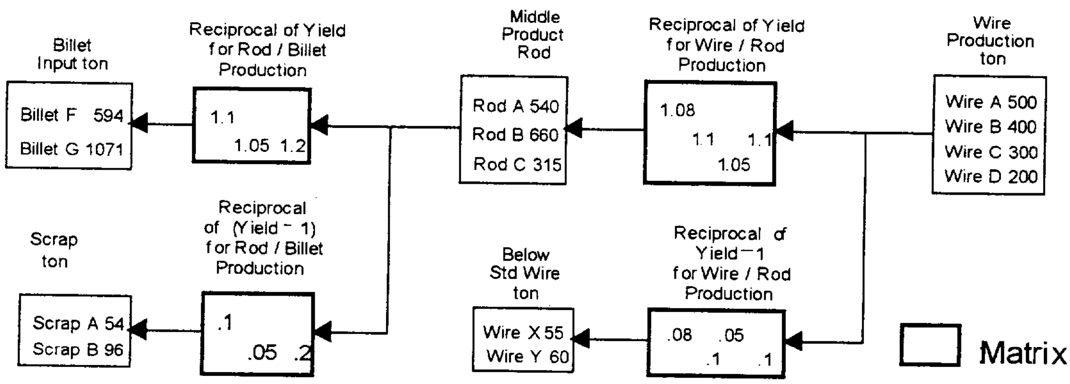


Figure 3-5 Block Diagram of Production Factors

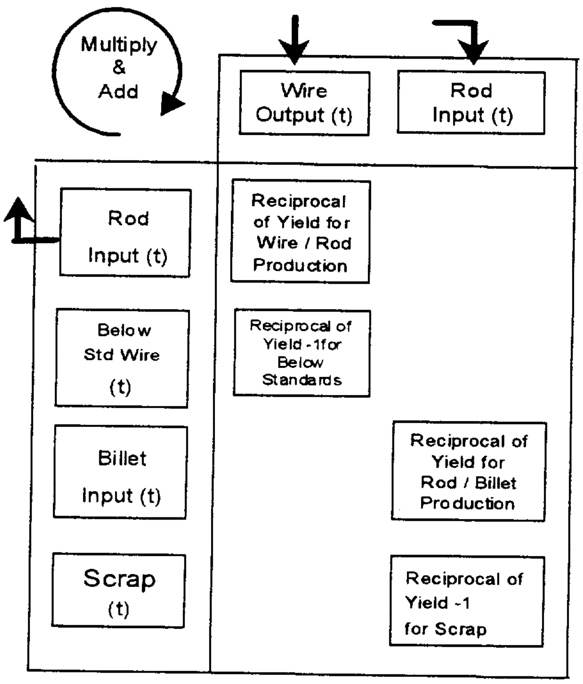


Figure 3-6

Structure Matrix converted from Block Diagram with Scalar Variable Image

Note: (t) : ton

A converted image of the block diagram to structure matrix is shown in Figure 3-6, in which representative names are placed capping the blocks. At present composition of blocks are not in sight.

The mapped image of the structure matrix is shown in Figure 3-7, with developed details of blocks: the plural values (vectors and matrix values) accompanying their meaning associated with each numerical value.

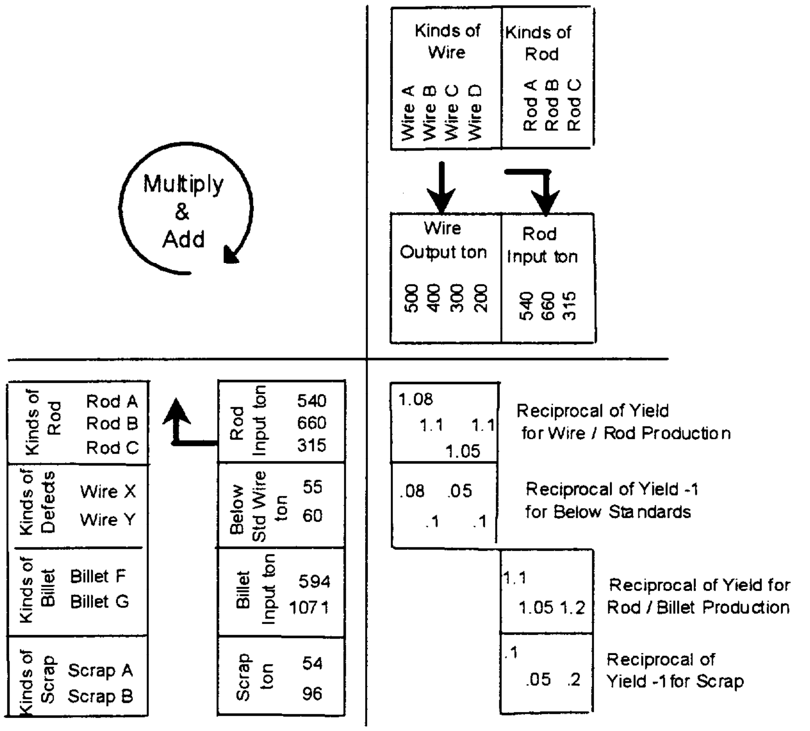


Figure 3-7 Product -Mix Expression of Material Requirement by Structure Matrix

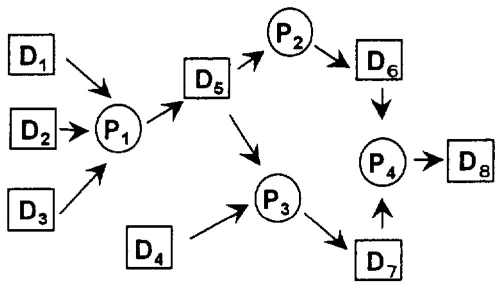
Another approach by following sequence of steps can be thought.

- A graph of business phenomenon is expressed in diagrams where contents of blocks are grasped as scalar values.
- The diagram is converted into a macro table of structure matrix.
- Expansion of blocks to plural values and arrangement of center block are performed.

Up to this point, calculations are limited within *Multiply & Add*. For common availability to business phenomena, the study to convert the graph shown in Figure 3-8 into structure matrix should be discussed.

Figure 3-8 Network Description of Input Process Output Relations

D_n: $Data_n$
P_n: $Process_n$



If multiple blocks are set for the input to a $\mathbf{P_n}$ process, processing of $\mathbf{P_n}$ must be waited until all of inputs are ready to be used. Zero values are kept in the input blocks, until all the inputs for $\mathbf{P_n}$ process: (located in the calculating chains) become ready to be used. These waiting actions are the kinds of pacing for the arrangement of difference caused by the previous calculating path.

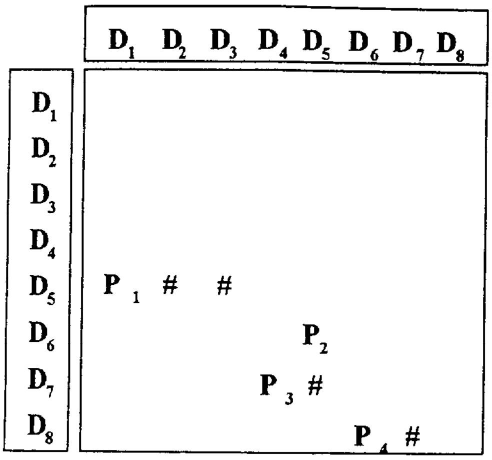


Figure 3-9 Description of Input Process Output by Square Matrix

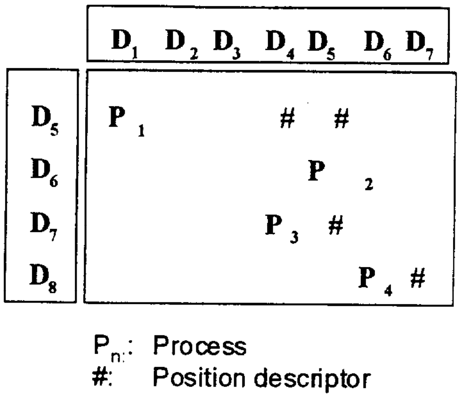


Figure 3-10 Description of Input Process Output by m n - Matrix (Non- Square Matrix)

In Figure 3-8 the graphs are formed as a structure matrix, with a rectangular shape. Here the processing types having multiple inputs are expressed with symbol P and symbol #, located in the same row. The dyadic calculation is represented by the combination of symbol P and #.(See $\mathbf{D}_7$, $\mathbf{P}_3$ uses $\mathbf{D}_4$ and $\mathbf{D}_5$, and process $\mathbf{P}_3$ waits until $\mathbf{D}_5$ becomes ready.) Here, the dyadic calculation means that two input blocks in upper part are used.(Also, center block associated with symbol P can be used. This relation can be extended to more than two blocks in upper part like getting $\mathbf{D}_5$.) The symbol # specifies the block in upper part at the time of processing of P. (In other wards, symbol # act as multiple wait of input for synchronized use of input blocks in upper part.) These details are discussed in the extension of calculation to Input-Process-Output and Type Symbols. Redundant part of structure matrix shown in Figure 3-9 is trimmed as shown in Figure 3-10. The trimming of structure matrix will be detailed in the next section.

Multiply & Add

The phrase: *Multiply & Add,* was an idea of writer: Toyama, in back of his mind 1955[Appendix I], for explaining matrix calculation more familiar after his first learning of the concept of matrix. At the first introducing stage of structure matrix to Kobe Steel Works, Kobe Steel Inc., the phrase: *matrix calculation* had been great obstacles to progress the project with support from top management.

Therefore, the phrase: *Multiply & Add* (In Japanese: *Tate -Seki-Yokowa*: meaning is *Vertically Multiply then Add* across sideways) was adopted in explanation. There were some hesitations in accepting this phrase from the people having mathematical background. Much to promoters' surprise, the phrase got good reputations from the people having business back ground. Their comments were "*Why mathematicians don't adopt such phrase?*" By this phrase, primary stage of matrix operation is applied to explain Inter Tables Processing. Thus, the idea of structure matrix became a base to handle a special type of table handling.

Thereafter, *Multiply & Add* was introduced in the explanation from the first and was populated as technical phrase to explain structure matrix smoothly.

3-1-2. From Rectangular Expression to Non-Rectangular Expression

We paid much of efforts to extract practical merits from of non- rectangular expression along the extension of rectangular matrix. Some people still think that the structure matrix in rectangular expression and non-rectangular expression are quite different. This section is prepared for introducing basic characteristics adopting non-rectangular expression with compensating this problem.

By the following three reasons, we adopted the non-rectangular expression.

- Saving the expressing area on the display screens
- Easy finding of calculation sequence
- Saving calculation

An example of a linked production process with non-rectangular expression is shown in Figure 3-11.

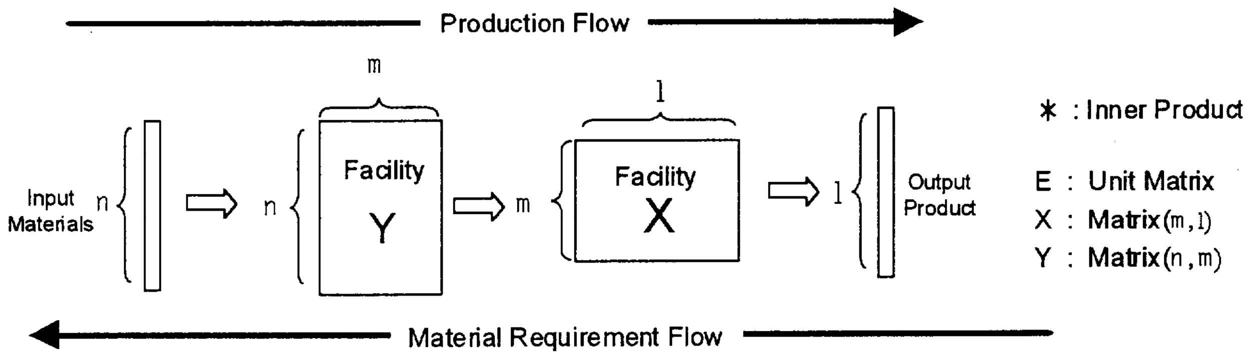


Figure 3-11 Expressing the Chain of Production Flow

Production flow through Facility X and Facility Y is given and material requirement process is normally performed with inverse direction. For more concrete image, let us imagine facility X as wire mill and Facility Y as rod mill shown in Figure 3-4. Relations of this size used for Input-Output relations are shown in Figure 3-12. This is a minimum calculation by inner product required for material flow.

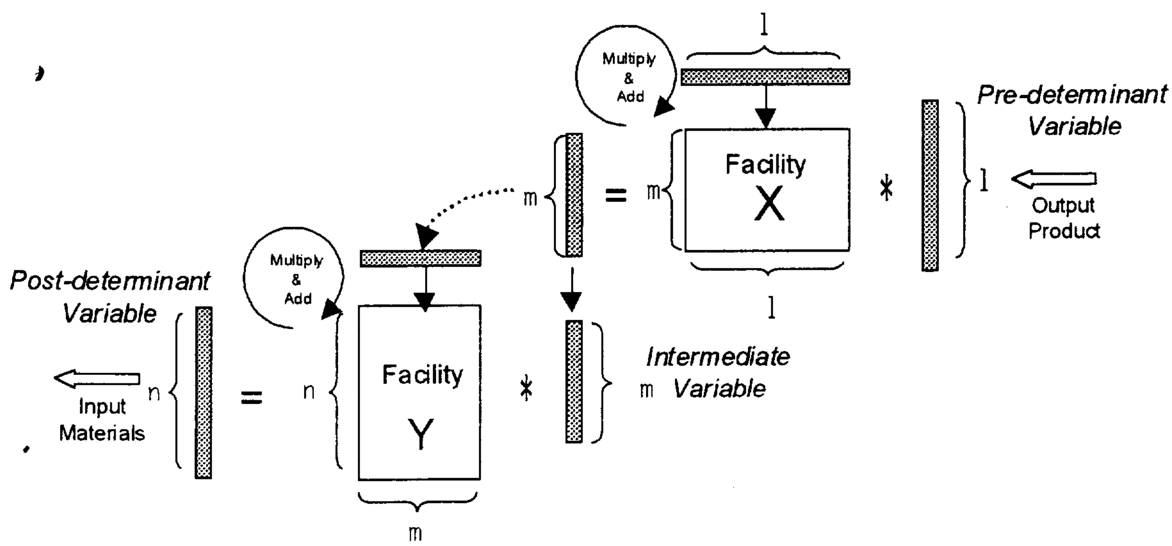


Figure 3-12 Matrices Linkage of Inner Product

This calculating relation can be placed in the expression of rectangular structure matrix in Figure 3-13. In this expression, calculation starts from upper part (A) with data in painted place. Other non-painted white places have zero value data. By executing *Multiply & Add*, left part (B) is obtained then whole left part (B) goes to upper part (B) turning their direction from vertical to horizontal. Again by *Multiply & Add*, (C) is got and goes to upper part. Then this calculation repeats until all the left become zero. You may understand that this method contains inefficient calculation.

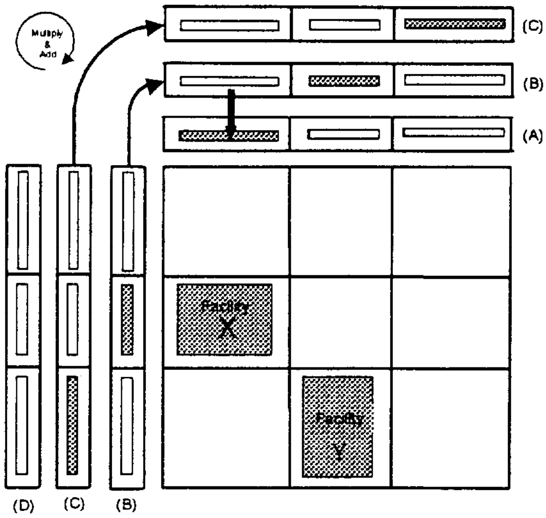


Figure 3-13
Expression on Rectangular Structured Matrix

Principle of another trial on rectangular structure matrix is shown in Figure 3-14. In this case, diagonal matrix is placed in the cell under the starting vector on the diagonal position of cells. Calculations: *Multiply & Add* with transferring left part to upper part are repeated until all the result of left part equals to that of upper part. By the easiness of programming, such calculations were tried for getting the production or energy balance of large plants as batch system of early ages. However, those expressions were not efficient from the side of developing models compactly and from the point of developing interactive package.

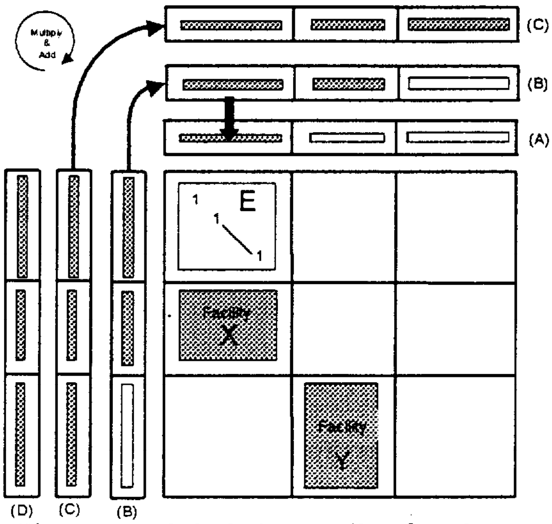


Figure 3-14 Calculations until Left and Upper values become same

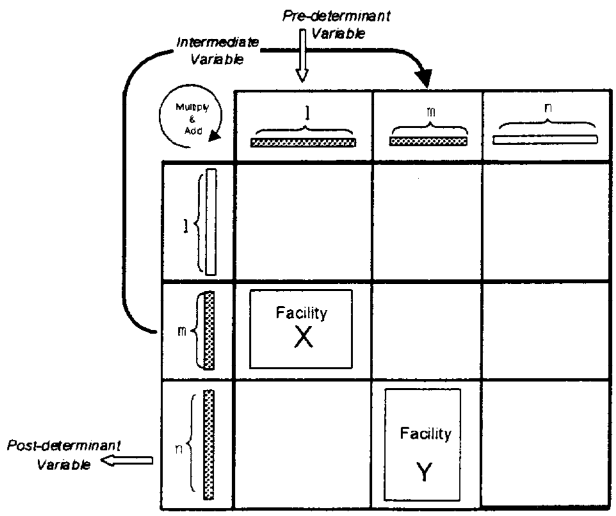


Figure 3-15 Calculation of Sectionalized Rectangular Structured Matrix

The important characteristic in this expression is that this forms a round robin table possible to relate all elements in upper part to the elements in the left elements (In Japanese: *Sou Atari Hyou*).

However, useless calculations exist, comparing the minimum calculation shown in the Figure 3-15. For solving this problem, upper and left parts should be sectionalized and handled by the unit of sectionalized blocks of vectors and matrices as shown in the right: Figure 3-15.

By placing the intermediate result in the left part and transferring it to upper part, calculation goes on repeatedly until all the blocks of left part are calculated with proper existence of matrix blocks in the center part. For discussing the condition, we should think a rectangular graph matrix in which these matrix blocks are represented as value 1 (one) as in Figure 3-16. As condition of matrix shape, the matrix should be an *association matrix* representing directed graph that doesn't contain loop or bi-directional relations. This rule is a main rule to guarantee the possibility of essential calculation in our study.

Figure 3-16 Graph Matrix Representing the Center Part

$$\begin{pmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{pmatrix}$$

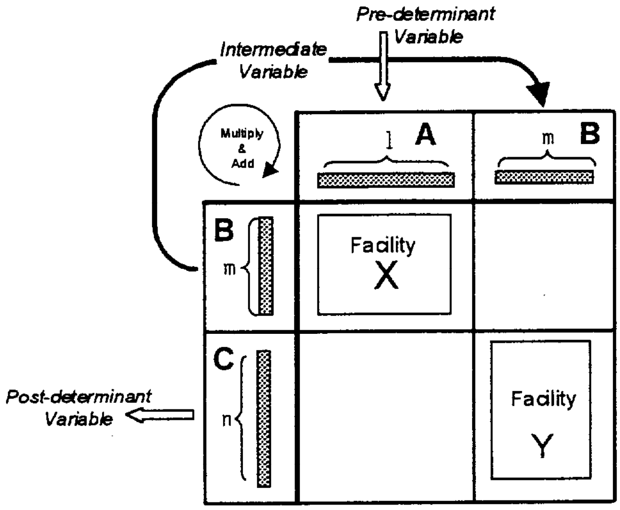


Figure 3-17 Expression of a Non-Rectangular Structure Matrix

However, this expression still contains useless area shown by hatched areas in Figure 3-15.
The expression saving the hatched area is a non-rectangular structure matrix shown in Figure 3-17.
This is the starting point of our architecture realizing the practical and generalized architecture of structure matrix.

By looking this expression, we can characterize the following three kinds of variables within both areas: upper and left parts.

- Pre-determinant Variable Block (A)
  They are blocks located only in the upper part and not located in the left part. Calculation starts from position of those variable's positions.
- Intermediate Variable Block (B)
  The results of intermediate variables in B are first given in the left part and transferred to the upper part. After transferred, the row containing the results is masked. Accordingly, the resultant blocks in the upper part can be treated evenly as pre-determinant variables for finding next calculations.
- Post determinant Variable Block (C)
  Those blocks are blocks located only in the left part, not in the upper part. The calculation ends here.

Thus by this discrimination of blocks by location, calculation sequences are established. In this description, please think vectors (or matrices) in both parts as variables and the existence of multiple number of these variables. As already discussed, placing of these variables as blocks are important for the linkage of analyzed phenomena and models expressed in structure matrices, not only saving of expressions and finding of calculation sequences.

It is an important point as non-rectangular expression, that it keeps still the possibility of large *Round Robin Tables* (In Japanese: *Sou Atari Hyou*) between upper elements and left elements, except regressive relations for themselves. This characteristic provides possibility of expression for complex phenomena. The problem is how to provide efficient and practical architecture to users with *Visibility with Transparency*.

As a reference of further discussion, some studies about rectangular structures are described in the following. The non-rectangular form is a deformed form of rectangular structure. Therefore, sometimes we must discuss the characteristics converting it to the rectangular forms.

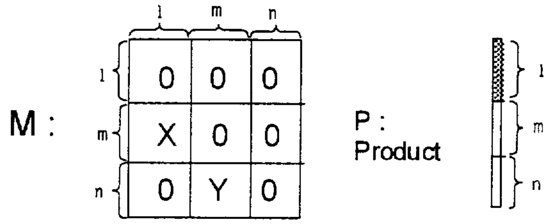


Figure 3-18 Center Part and Vector for Product Requirement

Characteristics of Series Sum of the Center Part

Let us take an example of combination of two facilities: X and Y with required output vector: P as in Figure 3-18 (Please refer Figure 3-14).

The large matrix: M is composed of sectioned matrices. In addition, vector P is a vector within which sectioned vectors are incorporated.

Generally, a relation between regular matrix and its series sum is given by the equation in the right if the convergence of series exists.

This is given by inserting M and E (for Eigen Matrix) as shown in Figure 3-19. Because of finite path length of two, power of M becomes zero after M [3].

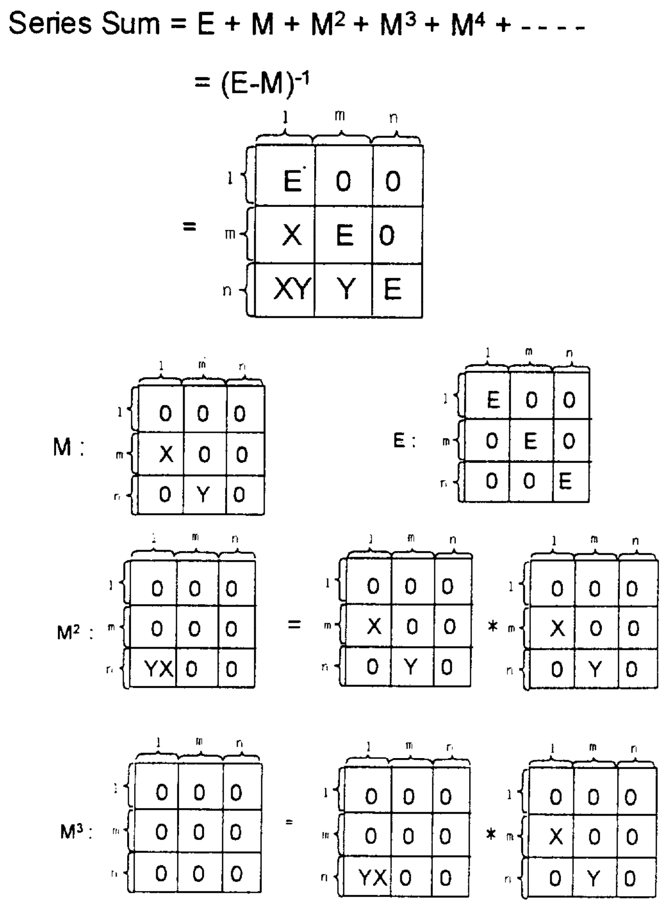


Figure 3-19 Power of Matrix: M

The calculated results and relations between product requirements and material requirements are shown in Figure 3-20. Please watch XY is given as a part of Sum Matrix. This figure illustrates aggregation of process flow.(Re-normalized) This method is used in expressing the large integrated steel works for grasping whole activities viewing as a single image.

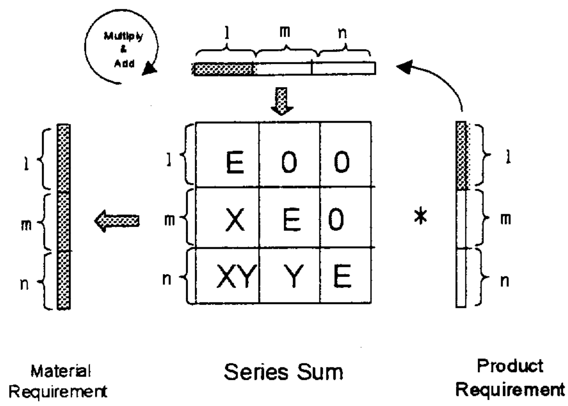


Figure 3-20 Calculation with the result of Series Sum

3-2. The realized architecture extending the idea of structure matrix

Our experience started with a sequence of methods called batch processing as follows.

- Making models in the form of structure matrix on paper, analyzing management phenomena.
- Reading out the calculating sequence somewhat mechanically by rote

	Considered Points	Batch System	Interactive System	Comments / where written
1	Consideration of Hierarchy	Not necessary	Intentionally organize the existence as Macro Table and Micro Tables.	See: General Architecture
2	Freedom from Rules	Almost no constraint	Certain restrictive rules required	See: Rules of Macro Table
3	Versatility of Margin Part (Upper and Left Part)	Plural strand can be placed (dual direction for calculation)	One strand only (*Multiply & Add* and its extensions)	See: Technology of Modeling and Type Symbol:T
4	Calculating Directions	Dual directions for *Multiply & Add* and *Add & Multiply*	*Multiply & Add plus* its extensions to *Input Process Output*	See: Type Symbol
5	Versatile Calculations	Building in user written logic	Preparing versatile Type Symbols	See: Type Symbol
6	Intermediate Calculated Results	Not specially paying attentions	Keep for user's check of calculation logic and for the chaining	See: General Architecture
7	Pointing and Displaying of Blocks	No needs	Pointing by cursor and displays on screen	See General Architecture
8	Association of Item Blocks	Loosely coupled on paper. Consideration necessary only for data input and report generation	Concept of Item Block was mandatory. Tightly coupled in modeling, displaying blocks and calculation	See: Axis Information
9	Size Define and Changes in Macro Level	Rewriting of Models on paper and re-programming with compiling and execution.	Interactive changes in MacroTable and operation of calculation	See: Rules of Macro Table
10	Size Definition and Change in Micro Level	Human consideration for influential blocks required	Influenced blocks by the change in Item must be detected and unanimous change must be executed.	See: General architecture, Axis Information
11	Series Handling	No needs of consideratio for special architectures	From the first time, architecture must be provided.	See: General architecture, Series Concept
12	Chaining Structure	No special idea	Independent Architecture: Chaining Structure was Established	See: Chaining Structure, Realized Chaining Structure

Table 3-1 Major Considered Point for Establishing Interactive System

- Programming by matrix language (IBM MATSYS used)

- Batch processing by computer then confirming the results

This approach was established by German experiences utilizing matrix language: IBM MATSYS.
After these experiences, we had to take a step toward interactive package responding the strong user requirements with quicker response moreover toward providing a mean for keeping user's continuity of thinking through out the modeling activities.
In establishing the architecture of the interactive system, following points in Table 3-1 were mainly considered.
For understanding details of realized architecture responding the requirement of PART I, considered points are related with many parts of this thesis and entering from rough sketch would be required. Next subchapter was prepared for more complete over all understandings of basic interactive architecture toward packageing, even considering some duplication.

3-2-1 Basic principle of realized structure matrix

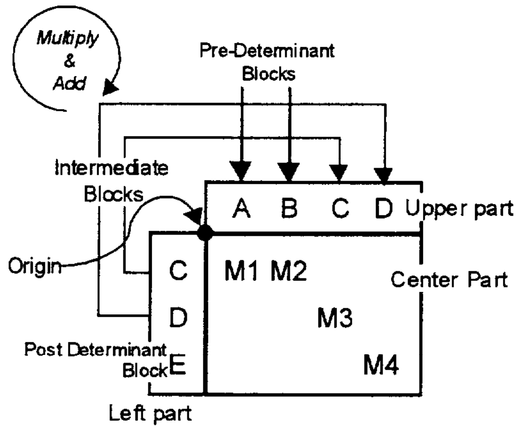


Figure 3-21 Naming of structure Matrix

Explanation of structure matrix by simple illustration
Let's start a rough explanation from Figure 3-21, which explains three parts of structure matrix as Upper Part, Left Part and Center part.
First we should start from symbols: A, B, C, D, E, M1, M2, M3, M4 as representative names given for scalar values.

- Start from upper symbols, not in the left part: A and B. (These are said predetermined Symbols.)
- Calculating relations are,

Vertically Multiply;	Upper data: A and B are multiplied vertically with center data: M1 and M2 by each and these results are hold in the original position of center data: M1 and M2.
Horizontally Add;	These hold results in the same row are horizontally added and stored in the symbol: C within the left part.
Circulation;	The data in left part symbol: C is transferred to upper part symbol: C.

This calculating circle is called Multiply & Add.

- Repeat these calculations with circulation until termination of reaching E.

$$C = M1 \times A + M2 \times B \quad \ldots\ldots (1)$$
$$D = M3 \times C \quad \ldots\ldots (2)$$
$$= M3 \times M1 \times A + M3 \times M2 \times B \quad \ldots\ldots (3)$$
$$E = M4 \times D \quad \ldots\ldots (4)$$
$$= M4 \times M3 \times C \quad \ldots\ldots (5)$$
$$= M4 \times M3 \times M1 \times A + M4 \times M3 \times M2 \times B \quad \ldots\ldots (6)$$

This set of calculation relation is the same as equations in the right. By generating equations toward (6) one by one, we can watch that predominant symbols: A and B and intermediate symbols: M1, M2, M3 and M4 are built in the final stage of result: E.
This means that if we can change data behind these sym-

bols interactively, we can grasp the every stage of influence of each factor.

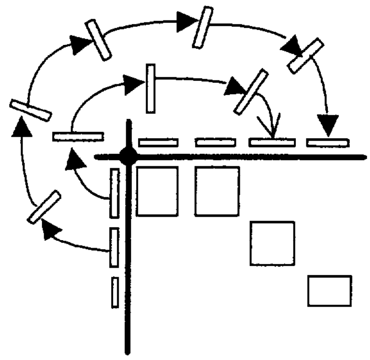


Figure 3-22 Extension to Vectors

Extension from scalar to vector or matrix

These elements used in the above illustration have been treated as representing scalar values. Then these elements in the upper and left parts are extended vectors or matrix, and accordingly, elements in the center part are extended to matrix synchronizing the extension of related elements in the above position of upper part and left position of left part. This means coincidence of sizes in structure matrix.

These extended elements are turned around the origin of structure matrix in transferring these elements, placing upper edge in the left to the left edge of the upper part as shown in Figure 3-22 and Figure 3-33. Irrespective of these extensions, calculation rule: Multiply & Add are kept in the whole of structure if the dimensional sizes of these elements are maintained with integrity.

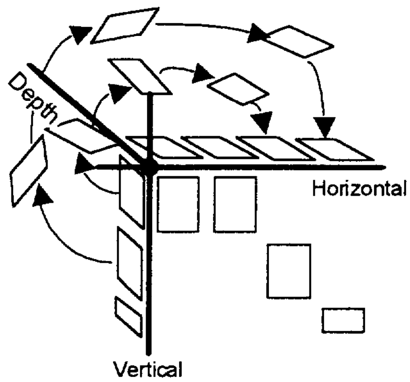


Figure 3-33 Extension to Matrices

3-2-2 Extension toward Table-Driven- Tables-Processing Architecture

For realizing the interactive handling of the set of organized tables with calculating capability following the structure matrix concept, a multilevel architecture with concept of *Table-Driven-Tables-Processing* must be established. An example expressed in the flat domain as given in Figure 3-24 can be organized as a set of two storied tables with a Macro Table and Micro Tables linked with it by the name as in Figure 3-25.

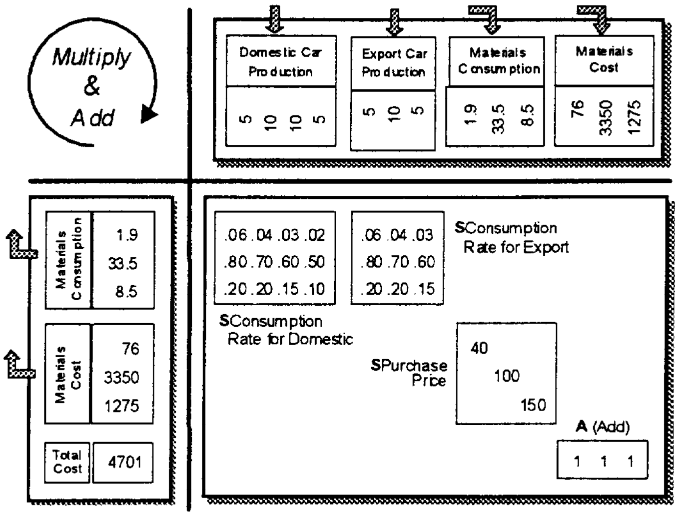


Figure 3-24 A Sample of Structure Matrix in Flat Domain

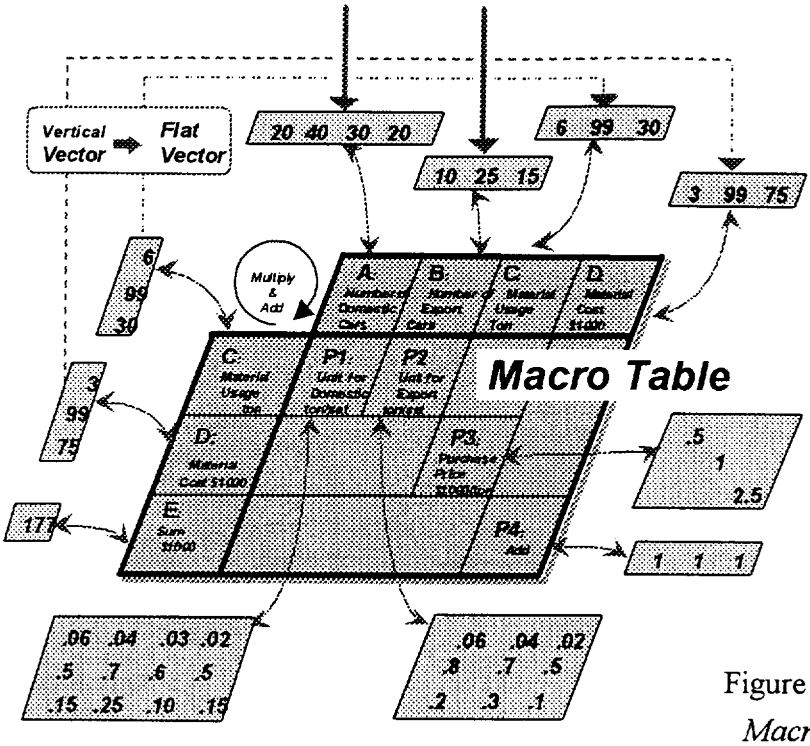


Figure 3-25 Relation Between *Macro Table* and *Micro Tables*

In the adopted examples in this figure, micro tables seem to be smaller compared with the macro table. However, there is no such restrictions in sizes that reflect real phenomena. The realized sizes will be shown in the realized architecture in the realized architecture's sketch in the later.

The distinctive feature of this architecture is as follows.

- Linkage between macro table and each micro table is only based on their names given to each micro table by registering them as elements of the macro table. We gave·the name: Block to micro tables implying accessible set of data as users' objects. Therefore, adding, inserting, deleting, renaming, and exchanging by blocks can be possible.
- Developing of each block can be possible by pointing the cursor on the block name in the macro table.
- Calculation sequence and the relation between blocks can be grasped by looking at the macro table.
- In grasping the models, users can enter into micro tables from the macro table as if providing Bird Eye Views. This capability is making the feasibility of maintenance and succeeding of models by end users.
- From the side of computer architecture, composed of expensive main memory and cheaper peripheral memories, this architecture structure with Macro Table and Micro Tables could generally fits well. Because in accessing micro table, macro table and only the targeted block (micro table) should be stayed in main memory. In calculating, macro table for finding calculating relations and only the necessary blocks should be fetched into the main memory as transit passing phenomena. This characteristic is also succeeded to the chaining architecture.

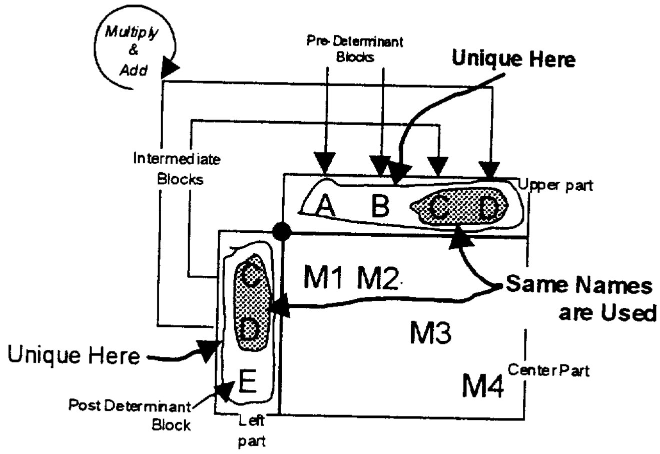
3-2-3 Characteristics of Macro Table

The rules and technologies required for handling the macro table are as follows.

- The two-dimensional sizes of Macro Table are decided by placing the blocks in lines in upper part and left part without blank position. Numbers of names in upper part and left part determine the two-dimensional size of macro table.
- The names of blocks must be unique within upper part, and the same within left part.
- Some common names can exist in both upper and left parts.

These are intermediate blocks in the calculation. The real data of these common blocks are uniquely exist as internal architecture. Therefore, display developing of block's contents from both upper and left parts can be possible by cursor pointing.

Figure 3-26 Location and Naming Rules in Macro Table



- As consequence of above, the blocks, not in the left part become Pre-Determinant Blocks. Similarly, the blocks, not in the upper part, become Post-Determinant Blocks. These characteristics depend only on the placing of block names in both parts.
- The name of the block in center part depends on the rule of Type Symbols prepared by the package. Some blocks bear actual value data with capped type symbol and following proper name. Some of them are pseudo block name having no actual data placing advanced type symbols.
- As nature of matrix calculation, the calculation results are equal even if elements in macro table are exchanged all together by all the row elements or by all the column elements.

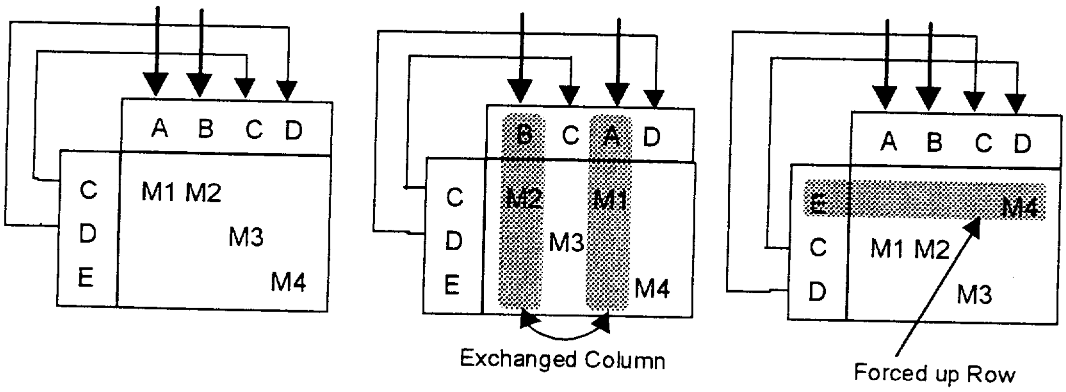


Figure 3-27 Same Results by the Exchange of Columns or Rows with All Together

This characteristic is well used for remodeling aiming easier understanding and for quicker reaching to the targeted blocks after calculations. This characteristic is extended to the model containing non-linear type symbols or Input Process Output models by associating the type symbol: D or # (Dummy and Wait).

- Change of calculating logic

For the change of calculating logic, this action must be made interactively and intuitively by end users without serious change of existing logic.

Taking the middle example in Figure 3-28, operational sequences on screen are as follows.

- First Step: Select adequate position on upper part to insert the upper block. Automatically vertical space opens
- Second step: Place upper block name to insert
- Third step: Register center block names considering the positional and logical relations

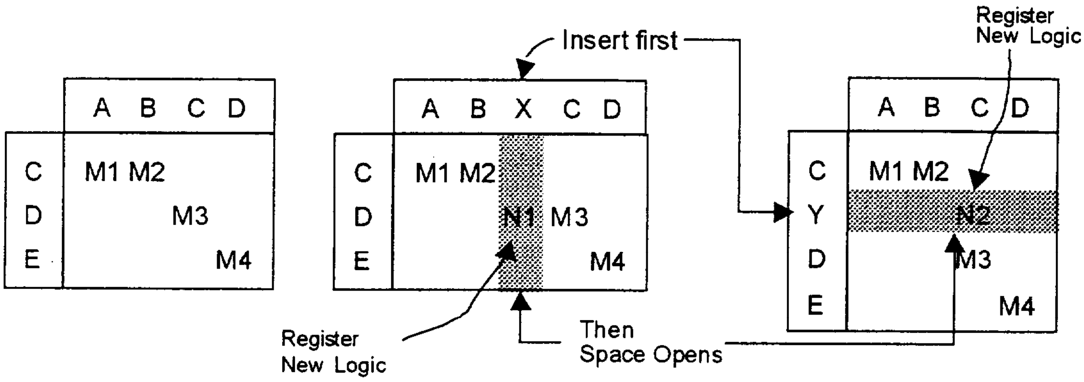


Figure 3-28 Sequence of Adding New Logic

Under the calculation frame of *Multiply & Add*, center block having matrix data capped by linear *Type Symbols* (like S, B, G, R, =, T (Transpose) and E with diagonal data) can be placed to the optional positions selected by modeling conveniences. This operation is extended to the pseudo or extended matrix operation of Type Symbols: A, E, M, V and @.

In addition, *non-linear Type Symbols* (like Q, C, P, %, T (Turn), *, / and X,) can freely be placed under the extended calculation frame: Input-Process-Output. Among many of them, multiple upper blocks are specified associating Type Symbol: D or # (Dummy and Wait).

The methodology of calculating sequence, responding the free placement of center blocks, can be established only by following the local needs of changes. This means it is not necessary to consider the calculation sequence, by automatically interpreting the layout of whole macro table to calculation sequence. Many of application programs armed with users' unique logic are commonly maintained by traditional methodologies like so called *Waterfall Type*. (i.e. Programmed logic is surveyed in details, and those programs are inserted or sometimes developed again for modification, then recompiled and tested.)

- Scrolling function in displaying the macro table organizing related three parts (Edit and Scroll)

Limited by screen sizes and human intellectual horizon, even the large macro table must be shown by screen scrolling with automatic editing of related three parts in to one table as in Figure 3-29.

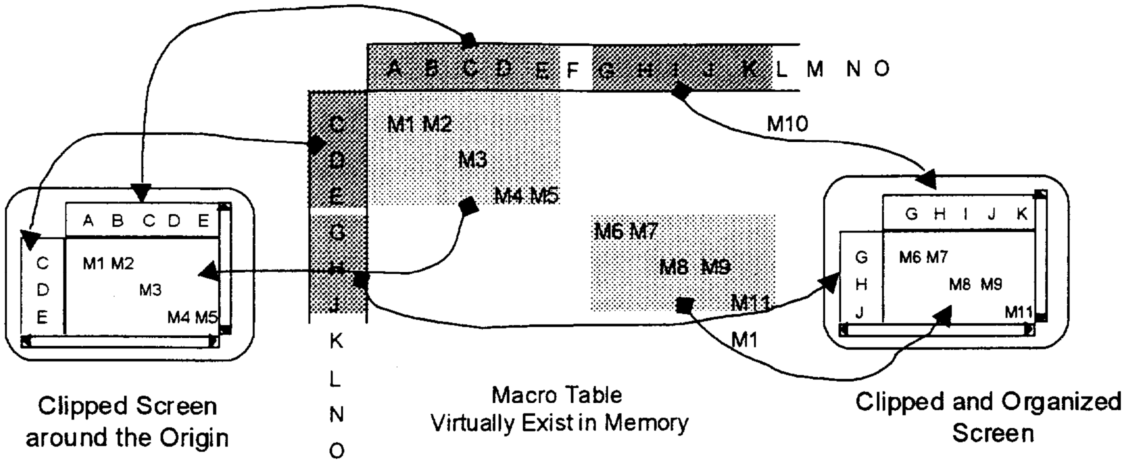


Figure 3-29 Clipping and Organized Screen for Displaying Macro Table

3-2-4 Characteristics of Micro Table and Axis Information

The fundamental characteristics required for the micro tables (blocks)

The functions of micro table must be supported by the followings.

(1) Macro table and micro tables must be linked through the name of each element of macro table.

(2) Displaying and change of numerical values in a micro table must be kept independent from other micro tables.

(3) According to the given calculation sequence prepared by reading. out micro table, calculations must be performed with integrity.

(4) Handling of numerical values' arrays in micro table must be associated with their meanings given for each location within the table. (For vector numerical data: vertical position's meaning; for matrix data (table): both vertical and horizontal meanings) Each numerical value has no meaning itself while staying in micro tables, so it should have concrete meaning in interactive handling.

(5) The influential micro tables by the location change of numerical values' arrays (Insert, Adding and Delete), must conformably be changed their location at all once. This operation should be performed interactively without involvement of source program handling.

(6) If possible, the above mentioned influential micro tables should be notified beforehand the location changes.

(7) Numerical values of micro tables in upper and left parts should be reserved after finishing the calculation.

The reasons are as follows.

- As for pre-dominant blocks, values should be reserved for displaying the calculated results and for starting the next calculation again.
- As for blocks in the left, values should be reserved for displaying the calculated results and for the building in chaining structures.

For realizing the above requirements (4), (5) and (6), a special idea: *Item* is mandatory for effective realizing of structure matrix architecture. Idea of *Item* is one of highlights in structure matrix technology.

Naming of *Item*

German originally established this idea from the needs of standardization in cost management. They named the list of component as KOL (Abbreviation of German words: Komponent List) and located in the margin part of structure matrix in the paper, without involving in the computerized architecture. In their application, KOL was associated only in preparing the array data of predominant blocks in the upper part and center blocks, and generating the reports of resultant data.

We had been privately thinking the necessity of the same function as an essential technology associating the structure matrix. When we found this strange coincidence in Germany and Japan, our astonishment was large and function of KOL was implemented with authorized name associating the structure matrix. We were merely stayed in the idea of structure matrix and were conscious of the necessity of KOL function. However, we were in the status of not defining the name.

Through the long study of German technology, we introduced the word: KOL and its method at the batch style implementation. Then succeeding the same name: KOL, this function word was expanded in the first stage of interactive program.

However, the name: KOL was rejected by the reason that German abbreviation didn't convey the real meaning for Japanese. So KOL was changed into 'Item Block,' and the name: 'component' was changed as 'Item' or 'Item name' with easy and worthy naming.

According the dimensional extension of blocks from vector to matrix (so table)in the margin part (Upper and left parts), those two-dimensional blocks having numerical values are turned to be associated with two item blocks. Center blocks with numerical values are associated with two item blocks: horizontal and vertical as before.

Note: When the writer visited Heosch Isen und Stahl AG, in Dortmunt, Germany, in Dec. 1979, Staff members of Hoesch, Dr R. Wartman, et al, tried to persuade him the importance of KOL. For the writer's smoother digesting, they became skeptical to my understanding, saying "All the Japanese visitor spent more than Two hours to let them understand the functional necessities, and they returned tilting their head. It seems mysterious that you can understand KOL with no objection." This is because the writer had been thinking the same needs as associated function of structure matrix.

Fundamental Functions of Item Block

In the example of vector data block in the margin part as shown in Figure 3-30, item blocks are located outside of the margin part (outside of upper part and left part). In this figure, macro table and micro tables are shown in the flat manner. In the hatched areas, Item Blocks are located. Upper item blocks are staring at the numerical data in upper margin part and left item blocks are staring at the numerical data. Also these item blocks are staring at the valued data in center blocks horizontally and vertically.

In packaging these ideas, item block names must be explicitly positioned in the macro table. By cursor pointing, the components: *Items* (or Item names) must be displayed, being developed in the list format.

It depends on the designers' idea as structure matrix architecture that *Item Block Names* in macro table should be explicitly located, or tacitly located in the behind. For the later case, the needs of displaying of *Item Block Names* are realized by another functions.

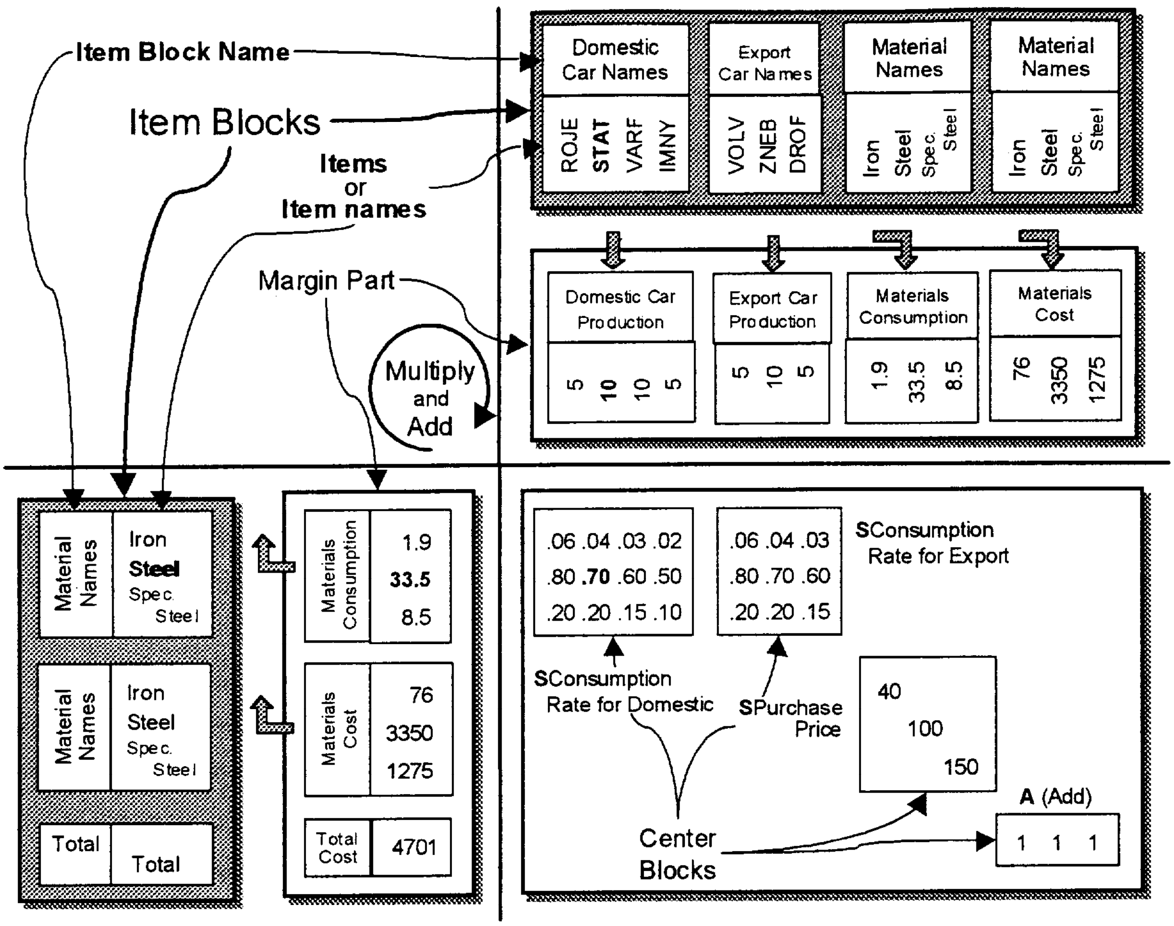


Figure 3-30 Item Blocks Associating the Data Blocks in Margin Part and Center Blocks

Looking Figure 3-30, numerical values in margin part are given specific meaning by corresponding Item (Item Name) of Item Block. Please look the bold characters in the figure. The value in the left margin part: **33.5** exists in the data block: *Material Consumption*. Look the Item Block in its left side. This value corresponds to the Item: **Steel**. Data Block (value array): *Material Consumption* is corresponded to the Item Block; *Material Names* (string array) by Block, and values are element-wisely corresponded to Items (Item name) one by one.

The same is about the value: 10 in the upper data block: *Domestic Car Production*. This value correspond to the *Car Name*: **STAT** in the Item Block: *Domestic Car Names*.

Also the value: **.70** in the center block: *SConsumption rate for Domestic*. This value is specified by two-dimensional meanings: **STAT** of Item Block: *Domestic Car Names* and **Steel** of Item Block: *Material Names* as cross point of these.

From this example, we can understand followings.

- An Item (Item name) is giving meaning to a value in data block.
- Item Block is also performing a function to give sequence of meaning array by associating Block having value data.
- Couple of an Item in the upper Item Block and an Item in the left Item Block is giving the meaning of a value in Center Block also fixing two-dimensional sequence and position.

- Their associated Item Blocks define the element's size of data blocks and center blocks.

  For interactively handling the block data, definitions of array size of numeric data (in case of vector and matrix) are necessary. Sometimes data are sometimes sparse or almost null and data in left part are resulted after finishing the calculation. As prerequisites for inter tables processing, establishing of block's size before the calculation is required. (At present, we are thinking that this strong restriction is not necessarily sufficient for covering all the management phenomena, and loosens of this restriction is reserved as future extensions.)

Common Use of *Item Block*

Looking the Figure 3-31, the same Item Blocks: *Material Names* are located as common use of this structure matrix.

In modeling, common use of Item Block has following advantages.

- Saving the duplicate work lord of defining items
- Establishing tool of standardized items as business model

  As examples of standardizing, sets of names or codes about following matters would be illustrated. Product and Product Group, Facility for processing, Parts, Material, Activity, Customer, Account, Overhead Items, Organization, Occupational category, etc.

These functions were already established before we know the German development, staring the needs of standardization of MIS. In addition to their efforts, we find important advantage of common Item Block for realizing interactive handling of structure matrix as table processing.

Advantage of Common Use of Item Block in Interactive Handling

Another important advantage is in interactive mode of responding to the changes of Items (Item Names) at the time of Insertion, Addition, Deletion and Rename. Figure 3-31 shows the example of typical case: f insertion of items.

At the insertion of Item: *ZZZZ* in Item Block: *Domestic Car Names* (Adding a type of domestic car), influential data block and center block can be detected from the macro table. Then preceding the operation: Insert, influential slots are detected and their spaces for inserting: [1] the corresponding values are opened.

Also in case of adding a type of material: *Plastics*, by selecting an Item Block: *Material Names*, Items are shown in list. By operation: Insert, influential data blocks: [2] and center blocks: [2], are detected. Then selecting proper position, open slots will be prepared.

By this mechanism, filling of numeric data can be performed by users by selecting the influenced blocks and place values for the opened spaces. About center block: A, opening of a space is unnecessary because substituting action to arrange the block size at the moment of calculation is prepared as a nature of Type Symbol: A.

By those interactive operations, users can detect the related position and insert their value data swiftly without involvement of investigating and reprogramming the developed programs (No programming).

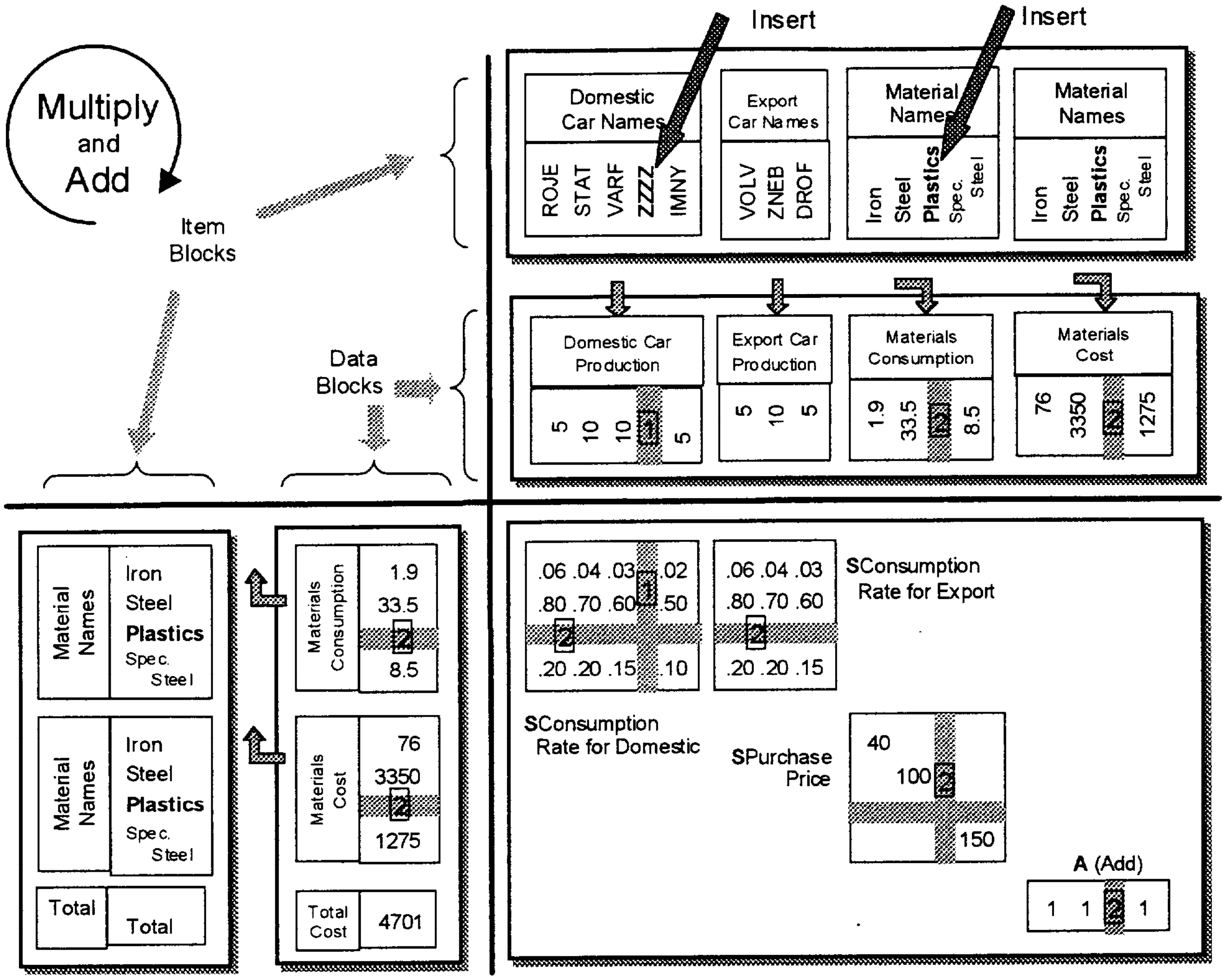


Figure 3-31 Influential Position by Inserting Items:ZZZZ andPlastics

Operations: Addition (add item in the last), Deletion and Rename can be performed according as the same way upon well-developed package.

Besides the original advantages, the big advantage of built-in *Item Blocks* as essential architecture of structure matrix is in the capability of detecting influential block and executing those operations interactively without involving programming. Utilizing the merit of *Item Block* decides the easiness of modeling and maintenance for end users.

For easier explanation, the shape of data blocks in the example of margin part has been vector. Together with our progress, these blocks are extended to the shape of two-dimensional tables associating two Item Blocks. Taking the example of data block in selling amount, one dimension would be kinds of product and another dimension can be sales branch office. Such Insertion Addition, deletion and Rename can be identical with that of center blocks. These architectural relations will be shown schematically in the later sections.

Thinking the relation between numeric data block and item block and considering the multi-dimensional table processing, item blocks are newly defined as more common word: Axis Information associated with table.

Dimension of Axes and their Naming

Major paths to reach the contents of block level from the selection of structure matrix are shown in Figure 3-32 according as the type of data and associated item blocks.

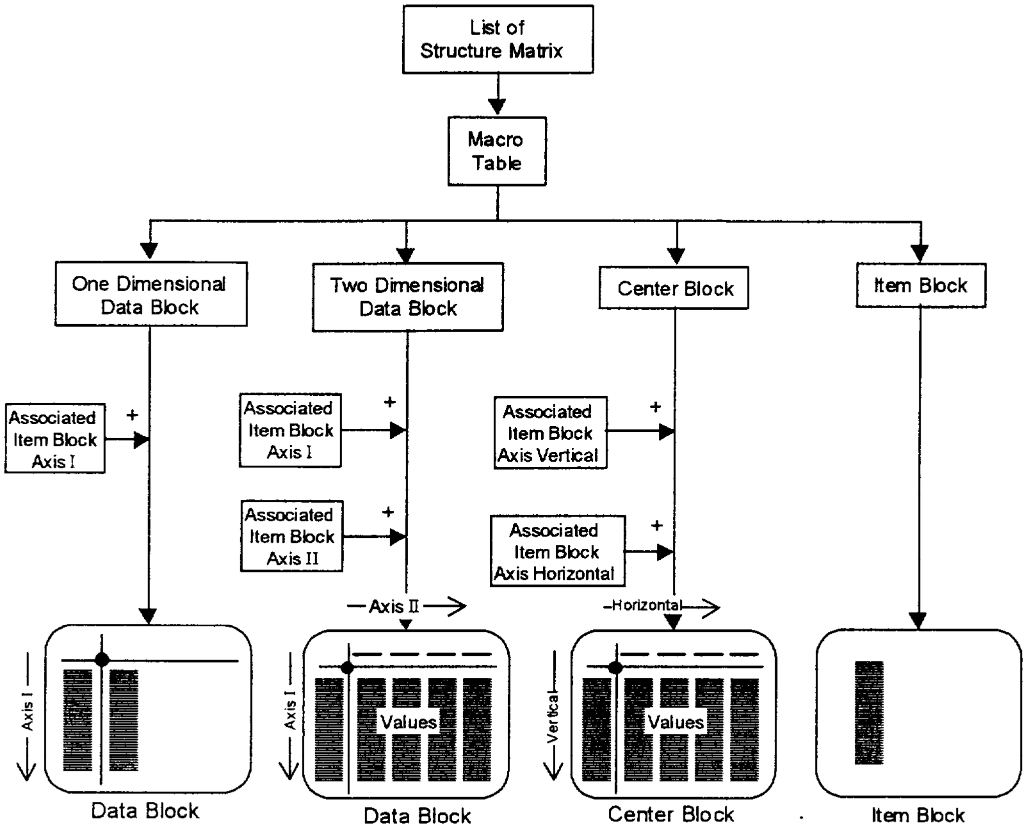


Figure 3-32 Trading Path toward Displaying Blocks

For displaying block data, next points are to be considered.

- Screen management of display is provided, being oriented for line by line (list of record) as de-facto standard.
- Numerical data is naked, so these should be displayed attaching their associated meaning of item information.
- Data displayed on screen are limited in size, so scrolling for vertical and horizontal directions must be provided with their associated items.
- Acknowledgment of displayed data, with their direction and with position in macro table, becomes difficult when multiple axes (matrix table) with associating item blocks are provided in data block.

To solve these problems is important for extending the structure matrix toward series of structure and for introducing multi-dimensional data in data block. For more expansion of inter-table processing, we must establish idea: defining directions of the block consistently with their macro table.

A case in which all data blocks are vector in direction: *Axis I* is shown in Figure 3-33 with major screen images.

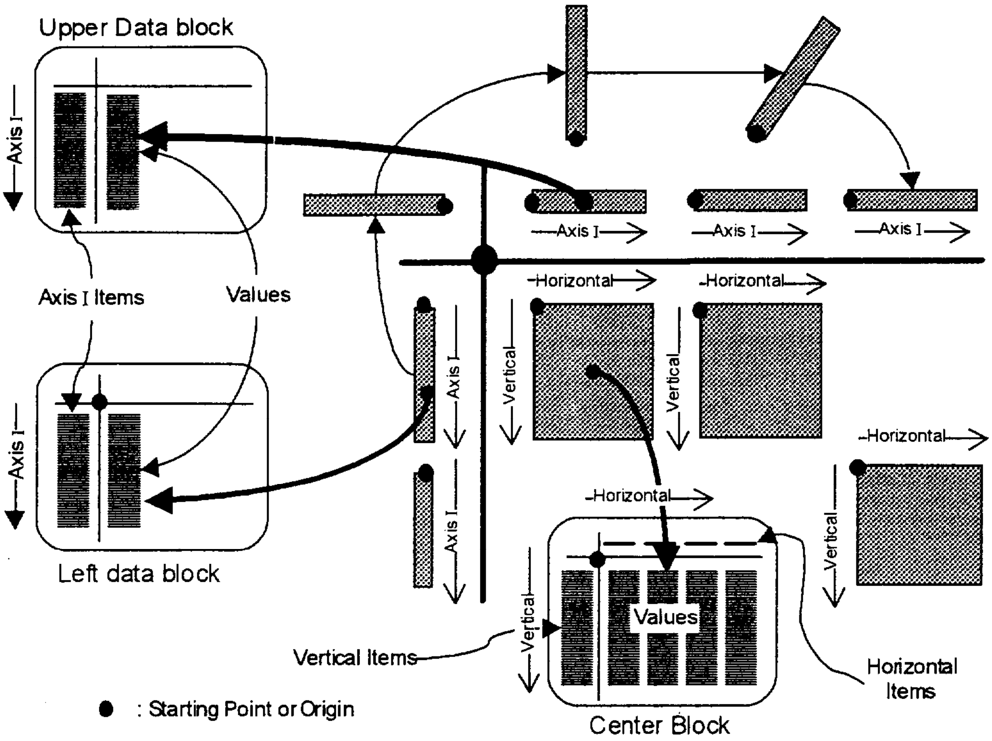


Figure 3-33 Mapped Structure Matrix and Axes of Blocks in Flat Domain

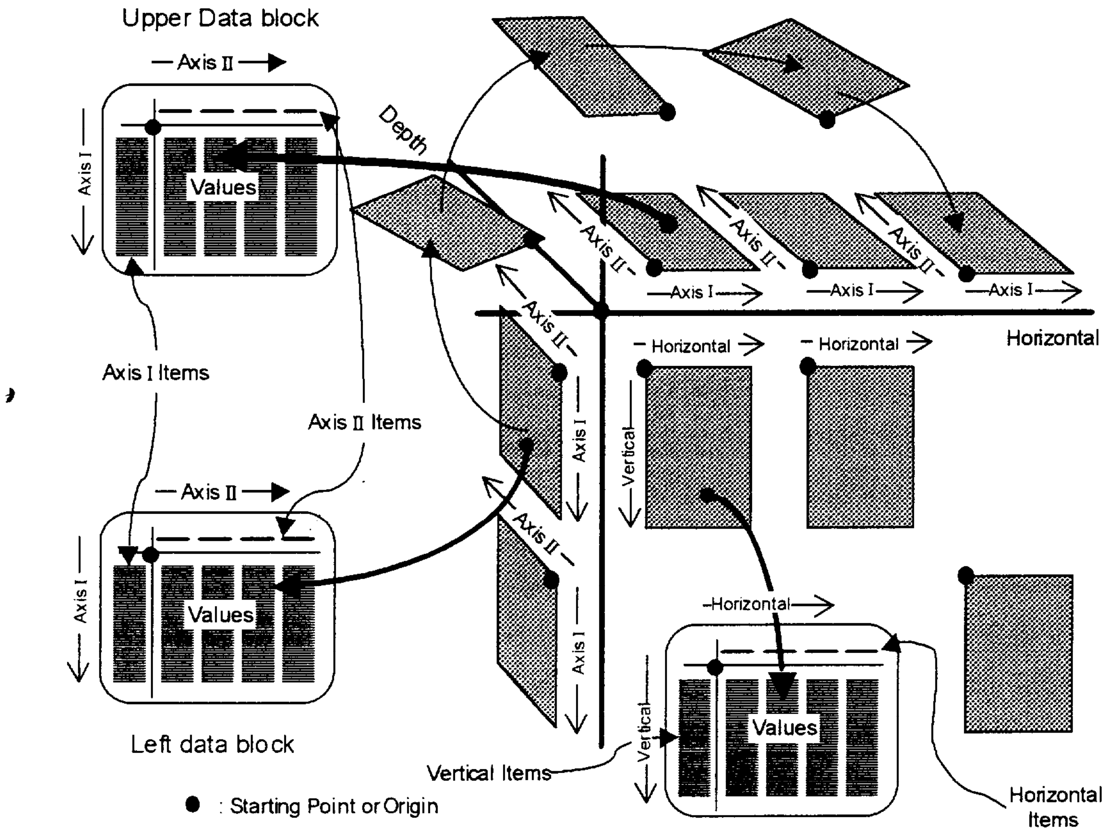


Figure 3-34 Mapped Structure Matrix and Axes of Blocks Having Depth Direction

In Figure 3-34, data blocks are expanded to two-dimensional table accompanying two item blocks, corresponding the individual dimension. Taking only first column of the data block, accordingly vector data, figure 3-34 becomes the same as Figure 3-33. Therefore, *Axis II* can be thought Depth direction to the *Axis I* within Front direction.

There is some confusion in the naming of Axis, like *Axis I* as Item direction and *Axis II* as Case or Depth side. The naming 'Case' was started as a prepared data for vector in parallel for case studies. By the advancement to adopt associated Item Block for individual data block, we must have clear definition *Axis II*.

Still there exist name 'case' and mixed use of word: 'Item Block' for *Axis I* and word: 'Case Block' for *Axis II*.

These naming should be put in order under the idea of Axis Information. Item Block should be defined as common information block and assigned to the necessary axis of blocks as Axis information associating with them for giving meanings from the side of the axis view.

Extension to establish definite Axis II information brought remarkable easiness in modeling assisted by auxiliary type symbols: T (Turn). By this type symbol, we don't need to fix direction of table at the beginning.

We learned these definitions are very important for smoother modeling that may start from the analysis and succeeded to the proto-typing. In addition, establishment of this idea is important to the size arrangement in the next paragraph.

Arrangement of data size at inter table processing

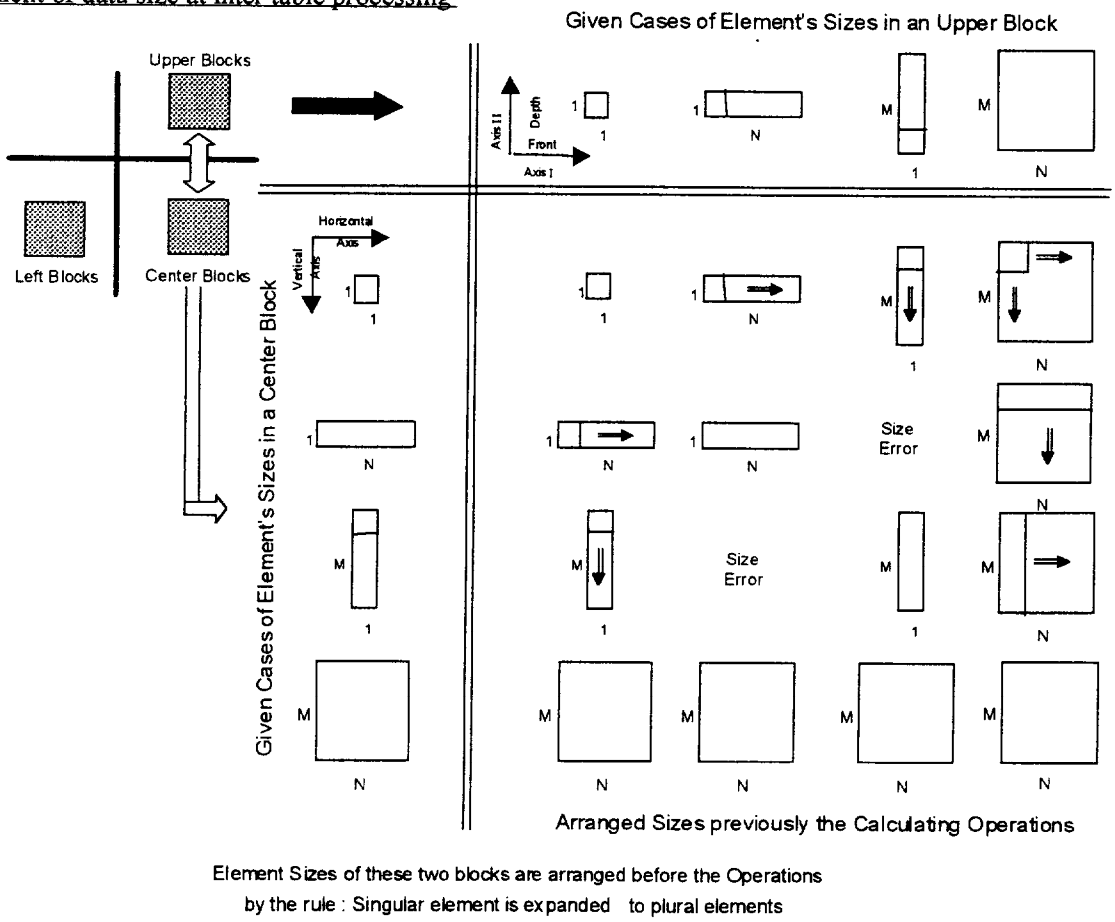


Figure 3-35 Rules of Data Size Arrangement by Different Sizes

At the *Inter table processing*, table sizes are different between the tables. Sometimes scalar value is given in stead of a single value table given as a parameter value of Type Symbols. Even those cases, data sizes must be arranged enough to calculate with adopting some rules. Those rules must be necessary for the two cases:

(A) Advancing the calculation execution

(B) Restoring the calculated result after the calculation

Figure 3-35 shows relation of (A) taking the example of dyadic operations and shows implemented combinatorial cases between different block sizes. Multiple block operations and scalar arrangement given by parameters is the same as in Figure 3-36.

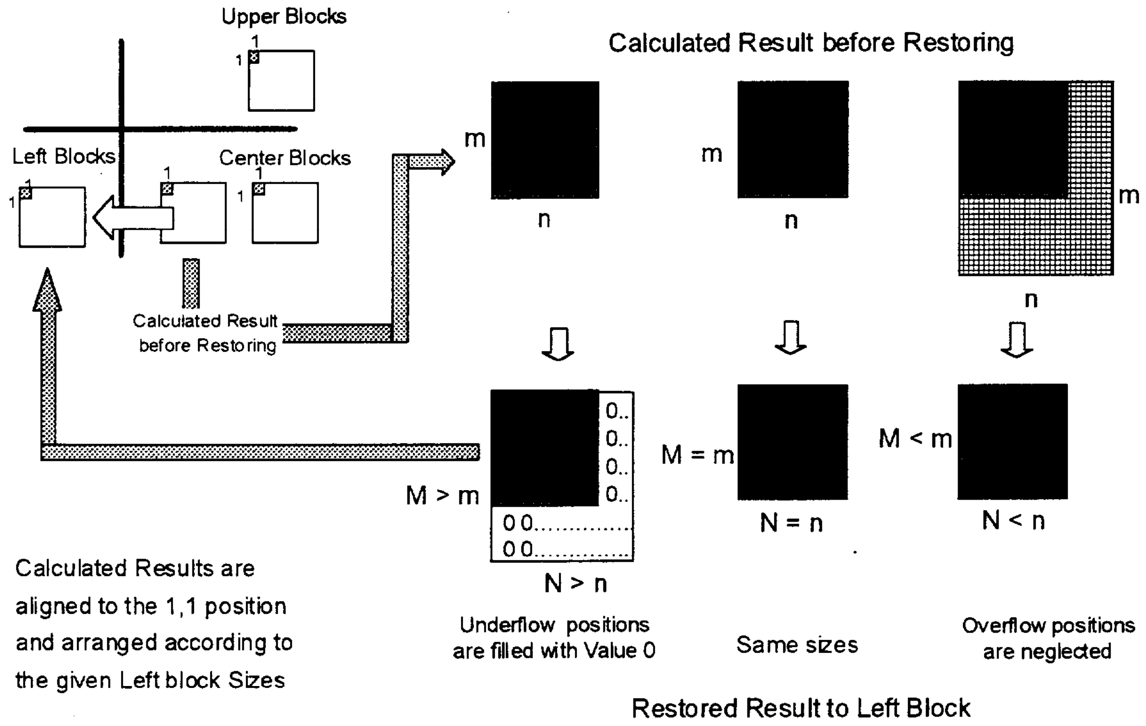


Figure 3-36 Various Cases of Data Size Arrangement After Calculating Operations

Sparse Matrix Handling

Blocks having numeric matrix data (data block and center block) are likely to form sparsely populated matrix in which null data occupy major portions. The word: *sparse matrix* is used for fully populated matrix in contrast to full matrix, from the point of calculating performances and storage efficiencies of system. The percentages of the population are practical design problems. This problem becomes serious when the sizes become large compared with the available computer capability of the age. As experienced cases, sparse data saving in disks and transforming full matrix for calculation were implemented considering the compaction of data and programming efficiency. In addition, for large size of matrix calculation, sparse and full matrix handlings are executed with mixed mode depending on block's population. The specialists of numeric calculation often proposed us deformation of matrix finding efficient calculating shapes. However, it was in vein. As a nature of data in management phenomena, we learned that we could not find any commonly applicable tricky method.. These sizable problems are practical engineering problems given to modeling of phenomena and the computer environments of the current ages.

3-2-5 Series Architecture

Idea of series for structure matrix was originated from the idea of modeling: *Time Series* phenomena. On modeling, we sometimes meet *Time Series* phenomena in which the shapes of structure matrix are identical to the first series and contents of micro table: numeric data are different as in Figure 3-37..

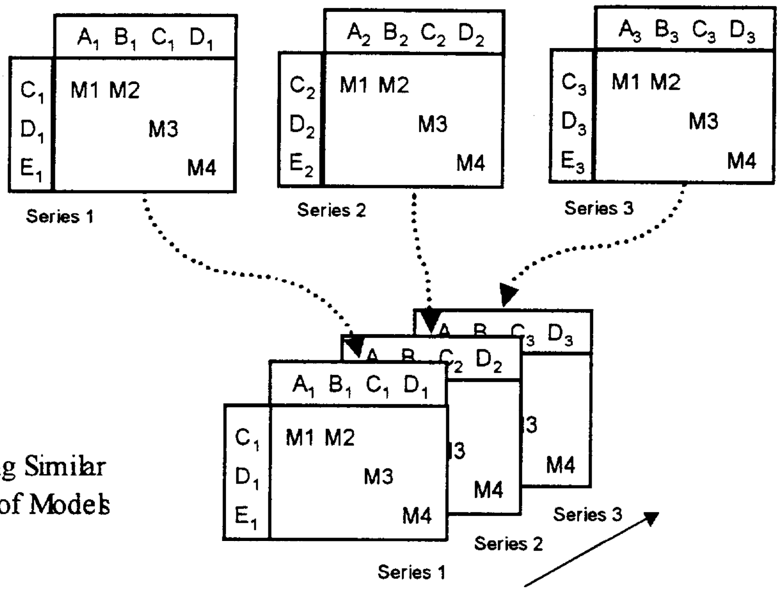


Figure 3-37 Understanding Similar Models as Overlapping of Models

For responding these needs, architecture to provide a common macro table linking individual micro tables for different series, is considered as in Figure 3-38.

