Anticipatory vs. Realized Input and Output Information in the Steering Models of Complex Production Processes

John Fogelholm D.Sc.(Tech), Ph.D.
Helsinki University of Technology
Department of Industrial Engineering and Management
Espoo, Finland.
E-mail: John.Fogelholm@hut.fi

Abstract

The most important aspect of any industrial application of models has to be considered to consist of its ability to predict as accurately as possible the resource or economic behaviour of the process under investigation (Fogelholm, 1999, p.543). The probably most useful scientific tool to judge the accuracies or calculate the complexities of the various input elements of any industrial process, the systematic treatment of these inputs in the form of a model, and thus also of the final output, has to be considered to consist of the application variety analysis. Variety is defined as the number of possible states of whatever it is whose complexity we want to measure (Beer, 1990, p.32). In this paper the usefulness of decision-making information of industrial economic processes will be studied from this perspective.

Keywords: Industrial Modelling, Economic Applications of Models, Anticipatory Aspects of Modelling

1 Introduction

This means that the anticipatory aspect of the actual use of a system, consisting of different input elements and the basic model that converts this data into output information, represents the main yardstick of its concrete usefulness. Contemplating the actual models in industrial use until now, one can discern a potentially evident, and mostly also realized increase in the accuracy of the anticipatory information supplied by the models. But as the production processes to be modelled have increased even more in technical complexity, the anticipatory capacity of models has not been able to keep pace with the technical aspect of the processes under scrutiny. In most cases, particularly those involving the economic aspect, as exemplified by the costing or other economy-capturing aspect requirements of the model, the final result has mostly been a fairly low-variety model of the actual process. One of the reasons for this gap between potential and actual accuracies of these kind of models, is due to, and accentuated by the use of aggregated basic input data supplied to the models, together with the frequent direct use for decision purposes, of realized one-of-a kind production information from industrial reporting systems and data bases.

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2 Variety-capturing influences of input data and model configurations

The variety-capturing capability of the output of models used for the steering activities of industrial processes is depending both on the accuracy of the input information supplied to the model, and on the configuration and detailedness of the model itself. Most of the present new developments of new and more accurate economic steering models has been concentrated on the second aspect, but the problem of the reliability and variety-capturing capabilities of the basic input data has been all but neglected.

The situation is shown in Fig.1. The input information generally consists of prognostic or anticipated resource consumption, whereby the individual value is sometimes fairly difficult to determine in advance, owing to different values of those parameters, which determine this individual input value. This problem is accentuated in the industries with a divergent production system like the paper industries, where most of the main resourse consumption elements, as for instance the required electricity consumption flucturate significantly even around the main input parameter (Fogelholm, 1998, p.503). The use of a mean value thus diminishes the accuracy and the required variety-capturing capability correspondingly.

The main emphasis on more accurate economic steering models has been on the actual models developed for each individual industrial case. The need for this kind of develpment was recognized even earlier, but the actual development started with the introduction of Activity -Based Costing in the late 80´s.

The first main publication in this field "Relevance Lost. The Rise and Fall of Management Accounting" (Kaplan & Johnson, 1987) starts with these, by now well-known words: "Today´s management accounting information, driven by the procedures and cycle of the organizations financial reporting system is too late, too aggregated and too distorted to be relevant for a managers planning and control decisions".

