An Examination of Some Aspects of Control Within a Framework of Management by Objectives

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Introduction:

Control, and its necessary prerequisite, planning, are essential for the success of any human endeavour and are now widely established concepts in most organisations, enshrined in formal corporate planning/budgeting systems. Generally the planning process is split into strategic planning and operational or tactical planning which deals with resource allocation for specific operational units.

The problem examined here is at the level of tactical planning and is concerned with the effects of the cyclic nature of target setting via the planning cycle and the long term consequences of managers attempts to control processes and achieve targets in the short term. An example of this situation is considered within the context of the coal mining industry, where the manager of a colliery, which is the basic operating unit in the industry, is responsible for achieving annual budgeted production targets with limited resources.

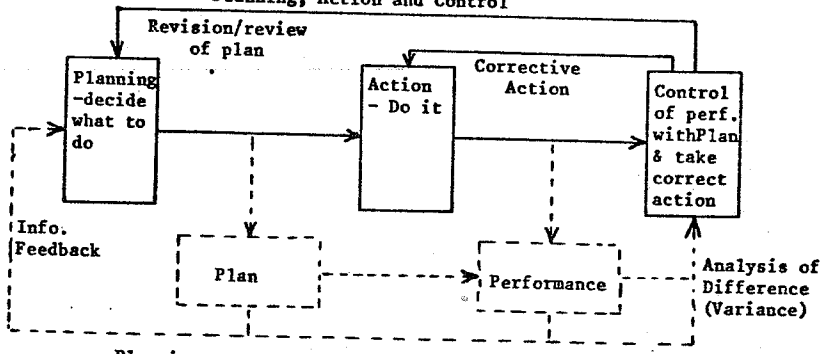
Planning and Control

The control of any operation or process in its simplest form, utilises a feedback control loop and, hence, implies the presence of a standard or target result; the existence of which again implies the existence of some mechanism for defining this desired result. Such a mechanism is the planning process. Planning, by defining a desired

state, leads to the definition of the process or decision making activity which generates the actual state, which means that the discrepancy, if any, between what is predicted to be the actual outcome of the process and what actually occurs may be fed back to correct the process, completing the loop and exercising control. As Ackoff (1) states "control is the evaluation of decisions after they have been implemented. It involves predicting the outcome of a decision, comparing it with the actual outcome, and taking corrective action if the match is poor".

The relationship between planning and control has been summarised by Higgins (2) in the following diagram:

Figure 1 Planning, Action and Control



Planning processes have been studied in detail over the last decade by a number of researchers and practitioners; for example Ackoff(1), Higgins(2),Argenti(3),Glueck(4),Tapeiro(5), and planning activities classified in a number of ways. The philosophy behind planning and control has also been elucidated into: Satisfying; Optimizing; and Ackoff's third philosophical base, that of Adaptive Planning.

Tactical planning is concerned with resource allocation in the short to medium term in order to meet the organisations strategic objectives and a major element in tactical planning is budget formulation. Management by Objectives as a planning and control tool, was formulated by Humble (6)

and is one attempt at this type of tactical planning, and which widens the objectives from the more obvious budgetary indices to include the personal development of the manager. However, all budgeting procedures suffer from the same disadvantage in that they are concerned with planning the use of existing resources.

Problem statement

Tactical planning as mentioned above tends to be discontinuous in that budgets are drawn up at fixed points in time. During these intervals control may be exercised continuously by the manager with control on him by higher management being exercised again at fixed points in time, when the manager is held accountable for his attainment of the plan. It is possible that unless the system being managed is sufficiently robust the longer term consequences of decisions made by managers in pursuing the short term objectives, may generate serious instabilities. Thus the planning and control system which forces these decisions on managers is at fault and, by respecifying targets and allowing a more flexible response, these problems may be partially overcome.

However, it has been argued that the planning and control systems described above are basically wrong in principle, for example Beer (7) argues - 'Planning must be adjusted continuously - because rational expectations and probable scenarios are both constantly changing, so that the decision taken yesterday is very probably and ostentatiously wrong today. More information has arrived and 'information is what changes us'.'