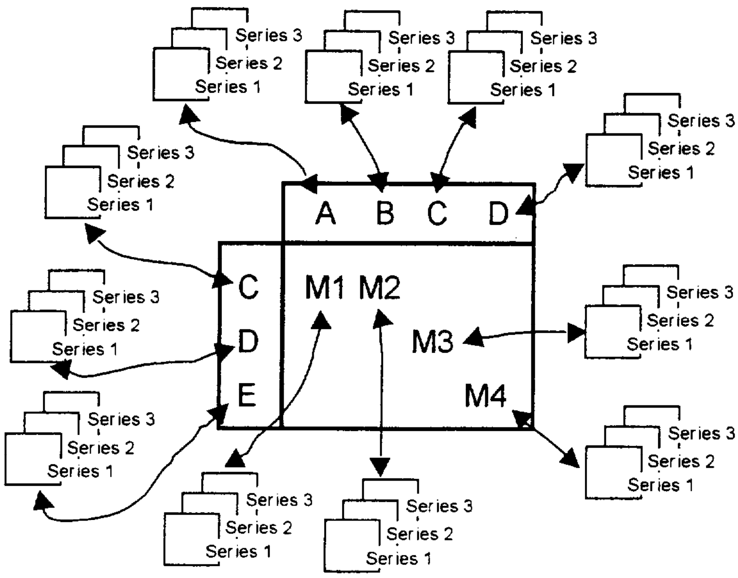


Figure 3-38 Series Architecture Using A CommonMacro Table

We started from Time Series idea in which phenomena in the same time domain should be calculated within the same time domain, and we found that we had no needs to be restricted by the frame of period by time. Therefore, removing the word: Time, a simple word: Series was adopted thinking common usage.

We adopted the idea, the transferring of causal relations among different series, should be designed to be performed on the chaining structure, thinking the more generalized chaining structure: complex chaining between multiple structure matrix and series structure. This chaining structure will be introduced in the later chapter of Chaining Structure.

However, series structure has the following restrictions as framed architecture.

- Their calculations are executed series by series.
  This means specific series can be calculated independently.
- Looking toward the Series direction, each Data Block in the margin part and each Center Block have the same associating Item Blocks.

By these restrictive framing, Series Structure has the following advantages.

- The model approach is easily possible by proto-typing that starts from developing the first series, extends the frame of micro table by coping the last series or a series of those, then modify the copied data of micro table for model completion.
- *Insert, Add, Delete* and *Rename* of the Item can be performed uniformly covering entire series by changing of the associated Item Block.
  This characteristic is brought by the restriction to use the same Item Block associating the series of micro table uniformly. When this modeling restriction can not be applied, each series of model should be made from a single structure matrix by copying, then the copied macro table and micro tables should be modified.
- Function for viewing or setting data in micro table toward series, can be provided by switching of the browsing toward series.

3-2-6 Sketch of Whole Architecture

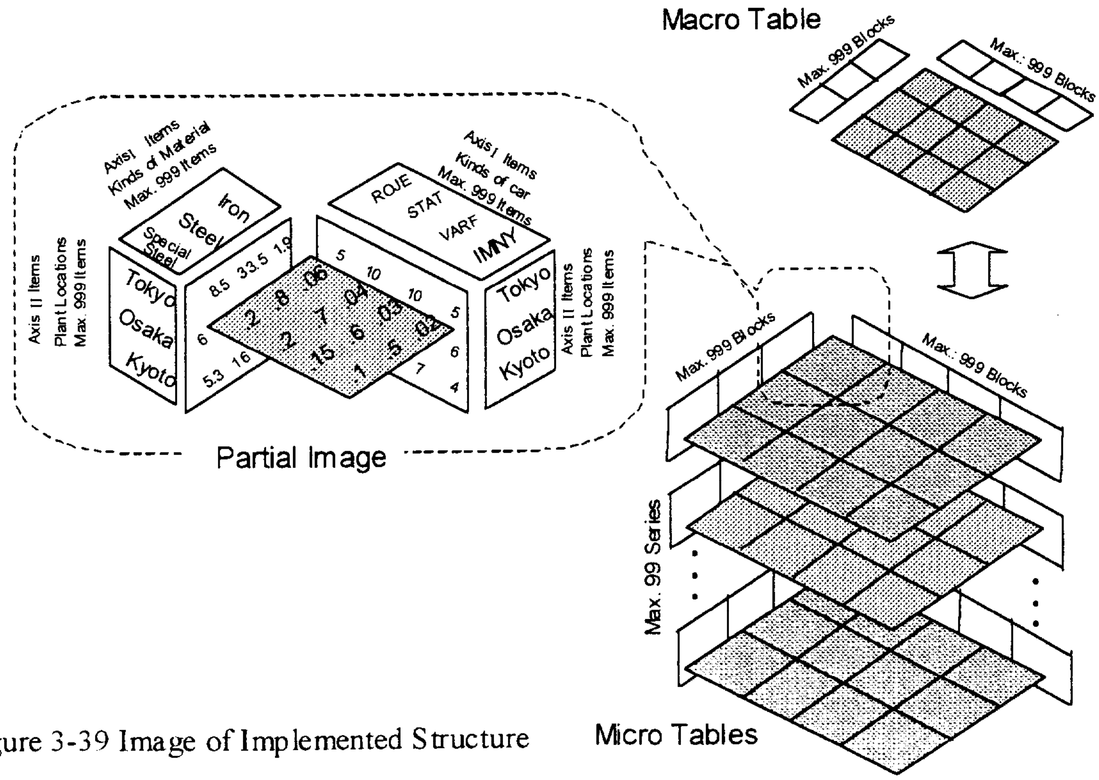


Figure 3-39 Image of Implemented Structure

This section is to show the concrete image of the architecture as we have implemented, summarizing the previous section. Figure 3-40 shows the relation between macro table and macro tables of series, and relation between associating Item blocks. Figure 3-39 shows conceptually the essential architecture of structure matrix focusing on the associated Item Blocks.

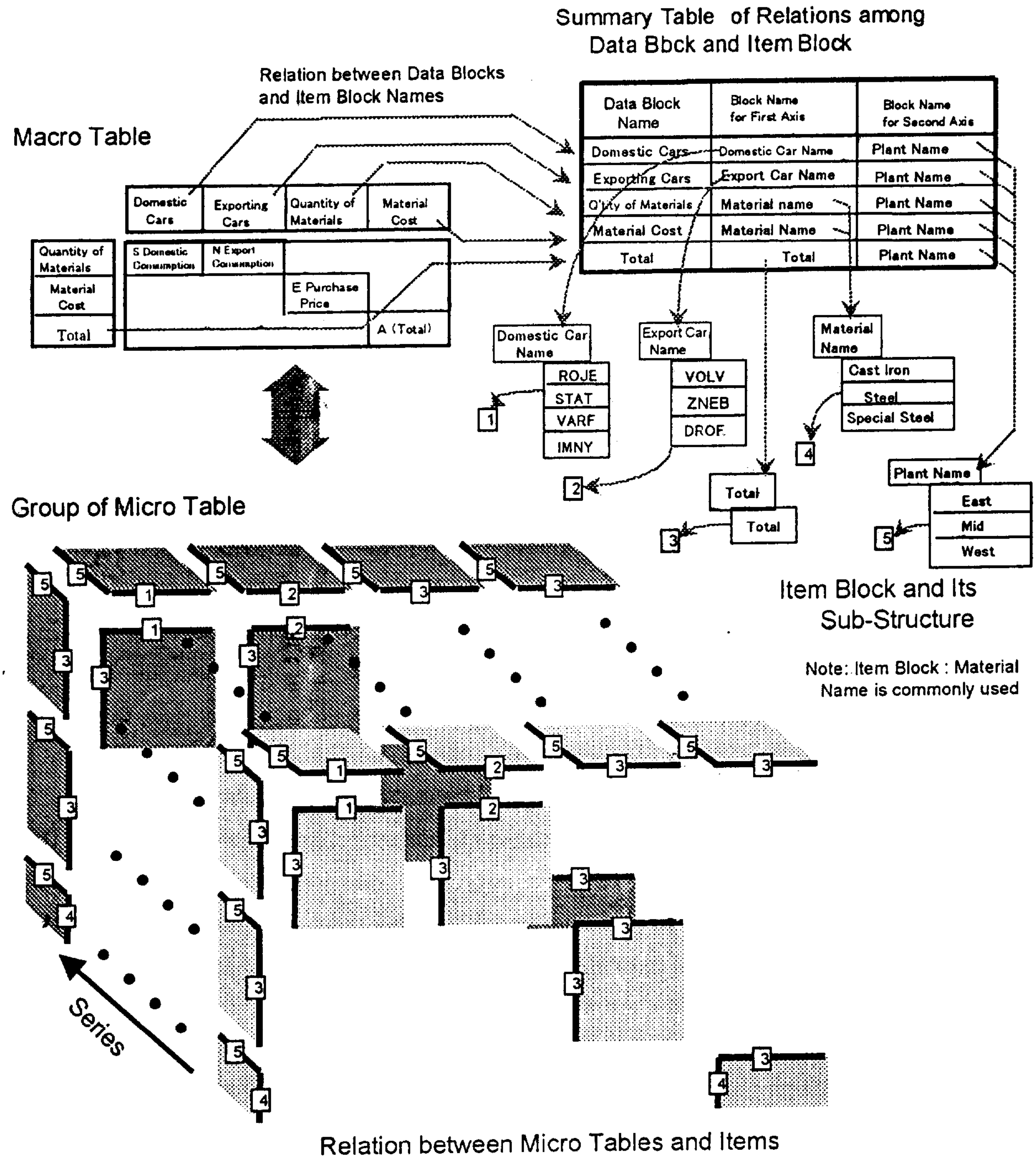


Figure 3-40 Over Viewing the Implemented Architecture around Item Blocks

3-2-7 Advanced Functions

Toward *Input Process Output*

At the start of the software packaging, we recognized that Multiply & Add can only absorb three calculations: Add, Minus and Multiply, and within the range of these three, major part of business phenomena can be described without programming. However, we have been acknowledged that only three calculations were insufficient for covering wider application. Therefore, our efforts compensating the uncovered area of logic were paid for many years by adding new type symbols through the boiling up of user requirements. Details of type symbols are written in the Appendix -II: Particular Type Symbols.

Our logic preparation by type symbols was performed as the following way.

- Dyadic type operations using upper block and center block

  This style can keep same style of Multiply in *Multiply & Add.*

  Complicated calculation and non-linear can be introduced.

  Example: Q (Quota), V (Volute), @ (Linear Loop),

- Single operation using upper block only

  In this style, center block works as a kind of operator having no data

  Example: T (Turn), T (Transpose), M (Matching), H (Horizontal Add)

- Dyadic type operations using two upper blocks

  In this style, a center block working as function must specify two upper blocks.

  Placing a type symbol as center block can naturally specify one of the two. However, another one block to be specified is left.

  There are two ways of specifying artificially as follows.

  - Specify upper block name in the center block together with type symbol.
  - Placing type symbol having the meaning of Dummy (Null operation) and Wait like D or # (These symbols may be said a kind of associating Type Symbols.), just under another specifying upper block. By this location, the calculation of main type symbol will be kept waiting until another specified upper block is ready to be used.
  - As combination of above two ways.

  As these examples are,

  * (Multiply upper blocks mutually), / (Divide by another upper block), %(Prorate)

  C (Condition), P (Production)

Extending the covered logic for more complex area by these ways, *Multiply & Add* could not be the basic rule of structure matrix any more. More general phrase reflecting those advancement was required.

New word: *Input Process Output* was adopted for mode shift from *Multiply & Add.*

In this phrase

Input is specified by upper part.

Process is specified by center part. A certain Type Symbol in center part utilizes Center Block and Dummy Type Symbol specifies the use of block in upper part.

Out put is given in the left part.

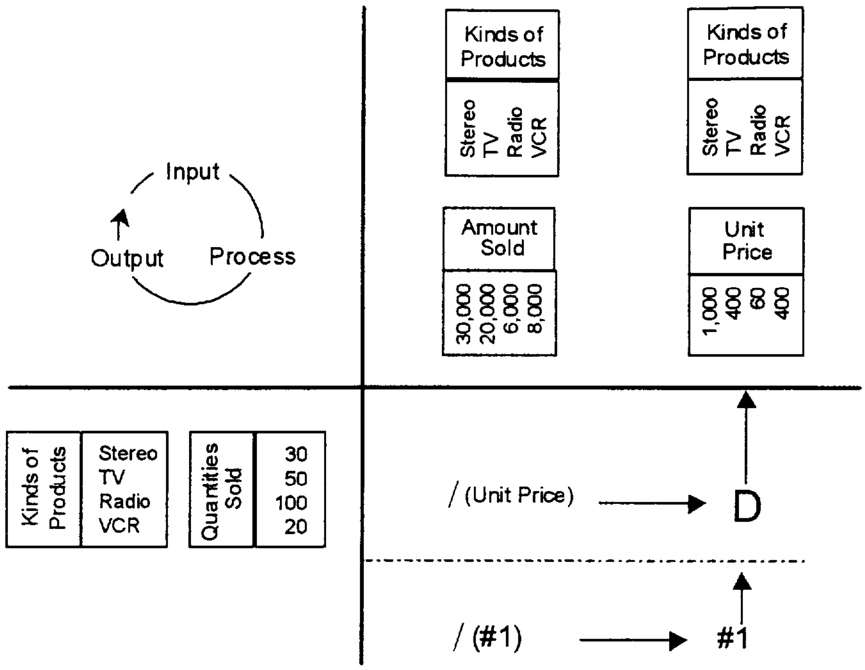


Figure 3-41 An Example of Calculation Style: *Input Process Output*

A simple case of *Input Process Output*: multiple input blocks in upper part and a single output block in left part is shown in Figure 3-41.

This calculating mode has the following advantages.

- Convenient for converting to model from IPO (*Input Process Output* analysis)
- Clear understanding of models
- *Multiply & Add* can be covered as a partial mode of this
- Coincidence with the architecture of chaining structure

  With this mode, unification of calculation mode was realized covering whole architecture: structure matrix and chaining structure.

Looped Calculation of Structure Matrix

Generally for many people, to understand mechanisms that contain looped phenomena is very difficult. In modeling approached by programming, another types of loop processing provided by programming are tend to be involved. Then these types of loops pile upon the native loop processing that were provided by phenomena themselves. This brings problems around models like understanding the phenomena themselves, modeling, understanding the developed models and their maintenance responding the change of phenomena.

Our idea is to provide easier tools to solve these loop problems along the extension of structure matrix by each level. For end users, it is rather easy to make net work models having no loop (These models form up type of destination matrix.). Consequently, the resultant models are difficult to be understood by others.

We can also think that structure matrix, currently discussing, can form a sort of destination matrix looking the macro table.

Therefore, to provide looped model in the following manner would be ideal.

- Make the loop aside and construct the model of straight foreword part.
- Confirm the calculation of straight foreword model
- Then, establish loop relations
- Perform calculation until convergence

Principle of implemented way of loop processing on structure matrix is shown in Figure 3-42 as a sketch.

In this figure, as a matter of course, operations to transfer intermediate block from left part to upper part are not described.

In the loop calculation, after the finishing the structure matrix calculation and convergence check, some blocks in the left part are transferred to the upper part and predominant blocks are replace by them according to the registration of Transfer table.

Convergence check may depend upon the resultant condition of a selected block in the left part.

The condition can be evaluated by certain values reached or by difference between this time and previous values.

For the case of out-of convergence, maximum number of loop processing should be preset.

This loop processing function is realized as an option of calculation function. Users can establish their model as non-loop, then form loop relation and execute it.

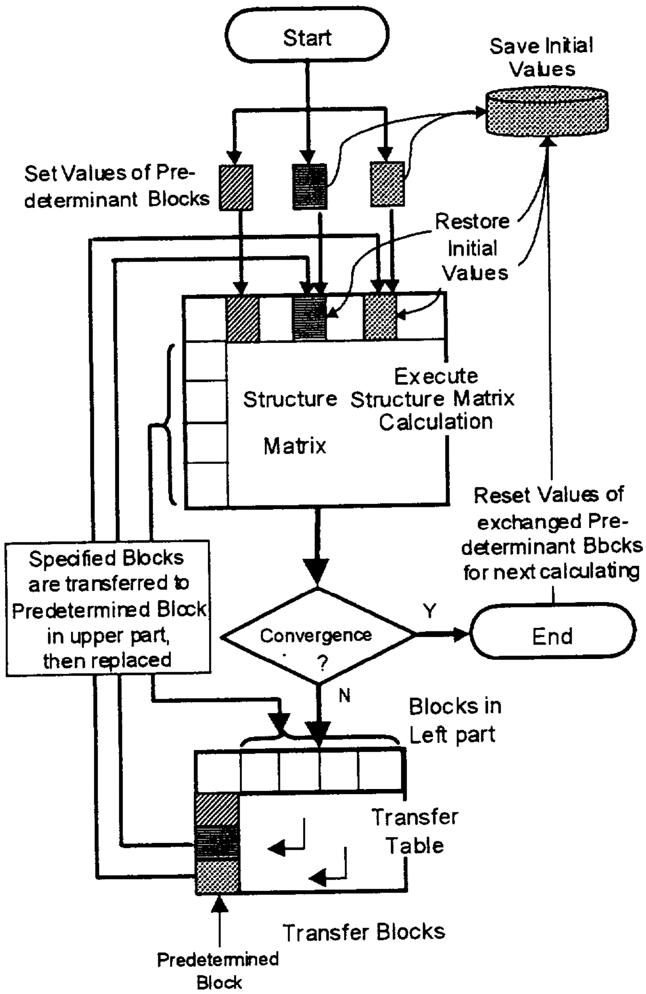


Figure 3-42 Calculation Process of Loop

In iterating this loop calculation, some pre-determinant blocks are replaced by the newly calculated values in the left blocks. Those values must be reset to the initial values before the loop calculation. Above all, the case study detaching from the chaining structure is important. The bold lines illustrate these movements as in the Figure 3-42.

Aggregating Function on Structure Matrix

This function can be provided as a kind of byproduct of structure matrix, for responding the request of model's aggregation. In a fortunate case, the aggregation results one matrix. The benefit of aggregation in structure matrix lies in the following points.

- Reduction of complexity of models for grasping the influence of one upper block.
- Providing the compact model from complex models

The combination rule of inner products in matrix calculations can be applied for the aggregation of models upon structure matrix. When we are assuming a flow example of combined three processes with each facilities' yield, material requirements' calculation ascending the process flow is shown in Figure 3-43.

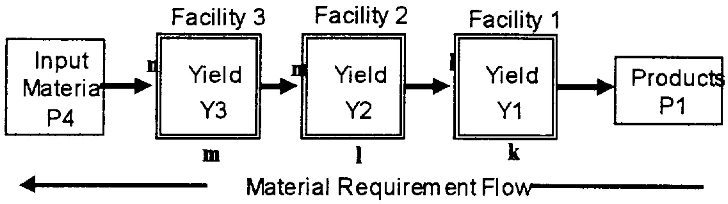


Figure 3-43 A Example of Aggregating Flow

For calculating Input Materials: P_4 can be written by the following equation and finally aggregated to a single matrix: Y_{321}.

$$P_4 = Y_3 \times Y_2 \times Y_1 \times P_1$$
$$= (Y_3 \times Y_2 \times Y_1) \times P_1$$
$$= Y_{321} \times P_1$$

The principle of this calculation will be shown as follows returning the basic characteristics of structure matrix. The process flow is described as Figure 3-44 and the center part can be looked Y as rectangular matrix in Figure 3-45.

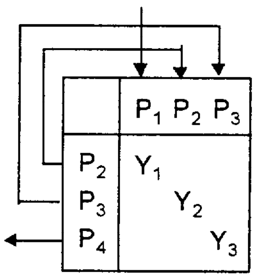


Figure 3-44 Structure Matrix of the Process Flow

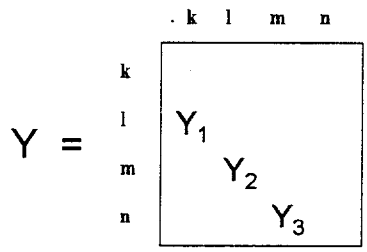


Figure 3-45 Center Part of the Structure Matrix as Rectangular Matrix

According to the basic characteristics of structure matrix, calculation can be considered as a matrix series sum of square matrix within the restriction having linear elements.

$$\mathrm{Sum} = E + Y + Y^2 + Y^3$$

The series sum is given by the above equation and Y^n after Y^4 becomes zero : 0.

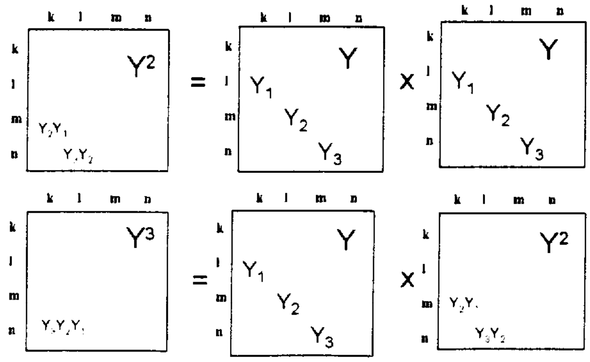


Figure 3-46 Intermediate Calculations

Then, the sum becomes as Figure 3-47 through the intermediate calculations in Figure 3-48.

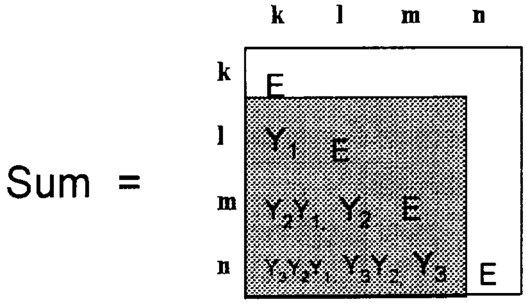


Figure 3-47 Sum as Aggregated Matrix

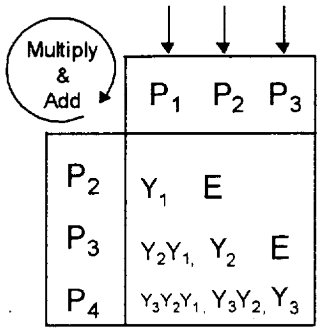


Figure 3-48 Aggregated Matrix in Structure Matrix Form

Figure 3-47 can be rewritten in the commonly used structure matrix as Figure 3-48. This means that the influences of upper blocks including intermediate blocks to the each left block can be directly calculated. The restriction for this type of aggregation is that all the center blocks contained in the calculation path must have the characteristic of linear.

Fortunately, these characteristics can be judged by the types of type symbols used in the path of model. These type symbols are limited in A, B, E, G, M (Axis I only: One dimensional), R (Reciprocal), S, T (Transpose only) V and. @.

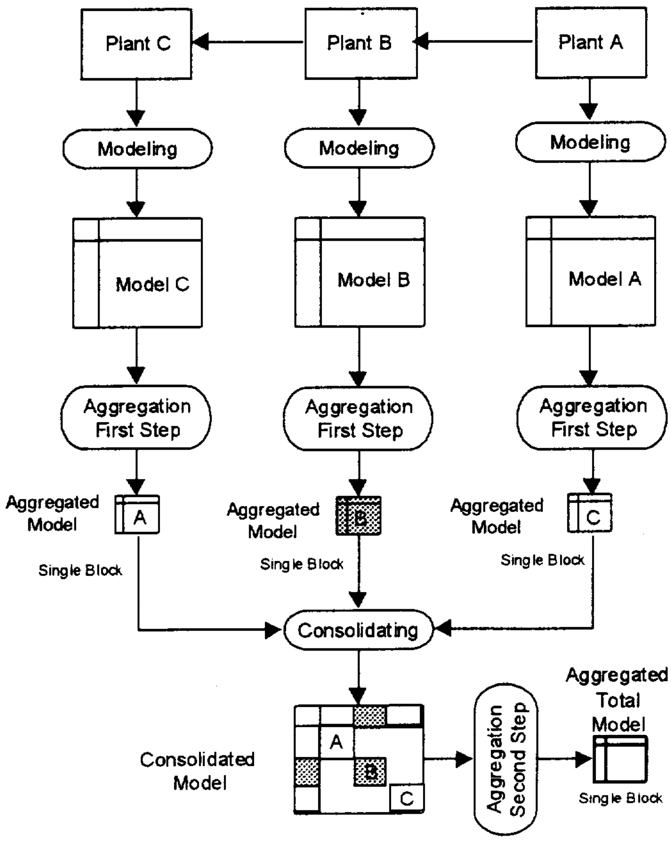


Figure 3-49
Re-aggregation of structured matrix

In addition, we can expand applicable range of this aggregation by giving the condition that the calculation of the model was previously finished. By this precedent calculation before the aggregation phase, two type symbols: * and /, can be conventionally usable. We can think this condition as insertion of upper block data to the center part by borrowing the calculated result using * and /.

German people originally developed the idea of aggregations in structure matrix. The extension covering these Type Symbols upon structure matrix was performed in the interactive mode.

Re-aggregation, making a model by consolidating the aggregated models, can be possible as shown in Figure 3-49. These types of modeling are applied as DSS (Decision Support System) covering huge steel works and consolidating the production planning and cost managing.

4. Chaining Structure

The fundamental needs of chaining of structure matrices will be discussed first. Then the case of our progress to establish current architecture based on the fundamental characteristics, and "Transformation of the structure matrix, will be introduced".

4-1. The Fundamental Needs of Realizing of Chaining Structure

Common needs for the chaining of structure matrices will be itemized the following points from the smoother building and operation catching up the changing needs of requirements.

- Smoother growth for the chaining of multiple single structure models

  For the first time of the modeling by a certain tool, the developing person as a first experience defends sometimes his subject, limiting it to small area without having successive plans.

  At the time of success, the developer naturally wants to go on further developments of other models. As a nature of learning, we can hardly expect people to have all over view from the beginning. Taking an example of making profit planning covering whole the company, we cannot request the model developing people to have all over view covering the whole the company image without having experience of the president or his assistant.

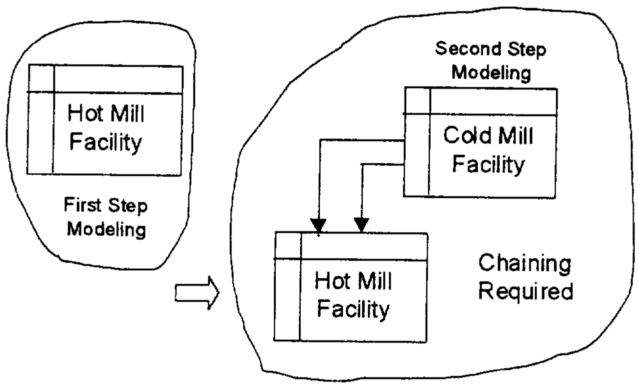


Figure 4-1 Successive Modeling Growth

  The mechanism and environments of the chaining must be prepared, so that the modeling people can start their modeling from the limited part of modeling without presupposing further plans. Pacing their growth, we must prepare enough mechanism to go on for the modeling spontaneously to other areas and chaining of them.

- Combine models partitioned by different managing area

  There are needs of collaborating the modeling works. Most of the greater modeling in businesses, models should be independently developed first according to the professional partition or managing partitions.

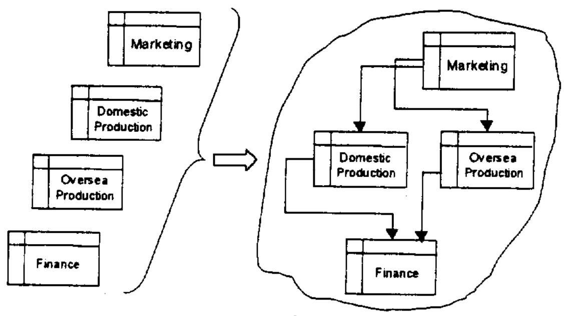


Figure 4-2 Chaining Individual Models

Then these models should be easily combined to a model without entering and adjusting the details of individual models.

- Independent change of single structure models

  The needs of local changes in single structure model happen independently from the chaining though the single structure model was enrolled as a member of the chaining model. In some cases, changes would give no affection to the Transfer conditions. However, sometimes, changes would be happen in names, position and deletion/addition (worst case) of blocks. Those things also happen in Item blocks, Item names and its sequences. In spite of such changes, whole model should be maintained safely with minimum local changes.

- Re-combinations of chained model

  Combined models to a chained model should be rearranged easily according to the needs of case studies. Among advanced users, sometimes number of chained models is larger than that of individuals. Please imagine the case that profit-planing covering a company having three divisions, and each of divisions has their own three plans as shown in Figure 4-3. For consolidating models toward total profit planing, it is required to survey more than nine cases for one case study will be required accompanying corporate arrangement. The easy mechanism capable for such us tremendous number of combinations and re-combinations will be required above all from the side of top requirements. These essential needs are not somewhat easy method explained by the phrase: link of models.

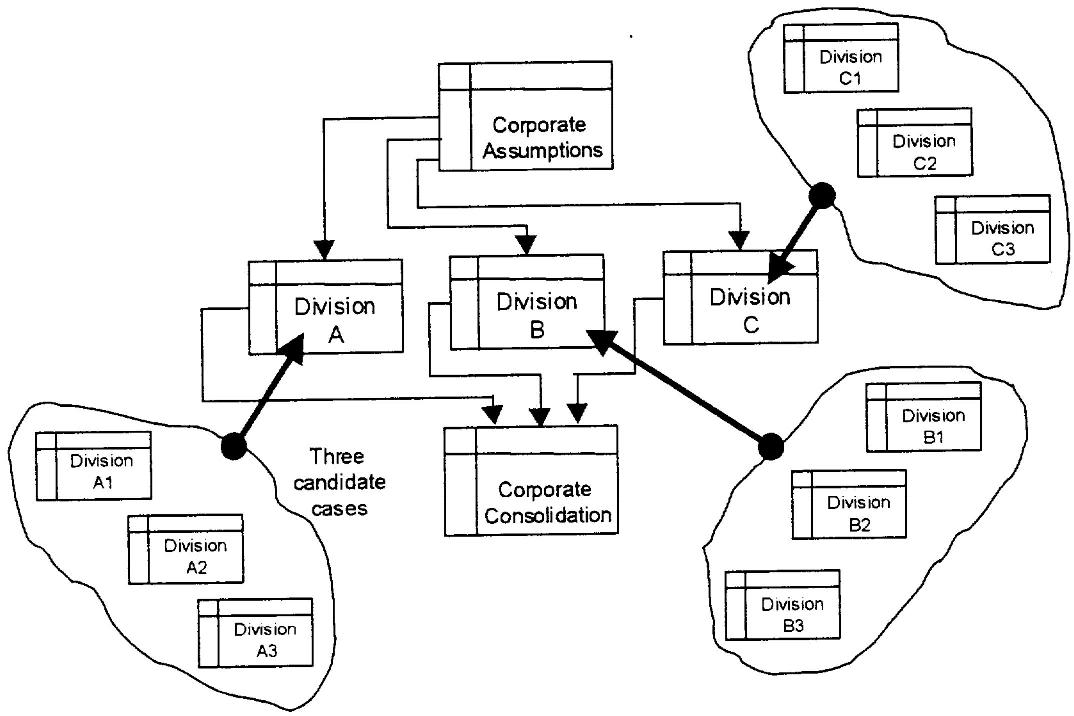


Figure 4-3 Generation of Multiple Case of Chaining Models

- Structure giving guarantee to be able to relate all the calculating values mutually.

  The chaining structure must provide a chance of capability to relate output of single structure model to the input of other single structure models, if required. In making consolidating models like corporate models, many activities in the bottom of operations are related to almost all the headquarters functions or controlling factors of the corporate. Therefore, we cannot neglect those relations in between the single structure models. For example in the traditional modeling of corporate models, energy and environmental activities are sometimes neglected at summarizing, by the reason why the model becomes too large to handle in relating other important managing factors. Sometimes those activities are discussed in the independent models separately from key management factors. So to speak, to provide the functional capability of *Turn In Outside* and *Round Robin* (In Japanese: Sou-Atari) become important beyond the traditional way of modeling.

4-2. A Transformation of Structure Matrix

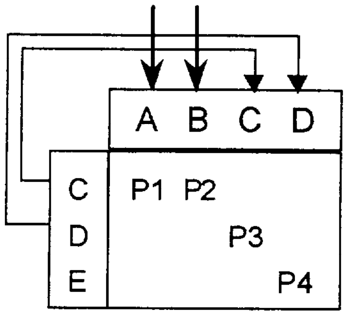


Figure 4-4 A simplified Structure Matrix

Architecture of Accompanied Transferring Table

The chaining structure is deduced from one of the essential structure accompanied with structure matrix. We should notice the margin part of the structure matrix previously shown as in Figure 4-4.

Please imagine those elements as scalar value first. The left elements: C and D are transferred to the upper elements: C and D. For the first understandings, we explained the characteristics of structure matrix assuming the relation: elements have both the same representative names and the same values. Consequently, by the coincidence of the element's names, the accompanied values are moved from the left part to the upper parts as implicitly.

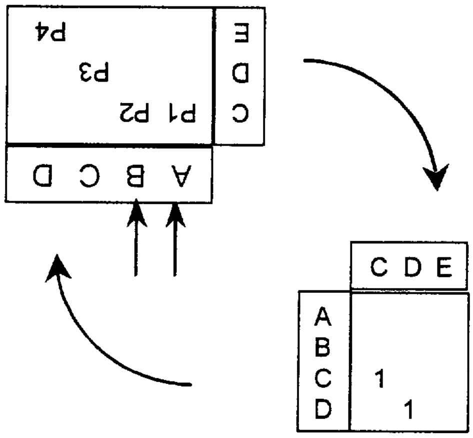


Figure 4-5 The Accompanied Matrix

Here we should notice that there exists an accompanied matrix to the structure matrix, and that it performs assignment of transferring from the left part to the upper part as shown in the Figure 4-5.(This thesis writer found this accompanied matrix.) Value: 1 in center part means that the values of upper elements are transferred (copied) to the left part according their positions.

This idea of placing values: 1s or 0s, as binary matrix in the Center Part of the accompanied matrix, will also be easily extended following the conceptual expansion of the elements in the upper and left part elements to vector or matrix.

In this stage, the chaining matrix can be thought as an accompanied relational table to the model describing structure matrix and describing relation in between all the league members of upper and left elements.

As a characteristic of the chaining matrix, it exists as characteristics that less than an element having value: 1 is located, when we notice its rows if transferring relation. The reason is that if we permit more than double values of 1 (one) in the row, we are confused in grasping the relation: where the left values come from. This is the result of pointing up for *Visibility with Transparency*.

We should also observe that the linear relation: *Multiply and Add* are preserved in the entire center part of accompanied table as transferring logic.

Partitioning of Center Part of the Accompanied Table

The partitioning of the center part should be synchronized, corresponding the extension of the elements in the upper and the left parts to the blocks like vectors or matrices (finally tables). A chaining sample of four single structure matrices: Marketing, Plant -Domestic, Plant-Oversea and Finance, is shown schematically in Figure 4-6 by the block diagrams.

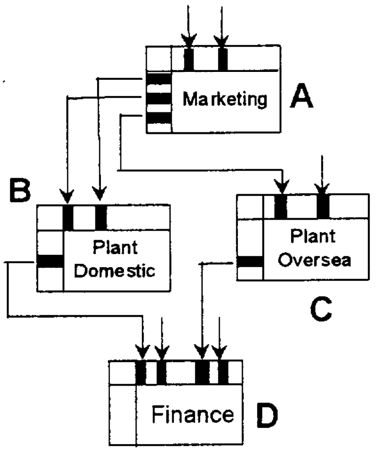


Figure 4-6 Chaining Structure Matrices

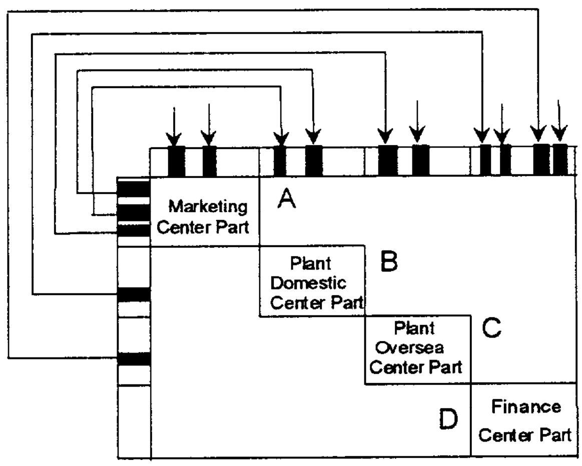


Figure 4-7 Expression in Large Structure Matrix

As a nature of structure matrix, this block diagram is shown in Figure 4-7 constructing a large structure matrix.

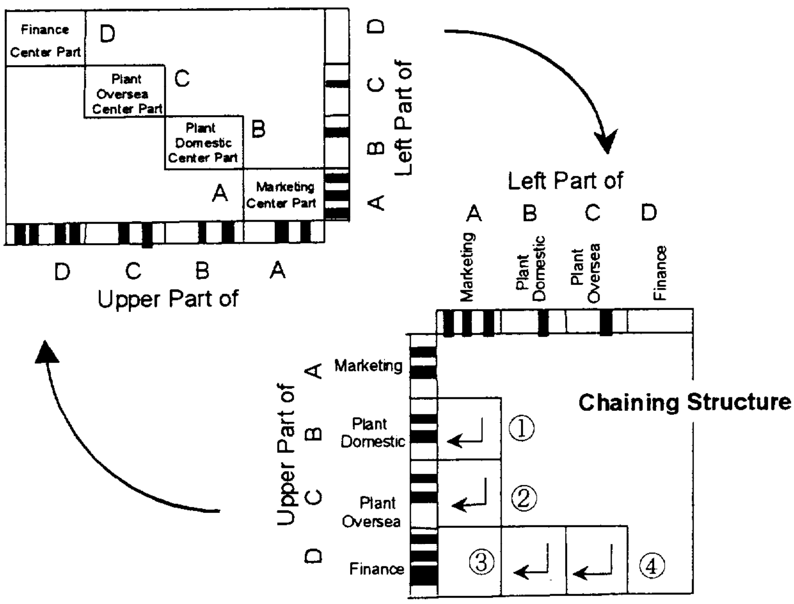


Figure 4-8 Large Structure Matrix and its Chaining Structure

4-3. Substantial rules for chaining of structure matrices

The essential aim of chaining for the designing should be as follows.

- Provide methodology along *Visibility with Transparency*, possible to reach the designated details of chaining, starting from all over view and arriving, also with minimized handling operations.
- Provide minimized knowledge about objected chaining models and its member structures for collaborations and long system life.
- Keep independence among chaining structure and its members as far as possible from changing of those models including re-combinations of single models.

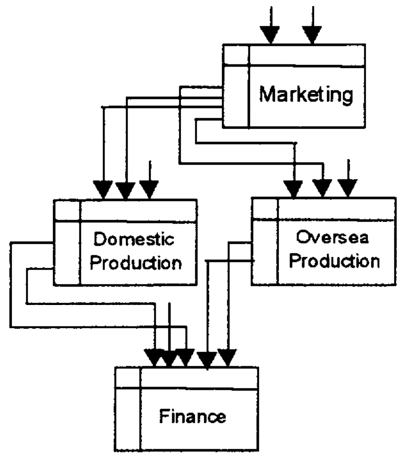


Figure 4-9
Complicate Block Transferring

Figure 4-8 shows detailed inter blocks' hand over among single structure models that are simply described in the previous Figure 4-7 using single arrows. As in the Figure 4-9, multiple blocks are transferred from the left part to the upper part of multiple single structures generally accompanying mismatched or different sequences. Again, such relation exists also within the detailed structure of transferring data between the blocks.

By these reasons, we reached to chaining architecture with the following simple philosophy..
The rules are:

- Each single structure can belong to multiple chaining structures as a member of those common children.
- Chaining structure should be established independently from single structure models perceiving the characteristics of associated structure matrix.
- Transferring relation in the chaining structure should be composed of nested tables of their relations, level by level from over view toward details as follows.
  - Transferring in the level of the single structures
    The left part of the sending single structure
    => The upper part of the receiving single structure
  - Transferring in the level of blocks
    The block of a sending candidate
    => The block of a receiving candidate
  - Transferring in the level of value data
    Value data of a sending candidate
    => Valued data of a receiving candidate

  In this last level, matching technology of which details will be introduced in the Type Symbol: M in the later part of this Part II, is applied as a mainline method of transferring block contents.

As concrete methodology, in advance for the transferring, associating *Axis I Item Block* of the sending block and associating *Axis I Item Block* of the receiving block are paired for the operation of Matching. Then full matching is operated among both Item Names. Then data, associated the matched position of items, are transferred.

4-4. The principle of the architecture realized.

For keeping *Visibility with Transparency*, the chaining structure must be constructed to be able to approach from macroscopic view and to be developed to microscopic view, forming hierarchical sequence, level by level with nested tables' sequence.
For realizing this requirement, our chaining structure was designed composed of followed three levels as nested tables. The example of this architecture is shown in Figure 4-10 schematically focusing chaining structure. Here a large structure matrix is dissolved into four small structure matrices attached to the chaining structure.

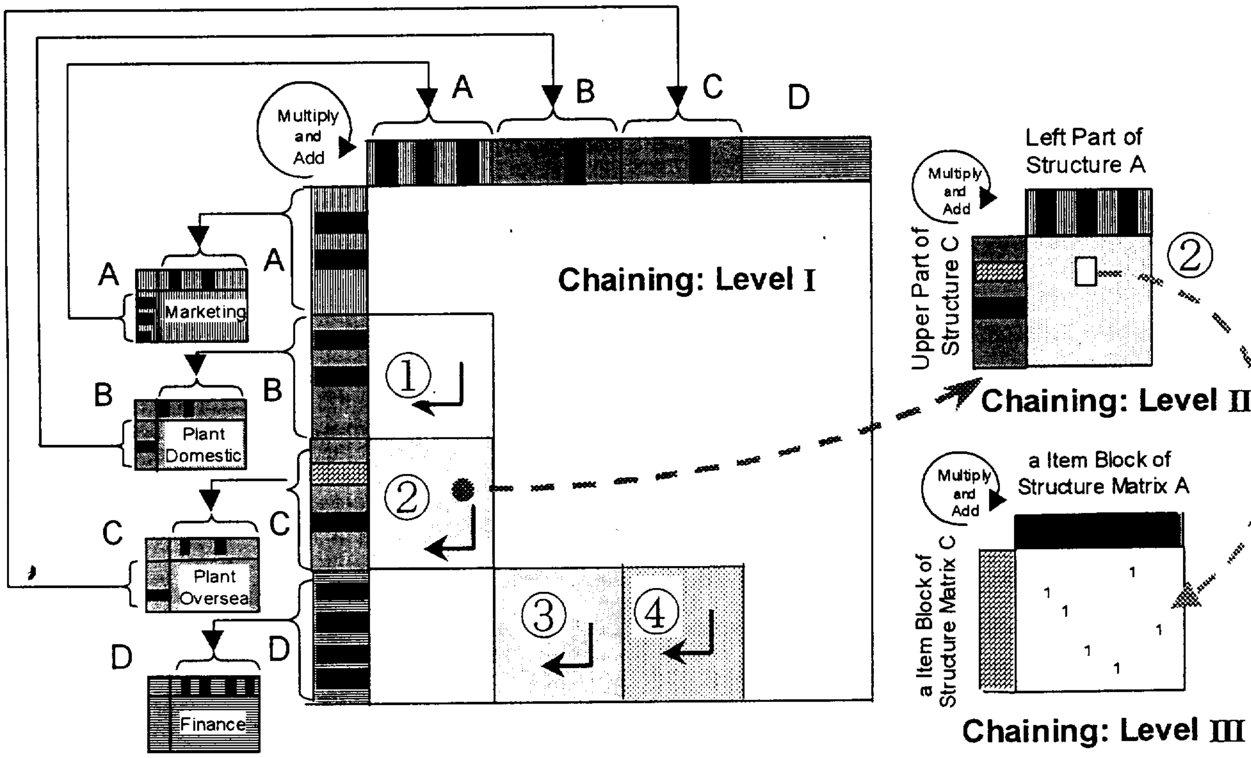


Figure 4-10 Architecture of Chaining Structure

Level I: Inter structure matrices

- In the chaining structure table, defined by a particular name, transferring causal relations is displayed. And this transferring exists between the left part of single structures (Sending) and upper part of single structures (Receiving) is displayed.

Level II: Inter their blocks

By selecting the position having the fold arrow, it displays transferring relations that exist between blocks of the left part of a single structure (Sending) and blocks of the upper part of a single structure (Receiving).

Level III: Inter Items

The mechanism of this level is a little different from the above two levels.

For easier understanding, let's think transferring of vector data between blocks. They exist between the block in the left part of output single structure and the block in the upper part of input single structure. (Think only the first axes of table)

Pointing the inter-block relation, the third level relations are arranged for setting.

We prepared the following three choices for users.

- Sequential transferring:

  The sending data are transferred to the receiving position by sequentially coupling the position from the start. If the number of Item names associated the sending block exceeds that of receiving, overflowed valued data are cut down. If shorted, zeros are filled for the shorted position. This method is effective for most cases, if the contents (*Item Names*) of Item block in both sides of blocks are the same.

- Assigning the matching position:

  This assignment is specified as receiving oriented, by showing the receiving *Item Names,* then selecting one sending *Item Name* from the list of the sending *Item Names.* This is a *one to one* assignment where transfer relations are effective, and the idea is identical with the insertion of Type Symbol: B composed of zero and one.

  This method is necessary for transferring the valued data between the alias happened in the different single structures. These phenomena happen commonly in the collaborated models: for example, some product names are different in marketing departments, production plants and research laboratories. Such arrangement work must be involved in some collaborated modeling work.

- Automatic *Item* matching

  Using the same idea of full matching function of which details are introduced in the Type Symbol: M (Matching), data in the matched position are transferred to the receiving position. Setting work of the transferring position is automatically and dynamically performed. This is most common case of the chaining, because of stability for dynamic change of models.

  Taking a case as example, the product order received in the marketing model must be distributed for the multiple plant models according to their specialty of product lines. These types of transferring are specified in each chaining of Level III and without detailed setting work, the transferring is easily performed. Applying such method, transferring of data near million is performed among single structures.

The extensions of the last two methodologies for the transferring of two-dimensional tables, existing in the data blocks (Using the Item of the second axis), are tried. From the *Visibility with Transparency*, transferring the data in one stretch does not seem to be well accepted, though arranged. Most end users apply the transferring to the first axis, and turn the result using type symbol: T (Turn), then apply the transferring of the first axis again (accordingly the second axis at the beginning).

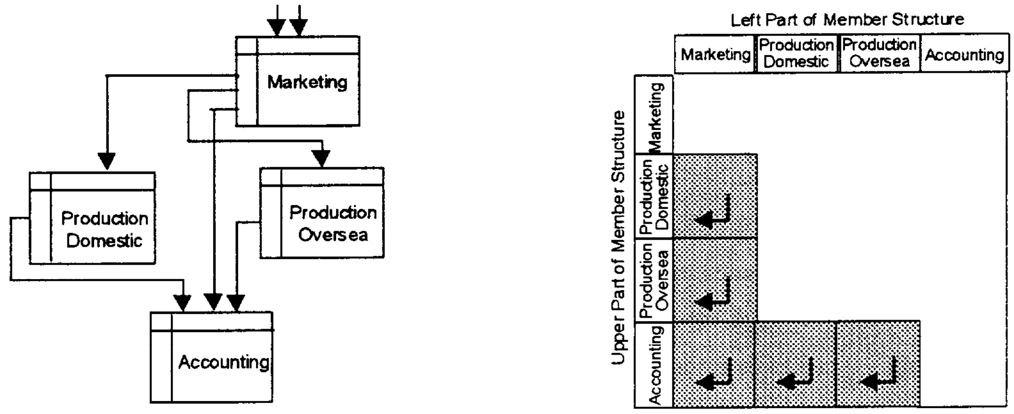
As a whole, this set of table for the chaining is realizing a kind of *Round Robin* table, placing single structure models independent from the chaining structure as satellite. The center part of Level II is implemented as list type table in which the candidate relation among the upper and left block can be set one to one, from the side of simpler understanding, evading the confusion of multiple transferring.

4-5 Various Type of Chaining Structure

Thinking the series of models (Mainly the series are used for time series where the major structures are maintained almost same in the time varied domains, but there is no necessity to be limited only in time varied phenomena.), chaining models can be classified the following three types. In this discussion, the types of intermixed chaining including loop are omitted, reserving for future discussion.

- Simple chaining
- Series chaining (Used mostly for time series)
- Compound chaining

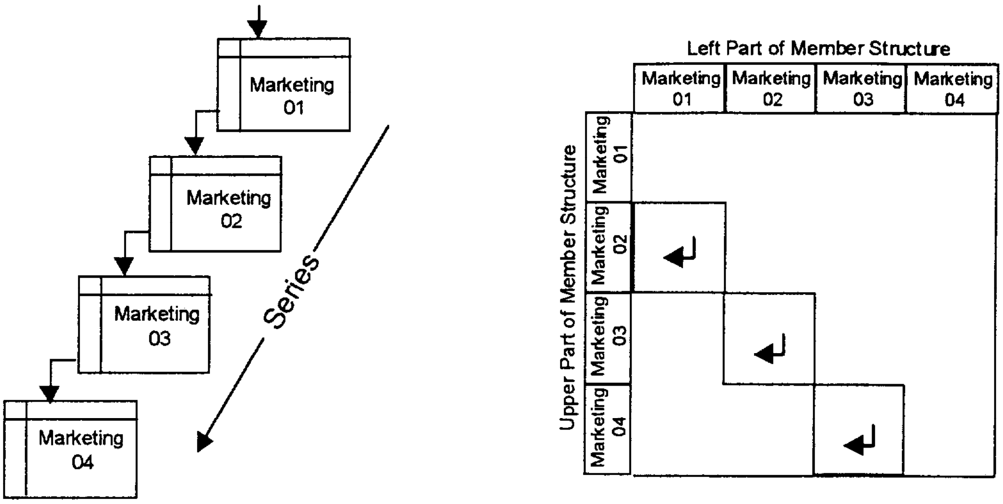
Simple chaining of their transferring block data among single structures to other structures as shown in Figure 4-11, is already explained, in introducing the chaining structure.



(a) Diagram of Simple Chaining (b) Macro Table of Simple Chaining : Level I

Figure 4-11 Simple Chaining Structure

Diagram of series chaining, that has relation of transferring block data toward upward sequence, is shown in (a) of Figure 4-12, and its macro level table is shown in (b). In applying series to time series, causal relation is brought in, forwarding the time position.

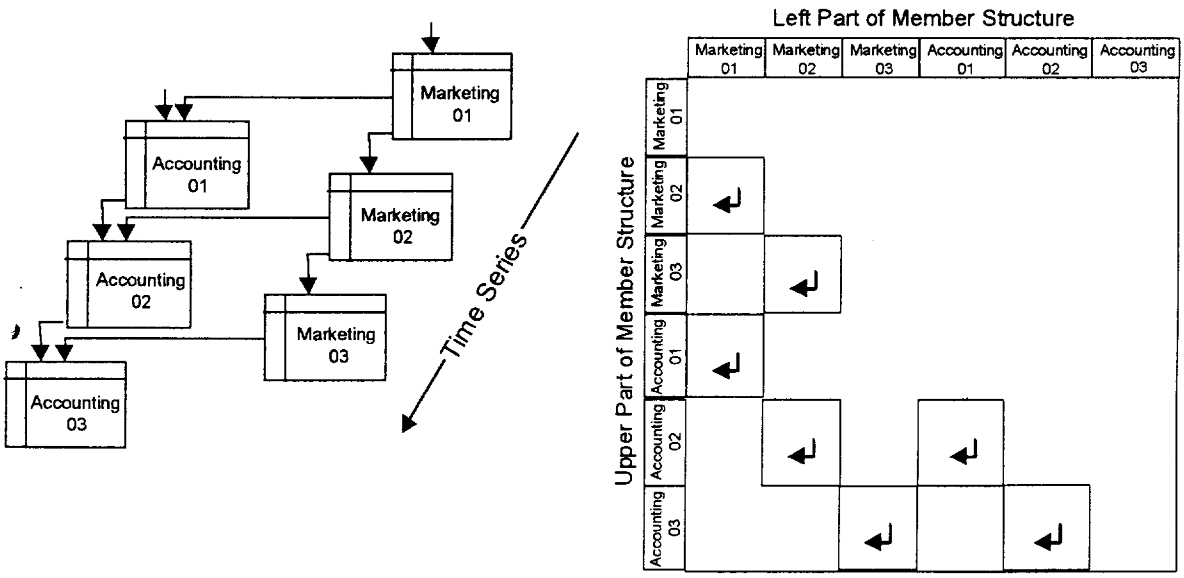


(a) Diagram of Series Chaining (b) Macro Table of Series Chaining: Level I

Figure 4-12 Series Chaining Structure

Series is one of the architecture toward depth direction, attached to the single structure model. However, each series structure is handled as an independent single structure in the chaining structure, only with the forward transferring direction.

An example of compound chaining, mixing of single and series structures shown in (a) diagrams of compound chaining, Figure 4-13, are expressed in (b). Here each series structure is also placed as an independent structure.



(a) Diagram of Compound Chaining (b) Macro Table of Compound Chaining: Level I

Figure 4-13 Compound Chaining Structure

4-6. A Case of Study for Designing the Chaining Architecture

In early stage of thinking the chaining architecture, there happened to have an idea that single structure matrices were a part of a large structure matrix to be placed in its upper level. The idea also includes the transferring tables linking those single structure matrices.

The idea was derived from the following idea that all member of single structured matrices and the transfer tables could be described in a large single structured matrix by the principle as shown in Figure 4-14. The common expression of structure matrix (a) in this thesis can be rewritten as rectangular expression. Then transferring relation from the left part to upper part can be rewritten as in (c). The upper and left parts can be unified attractively in the three dimensional spaces as in (d). Using this idea, the example of proposition for the chaining structure of four single structures as in Figure 4-8 can be expressed as in Figure 4-15.

This architecture can express the whole structure including the member structure matrix and chaining tables within a simple image and their single structure matrices can construct recursive structure as nested architecture.

Surely this architecture seems very beautiful like Mandala chart (Buddhist art: a well organized ideal world) and easy to understand if this architecture is maintained static.

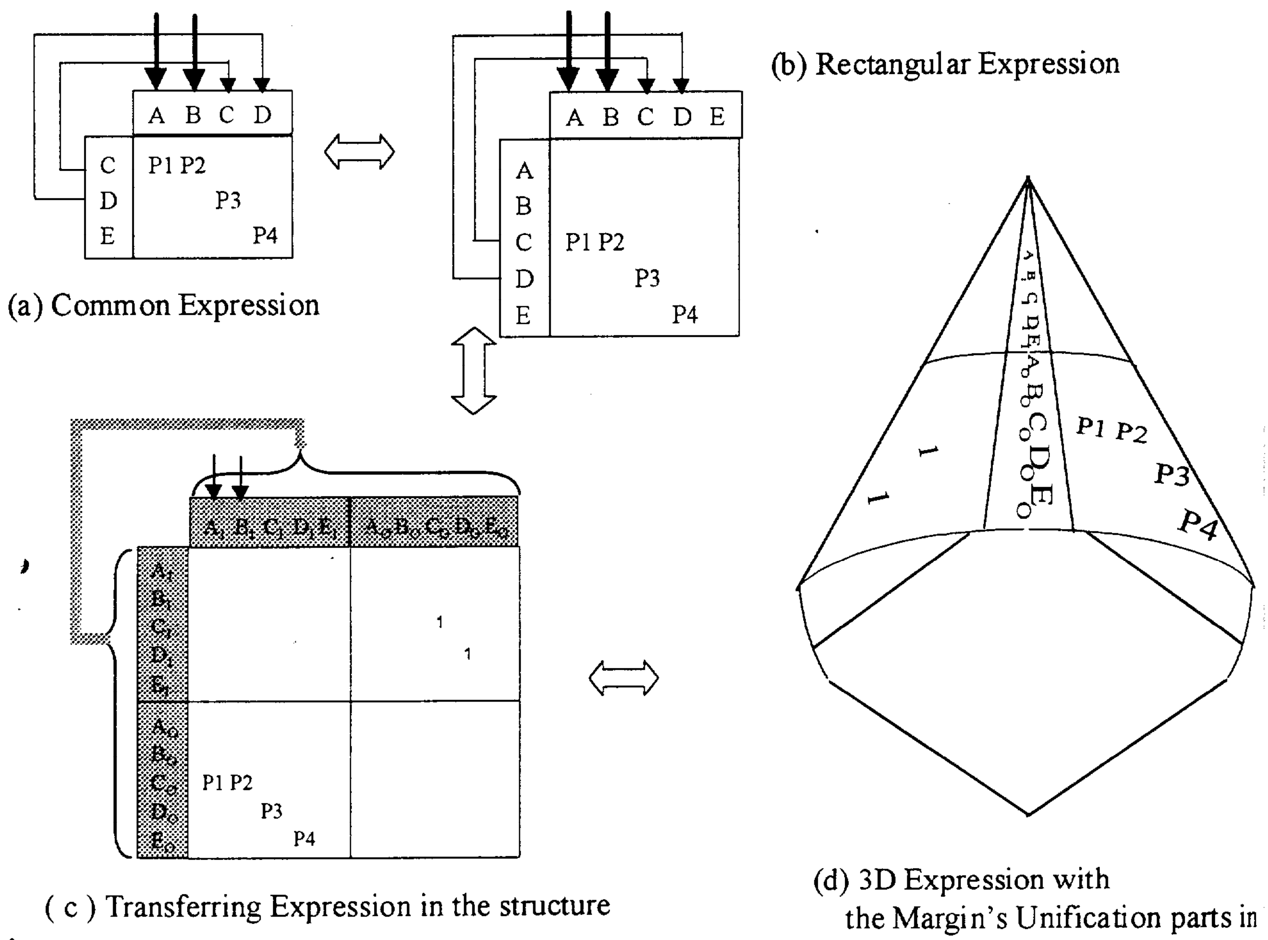


Figure 4-14 Structure Matrix Unifying Transferring Table

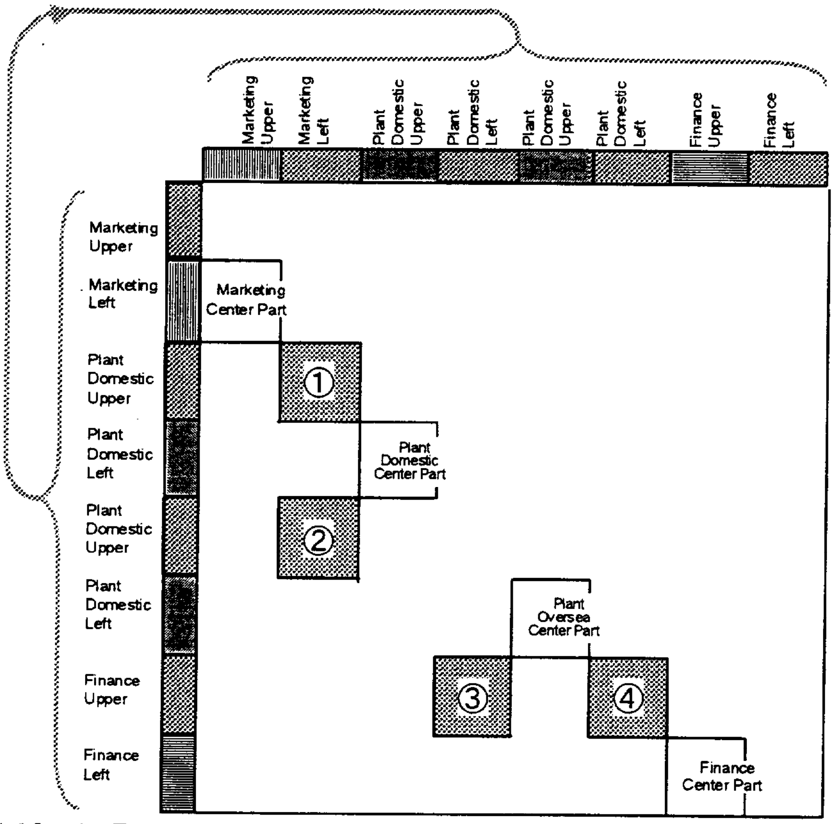


Figure 4-15 An Expression of a Large Single Structure Matrix unifying Transfer Tables

Though the striking beauty of its completeness and easy file forming under tree architecture from top unified table, we didn't adopt this structure by the following reasons

- We could hardly grasp the chaining structures in which their chaining tables were scattered to the whole.
- The single structure matrices were required to be active belonging to many chaining structures for case studies.
- We were required to provide a kind of *Object* for end users by giving the grasping unit like Chaining styucture, Single structure, Block then Item and data that forms exact hierarchical levels.
- The chaining works on collaborating job became very difficult, because all collaborators had to know the details of the models in placing and maintaining their responsible parts.
- Adding the involvement of time series structures, this architecture became complex and large to be handled upon computer screens. This was also more unrealistic, thinking of future extension toward pile up of higher chaining structures and loop processing upon current chaining structure.
- Responding the needs of changes happened in each level, was too difficult to be handled.
- Type symbols in different nested levels made the whole architecture uneasy to understand their management phenomena at the collaboration.

After our early stage of selection, some attempts to place this unifying idea was failed by the above crucial reasons.

5. Technology of Type Symbols in General

In this chapter, we discuss technology about Inter Block Operations. .Because these operations start after the calculation sequences read out from the structure matrix. Inter Block Operations are realized by Type Symbols or by the associative operation of them. In offering software package for business model builders, sufficient type symbols must be provided enough for propagating users' ideas according to the progress of model building. The subjects will be descended from general to particular.

5-1. History of Type Symbols

"How to organize type symbols in what way to responding the various needs" had been our long term efforts. In the figure 5-1, the history and the development of our idea were schematically shown.

Starting from Production and Cost Models

First idea started with a simple hypothesis: "*Business models are composed of rather simple Logic if resolved into basic elements*". Then through the study of German development, we had a hint that very simple notation could sufficiently and compactly express the terribly complicated causal relations among production factors and cost factors on structure matrix.[IBM Deutchland, 1997] (Please look at Figure 7-2-3 Structure Matrix of Steel Plant)

Consolidation of Two Calculation Mode

As an earlier experience, we introduced to make the package reflecting conscientiously German models having two styles of basic calculations: "*Multiply and Add*" and "*Add and Multiply*". The latter gave beginners confusion to jump to the image of possibility to calculate inverse causal relations, though it gave cost models reflecting production factors. In addition, they were disturbed by the possible size of displayable characters in those days. Above all, under the 80 characters' displays, the existence of two modes of calculation in one display screen caused invisibility, and it gave them complex image of computer system though the system had simple and compact relations. By the idea to make *transpose symbol* and to put the character T at the top of center block names, we could improve those models that were effective under single mode: *Multiply and Add.* (Details of those are introduced in chapter 6-2-1 Bilinear Relation of Consumption Factors and Unit Cost)

Alignment of Single Data to Plural Data

In earlier stage, we introduced the concept of data expansion: single date to plural data aligning the paired another block. This gave easier handling of data for users and lead to apply for the handling of multi-block and data given as parameters of specific type symbols. We learned the importance to establish those rules from the handling of arrays in APL (Interactive language: A Programming Language, used for the development of those packages for long terms.) Sample rules are shown in chapter 3-2-4 of this thesis: Arrangement of data size at inter table processing.

Representation of Center Block by Top Characters

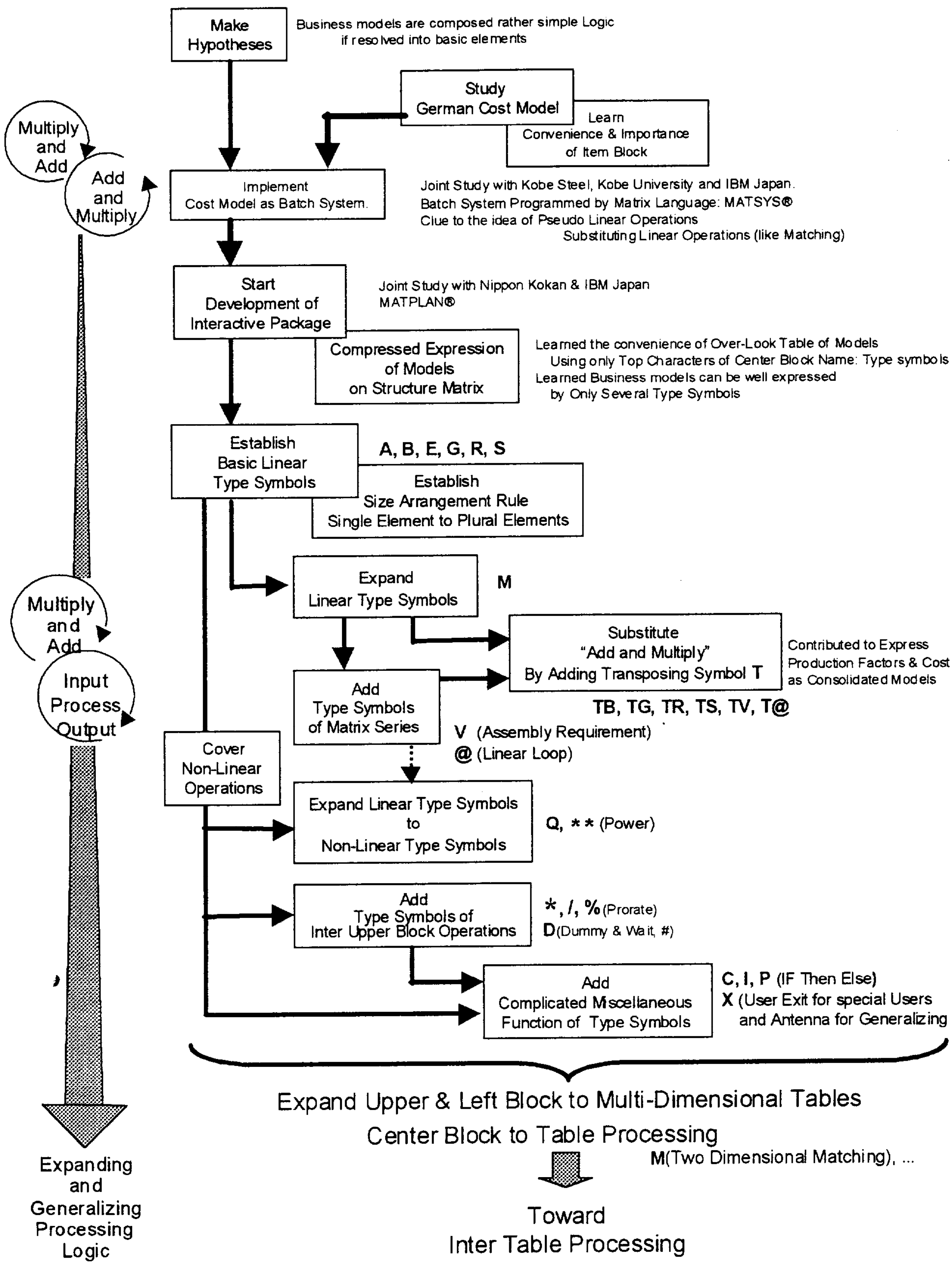


Figure 5-1 History of Type Symbols

By the strong request to overlook the entire model at a glance, idea to show compressed expression in the cross table, taking the top two (or three) characters of each center block name, was implemented on displayed screen and printed out. These top characters were abbreviation, but located. Knowing the meaning of upper and left blocks, users could easily understand the function in the crossed position, expressed as *Type Symbol*. (Refer Figure 5-13)

Using of small number of *Type Symbols* and rough overlooking brought good visibility to the models with conveniences. End-users accepted *Type Symbols* as more advanced representation rather than so called program function.

Covering Non-Linear Calculations

As natural process of modeling, it was required to respond the needs of non-linear calculations. The examples of these calculations were nonlinear processing between upper and center blocks, calculation among multiple upper blocks that were given as results of previous processing, condition processing and *User-Exit* functions. Existence of *User-Exit* was very powerful as an antenna for searching and learning what was common requirement and how to standardize.

Also idea of *Type Symbol*: **D** (bears duplex meanings: Dummy: and Delay) was very effective in controlling the calculation sequence. (Structure matrix as a linear modeling tool had a characteristic that the calculation result should not have been affected by the replacing a vertical train of blocks with other vertical train of blocks. Also the same characteristic existed between horizontal trains.)

In extending linear relation to the non-linear calculation using multiple upper blocks, we had to prepare certain environments. This meant that the environments did not require turn-up of calculating logic with its sequence, being affected by the local insertion or deletion of a train of lined blocks with these type symbols. For handling multiple upper blocks in a calculation, it was required that the mechanism for null action and waiting until all specified multiple blocks got the values succeeding the previous stage of calculations. (*Multiple wait* function) By the idea, we could realize non-linear calculation locally by embedding it within linear structure as a whole.

Toward *Input Process Output*

By those improvements, we could reach the idea to redefine the three areas of structure matrix: "Upper part as input area, Center part as Processing area and Left part as out put area." "*Multiply and Add*" became an embedded process of "*Input Process Output*." They brought us beautiful and sophisticated system for chaining of structure matrices. Some details are introduced in Chapter 3-2-7 Advanced Functions.

Many miner ideas are shown in each part of Type Symbols.

5-2. Idea of Type Symbols

Thinking the needs of type symbols, discussion must be done from the following two directions.

- How to provide the expressions to prompt easy modeling and to give easy understanding of the developed models: Legacy.

- How to provide the expressions for getting to fit the compressed table of structure matrix.

Essential calculation embedded in the structure matrix is *Add, Minus* and *Multiply*. These calculation and these combinations can cover major linear vector and matrix operations without programming in packages. Some variations or extended calculating operation must be prepared as common function hinted by the German development as in Figure 7-2-3 Structure Matrix of Steel Plant.

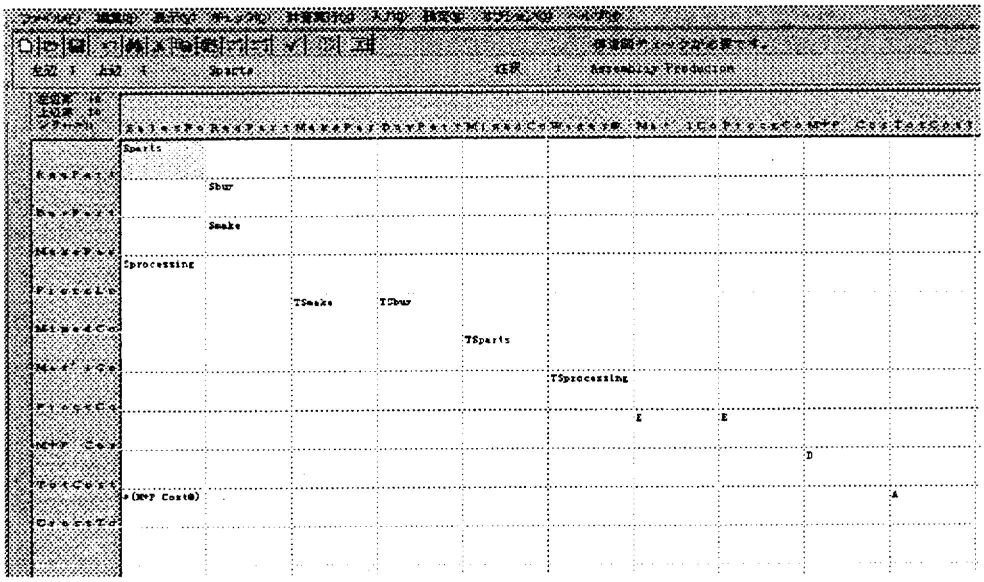


Figure 5-2 (a)
A sample Macro Table in Structure Matrix

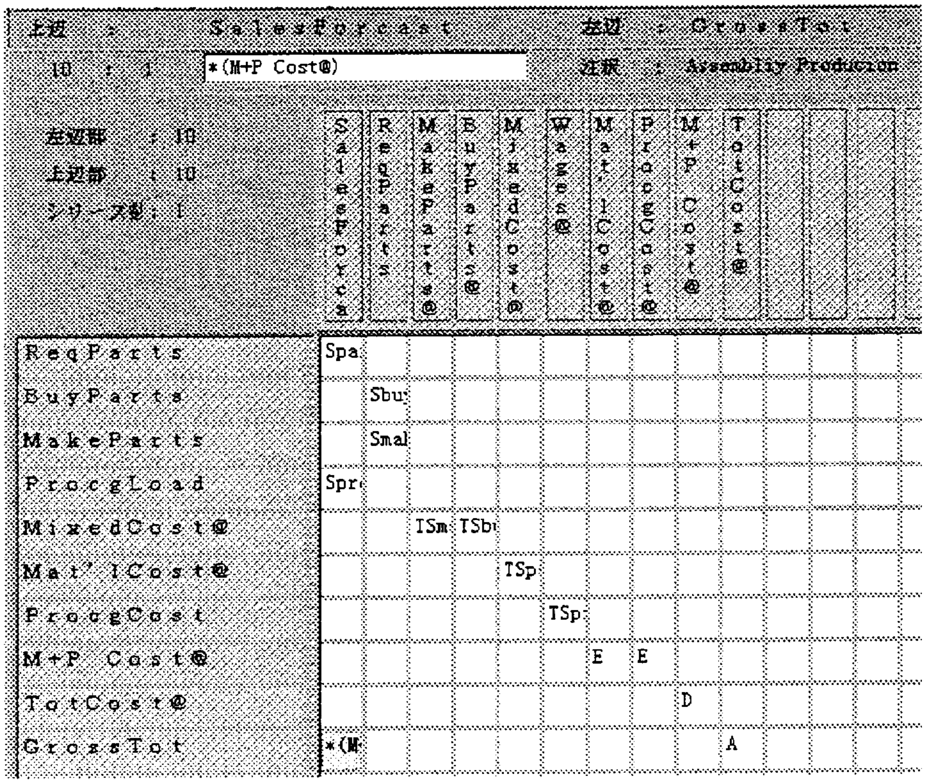


Figure 5-2 (b)
Compressed sample of the Macro Table

Figure 5-2 Concrete Example of Macro Table Screen

As stated before, one of our assumptions at the starting was "Most business models are composed with very simple units of logic, if we could dissolve modeled logic into elements limiting within the range of end user's touch." If so, these functions should be simplified into a single alphabetic character as *operator*. These single characters should have names that represent the function clearly as symbols.

The names should give familiar feeling to end users as commonly used in their daily business. We must decide so easy character that people, once understand the meaning, can remember their operations without any special efforts.

Evaluations for the idea of Type Symbols are as follows.

- Expression of models by structure matrix is a somewhat epoch-making for end users by the reason that they can easily understand their model without touching programs.
- The fact that complicated business model itself can be expressed only by such small number of simple symbols is a fresh astonishment for end users.
- End users showed rejection to the functions that smell something difficult being hedged with trouble some rules

On the other hand by the high evaluation of the simplicity, users promoted to make big models covering huge ranges of business, and accordingly they requested a bird-eye-view facility for entire model. (The strong request first came from Fukuyama Works, Nippon Kokan CO, to show total plant material flow and the cost structures.)

We additionally developed the function to show intensive tables like Figure 5-2 (b) that was intensively compressed macro table of original model Figure 5-2 (a)..

The following ideas were employed in composing the table.

- Taking the block names from the upper part of macro table and put them vertically in the upper part.
- Taking the block names from the left part of macro table and put them in the left part.
- Taking top two characters (or three characters) from each center block and locate them in the corresponding cross points of center part.
- If pointed a center block by cursor, its full length of the name is displayed in other area of screen.

Contributed by the idea of Type Symbols, compressed style of table was accepted as remarkable efficient method displaying the models. This so-called *compressed table* provides expanded span for viewing the models like a mapping methodology. This method was also applied in the printing of models, which could show wider area than displaying.

End users evaluated that the new model approach was visible. Because they could understand what kinds of data were treated as input and output from the names of upper and left blocks, then from the Type Symbols they could understand what calculation were performed. This is the way they can approach to the total understanding. If details are necessary, they can drill into the blocks.

With this realization, Type Symbols were planted in structure matrix as more convenient and advanced technology compared with current describing style of functions for the frequent calculations in modeling. By patterning the model, new approach was promoted to establish standardized model patterns for macro table.

5-3. Image of Type Symbols

For giving rough image of Type Symbols, some typical symbols will be introduced briefly with illustrations. Abundant functions deepened are introduced in details of Appendix II attached in this thesis. we sincerely hope you will refer it for understanding the extent of applicability in modeling.

Type symbol: S and closely related symbols.

The idea of the type symbol: **S** is shown in Figure 5-3. **S** has a meaning of *standard* and is provided for numerical values in the center block having no special restrictions. This is also a fundamental base of *Multiply Add.* Against **S**, there are the following variations restricting the numerical values containing in the center block. With the duplicate meaning: *Bundle, Binary* or *Bool,* type symbol: **B** restricts only in the numerical values: 1, 0 and -1 and rejects other values.

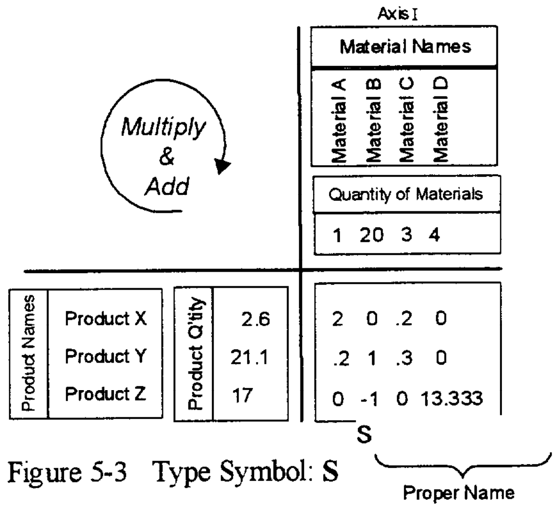


Figure 5-3 Type Symbol: S

Type symbol: **G** (assign to *Group*) provides numerical values that have characteristics: column wise (vertical) summations of the center block keep value: 1 with positive values, or otherwise all column values are 0. In addition, type symbol: **R** calculates the reciprocal value of the elements at first, then using these transformed values *Multiply & Add* is performed.

Type symbol **A** and **E**

Some type symbols have no numeric values like virtual block. As shown in Figure 5-4 and Figure 5-5, type symbols: **A** and **E** have no associated blocks and work as if they have values at the timing of calculation executions. We can save the workload of setting values. Also they can respond for the change of data size in the upper block and left block. (*Item Independent*)

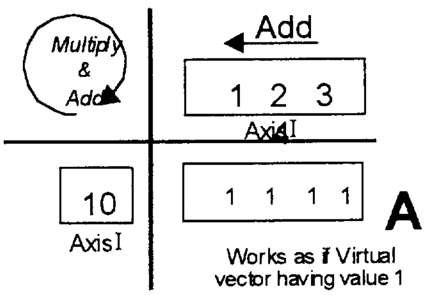


Figure 5-4 Type Symbol: **A**

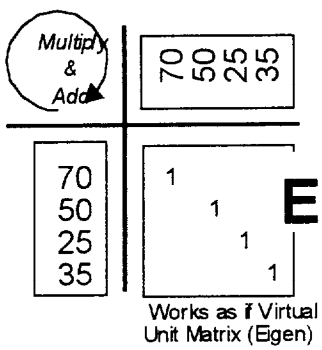


Figure 5-5 Type Symbol: **E**

Type symbol: **M**

There is a commonly used type symbol: **M** (*Matching*) which works virtually like type symbol: **B** without having any values. The case of one-dimensional matching is shown in Figure 5-6. Two-dimensional matching is conveniently used well as inter-table matching and its details are described in Appendix II.