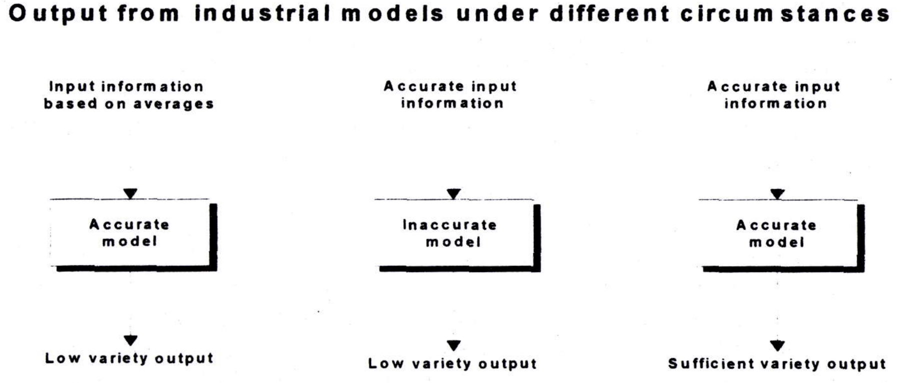

Fig. 1: Output from industrial models under different circumstances

Particularly the emphasis on the distortion and aggregation of the information supplied concerns this study. The same idea, expressed much earlier by Beer, conveys the same message "Society, whether social, industrial or economic, still reckons it can solve the problem of providing cheap, low-variety control of expensive, high-variety systems" (Beer, 1966, p.313). This means in practice, that previously the information from much resourse consumption, which should have been separated owing to their dependence on different allocation bases, was bundled together in the model, which significantly decreased their anticipated variety capturing capabilities.

3 Basic approaches to industrial decision making procedures

The final users of information, utilized for continuously required management decisions, particularly concerning economic aspects of the production, will either explicitly or implicitly require certain features of the system supplying this data. The decisive question hereby concerns the perceptional filters of the management approving the development of new information systems, and the hereby required resource behaviour models, and the decision makers general opinions, using this kind of information in their daily activities.

Fig. 2 exemplifies this situation. The previous approach could be exemplified by the vertical branch of the decision tree, found in industry in general. The reason for the previously, and even now sometimes overwhelming use of this kind of different accounting data files, is to be found in the previous paradigm, where this kind of information was the only one available. But at that stage of industrial development,

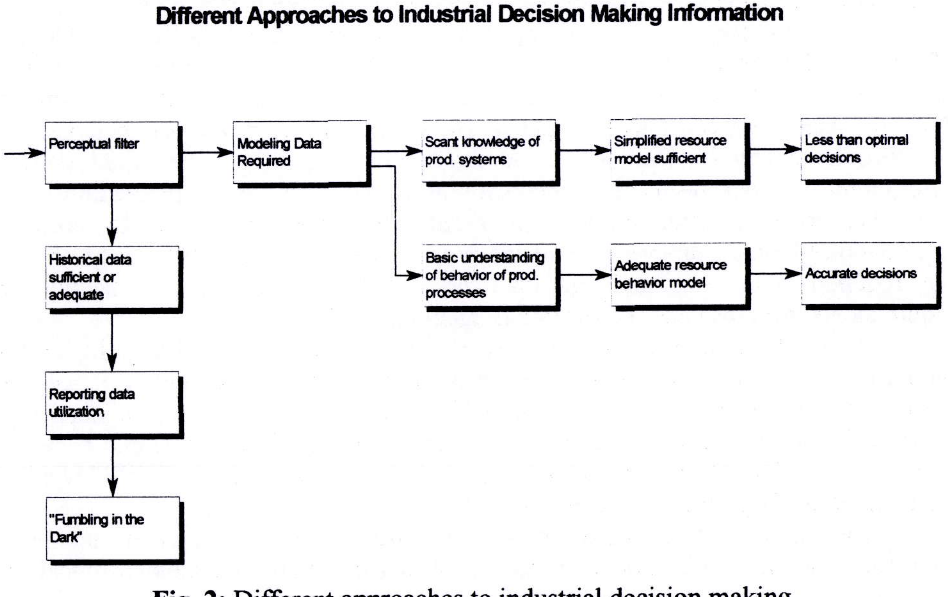

Fig. 2: Different approaches to industrial decision making

when the products were fairly standardized, and the prices of the required resource components were more stable than now days, the historical data was apparently also sufficient.

This situation pertains to the *situation in* Fig. 1 with accurate input information and an inaccurate model, which together produces output of low variety. But the underlying situation and the corresponding requirements have changed drastically lately.

Nowadays there is to be found a general understanding that the kind of information discussed in this paper, has to be based on the resource behavour of the industrial process involved. So the emphasis has been transferred to the two vertical branches of the decision tree. There are however, big discrepancies between the variety capturing capabilities of these two systems.