Such an approach of a continuously adaptive planning system is consistent with Ackoffs (1) Adaptive Planning philosophy mentioned above.

Colliery Operations and Planning

In a colliery coal is mined from a number of production faces which have a limited life. When a face is exhausted it must be replaced

at once by a developed face so as to ensure continuity of production. Development and production both demand the allocation of limited resources, primarily manpower, organised into shifts. Planning and control is such that annual budgets are fixed for expected production with detailed programs for scheduling work updated every three months.

Production has been emphasised over the last few years because of oil price rises, and this is reflected in the setting of targets and the accountability of managers. This has led to the situation where if the mining environment, i.e. geological conditions, deteriorates, a manager is tempted in the short term to sacrifice development for the sake of production in order to meet his target, and if he is unable to redress the balance due to continuing problems, there will be a consequent long term loss.

The system in its most general form is illustrated as a causal loop diagram in Fig.2, and is a simplified version of a more complex model developed in the course of an ongoing research program. By using the model based on Fig.2, it is possible to illustrate in a simplistic way this type of behaviour.

Conclusion

It is envisaged that System Dynamics can be of benefit at the level of Tactical Planning and Control in a number of ways. First, by the provision of a model of the type described above it will enable an operational manager to assess the potential consequences of his resource allocation decisions over time, and thus implement policies which, although may cause problems in the achievement of short term targets, should ensure long term continuity. Such a procedure would fulfil Stafford Beer's definition of the role of tactical planning as being a procedure to continuously detect and damp down instabilities.

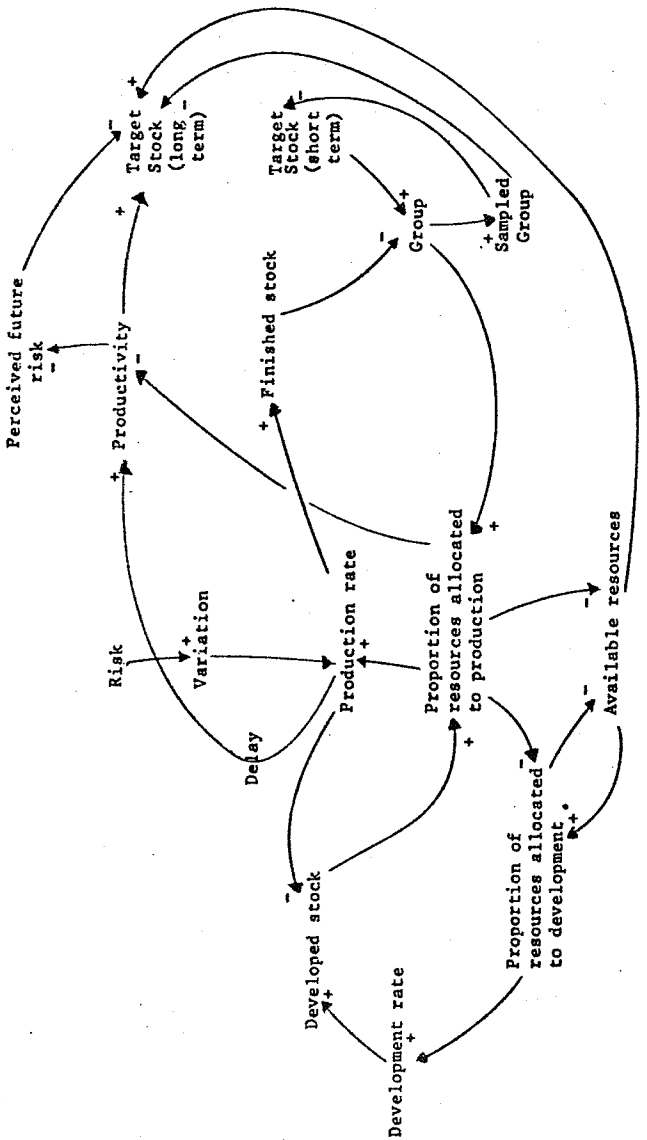


Figure 2 Generalised Model (simplified)

Secondly, and perhaps more importantly, System Dynamics will help in the design of a continuously adaptive planning and control system by the identification of real time information needs, and the specification of more relevant tactical objectives which relate more to the units of measure identified by Beer of

'actuality, capability and potentiality'.