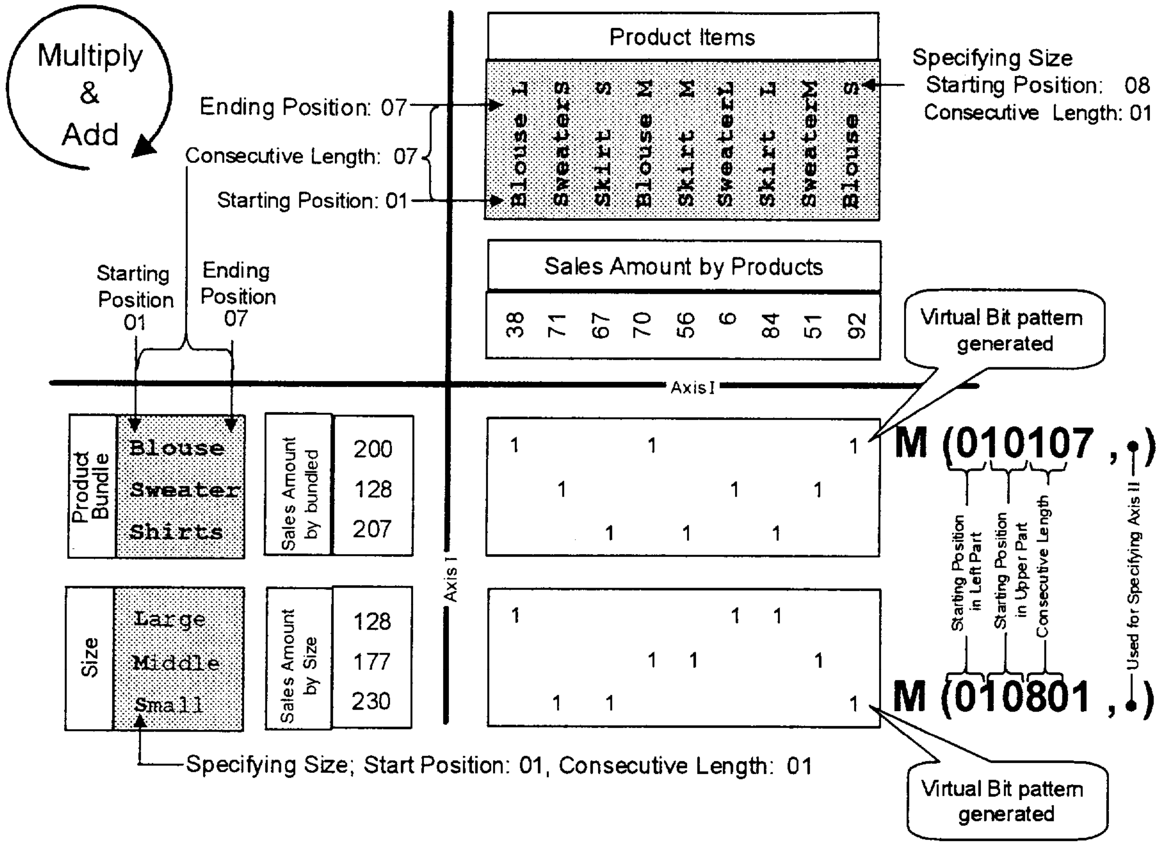


Figure 5-6 Type Symbol: M

Type symbol: **T**

Attaching the type symbol: **T** before type symbols: **B**, **G**, **R** and **S**, the data of center blocks can be used by transposing these center blocks located in other places of center part having cap characters: **B**, **G**, **R** and **S**. By this idea, the architecture of structure matrix can be extended to be able to handle *Horizontally Multiply and Vertically Add* operations covered by a single rotating direction: *Multiply & Add*.

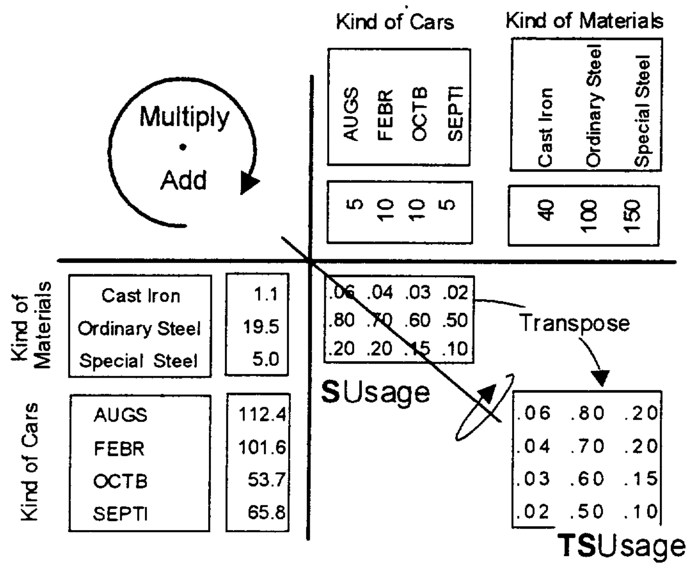


Figure 5-7 Type symbol: **T** capping on **S**Usage

In addition, this idea is extended to the type symbol: **V** and @ (will be discussed later). All of these symbols having linear characteristics are able to have cap character: **T**.

Type symbol: **V** and @

Taking examples in parts development as in Figure 5-8, tree structure of parts for product: *MMM* and product: *NNN* are shown. *XX* and *YY* mean intermediate parts and *A* ~ *G* having one character mean the lowest level of parts.

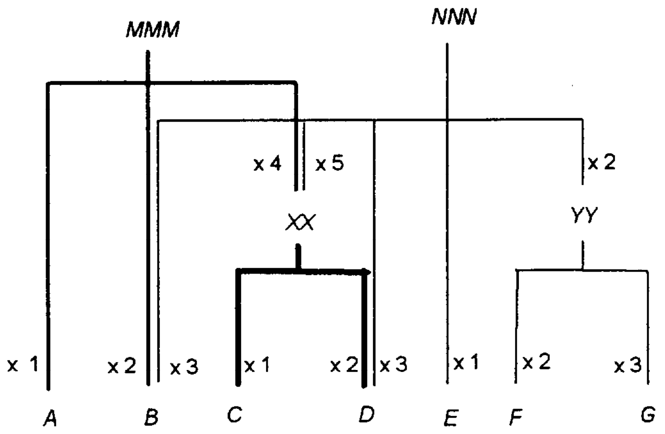


Figure 5-8 Tree Map of Parts Developments

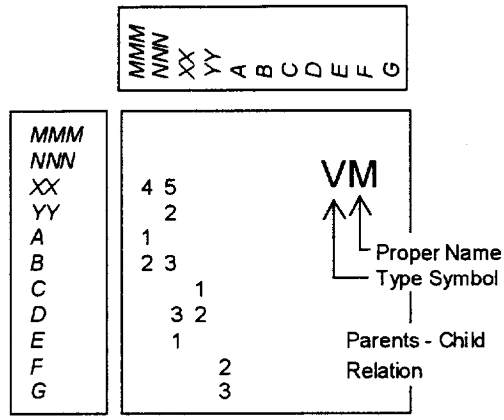


Figure 5-9 Type Symbol: **V**

The character: x and the adjoining numeric value specify number of the parts used for the direct upper level of part. The sample transformed to square matrix representation is shown in Figure 5-9 as type symbol: **V** in which upper block means parents, left block means children and the center block means coefficient of weight to children to parents (number of children or number of used parts for the above level). By giving number of product in upper block, required numbers of parts in each level are given in the left block.

As further extensions, there is a type symbol: @ which develops requirements in the network having loop: containing the parents and children's relations are reversed. The internal mechanism of type symbol: **V** and @, is following steps.

- Summation of the matrix series is calculated, thinking the center block is a matrix.
- *Multiply & Add* operation is performed between the result and the upper block.

Adding further, the results of type symbol: **V** and @, can be used as transposed values by capping character: **T** and sometimes these values give significant applications.

Type symbol: **Q**

As a variation of type symbol: **V**, type symbol: **Q** (Quota) utilizes the calculation function of tree structure. [Toyama, T., et al,1995], [Toyama, T. 1995]

This type symbol is used for the case, that the common cost must be burdened by all the organization or sales target for the company, and must be assigned according to the relevant yard sticks in each level of branches as shown in Figure 5-9 with underlined values. Figure 5-10 shows the assigning of top vales using type symbol: **Q**. In this case, No 1 Branch office assigns their target value according to the number of each section's employees, and No 2 Branch Office assigns their target value according to the number of sold sets. In type symbol: **Q**, tree organization is registered in the square matrix by giving value 1 into the relational part, thinking the upper part is parents and left part is children. In the upper block, top value to be assigned and yardsticks for assigning are given in each branch. The resultant values are given in the left block. The fundamental logic are developed as following sequence.

- Yardsticks are converted to assigning ratio in each parallel level

- These ratio values are written into the matrix temporally
- Idea of type symbol: **V** is applied like parts development idea

This method is convenient for following of the dynamic changing of organizations.

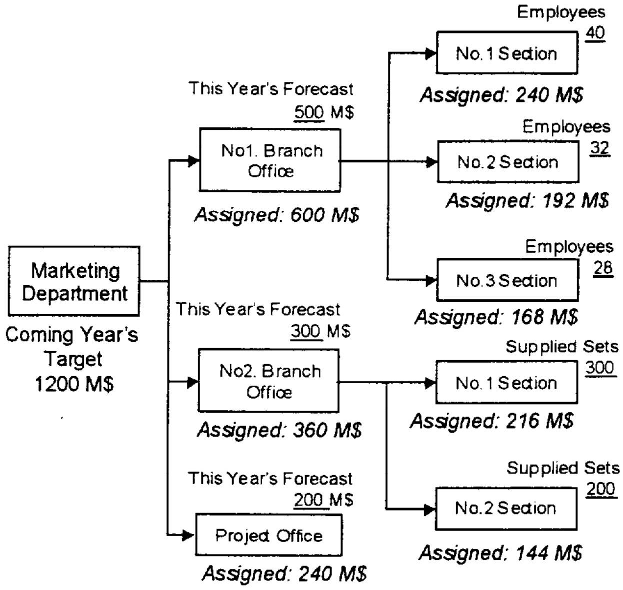


Figure 5-9 Outlook and Assigned Targets

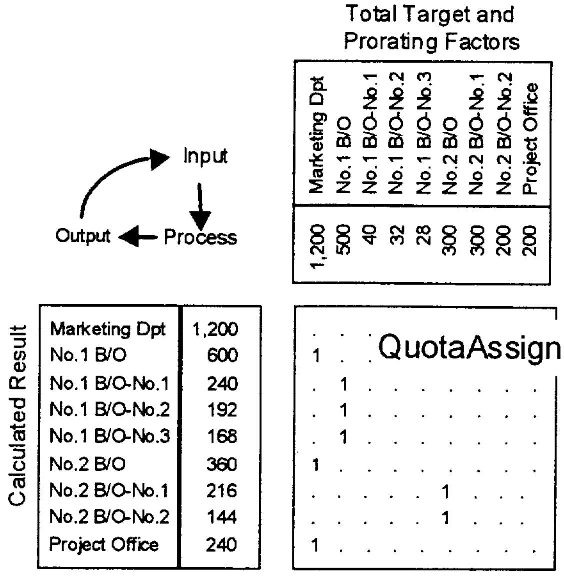


Figure 5-10 Type Symbol: Q

In the next section, a sample of application model ,where these type symbols are used embedded in the model, will be shown.

5-4. A Simple Model using few Type Symbols

For introducing the expressing of business structure model with embedded work of type symbols, take a simple example of wire making processes starting from billet supply, through Rod (Rolling) Process then Wire (Drawing) Process and reaching Wire Products as in Figure 5-11.

The detailed characteristics of the model are as follows.

Billet treatments

- As input of rod rolling process, Billet XX and YY are supplied from supplied from Process P and Q.
- Sales Department treats raw material: billet beside wire products.

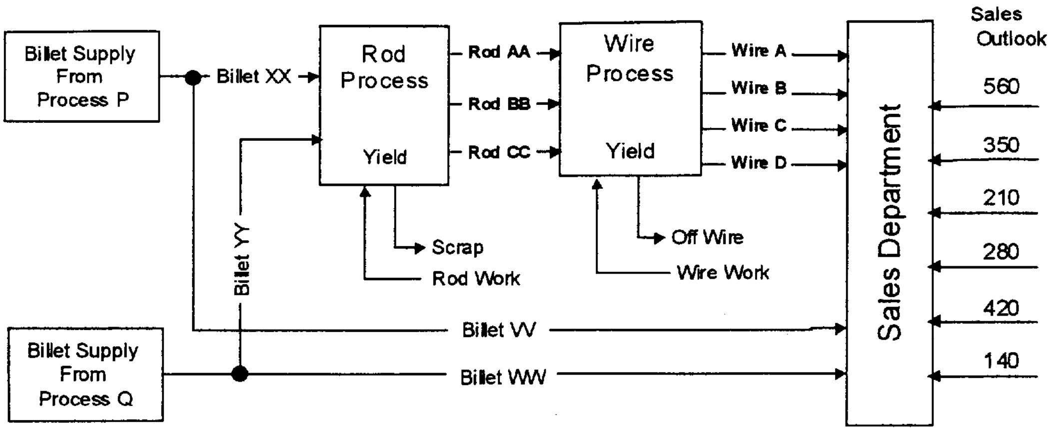


Figure 5-11 A Diagram of Wire Making Flow

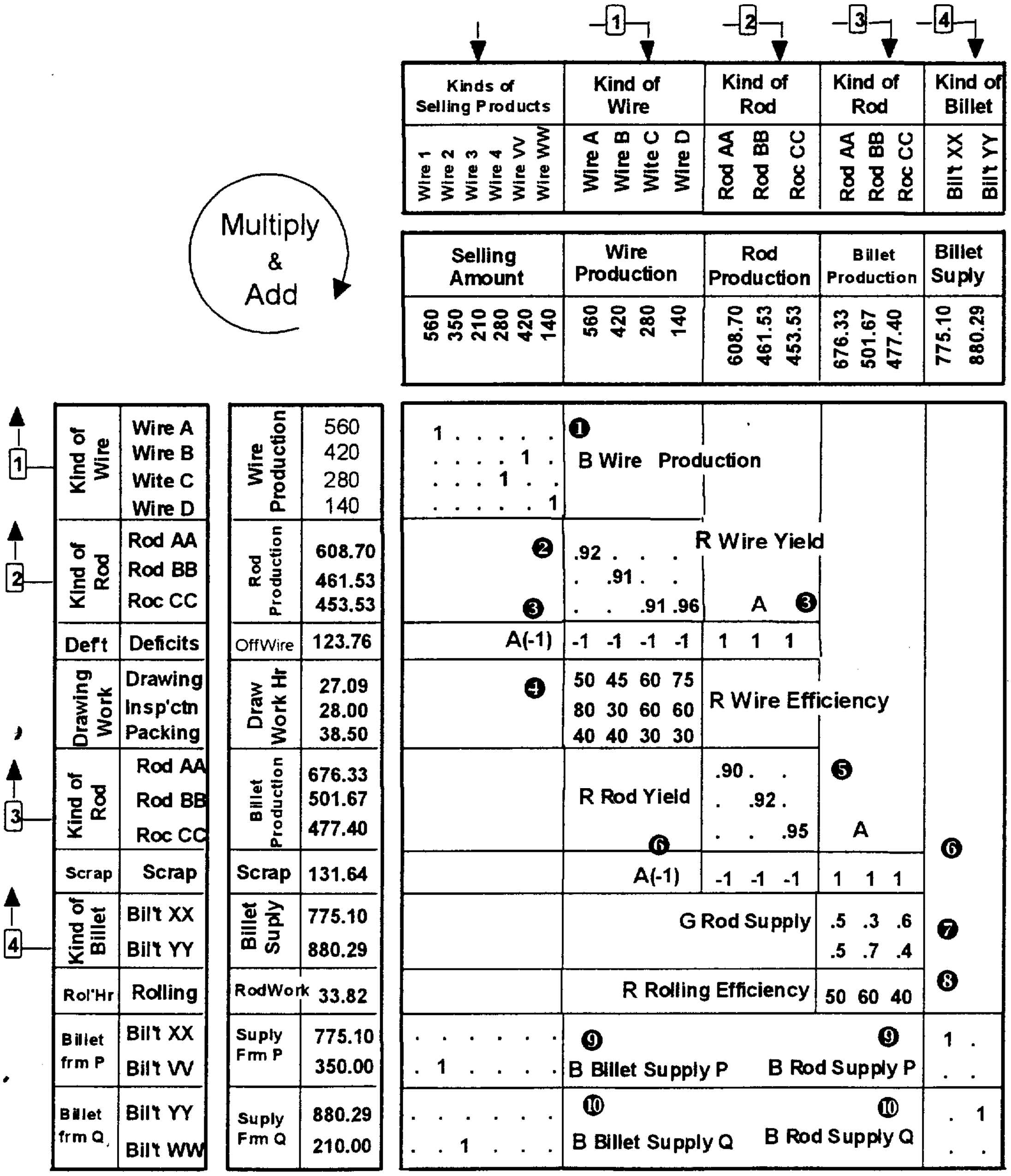


Figure 5-12 Wire and Rod Production Model

Rod process

- Billets are rolled to Rod AA, BB and CC forming Scrap generating yield values.
- This process consumes some Rod (Processing) Work like Rolling Hours, Inspection and Packing.

Wire process

- Rods are drawn to Wire A, B, C and D forming Off Standard Wire generating yield values.
- This process consumes some Wire (Processing) Work like Drawing Hours, Inspection and Packing.

The material requirements and consumption requirements are calculated upstream to the material flow.

A model on the structure matrix using type symbols is shown in Figure 5-12 and uses of type symbols are explained according to the round numbers as follows.

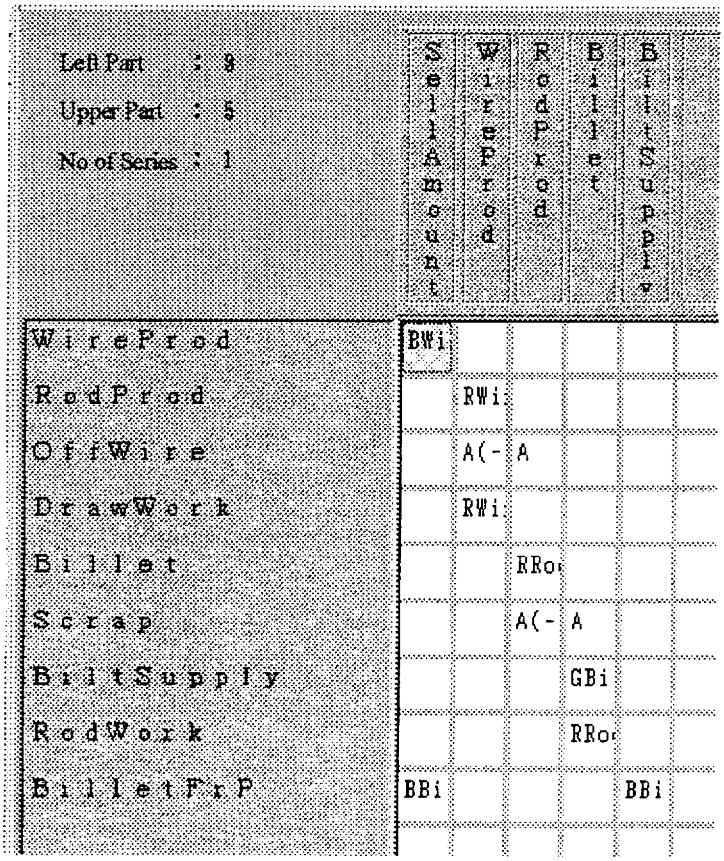
❶ **B Wire Production** binds together between Selling Products and Wire production.

❷ **R Wire Yield** binds Kinds of Wire and Kinds of Rod, and calculates the requirements of Rods as input toward upstream by converting the yield values to reciprocal values and by operating *Multiply & Add*.

❸ With **A(-1)** and **A**, amount of produced off standard wires are calculated by getting the difference between Input and Output materials.

❹ **R Wire Efficiency** holds efficiency values per hour. By the symbol: **R**, these values are turned reciprocal figure, then multiplied with upper product values: Wire productions, and finally summed. This process means total drawing hours, total inspection hours and total packing hours.

❺ Through R Rod Yield, Billet requirements are calculated, using converting reciprocal values, by *Multiply & Add*.



Left Part : 9

Upper Part : 5

No of Series : 1

	SellAmount	WireProd	RodProd	Billet	BiltSupply
WireProd	BWi				
RodProd		RWi			
OffWire		A(-	A		
DrawWork		RWi			
Billet			RRo		
Scrap			A(-	A	
BiltSupply				GBi	
RodWork				RRo	
BilletFrP	BBi				BBi

Figure 5-13 Condensed Macro Table of the Model

❻ With **A(-1)** and **A**, produced scrap is calculated by getting the differences of input and output.

❼ In the block of **G Rod Supply**, ratio values in column wise are given. Through this center block, billet supply sources are calculated.

❽ Through **R Rolling Efficiency** that has rolling efficiency values per hour, rolling hours occupied by this combination of rod production is calculated as RodWork.

❾ and ❿ binds values for supplying sources from upstream process P and Q by arranging the binding relation providing in center block of type symbol: **B**.

The macro table of this model is shown in Figure 5-13 as screen image. By this expression, users can grasp the outlook of the model as application by understanding the meaning of upper and left blocks and processing logic roughly by the characteristics of type symbols in their cross points.

5-5. List of Type Symbols and Various Categorizing

For the conveniences for further discussion, the realized typical Type Symbols are listed in the Table 5-1. In the assignment of the characters of type symbols in the list, some duplicate names are shown for more generalized discussion.

There are many directions of categorizing for Type Symbols.
Categorization from the point of linearity, non-linearity and control of processing flows are as follows.

◆ Symbols based on *Multiply and Add*

- Standard use of matrix data

  S: Normal Values are treated. Even when *Multiply and Add* are truly applied, this symbol must be capped.

- Extension of *Multiply and Add* by holding data type

  B: Only Boolean values are exclusively treated, and currently extended to -1, 0, 1.

  G: When values are positive or zero and vertical summation is 1 or zero, they are exclusively treated.

- Substituting positional data

  A: All the data are as if value 1, and the scalar parameter gives multiples. This type symbol substitutes type symbol: S having same value in all position.

  E: All diagonal data are as if value 1, and the scalar parameter gives multiples. This type symbol substitute S type having same values diagonally.

  M: One dimensional matching, substituting **B** having values: 1 and 0

- Borrow another center block data to different positions

  = : Borrow center block data from the continued name after '='.

  Currently the designing file to permit synonyms can save this Type.

  T: Borrow center block data with transposing from the continued name after

- Built-in calculation for center block data in advance for the *Multiply and Add*

  R: Reciprocal calculation is built-in before execution of *Multiply and Add*

Symbols	Meaning	Multiply and Add	Input Process Output	Proper Center Block	Specific Parameter	Referring Use of Another Upper	Explanation / Comments
A	Add	●			●		Add along Axis I, Instead of giving value: 1
B	Bundle, Binary, Bit	●		●			Originally giving values are limited only 1& 0, and recently -1 is permitted
C	Condition		●	●		●	Calculate proper Condition equation and gives bit values or bit map
D or #	Dummy and Wait		●			●	Null calculation. Used for recognition and wait for synchronizing with the calculation of referred type symbol *, /, %, C,P,X
E	Eigen or Each	●			●		Working as Adding of corresponding upper position without giving diagonal values: 1
		●		●	●		Proper diagonal data(different data) are hold
G	Distribute to Group	●		●			Distributing upper values by giving proper vertical ratio among left group. Summation of Ratio = 0
H	Horizontal Add		●				Adding of upper block along Axis II (toward the depth side direction)
I	Interrupt		●	●			In the middle of calculation, interrupts the calculation and arbitrary values can be set, looking the upper block's results
M	Matching	●			●		For one dimensional table's matching, bit pattern like Type symbol B is generated virtually comparing item's names attached to the Upper and Left Blocks, instead of making bit pattern explicitly. Data extraction/ data Insertion from/to table become very simple. This function is independent from the change of item. Particular part of the strings in items can be specified by the parameter.
			●		●		Above function is extended to two dimensional processing among the two tables and composing/decomposing between the tables can be performed.
P	Programming		●	●		●	If then else style coding by FORTRAN style can be registered and performed in the center block
Q	Quota		●	●			Allocating top values along the hierarchical organization registered in center block using distributing factors given in the upper block. Used for assigning top fixed values .
R	Reciprocal	●					Reciprocal inverse calculation of values in center block in advance to multiply and add. Used for resource requirements giving yield or working hours giving efficient figures....
S	Standard	●		●			Standard or normal use of values without giving specific restriction.
T	Transpose	●		●			Use other center block specified proper name after transposing it. Center block having Type Symbol: B, G, R, S, V, @ are the candidate. Typical use of these symbols are building of non-monetary models and by using transposing function cost models can be realized as extension of the previous models riding on the linear relations.
	Turn		●				Turning of upper block exchanging Axis I and Axis II
V	Volute		●	●			Resource development like Bill of Material Processing, using parents and children's relation matrix registered in the proper center block. (Inverse relation: child become his parents is rejected. For this relation, refer type Symbol: @)
X	Exit		●	●	●	●	User can built in user's proper logic that can not be covered by those Type Symbols.
*	Multiply		●			●	Multiply between the upper block and the referred other upper block
/	Divide		●			●	Divide the upper block by the referred other upper block
% or P	Prorate		●			●	Prorate the upper block by the referred other upper block having assigning ratio values. Prepared for cost assignment used for ABC, resource consumption, etc...
@	Linear Loop		●	●			Loop phenomena calculation based on network matrix relating parents and child given by the proper center block assuming the convergence. This is a kind of simultaneous linear equations and also a matrix series calculation. Prepared for the solution of looped plant processes, nested loop cost, costing starting from target cost,,,
>	Jump		●			●	Jump to the specified upper block as a result of condition processing on the proper center block
=	Equal		●	●		●	Borrow the center block specified proper name.

Table 5-1 A Typical Set of Type Symbols implemented (Mainly from MATPLAN/6000®)

- Matrix series type

  Matrix series calculation is applied using the center block, then the *Multiply and Add* are applied for the result.

These are linear calculation and can be thought small structure matrix calculation within the center block.

V: After calculating sum of matrix series using matrix of *Bill of Material* rejecting the loop relation is calculated, each level of required material is calculated by Multiply and Add. This application is not necessarily limited in material processing. Network calculation without loop can be applied in general

@: After calculating sum of matrix series in which the matrix contains loop relations, each level of required material is calculated by Multiply and Add. This application is not necessarily limited in material processing. Looped network calculation can generally be applied if converged.

◆ Symbols of non-linear calculations

From the starting, acknowledgment that only a function: *Multiply and Add* can not cover all the needs like divide for allocation of fixed cost.

- Dyadic operation with upper block and center block for non linear processing

  Q : Allocation of top values to each level of hierarchical organization given by center block data and prorating data in upper block data

- Dyadic operations with upper block and center block for two-dimensional tables (matrix table)

  H : Add upper block data to horizontal side, same as Symbol: **A** in one dimensional-data.

  M: Two-dimensional matching, same as Symbol: M in one-dimensional data.

  T : Turning the upper two-dimensional table (Exchange the axis I and axis II). Single independent character: **T** is used.

Axis I: front side axis or Item axis. Axis II: depth side axis or Case axis.

- Inter upper block calculation, associating with multiple upper blocks

  ***** : Multiply the direct upper block and specified upper block by the continued strings

  / : Divide the direct upper block and specified upper block by the continued strings

  %: Prorate the direct upper block and specified upper block by the continued strings

  C: Condition processing of equation specified by the followed string and giving result as bit map

  P : *If Then Else* processing according to the execution of registered condition and followed Then or Else processing.

◆ Calculation flow control

  D : Dummy (Null operation) and wait. Used associating with other type symbols in the same row or used as tentative positional memorizing.

  I : Interrupt in the middle of calculation operation and set left block data or quit calculations.

  > : Jump from current calculating position to the specified point if attached condition is satisfied

◆ User Exit

  X : User's exclusive logic. Some of them were leveled up to Type Symbols through evaluating commonness and usefulness. Therefore this is a kind of antenna for new applications. User exit is possible assuming use of multiple upper blocks.

Another important categorization is that Type Symbol has a characteristics of independence from the change (Insert, Delete and Addition) of Items associated to the block.

◆ Independent from Items' Change

A, D, E, H, I , M, T, >, =

◆ Dependent to Items' Change

B, C, G, P, Q, R, S, V, X, * , / , % (or P), @

5-6. A Study for Mathematical Formalization of Type Symbols

In this section, the results in our study are described for establishing the mathematical formation of type symbols.[Toyama, T.,1999] As a starting point of our study, type symbols treated were concentrated on eleven type symbols among proposed type symbols around twenty, not covering the following functions of type symbols.

- Controlling the calculation flow like condition branch
- Inter blocks calculations in upper part like multiply (*) and divide (/) between upper blocks
- Calculation handling two dimensional data in upper and left blocks
  (Limited only in one-dimensional data: vector data)

These eleven type symbols are classified into the following two categories.

- Basic class: Six types defining the class of linear transformation
- Meta-operator: Five types as definable functions defined between two functional spaces

The set of all the function from m dimensional linear space to n dimensional linear space is written as $Op(m, n)$ and its element is called an <u>operator</u>. When m and n are coincident, $Op(n, n)$ is simply written as $Op(n)$.

When $O \subset Op(m, n)$ and $O' \subset Op(m', n')$ are meaningful for certain m,m',n,n', a function from O to O' is called a <u>meta operator</u>.

The set of linear operators within $Op(m, n)$ is written $L(m, n)$, and $L(n, n)$ is simply written as $L(n)$.

For $X \in L(n)$, matrix expression of X is by (x_{ij}). When X meets the following conditions, it can be called a <u>tree operator</u>.

1. Existence of root

$$(\exists i)(\forall j)(x_{ij} = 0)$$

If i satisfies the formula $(\forall j)(x_{ij} = 0)$, i is called a <u>root</u>, and the set composed of all roots of X is described by $ROOT(X)$

2. Uniqueness of parents

$$(\forall i)(i \notin ROOT(X) \Rightarrow$$

$$(\exists ! j)(i \neq j \wedge x_{ij} = 1 \wedge (\forall k)(k \neq j \Rightarrow x_{ik} = 0))$$

These are the condition to express adjacent matrix when X is forming tree having $\{1, \cdots, n\}$ as node and is looked as simple directed graph. Directed branch is taken along the direction from the child to the parent. The disconnected graph having the plural of root can be included. The set composed of all the tree operators within $L(n)$ is written as $T(n)$. The set composed of all the matrices, expressing adjacent matrices of acyclic directed graph having $\{1, \cdots, n\}$ as node within the elements of $L(n)$, is written as

$A(n)$.

For the elements: X of $L(n)$, the set composed of all the elements in which series of $\sum_{n=0}^{\infty} X^n$ $(= E + X + X^2 + X^3 + \cdots)$ converges, is $C(n)$. Just then, the following propositions are effective.

Basic Class	Definitions
S Standard	$\underline{S} = L(m, n)$
A Add	$\underline{A} = \{ X \in L(m, n) \mid (\forall i, j)(x_{ij} = 1) \}$
B Binary	$\underline{B} = \{ X \in L(m, n) \mid (\forall i, j)(x_{ij} = 1 \vee x_{ij} = 0) \}$
M Matching	$\underline{M} = \underline{B}$ Note 2)
G Distribution to Group	$\underline{G} = \{ X \in L(m, n) \mid (\forall i, j)(x_{ij} \geqq 0) \wedge (\forall j)(\sum_{i=1}^{n} x_{ij} = 1 \vee \sum_{i=1}^{n} x_{ij} = 0) \}$
$\underline{E}^{(k)}$ Eigen	$\underline{E}^{(k)} = \{ X \in L(n) \mid (\forall i, j)((i = j \Rightarrow x_{ij} = k) \wedge (i \neq j \Rightarrow x_{ij} = 0)) \}$

Table 5-2 The definitions of Basic Class

Note 1): Here, m, n are fixed. And (X_{ij}) is the matrix expression of X.

Note 2): The operator as elements of **B** gives the correspondence between m elements of input variables and n elements of output variables. Type Symbol **M** (Matching) gives correspondence among variables by the corresponding rule among variable names. Therefore, **M**, the class of operator defined by type symbol **M**, is regarded the same light as **B**.

Proposition 1. For arbitrary n, following relation is concluded.

$$T(n) \subset A(n) \subset C(n) \subset L(n) \subset Op(n)$$

Hereinafter, please look Appendix about the proof.

Basic Class

On the preparation above, six type symbols **S**, **A**, **B**, **M**, **G** and **E** within the type symbols of structure matrix are defined as substances establishing subset of linear operator. Namely, six subclasses for $L(m, n)$ or $L(n)$, are defined (Actually five subsets). The subsets defined by these type symbols are expressed as **S**, **A**, **B**, **M**, **G**, **E** corresponding to each of type symbols and are to be called basic class. These definitions are described in the Table 5-2.

Then, the following relations are effective among basic classes.

Proposition 2 Followings are established for arbitrary m, n.

1. $\underline{A} \subset \underline{B}(=\underline{M}) \subset \underline{S} = L(m, n)$

2. $\underline{\mathbf{G}} \subset \underline{\mathbf{S}} = L\ (m, n)$

3. $\underline{\mathbf{E}}^{(1)} \subset \underline{\mathbf{B}} \subset \underline{\mathbf{S}} = L\ (n)$

Each of them is obvious.

The effectiveness of this proposition is obvious, because of definition of basic class. Accordingly, following corollary is effective.

Corollary Transforming functions provided by type symbols: **S**, **A**, **B**, **M**, **G**, **E** are identical with the function provided only by **S**.

That is, only **S** is sufficient noticing only the side of function to transform vector. Therefore, functions of five type symbols: **A**, **B**, **M**, **G**, **E** except **S** are to provide Visibility and Transparency to users.

Meta operator	Definition
$\underline{\mathbf{Q}}$ Quota	$\underline{\mathbf{Q}} : T(n) \rightarrow Op(n)$ For $T \in T(n)$, $\underline{\mathbf{Q}}(T)(x_1, \ldots, x_n) = (y_1, \ldots, y_n)$, $y_i = \begin{cases} x_i & \text{if } i \in ROOT(T) \\ \dfrac{x_i}{\sum_{k \in B} x_k} y_j & o.w. \end{cases}$ Here, $ROOT(T)$ is a set of node.
$\underline{\mathbf{R}}$ Reciprocal	$\underline{\mathbf{R}} : L(m, n) \rightarrow L(m, n)$, For $(x_{ij}) \in L(m, n)$, $\underline{\mathbf{R}}(x_{ij}) = (y_{ij})$, $y_{ij} = \begin{cases} 1/x_{ij} & \text{if } x_{ij} \neq 0 \\ 0 & o.w. \end{cases}$
$\underline{\mathbf{T}}$ Transpose	$\underline{\mathbf{T}} : L(m, n) \rightarrow L(n, m)$, For $X \in L(m, n)$, $\underline{\mathbf{T}}(X) = X^t$ X^t means transposed matrix of X.
$\underline{\mathbf{V}}$ Volute	$\underline{\mathbf{V}} : A(n) \rightarrow L(n)$, For $X \in A(n)$, $\underline{\mathbf{V}}(X) = \sum_{n=0}^{\infty} X^n$
$\underline{@}$ Linear Loop	$\underline{@} : C(n) \rightarrow L(n)$, For $X \in C(n)$, $\underline{@}(X) = \sum_{n=0}^{\infty} X^n$, if $\sum_{n=0}^{\infty} X^n$ converges

Table 5-3 Definition of Meta operator

Meta operator

Here, the definition as meta operators will be given for the five type symbols: *Q, R, T, V, @* among the type symbols of structure matrix. Meta operators defined by these type symbols are expressed as **Q**, **R**, **T**, **V**, **@** corresponding the type symbols, and definitions for these are shown in Table 5-3.

About the meta operators defined in the above, followings are concluded.

Proposition 3

1. In general, **Q**(T) is not a linear operator. That is, there is $T \in T(n)$, which is turned **Q**$(T) \notin L(n)$.
2. For arbitrary m, n, **R** : $L(m, n) \rightarrow L(m, n)$ is *bijective*.
3. For arbitrary m, n, **T** : $L(m, n) \rightarrow L(n, m)$ is *bijective*.
4. There exists $X \in A(n)$, to be **V** $(X) \notin A(n)$.
5. There exists $X \in C(n)$, to be **@** $(X) \notin C(n)$

In Figure 5-14, the relation of the result given by Proposition 1 and Proposition 3 is described.

Regard the meta operators as generators which generate new operators from given ones. And identify the operators the same as counter type symbols. The facts shown by the above propositions are that functions as quantifier of generating type symbols: **Q**, **V**, **@**, are different from the functions of **R**, **T**.

Q as an operator generates a non-linear operator for given tree. So **Q** has a specialized function which other type symbols don't have.

Also, **V** doesn't generally keep characteristics which given operator might have. So to speak, it doesn't have characteristics to express a-cyclic directed graph.

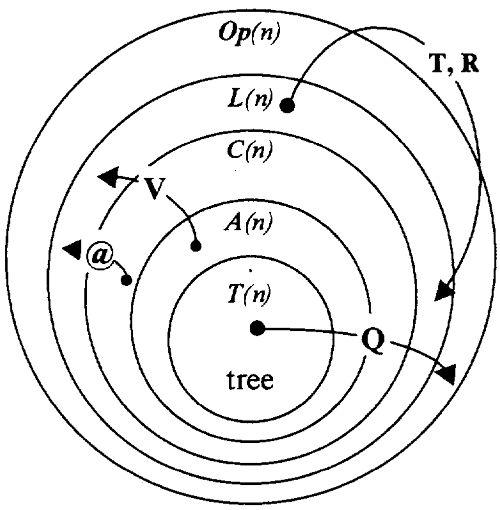


Figure 5-14 Map showing the relation between Preposition 1 And Preposition 3

@ generates new operators having the characteristics that sum of the matrix series converges. (In application, only the phenomenon that converges are treated.)

As shown above, three type symbols: **Q**, **V**, **@**, generate new operators that are not existed in their own defined domain. Different from these characteristics, **T** and **R** have not such functions of generating operator as mentioned characteristics, and give different matrix expression for aimed operator. Similarly with the case of basic class, functions of type symbol **T** and **R** can be said to provide *Visibility and Transparency* to users..

6. Business Structures Modeling on Structure Matrix

—— for building various value chains ——

Considering the Business Structure Model (Abbreviation: BSM will be used from now on in this chapter.), a substantial line of technologies, which covers whole business activities associated with computer usage, must be established. Thinking examples in profit planning where whole function of firms is covered, there are some dominant directions of job flows intensively linked with consolidated statements. We can watch that profit and losses of business activities are evaluated along these directions related with the causal logic expressed by numerical values. A typical case may have a flow starting from marketing or R&D through production to consolidated financial statements.

Note:

BSM is not necessarily a virtual existence. Accounting systems based on GAAP (Generally Accepted Accounting Principle) and cost accounting systems as institutional accounting systems are accepted as really existing mechanism in concrete business systems. So in some companies, use of the word "*Simulation*" is strictly forbidden to use for those systems.

People engaged in these systems insist that the cost systems and accounting systems followed by these are substantial systems really existed. However, they are afraid if those systems are thought to be virtual existence. In Japan some of these people suggest that the future part of these models adjoining current concrete models should have another word: *Feed-Forward Management* which shows reality for near future management, strictly discriminating common concept of simulation being approached by computing world.

Our purpose in this chapter is to introduce our organizing way to provide consistent methods for BSM. One of the main purposes is to show how our BSM methodologies developed on structure matrix and how powerful its extensions are for BSM. Another highlight is *T-H Theory* (Toyama and Higashihara Theory) is established on the way of our research by overlooking wide ranges of BSM relating non-monetary and monetary causal factors expressed on structure matrix.

This chapter introduces typical BSM by sketching concrete profit planning system first. Then principle of bilinear relation and its development on structure matrix with our architectural development for BSM will be discussed. Following the discussion, consistent BSM methods developed for the process plant, where materials are transferred through the processes, are discussed. In the last model, integration of production models and various types of variable cost models around cost centers will be discussed. After some experiences in Japan, succeeding the early progress in Germany, we changed the architecture of structure matrix about calculating direction from plural directions to single direction reserving bilinear relation. The aims are to provide transparency of model mechanism to users for easier handling and to respond with wider requirement to absorb non-linear relations.

With the new architecture and experiences, we applied this modeling method to wider management phenomena. As a matter of course, we found the bilinear relation can be applied in many phenomena where we are not conscious of linearity like the theme adopted in the later sub-chapters.

Through reexamining the models of above mentioned unconscious phenomena, Toyama and Higashihara found that the modeling method extended from bilinear relations can be applied generally for management phenomena in which non-monetary and monetary elements are mixed-up. A sub-chapter "T-H Theory is arranged as important theory dominating in the BSM" and the following sub-chapters show developed cases for assembly business model, common cost assigning models and shared service models.

The last part of this chapter introduces some models that are not necessarily linked with T-H Theory. These are about financial or accounting models in which causal relations are developed within monetary dimension.

In addition, established BSM method for assigning a burdening value from top to each level along with their hierarchical organization using various relevant yardsticks is introduced in a sub-chapter. This method can not be categorized in the coverage of T-H theory because of processing of non-linear relations.

Thinking above background with historical developments, themes in this chapter are arranged by the following sequence.

- The existence of relations among non-monetary and monetary factors in business structures modeling.
- Introduction of bilinear relation.
- Extension of structure matrix for convenient modeling of bilinear relations.
- Production planning and cost models in process plant where materials are transferred through facilities, with the outlook of cost types for the preparation of BSM.
- T-H Theory as consistent concept in the business structures modeling.
- Production planning and cost models about assembly business.
- Common cost assigning models of traditional way and ABC way with activity based cost estimation model.
- Modeling for *Shared Services* versus main line activities, with examples of design engineers center and head office staff in bank.
- Financial Models in which monetary dimensions are mainly used. With some preparation, an example of model: "consolidated statement" will be introduced
- Relevant assigning of a cost to hierarchical organization.

6-1. Requirements for Relating Non-monetary and Monetary World

Look the typical implemented cases of profit planning model in companies: S and K that cover whole the business activities. Consistent directional flow beginning at their marketing planning and terminating at the financial statements like B/S and P/L is shown in Figure 6-1 and 6-2. [Nakamura, S.,1984], [Kanie, S, et al,1991],[Fusimi, T., 1992][Asada, Tahawa, 1991] Most of the cases except some financial business, substantial activities at the forefront are driven by non-monetary factors and the business performances is mainly evaluated by financial values expressed in their statements. Even in the local organization, both non-monetary and monetary factors are organized in their local models.

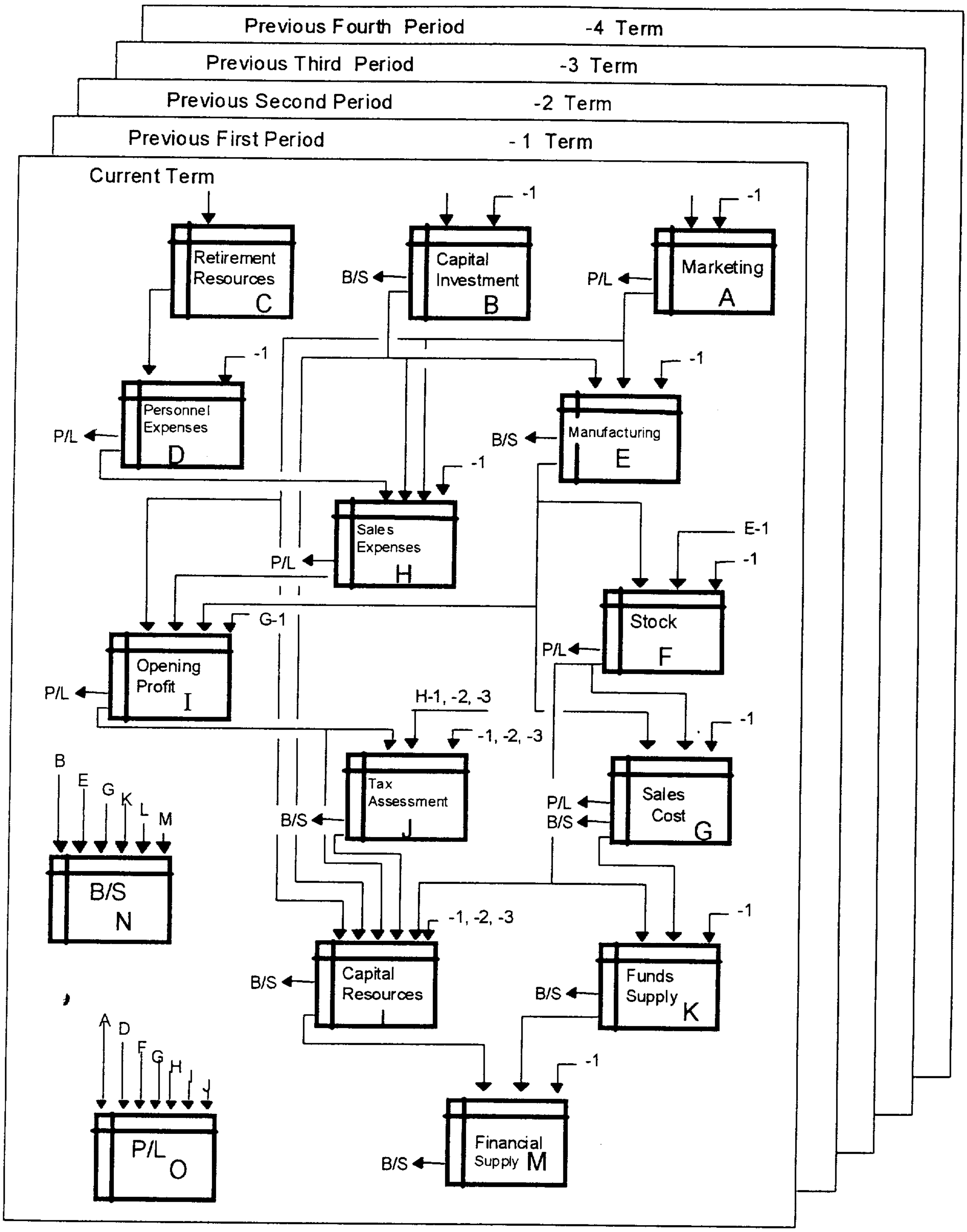


Figure 6-1 A Typical Consolidated Model of Short Term Profit Planning

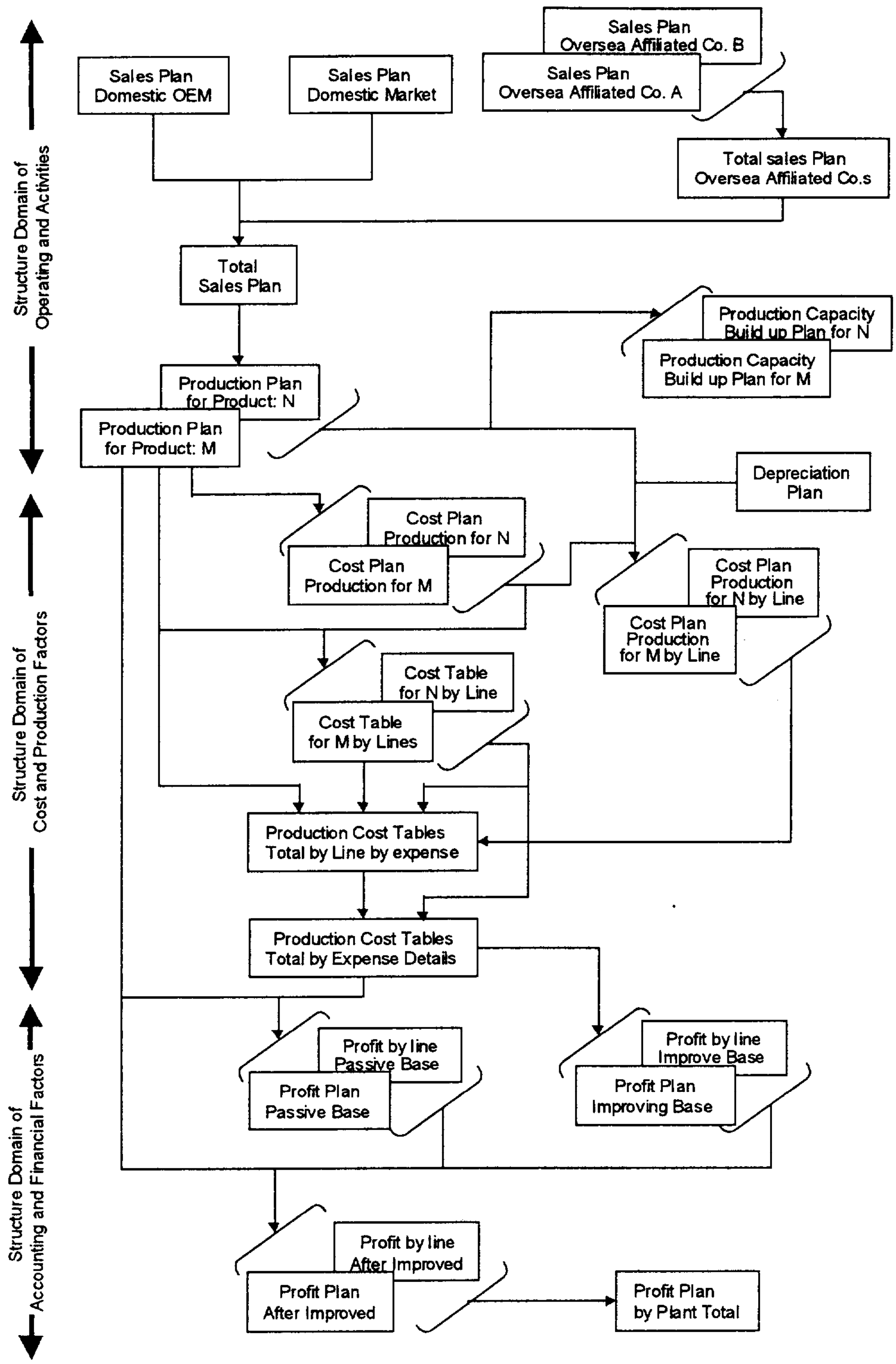


Figure 6-2 Outline of Profit Planning Model of an Auto Parts Maker

6-2. Modeling with Non-monetary and Monetary Factors

One of the long-cherished ideas is how tightly and how compactly we can link non-monetary activities in production world and monetary evaluated values, which are linked financial world without losing the reality in the complex world. Traditionally these two worlds are treated independently by two groups with different specialties. There had been delays in timing between production planning and cost planing, then sometimes cost planning system loses chances to reflect its results to the production planning by forming feed back loops. Since it was difficult to process diversified kinds of products one by one, it was commonly used traditional arbitrary interpretations to treat them by adapting averaged values or by giving simple equivalent coefficients by the people in charge of costing. Especially, this contradiction appeared as problems of processing cost, prompted by the technological advance in steel plants in Germany. The variance of processing costs by individual kinds of products became fairy larger than that of material costs. Enlarging requirements for making more realistic cost models with various production factors, promoted wider study among businesses and academic society. By the great efforts, new cost theory was established based on the structure matrix.

As my understanding, the nucleus of the idea was developed by combining the following three points.

- Bilinear relation: the gross consumption in production activities given by the mathematical multiplication (Inner product) between elemental level of consumption and each unit cost.
- Idea of Input Output Matrix proposed by W. Leontief.
- Description upon structure matrix that was proposed by Otto Pichler, who was a chemical engineer of E. G. Farben, Germany in the later part of age of thirties (1930).

Note: The oldest document currently traceable is his paper in the reference. [Pichler, O., 1953],[Pichler, O., 1953]

Bilinear relation and extension for modeling, for which we could find only title of the word and are unable to find logical foundation in German documents, is reviewed as a start of discussions in this sub-chapter.

Then, we can follow the relation between block diagram of production factors and models on structure matrix. Modeling of material flow and material cost, then modeling of processing consumption and processing cost, are to be described. Finally, organized models from the point of processing facilities are to be shown.

Through these discussions, our efforts to organize the models, *Express production factors, unit costs and total cost into one domain*, will be shown. The shifting from these independent paradigms into one domain seemed usual, but it took us three years to skip the walls.

The major purpose of this chapter is to provide the information how practically non-monetary paradigm and monetary paradigms could be integrated into one paradigm by using an example of process plant, preceding the generalized T-H Theory in the next sub-chapter.

6-2-1. Bilinear Relation of Consumption Factors and Unit Cost

Bilinear relation

Generally, the bilinear form given by linear space: "K^n composed of n elements of vectors", can be expressed as following equation for sets of n variables: $X=(\zeta_1,\ldots,\zeta_n)$ and $Y=(\eta_1,\ldots,\eta_n)$

$$f(X,Y)=\sum_{i,j=1}^{n} a_{ij}\zeta_i\eta_j$$

(Reffered from Rikagaku-Jiten, V5.Iwanami, pp767)

Here, consider X as material unit cost, Y as material consumption, f as total cost and think, $a_{ij}=1$, for simplification

In a simple example of automobile's material cost with concrete data, bilinear relation among Total cost, each material unit cost and each material consumption can be expressed as follows.

Total Cost f (10kyen); Material Unit Cost X (10 kyen); Material Consumption Y (ton)

$$[\,2{,}744\,] = [\,40, 100, 150\,] \times \begin{pmatrix} 1.1 \\ 19.5 \\ 5.0 \end{pmatrix}$$

Materials: Cast Iron, Steel, Special Steel. Materials: Cast Iron, Steel, Special Steel.

At this phase, lets try to trace this calculation back to each material consumption and production by each kind of automobiles. Then, upper calculation will be replaced as the equation in Figure 6-3, in which matrix data is given by material consumption by automobile, and is caught between vectors.

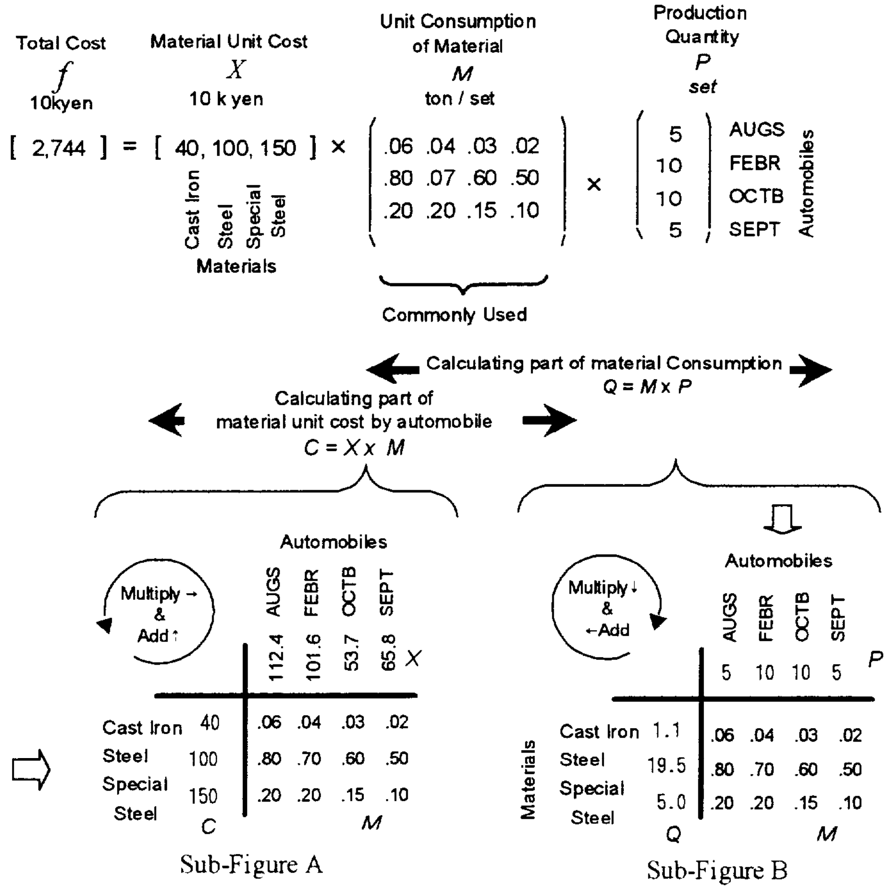


Figure 6-3 An extension of the bilinear relation

This bilinear expression can be dissolved into two equations in which the matrix is used jointly and these relations can be rewritten into two expressions of structure matrix as in the lower sub-figures in Figure 6-3.

Case A: Horizontally Multiply and Vertically Add

The lower left (Sub-Figure A) is expressing the unit cost of materials by kinds of automobile with: "Multiply(→) & Add(↑)" relations for given unit cost of supplied row materials.

Case B: Vertically Multiply and Horizontally Add

The lower right (Sub-Figure B) is expressing the row material consumption by kind of materials with: "Multiply(↓) & (←)Add" relations for given production number of by each automobile.

Extension of the common matrix as result of combination of matrices product

We can understand the common matrix: *M* as the result of combined series of matrices' product and we can project causal relations on actual management phenomena, like production of plant facilities, to each of those matrices. These calculations can be extended and widely applied to the matrix calculation describing relation between multiple input and multiple output, where *associativity, distributivity* and *commutability* for addition, and *associativity* and *commutability* for multiplication stand up. (These samples will be fully introduced in the later part of these sub-chapters.) In the theoretical approach for cost model, those relations are extended to the expression of material cost, processing cost, common fixed cost with non-monetary factors.

6-2-2. Principle Model of Traditional Expression

The Figure 6-4 shows the pattern progressed in Germany, in which the common matrix: *M* in the above sub-figures is used as duplicate uses.

We, in Japan, adopted German style expression first in which same number of different areas were prepared in upper and left parts and these areas located in the different parts were coupled to form pairs. Each pair (We gave the explicit name: Strand.) was used occasionally for two different calculations of Case A and Case B.

Total cost by each raw material can be calculated by multiplying each responding elements of vector X and vector Q.

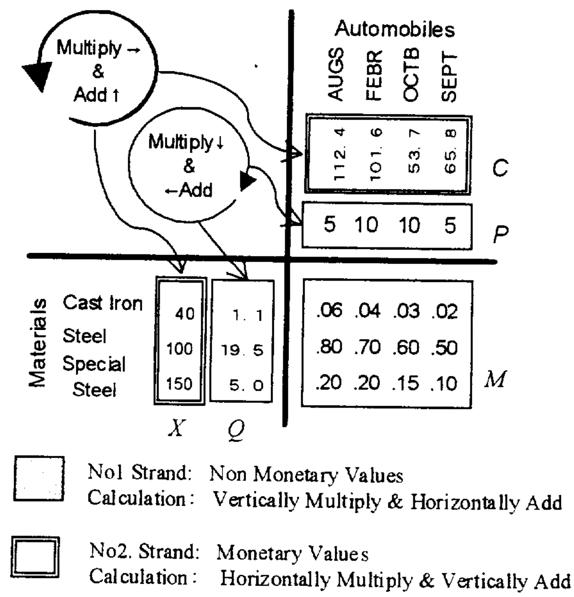


Figure 6-4 Duplicate use of Different Calculations

Also, total cost of each automobile can be calculated by multiplying each responding elements of vector P and vector C. These values are essential for planning and business management. Therefore, third strand for these calculations were to be required with different type of calculation. In addition, those strands must be prepared for the different type of cost behaviors like material cost and processing cost.

In our approaches in 1978~1980 in Japan, the model's processing was done by the following sequence.

- The macro table of structure models was made on the paper by handwriting.
- The calculating steps were read out from the written models rather by rote.
- Those steps were described by Matrix Language:: MATSYS (IBM package of S/360) then punched and compiled.[Theodor, B et al, 1975]
- After execution by batch system, result was printed and used for the evaluations.[Tamaki,T. 1983]

The provision of visibility projected on the pictures, which can arrange the complex relation among production and cost factors, had been epoch-making as initial success. However, as a nature of Decision Support System that requires swifter response, software packaging with interactive processing was required. To respond those requirements, the architecture of first package had a macro table with several strands.[Sugiura, H., 1989] And its micro table could be pointed and developed on the screen by clicking on the macro table.

We learned needs of effective architecture to built in the definite relation among following factors.

- Non-monetary values in work-site operations

  For example: those values expressed by non-monetary yardsticks like, products, materials and parts, supplemental materials, energy, water supplies, time consuming, man-hours etc.
- Unit cost expressed by monetary values

  For example: those values expressed by the unit of yardsticks like, unit cost by product tonnage, unit cost by material, unit cost of energy by KWH, wages by man-hour etc.
- Total cost

  Once above two are multiplied each other, these results are changed into values of financial domain like material costs or processing in a certain facility by products.

We gradually recognized problems obstructing our future development in this style of modeling as follows.

- Repulsion of beginner

  It was difficult to use multiple strands in differentiating the calculating directions between "Multiply (vertically) & Add (horizontally)" and "Multiply (horizontally) and Add (vertically)". This way of using went against the trend of times to learn the job from screen operations. Besides, the succeeding of jobs from the model developer or skilled end user was also difficult.
- Cause of misunderstanding

  There were people who judges prematurely "Multiply (horizontally) and Add (vertically)" as retroactive calculation of causal relations and it took much of explanation to explain principles. (Note: "Multiply (horizontally) and Add (vertically)" is for unit cost calculations and is not directly related with retroactive causal relations.
- Intertwined calculation among strands

  Examples of calculation are

  ① Quantities of non-monetary values

  ② Unit cost of materials

  ③ Variable Unit cost of variable processing

  ④ Total material cost

  ⑤ Variable processing cost

  ⑥ Fixed cost,

  ⑦ Variable cost as "② +③"

  ⑧ Total cost as "④ + ⑤ + ⑥".

In addition, there are calculation of difference between the plan and actual or difference between plans. There happened complex intertwines of these combinations, and these handling were troublesome.

- Obstruction toward chaining of structure matrix

  In chaining of multiple single structure matrices with multiple strands, intertwined combinations of strands were required and straightforward modeling couldn't be expected.

- Restricted modeling expression

  In modeling as management phenomena, not only linear model, but non-linear model or condition processing must be covered and common use of center block became obstacles for our challenge to more complex phenomena.

- Small screen area

To locate areas for several strands were not allowed from the point of displaying performance those days. Eighty characters' display was in all its glory those days, but was fatal for our application. This was the largest reason. Still now even current Window system is essentially far from solution of this problem. The initial tries (MATPLAN© and MATPLAN-2©) of displaying single strand by switching them were in vain, because of user's complain to involve opaque handling in display operation and problems of maintaining qualities derived from the complexity of the programs.

<u>The solution by deformed expression of structure matrix</u>

There are some misunderstandings that German way of structure matrix is not inherited or German way is quite different from ours. This section is prepared to avoid these misunderstandings and to get relevant evaluation as more sophisticated expression toward future development.

Our first target is focussed on the modeling production factors and cost structures.

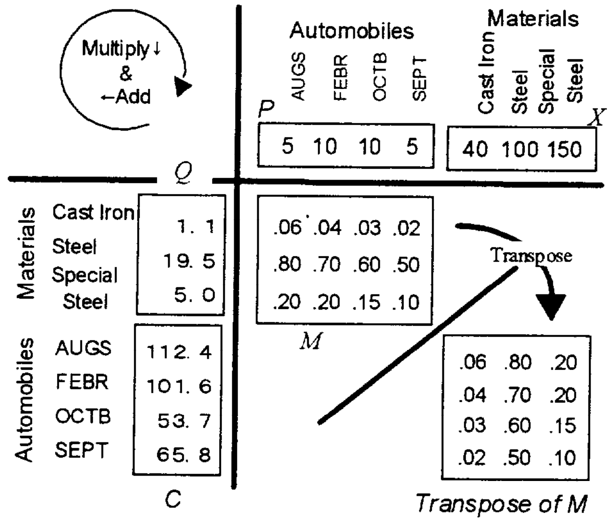


Figure 6-5 Consolidated Expression
(Vertically) Multiply & (horizontally) Add

In addition, the essential idea about the architecture of structure matrix was changed as shown in the followings and Figure 6-5.

- Only one strand is to be existed. Accordingly, the word, "Strand", is no more necessary.
- By adding a new type symbol: **T** , the function to transpose matrix in the center part as a block can be provided as a reusable block in other part of the center part.

  By this method, change in original matrix is reflected to other matrix transposed. The reason is that transposed matrix borrows the original matrix with transposing before actual calculation.

By an architectural improvement, the model structures in different domains became possible to be built in a unified domain only using the calculation: "Multiply (Vertically) & Add (Horizontally)".

The followings were the merits given by these simplifications.

- Easy expression to understand the relation between calculation and data.
- Simplification of chaining structure and easy operations.
- Accommodation of non-linear calculations partially.

The unification of calculation direction brought the chance to provide

- Non-linear calculation between the block in upper part and the blocks in center part.
- Inter blocks' operation between the blocks in upper part.
  (Multiple blocks necessary for calculation are to be specified in the block in center part.)
- More common expression of models which have non-linear relation.

By this improvement, integrated modeling of value chains covering non-monetary values, unit cost and total cost can be expressed in one domain.

Also realizing of a model, both to keep linear image entirely and to cover complex models partially mean the expansion of modeling span with easier approach for end users.

As a demerit of this architecture, model size in macro table becomes large as the times of common use of center part increases. But this inconvenience was almost overcome by adopting condensed macro table. (Refer Figure 5-13 in the Chapter 5:Type symbol).

6-2-3. Outlook of Cost Type

By the previous arrangement, foundations to build application models which links non-monetary values and monetary values are prepared. Before entering concrete modeling method, we should out look the cost structures by using a simple process example of steel plant in which two typical facilities: rod mill and wire mill are linked. Outlook of these structures is shown in Figure 6-6.

As shown in the top, production flow starts from billets (lump of row materials), which goes through Rod Mill facility, and becomes in process product: Rods, then goes through wire mill facility and becomes as wire products. This sample model process assumes production of product-mix, in-process product-mix and supply of material-mix, production planning and variable cost planning simultaneously. As in the figure, the cost in material process plant like steel industries, is typically categorized as material cost, processing cost and fixed cost. These categories reflect the behaviors of each cost structure.

- Material unit cost

  Most material cost is calculated along the production flow using the reciprocal value of yield. The calculating flow is the inverse direction to the material flow.

  Note: 1) Production of scrap or defect materials is neglected (These unit prices are zero.) for simple thinking. These models will be shown later.

  2) Note 1) being considered, summations of total material cost in such material process plant are kept the same value in all steps of direct process flow.

  3) Model of assembly type production will be discussed later.

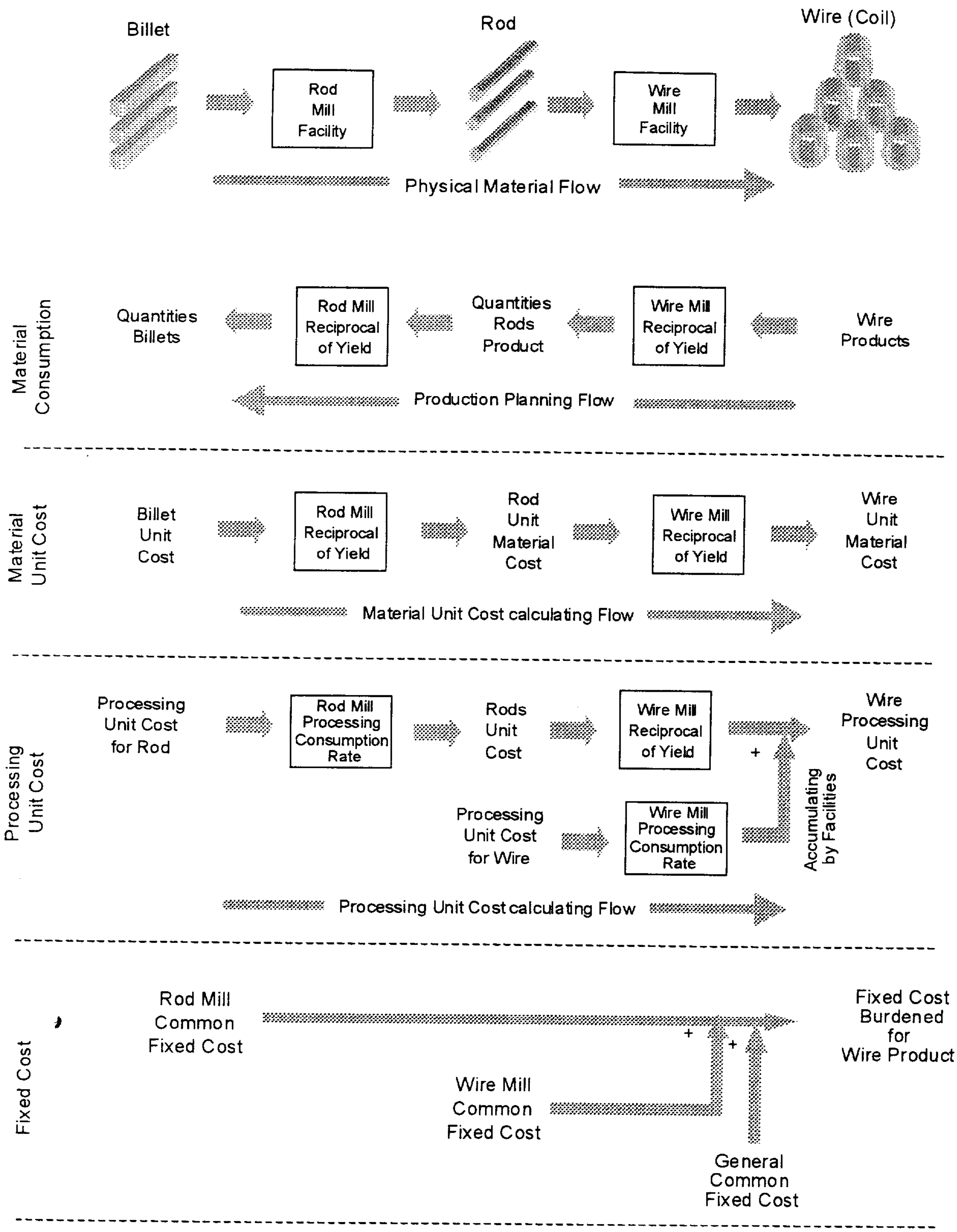


Figure 6-6 Major Types of Cost Transferring Facilities

- Processing unit cost

Processing unit cost has a nature to be accumulative along the proceeding of processing facilities, because the casting of processing consumption in each production facilities like cast energy, used tools, auxiliary materials, working load, used machine hours, etc., are independent and accumulated along the line.

For calculating the amount of those consumption, there is also calculating procedure along the inverse direction from the final product. However, because of complication, this process was abbreviated. You will find these relation afterward in detail.

- Fixed cost

Recently, driven by the prominent increase of fixed cost, there are efforts to look the pointless fixed cost and to assign it according the most relevant activities. The famous method is Activity Based Costing (ABC). In actual modeling, various types of relevant assigning, not limited in ABC, are required. These modeling methods will be discussed in the independent sub-chapter.

Within above major three cost types, previous two (proportional cost) varies proportional to the production factors and are discussed in this sub-chapter: 6-2.

6-2-4. Combing Material Requirements and Material Cost Models

The discussion here proceeds, assuming the following simple sample about materials behavior.

- Two facilities: Billets to Rods through Rod Mill facility, then Rods to Wires through Wire Mill facility, are linked forming a line as in (a) Flow of Material with scrap and below standard products of Figure 6-7.
- Multiple kinds of products and defects of product like scraps and below standard are handled.
- The model should be combined with production planning and cost planning about proportional cost.
- The yield values as matrix, are given as reciprocal of Input./Output ratio: (IOR) , so these are larger than 1. The ratio values of produced scrap and below standard defects to the output product of facilities, as matrix, are given by the reciprocal of Input./Output ratio: (IOR) - 1.

Each part of the block diagram in Figure 6-7, is developed as follows, reflecting the material flow (a).

- (b) Material Requirements
  - The diagram of material requirements is developed inversely according the finished products to the starting materials.

    Standard products) by each facility are modeled by using *Multiply & Add* calculations.
- (c) Unit Material Cost Calculating along Material Flow

  Unit material costs are calculated along the material flow. This diagram is the projection of material requirement diagram, except the facts that directions of causal relation are inverse to the diagram of material requirements: (b) and matrices are transposed.

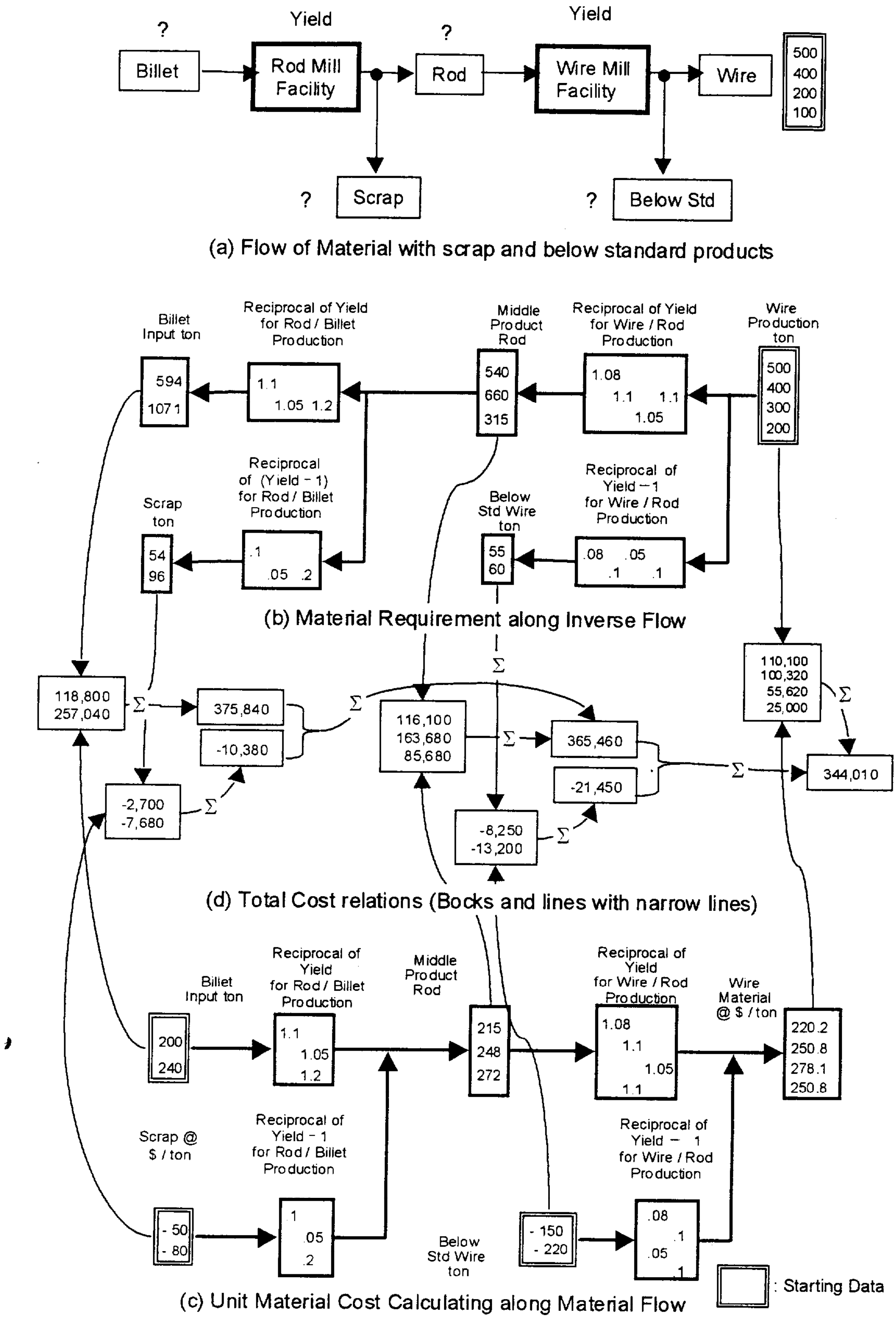
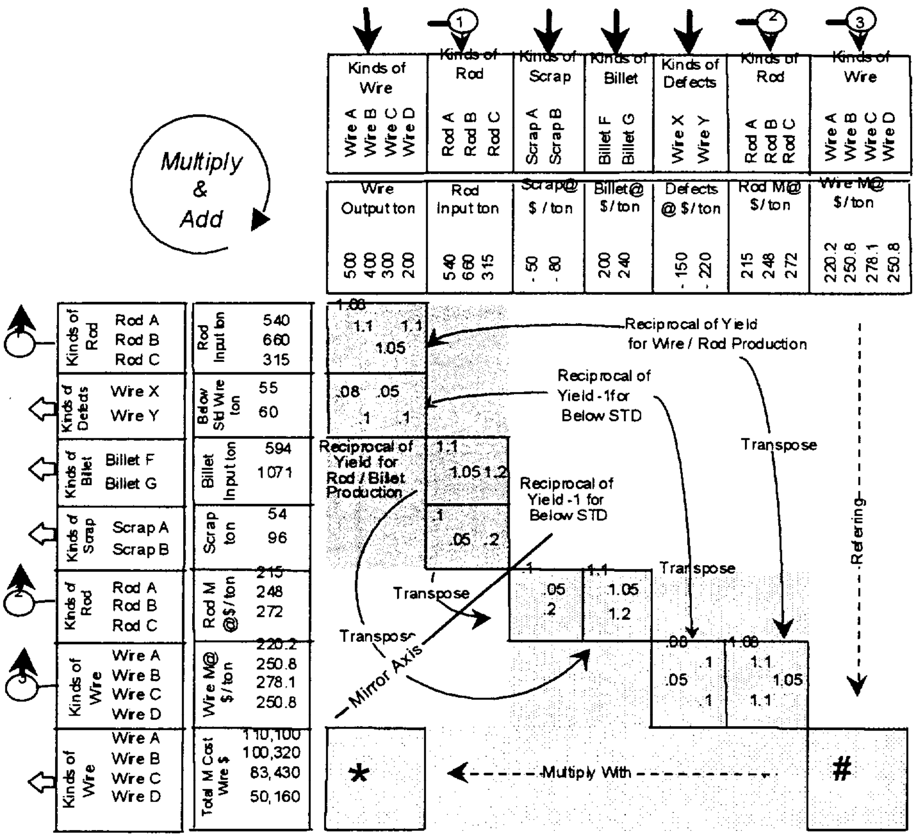


Figure 6-7 Material requirement and Material Cost Model

- (d) Total Cost relations

Total cost as multiplication of materials and unit costs are shown in dotted lines. (d) shows all the relation of total costs. In actual case, not all of them are required or some of them are adhocery required.



(b) Material Requirement along Inverse Flow

(c) Unit Material Cost Calculating along Material Flow

(d) Total Cost relations (Bocks and lines with narrow lines)

Figure 6-8 Material Requirement and Cost Model on Extended Structure Matrix

The combined model transformed from these diagrams in Figure 6-7, is shown on one domain as in Figure 6-8, that is our established style of structure matrix. Three areas of models are established as follows.

- Material requirement model (b)

Corresponding to the flow diagram that starts from the requirements of output by each product, up stream the chain of facilities and reaches material input, the model on the structure matrix was made starting from upper blocks and using *Multiply & Add* calculations, one by one. In the block diagram, material flow with produced waste is considered. Quantities of produced wastes (Scraps and Below Standard Products) by each facility are modeled by using *Multiply & Add* calculations

- Unit material cost model (c)

Relation between production factors and material cost forms symmetric relation concerning the mirror axis extended from the bilinear relation (By the principle of transposing of matrix) as in the figure.

(From the characteristics of matrix in macro table, replacing of column/row with other column/row gives the same calculating result. So, models should finally be made easy to understand and handle.)

This means that if we can design the non-monetary area about material production, we can develop monetary area: unit cost area without beating our brain in the proportional cost area, almost automatically.

- Total cost relations (d)

  There are many way of calculating factors items as shown in narrow lines of (d) in the Figure 6-8 and only one case of total costs of final products is shown in Figure 6-8. We can built in those factors according user needs. The reason to built in the model is that the total product cost, in general, would be indispensable in those modeling.

Remarkable fact by this modeling is that no programming is required for these calculations. Only efforts of understanding the mechanism of material flow and material cost structure is required. In addition, as you may understand from these examples, analysis of the factors and cost mechanism and expression of them by making block diagram can be fortunately skipped.

6-2-5. Combing Processing Consumption and Processing Cost Models

In the previous sub-sub-chapter, structural relations corresponding between material flow and unit material cost are discussed, which were induced from bilinear relation between quantities and unit material cost. The same correspondence exists between processing consumption and unit processing cost. The processing consumption, here, mean consuming quantities in process activities such as energy, water, working hours, machine hours, auxiliary materials and tools, debt servicing, etc., excluding raw or input materials. In addition, these processing consumption are thought to be proportional to production factors and sometimes treated with capping word: variable like variable processing cost as contrasted with the fixed cost.

Though the existence of the similarity between consumption and unit cost, there are clear difference in processing consumption and unit processing cost. The differences are as follows.

- The processing cost increases cumulatively by the member of facilities included according to the production flow.
- In transferring the facility to next facility, the processing costs must be multiplied by the reciprocal of the yield.