A simplified resource behaviour model naturally has lower variety capturing capabilities than one with more details included. These requirements pertain both to the input information and the actual model, and their manifestations will be discussed in some detail in this paper.

4 Input information considerations

Input elements in industrial processes, all of which have an economic impact on the final result under investigation, consists of both material and immaterial units. Additionally, one has to calculate with both actual resources and resource elements, consisting of lost opportunities of alternative utilization of the production process. This is only to serve as a reminder, that input elements can not be treated in a simplified way when scrutinizing the variety capturing aspects of the input elements.

The first step in accurate input determination focuses on the problem of identifying the most important, or alternatively the two most important allocation parameters, or resource and cost drivers, whereby the individual resource consumption could be determined and thus anticipated. These potential allocation parameters should be possible to identify from the basic information required at the initial stage of determining the total resource requirements of an individual order, production run or any other product configuration to produced. These basic requirements consist of information like the characteristics of the product under scrutiny, its final dimensions, the required order size and the optimal production path, just to mention the requirements from the paper production (Fogelholm, 1999a).

What all this implies, is that most of the most of the input data is in itself an output of a previous data treatment, and can not be considered to consist of only raw basic data. The situation is exemplified in Fig. 3, which shows one fundamental input information of any industrial steering model, and consists of the throughput behaviour of any potential product to be manufactured, or the resource behaviour of which is under scrutiny (Fogelholm, 1997, p.45).

The variety capturing capabilities of this particular resource input element has to be judged from the spread around the curve, calculated from the available historical data available for this particular resource consumption. As can be noticed from the Fig.3, the spread around the curve is fairly small, and thus acceptable.

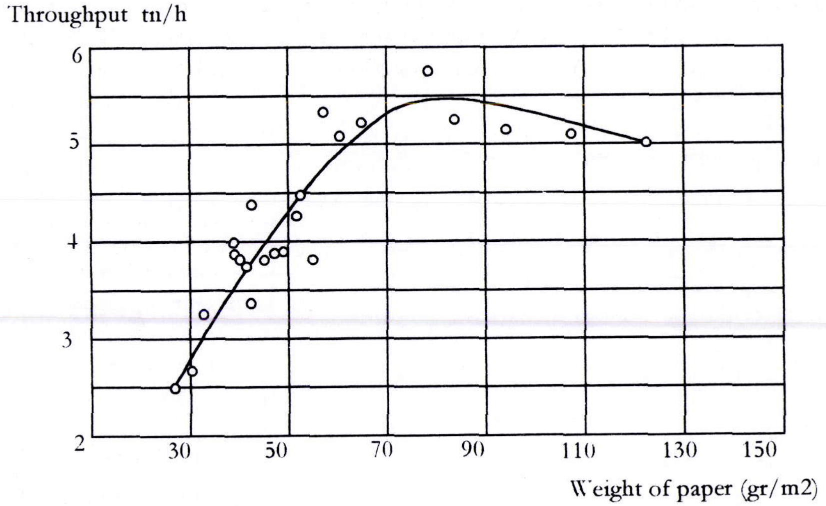

Fig 3: Acceptable input information for steering models

The situation is totally different in Fig.4, which shows a preliminary result using the first choice of parameter in this particular situation of resource determination.