Those relations are modeled in Figure 6-9, being composed of following four areas.

Area I Processing consumption area

Area II Processing cost area

Area III Processing cost area for integrating

Area IV Total cost area

The first two areas use the process standard values (or transposed). They are the relation of transposing as forming symmetric respect to the mirror axis. In the third area, reciprocals of the yield of rod/wire are multiplied for the processing costs of the rod facility, then the processing costs for wire processing are accumulated. The fourth area is prepared for the total costs and variations can be provided according the management needs.

By this consolidating technology, the processing cost can be calculated independently by each facility and accumulated along the material flow without involving the unrelated factors of downward process. By the traditional method, once all the consumption values are piled up, then converted to unit cost and distributed to each facility. Because of difficulties in expressing the cost structure, especially the processing cost, following on-the-spot solutions are tend to be adopted.

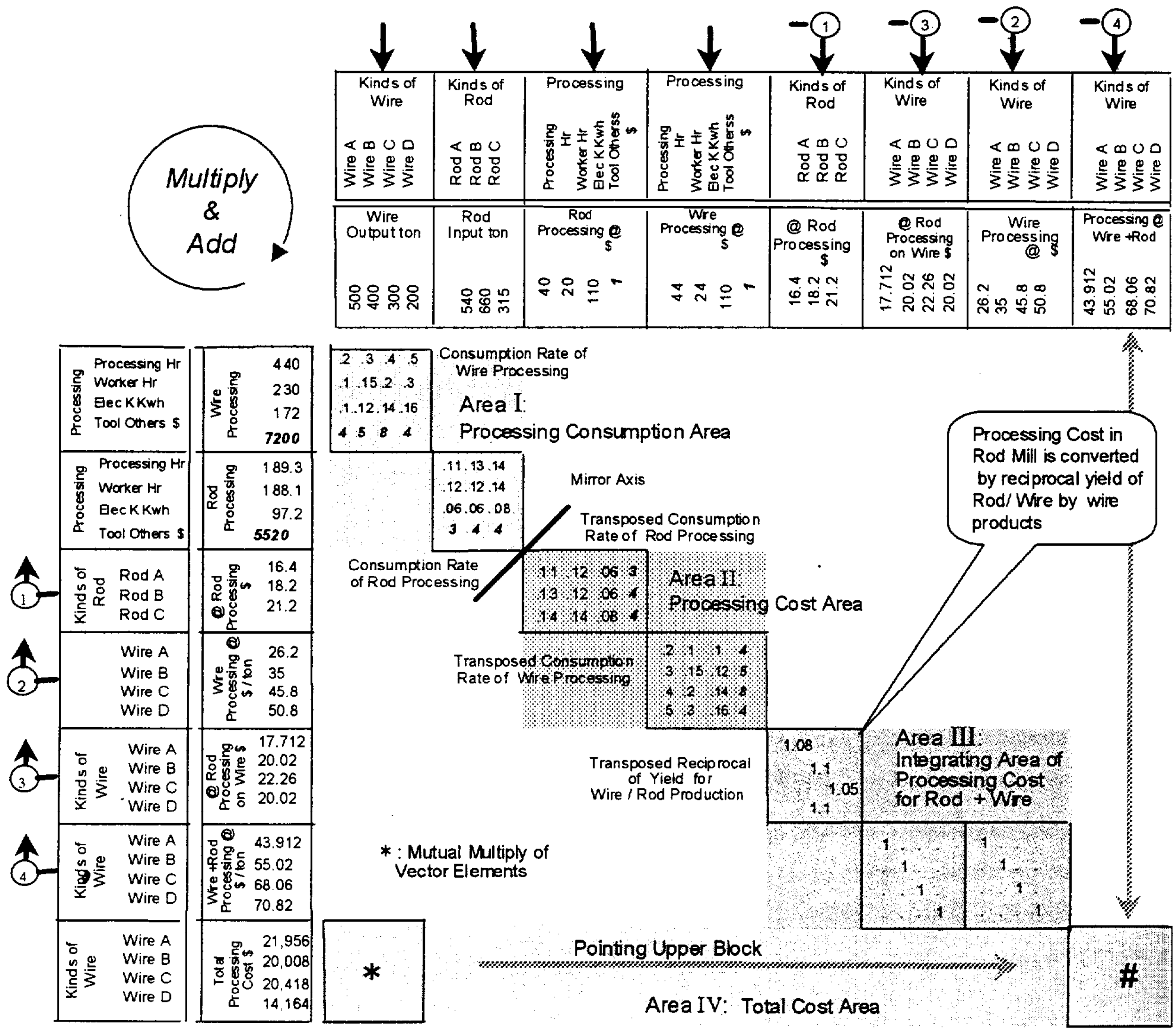


Figure 6-9 Combined Model of Processing Consumption and Processing Cost

The processing costs that should be treated as proportional cost for production factors, are easily pushed to add up to the fixed costs.

- ·So called equivalent coefficients are set arbitrary and the process consumption is distributed depending on the groundless or biased basis.

On the ages to attach greater importance to the processing cost rather than material cost driven by the progress of process engineering and diversification of needs, calculation of uncontrollable cost become meaning less. The method to provide more accurate processing cost linking complex production factors based on transparent structure are highly evaluated by users. [Tamaki, 1983][Suguura, 1989]

As essential describing method of model that combines causal relations among non-monetary and monetary values, consumption of process elements should be counted by non-monetary units as energy, supplemental materials and consumption of tools. However, some elements are too complicated to grasp by non-moneyed yardsticks with resolving efforts. Quantities of maintenance and repair activities and some kinds of tool's consumption meet these elements. To keep entire conformity in this integrated modeling, it is applied as one of the practical solution to these elements, that monetary values with unit cost of value 1 are mixed within the non-monetary values. In Figure 6-9, the part of italic characters shows such modeling method.

6-2-6 Integrated Model Arranged for Cost Centers

We had been discussing material production independent from the values of material transition and from the values added by processing, namely material cost and processing cost. Surely these are tightly combined. However, only simple summation of these models in a single domain is not so valuable. Some arranged integration in these modeling along the practical control span in production management, is necessary.

The model shown in Figure 6-10 is an integrated model of Figure 6-8 and Figure 6-9, arranged around rod making (Area I) and wire making (Area II) with accumulation of processing cost (Area III). In this figure, Total cost was abbreviated because of size limitation.

As pre-mentioned, even by exchange between rows or exchange between columns, linear model keeps the same calculating results. Therefore, we have the freedom how to divide and arrange the sub-model areas by our bundling idea according to the exchange rules. There would be various discussions among the bundling of control spans. The traditional idea may select facilities from the point of control spans in which cost responsibility would be burdened. A unit of continued processing plant as established object is often selected according to the understandings of production people. The important matter is that by our proposed architecture of structure matrix we can bundle the model areas as patterned images according to the modelers' requirements.

In the business structure modeling, establishment of models with standardized pattern is a key to success. Some such cases would be introduced in the next chapter.

The established modeling technology that covers non-monetary and monetary values brought following merits.

- It is not necessary for involving the arbitrary setting by equivalent factors that the commonly grasped costs are allocated to the indirectly influenced facilities and activities.
- It is possible to get variable processing unit cost for required elements by each stage of cast values.

  This brought scientific methodology of calculating transferring unit cost in each stage of process flow, because these costs are important not only for the estimation of cost as in-process product, but also for the flow with diverging process.

These two brought views to make *Cost Plan* and *Cost Variances* with high consistency.

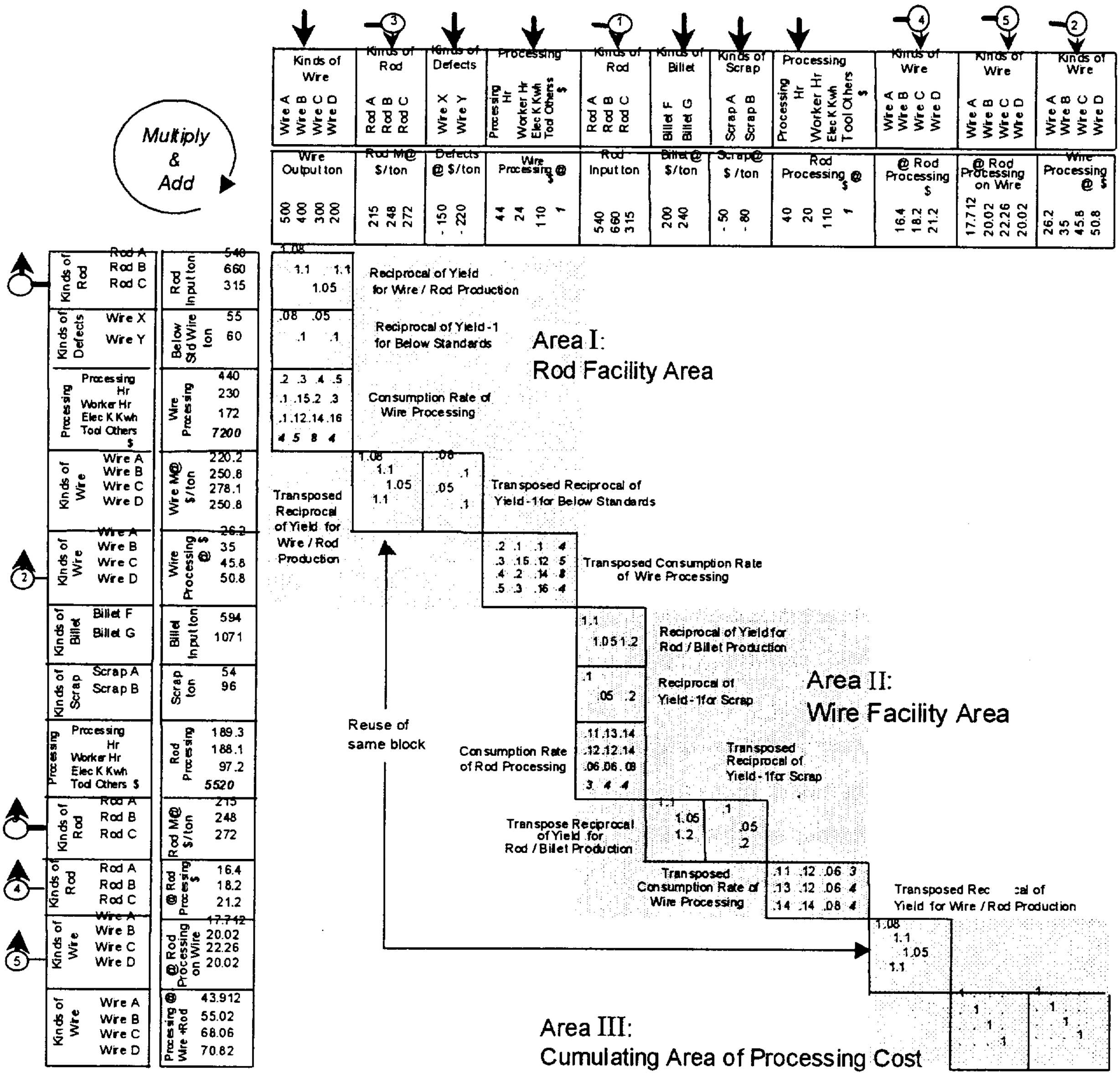


Figure 6-10　A Consolidated Cost Center Model by Facility

- By dynamically changing the model, model about various kinds of total cost can be built.
- The build-up models are expanded as chaining structure for further large models.
- Using the condense function given for fully utilizing the linear structure, the influence between two factors including production factors and cost factors can be grasped by manual operation.

  Note: Please refers 3-2-7 Advanced function, Aggregating Function on Structure Matrix.[IBM Deutch..., 1977]
- By this method with this new architecture, the production planning and cost planning can be unified.

Before this method, synchronization of production planning and cost planning are thought to be unrealizable, because large number of factors suggested enormous programming steps and endless maintenance efforts. With this unification, near future planning on the extension of monthly situation (calculation of monthly statements) is possible as a plant operating plan now. In some accounts, "*Feed-forward Management*" was named for the realization. These models are linked with marketing models, consolidate statements or energy models that may cover whole business plans and operated as collaborated planning. With the results of these models, we could demonstrate the fact: When computer models can reflect the management mechanisms with *Visibility with Transparency*, they become common property of business.

Note: We took three years to decide the switching of the architecture of structure matrix from original method developed in Germany.[Lassmann, G., 1968], [Wartmann,R.,1976],[Franke, R., 1975],[Franke, R.,1975], [Franke, R.,1976][Betriblichwirt., 1977] The effect was large enough thinking of many tradeoffs. We would like to express that the expressions of models in this sub-chapter are essentially based on the fruit of German development, experiences with Japanese customers and research with Administration School, Kobe University.

6-3. T-H Theory and T-H Modeling

In this chapter, we will introduce our efforts for providing theoretical background and standardized approaches in BSM. By reviewing the experiences rearrangement was executed, jointed with Takayuki Toyama and Isao Higashihara, and fruited as T-H Theory and T-H Modeling. The latter is the methodology for BSM on concrete model vehicles provided as structure matrix package. As a matter of course, the non-monetary and monetary relations in BSM are covered in the previous sub-chapter as general method. Also in next sub-chapters assembly business are covered. New findings prompted by T-H Theory are shown in the continued sub-chapters where extended ABC model for estimation of planned cost and two models about shared services will be introduced. In this chapter, explanation is prepared briefly because some details have already been introduced in the previous sun-chapter.

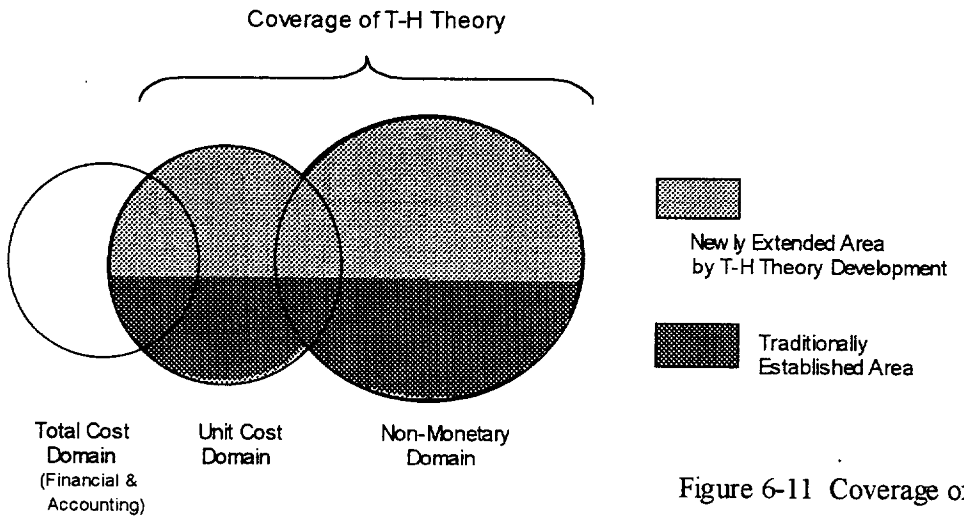
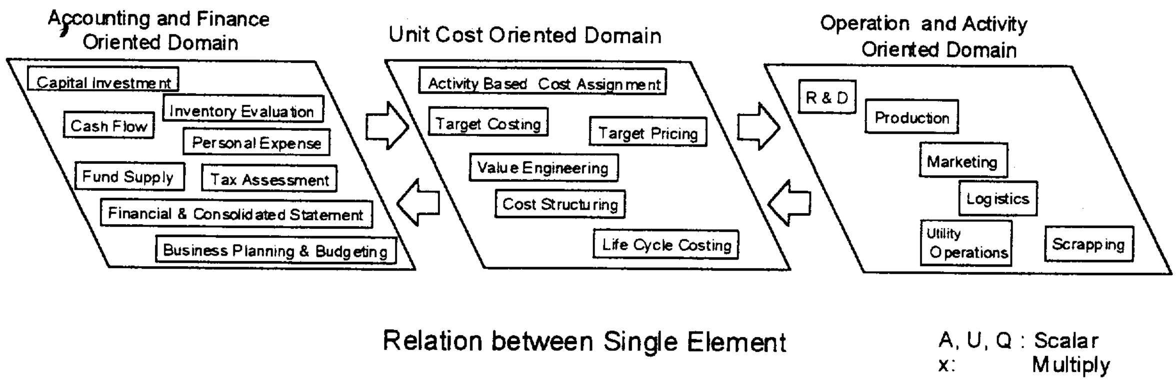


Figure 6-11 Coverage of T-H Theory

T-H Theory Step 1 A Point of Departure

A fundamental relation of elements in three domains is linked by the simple equation: (A) as in Figure 6-12.



Relation between Single Element

A, U, Q : Scalar
x: Multiply

$$A = U \times Q \quad \ldots (A)$$

A: Amount of Money, U: Unit Cost, Q: Quantity

Figure 6-12 The Relation linking Three Domains

Variation of this equation can be found in every field of businesses. One of such simple examples is as follows.

Profit = Sold Price * Sold Quantity - Unit Cost * Produced Quantity

Our idea is

"If the equation (A) is effective in the non-monetary monetary phenomena, BSM can be developed."

We should develop our idea toward more complex expressions.

T-H Theory **Step 2** Expansion to Multiple Elements

Former equation: (A) can be expanded to the vector equation: (B) by applying *bilinear relation* with inner product.

Scalar — Flat Vector — Vertical vector

$$\underbrace{U_1 \cdot Q_1 + U_2 \cdot Q_2 + ,,, + U_n \cdot Q_n}_{\text{Amount of Money}} = \underbrace{\begin{bmatrix} U_1, U_2, \cdots U_n \end{bmatrix}}_{\text{Unit Costs}} * \underbrace{\begin{bmatrix} Q_1 \\ Q_2 \\ \cdot \\ \cdot \\ \cdot \\ Q_n \end{bmatrix}}_{\text{Quantities}} \quad \ldots . \text{(B)}$$

$*$: inner product

For the requirement to get details before the summation for the left-hand side, the following corollary is prepared. By transforming one of vectors to diagonal matrix, this requirement can be solved.

Corollary 1 Calculation of Detailed Elements

$$\begin{bmatrix} U_1 Q_1 \\ U_2 Q_2 \\ \cdot \\ \cdot \\ U_n Q_n \end{bmatrix} = \begin{bmatrix} U_1 & & & \\ & U_2 & & \\ & & \ddots & \\ & & & U_n \end{bmatrix} * \begin{bmatrix} Q_1 \\ Q_2 \\ \cdot \\ \cdot \\ Q_n \end{bmatrix}$$

$$= \begin{bmatrix} Q_1 & & & \\ & Q_2 & & \\ & & \ddots & \\ & & & Q_n \end{bmatrix} * \begin{bmatrix} U_1 \\ U_2 \\ \cdot \\ \cdot \\ U_n \end{bmatrix}$$

Accordingly

$$\begin{bmatrix} U_1 \cdot Q_1 \\ U_2 \cdot Q_2 \\ \cdot \\ \cdot \\ U_n \cdot Q_n \end{bmatrix} = \begin{bmatrix} Q_1 \\ Q_2 \\ \cdot \\ \cdot \\ Q_n \end{bmatrix} * \begin{bmatrix} U_1 & & & \\ & U_2 & & \\ & & \ddots & \\ & & & U_n \end{bmatrix}$$

$$= \begin{bmatrix} U_1 \\ U_2 \\ \cdot \\ \cdot \\ \cdot \\ U_n \end{bmatrix} * \begin{bmatrix} Q_1 & & & \\ & Q_2 & & \\ & & \ddots & \\ & & & Q_n \end{bmatrix}$$

Instead of vectors: Q and U, we can use matrices as two dimensional tables.

Note: The transforming of vector to diagonal matrix can be done by software function.

T-H Theory Step 3 Suppose Existence of Intermediate Matrix

By introducing intermediate causal matrix and vector corresponding to the phenomena, the right-hand side of equation (A) is thought to be an aggregated result of equation (A) and can be expanded to the following equation (C)..

Scalar — Flat Vector — Vertical vector

$$U_1 \cdot Q_1 + U_2 \cdot Q_2 + ,,, + U_n \cdot Q_n = \begin{bmatrix} U_1 & U_2 & \cdots & U_n \end{bmatrix} * \begin{bmatrix} M_{11} & M_{12} & \cdots & M_{1m} \\ M_{21} & M_{22} & \cdots & M_{2m} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ M_{n1} & M_{n2} & \cdots & M_{nm} \end{bmatrix} * \begin{bmatrix} P_1 \\ P_2 \\ \cdot \\ \cdot \\ \cdot \\ P_m \end{bmatrix} \quad \ldots\ldots (C)$$

An Amount of Money — Unit Costs — Intermediate Causal Matrix — Level 1Quantities

A **U** **M** **P**

This relation corresponding to the concrete phenomena is discussed in Figure 6-3

Change the notation of (C) simpler.

$$A = \mathbf{U} \bullet \mathbf{M} \bullet \mathbf{P} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (D)$$

T-H›Theory Step 4 Matrix as result of Combination Law

In the equation (D), **M** can be the result of Inner Products of Matrices as follows which responds to the phenomena.

$$A = \mathbf{U} \bullet \underbrace{\mathbf{M_1} \bullet \mathbf{M_2} \bullet \ldots \bullet \mathbf{M_n}} \bullet \mathbf{P} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (E)$$

M resulted by combination law

This equation can be aggregated as favorable combinations according to combination law.

$$A = \mathbf{U} \bullet \mathbf{M_{12}} \bullet \mathbf{M_{3n}} \bullet \mathbf{P} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (E)$$

$$M_{12} = M_1 \bullet M_2 ,$$
$$M_{3n} = M_3 \bullet \ldots\ldots \bullet M_n$$

A simple example of such **M** as concrete image in the complicated part of above formula is shown as follows from the example in Figure 6-4 later.

M = [G BilletSupply] • [R Rod Yield] • [R Wire Yield]

Corollary 2

As variations, **M** can be the result of matrices calculations such as addition / deletion and inner product among matrices and final vectors., so long as the number of their elements fit together.

$$\begin{aligned} A = U \times (\; & M_{11} \bullet M_{12} \bullet \cdots\cdots \bullet M_{1\alpha} \bullet P_1 \\ + \; & M_{21} \bullet M_{22} \bullet \cdots\cdots \bullet M_{2\beta} \bullet P_2 \\ & \cdots\cdots\cdots\cdots\cdots\cdots \\ + \; & M_{n1} \bullet M_{n2} \bullet \cdots\cdots \bullet M_{n\omega} \bullet P_n) \quad \ldots\ldots\ldots\ldots \text{(F)} \end{aligned}$$

The number of multiplied matrices can be changed by the depth of causal relations.

T-H Theory - Step 5 Resolve Bilinear Relation into Two Parts

Equation (D) can be resolved into two parts: unit cost oriented part and quantity oriented part by jointly using M in both parts as follows..

$$A = U \bullet M \bullet P$$

$$Q = M \bullet P \quad \text{Quantity oriented part} \quad \ldots \quad \text{(G)}$$

$$Uc = U \bullet M \quad \text{Unit cost oriented part} \quad \ldots \quad \text{(H)}$$

Corollary 3 Transpose unit cost oriented part

Equation (H) can be changed by transforming as follows.

$$Uc^t = M^t \bullet U^t \quad \text{Unit cost oriented part} \quad \ldots \quad \text{(I)}$$

Here, Q, P, Uc^t and U^t are vertical vectors.

Accordingly, (G) and (H) can be treated in the same style.

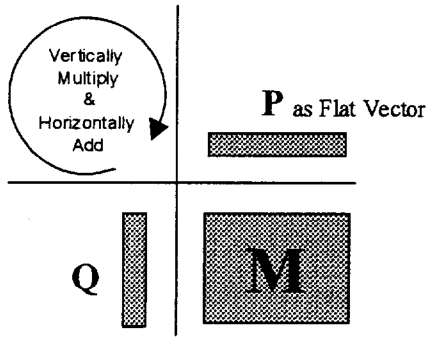
To calculate Amount: "A" after getting Uc^t, arithmetic multiplication and summation for element wise calculations can be introduced between Uc^t and P.

The discussion about how to express these relations on the extended structure matrix starts from here.

T-H Theory - Step 6 Modeling on Structure Matrix

Equation (G) can be placed on the structure matrix as follows.

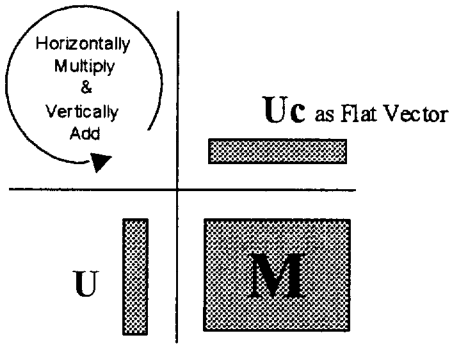
$$\mathbf{Q} = \mathbf{M} \bullet \mathbf{P}$$



as Vertical Vector

Equation (G) can be placed on the structure matrix as follows.

$$\mathbf{Uc} = \mathbf{U} \bullet \mathbf{M}$$



as Vertical Vector

Here, **M** is the center part of structure matrix reflecting equation (E) and (F).

T-H Theory Step 6 Modeling on Extended Structure Matrix

The architecture of Structure Matrix was improved to the Extended Structure Matrix suitable for processing the paired models of (E) and (F) with multiplying calculations: **(P x Uc)**, **(U x Q)** and summation of these resultants in one simple structure matrix as shown in Figure 6-13.

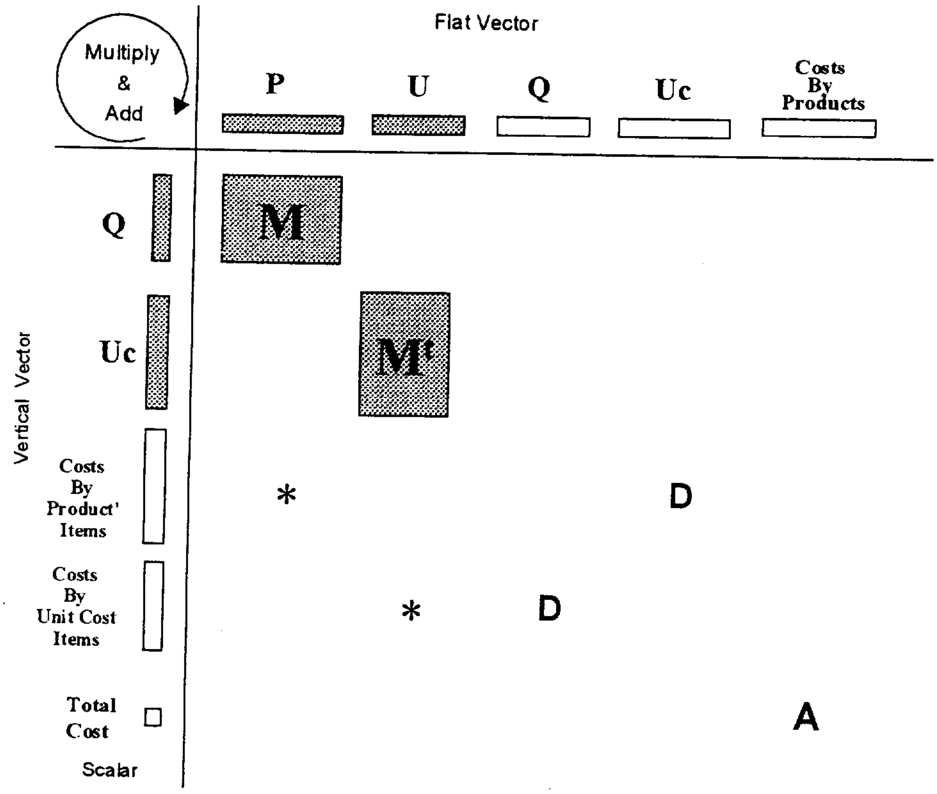


Figure 6-13 Decomposed Expression on Extended Structure Matrix
Details of painted parts are shown in 6-14

-H Theory Step 7 The Existence of Paired Model

In Figure 6-13, there exist original sub-model: "Set of **P**, **M**, **Q**" and associated sub-model: "Set of **U**, $\mathbf{M^t}$, **Uc**". About concrete image of these internal structures, please look Figure 6-14 where the original and associated sub-models are intensively shown. The conditions that original model must fulfill for the existence of corresponding associated sub-model are as follows.

- Linear model

  Original sub-model can be linear when expressed by calculations among Matrices and Vectors combined by addition and multiply.

- Judging method of linearity

  By the currently available package: "Supercel", the linear models are limited in the combination of Type symbols: **A**, **B**, **E**, **G**, **M** (One-dimensional matching only), **R**, **S**, **T** (Transpose only), **V** and **@**.

- Causal model

  The center part of sub-model: **M** must express the causal relation for the predetermined variables given by the block of vectors.

The important principle we found is

"If original sub-model (**M**) exists, we can think that associated sub-model ($\mathbf{M^t}$) exists. Just the contrary is true."

The models of process plant in the previous sub-chapter, shows existence of those associated models. Also several models after this sub-chapter were established based on this principle.

About illustrated model in Figure 6-13, some explanation for the existence of matrix data in upper and left part would be necessary.

In manufacturing process, material cost and processing cost are tend to be separately treated according to the behavioral nature of the cost.

Sub-model: "Set of **P**, **M**, **Q**" is composed of causal relation of production factors and sub-model: "Set of **U**, $\mathbf{M}^t$, **Uc**" is composed of causal relation of unit cost factors. However, in the sub-model: "Set of **U**, $\mathbf{M}^t$, **Uc**", upper and left part has matrix data separately prepared for material cost and processing cost. This separation is prepared for the later explanation.

By adding each of those as united cost as material and processing cost, existence of paired model can be imagined.

As a practical method of transposed model,

- Copy the original model to the transparent foil sheet
- Turn over the transparent foil sheet simultaneously changing the vertical side to horizontal.

We can thus easily register the transposed model to screen.

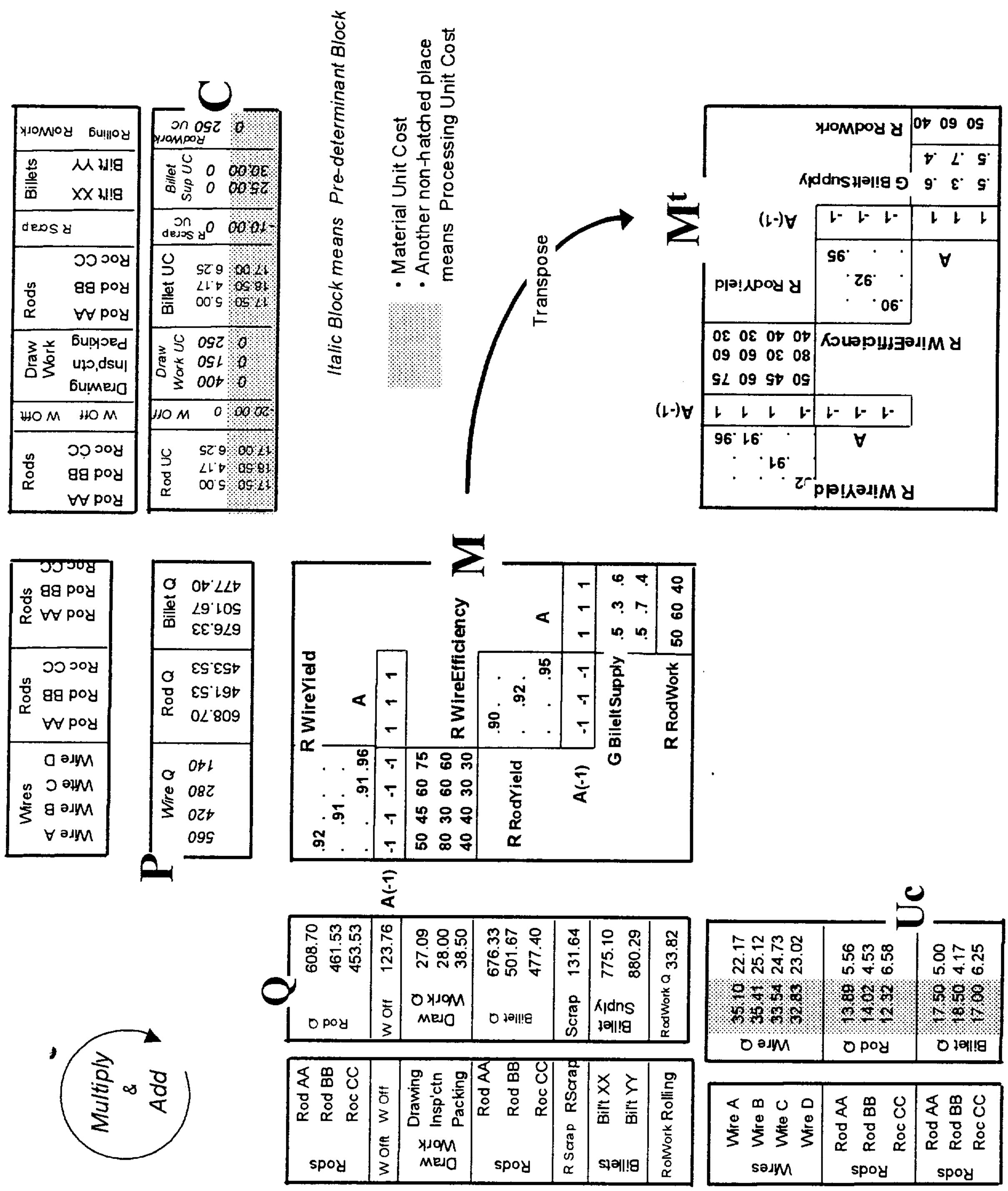


Figure 6-14 Transposed Model From Set of **P**, **M**, **Q** to Set of **C**, $\mathbf{M^t}$, **Uc**

The set of **P**, **M**, **Q** is for material requirement model and the set of **C**, $\mathbf{M^t}$, **Uc** is for unit cost model. Both models are linear. **C** and **Uc** are composed of two kinds of data related with material cost and processing cost.

Once a pair of bilinear model is established, the model is to be arranged for user's easier understanding and handling and also for the practice of the paradigms in which the models are embedded. The associated sub-model in Figure 6-14 is rearranged as two sub-models: Material Unit Cost and Processing unit Cost as in Figure 6-15.

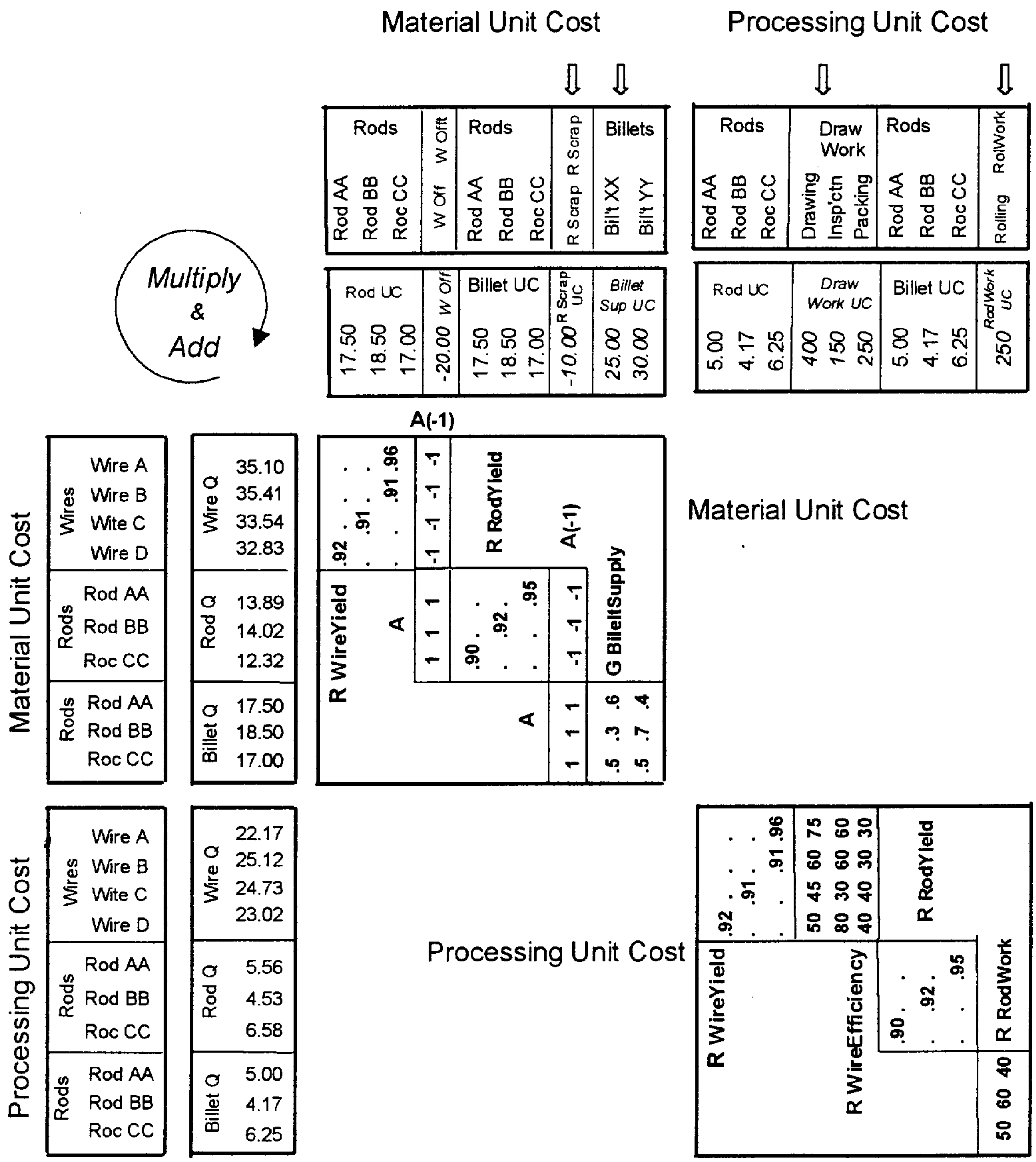


Figure 6-15 Model segmented for Material and Processing Unit Cost

The principles to rearrange are as follows.

- Separate the sub-model by the nature of major cost behavior.

- Search idle blocks in the separated sub-model and delete them by columns and rows

Generally from the application, the idle block has no value to be placed or value zeros are always placed in the block. In the sub-model in Figure 6-14, these characteristics are shown.

- Rearrange the shape to be easily understand and handled, by replacing column by column-wisely or rows by row-wisely. This method is supported by the nature of matrix.

T-H Theory Step 9 The Calculation of Cost as Monetary Amount

Again, in the Figure 6-16 as a sample, calculation among hatched vectors is shown.

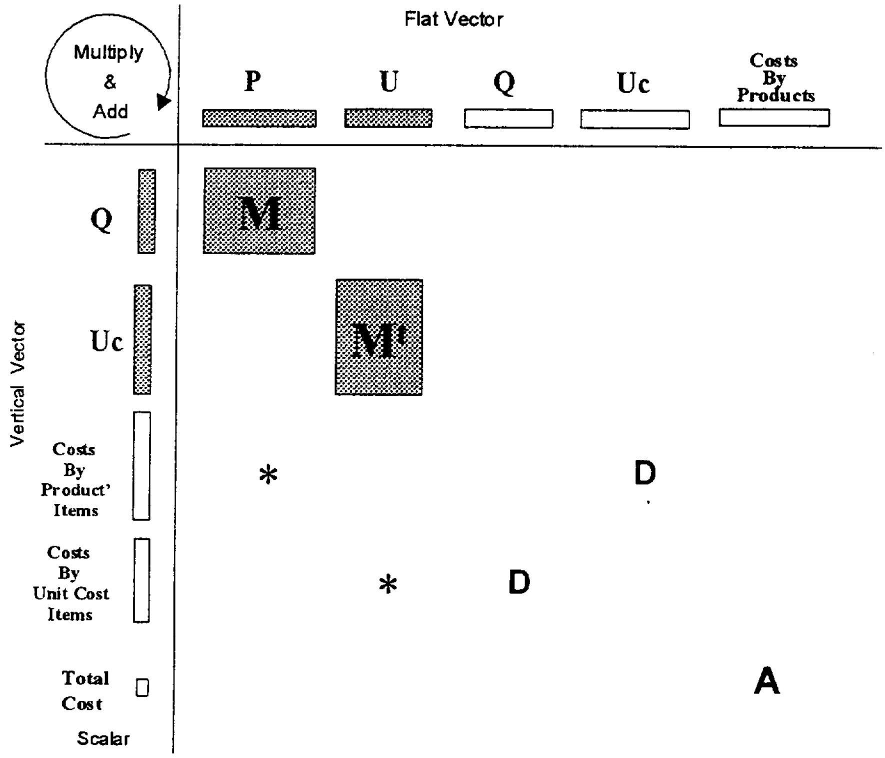


Figure 6-16 Decomposed Expression on Extended Structure Matrix

This provides possible management values. However, to include all of them makes the model lager and some of them would be not so important. Some reshuffling by selection of the blocks would be necessary to make the model compact for easier handling. In addition, to insert the necessary calculation ad hoc according to the needs would be a practical solution.

As conclusion of this sub-chapter, practical theories to provide models unifying the three paradigms: "non-monetary paradigm, unit cost paradigm and amount paradigm", are established.

From now on, if models are made on structure matrix, we should search the linear part and think of the transposed model. Then we can have the chance to make more in models.

6-4. Production Planning and Cost Model in Assembly Business

As an application of the T-H Theory, take a simple model of assembly enterprise that can be observed having single assembly process. In the previous sub-chapter: "6-2", a style of modeling in material process industry, where flow of the material is diversified through the transferring of process facilities, was discussed with required fineness. As another typical subject, more simplified style within the extent of linear casual relations of assembly process, where fundamental materials in production have intensive flow (bundling of parts) toward product, is discussed here.

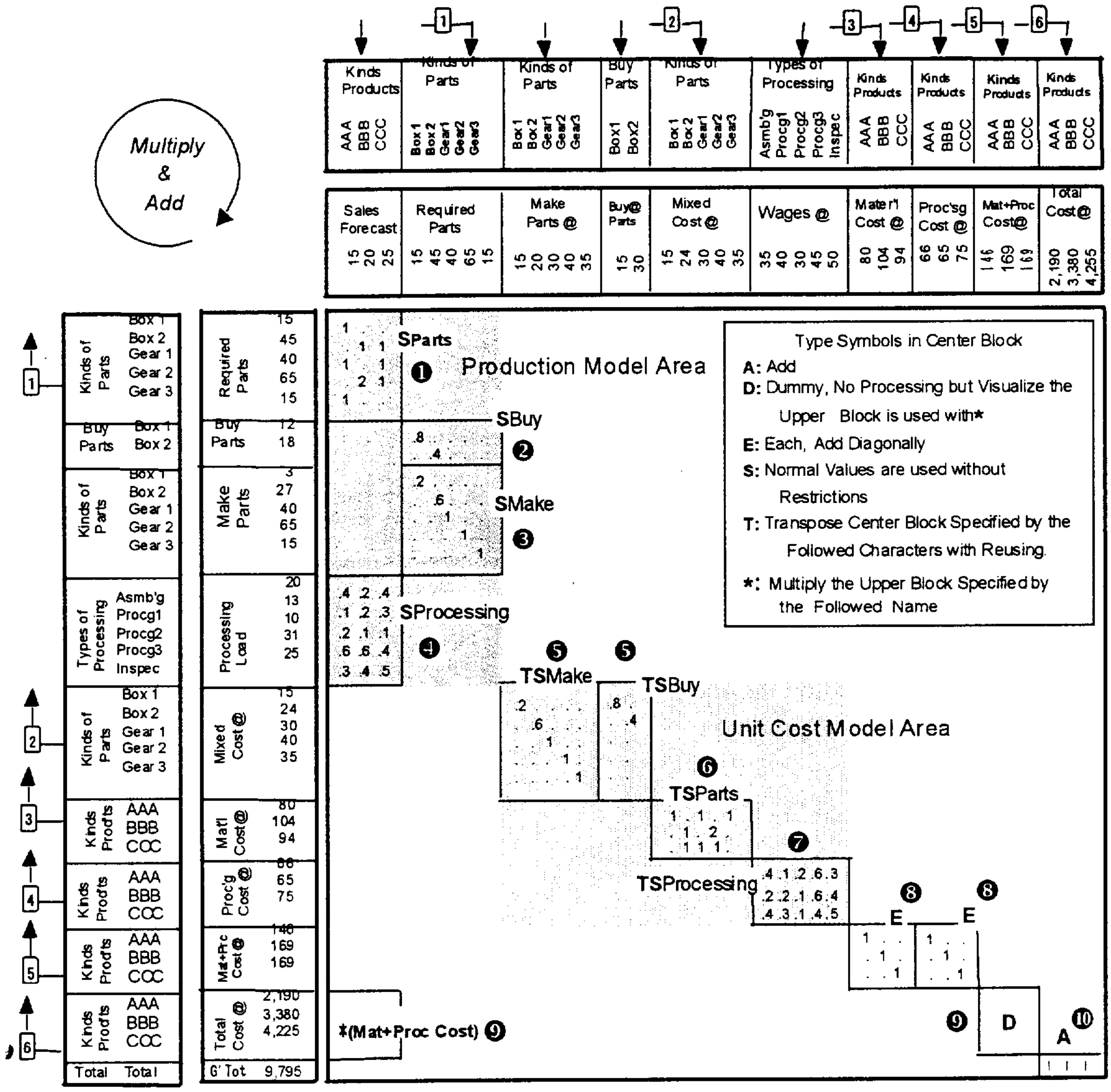


Figure 6-17 Management Model with Production and Direct Cost

As a simple example of parts' supplier, which produces Gear Box AAA, BBB and CCC, the model in Figure 6-17 shows relation of production factors and variable cost (material cost and processing cost). Their products " AAA, BBB and CCC" are assembled from some of five candidate parts "Box 1, Box 2, Gear1, Gear2 and Gear 3".

The first target is Production Model Area which covers parts requirements, and ratio of buy and make, and required workers' load. The contents of calculation are explained according to the circled numbers.

❶ Develop numbers of parts' requirements for the product. For more complicated developments with hierarchical levels, refer Type Symbol: **V** in Appendix I.

❷❸ These two center blocks are used as a pair for distributing the developed part's requirement for make or buy. The vertical sum crossing the two blocks are kept one (1). Value 1 means no purchasing here.

❹ Workers' loads (working hours) for each unit of products are given and sum of workers' load are calculated.

The second target: "Unit Cost Model Area" is to calculate variable unit cost relating the production factors by transposing the given structures in Production Model Area. Watch that all the blocks in this area are the transpose of these blocks. The allocation of these blocks can be replaced by columns or by rows according to users' conveniences for easier understanding or handling. About use of transposing structure, please refer the previous sub-chapter: "6-1-1. Bilinear relation of consumption factors and unit cost."

❺ These two blocks are the transpose of SBuy and Smake and give ratio factors to be multiplied for the supplying unit costs. So these results mean weighted costs for the mixed supplies.

❻ The transpose center block: TSParts means that the products in the left are made of what parts with what number of parts. So, by operating *Multiply & Add*, material unit costs by product are calculated for given parts cost.

❼ Using TSProcessing, processing costs ($) for each product are calculated for given workers' unit costs (cost for an hour: $)

The third target is to calculate total cost (not hatched in the figure).

❽ Total variable unit cost by product are calculated by adding two group of unit cost: "material costs and processing costs".

❾ Using the sale forecast target in the upper block and the variable unit cost in the upper block and with multiplication (Type symbol: * and direct specifying of succeeding upper block name with associating type symbol: **D**), each total product cost can be calculated.

❿ Using type symbol: **A**, total product costs by product are summed as total of variable cost (direct cost).

As a simple conceptual model, variable cost is composed of simple structure of material cost and processing cost excluding the idea of facilities' transferring.

For adding one more technology, if vector data of pre-determinant block in upper part forms diagonal matrix data as a square matrix (that is, two dimensional data having the same items), the calculation results values for each item.

The development of this model gave us a clue to establish T-H Theory. There is some medium and small sized manufacturing business introduced structure matrix package, which has been stimulated by this sample model almost excluding program developments for their cost management system and enterprise planning systems.

6-5. Models for Common Cost Assigning along ABC

Traditionally fixed cost was abandoned being considered as uncontrollable type of cost. However, by the increase of common fixed cost in business and by the progress of automation in plants and offices with information processing, we cannot leave handling of the fixed cost as it was. A typical example of making the ink cartridge of ink jet printer shows that only one percent of the manufacturing cost is the material cost and that the rest is common fixed cost because it is made fully by automation (Newspaper reported as a case of Cannon Corporation). Even in the financial businesses, by the progress of computerization with network processing, ratio of cost that has traditionally been grasped as common cost in total cost is increasing. Also in estimation for quotations relevant costing must be a key to be competitive. There are many matters to be discussed. About further details of these needs, we would like to suffice introducing famous book: Relevance Lost[Johnson, 1987]

The fact is that there are movements to control the amounts of common fixed cost, relating them to the generated reasons: starting original points of causal relations. Typical movement is ABC: Activity Based Costing, as my understanding, by which common fixed cost should be assigned to the activities with relevancy at work for getting the relevant product cost. The major expectation of these movements are to save idled cost and to get more relevant cost for the competitions.

From the side of preparing a series of value chain models, there are various types of models for assigning the common fixed cost to the activities with relevancy. Following five types of sample model are introduced in this chapter.

	Sub-sub-chapter
I. Traditional Model to Assign Manufacturing Overhead Cost	6-5-1.
II. ABC Model to Assign Manufacturing Overhead Cost	6-5-2
III. Extending ABC Model to Forecast Common Cost	6-5-3
IV. Model to Relate Activities of Competence Center.	6-6-1
V. Staff Activities to Relate Activities of Mainline Parallel Organizations	6-6-2

First two models were used for the discussion of traditional way and ABC way, visiting one of originator of ABC: "Dr. Robin Cooper, Professor of Drucker Graduate Management Center at Claremont Graduate University, 1995"[Cooper, R. 1988],[Sakurai, M. 1995] By comparing these two models, you can deepen understandings of the essentials of those methods. The models, III IV and V, may supplement the insufficient idea provided by ABC for indirect cost. When overlooking needs of these modeling, efforts paid in this subchapter may be the work to look cost that was treated as fixed cost to be proportional as possible relating the activities of their birthplaces in a broad sense.

6-5-1. Traditional Model to Assign Manufacturing Overhead Cost

The essential part of traditional way, is modeled on the structure matrix as shown in Figure 6-18, where manufacturing overhead costs are assigned to the products based on the ratio of consumed direct labor hours as typical index representing the manufacturing activities. For simpler explanation, following typical overhead cost items are taken as Axis II: depth side. (The top characters are used to handle these items.)

Abbreviation	Items	Overhead cost measured
D :	Direct Labor Related Cost	$ 1,200
S :	Setup Cost	$ 1,200
A :	Acquisition Related Cost	$ 1,000
T :	Transportation - In-plant Related Cost	$ 1,000
R :	Repair & Maintenance Related Cost	$ 2,000

The manufacturing quantities and direct labor hours for product A and B, are given as follows.

	Product A	Product B
Manufacturing quantities	400	100
Direct labor hours	1,000	200

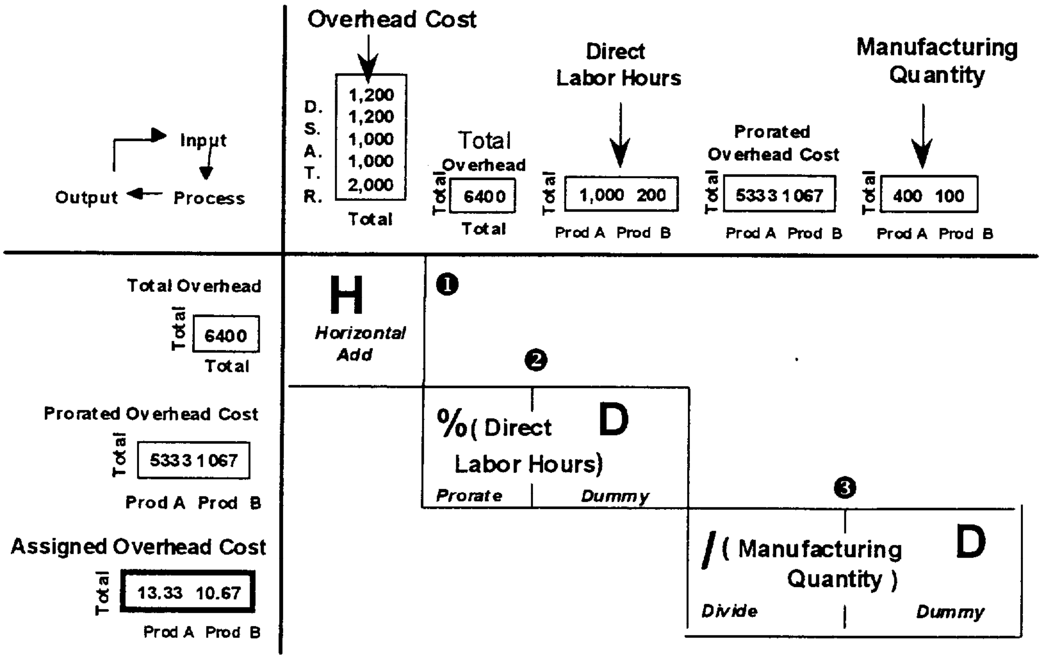


Figure 6-18 Traditional Way to Assign Manufacturing Overhead Cost

The calculating steps are as follows

❶ Add up overhead cost along horizontal axis (Axis II: depth side), using type symbol: H.

Total cost: $ 6400.

❷ Prorate total overhead cost: $6400 for product A and B by direct labor hours 1,000 and 200 hours, using type symbols: % and **D**.

Prorated costs: are resulted for Product A and B.

These sum is $ 6400.

❸ Divide prorated overhead costs: $ 5333 and $ 1067 by each numbers of product: 400 and 100 sets, using type symbols: / and **D**.

Assigned overhead costs are $ 13.33 and $ 10.67 for A and B. Almost same values

6-5-2. ABC Model to Assign Manufacturing Overhead Cost

The essential part of ABC way, where manufacturing overhead costs are assigned to the products based on each ratio of consumed activities with more relevancy, is modeled on the structure matrix in Figure 6-19. The data given for this model is kept the same except the values for the relevant activities for the comparison with the traditional way. So, look the model shown in Figure 6-18 in previous sub-sub-chapter for comparison.

For simpler explanation, following typical overhead cost items with activities by products are given as two dimensional table having Axis II: depth side. (The top characters are used for handling these items.)

Abbreviation	& Items	Overhead cost measured	Activities: Product A	Activities: Product B
D :	Direct Labor Cost Related	$ 1,200	1,000 hours	200 hours
S :	Setup Cost	$ 1,200	15 times	35 times
A :	Acquisition Cost Related	$ 1,000	5 man days	15 man days
T :	Transportation Cost - In-plant Related	$ 1,000	10 ton kilometers	40 ton kilometers
R :	Repair & Maintenance Cost Related	$ 2,000	100 man days	300 man days

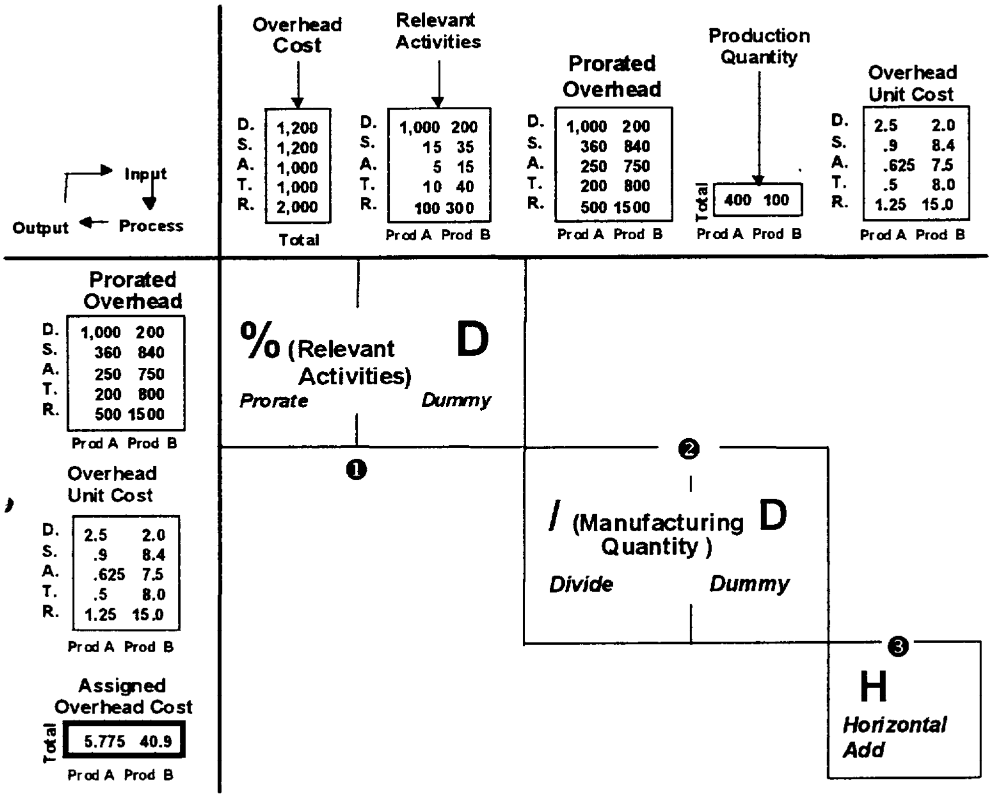


Figure 6-19 ABC Way to Assign Manufacturing Overhead Cost

The calculating steps are as follows

❶ Prorate each overhead cost by each relevant activity measured for each product: A and B, using type symbol: % with associating type symbol: D.

❷ Divide each of prorated overhead costs by the number of producing sets: for product A and B, using type symbols: / and associating type symbol: **D**. The vector data 400 and 100 are extended toward axis II. The results are given as a unit cost table by activities by products.

❸ Add up overhead unit cost along horizontal axis, using type symbol: **H**. Then, assigned overhead costs by each product are calculated as follows.

Assigned overhead unit cost	Product A	Product B
ABC way	$ 5.775	$ 40.9
Traditional way	$ 13.33	$ 10.67

As a result of both ways of calculations, the differences are remarkable. These models are often used for understanding the difference of principle of ABC and traditional method. In the practical system these models are used partly in every business model.. [Gyouda, M. 1992]

6-5-3. Extending ABC Model to Forecast Common Cost

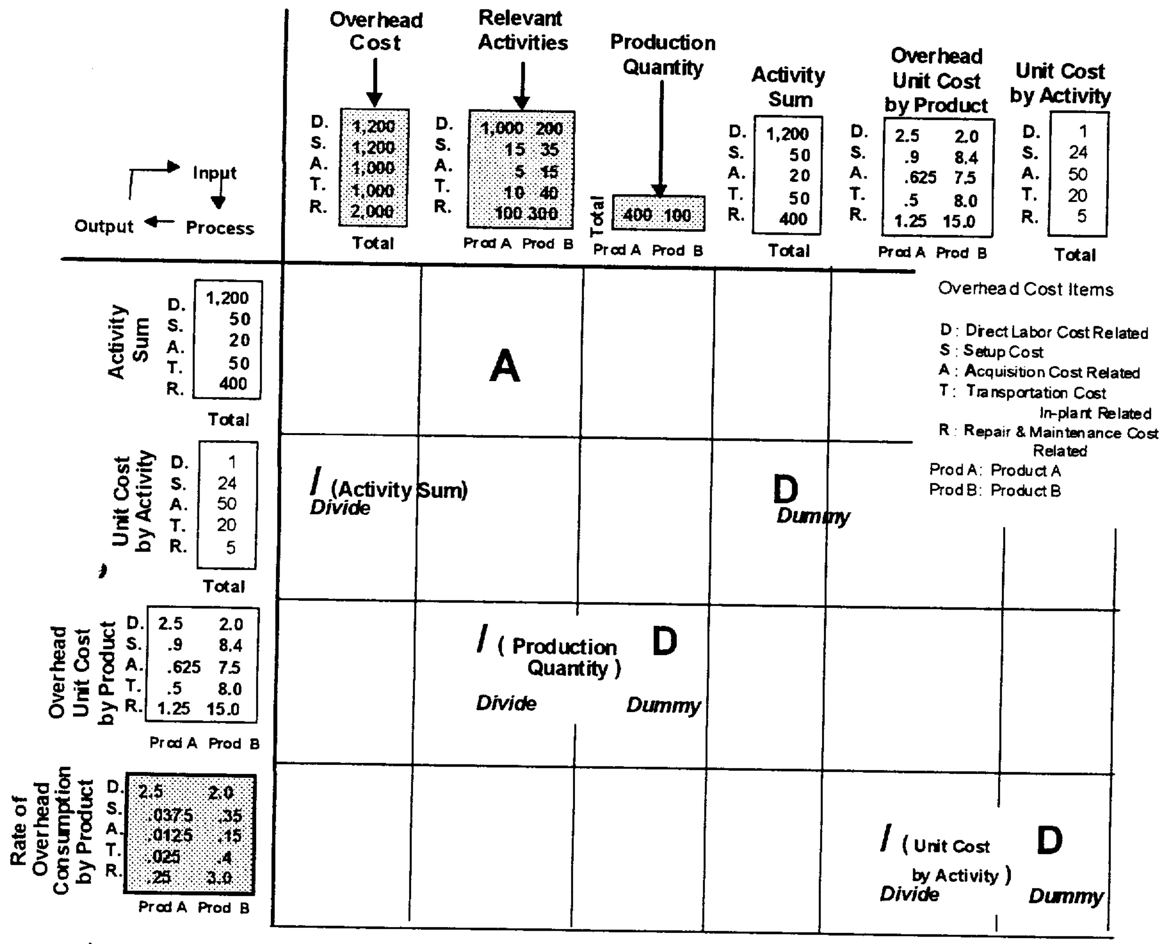


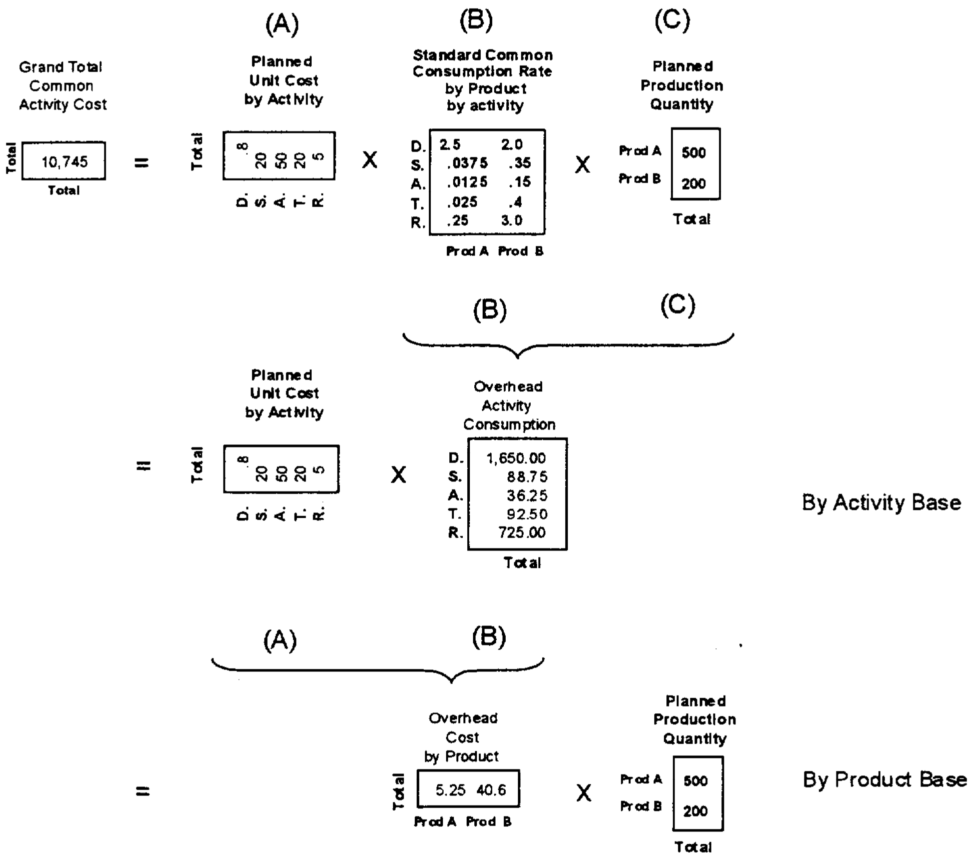
Figure 6-20 Model to Calculate Overhead Consumption Rates by Product

There are discussions among users that ABC is a kind of past calculation. The next equation shows a case of calculating unit figures in the pasted block of left part for getting the base of estimation.

The principle to use this block of figures can be placed in the following formula as (B) under the following conditions.

- (A) as planned unit cost by activity for this estimated conditions.
- (B) as planned production quantity for this estimated conditions
- the structure of activities are kept unchanged.

This formula is one of the cases of general approach that T-H Theory is applied by thinking that this block can be intermediate matrix.



So this formula can be changed to the following two formulas and by thinking that these vectors can be diagonal matrices, various management values can be calculated. These relations are modeled in Figure 6-21 on the extended structure matrix without placing the block (B) as a center block. These calculating relations can be gotten without such T-H Theory, but possibilities to draw the model with more general approaches can be provided by the theory.

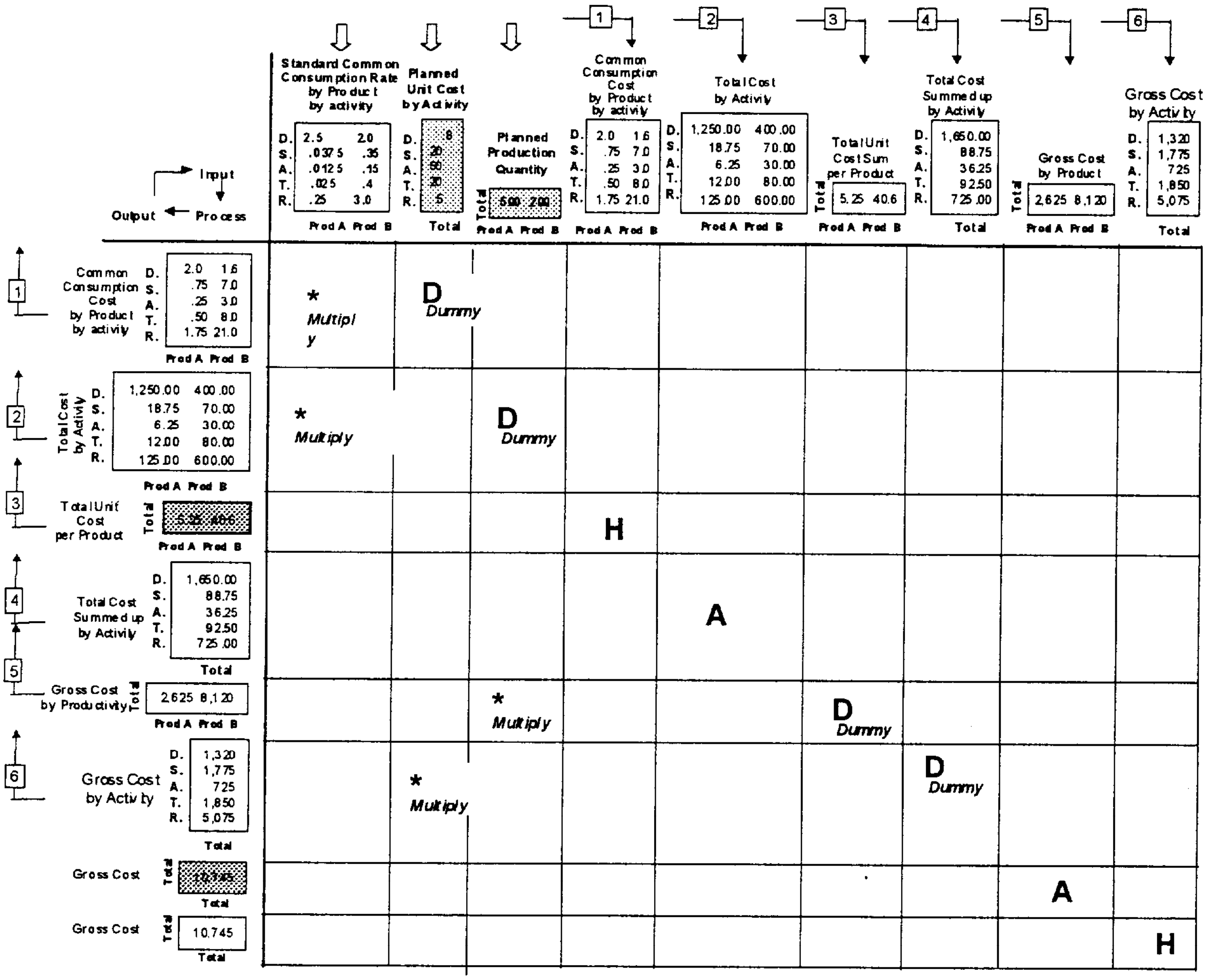


Figure 6-21 Model to Estimate Activities

6-6. Models for Shared Service Activities

To establish subtle relation between staff activities and main line activities had been one of big problems in arranging organizations. Recently, *Shared Service* is discussed from the point of difficulties in keeping the relation with main line of business, above all in systematizing, according the progress of *Outsourcing*. To provide familiarity with this word, we would like to explain my positive understanding as follows.

Shared service is a newly highlighted word for the organizational mechanism to concentrate the internal resource so that to provide high professional services with efficient cost. This service is essentially different from what is provided from traditional centralization, by which merely scale merits are pursued and the costs are assigned for the mainline of business according to the traditional distributing logic of overhead.

These highly professional services are provided to the internal organization regarding them as customers, assuming that reasonable reward shall be given. To keep high competence, education and training for specialist members must be executed along organized plan. Most of these organizations are targeted for a self-supporting accounting system

Therefore, minute modeling methodologies would to be able to combine the professional skills to the required elements of mainline business. Besides, the model should be applied for their planning having the liaison with activities of mainline business.

For those modeling, T-H theory was effectively applied. In this sub-chapter, typical two examples are introduced as follows.

- Model to Relate Activities of Competence Center
- Models to Relate Staff Activities to Activities of Mainline Parallel Organizations

By introducing the idea of later example, bankers appraised that they can finally establish a real cost accounting system after experiences of many implementations.

6-6-1) Model to Relate Activities of Competence Center

A simplified sketch of relation of general engineering company, in which two types of following function are formalized, is shown in Figure 6-22.

- Main line organization with divisions targeting the specialized market areas
- Contributing (Supporting) functions as an Engineering Design Center to centralize common use of specialties and their higher dedication and to level work.

Their activities among the two organizations are deeply related in the bottom and the relation varies quickly responding to the project progress. There is a need to provide describing methods to given insight to keep up such changing relations and grasp their work load with contributed cost, which links origin of causal factors.

The problems are how to relate these staff activities and how to assign their cost to the main business activities in modeling, in which these relations are used not only to analyze past phenomena but also to estimate near future with relevancy.

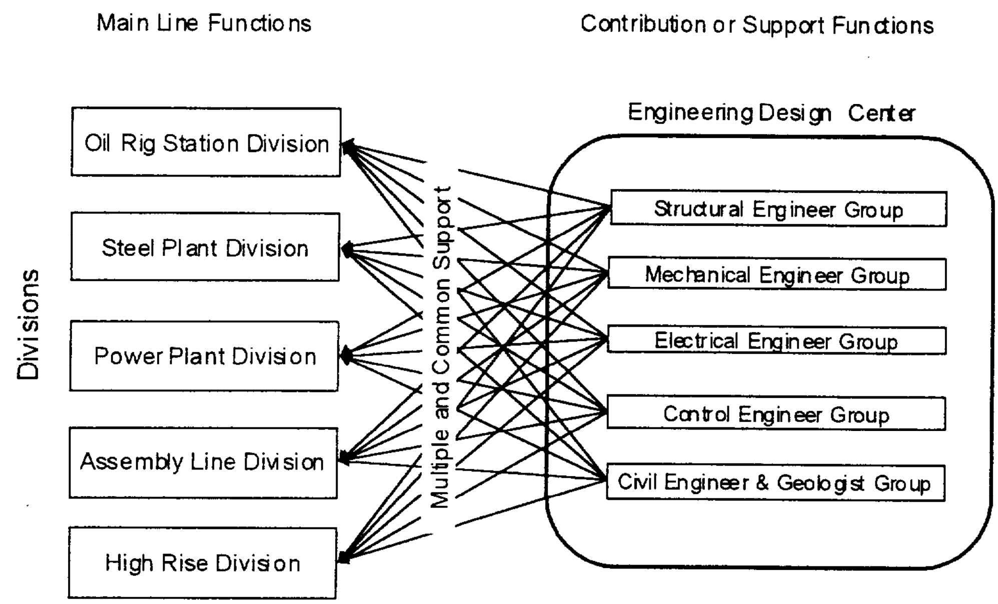


Figure 6-22 Relation between Main Line and Contributing Functions

For these modeling, extended idea of the *bilinear relation* discussed in the chapter 6-1-1 can be applied. (Refer the idea of bilinear relation in 6-3-1.)

The idea is

Input / Output relations ⇒ Contribution or supporting relations.

This means to replace the idea, upward resource requirements through the facility (yield), with the idea, contribution requirements through the ratio of staff service activities. The principle and development of the model on the structure matrix are simply shown in Figure 6-23.

The principle is explained after the circled numbers. In this illustration, divisions' activities are expressed conventionally by their sales amounts

❶ The bilinear relation gives total cost as an inner product of following two vectors.

- The horizontal vector: unit cost by the trade of engineers
- The vertical vector: work load required by the divisions

As a supplement of these relations to get individual result of the total cost as vector, diagonalizing of one of the two vectors to matrix is necessary as in the following operation

❷ If the required workloads: V_W are resolved as the combination of precedent causal factors expressed by the inner product of the matrix: M_C and vector: V_D in the following equation. Each element of the matrix represents contributing (or supporting) trade's person-months corresponding to the one million of selling amounts for each division.

$$V_W = M_C \times V_D$$

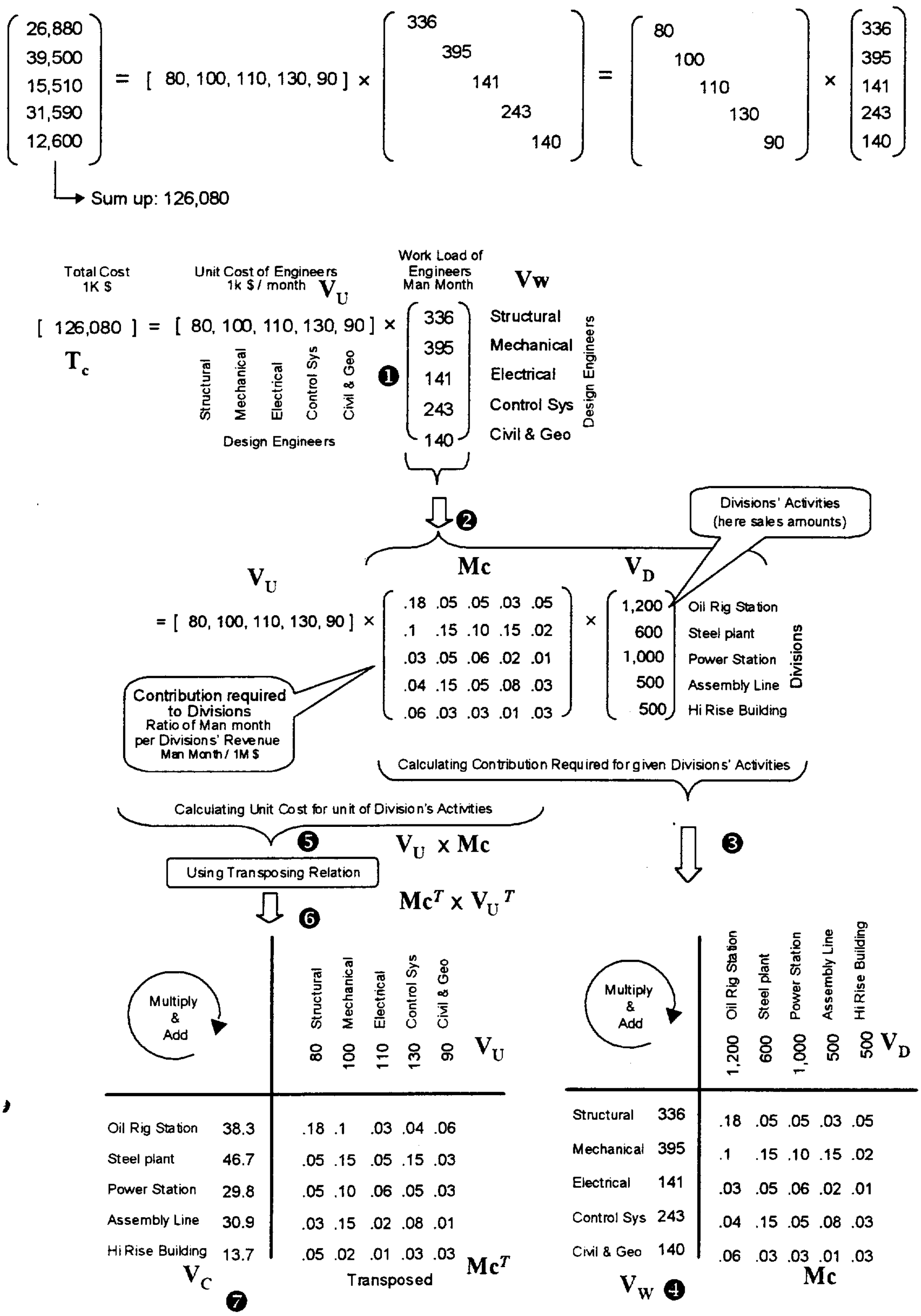


Figure 6-23 Principle of Describing the Contributing Relations Relations

❷ This equation can be resolved further to a chained series of inner products as follows by linear relation corresponding to the phenomena to be modeled.

$$V_W \;=\; M_1 \;\times\; M_2 \;\times \bullet\bullet\bullet \times M_n \;\times\; V_D$$

Or more complicated relation like follows depending on the phenomena

$$= \; M_1 \;\times\; (M_{21} \times \bullet\bullet\bullet \;\times M_{n1} \;\times V_{D1} \;+\; M_{21} \times \;\bullet\bullet\bullet\; M_{n2} \;\times\; V_{D2})$$

❸ Relation about contributing quantities can be developed as a structure matrix expression.

❹ As a result of structure matrix model, work-load required for the divisions' activities are calculated.

❺ Calculaton of unit costs: **Vc** for one unit (one M $) of corresponding divisions' activities, can be resolved to the multiplication of V_U and M_C. So is the same as ❷'.

❻ The relation: $V_U \times Mc$ can be changed to $Mc^T \times V_U{}^T$ by transposed relation Also the same relation is carried to the transposed relation.

❼ As a result of structure matrix model, unit cost required for the divisions' activities are calculated.

In Figure 6-24, the model with the latest logic embedded shows a simpler relation between service providing function and main line function of divisions which receive services.

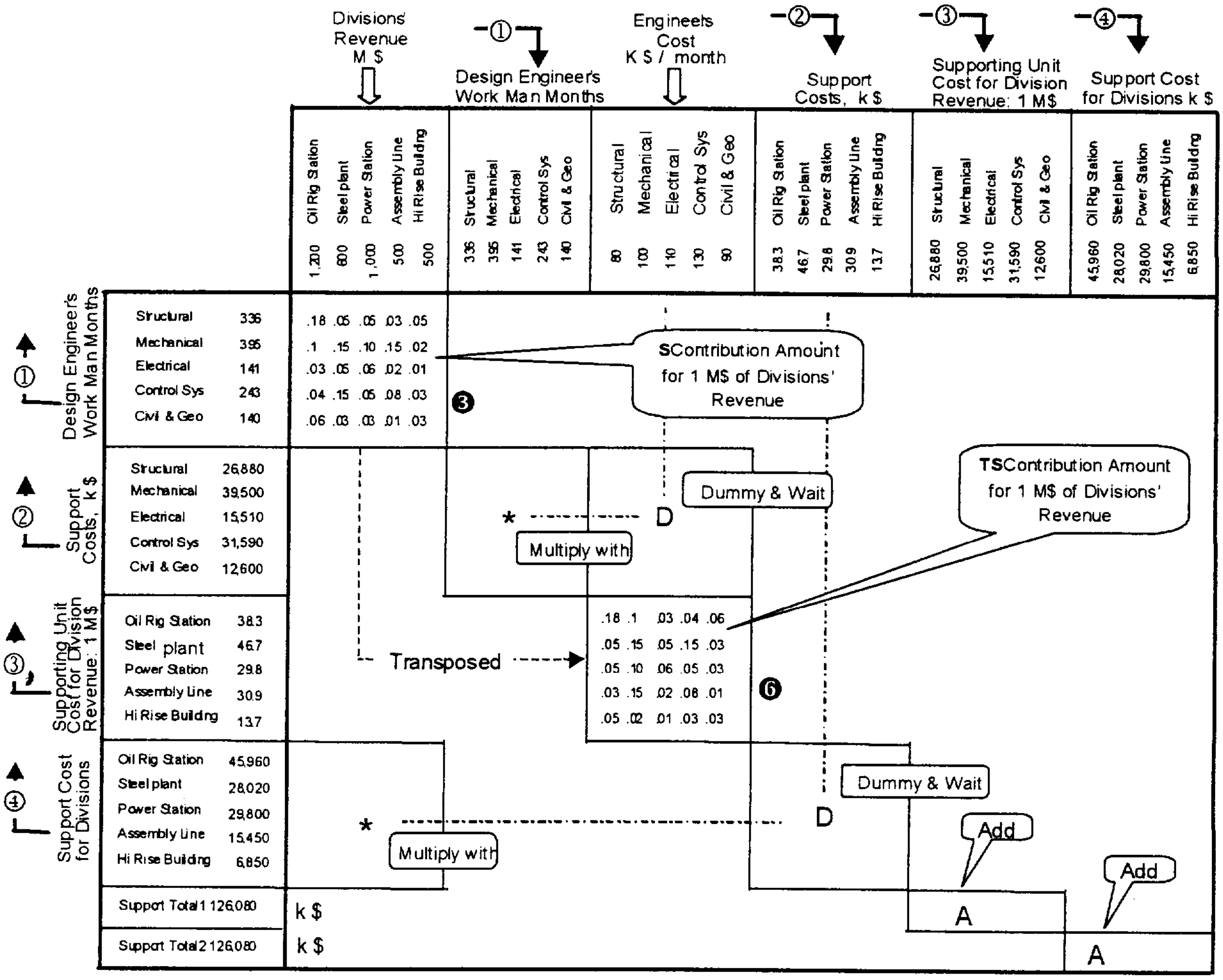


Figure 6-24 A Model of Supporting Function to Main Line Functions

6-6-2. Staff Activities to Relate Activities of Mainline Parallel Organizations

There are inter-organizational problems to relate staff activities to a set of resembled parallel organizations (B). These problems are typical in the following enterprises. Between activities of staff's organization (A) and activities of differently operated organizations that are overlapped as parallel similar organization (B), there are problems of describing them with visibility. The sharing of organizational functions is typical in the following organizations.

Activities of (A)	Activities of (B)
Bank Headquarter	Bank's branch offices
Supermarket Headquarter	Branches in supermarket
Franchise Headquarter	Franchise Shops

The organization of (B) sometimes form more than 100 of same types of formation and their activities are analyzed as pile up of almost same type of activities as in the example of Figure 6-25.. For more easier understandings, think the amounts of activities as summed cost for them in the figure. The problem is how to assign these costs with relevancy to the activities of each branch. In actual cases, these activities are treated as real yardsticks not only limiting monetary values.[Kobayasi,S., 1990],

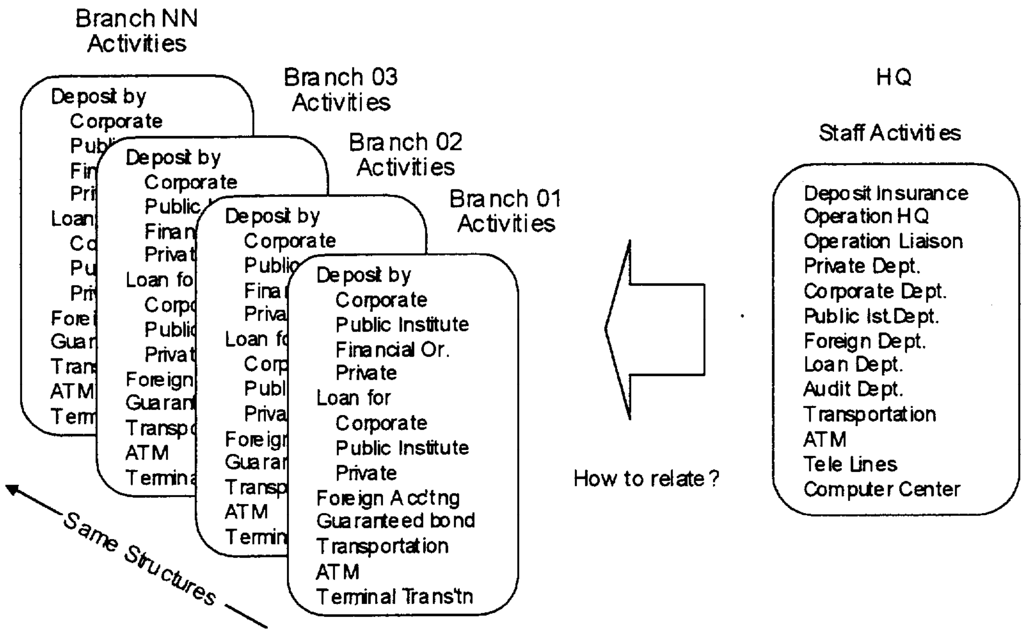


Figure 6-25 Relating Activities of two organizations: Head quarter and Branches

A simplified model is shown and its data and logic are illustrated in Figure 6-26 and in Figure 6-27.

As a general banking organization, units of branch office are arranged in parallel and head quarter function is tend to be established as a concentrated organization. In this model, starting data are shown in following three tables:

- A table of detailed activities by branch office
- A table of consumption amounts by head quarter functions (Vector data)
- A table which shows relation between branch office activities and head quarter functions. This table uses type symbol: **B** and the associated two-dimensional table that shows relation by locating value **1**.

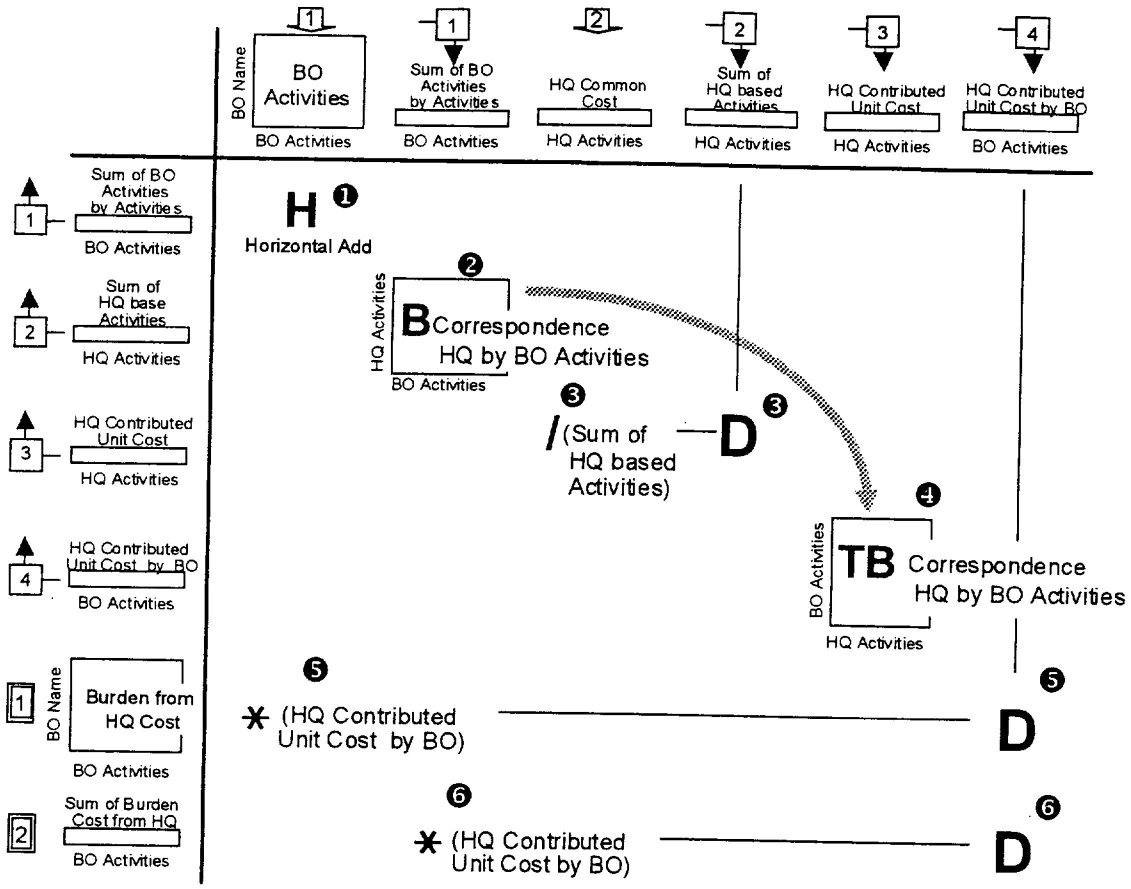


Figure 6-26 Assigning staff contribution to main activities

Calculating steps are as follows.

❶ Branch office activities by each branch are accumulated according to the branch offices' direction (Axis II) and sum of branch activities are given in [1].

❷ With *Multiply & Add* of [1] and B correspondence HQ by BO Activities, sum of each amount of BO activities is accumulated to the related amounts by HQ functions: [2].

❸ Head quarter's common cost grasped by each function are divided by each of the amounts of related activities by HQ functions:[2]. These provide the unit costs for each of HQ contributing function:[3].

❹ Using transposed relation as described in the previous sub-sub-chapter, the unit costs: [3] are transformed to the each of unit costs in BO activities: [4].

❺ By multiplying the unit costs of BO activities, contributed amounts of HQ functions for each items of BO activities by Branch are calculated depending the magnitude of BO activities.

❻ By the same way of multiplying the unit costs of BO activities, contributed amounts of HQ functions for each items of BO activities summed up to totals of BO activities are calculated.

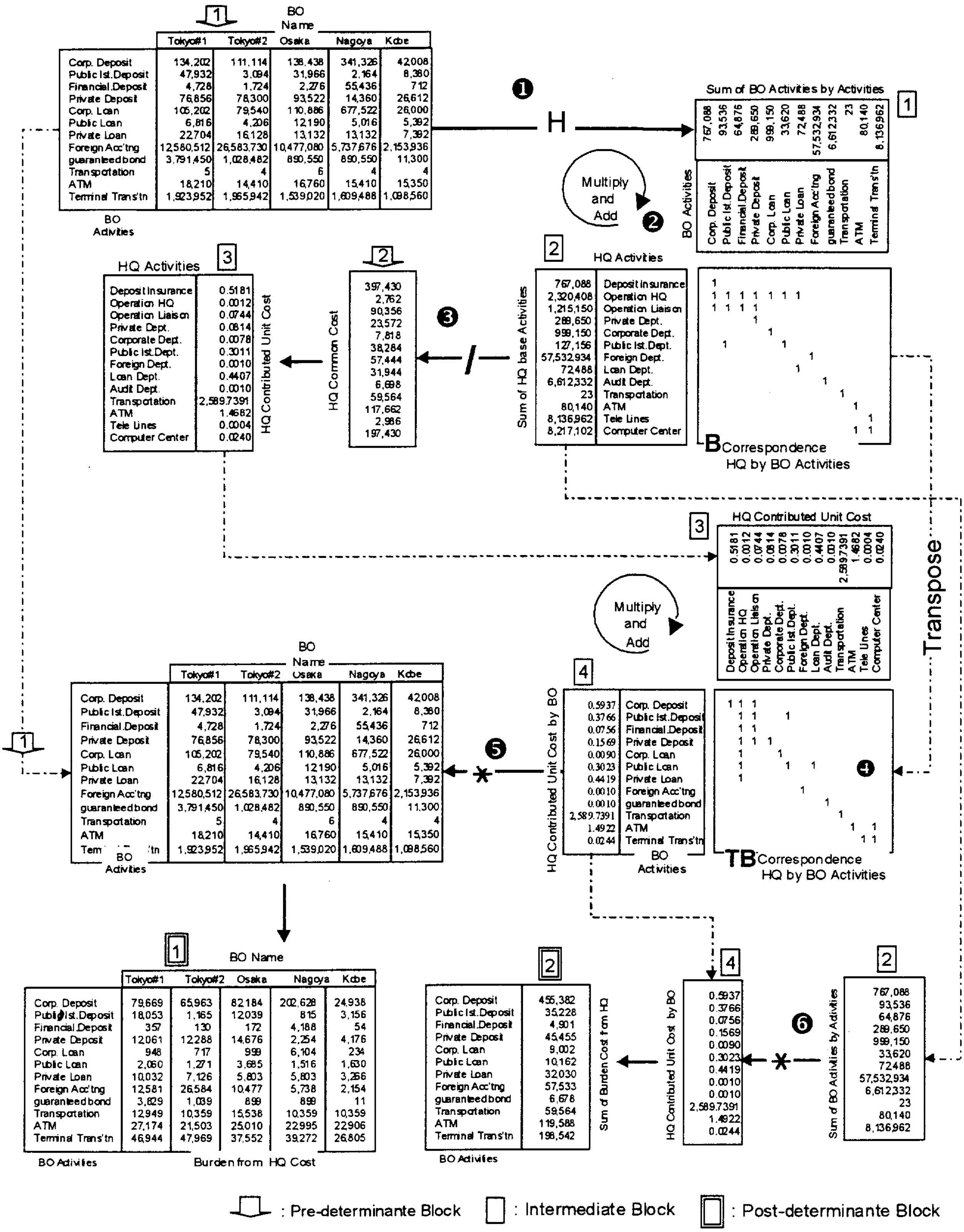


Figure 6-27 Data and Logic of Models in Figure 6-26

Formerly, keeping the linkage of two types of activities in different two types of organization, in which functions are operated by different managerial intentions with different timings, had been practically difficult in maintaining as managing systems. Much effort have been paid for making cost management system in banking in vain. With this methodology which has *Visibility with Transparency*, we received the reputation that the cost systems become practical, because of providing relevancy between contributing activities. In practical bank models, number of activities' items reaches near 1000 and many item blocks are used for different kinds of activities.

Strangely, we found that the characteristics deducted from the principle of bilinear relation appear even in the complex relation between contributing functions and main functions. This methodology: T-H Theory can be used in many sites of businesses beyond industries as common model approaches.

6-7. A Model to Assign a Cost to Hierarchical Organization

In most of the business modeling, there isn't enough accurate and economic way to measure the consumed amount of services in each level, but a top value is given. In such a case, the method to resolve the value to the consumption values in each point of organization is required. The methodology that we introduce here was established independently from T-H Theory. However, this technology is used commonly in BSM as a typical function and resulted as a type symbol. Therefore, we are introducing this function in one sub-chapter here.

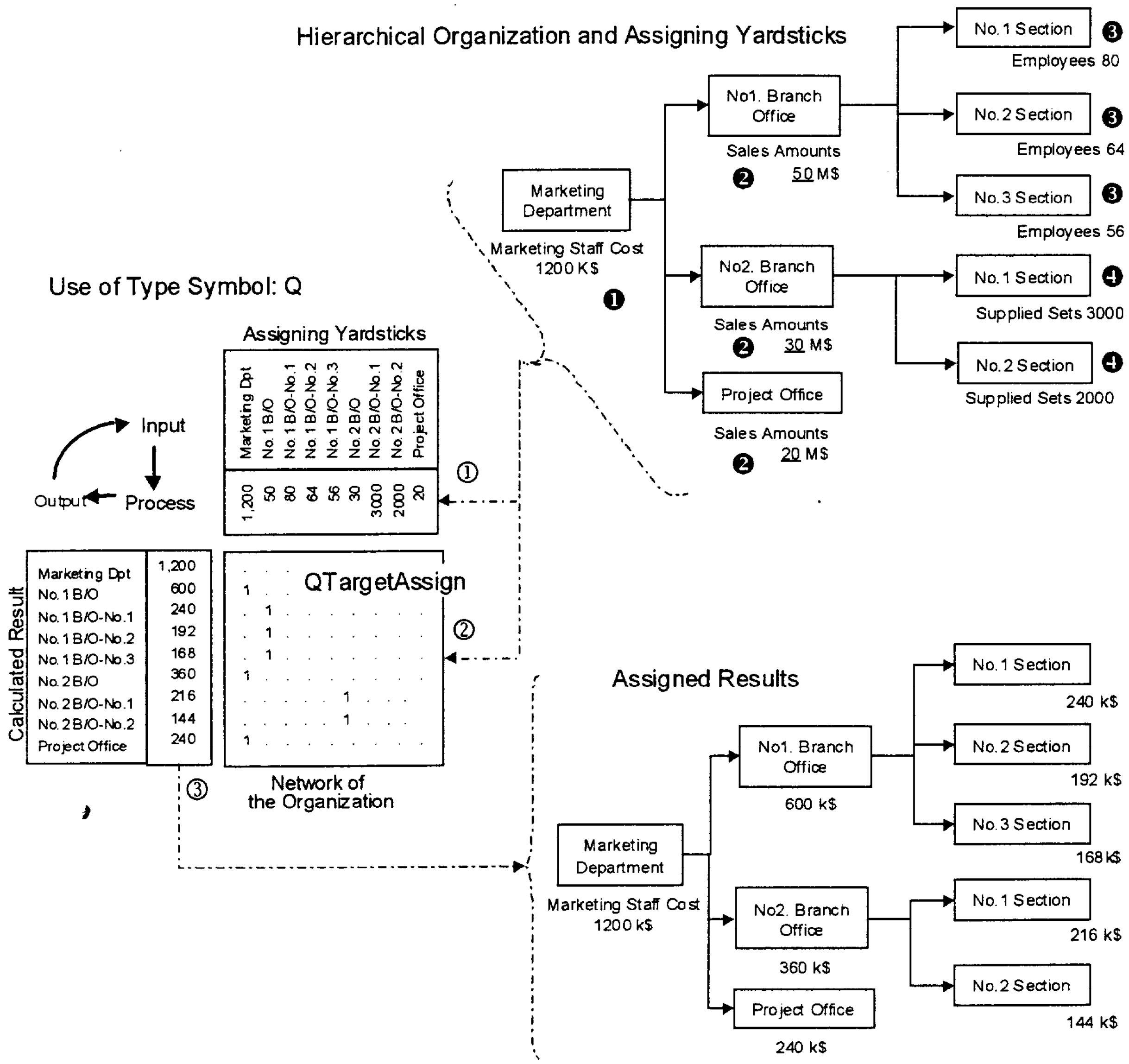


Figure 6-28 A Method of Hierarchical Assignment of A Value with Relevant Yardsticks

Such cases are common in assigning the utility's consumption, above all in assigning industrial water supply and waste water treatment, because measuring method itself requires energy loss or big investment that may not be welcome. In these cases, allocating logic should be tough enough for the organizational changes and change of relevant factors given in each branch of organizational level. We experienced the severe requirement of the measuring system in energy saving project at the integrated steel works: Hirohata, Nippon Steel Co. Formerly, the calculation was performed by the program written by COBOL. However, their programming couldn't catch up for the changes of organization, network of energy and utilities, and revised assigning logic given by the active forefront. Then we could establish new logic in more generalized way, represented as type symbol: **Q** (Quota) applying the method of matrix series sum. Details and its principle are in Type Symbol: **Q**, Appendix II.

Fortunately experiencing the wider usability of this method to assign a common value to hierarchical organizations, this method as a part of large model was applied in many cases to assign head quarter cost or marketing staff cost, those of which are commonly thought to be fixed cost.

The idea of our method is simply explained with the number and data in Figure 6-28.

Lets assume the problem is given as hierarchical diagram as hierarchical organization and assigning yardsticks as follows.

❶ Top value to be distributed is given. (Top value can be given as plural values.)

❷ The relevant yardsticks for the assignment are given by their sales amounts.

❸ The relevant yardsticks are based on the number of employees.

❹ The relevant yardsticks are the numbers of the accumulated sold sets because of supply parts.

These yardsticks are given in the block of upper part as in ① and the hierarchical organization is given ②, thinking the upper as parent and the left as children and giving value **1** in the related positions.

The calculated results in ③ are expressed in the hierarchical diagram in assigned results.

6-8 Financial Models

Currently, many kinds of approaches specialized only for financial or accounting area of modeling are provided. Therefore, peculiar way of modeling will be introduced, from the following views.

- Giving *Visibility with Transparency* for the calculation logic (Avoid making black boxes)
- Providing a part of consolidated business structure model.

As characteristics of logic used here, Add and Minus are the main role, and are natively absorbed in the fundamental function of structure matrix without special efforts. The different points from current technology like simulation languages, spreadsheet and professional packages, are in the style and image of expression.

- Provide easy understanding of causal relations in details of logic and data as table or as combination of tables.
- Provide the possibility to grasp the complicated structure of business model as pile up of flat models, even in expression of hierarchical chain like consolidated group. So to speak, easiness of expressing logic of consolidated statement
- Provide the interface of background models like models of unit cost, models of production and activities, etc.

Following three model approaches are introduced.

- Principle of calculating model of balance sheet
- Principle of *inside out* model in consolidated hierarchy.
- An example of consolidated statement model

6-8-1. Principle of Calculating Model of the Balance Sheet

To introduce how to calculate the balanced values of some accounts in balance sheet, take a too simple example as in Figure 6-29.

The debit side		The credit side	
Fixed Assets	**40**	Liabilities	**60**
		Capitals	**30**
Current Assets	**60**	Profit	*10*
Debit total	*100*	Credit total	*100*

Figure 6-29 A Simplified Balance Sheet

Assuming the case that values with bold characters are given, then values in italic characters are required.

Structure matrix model by blocks with a scalar value

A method of Structure matrix model by blocks with a scalar value is shown in Figure 6-30, by describing the calculating logic one by one. In the figure, value 1 and -1 are given in stead of showing by type symbol: A or A (-1). (Type symbol: E or E (-1) can be also usable for operation of a single valued block.)

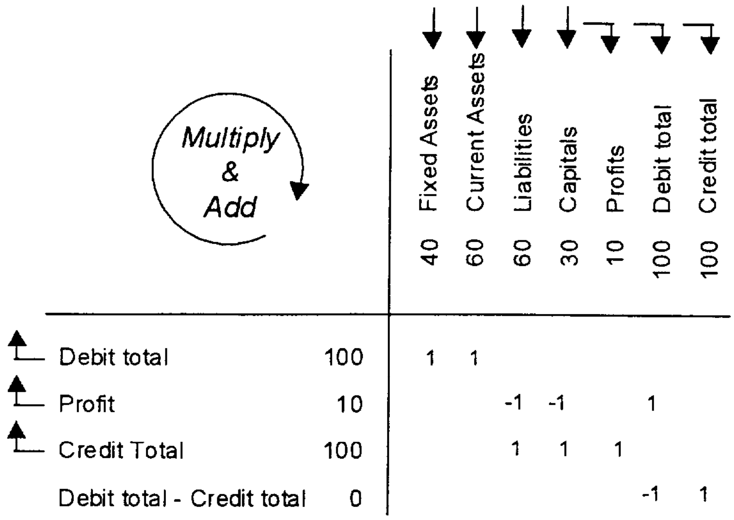


Figure 6-30 Calculate Balance Sheet Block by Block

A model using Type Symbol: **V** (Volute)

The previous method is a little complicated for modeling. Thinking that the calculation of balance sheet is composed of Add and Minus, the type symbol: **V** can be applied. Type symbol: **V** is prepared for the linear calculation with Multiply, Add and Minus in one center block. As internal logic, Type symbol: **V** calculates sum of matrix series, treating the data of center block as rectangular matrix. (As for details of principle, restriction and other applications, please refer Type Symbol: V, in Appendix II.)

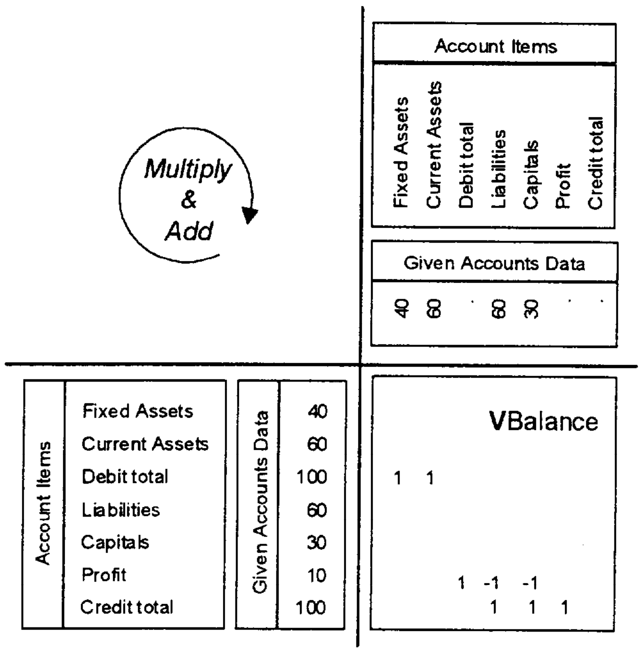


Figure 6-31 Balance Sheet Calculation by a Type Symbol: **V**

Therefore, prepare the same item block in upper and left and give initial accounts' values as in Figure 6-31.

To get the left item value, put 1 or -1 corresponding to the addition or deletion at the cross point of related positions to the upper items in the center block. In the actual cases of balance sheet calculations, type symbol: **M** for collecting input values in the accounts' position and separating the debit side and credit side, is applied as combined use with type symbol: **V**.

6-8-2. Principle of *INSIDE OUT* Model in Consolidated Hierarchy

For consolidating business structure models, Balance Sheet of their responsible business unit appears in many parts of different levels in the businesses' hierarchy as schematically shown in Figure 6-32. In this figure, the Balance Sheet treats only Assets, Liabilities and Capitals, representing the accounts' values.

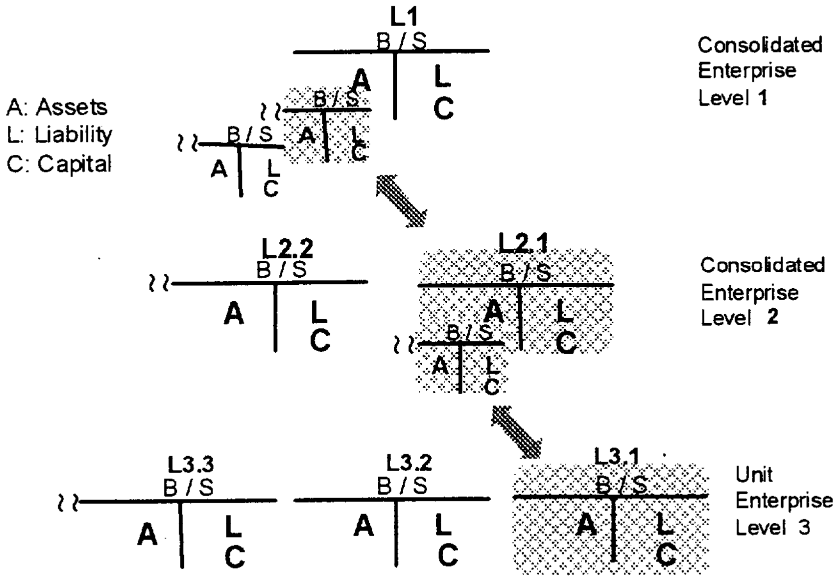
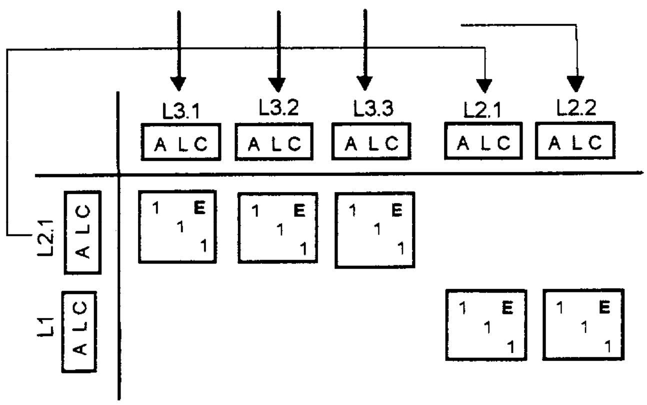


Figure 6-33 Hierarchical description of consolidated accounting structure

On the other hand, there are some management needs that some common account items must be summed up according to the specified accounting items and the public attentions such as Environmental Accounting, Accounting for Energy Savings, some ISO projects, etc.

Figure 6-33 Modeling the layer of Balance Sheet in Flat Structure



Beside reserving hierarchical organization as consolidated business models, a somewhat basic modeling function: *Inside Out* capable of taking out such accounting data on an ad hoc basis, must be provided without any special considerations beforehand.

For the typical example of consolidated accounting in Figure 6-33, each of the Balance Sheets must be arranged as a flat model, which contains hierarchical structures. An image of the model on structure matrix using type symbol: E is illustrated in Figure 5-5.

6-8-3. Example of Consolidated Statement Model

By the extended structure matrix technologies, models to calculate consolidated statements for the grouped company from each of financial statements and data of mutual relations can be easily described with visibility. In this sub-sub-chapter, the process model of the calculation for a simple company' group with data, will be followed.

The relation of companies within the group is as follows.

The representative company of the group:	Head Company		
Subsidiaries:	Company A, Company B, Company C		
Investment Relations	Head Company	→	Company A
		→	Company B
	Company A	→	Company B
	Company B	→	Company C

The purpose of this model is to grasp the financial status and periodic income as a group at the end of fiscal year 2000/3/31and as before the appropriation of the surplus.

As bases of the data of each financial status, following data is given in Figure 6-34 and simple adding up by type symbol: **H** is shown.

Each B/S before Consolidation

Each P/L before Consolidation

For the setoff and deduction, following data by the two dimensional tables are given in figure 6-35. In the figure, simple adding up by type symbol: **H** and **A** for getting gross totals and inter table calculations for getting *Unrealized Gross Profit of Inventories* are associated.

Relation of Capital Investment

Relation of Debts & Credits

Relation of Sales & Purchase Amount

Inventory among Mutual Transactions

Ratio set for Unrealized Gross Profit

The model is shown in Figure 6-36 and the hatched blocks in upper and left part are two dimensional tables. The details of center blocks in the model: B1, B2, B3, B4, B5, B6 as type symbol: B having values only 1, 0, -1 for arrangement of the consolidated Statements are shown in Figure 6-37.

As results of this model, Consolidated Statements of following three tables are shown in Figure 6-38.

Consolidated Balance Sheet

Consolidated Income Statement

Consolidated Earned Surplus Statement.

Each Balance Sheets before Consolidation

'2000/3/31

Consolidating Group

	Holdin Compan	Compan A	Compan B	Compan C		Simpl Sum
Cash	69,280	33,450	6,555	2,940		112,225
Notes Receivable	519,615	105,640	58,750	3,950		687,955
Inventories	588,895	174,305	246,925	38,970		1,049,095
Other Current Assets	111,535	86,270	28,945	10,350		237,100
< TotalCurrent Assets >	1,289,325	399,665	341,175	56,210		2,086,375
Buildings	508,270	105,640	72,000	21,650		707,560
Machinery & Equipments	223,865	123,245	25,500	12,990		385,600
Land	25,980	0	0	0		25,980
Vehicle & Delivery	103,920	10,560	6,600	4,760		125,840
Other Fixed Assets	103,920	4,400	4,250	1,700		114,270
< Total Fixed Assets >	965,955	243,845	108,350	41,100		1,359,250
Investments	130,000	60,000	3,400	100	H	193,500
<< Total Assets >>	2,385,280	703,510	452,925	97,410	⇒	3,639,125
Purchase Debt	502,290	154,935	187,320	17,320		861,865
Short-term Loans Payable	394,905	114,440	153,260	15,585		678,190
Other Current Assets	51,960	29,050	19,580	7,150		107,740
Long-term Loans Payable	277,125	110,000	74,075	17,300		478,500
Miscellaneous Allowances	277,125	86,270	27,670	17,250		408,315
Fixed Liabilities	155,880	40,220	5,530	11,300		212,930
< Total Fixed Assets >	710,130	236,490	107,275	45,850		1,099,745
Capital	500,000	85,000	10,000	3,500		598,500
Earned Surplus Reserve	41,565	10,500	1,000	430		53,495
General Reserve	7,530	25,000	2,500	4,300		39,330
Surplus Brought Forward	15,585	2,000	-4,900	1,905		14,590
Current Term Net Income	161,315	46,095	-23,110	1,370		185,670
< Capital Account >	725,995	168,595	-14,510	11,505		891,585
<< Total Liabilities & Capital>>	2,385,280	703,510	452,925	97,410		'3,639,125

Each Profit and Loss Statement before Consolidation

1999/4/01 ~ 2000/3/31

Consolidating Group

	Holding Company	Company A	Company B	Company C		Simple Sum
Sales	6,835,010	2,609,045	834,090	246,370		10,524,515
Cot	5	1,971,960	689,690	180,995		8,116,735
Gross Profit on Sales	1,560,920	637,085	144,400	65,375		2,407,780
Selling Expense	303,105	105,640	38,315	16,450		463,510
Administrative Expenses	917,985	396,150	102,175	45,850		1,462,160
Operating Profit on Sales	339,830	135,295	3,910	3,030		482,065
Non-operating Income	77,940	10,560	5,785	2,150	H	96,435
Income Deductions	95,260	29,930	32,355	2,075	⇒	159,620
Recurring Profit	322,510	115,925	-22,660	3,105		418,880
Extroardinary Income	29,440	5,105	680	45		35,270
Extroardinary Expense	18,185	6,150	1,060	200		25,595
Income before Tax	333,765	114,880	-23,040	2,950		428,555
Tax Reserve	172,450	68,785	70	1,580		242,885
Current Term Net Profit	161,315	46,095	-23,110	1,370		185,670

Figure 6-34 Given Data of Statements before Consolidation with Simple Addition

Relation of Capital Investment

Investor \ Invest	Head Co.	Co. A	Co. B	Co. C	H =>
Head Co.		85,000	5,000		90,000
Co. A			5,000		5,000
Co. B				3,500	3,500
Co. C					
A ⇓					98,500

Relation of Debts & Credits

Venders \ Purchasers	Head Co.	Co. A	Co. B	Co. C	H =>
Head Co.		242,485	37,235	10,390	290,110
Co. A	46,765		24,245	3,900	74,910
Co. B	2,035	850		32,905	35,790
Co. C			2,940		2,940
A ⇓					403,750

Relation of Sales & Purchase Amounts

Venders \ Purchasers	Head Co.	Co. A	Co. B	Co. C	H =>
Head Co.		1,082,530	753,440	3,050	1,839,020
Co. A	29,440		12,990		42,430
Co. B	4,900	5,885		32,905	43,690
Co. C	3,290	1,280	5,850		10,420
A ⇓					1,935,560

Inventries among Mutual Transactions

Venders \ Purchasers	Head Co.	Co. A	Co. B	Co. C
Head Co.		10,350	430	
Co. A	155,880		1,025	
Co. B	320,425	4,300		865
Co. C	90		7,750	

X

Ratio set for Unrelaized Gross Profit

Venders \ Purchasers	Head Co.	Co. A	Co. B	Co. C
Head Co.		0.24	0.24	0.24
Co. A	0.20		0.20	0.20
Co. B	0.18	0.14		0.20
Co. C	0.20	0.16	0.14	

||

Unrelalized Gross Profit of Inventories

Venders \ Purchasers	Head Co.	Co. A	Co. B	Co. C	H =>
Head Co.		2,484	103		2,587
Co. A	31,176		205		31,381
Co. B	57,677	602		173	58,452
Co. C	18		1,085		1,103
A ⇓					93,523

Figure 6-35 Data among the Group

		⇓	⇓	⇓	⇓	⇓	⇓	⇓	6	3	4	5	7	1	2	8	9	10	11
		Each B/S before Consolidation	Each P/L befor Consolidation	Relation of Capital Investment	Relation of Debts & Credits	Relation of Sales & Purchase Amount	Inventries among Mutual Transactions	Ratio set for Unrelaized Gross Profit	Unrelalized Gross Profit of Inven	capital Summed by Investers	Debts Summed by Venders	Sales Summed by Venders	Unrelalized Gross Profit by Vend	Simple Sum of B/Ss	Simple Sum of P/Ls	Total of Invested Capital in the Group	Total of Debts & Credit in the Groupl	Total of Sales in the Groupl	Total of Unrealized Gross Inventries in the Groupl
1	Simple Sum of B/Ss	H																	
2	Simple Sum of P/Ls		H																
3	capital Summed by Investers			H															
4	Debts Summed by Venders				H														
5	Sales Summed by Venders					H													
6	Unrelalized Gross Profit of Inventries						*	D											
7	Unrelalized Gross Profit by Venders								H										
8	Total of Invested Capital in the Group									A									
9	Total of Debts & Credit in the Groupl										A								
10	Total of Sales in the Groupl											A							
11	Total of Unrealized Gross Inventries in the Groupl												A						
	Consolidated Balance Sheet													E		B1	B2		B3
	Consolidated Income Statement														E			B4	B5
	Consolidated Earned Surplus Statement													B6					B7

Figure 6-36 A Model of Consolidated Statements

B6: Surplus

	Cash	Notes Receivable	Inventories	Other Current Assets	< TotalCurrent Assets >	Buildings	Machinery & Equipments	Land	Vehicle & Delivery	Other Fixed Assets	< Total Fixed Assets >	Investments	<< Total Assets >>	Purchase Debt	Short-term Loans Payable	Other Current Assets	< Total Current Assets >	Long-term Loans Payable	Miscellaneous Allowances	Fixed Liabilities	< Total Fixed Assets >	Capital	Earned Surplus Reserve	General Reserve	Surplus Brought Forward	Current Term Net Income	< Capital Account >	<<Total Liabilities & Capital>>
Surplus Brought Forward																								1				
Current Term Net profit																									1			
<< Total >>																								1	1			

B7: Profit_Res e for Unrealized

	Group Tota
Surplus Brought Forward	
Current Term Net profit	-1
<< Total >>	-1

	B1	B2	B3
Cash			
Notes Receivable		-1	
Inventories			-
Other Current Assets			
< TotalCurrent Assets >		-1	-
Buildings			
Machinery & Equipments			
Land			
Vehicle & Delivery			
Other Fixed Assets			
< Total Fixed Assets >			
Investments	-1		
<< Total Assets >>	-1	-1	-
Purchase Debt		-1	
Short-term Loans Payabl			
Other Current Assets			
< Total Current Assets >		-1	
Long-term Loans Payable			
Miscellaneous Allowances			
Fixed Liabilities			
< Total Fixed Assets >			
Capital	-1		
Earned Surplus Reserve			
General Reserve			
Surplus Brought Forward			
Current Term Net Incom			-
< Capital Account >	-1		-
<<Total Liabilities & Capita>	-1	-1	-

	B4	B!
Sales	-	
Cost of Sales	-	
Gross Profit on Sales		
Selling Expense		
Administrative Expenses		-
Operating Profit on Sales		
Non-operating Income		-
Income Deductions		
Recurring Profit		
Extroardinary Income		-
Extroardinary Expense		
Income before Tax		-
Tax Reserve		
Current Term Net Profit		

Figure 6-37 Data of Center Blocks

Consolidated Balance Sheet

2001/12/31

Cash	112,225
Notes Receivable	284,205
Inventories	955,572
Other Current Assets	237,100
< TotalCurrent Assets >	1,589,102
Buildings	707,560
Machinery & Equipments	385,600
Land	25,980
Vehicle & Delivery	125,840
Other Fixed Assets	114,270
< Total Fixed Assets >	1,359,250
Investments	95,000
<< Total Assets >>	3,043,352
Purchase Debt	458,115
Short-term Loans Payable	678,190
Other Current Assets	107,740
< Total Current Assets >	1,244,045
Long-term Loans Payable	478,500
Miscellaneous Allowances	408,315
Fixed Liabilities	212,930
< Total Fixed Assets >	1,099,745
Capital	500,000
Earned Surplus Reserve	53,495
General Reserve	39,330
Surplus Brought Forward	14,590
Current Term Net Income	92,147
< Capital Account >	699,562
<<Total Liabilities & Capital>	3,043,352

Consolidated Income Statement

2000/1/1-12/31

Sal	8,588,955
Cost of Sales	6,181,175
Gross Profit on Sales	2,407,780
Selling Expense	463,510
Administrative Expenses	1,462,160
Operating Profit on Sales	482,065
Non-operating Income	2,912
Income Deductions	159,620
Recurring Profit	325,357
Extraordinary Income	35,270
Extraordinary Expense	25,595
Income before Tax	335,032
Tax	242,885
Current Term Net Profit	92,147

Consolidated Earned Surplus Statement

2000/1/1-12/31

Surplus Brought Forward	14,590
Current Term Net profit	92,147
<< Total >>	106,737

Figure 6-38 Consolidated Statements

For easier expression of the model, and for shorter understanding, calculating logic is simplified.

7. Applied Cases

The intention of this chapter is to introduce how the Business Structure Models based on structure matrix technology was applied in business site. However, the project sizes of each are so big that even a single applied case would be commensurate with a volume of single paper having business histories. In addition, most applied cases are kept confidential because of competitive situation and needs of concealment at the definite stage of planning to protect from negotiating and organizational conflicts.

The facts that these new technologies are almost kept closed, above all the applied logic is easily leaked out by the openness of the models. Only ten to fifteen cases are openly reported.(Titles of papers and newspaper announcements are listed in the reference list though almost of them are Japanese names.)

In this chapter, after general view of applied cases, a case with actual figures used for the verification of this technology in infant age will be introduced rather deeply. A few cases will be briefly introduced from the point of typical ones moreover from the unexpected applying.

7-1. Overview of the Applications

According to my hazy recollection, the counted numbers of introduced cases, which categorized by industry and major coverage of application along the long devotion in this area, are shown in Table 7-1. (Note: the numbers in parentheses are in Korea.)

Some characteristics can be read out from the table as follows.

- Inclined propagation along industries

  Numbers in industries show propagation path from process, manufacturing and financial industries. The start was steel industry and propagated to other process industries like chemical, paper, etc. Following the introduction into manufacturing industries, it was introduced to the aggressive customers in financial industries. The step was industry after industry, crossing over high partitioning wall between industries. This phenomenon might be caused by the following reason.

  - Sectioning of the computer supplier's organizations
  - Earlier establishment of online production systems and strong requirements of establishing new effective and dynamic management system through the experience of oil shock I and II.
  - Complexity caused by non-homogeneity of products and process business with professionalism in managing activities.
  - Users' indifferent attitude against other industries' applications, stating their own specialties
  - Toyama's personal background in industry. Maybe this is the biggest reason
- Cost structures involved

  Most of these models involved unit costs as elements, except the systems limited only in financial statements. Even bank systems and personnel systems involved unit cost elements.

Industry		Manufacturing	Process	Distribution & Service	Finance	Government & Public Sector
Corporate Planning・Actual Reporting	Mid-Range Profit Planning & Budgeting	2+(1)	1	1		
	Yearly or Halfyear Profit Planning / Budgeting	4	5		4+(1)	1
	Quarter or Monthly Planning	4	3	4	1	(1)
	Including Actual Consolidate Statements	2+(1)				1
Independent Division or Departmental Planning		2	2	1		
Plant System	Production / Production Balance Planning	2	2	1		
	Production & Cost Planning	2	10+(2)			
	Cost Management	1+(2)	1			
	Utilities etc		2			1
Marketing Planning System		1	1			
Cost Estimate for Marketing		3+(3)				
System Integrator's System		5				
Personnel Planning & Wage System		2				
Education & Research in Univ		6+(10)				

Table 7-1. Categorizing of Applied Cases by Systems

- The start of the introducing opportunity

  There were no definite analysis data for starting. However, followings with their combination could be pointed out as major points.

  - Pursuit of new methodology responding the quick decision making was driven by top requirements

    The dissatisfaction of top management was very strong for applying the overload of sheer force of numbers.

  - Deadlock of the expansion and maintenance of the system developed by spreadsheet.

    Half of the introduced cases would be derived from this reason.

  - Requirements of integration and recombination of planning chaining large volume of data.

  - Maintainability by end users as a nature of extensive change of logic and data.

    Many maintenance efforts were paid by information processing department to respond end users' application logic changes.

  - Needs of quick development in short period

The details of the implemented cases are introduced in the paper in the Reference List of this thesis.

The common messages we could hear from these implemented cases were as follows.

- By having BSM, their targeting and follow up of business goals were shifted toward more logical thinking oriented.

  In the past, the target of cost reduction was likely to be given by top down without firm logical foundations rather arbitrary as spiritual slogan. In some businesses, top management had set the cost down target as 10 % without clear organizational assessment based on secure foundations. By this direction, the related activities like financing had shifted to the level assuming realized status of the target. At the term-end, top management found the unfulfilled status. Sometimes this brought the reason of cost ups. Some times these unhealthy cycles were repeated.

  By grasping total business mechanism base on BSM and through the case studies on the BSM, promising targeting with some prompting was realized as organization. Some people say this is management accounting. The writer is thinking the more.

- The total optimization can be realizable are more than the consolidation of partial optimization.

  As natural, businesses are based on the collaboration of peoples and organizations that have different background and missions.

  The implemented accounts insisted that the wider coverage of BSM with various combinations of the case study clearly gave the merit of BSM.

- The birth of new paradigm to communicate each others

  The introduction of BSM produced the chance to understand the mechanism of the business and communicate each other brought by its *Visibility with Transparency*.

Three cases introduced in this chapter are the typical cases which might pursue the BSM technologies to their ultimate levels.

7-2. Case I. Cost Management System in Company A

This is a report of implemented case in Company A briefed by the writer.

Company A case had been the full-scale project to establish structure matrix first in Japanese business, composed of the following main subjects.

- Jointing the academic studies of German technologies enough for full-scale adoption in business.
- Verification of consistency in calculation by new approach VS traditional method
- Implementation covering whole integrated works.

From the side of main theme of this thesis, this sub-chapter is concentrated on the practicality of structure matrix as BSM. Therefore, data of new cost models used for verifying the consistency with traditional cost system will be introduced in Appendix IV.

7-2-1. Environments and Brief History of Cost Management System

Company A had two major integrated iron and steel works and this thesis is a case for the works having major process of ore bedding and processing, blast furnace, steel making, casting, rolling and finishing, power plant, . etc., and making wire rod and bar steel as one of the world leaders.

The cost calculation systems were computerized and were covering the whole works from the end of 1960 to the end of 1970. However, the system was gradually loosing their flexibility among ten years. The company experienced the first oil shock in 1973. During the period, the company organization faced severe conditions to grasp the business performance, because confusion was caused by the change of standard costs in the traditional cost system. The company was driven to change their standard cost in the middle of fiscal year. This means was taken for remedy of big gaps between the planned standard cost and the jumped actual cost caused by chained reaction of the steep rise in crude oil. As natures of the products' diversity and complex processes, standard cost system was established as a base of the cost management system. However, maintaining of traditional cost system that had been the substitution of hand calculation by program became difficult.

In addition, as a nature of the business, versatile cost information was required from the following points

- Cost Down
  - Energy savings
  - Rearrangement of production facilities
  - Conversion to high performance facilities
  - Labor savings, etc.
- Profitability of Products
  - Responding the users' requirements for product diversification and grade-up of qualities.

Under such situation, the company began to consider the methodologies to solve their problems. Fortunately in 1976, they reached the writer who had already started his surveying of the German documents: COSTMAT Series.[IBM Deutch..., 1977].

(Note: COSTMAT was issued as fruits of joint research reports of German Steel Co.: HOESCH, German Iron and Steel Federation and Bochum University about cost management system applying structure matrix.)

Soon joint study was organized for understanding them. However, it was difficult for exact understanding to let the big business make up their mind to new system. Fortunately, one year and a half after, the writer encountered the study of Professor: T. Kobayashi, Administration School of Kobe University who had learned in Germany and kept the continued study of this area. Soon we jointed together and our study went on exactly.

After finishing the study, we met an opposition from one of the higher accounting controllers for our replacement plan instead of traditional systems. The reasons were as follows.

- Matrix was difficult to fit in with accounting people.
- New method might calculate strange cost and would violate the accounting rule of *continuity*.

For restoring these problems, proof tests of the coincidence against the results of both methods were performed using real 2000 data taken from steel making and ingot processing of the early nineteen sixties. The ingot processing was outdated and to be replaced soon by continuous casting process.

(Note: The studied model and data will be shown later in this sub-chapter and Appendix IV)

Luckily, the calculated total costs coincided and there was no objection. The top management admitted the superiority of easiness in the describing complicated factors. Then overall introduction to the works was hastened from cost center to cost center, starting from the front processes that were thought to be easy to implement because of smaller data volume.

7-2-2. The Back Ground of Development of New Cost Management Systems

The background to request the new cost management system had been as follows.

- Providing the cost information depending on the upheavals was caused by external factors.

  Grasping of cost information, depending on the change of purchasing prices and drastic change of operating capacity in processes was necessary.

- Cost information to meet the pursuit of the product having high added values

  Under the exacting change of market, the products were driven to be high-quality articles and characteristics of production were driven toward multiple kind with small lot. As a matter of course, introduction of new technologies and improvement of processes became common and influential cost factors were becoming versatile. Grasping of cost information must have been synchronized this status.

- Cost information to meet the diversification of values and their sudden changes

  Under the rapid changes of economic environments, unifying the sense of values to one direction was not favorable and grasping of cost information from the various viewpoints was required.

Thinking of these requests, methodologies to enrichment directed the following items.

- Make distinct the responsibility of the cost
- Make the management aim clear
- Stimulate managing efforts and motivations

Problems of cost management system at that age

The works had been placed great importance on the development of production control system and the cost management systems were fragmentally maintained after the development of standard cost calculation system. Therefore, chaining of the system was left unsatisfactory and lacked flexibility, then the following problems were carried.

- Limits in breaking down of decomposing and analyzing the cost variances
  - Increase in number of materials, number of operating capacity treated, and number of product-mixed

    The systems were developed at the age of full capacity, and in the precondition of system development, big swing of operation capacity was out of consideration.
  - Generous bundling of kinds for cost calculation

    By the complication of increased products' kinds and transiting process, calculating unit of cost was on increase. Then from the point of managing and operating cost systems, rough bundling must be adopted.
- Lack of flexibility in cost systems

  Various changes in their environment were anticipated and the requirements for various improvements would increase. However, the following reasons cornered counter measures.
  - Immoderate dependence to program logic

    Major parts of the system were processed by program logic without fully utilizing table technique limited by the computer capacity at the age of development stage.
  - Inadequate documentation of system development's specification

    System specifications and program specifications were not well maintained following the systems' changes
  - Deterioration of abilities to master their cost systems caused by reshuffling of the person in charge

    The ideas at the time of system developments and improvements and the preconditions were not well inherited for the end-users' and information system's organizations.
- Lack of abilities to respond special cost studies

  For responding the requirements to grasp various costs, the frequency of special cost studies became intense, and computer system of the ages could not deal them. There were limitations in the remedy because of the sheer force of numbers. Those sample cases of special cost studies were as follows.
  - Grasping the composition of cost at the final products by first stage of input elements like material cost, labors cost, expenses, etc.
  - Cost comparison for finding profitable products and their most suitable combinations
  - The estimation of the relevant cost and tracing of those actual responding the quotation and cost down

movements

- Compensation unbalanced burdening cost caused by the unbalanced facilities
- Calculate target cost (mid-range plan) to be budget cost by the term

7-2-3. Outline of Implemented New Cost Management System

The relative position of the new cost management system is placed in the hook-shape as in the Figure 7-1. The column in the right means authorized process based on Japanese GAAP (Generally Accepted Accounting Principle) and special cost studies. Horizontal part means effective use of cost system for cost oriented managing covering almost all the works activity linking non-monetary factors.

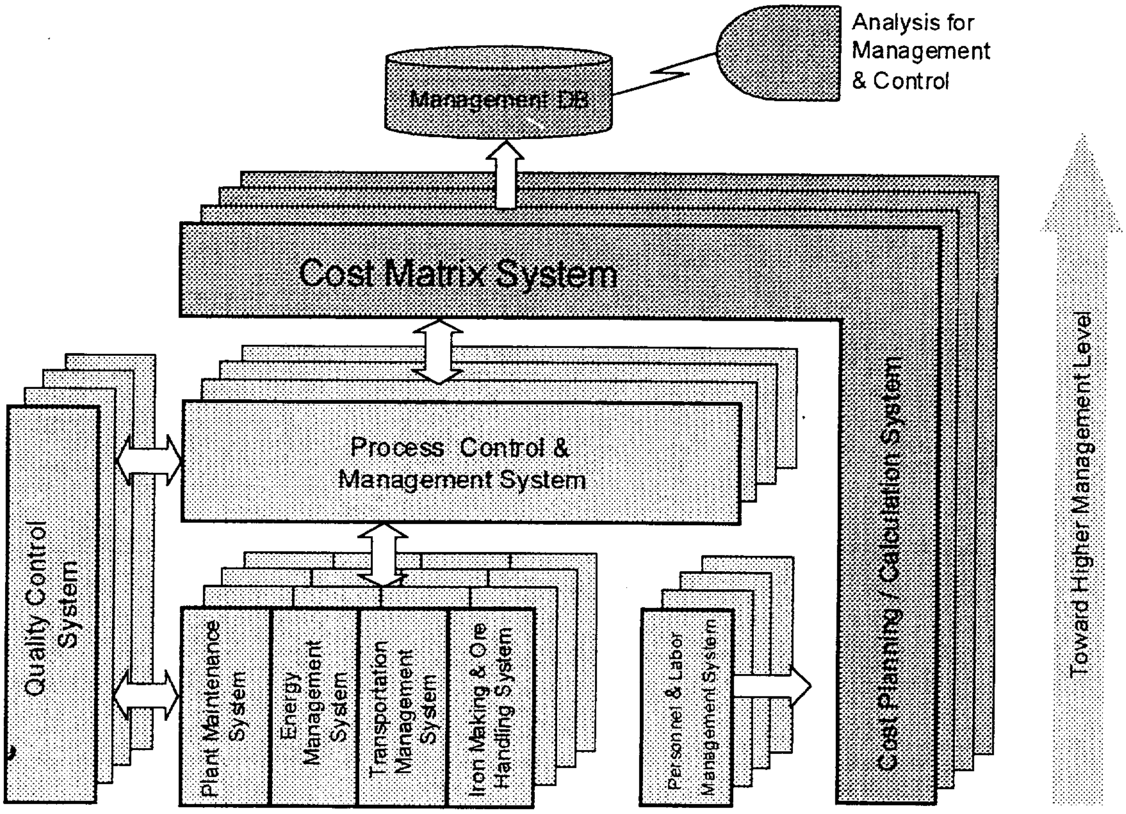


Figure 7-1 Cost System as Management System in the Integrated Steel Works

The system was developed aiming following points considering the previous situations.

- Grasping cost from various angles by the coexistence of various kind of cost calculation like Standard Cost System and special cost study system
- Calculate various kinds of unit cost like *by kind of various and mixed factors* (by product-mix, by semi-finished product-mix, by process cost-mix, etc.)
- Evaluation tracing the time series changes with displaying of them in time series
- Keeping consistency of calculation system between the actual and the plan

- Provide trial calculation systems based on the same mechanism for keeping the consistency with the actual
- Realizing cost management system as all the staffs' participation
- Clarification of responsibility for cost management cost (Imputed values to imputed organization)

They developed thirty systems covered almost of works by the unit of cost centers. Taking an example in steel making, the diagram of material flow and processing consumption (Auxiliary material consumption like oxygen, steam and fuel, tools consumption like ingot cases and other auxiliaries, processing hours, etc.) would be given as in Figure 7-2.

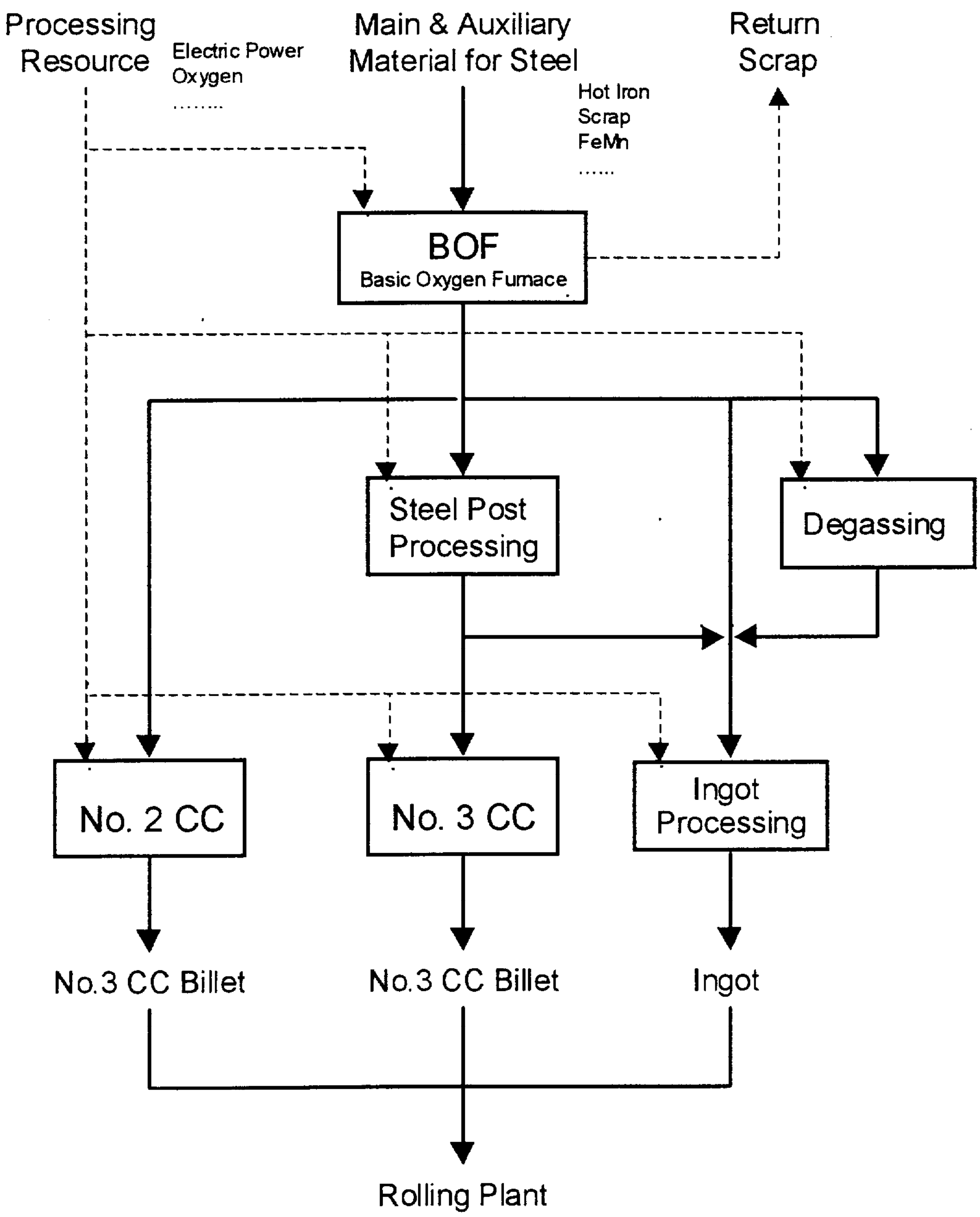


Figure 7-2 Flow of Material and Processing Consumption

							Quantity Se		Ingot Process				No.2 CC		No3 CC		Steel Post Process				Degassi		BOF				Influence Variable
							PI	A1	S1	Z1	Y1	T1	S2	Z2	S3	Z3	S4	Z4	Y4	T4	S5	Z5	S8	Z8	Y8	T8	X1
		Fixed Processing Unit Cost						FA1	FS1	FZ1	FY1	FT1	FS2	FZ2	FS3	FZ3	FS4	FZ4	FY4	FT4	FS5	FZ5	FS8	FZ8	FY8	FT8	
			Variable Processing Uni					VA1	VS1	VZ1	VY1	VT1	VS2	VZ2	VS3	VZ3	VS4	VZ4	VY4	VT4	VS5	VZ5	VS8	VZ8	VY8	VT8	VX1
				Material Unit Cost				MA1	MS1	MZ1			MS2	MZ2	MS3	MZ3	MS4	MZ4			MS5	MZ5	MS8	MZ8			
					Planne Quantity			QA1	QS1	QZ1	QY1	QT1	QS2	QZ2	QS3	QZ3	QS4	QZ4	QY4	QT4	QS5	QZ5	QS8	QZ8	QY8	QT8	
						Item	K52	K03	K03	K04	K05	K06	K03	K04	K03	K04	K04	K04	K11	K12	K04	K04	K04	K32	K19	K20	K52
Ingot Process	S1	FS1	VS1	MS1	QS1	K03		B S1A1																			
	Z1	FZ1	VZ1	MZ1	QZ1	K04			E																		
	Y1	FY1	VY1		QY1	K05			B Y1S1																		
	T1	FT1	VT1		QT1	K06					R T1Y1																
No.2 CC	S2	FS2	VS2	MS2	QS2	K03		B S2A1																			
	Z2	FZ2	VZ2	MZ2	QZ2	K04							E														
No.3 CC	S3	FS3	VS3	MS3	QS3	K03		B S3A1																			
	Z3	FZ3	VZ3	MZ3	QZ3	K04									E												
Steel Post Process	S4	FS4	VS4	MS4	QS4	K04				B S4Z1						B S4Z2											
	Z4	FZ4	VZ4	MZ4	QZ4	K04											E										
	Y4	FY4	VY4		QY4	K11											B Y4S4										
	T4	FT4	VT4		QT4	K11													R T4Y4								
De-gassing	S5	FS5	VS5	MS5	QS5	K04				B S5Z1																	
	Z5	FZ5	VZ5	MZ5	QZ5	K04																					
BOF	S8	FS8	VS8	MS8	QS8	K04				B S8Z1				B S8Z2				B S8Z4				B S8Z5					
	Z8	FZ8	VZ8	MZ8	QZ8	K32																	R Z8S8				
	Y8	FY8	VY8		QY8	K19																	B Y8S8				
	T8	FT8	VT8		QT8	K20																			R T8Y8		
Influence Variable & Consumption	X1	FX1	VX1		QX1	K52			B X1S1			B X1T1	B X1S2		B X1S3		B X1S4			B X1T4	B X1S5		B X1S8			B X1T8	
	V1		VP1		QV1	K81	R V1PL																				R V1X1

Notations of type symbols:

B: Bool (1 or 0), E: Each (Diagonal Value are 1), R: Reciprocal of Yield

Notations in margin parts

A: Set up quantities S: Producing quantities Z: Input quantities

Y: Influence variable for calculating required hours T: Required hours

X: Influence variable for calculating processing resources

PL: Length of plan period

V: Unit cost by each cost center

Figure 7-3. Structure Matrix of Steel Plant

From this diagram, staff of the works developed the model as shown in Figure 7-2-3 for the cost center for steel making. Only thirty or so of model sheets with associated diagram sheets for each were developed covering the cost structure of the entire cost center in the works.
In the Figure 7-3., there are four strands occupying upper and left parts.
Followings are those having associated calculating directions with the center part's elements.

- Planned Quantity	Vertically Multiply and Horizontally Add
- Material Unit Cost	Horizontally Multiply and Vertically Add
- Variable Processing Unit Cost	Horizontally Multiply and Vertically Add
- Fixed Processing Unit Cost	Horizontally Multiply and Vertically Add

Quantities and each type of unit cost on each strand were read out according to the associated calculation direction and programmed by matrix language (MATSYS) rather by rote. Then the programs were compiled and executed for calculation. Details of calculation would be described in Appendix IV with simplified model and data, which was used for the verifications.

7-2-4. Effects by Introducing New Cost Management System

Following effects were enumerated by users..

- Breaking away from the black box of system
  - Tangibleness of the calculation process (Transparency of system)

    Because the elements and calculating sequences on the Models were systematically placed, the meaning and processes are easily comprehensible.
  - Enrichment and advancement of the documentation of system

    Models themselves on the structure matrix were the documentation themselves (As system specification and program specification), moreover, standardization could be pursued by the systematic development of models having common shape for cost centers and each process facility.
- Unification of systems
  - Unification of calculating logic covering all the process of integrated works

    Cost calculation of processes starting from iron making and steel making to shipping, could be unified by each process.
  - Sharing use of common models

    Common models could be used sharing between plans and the actual, and between standard cost calculation and special cost studies, by replacing the output quantities to be given or by replacing the ratio of mixtures. Therefore, cost calculations for multiple purpose could be performed.

Upon these merits, the following merits were brought.

- Management using unit cost

  Along the calculating process, unit costs by elements were calculated in each process as a nature of model on structure matrix. Consequently, unit costs by each product as final output of product lines could be calculated.

- Distinction of cost variances and imputed values

  By using the same model, *plan and actual* were calculated and the cost variances by cost factors were precisely analyzed. Studies about the possible distinction of those cost variances were written in the next sub-sub-chapter.

- Responding the multi-purpose requests

  Trial calculation, special cost studies and cost estimation could be performed, by replacing the input quantities and ratio of the mixture by process facilities.

- Increase in the productivity of data processing organization

  They were released from voluminous workload for documentation at the time of development and improvement, because the models on structure matrix could be used also as documentation.

7-2-5. Cost Variances

As some of the big efforts in the study of new cost management system, various types of *Cost Variances* could be calculated consistently. The following are formulas, responding the covered area of steel making cost center.

Variance of Manufacturing Cost = Variance of material cost
+ Variance of variable processing cost
+ Variance of fixed processing cost

(Note: Variance of Operating Profit = Variance of Sales Volume
\+ Variance of Term-end Inventory
\- Variance of Beginning Inventory
\- Variance of Manufacturing Cost
\- Variance of Selling Expense
\- Variance of Administrative Expense)

Following variances for three types of cost between plan and actual, became consistently possible to report.

- Variances of material cost by main and auxiliary materials' brand (i), by grade hot steels (j), and grade ingots (k), could be calculated as follows.
  - Variance caused by material costs (i)
  - Variance caused by mixed quantity of materials (j)

    Variance caused by mixing ratio of materials based on the actual (i, j)

    Variance caused by mixing ratio of materials based on the plans (i, j)
  - Variance caused by yield of grade Ingots (j, k)
  - Variance caused by distribution ratio of grade ingots produced (k)

- Variance caused by production quantities of grade steel (k)

- Variance of variable processing cost by expense items and grade ingots (i), could be calculated as follows.
    - Variance caused by processing unit cost (i)
    - Variance caused by unit consumption (i, j)
    - Variance caused by processing hour (k)
    - Variance caused by distribution ratio of intermediate goods (k)

      ....Grade Ingot or Grade hot steel
    - Variance caused by production quantities of intermediate goods (k)
- Variance of fixed processing cost could be calculated as follows.
    - Variance by unit of operation ....Hours of ingot processing or BOF hours
    - Operation variance:

      Operation variance by intermediate goods (i)

      Variance caused by distribution ratio of intermediate goods (i)
    - Variance caused by production quantities of intermediate goods (I)

7-3. Case II Aggregated Model of Integrated Steel Works in Company B

This subchapter is prepared to introduce the aggregated model in the world class integrated iron and steel works. This model was operated as an associated system with the main line of the production and cost management system in which structure matrix technology was introduced. The works has introduced structure matrix entirely and the introduction had a significant impact on the plant operation. However, already similar case was discussed in Case I, previous subchapter of this thesis. Therefore, this subchapter will start from the aggregating of models and their integration as total model around material flow and material, based on the status that their production and cost management system were already established as shown in Figure 7-4[Sugiura, H., et al, 1989][Sugiura,H. et al, 1983]

As in Figure 7-5, given material flow was analyzed as block diagram with matrix: [R], [S], [B] and [G]. Usually material requirement model was built tracing inversely along material flow.
In this figure, following details must have been discussed from the side of characteristics of facilities, because the parallel flows or some minute branches of flows were structured around paralleled facilities. For example, blast furnace block contained plural blast furnaces, and most of the cases, their physical specifications and performances were different each other. These situations were also found in or bedding, sintering, BOF, Hot strip mill, etc. [B] and [G] were used for such parallel relations.

- Symbol: [R]

  This was a representation of reciprocal matrix and used for convert use of yield matrices. In these contents, such parallel characteristics were described.

- Symbol: [S]

  This type symbol was used as coefficients in calculating material requirement for given output.

- Symbol [G]

  This matrix gave the ratio that decides the providing upstream material's quantities to next process from multiple facilities.

- Symbol [B]

  This matrix decided the destination of materials to next process from the output of previous facilities, used against the material flow in the style to bundle the input materials of next process gathered for output material to next.

- Transferred values from each structure matrix

Most case, such matrix values representing facilities' operating values were brought from original structure matrix model, or once aggregated and brought from original model with the same logical operation. For an example, blast furnace had plural air-re-heating furnaces as attached facilities and this performance was influential to the performance of main furnace. As another typical example, plate mill had a main rolling mill with its attached finishing facilities. Those were modeled once as structure matrix models then these were aggregated to a single matrix and brought to another structure matrix model like Figure 7-6.

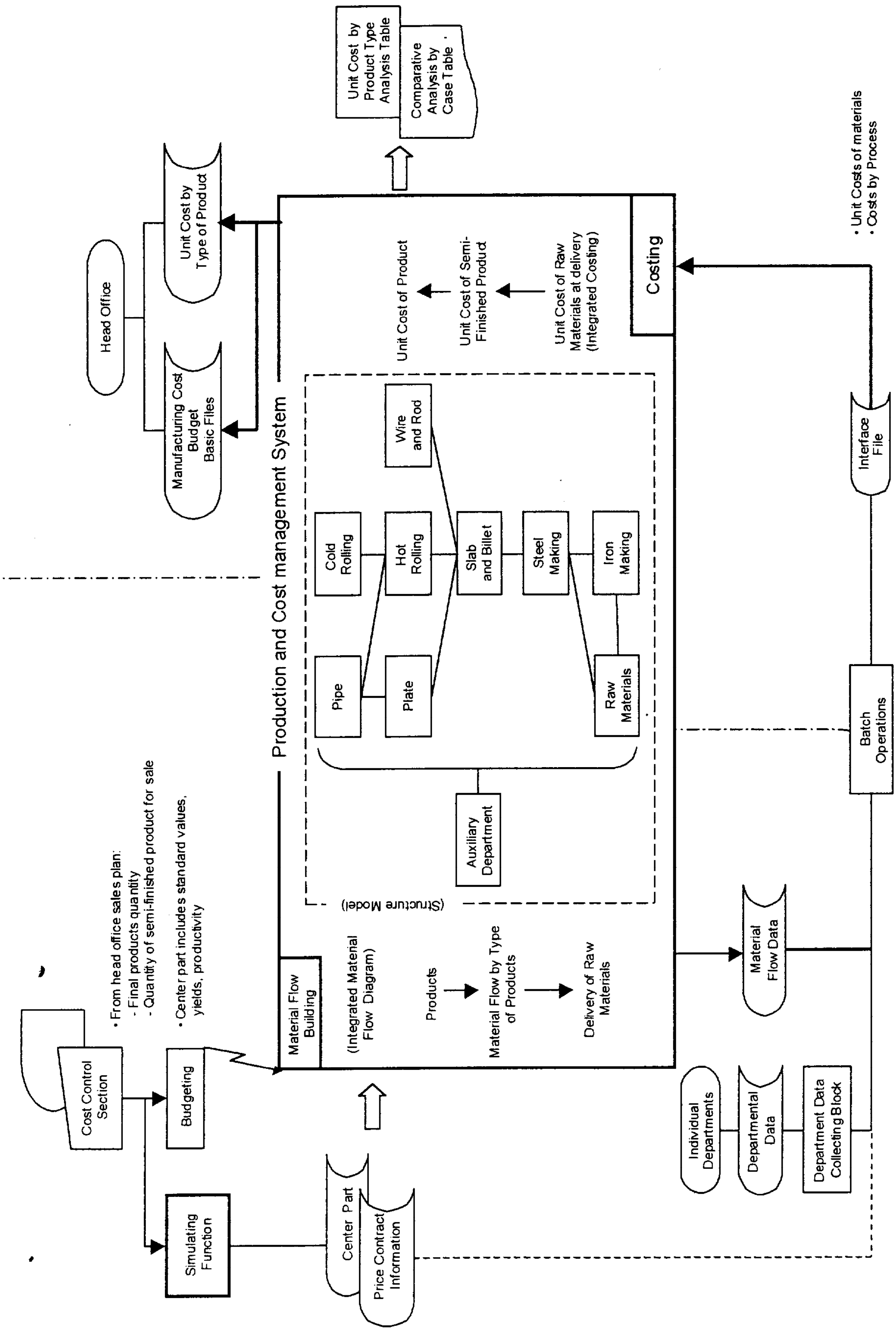


Figure 7-4 Production and Cost management System in a Integrated Works

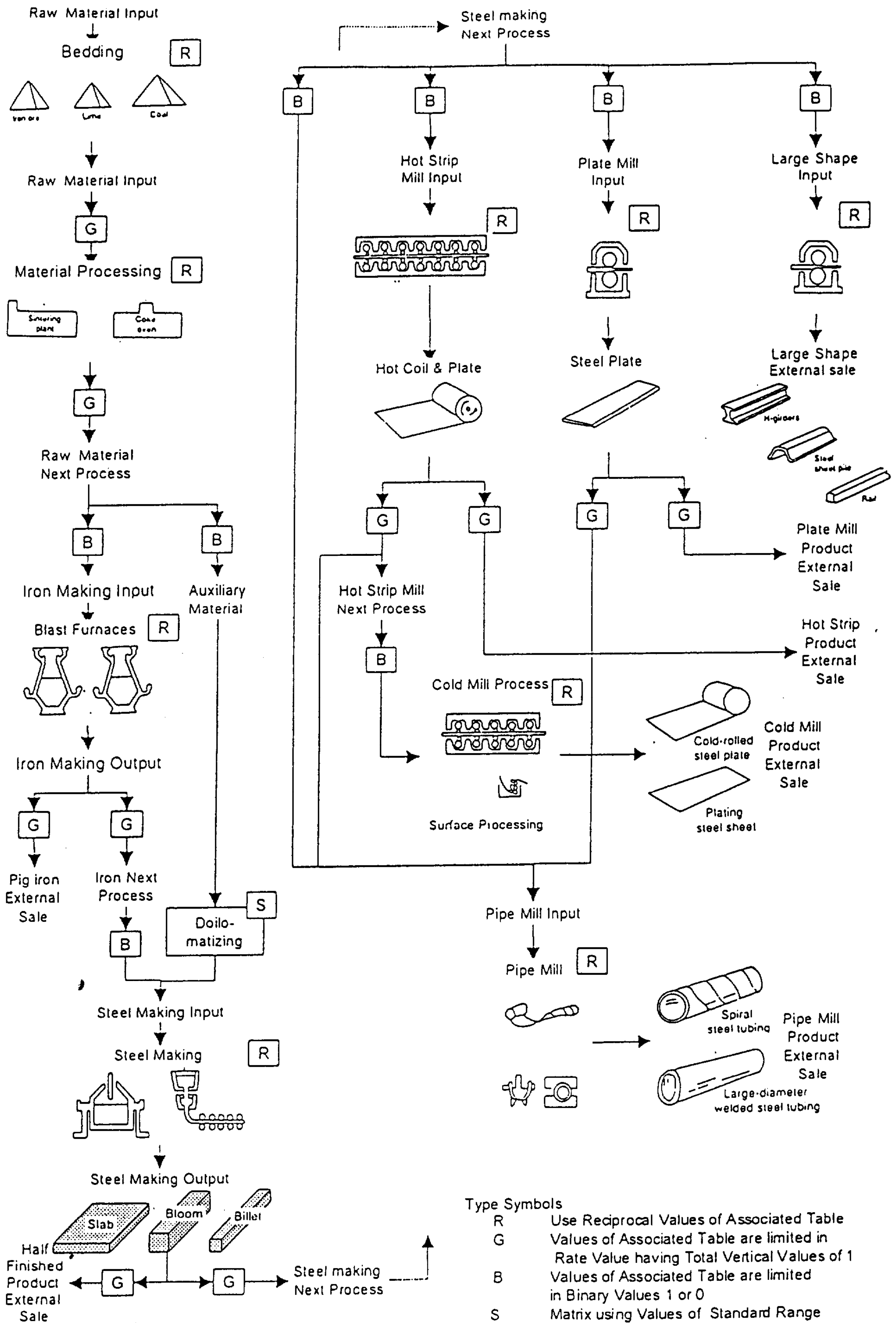


Figure 7-5 Block diagram of Material Flow in Integrated Iron and Steel Works

The meshed blocks: S1 ~ S7 at the bottom of the figure, were aggregated matrices, which were conventionally borrowing the Material flow model. About principle of aggregation, please refer 3-2-7 Advanced Functions in this thesis.

By the principle written in the advanced function, aggregated matrix could be calculated by specifying from (upper part) and to (left part) in the single structure matrix. As concrete operation in current package, by pointing the horizontal position in upper part and vertical position in the left part on the screen, the aggregated matrix was calculated, if theoretically existed.

Then, the aggregated matrix with associated blocks was newly reserved by the new structure matrix name. The model was thus made as shown in Figure 7-7 by integrating the total input material's requirements, each material unit cost by end products, total material cost by end products and grand total of material cost.

Some technical reviews of this method

- S1~S7: Reciprocal matrix of integrated yields

  To calculate accumulated yield (Ikkann budomari) was almost practically impossible by traditional methodologies in such complicated plants. Because, the traditional development depended on individual approaches with program development, and in addition, took considerable periods. During the development, precondition fluctuates and fixing of condition for developments became meaningless. If each model for cost centers was made, development and maintenance of integrated aggregation model were only a work of manual operation.
- Linear model and extensions

  If only the linear relations were linked along the calculating path, this type of aggregation was possible. Recently, by the software approach, the path including type symbols '*' and '/' was to be realized possible now, because the conditions that the calculation of the structure matrix was once executed and calculated results were reserved.
- Aggregation at discretion

  Required aggregation between some starting points and destinations could be possible if mathematical relation is established as option.
- Aggregated model for processing factors' consumption and these unit cost

These models could be developed by the same approach..

		⇩ Cold Mill Product External Sale	1 Cold Mill Input	⇩ Pipe Mill Product External Sale	2 Pipe Mill Input	⇩ Large Shape External Sale	3 Large Shape Input	4 Hot Srip Mill Next Process	⇩ Hot Srip Mill External Sale	5 Hot Coil & Plate	6 Hot Strip Mill Input	7 Steel PlateNext Process	⇩ Plate mill Product External Sale	8 Steel Plate	9 Plate Mill Input	10 Steel making Next Process	⇩ Half Finished Steel External sale	11 Steel making Output	12 Steel making Input	13 Auxiliary Material	14 Iron Next Process	⇩ Pig Tron External Sale	15 Iron Making Output	16 Iron Making Output	17 Raw Material Next Process	18 Raw Material Output
1	Cold Mill Input	R																								
2	Pipe Mill Input			R																						
3	Large Shape Input					R																				
4	Hot Srip Mill Next Process		B		B																					
5	Hot Coil & Plate							G	G																	
6	Hot Strip Mill Input									R																
7	Steel PlateNext Process				B																					
8	Steel Plate											G	G													
9	Plate Mill Input													R												
10	Steel making Next Process				B		B				B				B											
11	Steel making Output															G	G									
12	Steel making Input																	R								
13	Auxiliary Material																		S							
14	Iron Next Process																		B							
15	Iron Making Output																				G	G				
16	Iron Making Output																						R			
17	Raw Material Next Process																			B				B		
18	Raw Material Output																								G	
19	Raw Material Input	S1		S2		S3			S4				S5				S6					S7				R

Figure 7-6 Material Requirement Model of Integrated Iron and Steel Works

		⇓ Cold Mill Product External Sale	⇓ Pipe Mill Product External Sale	⇓ Large Shape External Sale	⇓ Hot Srip Mill External Sale	⇓ Plate mill Product External Sale	⇓ Half Finished Steel External sale	⇓ Pig Tron External Sale	1 Raw Material Input	⇓ Unit Cost of Raw Material Input	2 Unit Cost of Cold Mill Product External Sale	3 Unit Cost of Pipe Mill Product External Sale	4 Unit Cost of Large Shape External Sale	5 Unit Cost of Hot Srip Mill External Sale	6 Unit Cost of Plate mill Product External Sale	7 Unit Cost of Half-Finished Steel External sale	8 Unit Cost of Pig Tron External Sale	9 Total Cost of Cold Mill Product External	10 Total Cost of Pipe Mill Product External	11 Total Cost of Large Shape External Sale	12 Total Cost of Hot Srip Mill External Sale	13 Total Cost of Plate mill Product External	14 Total Cost of Half-Finished Steel External sale	15 Total Cost of Pig Tron External Sale
1	Raw Material Input	S1	S2	S3	S4	S5	S6	S7																
	Total Raw Material Cost								*	#														
2	Unit Cost of Cold Mill Product External Sale									TS1														
3	Unit Cost of Pipe Mill Product External Sale									TS2														
4	Unit Cost of Large Shape External Sale									TS3														
5	Unit Cost of Hot Srip Mill External Sale									TS4														
6	Unit Cost of Plate mill Product External Sale									TS5														
7	Unit Cost of Half-Finished Steel External Sale									TS6														
8	Unit Cost of Pig Tron External Sale									TS7														
9	Total Cost of Cold Mill Product External Sale	*									#													
10	Total Cost of Pipe Mill Product External Sale		*									#												
11	Total Cost of Large Shape External Sale			*									#											
12	Total Cost of Hot Strip Mill External Sale				*									#										
13	Total Cost of Plate mill Product External Sale					*									#									
14	Total Cost of Half-Finished Steel External Sale						*									#								
15	Total Cost of Pig Tron External Sale							*									#							
	Grand Total Material Cost																	A	A	A	A	A	A	A

Figure 7-7 Material Requirement and material Cost Models of Integrated Steel Works

Evaluations of users

- Without this methodology integrated yield could not develop.
- Top management can understand with some education
- Administration staff and technical staff could understand as common communication tools.
- Consistency was kept among detailed model
- Plant models were unexpectedly maintained as linear models above all in the backward process like rolling process area. Also non-linearity could be covered with changing the coefficients.
- Practical use compared with Linear Programming (LP) model.