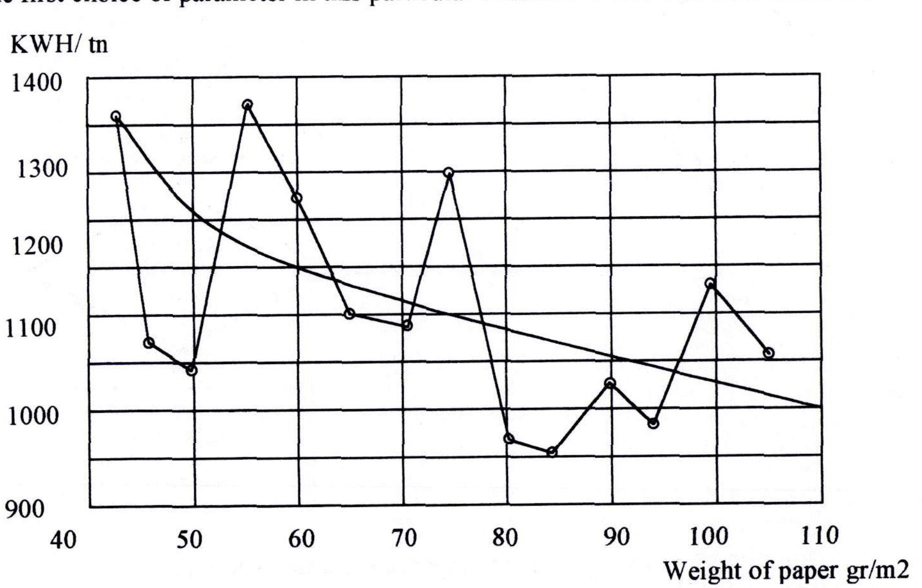

Fig 4: Preliminary input information for steering model

As easily can be noticed from the curve, one has first to decide, if the variety capturing capability of this particular resource consumption element is economically insignificant or marginal, and if thus a lower variety capturing capability can be accepted. As the situation in Fig. 5 clearly shows, there are two options available in this case. The first one is to try to use alternative cost drivers or allocation basis, and to try to find out, if a higher variety capturing capability can be achieved. This is an easier solution, as the same amount and the same basic data can be utilized. The other alternative consists of the inclusion of a second allocation parameter, in which case amount of required basic data will increase substantially.