  If LP method was used, model might easily exceed 100,000 equations and findings of troubled points by missed-data were impossible. By this method, missed part could be easily found and they could avoid suffering from the trouble of infeasible solution. In such a large steel plant, condition equation reflecting neck process might have been within 300 and plant people could practically operate these for these models by watching the building-in slacks' factor without high specialization for LP.

Afterward, this technology was applied to the energy and material balance system covering entire works.

7-4 Case III BSM as Feed Forward Management System in Company C

This is the case that BSM was introduced in a material division for construction covering three plants and a net work of supply stations in a conglomerate. Nowadays businesses are facing dynamic changing and uncertain environment, and are forced to make exact and speedy decisions. Each of decisions made in business should be supported by exact actual data and on site information. Through the development of new profit and cost system as BSM, the systems became powerful to grasp the actual cost based on user's logic. Chaining method of single models on BSM was evaluated as powerful tool to the effective management planning also in the re-engineering and cost engineering.

7-4-1. The New Profit and Cost Management System

Before entering the main theme, the division and problems will be introduced briefly.
The main products of the division were cement, construction material and light metal with annual sales of $1.5 billion, and the productions were made in the following three plants located nearby.

Plant A	Versatile product with small lot production
Plant B	Mass production oriented
Plant C	Modern highly automated plant

The finished products were once concentrated in plant A then distributed by ship to near 50 profit or cost centers. The service net work must have covered all over Japan with low distribution cost and stable supply.

The objective of this new profit and cost system was to reduce total plant cost and distribution cost.
Many trials with traditional model approach using spreadsheet and conventional simulation language were all failed, though the computer cost and its technologies were exceedingly improved. The major reason was they lack flexibility of the changes.
Generally, management activities must be changed, according the changes by the end users' requirements.
BSM must be supported by effective model changes that may involve re-combining of partial models.
However, the division was facing harder condition to execute cost down and profit increased under the unstable environments.
Management requests were to respond the following questions as concrete samples.

- Which product was more profitable among many?
- Was there any concrete way to reduce the cost of this product?
- How would it be the profit of each product when cut off rate of Yen/dollar less than 100 happens?

To respond these questions precisely issued in ad hoc from management under the dramatically and irregularly changing conditions was proved impossible by current approaches.
To overcome this status, new profit planning and cost management system must be implemented based on

new methodology as BSM.

At the development of the new system, the following subjects were focused.

- Precise grasp of cost raising or cost driving factors

  Lets think unstable and changing status like purchasing cost of raw materials, energy prices, labor cost, yield and operating mix.

  "How would be the influence to the cost and to which product would be final the influenced in minute mesh?" were the problems. These estimations must have been provided quickly.

- To seek the case of minimized cost by repeating the simulation for the assumed cases and by the change of these combinations
- Drastic improvement of business process efficiencies of cost management

  The following improvement for the cost managing activities was required.

  - Drastic speedups with saving of workload are required to one or two days by the new system for the past status of about two weeks.

- Documenting for decision making by end users

  As results of pursuing the speed of decision succeeding the simulations, documentation for calculation logic by each case must have been reserved sufficiently as precise and visible documents.

- Quick development of the system and to reduce the cost of system development and its maintenance cost.
- Improvement of business process and organization toward cost reduction

  By making the model of organizational function and plant process logic, there was an expectation to clarify the point to be improved.

For solving these status, real time data and computer resources were concentrated under the new concept FFM (Feed -Forward Management) supported by the BSM built on structure matrix technology.

7-4-2. Effectiveness of BSM in FFM

As shown Figure 7-8, higher management gave directions and objective figures of cost down in the planning phase. Thinking the case that cost cutting of ten percentages was given, planning staffs did not have enough means and data to certain the possibilities of realizing..

The reasons are

- Current activities and activities were not grasped at the end-users' level
- The planning staffs were the status not understanding the relation between the plant behavior and the cost enough to estimate it.

Further explanation might be required for these.

- Various activities as daily operations by end-users.

As daily operation, various activities were performed by end users and there existed gaps about actual information between planning staffs and end-users. The actual information had the following three backgrounds.

- Voluminous data reaches order of billions when the accuracy were required for the costing table and its contents about condition information to support exact line operations and experienced know - how in operation.

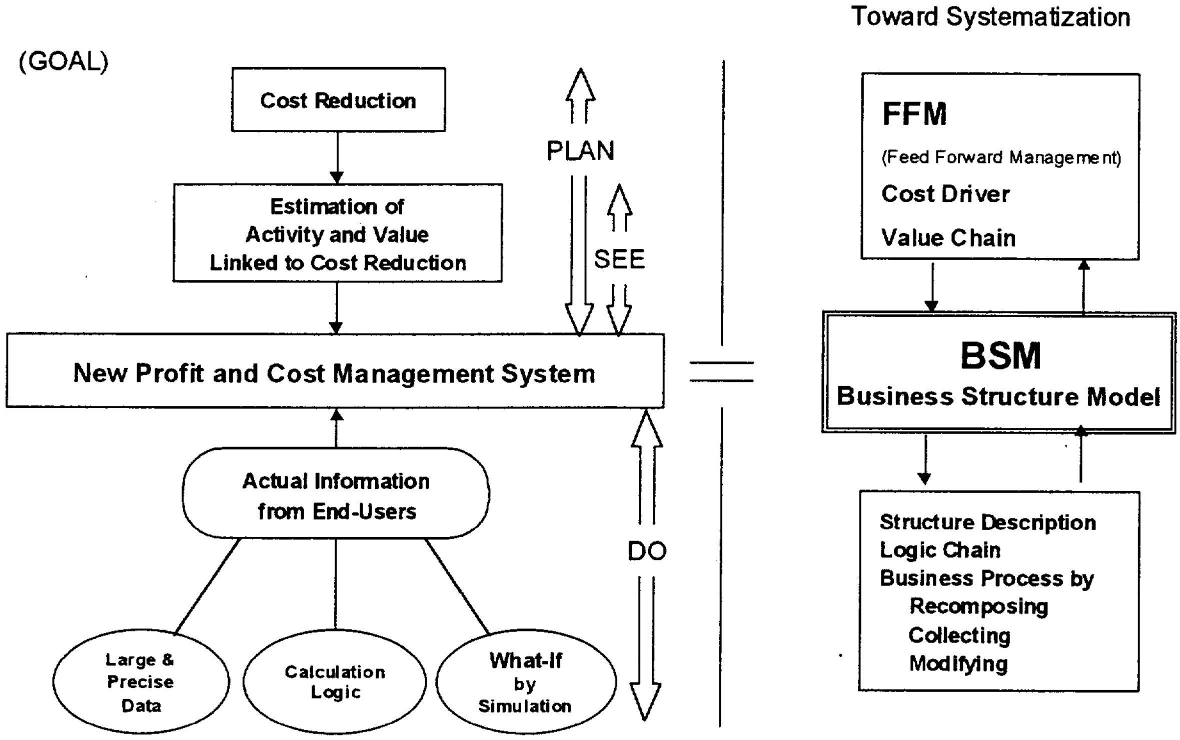


Figure 7-8. Necessity of FFM and BSM

- In logic for calculation, the follows such as costing, pricing, taxing, scheduling and allocations of resources were not unified.

  The above mentioned costing, pricing, etc. were embodied by their own methods individually and by different traditional methods like spread sheet and conventional languages. In addition, individual logic was processed deeply and differently in own world case by case. By traditional methods, calculation logic was reserved as black box and end users' arbitrariness and unintentional mistakes were easily involved without correction. The summarized reports to tops with these gaps easily lead to ill decisions.

  For making precise decision to perform the organizational responsibilities clear, visualizing the flow of business process and their logic, in which value chains were associated, was mandatory.

- What-if simulation was trial and error oriented operation as one of the key to reduce cost and generate values. Examples of these searches were as follows.

  Seek possibilities of increase of selling and revenue for the customer

Seek acceptable price to a customer

Find proper relation between lot size and operating speed of plant.

Rearrangement recycling times for reducing the electric power cost

- Activities of the cost reduction process covering whole business processes

  By describing the process flow, we could recognize sensibility by checking the model partly and wholly.

  From the point of cost reduction and profitability, the optimizations of each organization did not always mean the whole optimization. For example, increase of yield ratio in a line sometimes caused decrease of total yield. Considering these phenomena, coverage of optimization should be performed on the status that the current process flow must have been grasped and their logic should be recognized as structure associating the business process. And, they must be described as visible logic chain and chain of values, however long the chain might be.

BSM having such long chains were visibly embodied with exactness and estimations are realized with accuracy. Also recomposing and modifying of models toward re-engineering were implemented.

7-4-3. Model Flow in the New Profit and Cost System

Actual business flow was shown in the figure 7-9 and the models are described in Figure 7-10 as model flow.

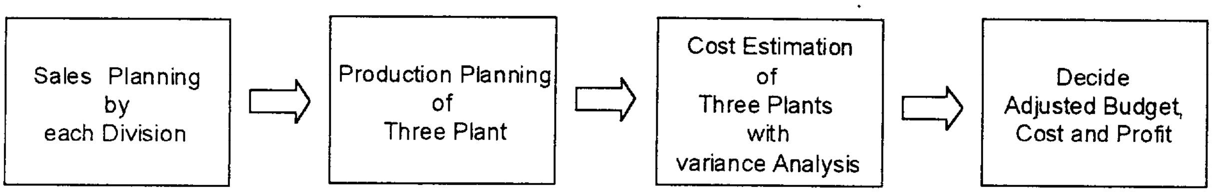


Figure 7-9 Actual Business Flow

In the model flow map the upper part shows budgeting system having 15 single models with time series and lower part shows cost system with 11 single models with time series. The minuteness was more than ABC/ABM method. (ABC/ABM means Activity Based Costing and Activity Based Management.)

Some brief explanations of models were as follows.

Model (1): Following various types of depreciation were prepared covering the characteristics of the equipment and property.

Straight-line method

Fixed percentage on declining-balance method

Productive-output method

Service-distance method

Model (2): Plant repairing cost was modeled minutely because of largest expense amount.

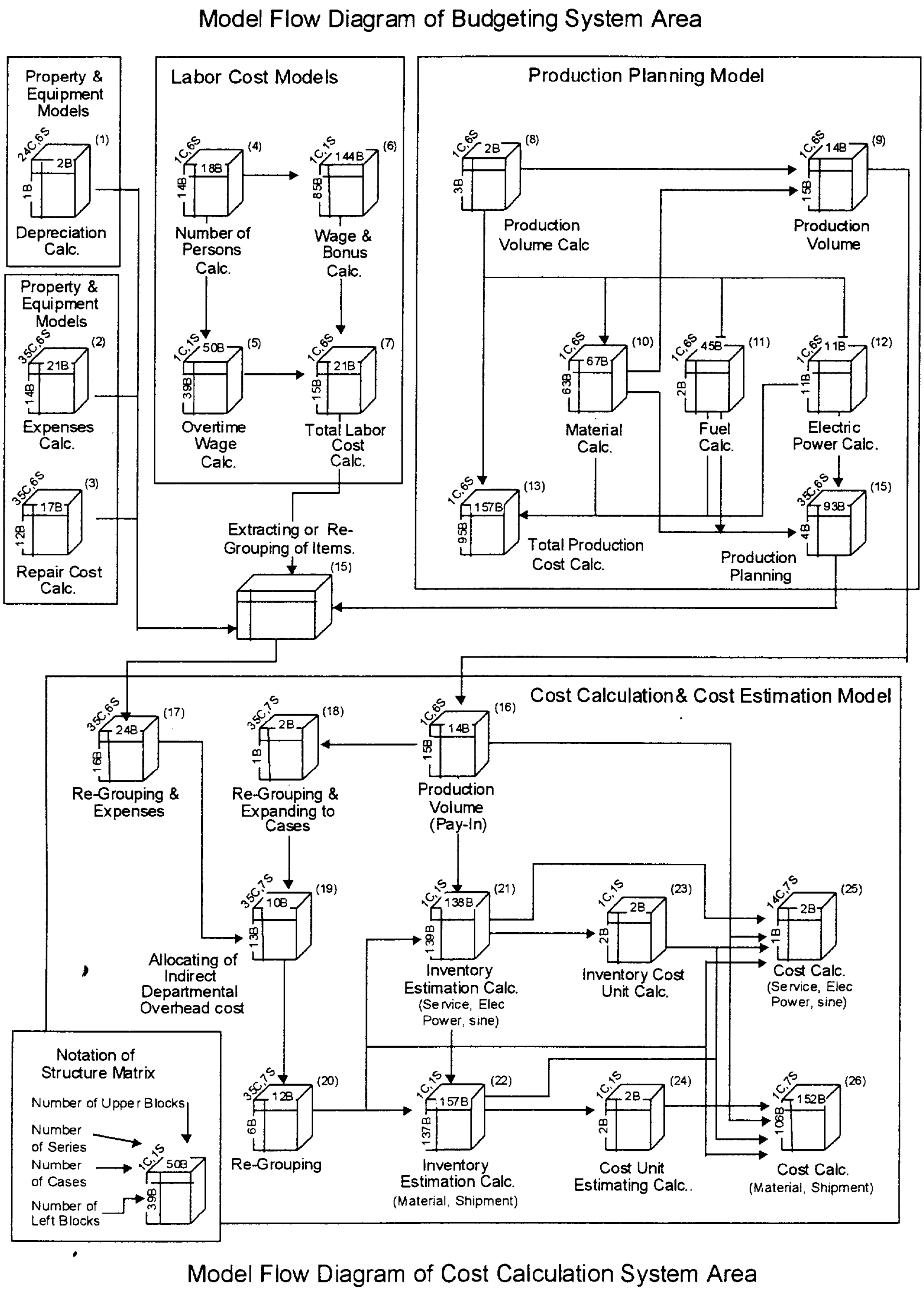


Figure 7-10 Total Model Flow Diagram of New Profit & Cost System

Model (8)~(14): These production models were used for pre-planning based on inputted data from end-users in three plants. After adjustment in the next costing models and variance analyzing models, precise budget, profit and cost were made.

Model (16): Perpetual inventory were calculated in this model. Materials, work in process, finished goods, etc. were calculated by various *continuous inventory methods*. *Moving-average method* by month was mainly used for shorten the gap between cost flow assumption and physical flow of goods.

Model (19): Plenty of products were made by common producing equipment. Their variable cost and fixed cost were allocated to thousands of products according to the production criteria with volume.

Model (25)~(26): The allocation of overhead cost was performed in these models. The allocating criteria were calculated by multi-factors considering theoretical and experienced bases, like production volume, service-time, running time and physical figures. Also, the influence of material mix, variances of blending and yield was analyzed.

These integrated plant-costing models were executed in very short time in spite of big data. If exchange rate and operating rate change, thousands of material cost (almost 56 Million items in half year's plan) could be estimated in a day interactively. Thus, paradigm of FFM (Feed Forward Management) was re-alized providing speedy decisions.

8. Conclusion

All the simple needs in our mind in 1960s were fortunately solved along the line of the writer's cherished idea: structure matrix. Our happiness is that we had been thinking the same idea before we met with the German progress. Already, we had a key idea similar to the idea of *KOL* (*Komponent List*; currently equals to our naming of Item Block). which is indispensable to realize the changing of items without programming. Therefore, we can easily import idea of KOL. Surely, German advancement was a great amazement for us and we spent a lot of time in digesting it. Moreover, it is quiet pressing that structure matrix with its extension contains all things required at the beginning. We could happily enter the structures of customers' application in deep, being supported by the essential superiority of structure matrix. It gave us chances to compile our application knowledge.

Our happiness is that the writer had been thinking ***Two-way Visibility with Transparency*** as essential standpoint of systems in BSM (This name was given afterwards.) area as management systems to be the successor of on-line production control system. This guided us to improve the structure matrix methodology toward current BSM. Through the long history, we could have sufficient chances to think similarities among different applications. Consequently, we could draw out common ideas and functions for the packaging.

The writer would like to review the path to reach current capabilities.

After learning the German advancements, to stretch the advantage of structure matrix was a continued hard work for us. Some people said, "Why did it take such a long time?" · The following reasons can be pointed.

- The writer met with strong oppositions to matrix itself for that day and age.
- There were difficulties in explaining structure matrix. The reason was that it was separated from the traditional management technologies, moreover from computer technologies.
- We had to progress demonstratively the establishment of wider applicability of BSM by industry. In many cases, the more BSM was successful, the more customers kept their implemented information confidential in the competitive situation and superiority in negotiation.
- Data in businesses were not yet prepared well in computers as are today.
- Our efforts were greatly consumed both in underdeveloped stage of computer and in calculating power. Restriction by displaying technology and driving software made us greatly consume our energy consumed to compensate its infancy at that time.

However, the needs of times are becoming in sharp and computer environments are ready now with a fair wind.

Here, we often encounter some simple questions.

"What is the structure matrix?" "How does it work?"

- The table has essential characteristics of a two-dimensional *Round-Robin* Table (So-atari-hyo) which can thoroughly express causal relations from all the angles.

- By folded it into a set of linked tables as structured architecture, the part that has causal relation can be effectively displayed and manipulated having *Visibility with Transparency*.
- On the calculation sequence of causal relation based on matrix inner product, nonlinear calculations can be placed, and these calculations can be extended to Input-Process-Output (IPO) in more generalized way.

By these reasons, the essential body of structure matrix can be the vehicle of business structure modeling (BSM).

Nowadays, BSM has become easy handling as terminal manipulation of the packaged software.. At the age when structure matrices become commonly available, most people will feel no strong impression for our attained architecture.

The correctness of our three hypotheses (Refer chapter 3), is demonstrated, and this is the fruit of the following efforts. They are our inventions in pursuit of interactive approaches after the inheritance of the German developments.

Our major creative efforts can be summarized into the following points.

- Establishment of nucleus modeling method as BSM

  From the side of BSM, to be able to cover company wide modeling, non-monetary values and monetary values must be linked. In many places, there are three values of consuming quantity (materials, energies, services, etc.). They are non-monetary values, unit costs and total amounts that are given by inner products of the former twos. Their chains are the mainstays of BSM in reflecting management activities. It is mandatory to be able to handle them in a common domain. According to the German way, switching of models is required. Therefore, we must shift from the German traditional way to a new architecture. After three years' agony, unification to one directional calculation using type symbol: **T** was adopted. Without this invention, we are sure current BSM would never be realized.

- *Multiply & Add* toward *Input-Process-Output*

  Unification to one directional calculation was enough fruitful for turning the concept from *Multiply & Add* mode to *Input-Process-Output* mode (IPO) including non-linear processing.

- Automatic sequencing of calculation

  Many efforts are paid for finding the sequence automatically, we can respond the change of calculation logic interactively without overturn the program.

- Reexamination of *Bilinear Relations* in BSM

  By facing the study to write this thesis, we could have a chance to reexamine this matter and found that this relation was already used unconsciously in the modeling of service providing amang independent organizations. We could formalize this method as T-H theory on this thesis.

- 'Concept of Item Block

  Item block is the most difficult concept for beginners. This idea was started from the standardizing concept in application. But associating this idea to table handling, we can effectively respond to the change of items interactively, without overturn of the developed programs, being supported by the common use of item block and item independent type symbols.

- Concept of *Chaining*

  As the writer's simple understanding, one of essential managerial activities is in pursuing of resources' combinations toward increase of the performance. In planning, combination and recombination are mandatory.

  Top managers sometimes have both fertile imaginations and irritations for making structural changes to the culmination of plans. However, current system approaches are focussed on minute piling up of local plans to a single pyramid. Methodology for reconstruction or recombining of models is blurred, and packages for ERP (Enterprise Resource Planning system) seem to be developed paying less attention to dynamic structural changes.

  We often find that users are preparing the number of chaining models more than the number of single models. We originated this chaining architecture and most highly evaluated part of BSM technologies from the end users.

  This architecture is a result of deep discerning of structure matrix and needs of modeling as BSM, namely to provide the modeling capability of *Top Down*, *Bottom Up* and *Side Link*.

- Type Symbols

  We prepared numbers of Type Symbols less than that of Alphabet. The mainly used symbols are within tens that we need not to memorize. This fact itself is a surprise of the scholars in management science area. Our surprises are heavy use of type symbol: **M** (Matching) among many type symbols. This becomes increasingly important according to the expansion of upper and left blocks to two-dimensional tables.

  Usage of this symbol exceeds more than 50 percentages and sometimes reaches 80 percentages. Our discovery is that model of management system can be said as lump of matching. This may be caused by the fact that Inside-Out functions are heavily built in the BSM.

- Two-dimensional Tables in Upper and Left Parts

  As a course of package extension, upper and left blocks were extended to two-dimensional table having two associated *item blocks* responding to each axis. At the same time, type symbol: **T** was extended to have the turning function of upper block (Exchange of the axis) and two-dimensional matching was added to type symbol: M.

  By this extension, we can model ad hoc without considering what axis is the main. This brought us a great easiness of the modeling

As fruits of above inventions, the writer recognized the following conclusions.

- We recognized the existence of uncultivated area in MIS and our defined BSM can be a powerful solution to meet this area.
- *Visibility with Transparency* should be placed as a stem of BSM and this can be possible around our technology and its extension in this thesis.
- A set of technology of tables handling can be established based on structured matrix concept.
- As extension of performance-linked system, we could succeed to let the implemented customer say

"FFM (Feed-Forward-Management) is realized". This fact should not be retained only in the area of management accounting.

- As important issues of the day, we are able to provide the dynamic means to sound the structural reformation of businesses.

O. Pichler might have originated structure matrix as common tools of communication between engineers and administration people. However, our BSM is realizing more common means as *organizational intelligence* than the communication tools for the people having different backgrounds.

The 21st century is a century of globalization. Our BSM approaches are providing means of standardization responding to the given chance in which we find commonness of model depending on each level. For example, these chances are given as the *Item* level, the *Type Symbol* level, *Single Structure* level and *Chaining Structure* level for each level of the complicated phenomena. With these approaches, we can bring standardization to the substances, which apparently seem different. The writer believes to popularize BSM is a mission in life toward realizing *Visibility with Transparency* associating with the standardization.

However, the writer thinks we may be standing merely on the entrance of BSM.
The followings will be the important subjects, which the writer is placing as future directions.

- Architectural advancement as vehicle of BSM

  The idea of item block has been powerful as a key technology in BSM, so to speak, railway transportation. We have been restricted in exchange of efficiency. But we need more flexible architecture, so to speak, automobile. We must find the subject equivalent to the automobile.

- Cooperation with multi-dimensional data base

  Recently, multi-dimensional database becomes practical. If we look it as a type of its metamorphosis, we must place it in the body of structure matrix. If we can place it well, BSM will show progress more.

- Harmonizing with other modeling methods.

  Currently, harmonizing other powerful modeling methodology like System Dynamics (SD), Monte Carlo Simulation is required. Already the writer had a cooperative academic study which was performed about SD.[Kameyama, S., et al, 1997] In these systems, loop processing in modeling is peculiar. In addition, about Monte Carlo Simulation, we experienced a simulation on wage and promotion system using real employee data.

- Expansion of application area toward social and economy systems

  Our applied areas of BSM are clustered on business area as the naming shows.(These facts had been owed to writer's professional birthplace.) Essentially, BSM does not play favorites.

  Already the following areas are expected as hopeful to be applied.

  - Modeling in individual government sectors
  - National Model (especially as satellite model linked with SNA)

- Global energy balance and environmental models having multiple factors
- Finance models, which can handle risk of chain reaction bankruptcies.

The writer is dreaming the time that the contents of the item blocks will be the human names, business names, government sectors' names, earth resource names, etc., so to speak, every thing.

By those methodologies, it should be left to computers that we can find clear causal relations as set of logic and data. Valuable human efforts should be concentrated to find the structures in the non-structure world and in finding the adequate values of data to be cast in BSM

At finishing this thesis, the writer has been wondering himself about the following problems.

The developed models are sometimes really beautiful.

- Why are we enchanted with the beauty of models?
- What does drive us so long this world?
- Can we get the solution while we are alive?

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Appendix I Activities before the Encounter with German Documents

This Appendix I was prepared as a style of epilogue for responding the question about the back ground why and how did the writer enter this world. So, the origin of idea and approach facing the needs before the contact to German progress was introduced compliment the block diagrams (4) (5) (6) (13) in Figure 1-3 in Chapter 1.

In this thesis the phrase: "*Multiply & Add*" is used for making easier the *Matrix Inner Product*. Trough this paper, you may understand that this phrase was not suddenly produced.

Note: *Multiply & Add* is again abbreviated from "*Vertically Multiply and Horizontally Add*" (In Japanese, *Tate-Seki-Yoko-wa*)"

Originally, there existed a calculation corresponding "*Horizontally Multiply and Vertically Add*" (In Japanese, *Yoko-Seki-Tate-wa*)" forming a pair on the bilinear cost theory. However, as stated in chapter 3, 5, 6 and 7, those two paths were unified by adopting Type Symbol: **T** (transpose). "*Vertically Multiply and Horizontally Add*" could be abbreviated to "*Multiply & Add*".

Discussion with Professor Hiraku. Tohyama

Before the writer met the German document, he had independently reached the almost similar idea of structure matrix though he did not have the name. The writer would like to recall some old events.

In autumn of 1954, the writer as a freshman of Tokyo Institute of Technology visited the late Professor of Mathematics: Hiraku Tohyama, to make sure of misprints in his book: Gyoretsu-ron (Theory of Matrix). The simple misprints of suffixs made him difficult in digesting the demonstrations of the preposition at the beginning part of books. Instead of using suffixes like *i, j and k*, the writer proposed him an idea to express mechanism of inner product between matrix and vector as shown in the right of Figure A1-1 instead of traditional expression in the left. Also adopt the words: *Vertically Multiply and Horizontally Add* in stead of using the word: *Inner Product*. The idea using the words: *Vertically Multiply and Horizontally* were modified as *Multiply & Add*, then they became a key word providing current structure matrix.

$$\begin{bmatrix} L_1 \\ L_2 \\ L_3 \end{bmatrix} = \begin{bmatrix} M_{11} & M_{12} & M_{13} & M_{14} \\ M_{21} & M_{22} & M_{23} & M_{24} \\ M_{31} & M_{32} & M_{33} & M_{34} \end{bmatrix} \times \begin{bmatrix} U_1 \\ U_2 \\ U_3 \\ U_4 \end{bmatrix}$$

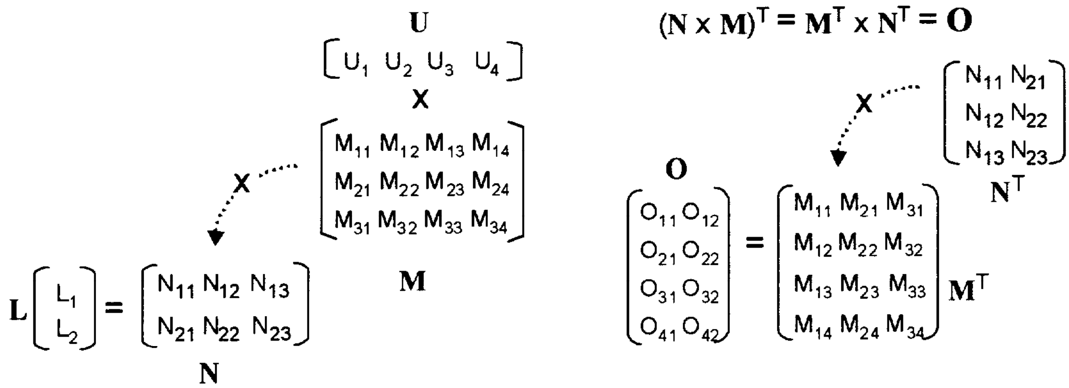
Traditional Expression

$$\begin{array}{cc} & \begin{bmatrix} U_1 & U_2 & U_3 & U_4 \end{bmatrix} \\ & \times \\ \begin{bmatrix} L_1 \\ L_2 \\ L_3 \end{bmatrix} = & \begin{bmatrix} M_{11} & M_{12} & M_{13} & M_{14} \\ M_{21} & M_{22} & M_{23} & M_{24} \\ M_{31} & M_{32} & M_{33} & M_{34} \end{bmatrix} \end{array}$$

Proposed Expression

Figure A1-1 Proposed Expression of Inner Product

According his proposed way, we did not have a need to think of troublesome sizes of matrix elements, becauße numbers of elements coincide both in horizontal and in vertical. By extending this idea as Figure A1-2, chain of inner products could be expressed as if a cascade and the transposed relation of inner product could be schematically approached. Accordingly, matrix could be more familiar for ordinary people and would be broadened further.



Combination of Inner Product as Cascade Expression

Transposed Inner Product

Figure A1-2 Schematic Expression of Formula

After admitting the writer's proposal, the professor said, "Kowa Seki, the great leader of mathematics developed in Japan during Edo period, had been thinking almost the same methods. European culture had been built upon phonetic symbol placing them in horizontal lines of description and consequently formula became raw wise oriented. Surely if picturesque approach like Seki did were developed more, approach to the entrance part of primary matrix operation would be different. Accordingly, matrix would be more familiar for us. But the occidental way was already established firmly." Soon afterward he became the famous educator in mathematics, thinking out so called Water Method (Suido Housiki). The writer did not know he had an idea to incorporate writer's proposal to his methods, but the writer had long been keeping this event in his mind.

Encounter with needs of new descriptive methods

After the graduation in 1958, the writer joined Fuji Iron & Steel Corporation (currently Nippon Steel Corporation) and assigned to Hirohata Works, integrated steel works. For him, the company seemed to have many things. They were integrated covering various engineering fields and the collaborated workings were crucial.

Some problems that the writer experienced were caused by the lack of relevant describing. They might not be solved well even by using of current calculators and computers except the methodology in this thesis. Some of them were as follows.

Budget estimation for many cases

He engaged in the construction plans of new blast furnace. Our culminated plans and budgets were tossed about by the change of the furnace location. For more than ten times of changes, the writer could not exactly explain the detailed difference between the past plans for various view points of management idea and investigation. The writer was accused why he could not explain the difference consistently. The writer finally reached the conclusion that this was not caused by the lack of his smartness but caused by the lack of relevant method to describe the structure of logic and data used for the complicated estimation.

Balance model of material and utilities covering whole works.

Models consolidating flow and stock of various facilities, materials, products and utilities, were the vague discussing points among the co-working staffs. The modeling method had to support incompatible requirements to provide detailed modeling overall views covering the whole works. We were gradually expecting something along the matrix methodologies.

Relevant cost model

At the beginning of 1960, concept of US style direct costing was gradually being accepted in stead of traditional concept of total cost. New idea was essentially based on scalar oriented thinking. In handling of multiple products (Product mix), equivalence coefficients were arbitrarily set based on a selected base product. The common methodology was not yet appeared to explain the processing costs consistently linking the causal processing factors. Under these circumstances, it had been difficult for long years to explain the exact increase of processing cost. The cost was driven higher by the shifting to the minute product-mix at the depressed period compared with boom days. Inconsistent simplification reluctantly concluded that the increasing of processing cost was responsible for the lack of plant side efforts, not for the lack of marketing side efforts.

For this status, the writer reached the idea that matrix technology was mandatory for handling mix factors in parallel, and chains of matrices were necessary for expressing flow of materials and chain of causal relations. By boiling down these requirements and associating the discussion with Professor Tohyama, the writer reached the idea of structure matrix thought the writer did not know the name. From the point of standardizing (i.e. from the point of increasing the chances of reuse), the writer reached the idea to associate the function of current item block (German people gave a name: KOL (Abbreviation of Komponent List)). Thus the writer became incomprehensible for the status that such practical methodologies were not proposed as common modeling theory, though computers were gradually penetrating and matrix ideas were being adopted as practical methodologies.

The writer has long been engaged in the titled area of this paper. As origination of writer's first idea, can be traceable back to September 1955, freshman of Tokyo Institute of Technology.(Details of first idea are reported in the history part of this chapter.) Starting of concrete activity was in 1976, when the writer was struck by the fact that in a draft paper of a Corporate Planning Conference held in Belgium the writer found the same idea: structure matrix, which had long been cherished in his mind, was described. The paper was almost abandoned by the reason that nobody could understand the contents so it was thought valueless. *What a coincidence between East and West!*

At a glimpse, the writer sensed the values and was struck by their concrete advancement because their development was done on the same professional area: steel industry. The writer immediately realized essential needs of this technology in computer ages as common technology in wider industries and indispensable practical methodology in establishing Management Information System (MIS) and Global Econometric Modeling.

Knowing German development, the writer determined to enter this area however hard it was. Surely it was long and tough for him after the decision and efforts for this are accumulated for 24 years. Fortunately, the writers favorite collaborators and customers supported him for these years.

Appendix-II Particular Type Symbols- Expressing Technology of Complex Phenomena

Type symbols explaining here are typical set made from our experience and we must prepare more symbols according to the application expansion. Those set will be the start of discussion.

1. Naming rule of Center Block

In entering discussion of individual type symbols, common sample of naming rules are shown in Figure II-1.

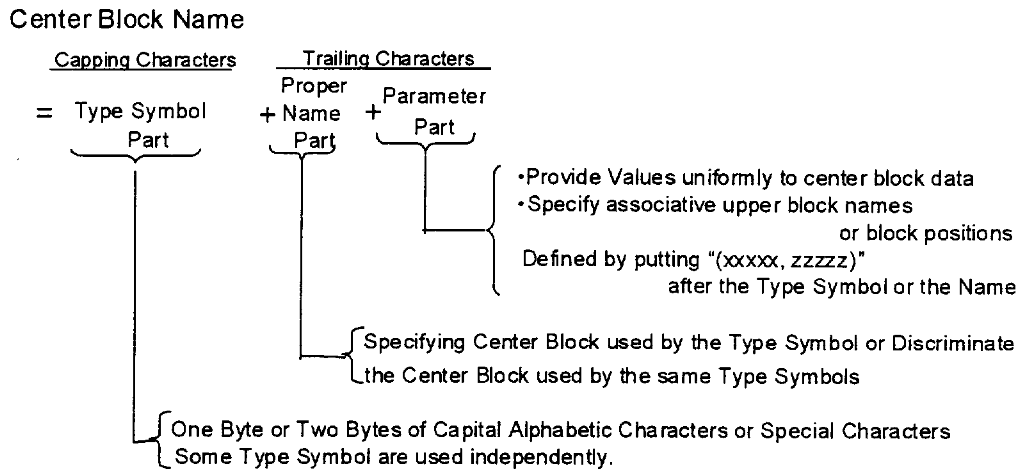
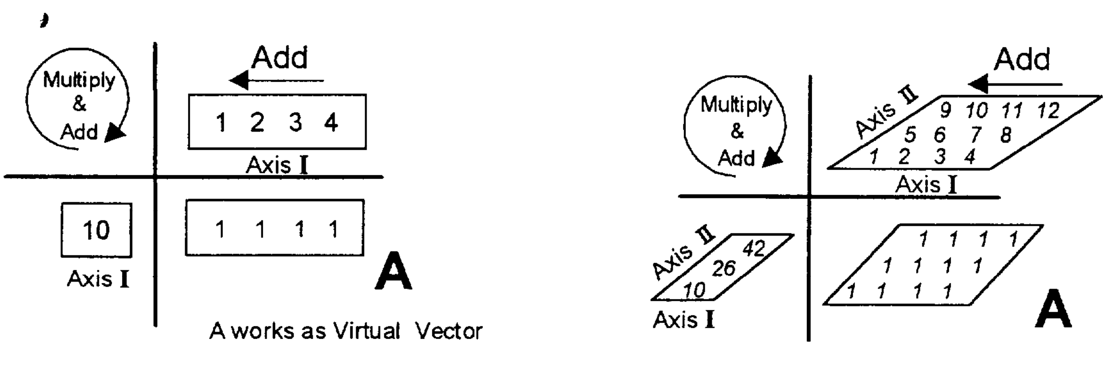


Figure II-1 A Sample of Defining Center Block Name

2. Type Symbol: A

Symbol **A** is named to duplicate two meanings: Add and All.

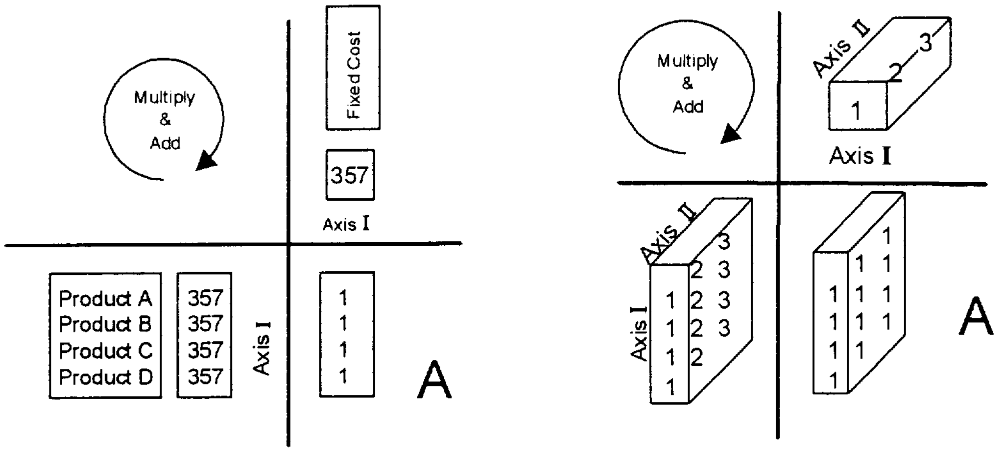
This symbol functions as "Add the values of upper block to left (Axis I: Item side) instead of preparing value: ones in **S** type center block". Principles are in Figure II-2, simply showing the cases of vector data and matrix data. By giving values in parameter, results become value times.



(a) Case of Axis **I** Only, No depth extent

(b) Case of Axis **I** and Axis **II**: Upper and Left Blocks have depth

Figure II-2 Principle of Type Symbol **A**: Ad



(a) Case of Axis I only,No depth extent

(b) Case of Axis I and Axis II ,
Upper and Left Blocks have depth

Figure II-3 Case of Type Symbol: **A** Used for Amplifying Upper Values

As another usage, sometimes a scalar value must be amplified as vector values. Such time type symbol: S must be used to fill the vertical area with multiple value of 1. Instead of this preparation, **A** substitutes this function. The principle is shown in Figure II-3.

3. Type Symbol: B

Symbol **B** is named to duplicate triple meanings: Bundle, Boolean and Bit from originated by German. This symbol provides various significant points of views as management system. This function gave us hints of type symbol: **M** (Matching).

Function of type symbol: **B** can be categorized into as follows.

- Bundle (Sum up) values in the upper values
  Categorize upper items in the same group by giving the value: 1 in the corresponding positions of center block
- Select or pick out values from the upper block
- Change or rearrange the sequence
  According to the Sequence given in the left items by giving value 1 in the matched positions of center part
- Insert or delete the items in upper block

Holding values in the associated center block is limited in the following values.

- Original idea: 0 and 1 Binary Values
- Currently extended from original idea: 1, 0, -1 Three values (requested from financial applications)

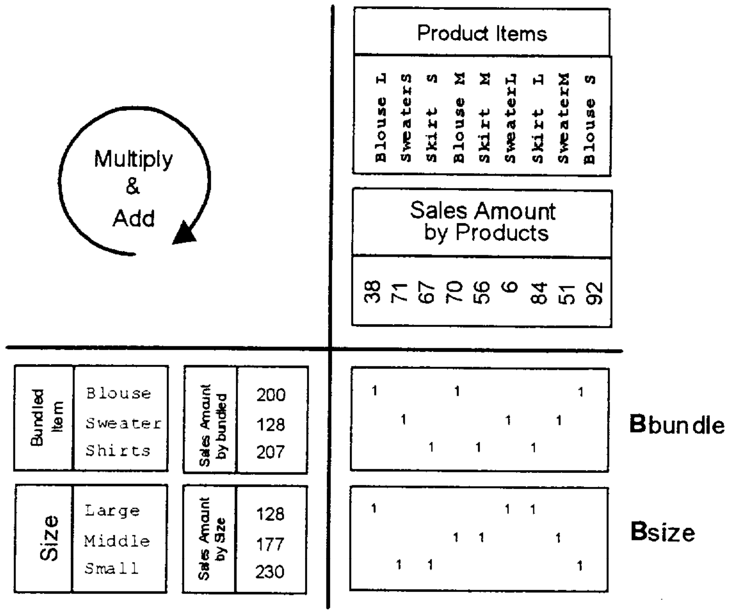
These allocations of values substitute for using type symbol: S.

In Figure II-4, a sample of Bundling is shown where are the bundling products are categorized by brand and size. Users must set type symbol **B** then prepare their bit matrix thinking the meaning of both sides of items.

Figure II-5 will give more realistic image of **B** associating another upper blocks. For more advancement, Refer type symbol: **M** (matching)

Figure II-4

Principle of Type Symbol: **B**



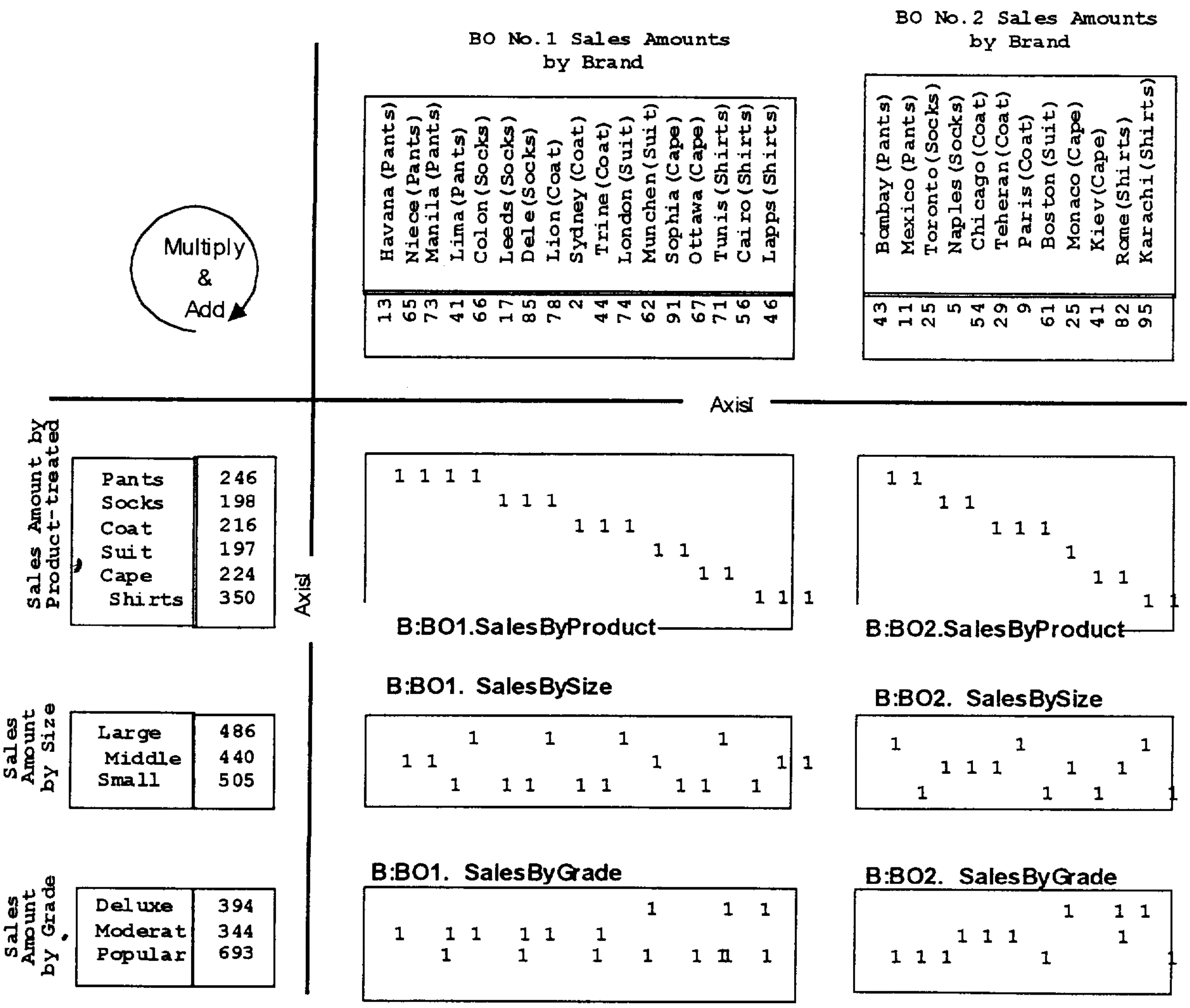


Figure II-5 Principle of Function **B** by Example

4. Type Symbol: C

Purpose of type symbol: **C** is getting a bit map as executed results of previously registered conditional equation in the center block at making the macro table. In the equation, all the upper blocks can be the candidates to be used for comparison. Therefore, timing to be ready to be used is important in specifying the blocks in the execution of the equation. How to synchronize their execution time as modeling is a subject. To synchronize blocks in upper part, type symbol: **D** or #X, #XX are used as shown in Figure II-6. Operating characters are usable in the equation as follows:

Comparison operator:	=, <, <=, >, >=, <>,
Set operator:	AND, OR
Grouping operator:	(,)

Let's take an example electric appliances' shop. The case to select better sales record than the target from the table arranged by product category by person are shown also in Figure II-6. This case uses condition bit map associated with other type symbols: *

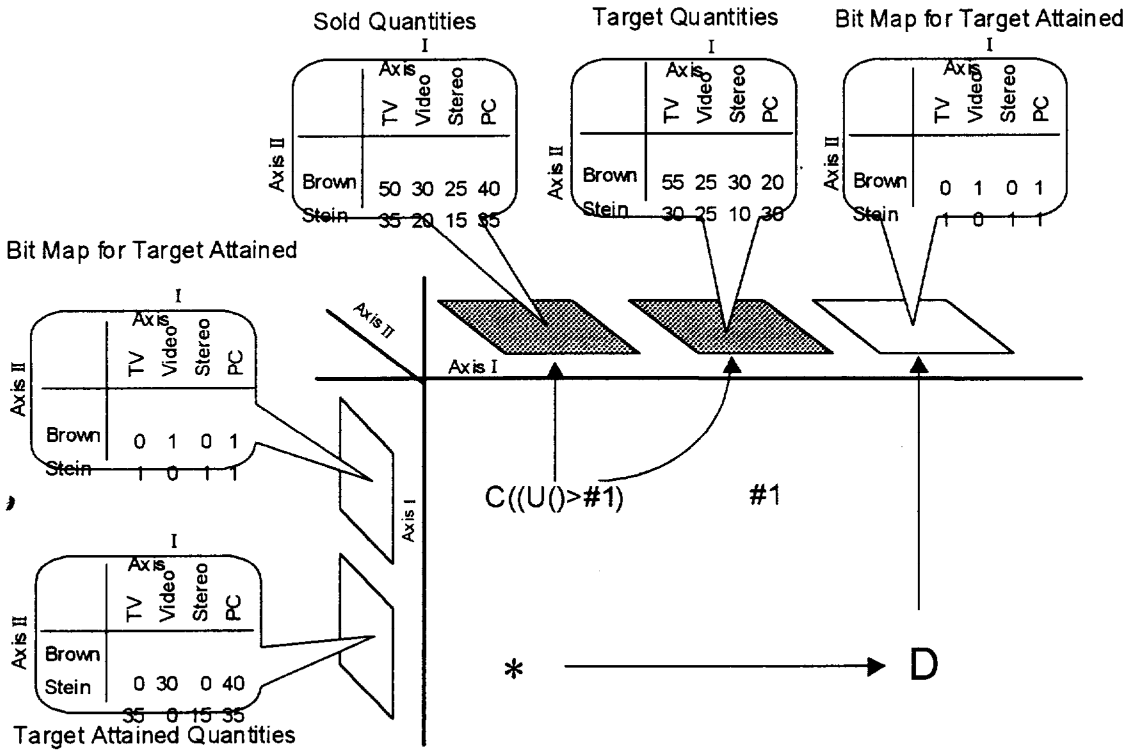


Figure II-6 An Example of Type Symbol: **C** and Use of Bit Map for Further Processing

5. Type Symbol: D

The idea of Dummy Symbols: **D** was invented for enabling the process of multiple upper blocks to other type symbols (so called mother type symbols) like **C**, **P**, **X**, *, /, %., located in the same row of macro table with null operation.

Note: As another method to specify upper blocks not in the directly above, type symbols # can be placed instead of type symbol: **D.** This symbol cooperates with the mother type symbols and succeeding character after # can communicate with mother type symbol in the same row of macro table.
Here, mother type symbols mean one of paired type symbols that decide main operation. Taking the paired example of "*" and "D" , "*" decides "multiplication". Therefore "*" is the mother type symbol.

Another function of **D** is to wait until the specified upper block (in right upper **D**) becomes ready to use. So to speak, this means multiple wait function for operating mother type symbol working as dyadic, triadic or more function. For more details, refer 3-2-7 in this thesis.

6. Type Symbol: E

The idea of type symbol: **E** was given in German documents: COSTMAT giving the meaning: Eigen as Unit Matrix. **E** works as if diagonal values of center matrix equal 1 without setting real value ones at the execution of calculation as Figure II-7

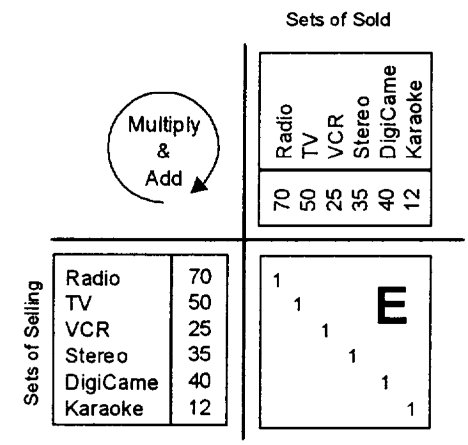


Figure II-7 Type Symbol: **E**

Principle to generate the same values in the left block

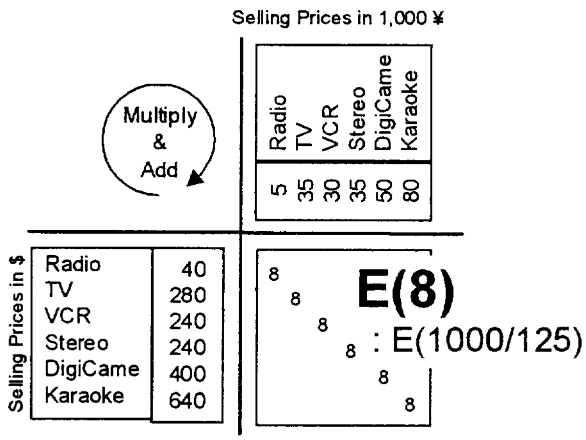


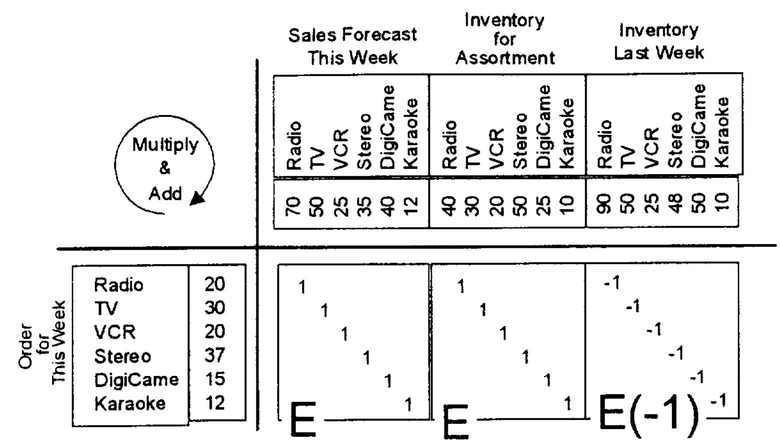
Figure II-8 Type Symbol: **E** with Parameter

Example of accompanying using coefficient factor

The merit of this type symbol is to attach a parameter specification. For example like Figure II-9, the exchange by currency rate can be handled easily with equality.
By this characteristics simple *inter table* calculations between upper blocks can be performed as in Figure II-9. As shown in the above example, E works responding each items. Therefore as meaning of **E**, Each is given for easier understanding.

Another important merit of this symbolizing is that this type symbol is independent from the addition and deletion of items. This characteristic brings stiffness for the changes without digging up the structure of models. Namely, re-programming or re-arrangements are required if program or spreadsheet developed these models.

Figure II-9
Example of calculating
upper blocks



A case of consolidated accounting that contains hierarchical and flat relations shown in Figure II-10, can be modeled as shown in Figure II-11.

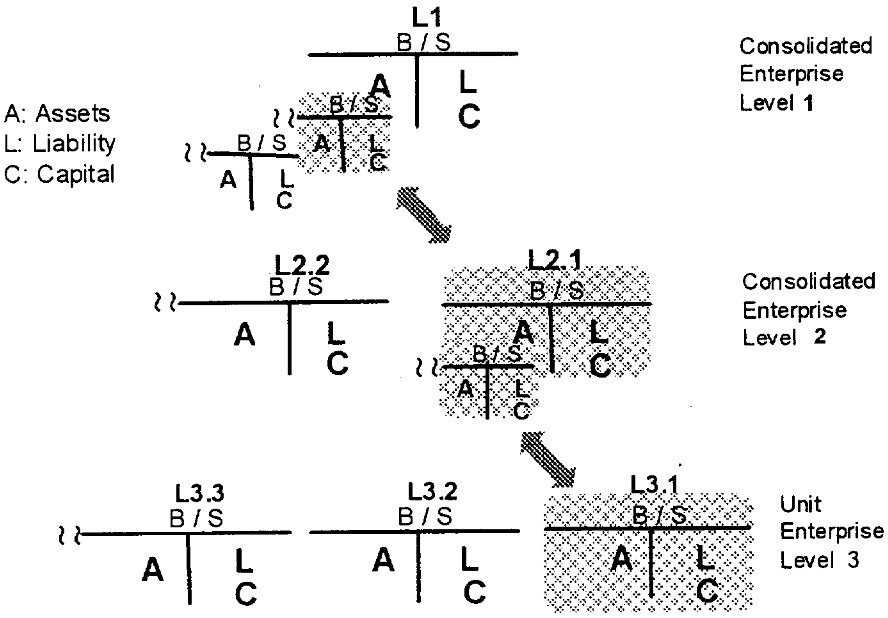


Figure II-10 Hierarchical description of consolidated accounting structure

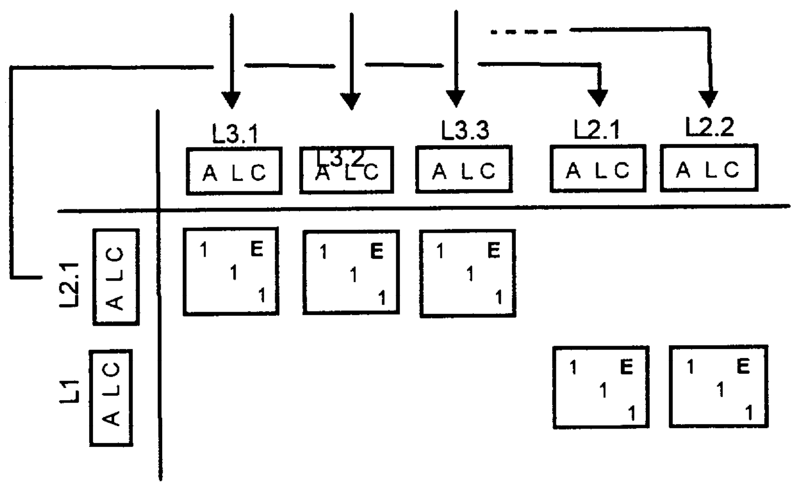


Figure II-11 Consolidated accounting structure on structure matrix using type symbol: **E**

Extension of Type Symbol: E

A special case, which real data are diagonally located in the center block, is treated as an extension of type symbol: **E** and is used as capping character upon proper specifying characters like **EZZZZZ**.
There are the following reasons for diagonal real data handling discriminating from standardized handling by type symbol: **E**.

- Large population of data located in diagonal for example: most cases, yield data are likely to be located in diagonal.
- Giving hint how data are located only looking compressed macro table.
- Effective display of data by list type in screen.
- Efficiency in calculation and reserving data.

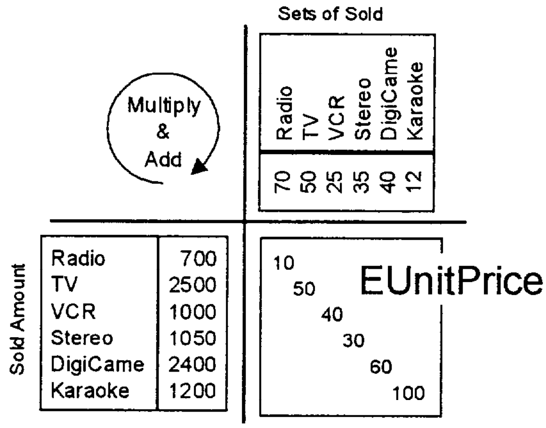
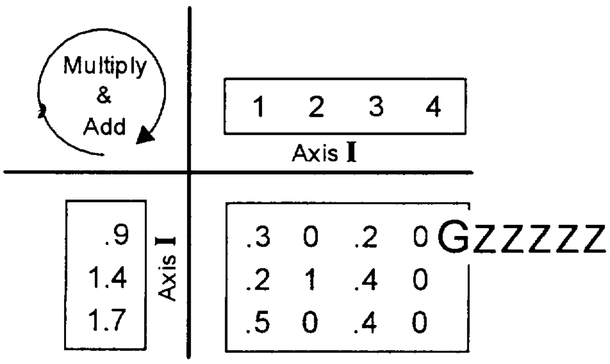


Figure II-12
Type Symbol: E for Real Diagonal Data

7. Type Symbol: G

German models of COSTMAT originated the idea of this symbol. The naming of this function was given thinking the assignment of sources to what groups by each required product in the upper block.



Case of Axis **I** Only,
No depth side extent

Figure II-13 Type Symbol: **G**

Therefore, the summation of each horizontal element should be 1 and larger or equal to 0, or all 0s. In the interactive package function, assign this figure as summation: just 1, is troublesome. So " ? " function, as shown in Figure II-13, is considered by the method: If put " ? " in some position, then the result given by the calculating the sum of the t horizontal elements left and decrease of it from 1, is shown in the same position.
This is often used for assigning the completion rate of process in complicated process cost allocation.

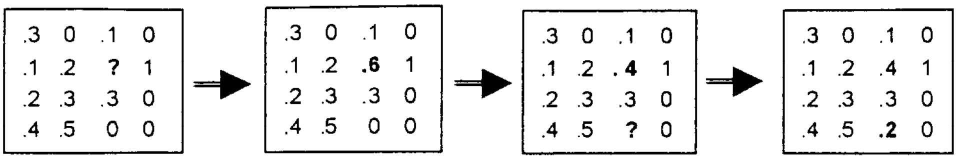
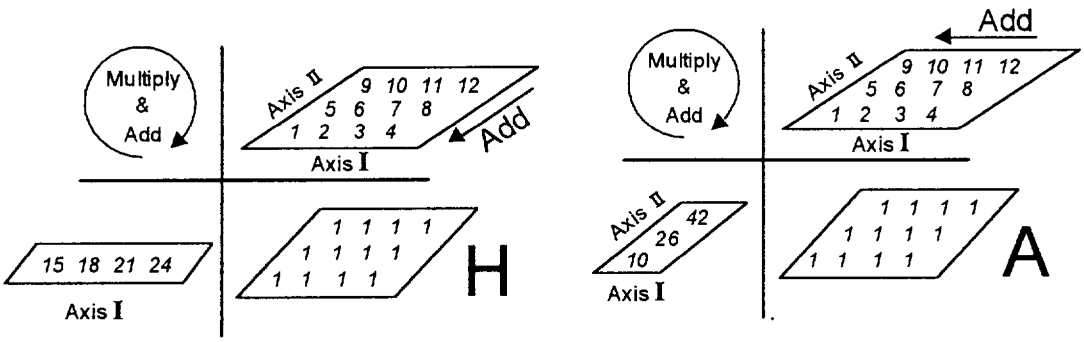


Figure II-14 Transition of ? Function to keep ratio

8. Type Symbol: H

This function was prepared for two-dimensional table processing, facing extension of the second axis: Axis II.

The meaning: **H**, horizontal was given thinking the depth side (Axis II), d clearly discriminating the symbol: **A**, Add. This function can be performed with the two symbols' combination: **R** (Rotate) and **A** (Add).



(a) Case of Horizontal Add
Upper Block have depth

(b) Case of Add
Upper and Left Block have depth

Figure II-15 Type Symbol : **H** and **A**

9. Type Symbol: M

This function was developed as an extending idea of type symbol: **B**, because assigning and placing preparation of binary data in **B** matrix tables thinking the meaning of each item, was very tiresome if its table size became large. Also maintaining B matrix table, it was required to respond the change of items without special maintaining efforts.

For the cases that the number of items became large in business modeling, we fortunately found that most contents used as item was occupied by coded items that were organized by business, like product code, accounting code, material code, customer class code, utility code, etc. For the case that the model was linked with actual system, major part of the valued data was imported associating the coded data. Therefore function: Matching for *Axis I* with code position specifying was developed first. This function was very heavily used substituting **B** matrix table. Also characteristics of independence from the item changes: Insert/ Delete/ Renaming of items was highly evaluated by customers.

At the time of functional expansion to two-dimensional table processing, the matching function was expanded following it. By this expansion, matching can perform Inter Table Processing functions. Some of them are

- Extract coincident data from table and place them to another table, automatically aligning the data position
- Automatically unifying the sequences of data from different tables

By these functions, function: Matching becomes the most heavily used type symbol. As implemented models Matching: **M** occupies more than 50 % of frequencies and sometimes frequency more than 80 percentages can be found. This means that matching function should be placed as important fundamental characteristics of business modeling. The reasons why users utilize this *Matching* so heavily can be found as follows.

- It is the problem that sparsely scattered elements to the whole model are likely to be neglected at the modeling, by the reason that it is not the main theme of the organizational target or not the key problems of in their responsible spots at present. The points are, for example, in energy saving, environmental processing, etc. in establishing production models.

  However, those problems are sometimes important if those neglected elements are summarized corporate widely. In integrating the models to a corporate model, effective methodologies to bundle those small subjects without neglect were not targeted and were unfortunately not provided.

  The *Matching* can support these methodologies of which important items from the different point of views, are *turned inside out* from edge of the organizational tree.
- The business modeling for responding the current needs in business, is required with more reality. Therefore elaboration in modeling must be pursued, applying *mix concept*, like product mix, supply mix, utility mix, activity mix. So needs of describing combinatorial relation inflate exceedingly.
- Ease-of-use of Matching, above all automatic adaptation to the Item change, fit the above needs.

Syntax of Matching

M(,)

First argument:

Specify Item name of **Axis I** attached to the Upper and Left Block
- Character-wise Matching for Full Length for the Two Dimensional Table with no specifying
- Character-wise Matching for the specified position of the string

Second argument (after ","):

Specify Item name of **Axis II** attached to the Upper and Left Block
- Character-wise Matching for Full Length for the Two Dimensional Table with no specifying
- Character-wise Matching for the specified position of the string
- Null Matching for One Dimensional Tables

Principle of Matching

Principles are shown in the following sequence from simple to complicated.

- One-dimensional Full Matching
- One-dimensional Matching
- Two-dimensional Matching by specified character position

Principle of One-dimensional Full Matching

Principle of matching applied for only Axis I (Item) are shown by example in the Figure II-16.

Think of followings.

- Imagine Bit pattern table like type symbol: B, which could be thought virtually generated
- Locate Value 1 for the positions where both full character length of item names is matched
- Then Multiply and Add operation is performed between upper values and this bit table

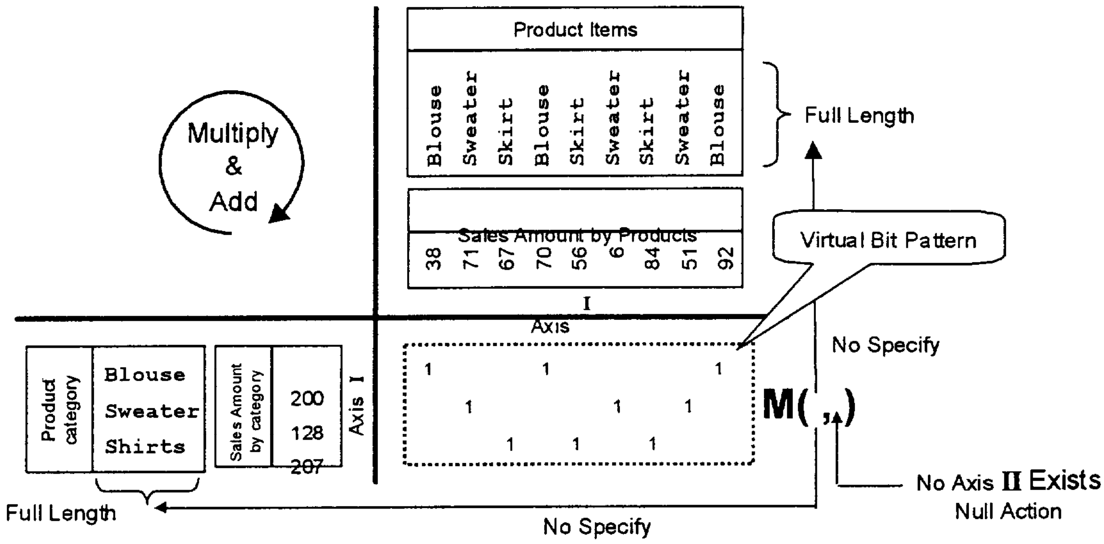
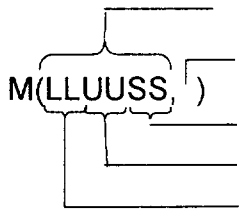


Figure II-16 Principle of One-dimensional Full Matching

Principle of One-dimensional Matching by specified character position

In stead of above mentioned One-dimensional Full Matching, parts of the character strings are applied for matching. Therefore specifying rule of starting character position of upper and left item blocks and length of characters in byte, are shown in the followings.



Specify Item of Axis I for Matching

Reserved for the case of two dimensional table for Axis II Matching

Length (Byte) of Continued **String** to be Matched

Starting Position (Byte) of **Upper** Block's Axis I in Matching

Starting Position (Byte) of **Left** Block's Axis I in Matching

Figure II-17 illustrates its principle to specify the character position of the Item names by example.

Specifying of character position has very significant meaning if the character position of item names were assigned special meanings: so to speak code having positional meanings.

For example according to the Figure II-17,

	Character Position	Continued Length	Meaning
Upper Items	1~7 byte	7 byte	Product Name
	1	1	Size of Product
Left Items			
Product bundled	1~7	7	Product name
Product size	1	1	Product size

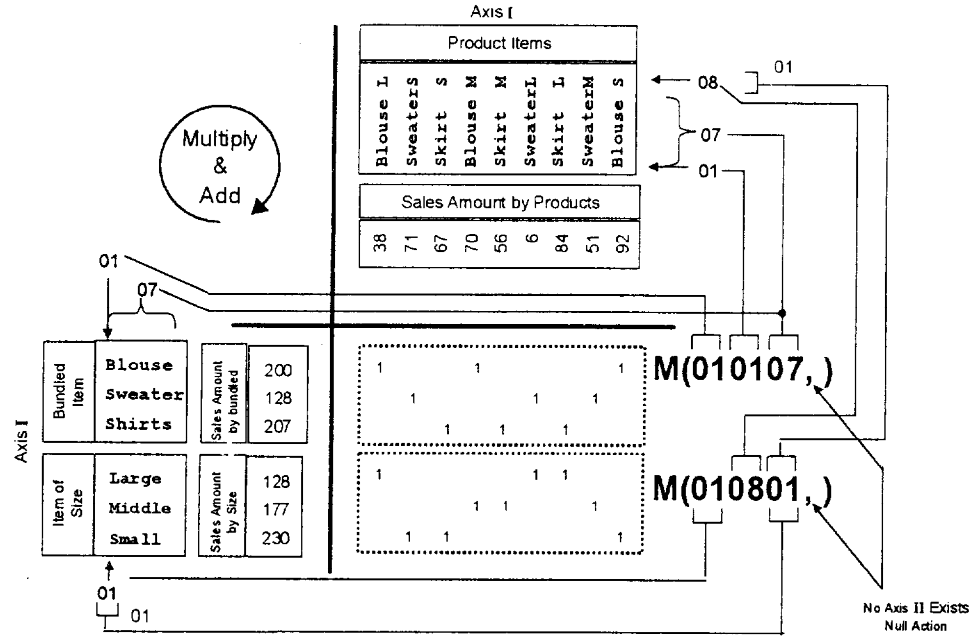


Figure II-17 Principle of One-dimensional Matching by specified character position

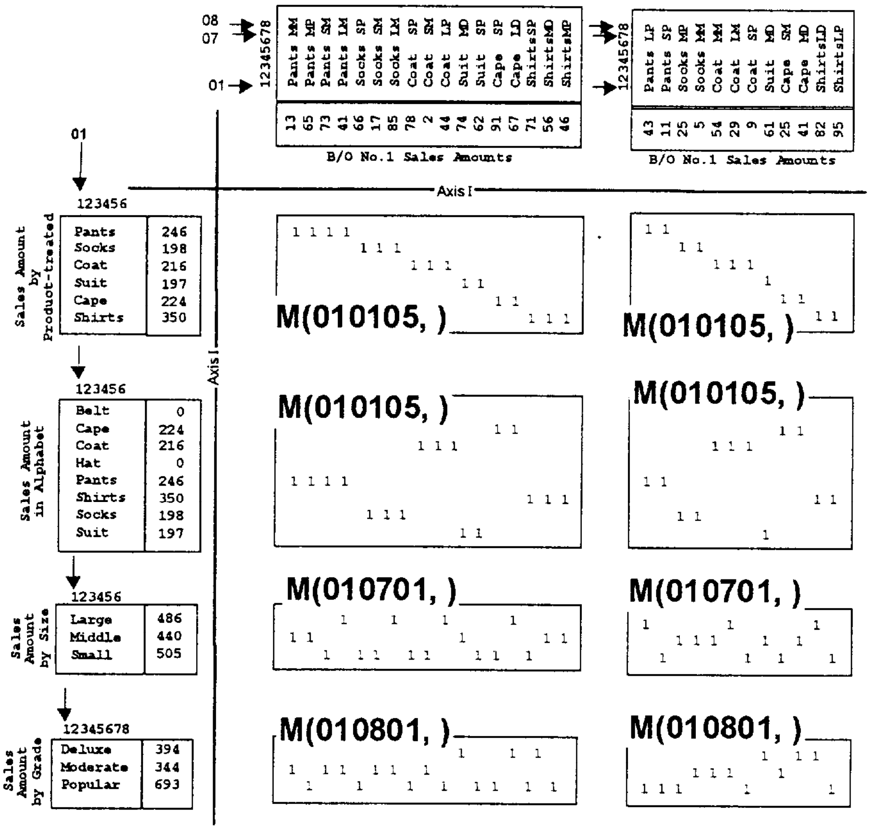


Figure II-18 Realistic Image of One-dimensional Matching

Figure II-18 is prepared for giving more realistic image in using Matching. In this case type symbol: M occupies major part of center block as parallel use and upper data are reorganized for different type of views.

These positional matching induce variable ideas to edit character position. For example, some parts of code positions are cut down into another synthesized code and Matching functions are performed.

Two-dimensional matching

Such matching technology can be applied also for the Axis II (Case axis) of upper two-dimensional table and left two-dimensional table defining the following character-wise definition.

M(LLUUSS, LLUUSS)

Axis I

- Starting Position (Byte) of **Left** Block's in Matching
- Starting Position (Byte) of **Upper** Block's in Matching
- Length (Byte) of Continued **String** to be Matched

Axis II

- Starting Position (Byte) of **Left** Block's in Matching
- Starting Position (Byte) of **Upper** Block's in Matching
- Length (Byte) of Continued **String** to be Matched

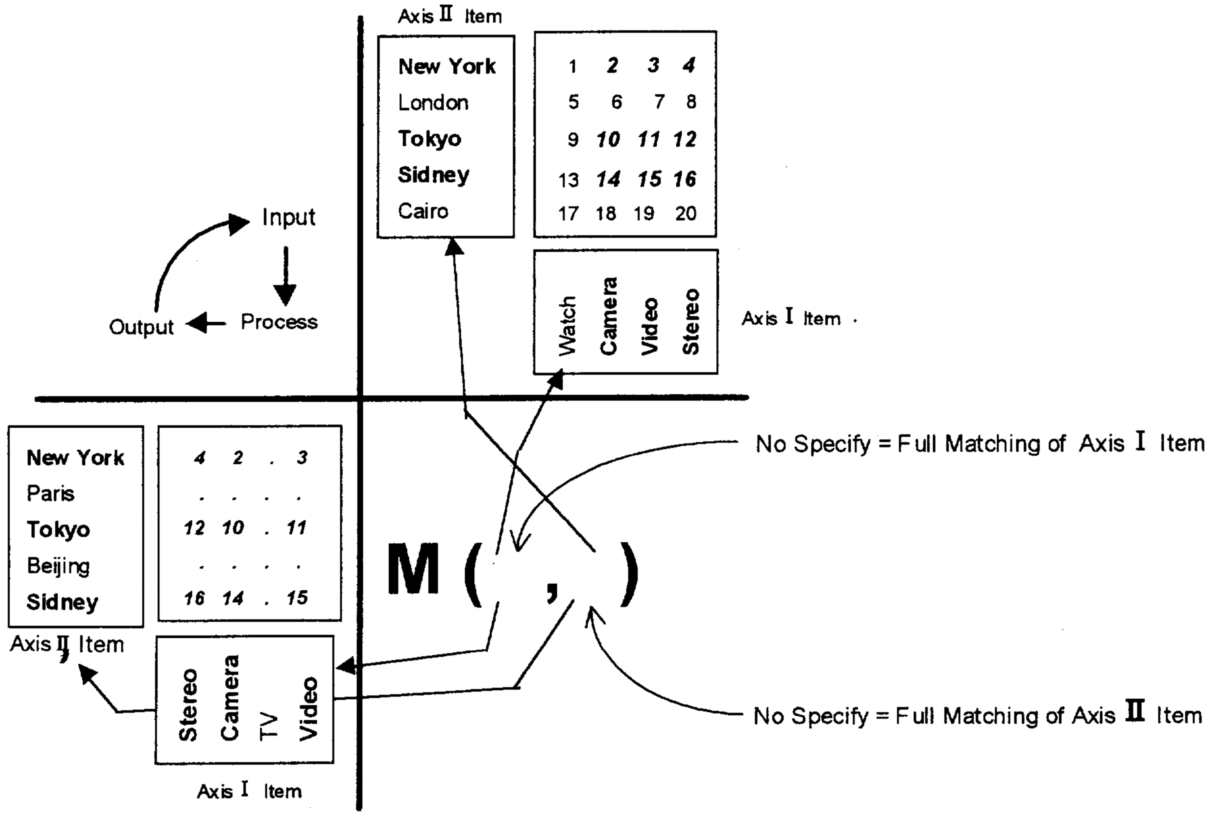


Figure II-19 Principle of Two-dimensional Matching

These two-dimensional matching can be used for describing inter table relations

Figure II-20 is shown as a typical inter-table processing application of project work load and costing. Before this methodology, such applications were developed individually by local requirement on spreadsheet, with enormous efforts. Because of the difficulties of maintaining, developed applications were abandoned.

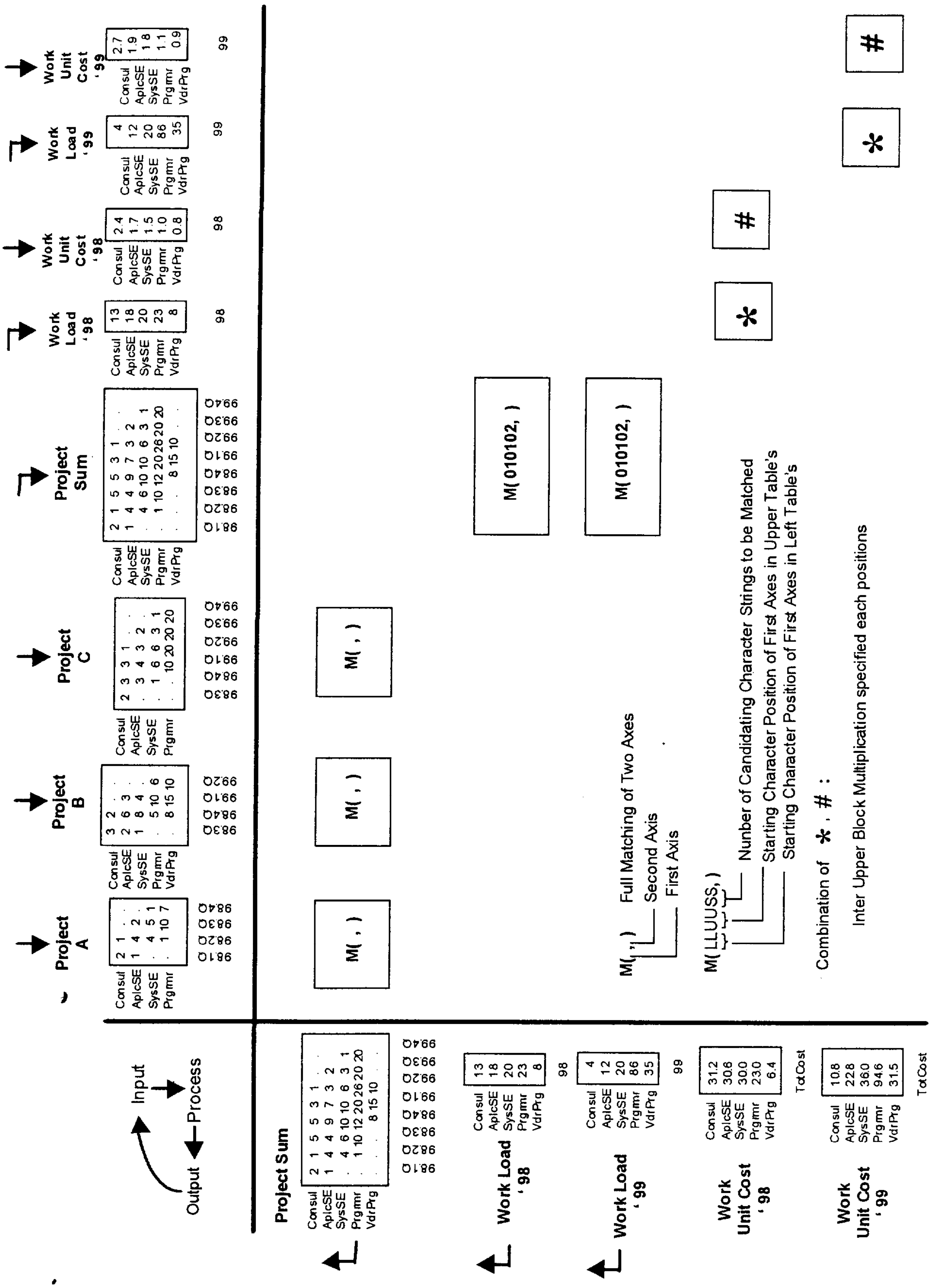


Figure II-20 Applied Case of Type Symbol: M Matching in Project Work Load and Project Cost Estimation

10.. Type Symbol: P

Production rule like *If then Else* can be performed. Details are abbreviated.

11. Type Symbol: Q

The purpose of this symbol: **Q** is in assigning top value (Top value can be plural values.) to hierarchical organizations according to the prorating index values given in each level of tree organization. This technology on structure matrix, is one of the four technologies assigning top values according to activities.

This fundamental idea is to prorate a parent value to their sons using relevant index given each level. These prorate is performed by each level from top to down ward according the hierarchical chains. In this case, each brother has its own index value to be used for the prorating among the same level and sometimes the dimension of those index differ in organizational branches.

This work may seem very simple but if the organization level deepens, computerizing will be very trouble worthy by the lack of dynamic adaptation following up by traditional programming.

Moreover thinking the case study of organizational change, this work is terribly complex. We can often find the case that common index is uniformly applied for the entire organization and the lack of local appropriateness is neglected. For compensating these situations, many business staffs under the line managers are ought to be engaged by handwork. By the strong needs as an essential technology of management systems, the function is first supplied as *user exit*. Recognizing the wider usage, this function was upgraded as type symbol: **Q**.

Typical applied cases are,

Assigning of sales quotas according to the organization plans,

Assigning common fixed cost for organizations like sales cost

Assigning energy and utilities that measurements of its consumption are technically impractical and some alternative as yardsticks are applied as calculated values from other source of data. (Some details will be discussed later.)

For discussion, let us take a simple case: assignment of sales target to an organization by breaking down total target for coming year. Think two levels' organization at first as Figure II-21 in which prorating factor is to be assigned by each forecast of this year.

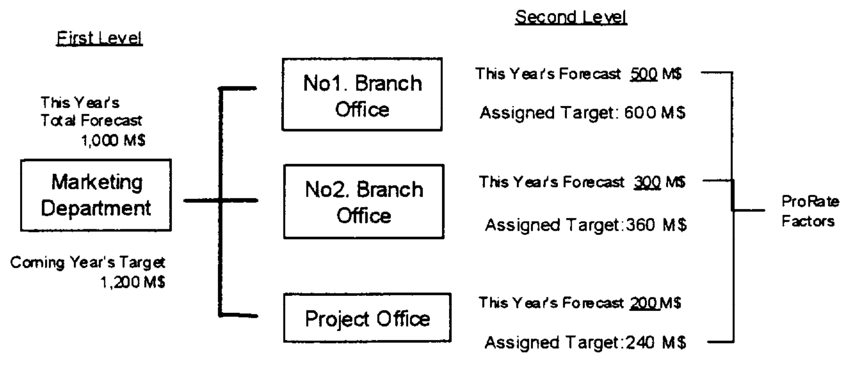


Figure II-21
Assignment of sales target

In this two levels' organization, total amount 1,200M$ for coming year is prorated this year's forecast: 500 M$, 300 M$ and 200 M$ and results: 600 m$, 360 M$ and 240 M$ are given using type symbol: % (Prorate).

Then let us think assignment of target to the third level's organization as Figure II-22. The third level's target is to be assigned by each Prorate Factors. The most moderate factors for the third level of No.1 Branch should be thought number of employees in their sections. The most moderate yardsticks for No.2 Branch should be based on the number of sold sets, because these sections are selling supply parts.

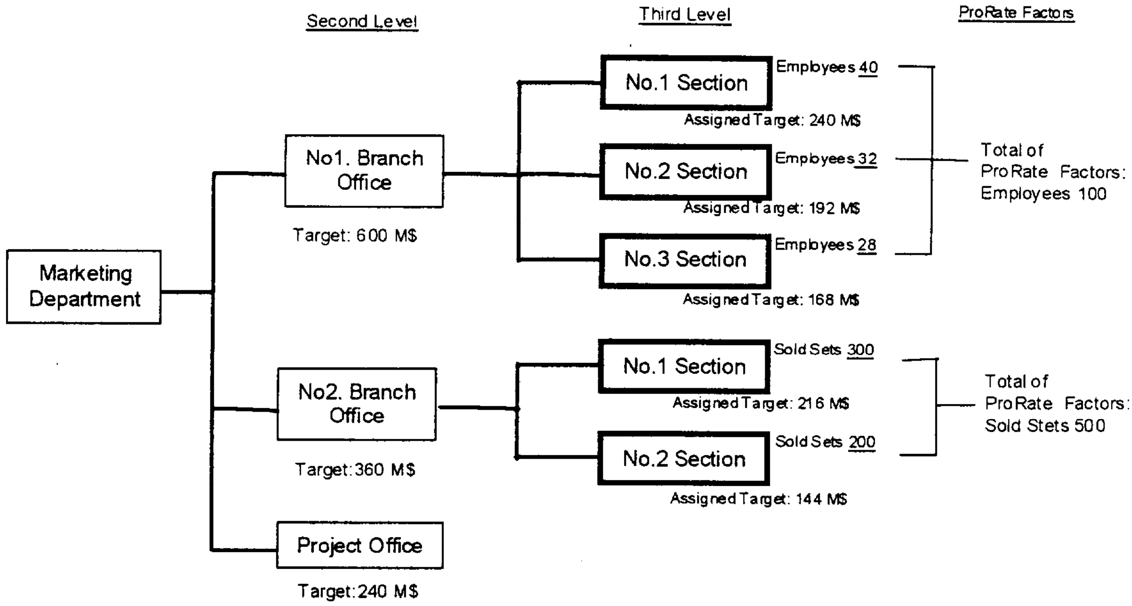


Figure II-22 Third Level Assignment of Sales Target Coming Year

Type symbol: Q is prepared as integrating those different levels of assignment in a function using given top values to hierarchical organization, according to the given prorating values given to each branch, as shown next Figure II-23.

In the upper block, top values to be distributed and corresponding yardsticks to each branch of the organization should be placed.

In the center part, value 1 should be placed at the cross points of upper organization item and left organization item, reflecting the graph of organization chart. This means that an upper element above the cross point in the upper margin means the parent and a left element of the cross point in left margin means the child. We can apply the idea to the relevant assigning for hierarchical organization by the condition that the organization never includes looped relation, that is, reversed relation that the child can be his parent. It is the applicable case that that elements of children never become parents elements as organizational characteristics. In addition, difference of composed levels in the branch of hierarchy as the case of Project Office in Figure II-23 is accepted.

The results by each branch including the tops are given in the left block.

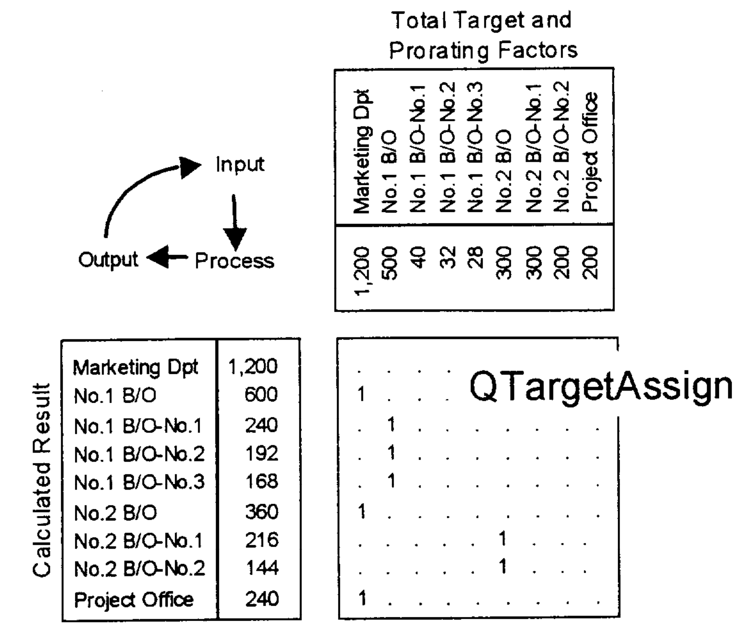


Figure II-23
Expression by Type Symbol: **Q**

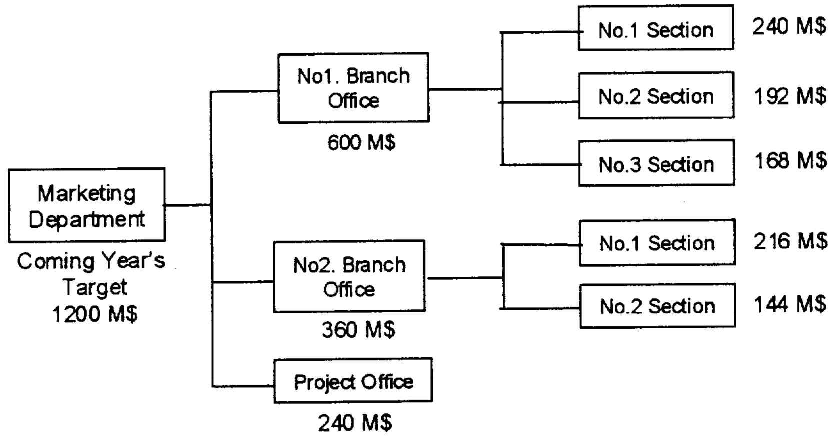


Figure II-24 Calculated Result of Target Assignment to Organization using Type Symbol: **Q**

About the case of organizational changes shown in Figure II-24, settings of the upper block and the center block are changed as Figure II-25 (See gothic characters) and assigned results are calculated as given in the left block.

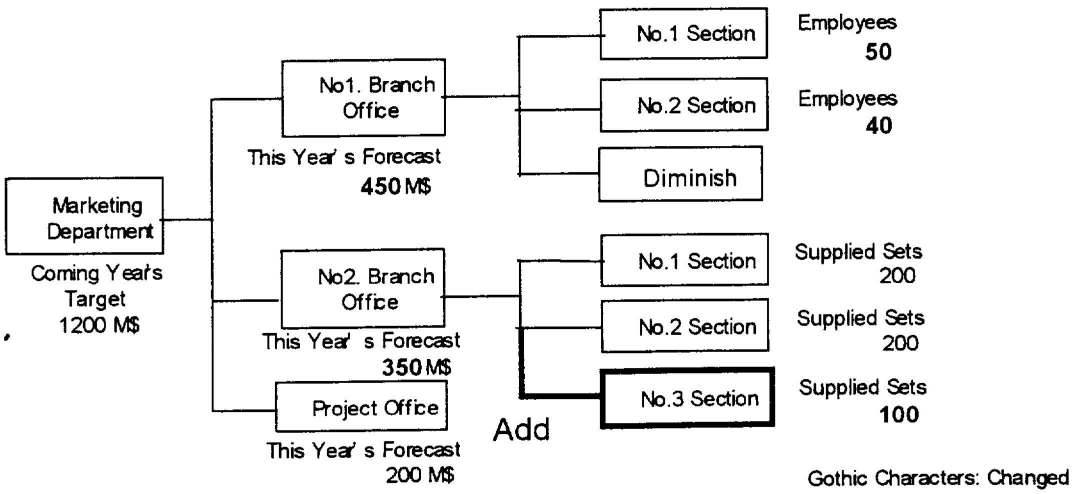


Figure II-25 Organizational and Yardsticks' Changes happened on the Previous Case

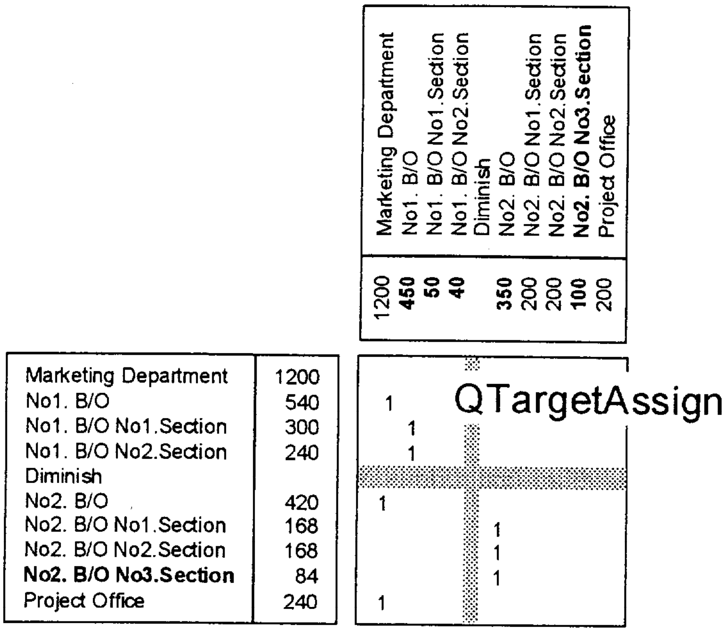


Figure II-26
Change of Setting in the Model
and Result of Assignment

Principle of Type Symbol: **Q**

Schematic principle of calculating logic in type symbol: **Q** is shown in Figure II-27 taking previous example.
This calculation starts from the upper block and the associated center matrix. Prepared intermediate result by four arithmetic matrix operations and inner product, are sent to the logic of weighted network calculation that is the same as the type symbol: **V**. Using this series summation, the assigned amounts are resulted in the left block. As prerequisite knowledge, refer the idea in the section of type symbol: **V** in which the part's developments along the *Bill ofMaterial* network with weighted coefficients are described.

As knowledge got from the management system of energy and utility saving, some extended models, applied upon this type symbol are explained in the following.
The saving activities in energy and utilities in plant, evaluation of the saving efforts should be synchronized with their measurement cycles like daily, weekly and monthly. In a large plan like integrated steel works, various kinds of resources like followings and services are used as complex.

Electric power supply with various Voltages,
Various gas supply like : Fuel gas, Oxygen, Nitrogen.....
Compressed air supply with different pressure,
Steam supply with different entropy,
Water supply, Waste water Handling, Telephone ....

Their consumption should be taken into the system directly from the plant sites as start of management figures, and those non-monetary figures are to be converted to monetary figures with tight correspondence for evaluating the saving efforts. In these saving management system, their efforts should be fed back by both figures of non-monetary and monetary values giving familiarity to support their improvement actions. There exist many distinguishing problems of top consumed values using type symbol: **Q**s. Measurements by each local site are ideal, but measuring costs themselves are sometimes huge and complex.

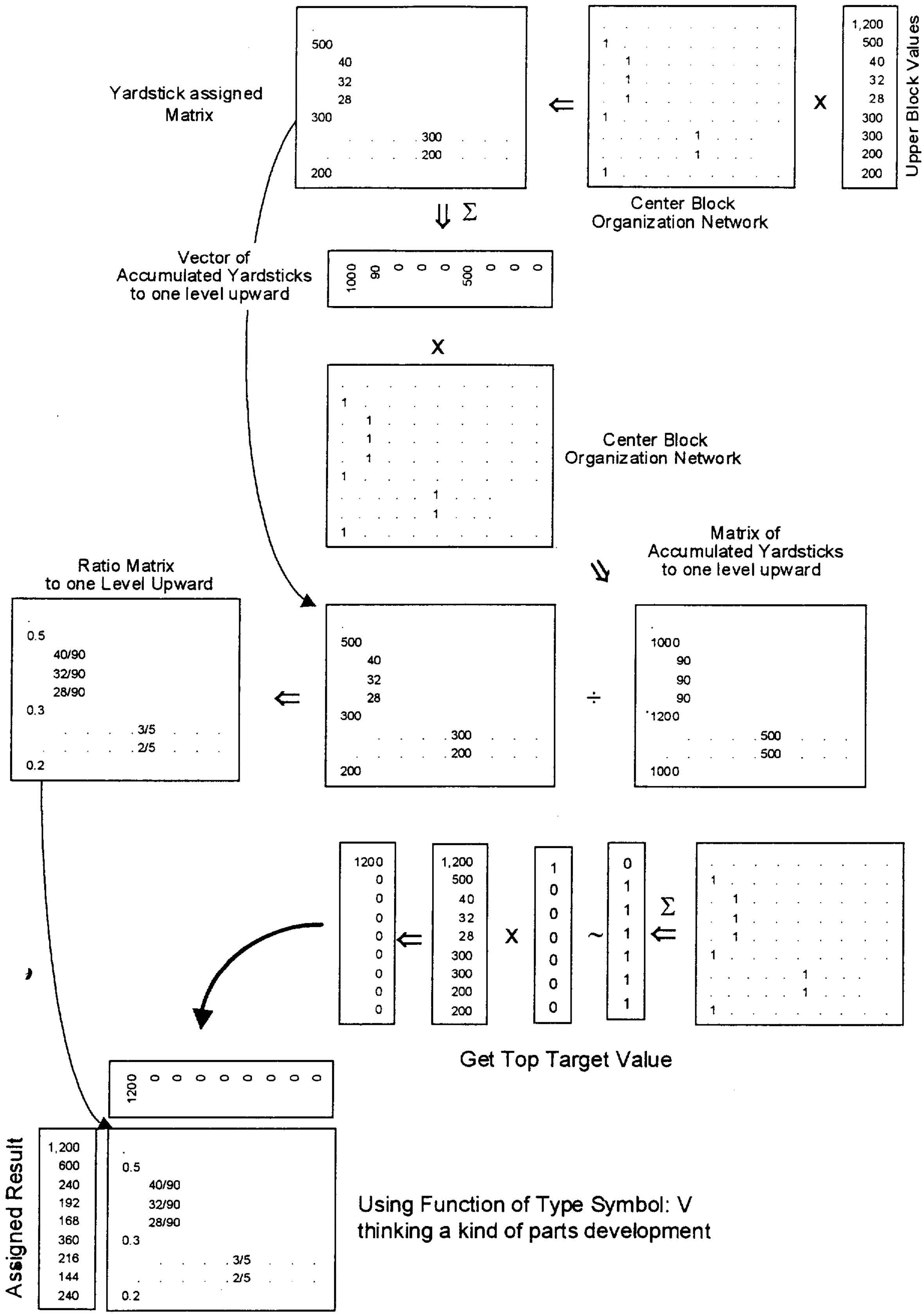


Figure II-27 The Schematic Principle of Calculating Logic in Type Symbol: Q

So the quick and exact responding for the change of plant facilities, production mix and supplying resource cost, such technology to keep the mechanism of assigning logic to be visible and accordingly changeable by users are required. Sometimes measuring itself is harmful for the purpose of energy saving. Taking example in measurement of water supply, Venturi tubes are required to insert in pipelines. This insertion itself makes energy losses on the contrary of the saving purpose. So applying type symbol: **Q** finding and combining proper yardsticks, like production amount, production hours, working hours, etc,, is often implemented avoiding the measurement.

Sometimes complex flows reflecting real resource supply in plant like Figure II-28 and Figure II-29 are involved in these models. Type symbol: **Q** can naturally solve these problems because center matrix can represent such networks.

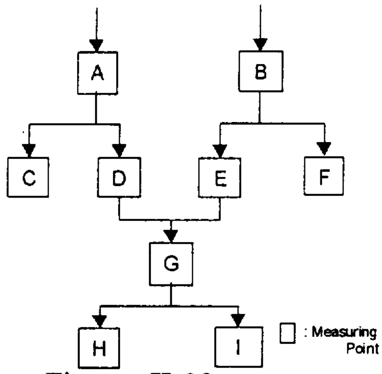


Figure II-28

Assignment supplied from Dual Sources Flow

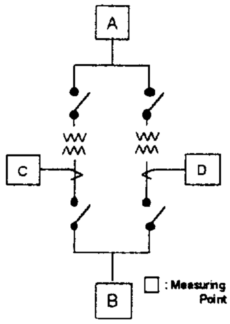


Figure II-29

Assignment including Parallel

Correction of calculating errors and rounding

Users' requirements for error adjustment in applying this type symbol: **Q**, are intense for such cases that the summation of assigned figures for the children should be broken down keeping it as their direct parent's value by each level. Accordingly, top value must keep consistency with the assigned values in all the tree structure. This function was implemented by tough programming.

In addition, it is required to keep the consistency of the rounding in each level in the down ward assignments of top figure. Some parameters must be specified as an attribute of type symbol: **Q**. These requirements are common, when this symbol: **Q** is used in the breakdown and the piling up of organizational target as planning models, for instance, marketing, production amount, costs saving, etc.

12. Type Symbol: R

The purpose of this type symbol is prepared for easy interface with common feelings of end users. We meet many cases in which user wants to handle values as commonly used images (thinking realistic yield values for end users). Therefore, it should be changed into executable values (reciprocal value of yield) in computer, then the basic calculation of *Multiply and Add* will be executed. Type symbol: **R** is prepared for changing the values of center block to reciprocal values before the execution of *Multiply and Add* as in Figure II-30. In addition, if original values are zero, also reciprocal values are treated as zero.

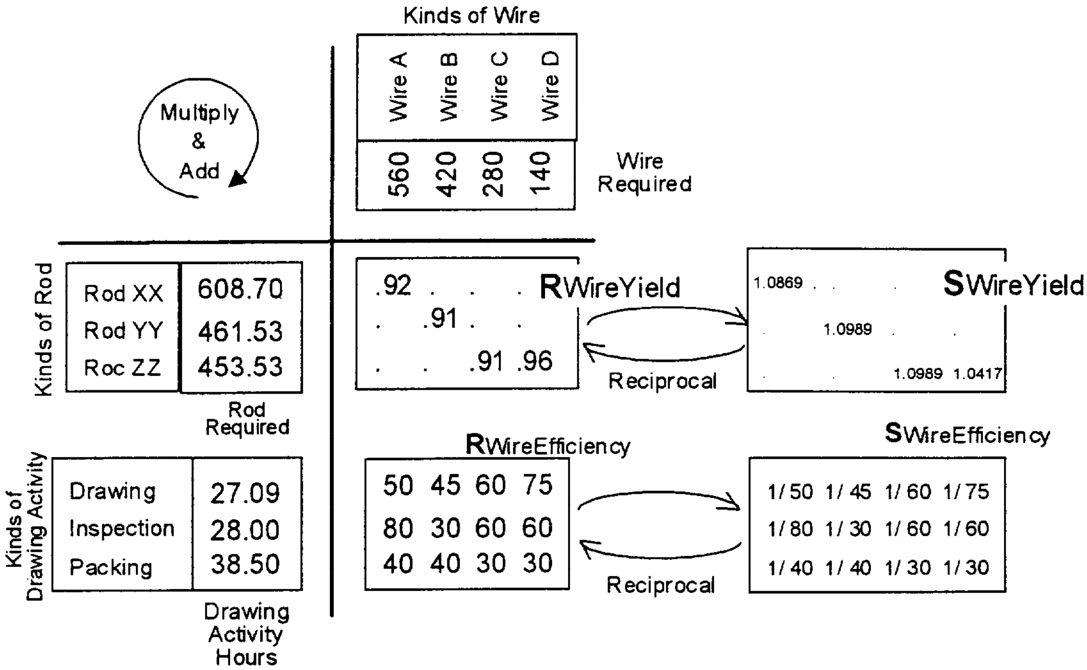


Figure II-30 An Example of Type Symbol: R in production Planning

This function was required first by Fukuyama Works, Nippon Kokan Kaisha for smooth handling of planning values. They highly evaluated the function that end users can interface with the original values without facing their reciprocals.

13. Type Symbol: S

Type symbol: S is a capped letter given to the center block and this symbol specifies nothing for special characteristics as other type symbol gives. The naming was derived from top character of standard use. This symbol must not be abbreviated.

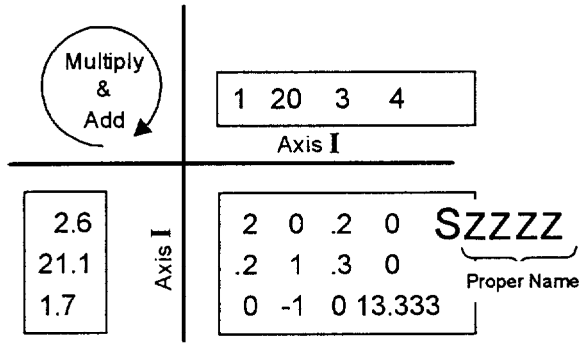


Figure II-40
Sample of Type Symbol: S

The saved values as block are real numbers and the value can cover other type symbols of **B**, **G**, **R**

A special case whose data are diagonally located in the center block is treated as extension of type symbol: **E** using it as capping character upon proper specifying characters like EZZZZZ. Refer the section of type symbol: **E**.

14. Type Symbol: T

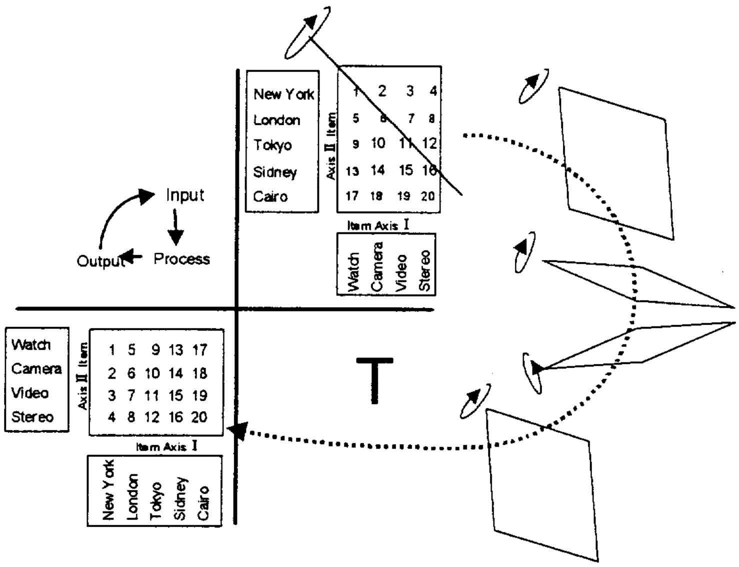
Type symbol: **T** has following two functions.

- Single character is used
- Character **T** is used as capping other center block.

Type symbol: **T** with no associate table

This symbol was introduced at the extension of table handling to tow-dimensional table. The function is to overturn the upper block along diagonal line to exchange the Axis I and Axis II (Item and the Case) as in Figure II-41. This is a kind of transpose of upper table mathematically. Accordingly, the name of the resultant left block must be changed. As for naming, the word: Rotate is sometimes used for the meaning of rotation. By this function, adaptability of two-dimensional table handling is enlarged.

Figure II-41
Type Symbol: T



Type symbol: **T** as Capped Character of Other Center Block

This function was first prepared for unifying the dual calculation method: *Multiply Vertically and Add Horizontally* and *Multiply Horizontally and Add Vertically*, on structure matrix. The German Cost Theory based on structure matrix has dual structure in calculating relation between non-monetary factors' structure and monetary (cost) structure as bilinear relations. Details of How and Why they are unified, are written in another part of this thesis. Therefore, only functional relation together with type symbol: **T** as *Transposing of Center Block* is described briefly. Transpose is an arithmetic common operation, therefore type symbol: **T** is frequently used as general use. By its origination, **T** is heavily used in material cost and processing cost models. Sometimes it appears in cost related models like wider cost models of complicated activities. This will be discussed in details in the later part of this thesis as various types of activity costing for complex assignment of common cost.

Function of Symbol: T is to transpose the specified Center Block as associated proper name and let it to calculate by *Multiply and Add* rule as in Figure II-42. The center blocks as candidate to be transposed are limited only for the block to have the characteristics of linear type symbol (capped): **B**, **G**, **R**, S, V, @, and to be existed within the same structure matrix. As shown in the examples of naming as follows, type symbol characters occupy two top characters.

In addition, as another rule, plural number of *Transposed Center Block* can be existed for an original center block. Because the *transposed center blocks* do not exist really, original center blocks are referred then are transposed prior to the actual execution of *Multiply and Add*. This mechanism also provides conveniences for maintenance of transposed center blocks. Because modified center block is virtually reflected to all transposed center block.

Original Center Block Name	Transposed Center Block Name
Bzzzzz	**TB**zzzzz
Gkkkkk	**TG**kkkkk
Rfffff	**TR**fffff
Sjjjjj	TSjjjjj
Vyyyyy	**TV**yyyyy
@uuuuu	**T**@uuuuu

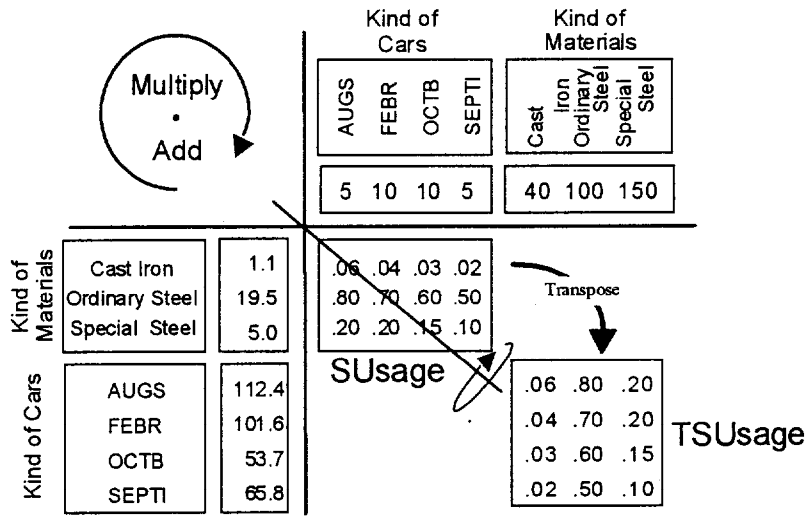


Figure II-42
A sample of Transpose using a center block: SUsage

Associated transformed function: Transform Vector to Diagonal Matrix

The function is to transform a vector given at the upper block to a diagonal matrix and place it into the Left Block as in Figure II-43 and II-44. This function cannot be attained by essential Matrix Algebra Operation but by the needs, this is built-in associating the type symbol: **T** with parameter **E**.

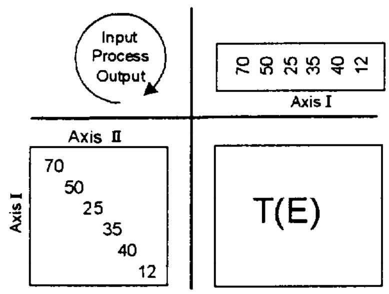


Figure II-43
Transforming of Vector to Diagonal Matrix

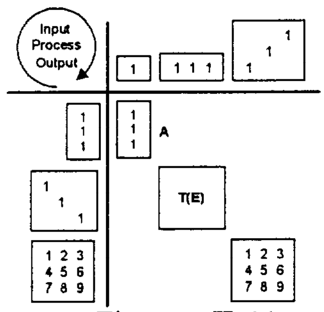


Figure II-44
Transform Block from Center Block

The needs are

- To calculate each effect by the elements given in the upper vector as predetermined block.
  This is effective in the following calculations.
    each cost by elements
    grasping their effects in the linear calculations following this calculation
- To get associated linear center block in left block by setting the upper block, vector having value 1.
  This function is used for calculating condensed matrix in other chapters (Applied Cases).

15. Type Symbol: V

This type symbol is prepared for the processing of parents and children's relation, supported by the tough logic processing using a single center block. This relation is sometimes known as Bill of Material (BOM) or Material Requirement Planning (MRP). In this discussion, there is an assumption that the parents and the children's relation does not contain reversed relation that children become parents inversely. Such reversed relation will be discussed in the section of type symbol: @. The naming V was given thinking Volute or Vortex in a center block.

Calculating Principle

Thinking the parts development in tree structures shown in the left side of Figure II-45, it can be expressed in the rectangular matrix: VM shown in the right side of Figure II-45.

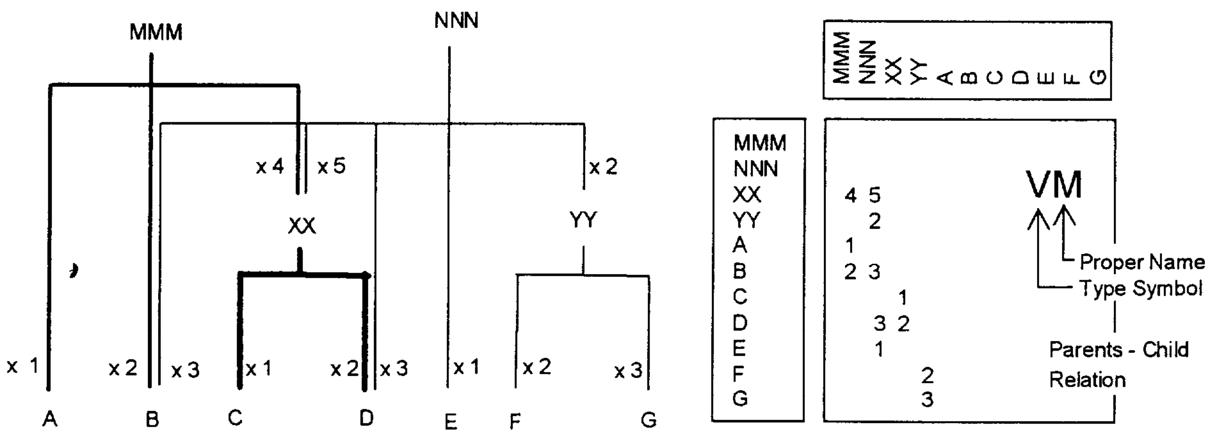


Figure II-45 Parts Development Structure and its Expression by Rectangular Matrix

In the figure ' x ' means number of required parts, and in the expression of rectangular matrix: VM, the associating item names are taken from the branch names. *Parts Developing Matrix*: VM constructs a weighted network matrix corresponding the parents and children's relations in the left.
Let us think the summation: SVM: *Total Parts Development Matrix* made of matrix series of VM as the following equation:

$$SVM = E + VM + VM^2 + VM^3 + VM^4 + VM^5 + \ldots\ldots$$

VM^n becomes 0 after n = 3, because maximum path length is two in the network. So effective part is shown in Figure II-46.

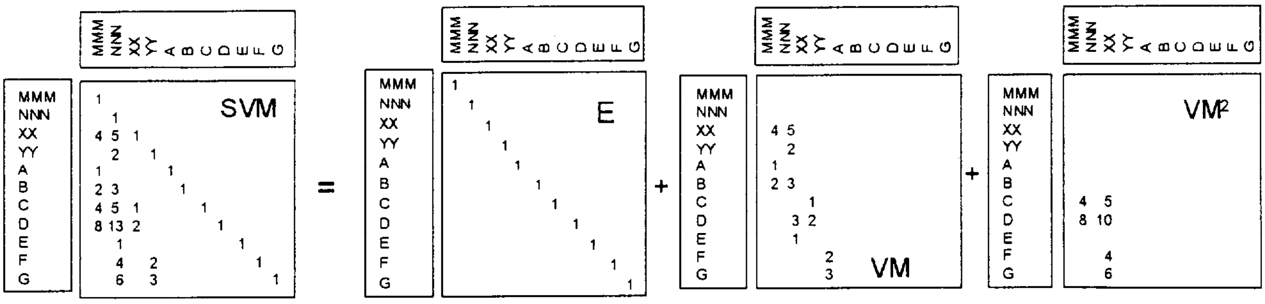


Figure II-46 Total Parts Development Matrix: Summation of Matrix Series for VM

Above equation can be rewritten: SUM = (E - VM $)^{-1}$. Matrix: SUM is thought to be the re-normalized (*Kurikomi* in Japanese) matrix of the matrix series.
Averting the processing of calculated fractions, the series sum equation is practicable because its calculation ends infinite terms.

After getting *Total Parts Development Matrix*, required Total Parts can be calculated for the given parents parts as shown in Figure II-47. In this sample, not only the top requirements (Top developments), but intermediate parts are developed. By giving the requirements in upper block, needs in all levels can be developed including tops, intermediates and bottoms. Type symbol: V includes calculation principle of *Total Parts Development Matrix* and *Multiply and Add* operation.

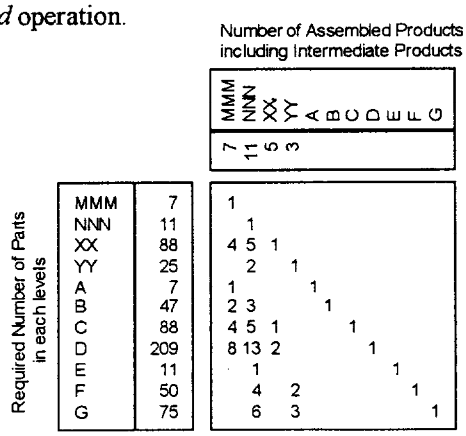


Figure II-47
Total Parts Development using
Total Parts Development Matrix

As an extension of this idea, each level of net total parts development can be calculated by using and giving current inventories as minus values as shown in the example shown in Figure II-47.

The parts development discussion is proceeded by assuming integer value of products, and these values can be extended to real values. As another idea, method of utilizing Axis II is useful for the parts development of multi-top development by assigning each top to different depth slot (items of Axis II: Case). By this expression, result of each top development can be separately grasped.

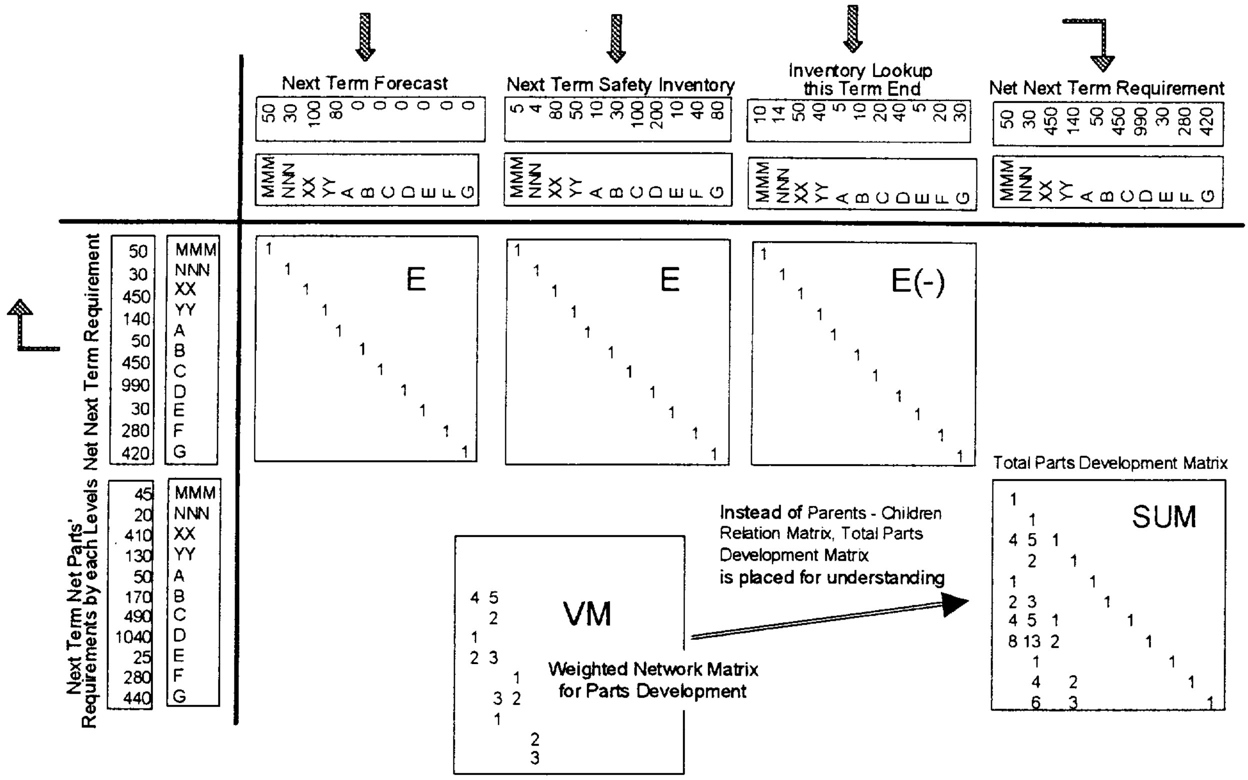


Figure II-48 A Model for Next Term Net Parts' Requirements

Why type Symbols: **V** was introduced.---- For Reference------

From the point of the modeling technology of structure matrix, there is a discussion *why* structure matrix itself is not directly used without specialized type symbol: **V**. Yes. Surely, structure matrix can calculate it as shown in Figure II-48, by placing two "SM"s (Weighted network matrix) and three "E"s. The reason is "SM" represents two levels of development depth. (Don't make a hasty conclusion. The illustrated model is not calculating developments of parts level by level.) Exactly speaking, this model is calculating one path's development first. Then using this result, two paths' developments are calculated by operating the inner product of the weighted network matrix, selecting the two paths.

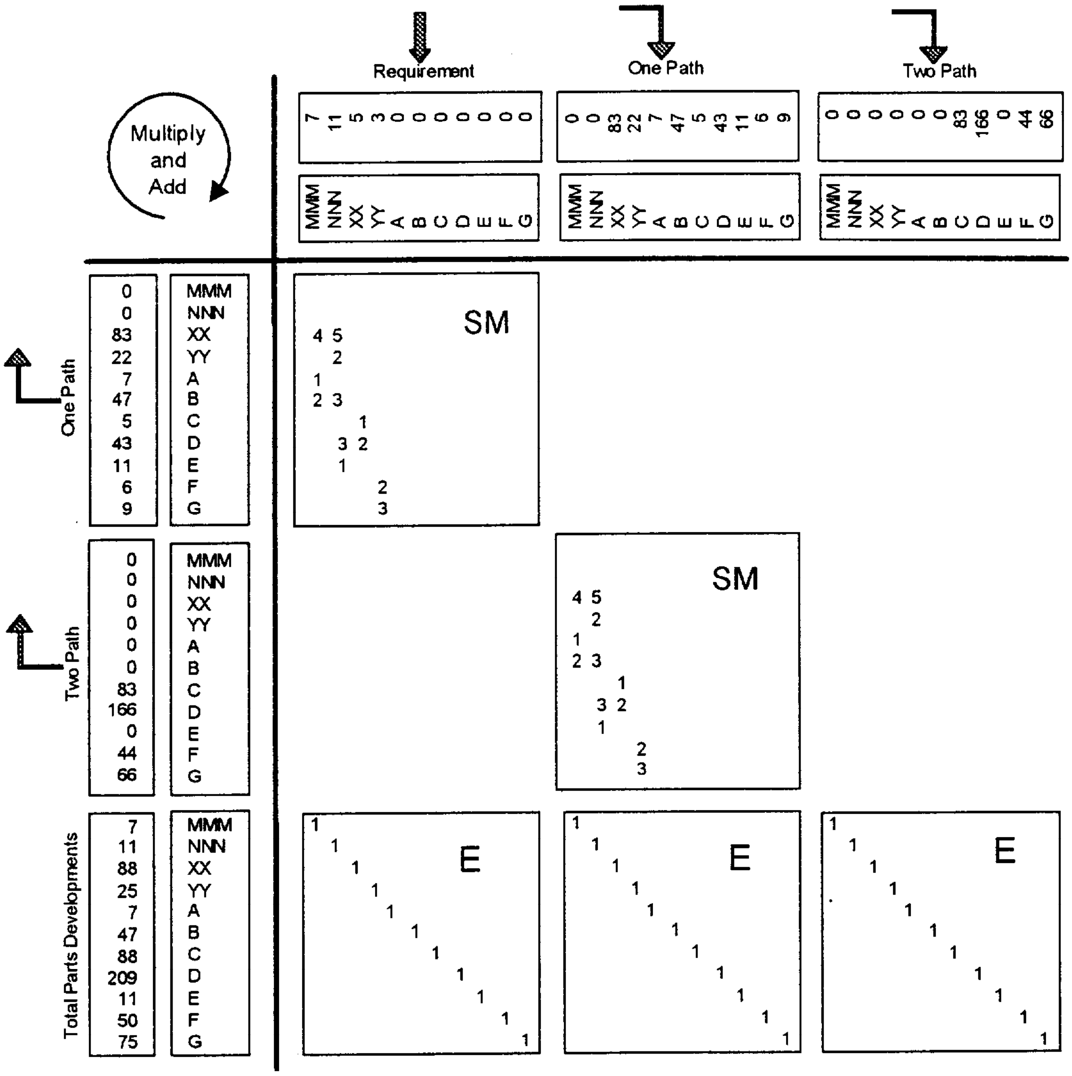


Figure II-49 Parts Development using Original Calculation of Structure matrix

There are following three reasons.

- Needs of parts development grasping the developing levels.

  By the method shown in Figure II-49, users can develop parts by grasping the development levels. If the sizes of this matrix become large, users may feel difficulties in grasping development levels contained in the matrix. If development levels are larger than the expected and placements of "SM" and "E" are insufficient, the calculated results are invalid. (Surplus placement is valid, because results for surplus power of "SM" become all zero.) Type symbol: **V** can calculate the matrix series until the power of "SM" becomes all zero.

- Necessity to built-in protecting function for input mistakes

  The function is necessary to reject reversed relation (children become parents.) in the weighted network matrix as a nature of parts development. As sizes of the matrix become large, this confusion sometimes happens by input mistakes,

- Requirement to make the model compact

  By adopting type symbol: **V**, macro table of the parts development becomes compact and easy to understand. Adding this, setting and input workload will decrease.

Calculation of Assemble Cost

Using function of type symbol: T (Transpose), assemble cost can be easily calculated if weighted network matrix is established by using type symbol: **V**.

Problem is how to get cost of assembled top products, giving unit cost of end parts as in Figure II-50. This assembling structure is succeeding the previous example in Figure II-51.

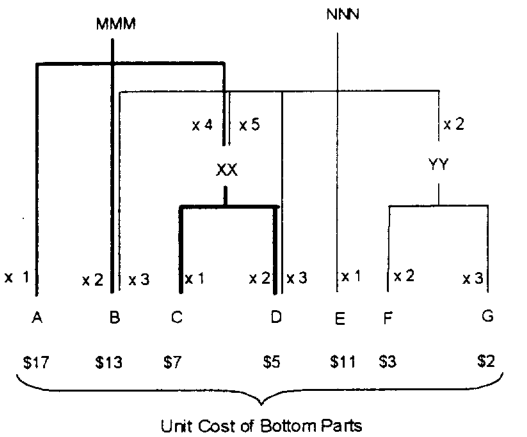


Figure II-50
Sample of Assemble Cost Structure

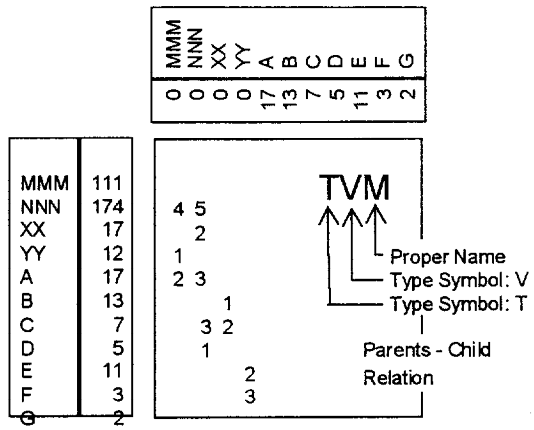


Figure II-51
Transposed Relation of the Structure

The idea of the internal processing just before the execution of *Multiply and Add*, is shown in Figure II-52. The matrix shows transposed result after getting series sum of VM.

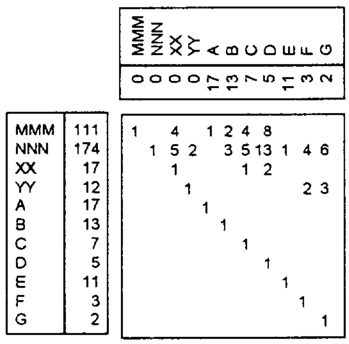


Figure Ii-52 Internal Logic of **TVM**

Adding those assemble costs, assembling work costs are required in the assembling node as shown in Figure II-53, those cost structures can be described using the Axis II (Case) Items and calculated like Figure Ii-54.

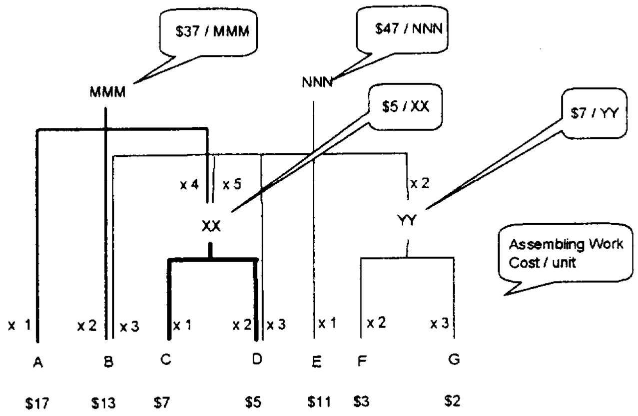


Figure II-53
Structure with Assembling Work Cost

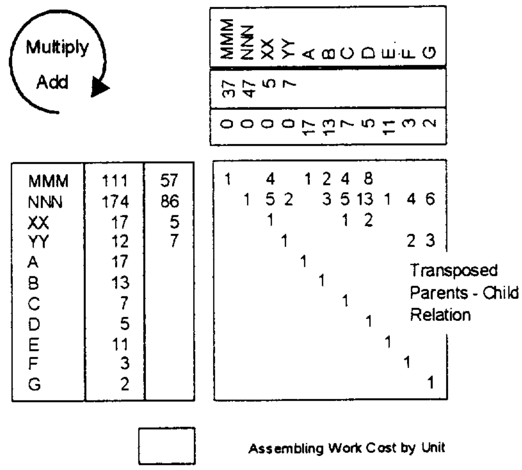


Figure II-54
Calculation of Assembly Cost

Model for Parts Requirements and Assembly Cost

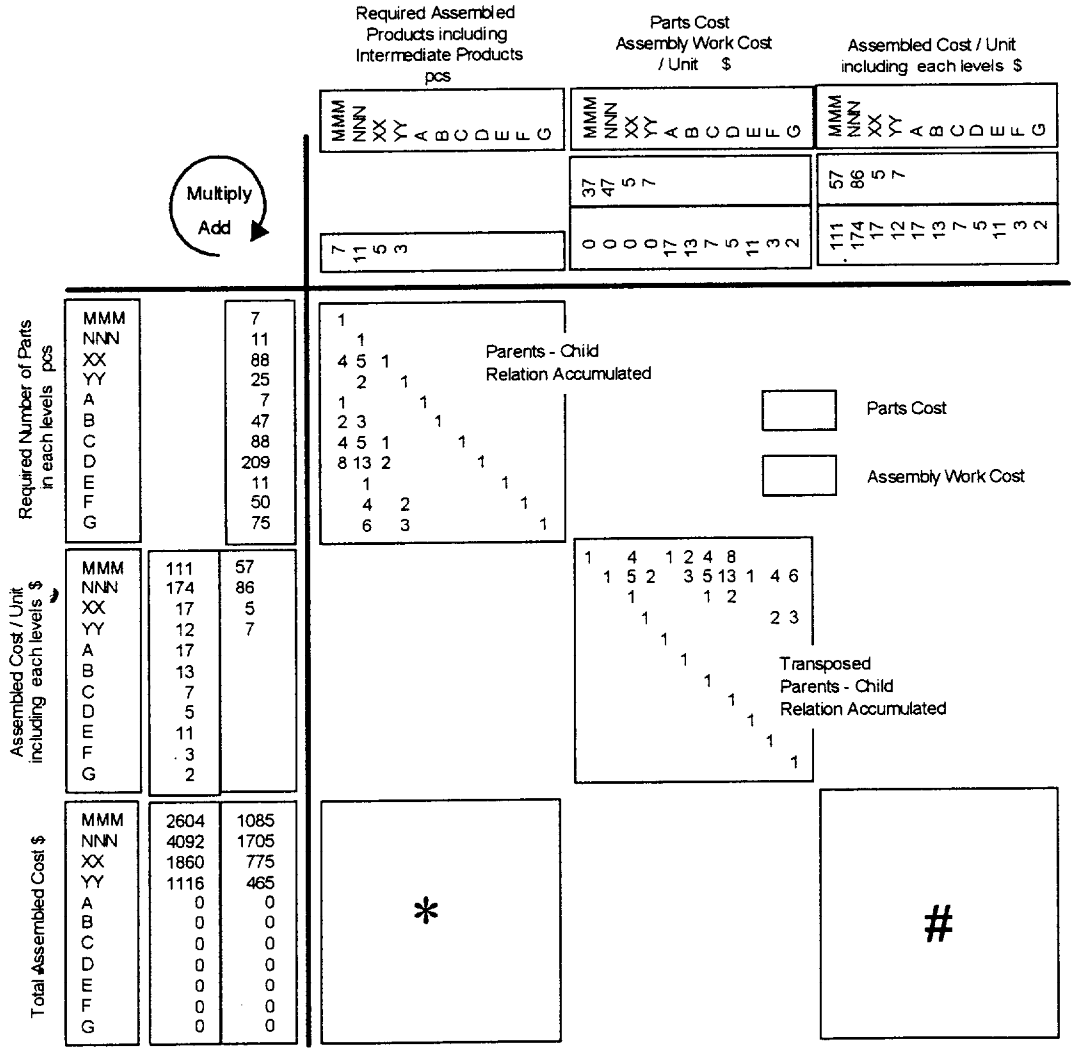


Figure Ii-55 A Total Model Parts Requirements and Assembly Cost

Technologies already explained are organized in Figure II-55 using type symbols: **V**, **T** and # (**D**) schematically.

16. Type Symbol: X User-Exit

The purpose of this function is to provide the slots to absorb local needs of users that might be the dedicated routines to be built-in. Another purpose is to prepare the mechanism to know the population of needs for the developed new logic, which might be turned to the common type symbol with level-ups. Type symbol: **Q** and Extended function of **E** as vector transformation to diagonal matrix were thus supplied through the historical experience of user-exit.

Sometimes user-exit routines are developed to keep users' own confidentiality like military base in bedding open and visible models.

As a note to be prepared function for the smooth development of user-exit routines, macro functions should be supplied for their direct upper block data with its item blocks and specified upper block with its item block as user-exit arguments.(Include indirect specifying by # and associated characters)

As another note, package vendor should prepare the following mechanism for smoother version ups.

- User should be possible to keep their legacy of developed users' routines.
- Package vender should be possible to maintain or replace the vender supplied user-exit functions.

This requirement has an analogy to the design of word transformation function in word processor package.

17. Type symbol: @

This type symbol is prepared for the processing of parents and children's relation within a single center block like type symbol: V. The characteristic of this function is processing of linear loop whose relation between the parents and children is proportional. The difference is that the inverse relation between children and their parents (Looped Relation) can be permitted on condition of convergence. For larger loop covering the whole single structure matrix, functional phase of calculation is prepared as bigger loop processing whose non-linear elements can be permitted within the range of convergence. About the naming, '@' is selected by its loop image.

The linear loop can be found in most of management and social modeling as essential phenomena. We can find the following common illustrations as easily understandable phenomena.

Energy saving process of heat contained in exhausted gas in reheat furnace
Reuse of scrap or defect material by recycling in chemical and metals process
Econometric models by Input Output Analysis
....

Generally, there is a likeliness to make looped structures among the chains of material and energy in production and environmental problem, and the chains of revenue and expenditures. The problem is that they can be easily expressed as linear loop or not.

Calculating Principle

Let us take an easier example of the reheat furnace model as in Figure II-56. Here 60 percentage of heat content in exhaust gas is recovered as heating energy loop of the inlet air forming. The problem is to calculate the energy: Heat by Fuel required for the 100 tons of Material to be heated.

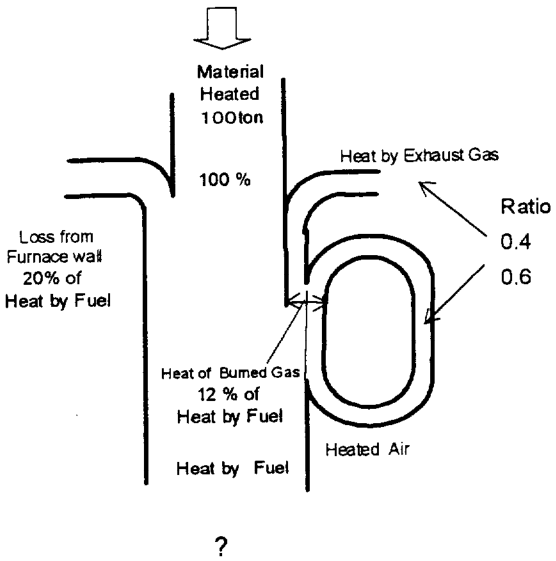


Figure II-56
A Sample of Energy Flow of Reheat Furnace

	Heat taken by Hot Metal	Heat loss from Furnace Wall	Heat of Burned Gas	Heat by Exhaust Gas	Heated Air	Heat by Fuel
Heat taken by Hot Metal	0	0	0	0	0	0
Heat loss from Furnace Wall	0	0	0	0	0	.20
Heat of Burned Gas	0	0	0	0	0	.12
Heat by Exhaust Gas	0	0	.4	0	0	0
Heated Air	0	0	.6	0	0	0
Heat by Fuel	1	1	0	1	0	0

SRF

Figure II-57
Weighted Network Matrix for the sample

The energy flow of the reheat furnace is represented as a weighted network matrix shown in Figure II-57 giving name: SRF. Let us think SUM as Summation of finite matrix series of WN: weighted network matrix shown in the following equation:

$$SUM = E + SRF + SRF^2 + SRF^3 + SRF^4 + SRF^5 + \cdots\cdots\cdots$$

E: Unit Matrix (Eigen Matrix: Value 1 are located Diagonally)

In calculating above equation can be rewritten.

$$= 1 / (E - SRF) \qquad \text{if converged}$$

SUM as sum of matrix series of SRF is calculated as in Figure II-58.
(Matrix: SUM is a *re-normalized* matrix of matrix series.)

Giving SRF as center block: @SRF is calculated as in the Figure II-59 by giving value 100 for corresponding position of 'Heat taken by Hot Metal' in the upper block as vector. The required value: 'Heat by Fuel' and other values in the flow are calculated together as Heat Consumption.

Figure Ii-58

SUM as summed result of Matrix Series SRF

	Heat taken by Hot Metal	Heat loss from Furnace Wall	Heat of Burned Gas	Heat by Exhaust Gas	Heated Air	Heat by Fuel
Heat taken by Hot Metal	1	0	0	0	0	0
Heat loss from Furnace Wall	0.2659	1.2659	0.1063	0.1595	0	0.2659
Heat of Burned Gas	0.1595	0.1595	1.0638	0.1595	0	0.1595
Heat by Exhaust Gas	0.0638	0.0638	0.4255	1.0638	0	0.0638
Heated Air	0.0957	0.0957	0.6382	0.0957	1	0.0957
Heat by Fuel	1.3297	1.3297	0.5318	1.3297	0	1.3297

SUM

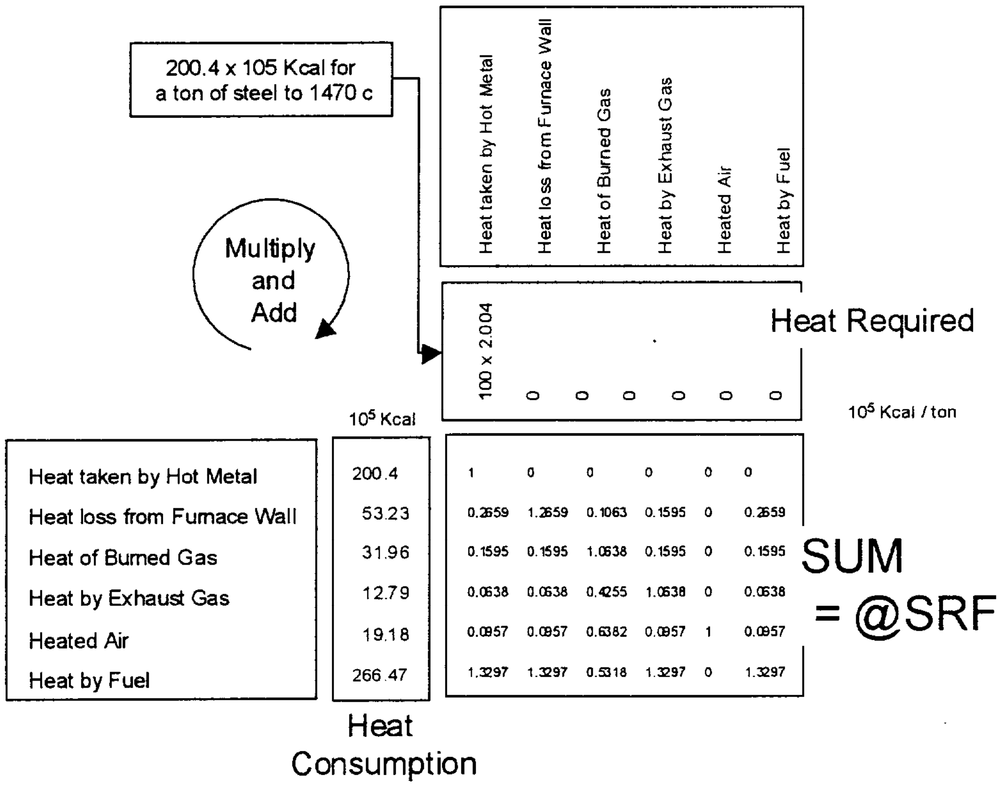


Figure II-59 Flow of Heat Consumption in Reheat Furnace

Using the extended model of reheat furnace, unit cost and total cost for the given fuel cost can be calculated by the same way as shown in parts cost in Figure II-60. The calculated results are shown schematically in Figure II-61.

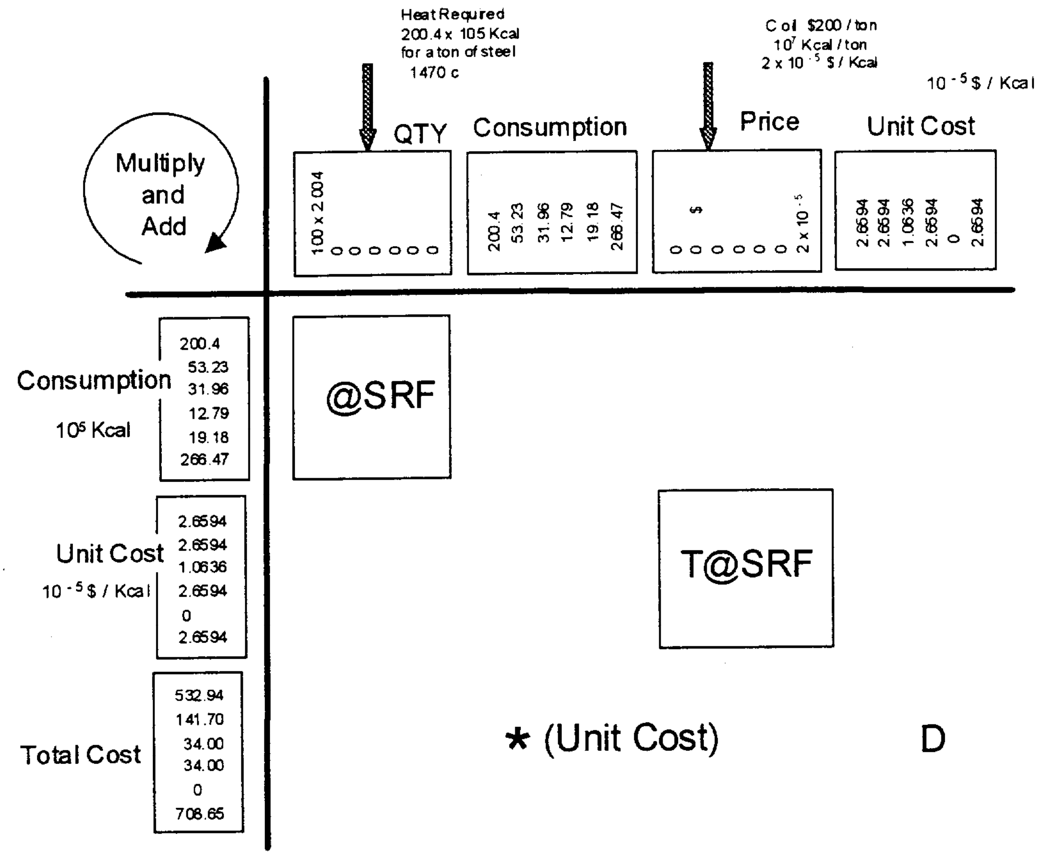


Figure II-60 Calculation of Energy Flow and Cost Flows

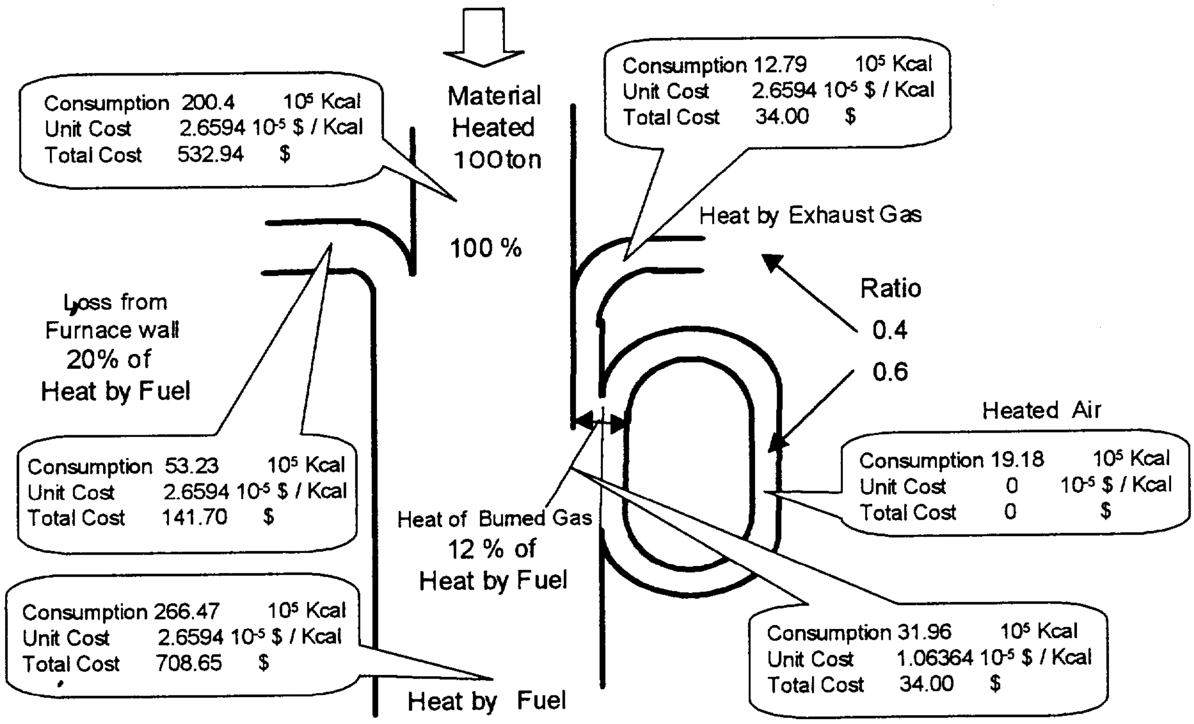


Figure II-61 Calculated Energy Flow and Cost Flows

18. Type Symbol: * and /

Type symbol: * and / are prepared for the requirements for multiplying and dividing between upper blocks. One of the two blocks is a direct upper block to be multiplied and divided. Another block, having multiplier and denominator, is located apart from the direct upper position as in Figure II-62 and Figure II-63. Therefore, method must be prepared for specifying the block, not located apart from the direct upper position.

One of the methods specifies its upper block name as a parameter of type symbol and specifies the location by placing type symbol: **D** at the cross point of the horizontal line containing the type symbol and the vertical line of prorating block. As another variation of software design, abbreviation of parameter setting and placing of type symbol: **D** or # (Dummy and Wait) can be considered. By programming efforts, the leave out placing the character: D can be possible. But for out-looking the model using the macro table, this character should be placed without omission. As a rule, Dividing by denominator having zero value should be treated as zero value.

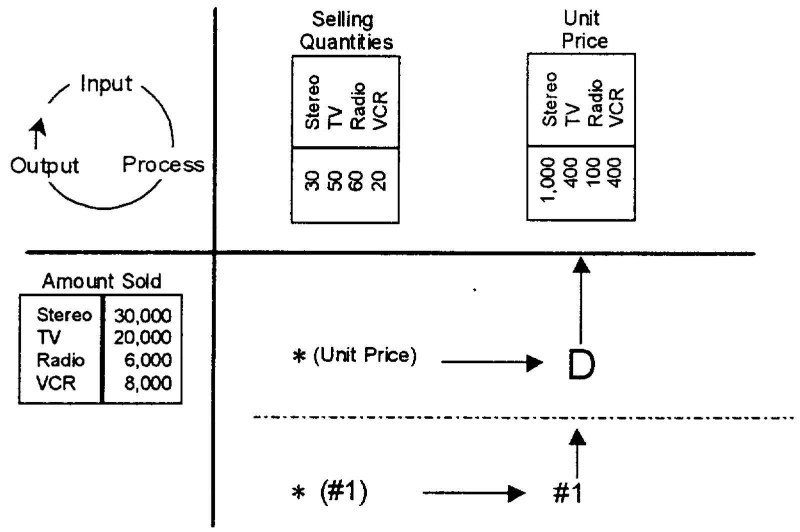


Figure II-62
Sample of Type Symbol: *

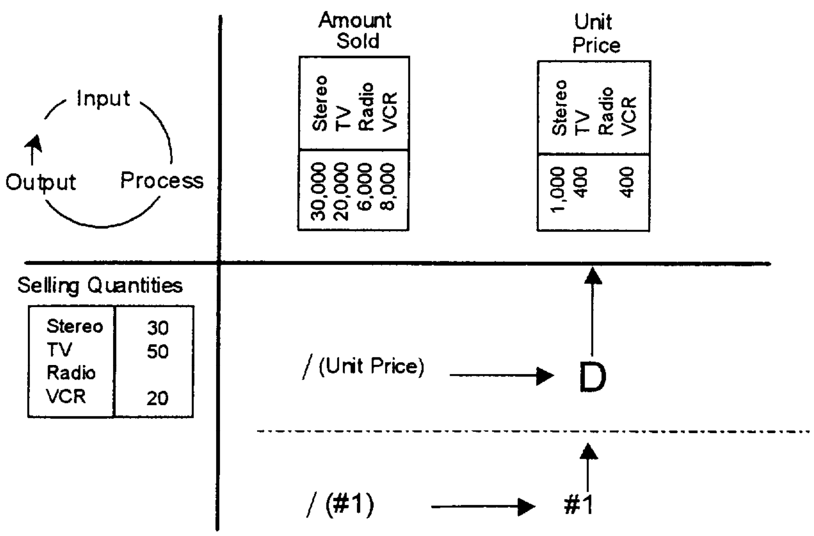


Figure II-63
Sample of Type Symbol: /

By adopting these notations, we can specify the upper blocks that are located apart from the direct upper position as associate block of calculation. By the method, we can place *Input-Process-Output* as main processing of structure matrix, as supper set of *Multiply and Add.* (*Multiply and Add* is included.) This technology opened us wider approach as general way toward the modeling.

19. Type Symbol: % Prorate

Type symbol: % is prepared for simpler and easier handling of prorating process between upper blocks. One of the two blocks is a direct upper block to be prorated. Another block, having prorating ratio values, is located apart from direct above position as in Figure II-64. Therefore specifying method must be prepared for the block not located in the direct upper direction. One of the methods is to specify its upper block name as a parameter of type symbol and specify the location by placing type symbol: **D** at the cross point of the horizontal line containing the type symbol and the vertical line of prorating block. As variation of software design, abbreviation of parameter setting and placing of type symbol: **D** or # (Dummy and Wait) can be considered.

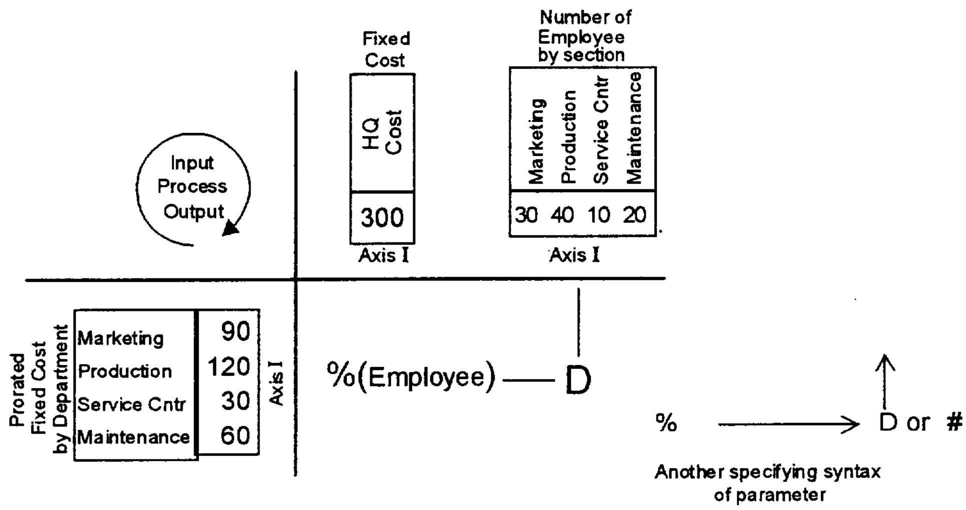


Figure II-64 Prorating HQ fixed cost by the employee's population in Sections

First, this function is performed as combination of type symbol: A, / and *. By this symbol, macro table of model becomes intelligent and efficient in setting and execution. In addition, this function can be thought as organizational quota function: type symbol: **Q** used only for one level. From the side of calculating performance, this function is further efficient than Q.

Appendix III Proof of Propositions

This Appendix is prepared for the proving propositions written in the Chapter 4-6: A Study for Mathematical Formalization of Type Symbols

Proof of Proposition 1

$C(n) \subset L(n) \subset Op(n)$ is obvious.

(1) $A(n) \subset C(n)$

Assuming $X \in A(n)$. As well known, X^n represents adjacent matrix of path length: n on the graph[8].

Because acyclic graph doesn't have infinitive path length, certain n_0 exists and $X^n = 0$, for arbitrary n with $n > n_0$. Accordingly $X \in C(n)$.

(2) $T(n) \subset A(n)$

This is obvious because tree is acyclic.

Q.E.D.

Proof of Proposition 3

1. Assuming

$$T = \begin{pmatrix} 0 & 0 \\ 1 & 0 \end{pmatrix}$$

$\underline{Q}(T)(100, 1) + \underline{Q}(T)(100, 0) = (100, 100) + (100, 0) = (200, 100)$ is effective.

On the other hand, $\underline{Q}(T)((100, 1) + (100, 0)) = \underline{Q}(T)(200, 1) = (200, 200)$ is effective.

Then, $\underline{Q}$ is not linear operator.

2. Obvious by the definition $\underline{R}$.

3. Obvious by the definition $\underline{T}$.

4. Assuming $X = \begin{pmatrix} 0 & 0 & 0 \\ 2 & 0 & 0 \\ 3 & 0 & 0 \end{pmatrix}$, then $X \in A(3)$ and

$$\underline{V}(X) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} + \begin{pmatrix} 0 & 0 & 0 \\ 2 & 0 & 0 \\ 3 & 0 & 0 \end{pmatrix} + \begin{pmatrix} 0 & 0 & 0 \\ 2 & 0 & 0 \\ 3 & 0 & 0 \end{pmatrix}^2 + \cdots = \begin{pmatrix} 1 & 0 & 0 \\ 2 & 1 & 0 \\ 3 & 0 & 1 \end{pmatrix}$$

is resulted and $\mathbf{V}(X) \notin A(3)$.

5.

Assuming $X = \begin{bmatrix} 2/3 & 0 \\ 0 & 0 \end{bmatrix}$, then $X \in C(2)$ and

$$\sum_{n=0}^{\infty} X^n = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} + \begin{bmatrix} 2/3 & 0 \\ 0 & 0 \end{bmatrix} + \begin{bmatrix} 2/3 & 0 \\ 0 & 0 \end{bmatrix}^2 + \cdots = \begin{bmatrix} 3 & 0 \\ 0 & 1 \end{bmatrix}$$

is resulted but $\sum_{n=0}^{\infty} X^n \notin C(2)$.

Q.E.D.

Appendix IV. Models and Data used for Proving

This appendix is prepared for supplementing the Applied Case I of Chapter 7.
The objective process is steel making composed of BOF and Ingot processing (Currently this process is almost replaced by Continuos Casting Process by technical innovation.) as shown in Figure A-IV-1 and the proving models as cost center is made covering these two process.

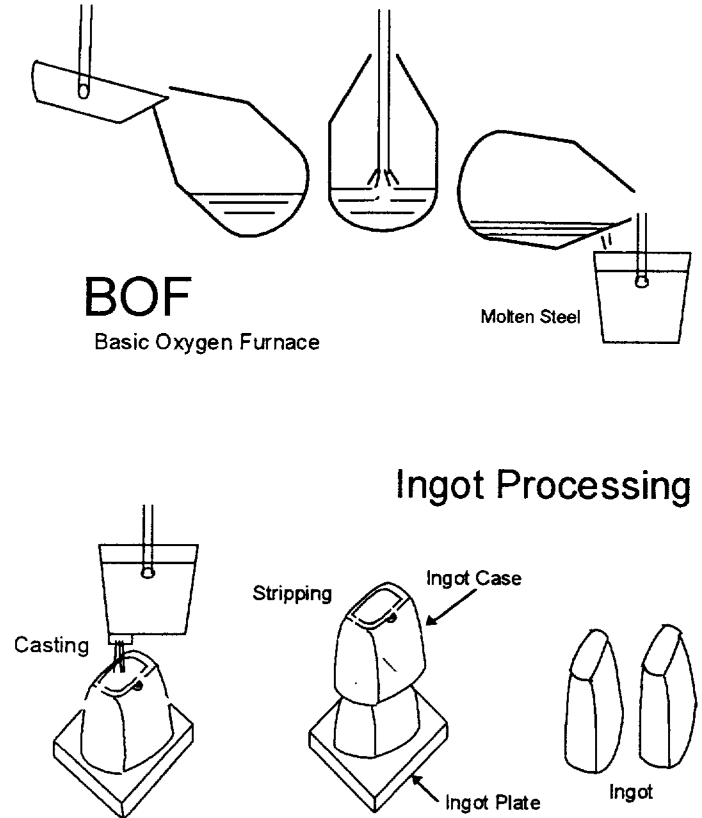


Figure A-IV-1 Sketch of Steel Cost Center Processes

Model for this cost center is shown in Figure A-IV-2, expressed by traditional way with multiple strands in the margin part.
Taking example in surrounded area by bold lines, calculating equations can be read out as follows. (Note: T : Transpose, * : Matrix inner product)

- Equations of Material and Processing Qantities

Cast Steel Quaty = SMeltSteelRto'54'54 * GD-Ingot Quaty
GD-Steel Bundl Quaty = BIngotBundle'11'54 * GD-Ingot Quaty

IngotHour Quaty = SIngotHourRto'11'11 * GD-Steel Bundl Quaty

- Equations of Material Unit Cost

GD-IngotUC = T(SMeltSteelRto'54'54) * CastSteelUC

- Equation of Processing Unit Cost

GD-Steel Bundl UC = T(SIngotHourRto'11'11) * IngotHour Proc UC

GD-Ingot UC = T(BIngotBundle'11'54) * GD-Steel Bundl UC
+ T(SMeltSteelRto'54'54) * CastSteel UC

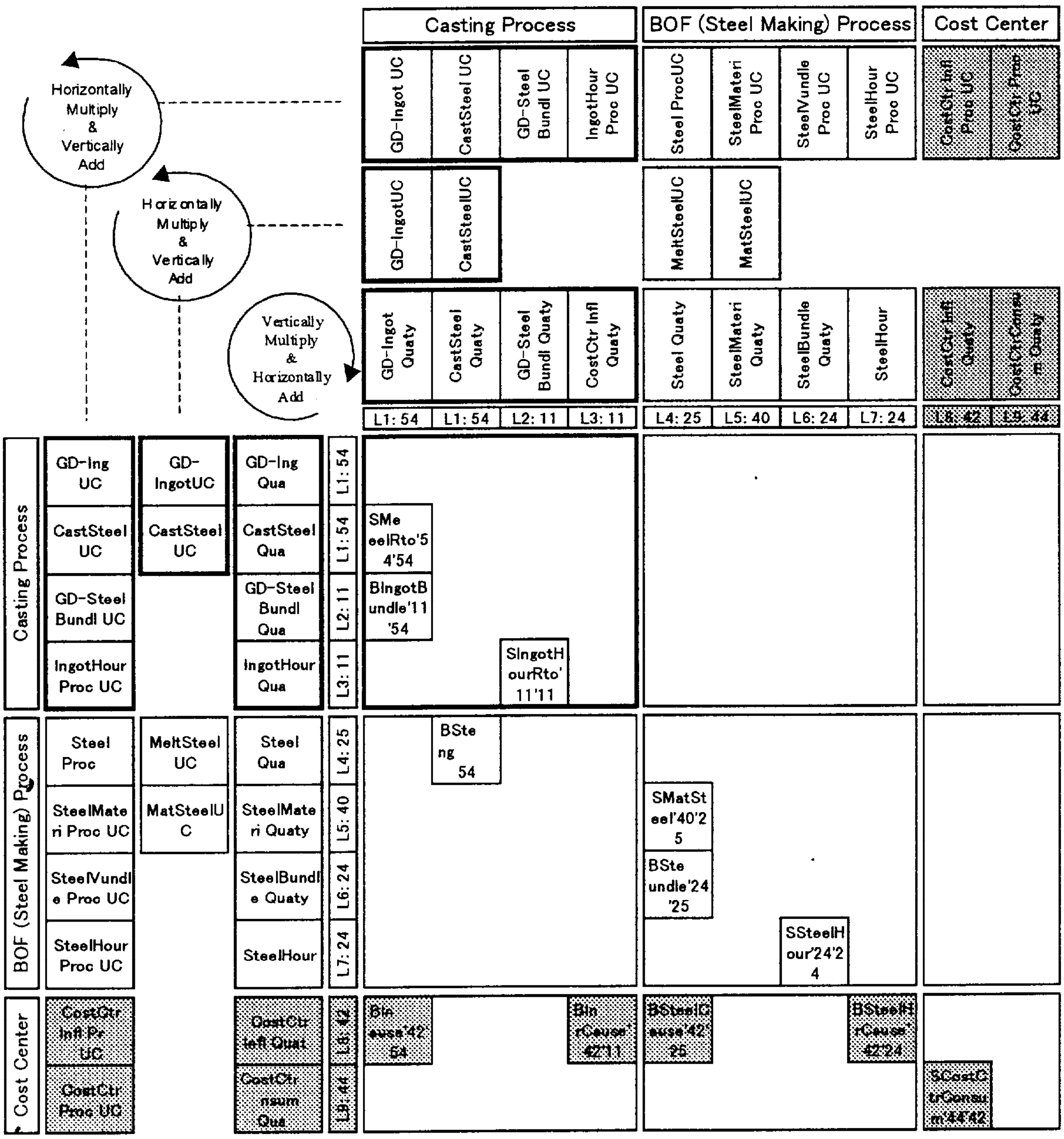


Figure A-IV-2 Traditional Expression of Production Factors and Unit Cost Factors

Figure A-4-3. is the model expressed by current style upon extended structure matrix using only one directional calculation.