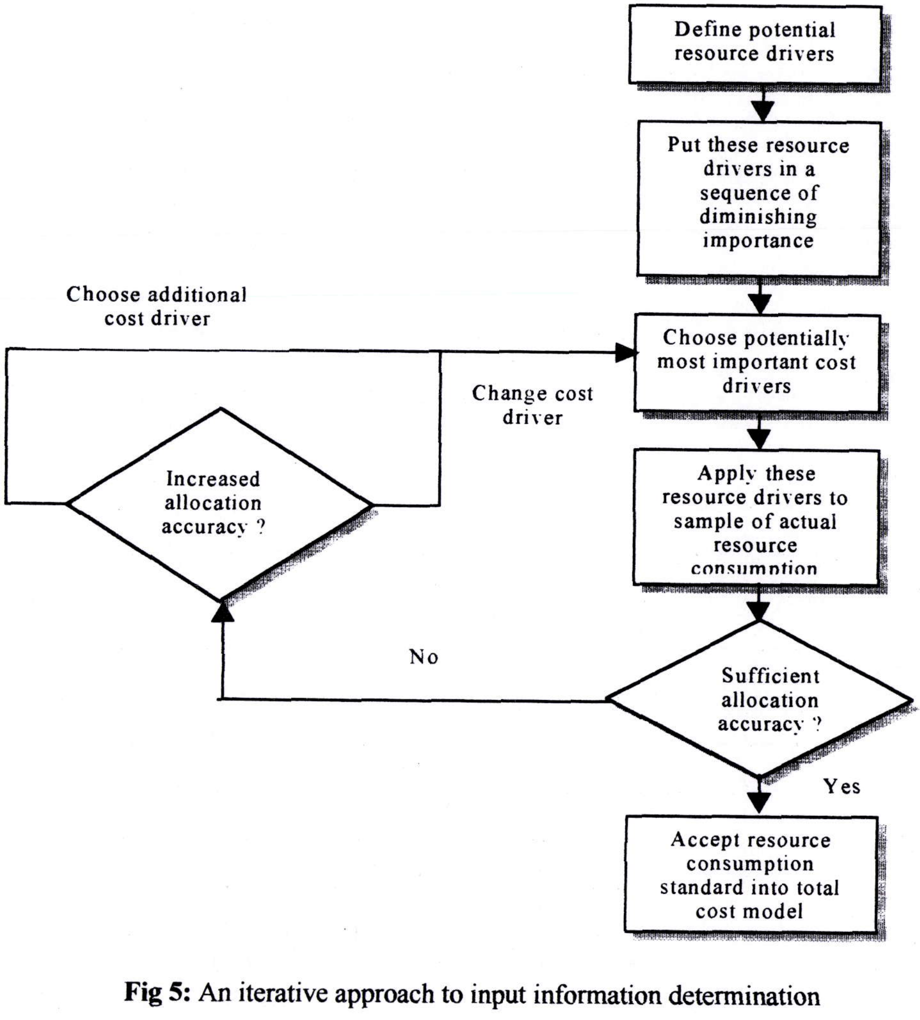

Fig 5: An iterative approach to input information determination

But these types of decisions have to be done ex post, after that an initial trial has been made with the theoretically most promising initial parameter. One has thus to settle for an iterative approach to maximize the variety capturing capabilities of the input information of industrial steering models. There does not exist any shortcuts for this kind of situations, and an iterative approach is the only solution in situations, where an increased variety capturing capability is deemed necessary.

The aforementioned considerations concerning the variety capturing capabilities of the required input information of industrial steering models and systems, illustrates the need for a close scrutiny of the required input information, which in many cases seems to have been neglected, and has not achieved the importance, that the impact on the final result, in the form of sufficient variety capturing capabilities of the output information of the model would justify.

5 Variety Capturing Capabilities of the Basic Model

The variety capturing capabilities of the basic model is totally dependent on the accurateness of the resource behaviour pattern included in the final model. The development of this part of the information system for complex production processes has been really fast, and the taxonomy of the model has shifted from a accounting-focused approach to models, based on the actual resource behaviour of the production process, according to the insights of Activity-Based Costing. The level of accuracy of the final model, based on a detailed mapping of the production process, and a clear conception of the resource consumption in different stages of the production process, is totally dependent on the amount of time allocated to this stage of system development. Basically this problem, as also shown in Figure 2, is connected to the time, allotted to this task.

The situation, as far as the variety capturing capabilities of the main model is concerned, is outlined in Figure 6. The unit-level resource group, which includes required raw materials, auxiliary materials, labour, energy and other throughput related resources can be determined and anticipated with a high degree of accuracy. The variety capturing capabilities of the model concerning this resource group can thus be considered to be adequate. The main variety diminishing feature would be to use averages, particularly in the allocation of economically important resource elements or features, like that of the throughput values. One of the main characteristics of the model outlined in this paper concerns the high degree of allocation accuracies developed for the resource groups on this resource group level.

The next level in the taxonomy of resource elements included in the model consists of the batch level resources. This resource group can be distinguished from the previous one, both from the point of view of anticipated resource allocation accuracies, which particularly pertains to set-up or grade change activities, where the actual time and also the potential re-circulated waste is difficult to accurately anticipate, and from the point of view, that the determination of this kind of production resource, like that of the lost production time, represents a calculated cost, which is not possible to price in the same way as those of the resources on the unit level. The final allocation accuracies are, thus smaller than those on the previous level.