Followings are the list of data used for the verification.

- Blocks in the center part

  Attached paid numbers are matrix size.

  SmeltSteelRto 54:54
  BSteelIngotBundle 25:25
  BIngotBundle 11:54
  SMatSteel 40:25
  BIngotCase 42:54
  BSteelBundle 24:25
  SingotHourRto 11:11
  BsteelCause 42:25
  BingotCause 42:11
  BsteelHrCause 42:24
  ScstCtrConsum 44:42

- Blocks in upper and left part

  Attached extension character means Item block name and number of item names.

  GD Ingot Quaty L1_54
  CastSteel Quaty L1_54
  GD-Ingot Bundl Quaty L2_11
  Ingot Hours L3_11
  Steel Quantty L4_11
  Steel Materi Quantity L5_40
  Steel Bundle Quantity L6_24
  Steel Hour Quantity L7_24
  Cost Ctr Influ Quantity L8_42
  CostCtrConsum Quaty L9_44
  SteelMateri Unit Cost L5_40
  SteelMateri Unit Cost L5_40
  Cast Steel Material UC L1_54
  CostCtr Proc UC L9_44
  CostCtr Infl Proc UC L8_42
  SteelHour Proc UC L7_24
  SteelBundl Proc UC L6_24
  Steel Proc UC L4_25
  Ingot Hour Proc UC L3_11
  GD-Steel Bundl Proc UC L2_11
  VastSteel Proc UC L1_54
  GD-Ingot Proc UC L4_54

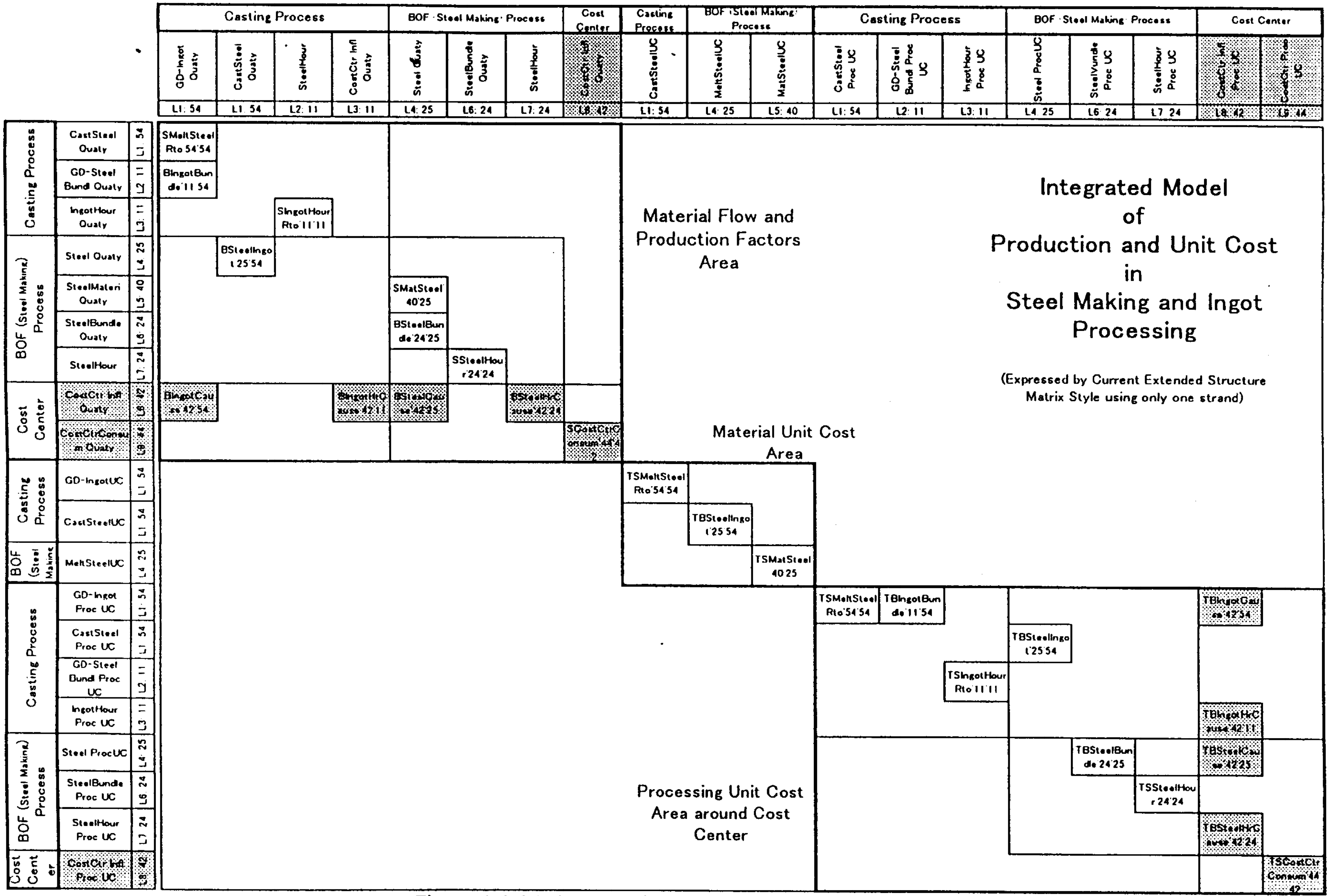


Figure A-IV-3 Integrated Model of Production Factors and Unit Cost Factors

SMeltSteelRto 54:54

SMeltSteelR to 54: 54

		1 Steel Grade 01 AD06	2 Steel Grade 02 CD10	3 Steel Grade 03 BB06	4 Steel Grade 04 AD06	5 Steel Grade 05 AD06	6 Steel Grade 06 AD10	7 Steel Grade 07 AD06	8 Steel Grade 08 AL050	9 Steel Grade 09 CD10	10 Steel Grade 10 BB06	11 Steel Grade 11 AD06	12 Steel Grade 12 AD10	13 Steel Grade 13 AL050	14 Steel Grade 14 AD06	15 Steel Grade 15 CD10	16 Steel Grade 16 AD06	17 Steel Grade 17 AD10	18 Steel Grade 18 AL050	19 Steel Grade 19 BB06
1	Steel Grade 01 AD060	1.196																		
2	Steel Grade 02 CD100		1.0237																	
3	Steel Grade 03 BB060			1.0249																
4	Steel Grade 04 AD060				1.0371															
5	Steel Grade 05 AD060					1.0303														
6	Steel Grade 06 AD100						1.0263													
7	Steel Grade 07 AD060							1.04												
8	Steel Grade 08 AL050								1.0496											
9	Steel Grade 09 CD100									1.0252										
10	Steel Grade 10 BB060										1.0362									
11	Steel Grade 11 AD060											1.0341								
12	Steel Grade 12 AD100												1.0382							
13	Steel Grade 13 AL050													1.0613						
14	Steel Grade 14 AD060														1.0409					
15	Steel Grade 15 CD100															1.0328				
16	Steel Grade 16 AD060																1.0388			
17	Steel Grade 17 AD100																	1.0435		
18	Steel Grade 18 AL050																		1.0502	
19	Steel Grade 19 BB060																			1.0342
54	Return Scrap	0.196	0.0237	0.0249	0.0371	0.0303	0.0263	0.04	0.0496	0.0252	0.0362	0.0341	0.0382	0.0613	0.0409	0.0328	0.0388	0.0435	0.0502	0.0342

		20 Steel Grade 20 ADI	21 Steel Grade 21 ADO	22 Steel Grade 22 ALO	23 Steel Grade 23 ADO	24 Steel Grade 24 ADO	25 Steel Grade 25 ADO	26 Steel Grade 26 CDI	27 Steel Grade 27 ADO	28 Steel Grade 28 ADI	29 Steel Grade 29 DLI	30 Steel Grade 30 ADO	31 Steel Grade 31 ADI	32 Steel Grade 32 ALO	33 Steel Grade 33 ADO	34 Steel Grade 34 ADI	35 Steel Grade 35 ALO	36 Steel Grade 36 ADO	37 Steel Grade 37 ALO	38 Steel Grade 38 ADO
20	Steel Grade 20 AD100	1.0265																		
21	Steel Grade 21 AD060		1.0444																	
22	Steel Grade 22 AL050			1.0601																
23	Steel Grade 23 AD060				1.038															
24	Steel Grade 24 AD060					1.0335														
25	Steel Grade 25 AD060						1.0462													
26	Steel Grade 26 CD100							1.0254												
27	Steel Grade 27 AD060								1.0319											
28	Steel Grade 28 AD100									1.0333										
29	Steel Grade 29 DL100										1.0386									
30	Steel Grade 30 AD060											1.0355								
31	Steel Grade 31 AD100												1.0397							
32	Steel Grade 32 AL050													1.0471						
33	Steel Grade 33 AD060														1.0374					
34	Steel Grade 34 AD100															1.0385				
35	Steel Grade 35 AL050																1.0496			
36	Steel Grade 36 AD060																	1.033		
37	Steel Grade 37 AL050																		1.0292	
38	Steel Grade 38 AD060																			1.0398
54	Return Scrap	0.0265	0.0444	0.0601	0.038	0.0335	0.0462	0.0254	0.0319	0.0333	0.0386	0.0355	0.0397	0.0471	0.0374	0.0385	0.0496	0.033	0.0292	0.0398

		38 Steel Grade 39 ALO	40 Steel Grade 40 ADO	41 Steel Grade 41 ADO	42 Steel Grade 42 ALO	43 Steel Grade 43 ADO	44 Steel Grade 44 BBO	45 Steel Grade 45 ADO	46 Steel Grade 46 ADO	47 Steel Grade 47 ALO	48 Steel Grade 48 ALO	49 Steel Grade 49 ADI	50 Steel Grade 50 CDI	51 Steel Grade 51 ADO	52 Steel Grade 52 ADO	53 Steel Grade 53 ADO	54 Return Scrap
39	Steel Grade 39 AL050	1.0548															
40	Steel Grade 40 AD060		1.0405														
41	Steel Grade 41 AD060			1.0457													
42	Steel Grade 42 AL050				1.0514												
43	Steel Grade 43 AD060					1.0358											
44	Steel Grade 44 BB060						1.048										
45	Steel Grade 45 AD060							1.038									
46	Steel Grade 46 AD060								1.0382								
47	Steel Grade 47 AL050									1.0337							
48	Steel Grade 48 AL050										1.0688						
49	Steel Grade 49 AD100											1.0531					
50	Steel Grade 50 CD100												1.0191				
51	Steel Grade 51 AD060													1.0524			
52	Steel Grade 52 AD060														1.0511		
53	Steel Grade 53 AD060															1.035	
54	Return Scrap	0.0548	0.0405	0.0457	0.0514	0.0358	0.048	0.038	0.0382	0.0337	0.0688	0.0531	0.0191	0.0524	0.0511	0.035	0

BSteelIngotBundle 25:54

		1 Steel Grade 01 AD060	2 Steel Grade 02 CD100	3 Steel Grade 03 BB060	4 Steel Grade 04 AD060	5 Steel Grade 05 AD060	6 Steel Grade 06 AD100	7 Steel Grade 07 AD060	8 Steel Grade 08 AL050	9 Steel Grade 09 CD100	10 Steel Grade 10 BB060	11 Steel Grade 11 AD060	12 Steel Grade 12 AD100	13 Steel Grade 13 AL050	14 Steel Grade 14 AD060	15 Steel Grade 15 CD100	16 Steel Grade 16 AD060	17 Steel Grade 17 AD100	18 Steel Grade 18 AL050	19 Stepl Grade 19 BB060	20 Steel Grade 20 AD100	21 Steel Grade 21 AD060	22 Steel Grade 22 AL050	23 Steel Grade 23 AD060	24 Steel Grade 24 AD060	25 Steel Grade 25 AD060	26 Steel Grade 26 CD100	27 Steel Grade 27 AD060	28 Steel Grade 28 AD100	29 Steel Grade 29 DL100	30 Steel Grade 30 AD060	31 Steel Grade 31 AD100	32 Steel Grade 32 AL050	33 Steel Grade 33 AD060	34 Steel Grade 34 AD100	35 Steel Grade 35 AL050	36 Steel Grade 36 AD060	37 Steel Grade 37 AL050	38 Steel Grade 38 AD060	39 Steel Grade 39 AL050	40 Steel Grade 40 AD060	41 Steel Grade 41 AD060	42 Steel Grade 42 AL050	43 Steel Grade 43 AD060	44 Steel Grade 44 BB060	45 Steel Grade 45 AD060	46 Steel Grade 46 AD060	47 Steel Grade 47 AL050	48 Steel Grade 48 AL050	49 Steel Grade 49 AD100	50 Steel Grade 50 CD100	51 Steel Grade 51 AD060	52 Steel Grade 52 AD060	53 Steel Grade 53 AD060	54 Return Scrap
1	Steel Grade 01 AD060	1																																																					
2	Steel Grade 02 CD100		1																																																				
3	Steel Grade 03 BB060			1																																																			
4	Steel Grade 04 AD060				1	1																																																	
5	Steel Grade 06 AD100						1																																																
6	Steel Grade 07 AD060							1	1																																														
7	Steel Grade 09 CD100									1	1																																												
8	Steel Grade 11 AD060											1	1	1	1																																								
9	Steel Grade 15 CD100															1	1	1	1	1																																			
10	Steel Grade 20 AD100																				1																																		
11	Steel Grade 21 AD060																					1	1	1																															
12	Steel Grade 24 AD060																								1	1																													
13	Steel Grade 26 CD100																										1	1	1	1																									
14	Steel Grade 30 AD060																														1	1	1	1	1	1																			
15	Steel Grade 36 AD060																																				1	1	1	1															
16	Steel Grade 40 AD060																																								1	1	1												
17	Steel Grade 43 AD060																																											1	1										
18	Steel Grade 45 AD060																																													1									
19	Steel Grade 46 AD060																																														1	1							
20	Steel Grade 48 AL050																																																1						
21	Steel Grade 49 AD100																																																	1					
22	Steel Grade 50 CD100																																																		1	1			
23	Steel Grade 52 AD060																																																				1		
24	Steel Grade 53 AD060																																																					1	
25	Return Scrap																																																						1

BIngotBundle 11:54

BIngotBundle 11: 54

		1 Steel Grade 01 AD06	2 Steel Grade 02 CD10	3 Steel Grade 03 BB06	4 Steel Grade 04 AD06	5 Steel Grade 05 AD06	6 Steel Grade 06 AD10	7 Steel Grade 07 AD06	8 Steel Grade 08 AL05	9 Steel Grade 09 CD10	10 Steel Grade 10 BB06	11 Steel Grade 11 AD06	12 Steel Grade 12 AD10	13 Steel Grade 13 AL05	14 Steel Grade 14 AD06	15 Steel Grade 15 CD10	16 Steel Grade 16 AD06	17 Steel Grade 17 AD10	18 Steel Grade 18 AL05	19 Steel Grade 19 BB06	20 Steel Grade 20 AD10	21 Steel Grade 21 AD06	22 Steel Grade 22 AL05	23 Steel Grade 23 AD06	24 Steel Grade 24 AD06	25 Steel Grade 25 AD06	26 Steel Grade 26 CD10	27 Steel Grade 27 AD06	28 Steel Grade 28 AD10	29 Steel Grade 29 DL10	30 Steel Grade 30 AD06	31 Steel Grade 31 AD10	32 Steel Grade 32 AL05	33 Steel Grade 33 AD06	34 Steel Grade 34 AD10	35 Steel Grade 35 AL05	36 Steel Grade 36 AD06	37 Steel Grade 37 AL05	38 Steel Grade 38 AD06	38 Steel Grade 39 AL05	40 Steel Grade 40 AD06	41 Steel Grade 41 AD06	42 Steel Grade 42 AL05	43 Steel Grade 43 AD06	44 Steel Grade 44 BB06	45 Steel Grade 45 AD06	46 Steel Grade 46 AD06	47 Steel Grade 47 AL05	48 Steel Grade 48 AL05	49 Steel Grade 49 AD10	50 Steel Grade 50 CD10	51 Steel Grade 51 AD06	52 Steel Grade 52 AD06	53 Steel Grade 53 AD06	54 Return Scrap
1	Steel Grade 26 CD100		1							1						1											1																												
2	Steel Grade 33 AD060	1			1	1		1				1			1		1					1		1	1	1		1			1			1																					
3	Steel Grade 34 AD100						1						1					1			1								1			1			1																				
4	Steel Grade 35 AL050								1					1					1				1										1			1																			
5	Steel Grade 19 BB060			1							1									1																																			
6	Steel Grade 29 DL100																													1																									
7	Steel Grade 50 CD100																																																		1				
8	Steel Grade 53 AD060																																				1		1		1	1		1		1	1					1	1	1	
9	Steel Grade 49 AD100																																																	1					
10	Steel Grade 48 AL050																																					1		1			1					1	1						
11	Steel Grade 44 BB060																																												1										

SMatSteel 40: 25

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		Steel Grade 01 AD060	Steel Grade 02 CD100	Steel Grade 03 BB060	Steel Grade 04 AD060	Steel Grade 06 AD100	Steel Grade 07 AD060	Steel Grade 09 CD100	Steel Grade 11 AD060	Steel Grade 15 CD100	Steel Grade 20 AD100	Steel Grade 21 AD060	Steel Grade 24 AD060	Steel Grade 26 CD100	Steel Grade 30 AD060	Steel Grade 36 AD060	Steel Grade 40 AD060	Steel Grade 43 AD060	Steel Grade 45 AD060	Steel Grade 46 AD060	Steel Grade 48 AL050	Steel Grade 49 AD100	Steel Grade 50 CD100	Steel Grade 52 AD060	Steel Grade 53 AD060	Return Scrap
1	Melt Iron	1.0011	0.9078	0.9560	0.9720	0.9966	0.9806	0.9183	0.9460	0.9262	0.8863	0.9347	0.9651	0.9291	0.9453	0.9668	0.9698	0.9110	0.9731	0.9581	0.9714	0.9030	0.9599	0.9582		
2	Return Scrap Ordinary Steel	0.1013	0.1559	0.1097	0.0731	0.0474	0.0610	0.1343	0.0689	0.1047	0.0765	0.0730	0.0542	0.0750	0.0610	0.0337	0.0184	0.1223	0.0386	0.0496	0.0247	0.0520	0.1059	0.0674		
3	CaO	0.0401	0.0271	0.0315	0.0509	0.0320	0.0548	0.0310	0.0419	0.0350	0.0406	0.0404	0.0436	0.0389	0.0429	0.0450	0.0453	0.0305	0.0449	0.0450	0.0486	0.0394	0.0479	0.0494		
4	Doromite Light Burned	0.0355	0.0251	0.0226	0.0184	0.0213	0.0177	0.0261	0.0196	0.0223	0.0139	0.0205	0.0199	0.0208	0.0194	0.0218	0.0227	0.0126	0.0183	0.0174	0.0191	0.0174	0.0237	0.0242		
5	Iron Ore for Steel Making	0.0125	0.0123	0.0238	0.0120	0.0317	0.0080	0.0138	0.0117	0.0119	0.0000	0.0093	0.0107	0.0111	0.0096	0.0091	0.0084	0.0126	0.0104	0.0080	0.0052	0.0211	0.0231	0.0183		
6	Scale S-L	0.0178	0.0190	0.0192	0.0261	0.0295	0.0271	0.0196	0.0229	0.0211	0.0227	0.0228	0.0242	0.0223	0.0237	0.0250	0.0255	0.0169	0.0244	0.0253	0.0260	0.0227	0.0329	0.0266		
7	CaF2	0.0000	0.0000	0.0000	0.0012	0.0000	0.0028	0.0000	0.0012	0.0001	0.0000	0.0004	0.0010	0.0003	0.0007	0.0009	0.0009	0.0005	0.0009	0.0013	0.0033		0.0010	0.0006		
8	F Si 2	0.0022		0.0012	0.0016	0.0021	0.0006		0.0010	0.0011	0.0050	0.0021	0.0018	0.0016	0.0010	0.0024	0.0025	0.0001	0.0011	0.0137	0.0008		0.0015	0.0008	0.0021	
9	F Mn Hc	0.0023	0.0048	0.0000	0.0005		0.0065	0.0049	0.0016	0.0031	0.0055	0.0025	0.0055	0.0013	0.0005	0.0121	0.0045	0.0044	0.0025	0.0004	0.0073	0.0111	0.0089	0.0009	0.0010	
10	Al Other															0.0003	0.0004							0.0005		
11	Carbon				0.0001		0.0004					0.0002	0.0001			0.0005	0.0003				0.0005					
12	Carbon Addition	0.0002	0.0002		0.0007	0.0003	0.0003	0.0003	0.0005	0.0005	0.0008	0.0008	0.0008	0.0008	0.0007	0.0008	0.0006	0.0003	0.0005	0.0005	0.0007				0.0008	
13	AL2O3																0.0001							0.0001		
14	FeCr HSE Lump								0.0003			0.0001	0.0008		0.0005	0.0025	0.0142		0.0065	0.0058	0.0103					
15	Cold Pig Iron				0.0200		0.0226	0.0007	0.0290	0.0141	0.0601	0.0339	0.0125	0.0240	0.0297	0.0298	0.0244	0.0052	0.0087	0.0241	0.0123	0.0635	0.0042	0.0229		
16	Ret-Scrap Alloy Steel 1								0.0088	0.0027		0.0038	0.0187	0.0168	0.0163	0.0156	0.0102		0.0316	0.0129	0.0202					
17	Ca Si														0.0005					0.0007					0.0001	
18	FAS		0.0001		0.0003				0.0005					0.0001	0.0010	0.0001	0.0001		0.0008							
19	Si Mn	0.0059			0.0062	0.0051	0.0003		0.0079	0.0032	0.0134	0.0085	0.0085	0.0048	0.0094	0.0059	0.0036	0.0009	0.0081	0.0112		0.0038	0.0015	0.0185	0.0052	
20	FeS2														0.0001			0.0040								
21	Al 90% up	0.0001		0.0002	0.0002				0.0006	0.0004		0.0005	0.0006	0.0004	0.0002				0.0003	0.0001			0.0002		0.0005	
22	Ret Scrap Alloy Steel 2							0.0001	0.0003				0.0019		0.0003	0.0020	0.0156									
23	FeMo L-C															0.0005	0.0025			0.0001						
24	FeMn L-C L-Si																	0.0099					0.0028	0.0004		
25	FeP																	0.0011				0.0024				
26	FeCr L-C																0.0010				0.0004					
27	CaCN2															0.0004	0.0004									
28	Boring Scrap				0.0025		0.0031	0.0001	0.0024	0.0013		0.0026	0.0048	0.0050	0.0036	0.0020	0.0032	0.0007	0.0052	0.0039						
29	FeSi2 L-Al				0.0003		0.0028					0.0002									0.0022			0.0072		
30	FeNi L-C Pure																0.0002			0.0003						
31	Cu-S																			0.0005		0.0010				
32	FeMn H-C			0.0034			0.0012									0.0002	0.0008						0.0056	0.0041		
33	FeVa										0.0007								0.0018							
34	Ret-Scrap Alloy Steel 3							0.0003	0.0003				0.0028			0.0015	0.0070									
35	FeTi																							0.0026		
36	FeTi-B															0.0001										
37	Scrap K A P						0.0001																			
38	AAABBB																									
39	FeSi2 L-Al L-Ti																				0.0174					
40	Return Scrap	0.1638	0.0231	0.0243	0.0350	0.0256	0.0450	0.0286	0.0344	0.0362	0.0257	0.0458	0.0344	0.0323	0.0359	0.0377	0.0432	0.0377	0.0366	0.0367	0.0643	0.0504	0.0341	0.0486		1

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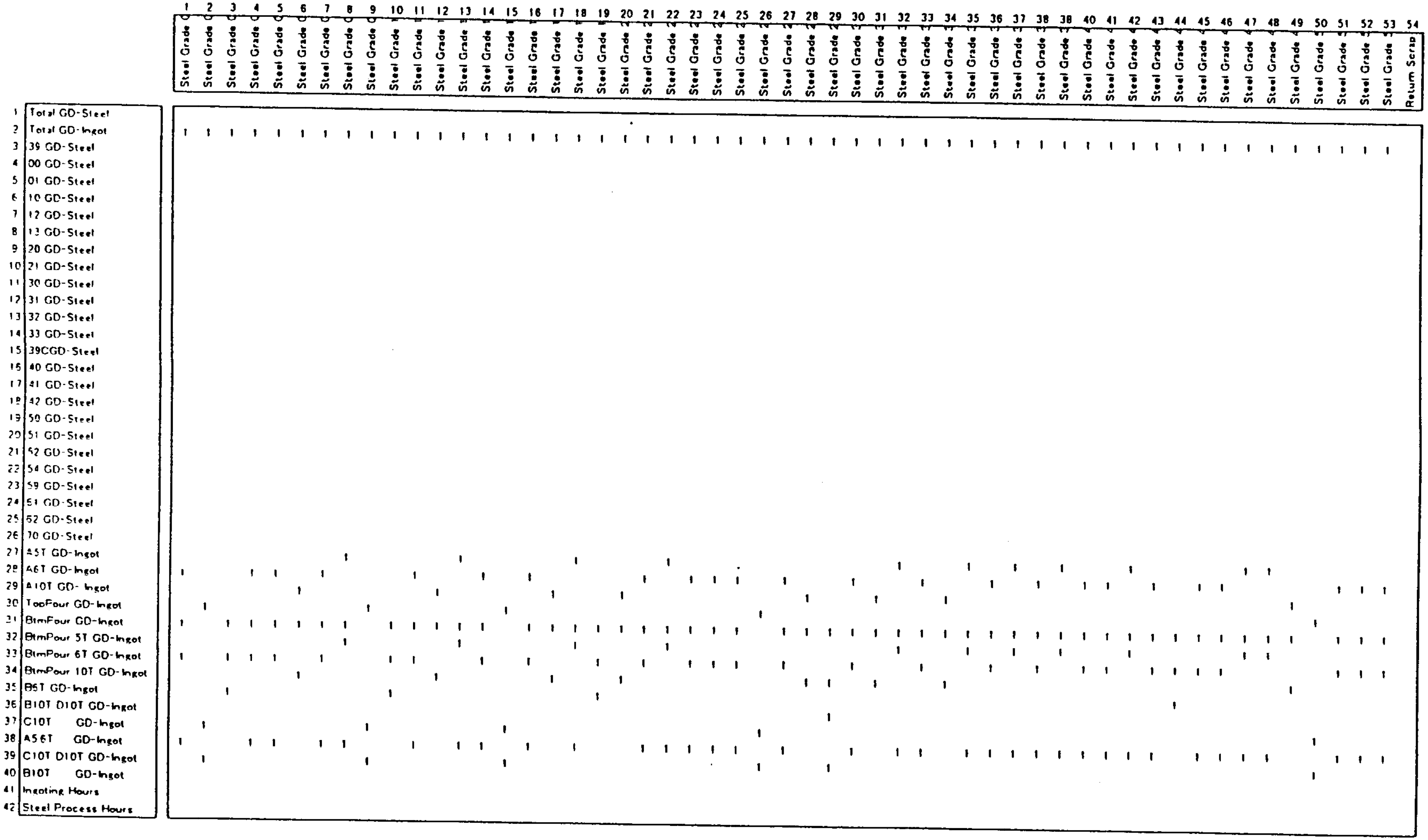

BSteelBundle 24: 25

		1 Steel Grade 01 AD060	2 Steel Grade 02 CD100	3 Steel Grade 03 BB060	4 Steel Grade 04 AD060	5 Steel Grade 06 AD100	6 Steel Grade 07 AD060	7 Steel Grade 09 CD100	8 Steel Grade 11 AD060	9 Steel Grade 15 CD100	10 Steel Grade 20 AD100	11 Steel Grade 21 AD060	12 Steel Grade 24 AD060	13 Steel Grade 26 CD100	14 Steel Grade 30 AD060	15 Steel Grade 36 AD060	16 Steel Grade 40 AD060	17 Steel Grade 43 AD060	18 Steel Grade 45 AD060	19 Steel Grade 46 AD060	20 Steel Grade 48 AL050	21 Steel Grade 49 AD100	22 Steel Grade 50 CD100	23 Steel Grade 52 AD060	24 Steel Grade 53 AD060	25 Return Scrap
1	Steel Grade 1 AD060	1																								
2	Steel Grade 2 CD100		1																							
3	Steel Grade 3 BB060			1																						
4	Steel Grade 4 AD060				1																					
5	Steel Grade 6 AD100					1																				
6	Steel Grade 7 AD060						1																			
7	Steel Grade 9 CD100							1																		
8	Steel Grade 11 AD060								1																	
9	Steel Grade 15 CD100									1																
10	Steel Grade 20 AD100										1															
11	Steel Grade 21 AD060											1														
12	Steel Grade 24 AD060												1													
13	Steel Grade 26 CD100													1												
14	Steel Grade 30 AD060														1											
15	Steel Grade 36 AD060															1										
16	Steel Grade 40 AD060																1									
17	Steel Grade 43 AD060																	1								
18	Steel Grade 45 AD061																		1							
19	Steel Grade 46 AD062																			1						
20	Steel Grade 48 AL050																				1					
21	Steel Grade 49 AD100																					1				
22	Steel Grade 50 CD100																						1			
23	Steel Grade 52 AD060																							1		
24	Steel Grade 53 AD060																								1	

SIngotHourRto 11: 11

		1 Steel Grade 26 CD1	2 Steel Grade 33 AD06	3 Steel Grade 34 AD10	4 Steel Grade 35 AL05	5 Steel Grade 19 BB06	6 Steel Grade 29 DL10	7 Steel Grade 50 CD1	8 Steel Grade 53 AD06	9 Steel Grade 49 AD10	10 Steel Grade 48 AL05	11 Steel Grade 44 BB06
1	39 CD100 Cast Time	1.861										
2	40 AD060 Cast Time		7.04									
3	40 AD100 Cast Time			6.954								
4	40 AL050 Cast Time				7.87							
5	30 BB060 Cast Time					2.08						
6	39 DL100 Cast Time						0.534					
7	61 CD100 Cast Time							0.467				
8	70 AD060 Cast Time								7.03			
9	59 AD100 Cast Time									1.948		
10	54 AL050 Cast Time										6.34	
11	50 BB060 Cast Time											4.503

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		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		Steel Grade 01 AD060	Steel Grade 02 CD100	Steel Grade 03 BB060	Steel Grade 04 AD060	Steel Grade 06 AD100	Steel Grade 07 AD060	Steel Grade 09 CD100	Steel Grade 11 AD060	Steel Grade 15 CD100	Steel Grade 20 AD100	Steel Grade 21 AD060	Steel Grade 24 AD060	Steel Grade 26 CD100	Steel Grade 30 AD060	Steel Grade 36 AD060	Steel Grade 40 AD060	Steel Grade 43 AD060	Steel Grade 45 AD060	Steel Grade 46 AD060	Steel Grade 48 AL050	Steel Grade 49 AD100	Steel Grade 50 CD100	Steel Grade 52 AD060	Steel Grade 53 AD060	Return Scrap
1	Total GD-Steel	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
2	Total GD-Ingot																									
3	39 GD-Steel	1																								
4	00 GD-Steel		1																							
5	01 GD-Steel			1																						
6	10 GD-Steel				1																					
7	12 GD-Steel					1																				
8	13 GD-Steel						1																			
9	20 GD-Steel							1																		
10	21 GD-Steel								1																	
11	30 GD-Steel									1																
12	31 GD-Steel										1															
13	32 GD-Steel											1														
14	33 GD-Steel												1													
15	39CGD-Steel													1												
16	40 GD-Steel														1											
17	41 GD-Steel															1										
18	42 GD-Steel																1									
19	50 GD-Steel																	1								
20	51 GD-Steel																		1							
21	52 GD-Steel																			1						
22	54 GD-Steel																				1					
23	59 GD-Steel																					1				
24	61 GD-Steel																						1			
25	62 GD-Steel																							1		
26	70 GD-Steel																								1	
27	A5T GD-Ingot																									
28	A6T GD-Ingot																									
29	A10T GD- Ingot																									
30	TopPour GD-Ingot																									
31	BtmPour GD-Ingot																									
32	BtmPour 5T GD-Ingot																									
33	BtmPour 6T GD-Ingot																									
34	BtmPour 10T GD-Ingot																									
35	B6T GD-Ingot																									
36	B10T D10T GD-Ingot																									
37	C10T GD-Ingot																									
38	A5.6T GD-Ingot																									
39	C10T D10T GD-Ingot																									
40	B10T GD-Ingot																									
41	Ingoting Hours																									
42	Steel Process Hours																									

BIngotHrCause 42: 11

#		1 39 CD100 Cast Time	2 40 AD060 Cast Time	3 40 AD100 Cast Time	4 40 AL050 Cast Time	5 30 BB060 Cast Time	6 39 DL100 Cast Time	7 61 CD100 Cast Time	8 70 AD060 Cast Time	9 59 AD100 Cast Time	10 54 AL050 Cast Time	11 50 BB060 Cast Time
1	Total GD-Steel											
2	Total GD-Ingot											
3	39 GD-Steel											
4	00 GD-Steel											
5	01 GD-Steel											
6	10 GD-Steel											
7	12 GD-Steel											
8	13 GD-Steel											
9	20 GD-Steel											
10	21 GD-Steel											
11	30 GD-Steel											
12	31 GD-Steel											
13	32 GD-Steel											
14	33 GD-Steel											
15	39CGD-Steel											
16	40 GD Steel											
17	41 GD-Steel											
18	42 GD-Steel											
19	50 GD-Steel											
20	51 GD-Steel											
21	52 GD-Steel											
22	54 GD-Steel											
23	59 GD-Steel											
24	61 GD-Steel											
25	62 GD-Steel											
26	70 GD-Steel											
27	A5T GD-Ingot											
28	A6T GD-Ingot											
41	Ingoting Hours	1	1	1	1	1	1	1	1	1	1	1
42	Steel Process Hours											

BSteelCause 42: 25

#		1 Steel Grade 01 AD060	2 Steel Grade 02 CD100	3 Steel Grade 03 BB060	4 Steel Grade 04 AD060	5 Steel Grade 06 AD100	6 Steel Grade 07 AD060	7 Steel Grade 09 CD100	8 Steel Grade 11 AD060	9 Steel Grade 15 CD100	10 Steel Grade 20 AD100	11 Steel Grade 21 AD060	12 Steel Grade 24 AD060	13 Steel Grade 26 CD100	14 Steel Grade 30 AD060	15 Steel Grade 38 AD060	16 Steel Grade 40 AD060	17 Steel Grade 43 AD060	18 Steel Grade 45 AD060	19 Steel Grade 46 AD060	20 Steel Grade 48 AL050	21 Steel Grade 49 AD100	22 Steel Grade 50 CD100	23 Steel Grade 52 AD060	24 Steel Grade 53 AD060	25 Return Scrap
1	Total GD-Steel	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
2	Total GD-Ingot																									
3	39 GD-Steel	1																								
4	00 GD-Steel		1																							
5	01 GD-Steel			1																						
6	10 GD-Steel				1																					
7	12 GD-Steel					1																				
8	13 GD-Steel						1																			
9	20 GD-Steel							1																		
10	21 GD-Steel								1																	
11	30 GD-Steel									1																
12	31 GD-Steel										1															
13	32 GD-Steel											1														
14	33 GD-Steel												1													
15	39CGD-Steel													1												
16	40 GD Steel														1											
17	41 GD-Steel															1										
18	42 GD-Steel																1									
19	50 GD-Steel																	1								
20	51 GD-Steel																		1							
21	52 GD-Steel																			1						
22	54 GD-Steel																				1					
23	59 GD-Steel																					1				
24	61 GD-Steel																						1			
25	62 GD-Steel																							1		
26	70 GD-Steel																								1	
27	A5T GD-Ingot																									
28	A6T GD-Ingot																									
41	Ingoting Hours																									
42	Steel Process Hours																									

BSteelHrCause 42: 24

#		1 B9 ProcessTime	2 00 ProcessTime	3 01 ProcessTime	4 10 ProcessTime	5 12 ProcessTime	6 13 ProcessTime	7 20 ProcessTime	8 21 ProcessTime	9 30 ProcessTime	10 31 ProcessTime	11 32 ProcessTime	12 33 ProcessTime	13 39 ProcessTime	14 40 ProcessTime	15 41 ProcessTime	16 42 ProcessTime	17 50 ProcessTime	18 51 ProcessTime	19 52 ProcessTime	20 54 ProcessTime	21 59 ProcessTime	22 61 ProcessTime	23 62 ProcessTime	24 70 ProcessTime
1	Total GD-Steel																								
2	Total GD-Ingot																								
3	39 GD-Steel																								
4	00 GD-Steel																								
5	01 GD-Steel																								
6	10 GD-Steel																								
7	12 GD-Steel																								
8	13 GD-Steel																								
9	20 GD-Steel																								
10	21 GD-Steel																								
11	30 GD-Steel																								
12	31 GD-Steel																								
13	32 GD-Steel																								
14	33 GD-Steel																								
15	39CGD-Steel																								
16	40 GD Steel																								
17	41 GD-Steel																								
18	42 GD-Steel																								
19	50 GD-Steel																								
20	51 GD-Steel																								
21	52 GD-Steel																								
22	54 GD-Steel																								
23	59 GD-Steel																								
24	61 GD-Steel																								
25	62 GD-Steel																								
26	70 GD-Steel																								
27	A5T GD-Ingot																								
28	A6T GD-Ingot																								
41	Ingoting Hours																								
42	Steel Process Hours	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Cost Center Consumption Ratio for Influence factor

SCstCtrConsum 44:42

1

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
		Total GD-Steel	Total GD-Ingot	39 GD-Steel	00 GD-Steel	01 GD-Steel	10 GD-Steel	12 GD-Steel	13 GD-Steel	20 GD-Steel	21 GD-Steel	30 GD-Steel	31 GD-Steel	32 GD-Steel	33 GD-Steel	39CGD-Steel	39 GD-Steel	41 GD-Steel	42 GD-Steel	50 GD-Steel	51 GD-Steel	52 GD-Steel	54 GD-Steel	59 GD-Steel	61 GD-Steel	62 GD-Steel	70 GD-Steel
1	BOF Maintenance	517.3582																									
2	Main Fuel O2			50 1204	47 4924	48 6904	47 6943	44 6428	58 6851	47 9678	48 6068	46 6099	50.3296	48.5969	49.0425	46.8688	48.3452	52 2344	53.2405	47 2902	47 2215	46 6155	65 9459	47 9069	56 231	55 5689	46 0919
3	Miscella Fuel	100 2488	17 2552																								
4	Work Etc	493 9269	437 877																								
5	Work Heat Reserve-5T																										
6	Work Heat Reserve-6T																										
7	Work Heat Reserve-10T																										
8	Work Heat Keep-5T																										
9	Work Heat Keep-7T																										
10	Work Heat Keep-10T																										
11	Work Heat Chimny-7T																										
12	Work Heat Chimny-10T																										
13	Work Slide-Upper																										
14	Work Slide-Lowerr																										
15	Work Flat-5T																										
16	Work Flat-7T																										
17	Work Flat-10T																										
18	Work Ground-7T																										
19	Work Ground-10T																										
20	Misc Expendables		124 962																								
21	Misc Expend Btm-7T	38 8945																									
22	Misc Expend Btm-10T																										
23	Expend Tools&Equip		2 6039																								
24	Ingot Case etc	7 035	7 6723																								
25	Ingot Case A5T																										
26	Ingot Case A7T																										
27	Ingot Case A10T																										
28	Ingot Case C10T																										
29	Ingot Case B10T																										
30	Ingot Case Support		21 1355																								
31	Ingot Case B6T																										
32	Ingot Plate K65B																										
33	Ingot Plate K70D																										
34	Ingot Plate A100G																										
35	Ingot Plate B100C																										
36	Processing Scrap																										
37	ByProd Steam																										
38	Wages	314 5406																									
39	Electric Power		4 5366																								
40	Yard Work 1	29 0584	478 389																								
41	Yard Work 2	88 9044	2 6293																								
42	IngotCase Repair	2 1138	59 9955																								
43	Bof Fixed Cost																										
44	Ingoting FixCost																										

Cost Center Consumption Ratio for Influence factor

SCstCtrConsum 44:42

27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
A5T GD-Ingot	A6T GD-Ingot	A10T GD- Ingot	TopPour GD-Ingot	BtmPour GD-Ingot	BtmPour 5T GD-Ingot	BtmPour 6T GD-Ingot	BtmPour 10T GD-Ingot	B6T GD-Ingot	B10T D10T GD-Ingot	C10T GD-Ingot	A5,6T GD-Ingot	C10T D10T GD-Ingot	B10T GD-Ingot	Ingoting Hours	Steel Process Hours
262 916															
	301 242														
		388 796													
291 449															
	267 041														
		423 471													
						66 0771									
							1529.569								
			63 2885												
				117 875											
6 7263															
	5 9027														
		25 9003													
	33 0595														
		33 7115													
	3 0534														
		22 8031													
463 195															
	498 421														
		908 061													
										324.408					
									1587.879						
								103.561							
											61.7828				
		137 391													
														0.9775	
														75.381	1129.467
															1
														1	

Values of Blocks in Upper and Left Part

Italic figures: Predetermined values

GD Ingot Quaty

L1_54

1	Steel Grade 01 AD060	*83.899*
2	Steel Grade 02 CD100	*4.298.946*
3	Steel Grade 03 BB060	*168.494*
4	Steel Grade 04 AD060	*685.673*
5	Steel Grade 05 AD060	*86.731*
6	Steel Grade 06 AD100	*84.280*
7	Steel Grade 07 AD060	*437.736*
8	Steel Grade 08 AL050	*1.296.392*
9	Steel Grade 09 CD100	*5.002.187*
10	Steel Grade 10 BB060	*3.334.098*
11	Steel Grade 11 AD060	*9.586.237*
12	Steel Grade 12 AD100	*3.321.991*
13	Steel Grade 13 AL050	*86.517*
14	Steel Grade 14 AD060	*778.354*
15	Steel Grade 15 CD100	*4.327.835*
16	Steel Grade 16 ADO6O	*3.734.912*
17	Steel Grade 17 AD100	*942.614*
18	Steel Grade 18 AL050	*1.198.257*
19	Steel Grade 19 BB060	*1.197.976*
20	Steel Grade 20 AD100	*91.497*
21	Steel Grade 21 AD060	*350.454*
22	Steel Grade 22 AL050	*259.258*
23	Steel Grade 23 AD060	*174.759*
24	Steel Grade 24 AD060	*862.559*
25	Steel Grade 25 AD060	*171.995*
26	Steel Grade 26 CD100	*88.677*
27	Steel Grade 27 AD060	*2.164.766*
28	Steel Grade 28 AD100	*508.384*
29	Steel Grade 29 DL100	*799.764*
30	Steel Grade 30 AD060	*31.220.025*
31	Steel Grade 31 AD100	*1.023.252*
32	Steel Grade 32 AL050	*4.800.461*
33	Steel Grade 33 AD060	*1.649.662*
34	Steel Grade 34 AD100	*255.441*
35	Steel Grade 35 AL050	*591.093*
36	Steel Grade 36 AD060	*1.389.819*
37	Steel Grade 37 AL050	*84.724*
38	Steel Grade 38 AD060	*6.238.519*
39	Steel Grade 39 AL050	*433.101*
40	Steel Grade 40 AD060	*1.546.375*
41	Steel Grade 41 AD060	*12.188.606*
42	Steel Grade 42 AL050	*343.652*
43	Steel Grade 43 AD060	*5.276.681*
44	Steel Grade 44 BB060	*2.079.064*
45	Steel Grade 45 AD060	*853.885*
46	Steel Grade 46 AD060	*6.110.731*
47	Steel Grade 47 AL050	*85.921*
48	Steel Grade 48 AL050	*444.193*
49	Steel Grade 49 AD100	*86.481*
50	Steel Grade 50 CD100	*532.704*
51	Steel Grade 51 AD060	*524.164*
52	Steel Grade 52 AD060	*1.327.224*
53	Steel Grade 53 AD060	*261.379*
54	Return Scrap	*4.559.331*

CastSteel Quaty

L1_54

1	Steel Grade 01 AD060	83.8994000
2	Steel Grade 02 CD100	4.298.9462540
3	Steel Grade 03 BB060	168.4935600
4	Steel Grade 04 AD060	685.6734795
5	Steel Grade 05 AD060	86.7306540
6	Steel Grade 06 AD100	84.2797560
7	Steel Grade 07 AD060	437.7360000
8	Steel Grade 08 AL050	1.296.3924480
9	Steel Grade 09 CD100	5.002.1865960
10	Steel Grade 10 BB060	3.334.0978440
11	Steel Grade 11 AD060	9.588.2372460
12	Steel Grade 12 AD100	3.321.9908320
13	Steel Grade 13 AL050	86.5171760
14	Steel Grade 14 AD060	778.3537930
15	Steel Grade 15 CD100	4.327.8347920
16	Steel Grade 16 ADO6O	3.734.9119080
17	Steel Grade 17 AD100	942.6144200
18	Steel Grade 18 AL050	1.198.2571960
19	Steel Grade 19 BB060	1.197.9759120
20	Steel Grade 20 AD100	91.4970775
21	Steel Grade 21 AD060	350.4536420
22	Steel Grade 22 AL050	259.2580560
23	Steel Grade 23 AD060	174.7576800
24	Steel Grade 24 AD060	862.5591000
25	Steel Grade 25 AD060	171.9952800
26	Steel Grade 26 CD100	88.6765920
27	Steel Grade 27 AD060	2.164.7662555
28	Steel Grade 28 AD100	508.3836000
29	Steel Grade 29 DL100	799.7635440
30	Steel Grade 30 AD060	31.220.0247050
31	Steel Grade 31 AD100	1.023.2519460
32	Steel Grade 32 AL050	4.800.4613630
33	Steel Grade 33 AD060	1.648.6620150
34	Steel Grade 34 AD100	258.4411100
35	Steel Grade 35 AL050	591.0927360
36	Steel Grade 36 AD060	1.389.8188600
37	Steel Grade 37 AL050	84.7237440
38	Steel Grade 38 AD060	6.238.5192540
39	Steel Grade 39 AL050	433.1008800
40	Steel Grade 40 AD060	1.546.3754925
41	Steel Grade 41 AD060	12.188.6060010
42	Steel Grade 42 AL050	343.6816320
43	Steel Grade 43 AD060	5.276.6811190
44	Steel Grade 44 BB060	2.079.0643200
45	Steel Grade 45 AD060	853.8847500
46	Steel Grade 46 AD060	6.110.7309980
47	Steel Grade 47 AL050	85.9211440
48	Steel Grade 48 AL050	444.1932800
49	Steel Grade 49 AD100	86.4805720
50	Steel Grade 50 CD100	532.7039520
51	Steel Grade 51 AD060	524.1636060
52	Steel Grade 52 AD060	1.327.2239700
53	Steel Grade 53 AD060	261.3789000
54	Return Scrap	4.559.3314430

GD-Ingot Bundl Quaty

L2_11

1	Steel Grade 26 CD100	13.355.520
2	Steel Grade 33 AD060	50.191.310
3	Steel Grade 34 AD100	5.999.375
4	Steel Grade 35 AL050	7.849.880
5	Steel Grade 19 BB060	4.540.380
6	Steel Grade 29 DL100	770.040
7	Steel Grade 50 CD100	522.720
8	Steel Grade 53 AD060	34.303.390
9	Steel Grade 49 AD100	82.120
10	Steel Grade 48 AL050	1.318.520
11	Steel Grade 44 BB060	1.983.840

Ingot Hiurs

L3_11

1	39 CD100 Cast Time	24.857.293824
2	40 AD060 Cast Time	353.331.765007
3	40 AD100 Cast Time	41.722.053500
4	40 AL050 Cast Time	61.755.005960
5	30 BB060 Cast Time	9.462.151920
6	39 DL100 Cast Time	410.970348
7	61 CD100 Cast Time	244.005696
8	70 AD060 Cast Time	241.149.401361
9	59 AD100 Cast Time	160.002608
10	54 AL050 Cast Time	8.359.944208
11	50 BB060 Cast Time	8.933.033136

Steel Quanty

L4_11

1	Steel Grade 01 AD060	83.8994000
2	Steel Grade 02 CD100	4.298.9462540
3	Steel Grade 03 BB060	168.4935600
4	Steel Grade 04 AD060	772.4041335
5	Steel Grade 06 AD100	84.2797560
6	Steel Grade 07 AD060	1.734.1284480
7	Steel Grade 09 CD100	8.336.2844400
8	Steel Grade 11 AD060	13.775.0990470
9	Steel Grade 15 CD100	11.401.5942280
10	Steel Grade 20 AD100	91.4970775
11	Steel Grade 21 AD060	784.4693780
12	Steel Grade 24 AD060	1.034.5543800
13	Steel Grade 26 CD100	3.561.5899915
14	Steel Grade 30 AD060	39.541.9338750
15	Steel Grade 36 AD060	8.146.1627380
16	Steel Grade 40 AD060	14.078.6631255
17	Steel Grade 43 AD060	7.355.7454390
18	Steel Grade 45 AD060	853.8847500
19	Steel Grade 46 AD060	6.196.6521420
20	Steel Grade 48 AL050	444.1932800
21	Steel Grade 49 AD100	86.4805720
22	Steel Grade 50 CD100	1.056.8675580
23	Steel Grade 52 AD060	1.327.2239700
24	Steel Grade 53 AD060	261.3789000
25	Return Scrap	4.559.3314430

Steel Materi Quantiyty

L5 40

1	Melt Iron	118.476.57301217
2	Return Scrap Ordinary Ste	8.939.19635353
3	CaO	5.107.78203190
4	Doromite Light Burned	2.568.81184954
5	Iron Ore for Steel Making	1.334.41651015
6	Scale S-L	2.890.97619003
7	CaF2	89.42457134
8	F Si 2	223.23224297
9	F Mn Hc	377.24008523
10	Al Other	8.73892606
11	Carbon	9.55001805
12	Carbon Addition	70.32520739
13	AL2O3	1.54058871
14	FeCr HSE Lump	291.15803440
15	Cold Pig Iron	2.752.69353399
16	Ret-Scrap Alloy Steel 1	1.265.27533817
17	Ca Si	24.13476133
18	FAS	50.35284865
19	Si Mn	766.53136455
20	FeS2	33.37717514
21	Al 90% up	24.58615029
22	Ret Scrap Alloy Steel 2	254.71386188
23	FeMo L-C	39.88940440
24	FeMn L-C L-Si	76.31199860
25	FeP	8.29887336
26	FeCr L-C	14.25634044
27	CaCN2	8.88993035
28	Boring Scrap	318.28735383
29	FeSi2 L-Al	15.77741257
30	FeNi L-C Pure	4.67472827
31	Cu-S	3.18480664
32	FeMn H-C	26.90607189
33	FeVa	1.60104050
34	Ret-Scrap Alloy Steel 3	120.30005330
35	FeTi	3.45078232
36	FeTi-B	0.81461627
37	Scrap K A P	0.17341284
38	AAABBB	
39	FeSi2 L-Al L-Ti	7.72896307
40	Return Scrap	9.110.77080743

Steel Bundle Quantityty

L6 24

1	Steel Grade 1 AD06(	83.899400
2	Steel Grade 2 CD10(	4.298.946254
3	Steel Grade 3 BB06(	168.493560
4	Steel Grade 4 AD06(	772.404134
5	Steel Grade 6 AD10(	84.279756
6	Steel Grade 7 AD06(	1.734.128448
7	Steel Grade 9 CD10(	8.336.284440
8	Steel Grade 11 AD06	13.775.099047
9	Steel Grade 15 CD1C	11.401.594228
10	Steel Grade 20 AD1C	91.497078
11	Steel Grade 21 AD06	784.469378
12	Steel Grade 24 AD06	1.034.554380
13	Steel Grade 26 CD1C	3.561.589992
14	Steel Grade 30 AD06	39.541.933875
15	Steel Grade 36 AD06	8.146.162738
16	Steel Grade 40 AD06	14.078.663126
17	Steel Grade 43 AD06	7.355.745439
18	Steel Grade 45 AD06	853.884750
19	Steel Grade 46 AD06	6.196.652142
20	Steel Grade 48 AL05(	444.193280
21	Steel Grade 49 AD1C	86.480572
22	Steel Grade 50 CD1C	1.056.867558
23	Steel Grade 52 AD06	1.327.223970
24	Steel Grade 53 AD06	261.378900

Steel Hour Quantity

L7 24

1	B9 ProcessTime	22.59410842
2	00 ProcessTime	843.02336041
3	01 ProcessTime	33.69871200
4	10 ProcessTime	166.29860994
5	12 ProcessTime	16.89809108
6	13 ProcessTime	444.97735976
7	20 ProcessTime	1.595.56484182
8	21 ProcessTime	2.917.56597815
9	30 ProcessTime	2.222.17071504
10	31 ProcessTime	18.19876871
11	32 ProcessTime	166.22906120
12	33 ProcessTime	225.53285484
13	39 ProcessTime	704.83865932
14	40 ProcessTime	8.434.29449554
15	41 ProcessTime	1.959.96675476
16	42 ProcessTime	3.394.36567956
17	50 ProcessTime	1.442.46168059
18	51 ProcessTime	184.52449448
19	52 ProcessTime	1.344.67351481
20	54 ProcessTime	119.17705702
21	59 ProcessTime	16.09403445
22	61 ProcessTime	242.55110456
23	62 ProcessTime	322.38270231
24	70 ProcessTime	50.28930036

Cost Ctr Influ Quantiry

L8 42

1	Total GD-Steel	125.476.42644300
2	Total GD-Ingot	120.917.09500000
3	39 GD-Steel	83.89940000
4	00 GD-Steel	4.298.94625400
5	01 GD-Steel	168.49356000
6	10 GD-Steel	772.40413350
7	12 GD-Steel	84.27975600
8	13 GD-Steel	1.734.12844800
9	20 GD-Steel	8.336.28444000
10	21 GD-Steel	13.775.09904700
11	30 GD-Steel	11.401.59422800
12	31 GD-Steel	91.49707750
13	32 GD-Steel	784.46937800
14	33 GD-Steel	1.034.55438000
15	39CGD-Steel	3.561.58999150
16	40 GD-Steel	39.541.93387500
17	41 GD-Steel	8.146.16273800
18	42 GD-Steel	14.078.66312550
19	50 GD-Steel	7.355.74543900
20	51 GD-Steel	853.88475000
21	52 GD-Steel	6.196.65214200
22	54 GD-Steel	444.19328000
23	59 GD-Steel	86.48057200
24	61 GD-Steel	1.056.86755800
25	62 GD-Steel	1.327.22
26	70 GD-Steel	261.3789
27	A5T GD-Ingot	9.168.40
28	A6T GD-Ingot	84.494.70
29	A10T GD- Ingot	6.081.50
30	TopPour GD-Ingot	13.878.24
31	BtmPour GD-Ingot	107.038.86
32	BtmPour 5T GD-Ingot	9.168.40
33	BtmPour 6T GD-Ingot	91.018.92
34	BtmPour 10T GD-Ingc	6.851.54
35	B6T GD-Ingot	6.524.22
36	B10T D10T GD-Ingot	770.04
37	C10T GD-Ingot	13.878.24
38	A5.6T GD-Ingot	93.663.10
39	C10T D10T GD-Ingot	14.648.28
40	B10T GD-Ingot	
41	Ingoting Hours	750.385.63
42	Steel Process Hours	26.888.37

CoostCtrConsum Quaty

L9 44

1	BOF Maintenance	64.916.258.12698
2	Main Fuel 'O2'	6.162.630.28068
3	Miscella Fuel	14.665.309.83684
4	Work Etc	114.923.021.32680
5	Work Heat Reserve-5T	2.410.520.88808
6	Work Heat Reserve-6T	25.453.352.41740
7	Work Heat Reserve-10T	2.364.459.10557
8	Work Heat Keep-5T	2.672.116.42740
9	Work Heat Keep-7T	22.563.532.28376
10	Work Heat Keep-10T	2.575.336.16100
11	Work Heat Chimny-7T	6.014.266.27873
12	Work Heat Chimny-10T	10.479.892.79780
13	Work Slide-Upper	878.332.99224
14	Work Slide-Lowerr	12.617.162.21758
15	Work Flat-5T	61.669.40892
16	Work Flat-7T	498.746.86569
17	Work Flat-10T	157.512.54495
18	Work Ground-7T	2.793.352.53465
19	Work Ground-10T	205.016.31869
20	Misc Expendables	19.990.433.26052
21	Misc Expend Btm-7T	257.996.11698
22	Misc Expend Btm-10T	138.676.93863
23	Expend Tools&Equip	1.197.582.68370
24	Ingot Case etc	927.712.22797
25	Ingot Case A5T	4.246.768.95692
26	Ingot Case A7T	42.113.932.86870
27	Ingot Case A10T	5.522.369.03934
28	Ingot Case C10T	4.502.210.69410
29	Ingot Case B10T	1.222.730.49917
30	Ingot Case Support	2.555.643.26137
31	Ingot Case B6T	
32	Ingot Plate K65B	675.656.70469
33	Ingot Plate K70D	5.786.768.57468
34	Ingot Plate A100G	835.542.67955
35	Ingot Plate B100C	733.501.95095
36	Processing Scrap	
37	ByProd Steam	39.467.430.45924
38	Wages	86.934.350.46951
39	Electric Power	4.194.696.68333
40	Yard Work 1	69.000.778.29189
41	Yard Work 2	583.159.38810
42	IngotCase Repair	7.254.481.57307
43	Bof Fixed Cost	26.888.37194
44	Ingoting FixCost	750.385.62757

SteelMateri Unit Cost

L5 40

1	Melt Iron	*29.910*
2	Return Scrap Ordinary Ste	*33.000*
3	CaO	*10.945*
4	Doromite Light Burned	*19.766*
5	Iron Ore for Steel Making	*6.622*
6	Scale S-L	*7.590*
7	CaF2	*15.730*
8	F Si 2	*219.670*
9	F Mn Hc	*99.770*
10	Al Other	*404.250*
11	Carbon	*73.700*
12	Carbon Addition	*67.870*
13	AL2O3	*173.800*
14	FeCr HSE Lump	*196.240*
15	Cold Pig Iron	*30.800*
16	Ret-Scrap Alloy Steel 1	*33.770*
17	Ca Si	*350.900*
18	FAS	*295.570*
19	Si Mn	*101.090*
20	FeS2	*55.110*
21	Al 90% up	*330.000*
22	Ret Scrap Alloy Steel 2	*39.930*
23	FeMo L-C	*2.257.640*
24	FeMn L-C L-Si	*337.150*
25	FeP	*191.500*
26	FeCr L-C	*324.720*
27	CaCN2	*96.800*
28	Boring Scrap	*28.050*
29	FeSi2 L-Al	*250.470*
30	FeNi L-C Pure	*1.304.600*
31	Cu-S	*363.000*
32	FeMn H-C	*243.760*
33	FeVa	*1.990.890*
34	Ret-Scrap Alloy Steel 3	*37.620*
35	FeTi	*1.026.500*
36	FeTi-B	*1.155.000*
37	Scrap K A P	*19.800*
38	AAABBB	*19.800*
39	FeSi2 L-Al L-Ti	*256.770*
40	Return Scrap	*-33.550*

SteelMateri Unit Cost

L5 40

1	Steel Grade 01 AD06	30.369.6965
2	Steel Grade 02 CD10	32.947.0889
3	Steel Grade 03 BB06	33.534.2909
4	Steel Grade 04 AD06	33.411.5397
5	Steel Grade 06 AD10	32.595.4398
6	Steel Grade 07 AD06	33.609.2966
7	Steel Grade 09 CD10	32.465.5804
8	Steel Grade 11 AD06	33.314.3107
9	Steel Grade 15 CD10	32.495.4542
10	Steel Grade 20 AD10	35.261.3712
11	Steel Grade 21 AD06	32.923.2046
12	Steel Grade 24 AD06	34.077.8636
13	Steel Grade 26 CD10	32.780.8811
14	Steel Grade 30 AD06	33.562.5719
15	Steel Grade 36 AD06	35.866.1116
16	Steel Grade 40 AD06	42.208.7919
17	Steel Grade 43 AD06	35.228.0665
18	Steel Grade 45 AD06	38.176.8497
19	Steel Grade 46 AD06	37.789.6682
20	Steel Grade 48 AL05	38.531.1322
21	Steel Grade 49 AD10	32.259.6604
22	Steel Grade 50 CD10	36.226.7433
23	Steel Grade 52 AD06	39.157.7582
24	Steel Grade 53 AD06	32.999.4302
25	Return Scrap	-33.550.0000

CastSteel Material CC

L1 54

1	Steel Grade 01 AD060	30,369.6965000
2	Steel Grade 02 CD100	32,947.0889000
3	Steel Grade 03 BB060	33,534.2909000
4	Steel Grade 04 AD060	33,411.5397000
5	Steel Grade 05 AD060	33,411.5397000
6	Steel Grade 06 AD100	32,595.4398000
7	Steel Grade 07 AD060	33,609.2966000
8	Steel Grade 08 AL050	33,609.2966000
9	Steel Grade 09 CD100	32,465.5804000
10	Steel Grade 10 BB060	32,465.5804000
11	Steel Grade 11 AD060	33,314.3107000
12	Steel Grade 12 AD100	33,314.3107000
13	Steel Grade 13 AL050	33,314.3107000
14	Steel Grade 14 AD060	33,314.3107000
15	Steel Grade 15 CD100	32,495.4542000
16	Steel Grade 16 AD060	32,495.4542000
17	Steel Grade 17 AD100	32,495.4542000
18	Steel Grade 18 AL050	32,495.4542000
19	Steel Grade 19 BB060	32,495.4542000
20	Steel Grade 20 AD100	35,261.3712000
21	Steel Grade 21 AD060	32,923.2046000
22	Steel Grade 22 AL050	32,923.2046000
23	Steel Grade 23 AD060	32,923.2046000
24	Steel Grade 24 AD060	34,077.8636000
25	Steel Grade 25 AD060	34,077.8636000
26	Steel Grade 26 CD100	32,780.8811000
27	Steel Grade 27 AD060	32,780.8811000
28	Steel Grade 28 AD100	32,780.8811000
29	Steel Grade 29 DL100	32,780.8811000
30	Steel Grade 30 AD060	33,562.5719000
31	Steel Grade 31 AD100	33,562.5719000
32	Steel Grade 32 AL050	33,562.5719000
33	Steel Grade 33 AD060	33,562.5719000
34	Steel Grade 34 AD100	33,562.5719000
35	Steel Grade 35 AL050	33,562.5719000
36	Steel Grade 36 AD060	35,866.1116000
37	Steel Grade 37 AL050	35,866.1116000
38	Steel Grade 38 AD060	35,866.1116000
39	Steel Grade 39 AL050	35,866.1116000
40	Steel Grade 40 AD060	42,208.7919000
41	Steel Grade 41 AD060	42,208.7919000
42	Steel Grade 42 AL050	42,208.7919000
43	Steel Grade 43 AD060	35,228.0665000
44	Steel Grade 44 BB060	35,228.0665000
45	Steel Grade 45 AD060	38,176.8497000
46	Steel Grade 46 AD060	37,769.6682000
47	Steel Grade 47 AL050	37,769.6682000
48	Steel Grade 48 AL050	38,531.1322000
49	Steel Grade 49 AD100	32,259.6604000
50	Steel Grade 50 CD100	36,226.7433000
51	Steel Grade 51 AD060	36,226.7433000
52	Steel Grade 52 AD060	39,157.7582000
53	Steel Grade 53 AD060	32,999.4302000
54	Return Scrap	-33,550.0000000

CostCtr Proc UC

L9 44

1	BOF Maintenance	1.0000
2	Main Fuel (O2)	18.5300
3	Miscella Fuel	1.0000
4	Work Etc	1.0000
5	Work Heat Reserve-5T	1.0000
6	Work Heat Reserve-6T	1.0000
7	Work Heat Reserve-10	1.0000
8	Work Heat Keep-5T	1.0000
9	Work Heat Keep-7T	1.0000
10	Work Heat Keep-10T	1.0000
11	Work Heat Chimny-7T	1.0000
12	Work Heat Chimny-10T	1.0000
13	Work Slide-Upper	1.0000
14	Work Slide-Lowerr	1.0000
15	Work Flat-5T	1.0000
16	Work Flat-7T	1.0000
17	Work Flat-10T	1.0000
18	Work Ground-7T	1.0000
19	Work Ground-10T	1.0000
20	Misc Expendables	1.0000
21	Misc Expend Btm-7T	1.0000
22	Misc Expend Btm-10T	1.0000
23	Expend Tools&Equip	1.0000
24	Ingot Case etc	1.0000
25	Ingot Case A5T	1.0000
26	Ingot Case A7T	1.0000
27	Ingot Case A10T	1.0000
28	Ingot Case C10T	1.0000
29	Ingot Case B10T	1.0000
30	Ingot Case Support	1.0000
31	Ingot Case B6T	1.0000
32	Ingot Plate K65B	1.0000
33	Ingot Plate K70D	1.0000
34	Ingot Plate A100G	1.0000
35	Ingot Plate B100C	1.0000
36	Processing Scrap	1.0000
37	ByProd Steam	-1.1100
38	Wages	1.0000
39	Electric Power	0.5000
40	Yard Work 1	1.0000
41	Yard Work 2	1.0000
42	IngotCase Repair	1.0000
43	Bof Fixed Cost	0.0000
44	Ingoting FixCost	0.0000

CostCtr Infl Proc UC

L8 42

1	Total GD-Steel	1,149.48334
2	Total GD-Ingot	1,191.08110
3	39 GD-Steel	933.74305
4	00 GD-Steel	884.78341
5	01 GD-Steel	907.10215
6	10 GD-Steel	888.54481
7	12 GD-Steel	831.69536
8	13 GD-Steel	1,093.30341
9	20 GD-Steel	893.64011
10	21 GD-Steel	905.54468
11	30 GD-Steel	868.34244
12	31 GD-Steel	937.64045
13	32 GD-Steel	905.36025
14	33 GD-Steel	913.66178
15	39CGD-Steel	873.16574
16	40 GD-Steel	900.67108
17	41 GD-Steel	973.12687
18	42 GD-Steel	991.87052
19	50 GD-Steel	881.01643
20	51 GD-Steel	879.73655
21	52 GD-Steel	868.44677
22	54 GD-Steel	1,228.57212
23	59 GD-Steel	892.50555
24	61 GD-Steel	1,047.58353
25	62 GD-Steel	1,035.24861
26	70 GD-Steel	858.69210
27	A5T GD-Ingot	1,024.28730
28	A6T GD-Ingot	1,108.71940
29	A10T GD- Ingot	1,940.13360
30	TopPour GD-Ingot	63.28850
31	BtmPour GD-Ingot	117.87460
32	BtmPour 5T GD-Ingot	
33	BtmPour 6T GD-Ingot	66.07710
34	BtmPour 10T GD-Ingot	1,529.56860
35	B6T GD-Ingot	103.56130
36	B10T D10T GD-Ingot	1,587.87920
37	C10T GD-Ingot	324.40790
38	A5.6T GD-Ingot	61.78280
39	C10T D10T GD-Ingot	
40	B10T GD-Ingot	
41	Ingoting Hours	76.35850
42	Steel Process Hours	1,129.46710

SteelHour Proc UC

L7 24

1	89 ProcessTime	1,129.47
2	00 ProcessTime	1,129.47
3	01 ProcessTime	1,129.47
4	10 ProcessTime	1,129.47
5	12 ProcessTime	1,129.47
6	13 ProcessTime	1,129.47
7	20 ProcessTime	1,129.47
8	21 ProcessTime	1,129.47
9	30 ProcessTime	1,129.47
10	31 ProcessTime	1,129.47
11	32 ProcessTime	1,129.47
12	33 ProcessTime	1,129.47
13	39 ProcessTime	1,129.47
14	40 ProcessTime	1,129.47
15	41 ProcessTime	1,129.47
16	42 ProcessTime	1,129.47
17	50 ProcessTime	1,129.47
18	51 ProcessTime	1,129.47
19	52 ProcessTime	1,129.47
20	54 ProcessTime	1,129.47
21	59 ProcessTime	1,129.47
22	61 ProcessTime	1,129.47
23	62 ProcessTime	1,129.47
24	70 ProcessTime	1,129.47

SteelBundl Proc UC

L6 24

1	Steel Grade 1 AD060	304.165490
2	Steel Grade 2 CD100	221.488498
3	Steel Grade 3 BB060	225.893420
4	Steel Grade 4 AD060	243.174267
5	Steel Grade 6 AD100	226.458154
6	Steel Grade 7 AD060	289.821258
7	Steel Grade 9 CD100	216.180003
8	Steel Grade 11 AD060	239.221132
9	Steel Grade 15 CD100	220.133138
10	Steel Grade 20 AD100	224.651006
11	Steel Grade 21 AD060	239.334078
12	Steel Grade 24 AD060	246.223828
13	Steel Grade 26 CD100	223.521539
14	Steel Grade 30 AD060	240.915332
15	Steel Grade 36 AD060	271.749784
16	Steel Grade 40 AD060	272.314518
17	Steel Grade 43 AD060	221 488498
18	Steel Grade 45 AD061	244.077840
19	Steel Grade 46 AD062	245.094361
20	Steel Grade 48 AL050	303.036023
21	Steel Grade 49 AD100	210 193827
22	Steel Grade 50 CD100	259.212699
23	Steel Grade 52 AD060	274 347559
24	Steel Grade 53 AD060	217 309470

Steel Proc UC

L4 25

1	Steel Grade 01 AD06	2.387.391882
2	Steel Grade 02 CD10	2.255.755250
3	Steel Grade 03 BB06	2.282.478912
4	Steel Grade 04 AD06	2.281.202416
5	Steel Grade 06 AD10	2.207.636858
6	Steel Grade 07 AD06	2.532.608011
7	Steel Grade 09 CD10	2.259.303457
8	Steel Grade 11 AD06	2.294.249156
9	Steel Grade 15 CD10	2.237.958915
10	Steel Grade 20 AD10	2.311.774794
11	Steel Grade 21 AD06	2.294.177665
12	Steel Grade 24 AD06	2.309.368943
13	Steel Grade 26 CD10	2.246.170623
14	Steel Grade 30 AD06	2.291.069748
15	Steel Grade 36 AD06	2.394.359996
16	Steel Grade 40 AD06	2.413.668373
17	Steel Grade 43 AD06	2.251.988264
18	Steel Grade 45 AD06	2.273.297725
19	Steel Grade 46 AD06	2.263.024466
20	Steel Grade 48 AL05	2.681.091480
21	Steel Grade 49 AD10	2.252.182714
22	Steel Grade 50 CD10	2.456.279569
23	Steel Grade 52 AD06	2.459.079506
24	Steel Grade 53 AD06	2.225.484907
25	Return Scrap	0.000000

Ingot Hour Proc UC

L3 11

1	39 CD100 Cast Time	76.358500
2	40 AD060 Cast Time	76.358500
3	40 AD100 Cast Time	76.358500
4	40 AL050 Cast Time	76.358500
5	30 BB060 Cast Time	76.358500
6	39 DL100 Cast Time	76.358500
7	61 CD100 Cast Time	76.358500
8	70 AD060 Cast Time	76.358500
9	59 AD100 Cast Time	76.358500
10	54 AL050 Cast Time	76.358500
11	50 BB060 Cast Time	76.358500

GD-Steel Bundl Proc UC

L2 11

1	Steel Grade 26 CD10	142.118440
2	Steel Grade 33 AD06	537.540932
3	Steel Grade 34 AD10	531.027552
4	Steel Grade 35 AL05	600 712320
5	Steel Grade 19 BB06	159 131114
6	Steel Grade 29 DL10	40 752531
7	Steel Grade 50 CD10	35 644148
8	Steel Grade 53 AD06	536 792619
9	Steel Grade 49 AD10	148 776901
10	Steel Grade 48 AL05	484 143433
11	Steel Grade 44 BB06	343 834690

CastSteel Proc UC

L1 54

1	Steel Grade 01 AD060	2.387.391882
2	Steel Grade 02 CD100	2.255.755250
3	Steel Grade 03 BB060	2.282.478912
4	Steel Grade 04 AD060	2.281.202416
5	Steel Grade 05 AD060	2.281.202416
6	Steel Grade 06 AD100	2.207.636858
7	Steel Grade 07 AD060	2.532.608011
8	Steel Grade 08 AL050	2.532.608011
9	Steel Grade 09 CD100	2.259.303457
10	Steel Grade 10 BB060	2.259.303457
11	Steel Grade 11 AD060	2.294.249156
12	Steel Grade 12 AD100	2.294.249156
13	Steel Grade 13 AL050	2.294.249156
14	Steel Grade 14 AD060	2.294.249156
15	Steel Grade 15 CD100	2.237.958915
16	Steel Grade 16 AD060	2.237.958915
17	Steel Grade 17 AD100	2.237.958915
18	Steel Grade 18 AL050	2.237.958915
19	Steel Grade 19 BB060	2.237.958915
20	Steel Grade 20 AD100	2.311.774794
21	Steel Grade 21 AD060	2.294.177665
22	Steel Grade 22 AL050	2.294.177665
23	Steel Grade 23 AD060	2.294.177665
24	Steel Grade 24 AD060	2.309.368943
25	Steel Grade 25 AD060	2.309.368943
26	Steel Grade 26 CD100	2.246.170623
27	Steel Grade 27 AD060	2.246.170623
28	Steel Grade 28 AD100	2.246.170623
29	Steel Grade 29 DL100	2.246.170623
30	Steel Grade 30 AD060	2.291.069748
31	Steel Grade 31 AD100	2.291.069748
32	Steel Grade 32 AL050	2.291.069748
33	Steel Grade 33 AD060	2.291.069748
34	Steel Grade 34 AD100	2.291.069748
35	Steel Grade 35 AL050	2.291.069748
36	Steel Grade 36 AD060	2.394.359996
37	Steel Grade 37 AL050	2.394.359996
38	Steel Grade 38 AD060	2.394.359996
39	Steel Grade 39 AL050	2.394.359996
40	Steel Grade 40 AD060	2.413.668373
41	Steel Grade 41 AD060	2.413.668373
42	Steel Grade 42 AL050	2.413.668373
43	Steel Grade 43 AD060	2.251.988264
44	Steel Grade 44 BB060	2.251.988264
45	Steel Grade 45 AD060	2.273.297725
46	Steel Grade 46 AD060	2.263.024466
47	Steel Grade 47 AL050	2.263.024466
48	Steel Grade 48 AL050	2.681.091480
49	Steel Grade 49 AD100	2.252.182714
50	Steel Grade 50 CD100	2.456.279569
51	Steel Grade 51 AD060	2.456.279569
52	Steel Grade 52 AD060	2.459.079506
53	Steel Grade 53 AD060	2.225.484907
54	Return Scrap	0.000000

GD-Ingot Proc UC
L1 54

1	Steel Grade 01 AD	5,938.396623
2	Steel Grade 02 CD	4,030.112590
3	Steel Grade 03 BE	3,977.037851
4	Steel Grade 04 AD	5,448.910958
5	Steel Grade 05 AD	5,433.398781
6	Steel Grade 06 AD	7,575.383159
7	Steel Grade 07 AD	5,716.988264
8	Steel Grade 08 AL	5,653.963488
9	Steel Grade 09 CD	4,037.133844
10	Steel Grade 10 BE	3,978.815456
11	Steel Grade 11 AD	5,455.558984
12	Steel Grade 12 AD	7,691.574926
13	Steel Grade 13 AL	5,430.624749
14	Steel Grade 14 AD	5,471.159879
15	Steel Grade 15 CD	4,032.259907
16	Steel Grade 16 AD	5,407.867653
17	Steel Grade 17 AD	7,644.995580
18	Steel Grade 18 AL	5,346.042572
19	Steel Grade 19 BE	3,952.222324
20	Steel Grade 20 AD	7,682.722279
21	Steel Grade 21 AD	5,479.115086
22	Steel Grade 22 AL	5,427.795863
23	Steel Grade 23 AD	5,464.432349
24	Steel Grade 24 AD	5,469.808735
25	Steel Grade 25 AD	5,499.137720
26	Steel Grade 26 CD	4,024.119297
27	Steel Grade 27 AD	5,400.899398
28	Steel Grade 28 AD	7,630.653557
29	Steel Grade 29 DL	6,800.028841
30	Steel Grade 30 AD	5,455.478657
31	Steel Grade 31 AD	7,691.710670
32	Steel Grade 32 AL	5,394.717253
33	Steel Grade 33 AD	5,459.831689
34	Steel Grade 34 AD	7,688.961386
35	Steel Grade 35 AL	5,400.444927
36	Steel Grade 36 AD	5,555.701495
37	Steel Grade 37 AL	5,343.444542
38	Steel Grade 38 AD	5,571.983143
39	Steel Grade 39 AL	5,404.740157
40	Steel Grade 40 AD	5,593.749561
41	Steel Grade 41 AD	5,606.300637
42	Steel Grade 42 AL	5,416.900161
43	Steel Grade 43 AD	5,414.937063
44	Steel Grade 44 BE	4,182.512491
45	Steel Grade 45 AD	5,442.010658
46	Steel Grade 46 AD	5,431.799619
47	Steel Grade 47 AL	5,218.457624
48	Steel Grade 48 AL	5,744.719807
49	Steel Grade 49 AD	7,299.208418
50	Steel Grade 50 CD	4,117.616157
51	Steel Grade 51 AD	5,667.316238
52	Steel Grade 52 AD	5,667.066087
53	Steel Grade 53 AD	5,385.704498
54	Return Scrap	0.000000