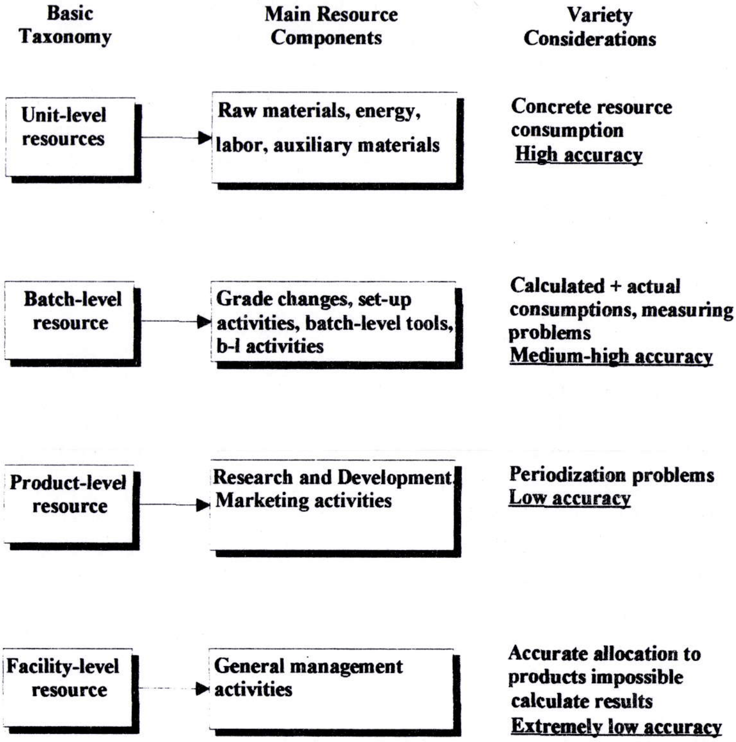

Fig 6: Allocation accuracies of main model

The product level resource group includes elements, which usually are outside the actual production process, and are more difficult to allocate owing to the periodization problem. This is due to the fact, that the prognostic time span of these kind of activities and their impact on the development and marketing of the products concerned, is difficult to determine accurately in advance.

The main problem of the accurate determination of elements in the last resource group included in the main ABC taxonomy concerns the facility level resources. The final allocation of these different kind of resources, which include both human resources, different kind of depreciation, and a lot of general overhead activities and their costs, are not possible to allocate with the same methods and accuracies as those of the unit and batch levels. The best example of the problems involved is from the paper industry and concerns the allocation of head office resources to the products, made on individual paper machines in mills, usually situated far away from these kind of offices. As an example could be quoted the solution, as found in one paper company, and which allocates the total resources of the head office first to the different factories, then to the individual machines, and finally down to the individual production runs and products. These kind of allocations can not be scientifically determined in the same way as those on the unit level and batch level, but have to be determined from an accounting point of view.

6 Additional shortcomings of industrial information utilization

One additional fundamental variety-diminishing feature of information, used for industrial decisions, could be labeled sheer ignorance (Beer, 1990, p.40). This means that the decision-maker has in his mind a simplified model, which steers his decision making process. "As we speculate on richer information systems, in which the model of the users decision making is far from being complete, we have to consider more and more deeply the kind of presuppositions that need to be stored in these systems about the users needs and resources" (Churchman, 1969, p. 46). This means in practice, that if the basic decision model is flawed, no variety capturing potential information can rectify the situation. The most common manifestation of this problem in real life, as noticed by this author, is exemplified in Fig.7.

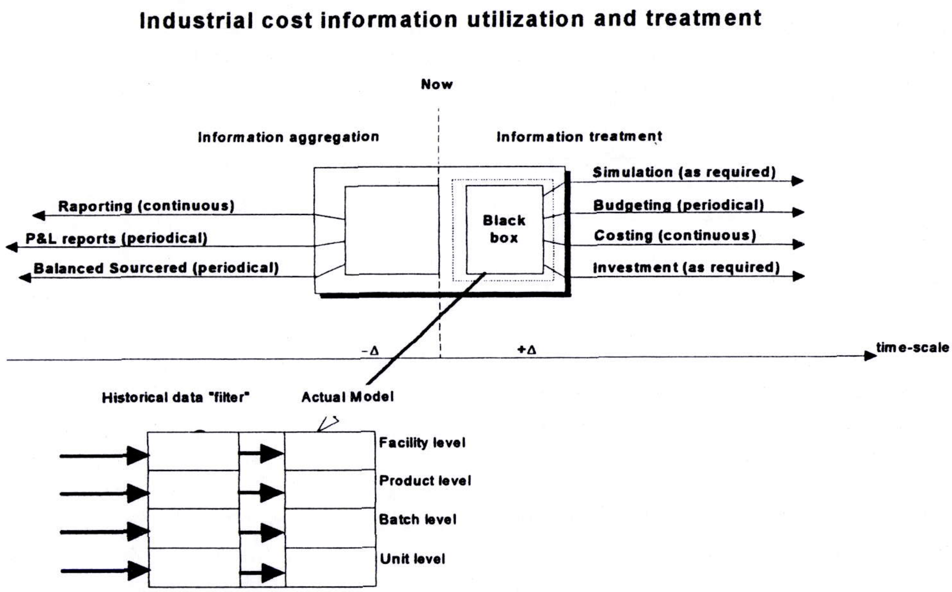

Fig. 7: Industrial cost information utilization and treatment

This situation concerns the massive or exclusive use of historical, or realized production resource-, or the corresponding cost information, as the main basis for decisions concerning the economic behaviour of future production sets or orders.

The main variety diminishing feature of this kind of use of historical data is due to the fact, that any reporting system can only determine the actual realized costs or resource consumption of previous, individual production runs, which anyhow in some respect will differentiate from a new or potential production run. This can concern such factors like the raw material content of the product, its required final dimensions, or the required amount to be produced, which all factors have a decisive impact on the cost breakdown, but which can not be accurately prognosticated exclusively from previous runs It also means, that aggregated production information can not be substituted for information from steering models, which can anticipate in a totally different way the impact of any minor differences in the parameters of the potential production runs.

7 Conclusion: Approaches to acceptable steering information

This paper has focused on the properties of the steering information of complex production processes, and the impact on the final decision making information of the required input information, and of the capacity of the model to convert this basic information into acceptable output information. The anticipatory aspect, in the form of variety capturing capability of the data hereby generated, is the main aspect of this scrutiny. The final usefulness of the information hereby generated can also be judged from the point of view of the validity of the information actually used. This can, and is usually expressed in the form of an algorithm (Ghauri et al, 1995,p.46) as follows

$$X_{observed} = X_{true} + X_{bias} + X_{random} \qquad (1)$$

The observed or accepted result of anticipated accuracy of the final information in actual use in decision making situations, thus consists of a true value, which is next to impossible to achieve in the modelling of complex production processes, a random variety, which can never be fully eliminated except in totally deterministic surroundings, and the bias of the result, caused by lack of validity. Particularly the impact of bias is of utmost importance in situations, where the decision-makers themselves have not been actively involved in the development procedures, and thus have to rely on information from information systems, where the variety capturing capabilities is not sufficient. This type of insufficiency is apparently most common in production processes, where products are manufactured in a modular way in many versions, the batch sizes vary all the time, and the production paths can be changed as required. Decision-makers thus pay the price in situations, where the Ashbys´s law (Ashby, 1956) referred to in the introduction, is not fulfilled. These situations could in industry in general be more common than generally admitted.

References

1. Ashby, W. Ross (1965). An Introduction to Cybernetics. Chapman and Hall.
2. Beer, Stafford (1966). Decision and Control. John Wiley & Sons.
3. Beer, Stafford (1990). The Hearth of Enterprise. John Wiley & Sons.

4. Churchman, C. West (1969). On Management Information Systems. The McKinsey Quarterly. Vol. VI, No. 1, pp. 43-51
5. Fogelholm, John (1999a). The Utilization of Cybernetics in the Steering of Complex Production Processes. CP 465, Computing Anticipatory Systems: CASYS'98 - Second International Conference. Edited by D. Dubois. American Institute of Physics, pp. 543-554.
6. Fogelholm, John (1999b). Adequate Modelling as a Prerequisite for Successful Industrial Simulation Activities. Nordic Operations Analysis Conference. Östersund, Sweden. 27-29.9, 5 p
7. Fogelholm, John (1997). Product Costing in the Paper Industries. Journal of Cost Management. Warren, Gorham & Lamont. Vol. 11, No.5.
8. Fogelholm, John (1998). Cost modelling in the Paper Industries. Cybernetics and Systems. Vol.2. Proceedings of the Fourteenth European Meeting on Cybernetics and Systems Research. Edited by Robert Trappl. University of Vienna, pp.501-506.
9. Ghauri, Pervez & Grönhaug, Kjell & Kristianslund, Ivar (1995). Research Methods in Business Studies: A Practical Guide. New York. Prentice Hall
10. Johnson, Robert & Kaplan, Robert (1987). Relevance Lost. The Rise and Fall of Management Accounting. Boston. Harvard Business School Press.