This is of importance to the coal industry due to the current implementation of real time information retrieval equipment in collieries.

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Examination of Some Aspects of Control within a Framework of Management and Objectives

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1. Introduction

Planning and Control are essential for the success of any human endeavour and are now widely established concepts in most organisations, usually enshrined in formal corporate planning/budgeting systems. The process of planning may be analysed in a number of different ways, but generally there is a consensus on the need to split the process up into strategic planning, which directs the whole organisation and tactical or operational planning which deals with resource allocation for specific operational units and integrates them into the whole.

The problem of endogenous generated dynamics at the corporate level is an area of investigation long associated with System Dynamics, but problems associated with operational planning and control less so. The problem or potential problem examined here is concerned with the effects of short term target setting in the planning cycle, and the long term consequences of managers' attempts to control processes to achieve these. An example of this situation is considered within the context of the coal mining industry where the manager of a colliery, which is the basic operating unit, is responsible for achieving annual budgeted production targets, with limited resources.

2. Planning and Control

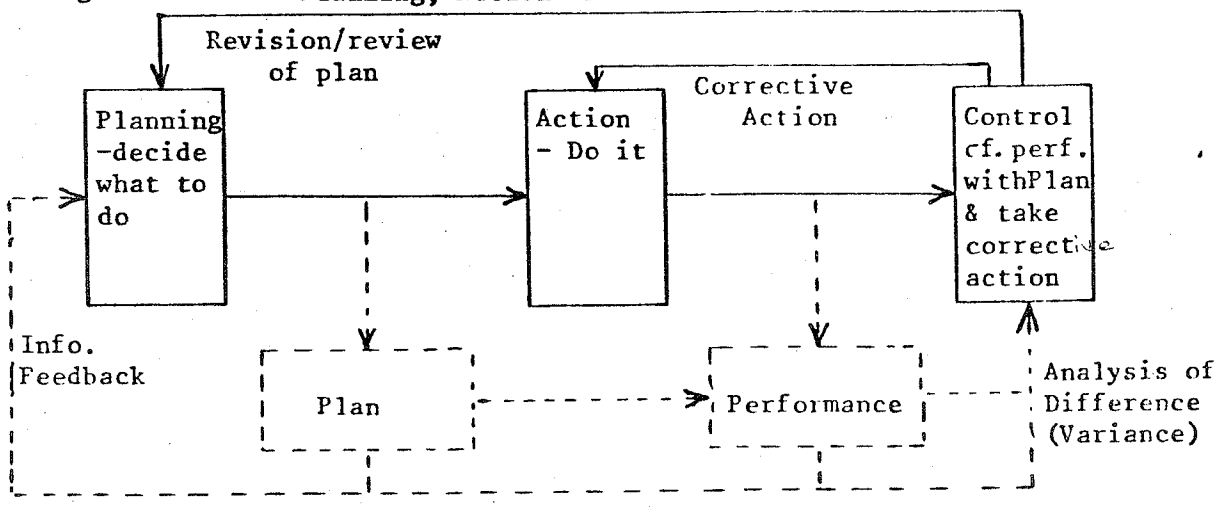
The control of any operation or process in its simplest form utilises the negative feedback control loop and hence implies the presence of a standard or target result, the existence of which again implies the existence of some mechanism for defining this desired result. Such a mechanism is the planning process. Planning, by defining a desired state leads to the definition of the process or decision making activity which generates the actual state, which means that the discrepancy, if any, between what is predicted to be the actual outcome of the process, and what actually occurs may be fed back to correct the process, completing the loop and exercising control. As Ackoff (1) states

> 'Control is the evaluation of decisions after they have been implemented. It involves predicting the outcome of a decision, comparing it with the actual outcome, and taking corrective action if the match is poor'.

It is interesting that although control is a negative feedback process, planning is considered by Donald (2) to be a positive feedback process, as it involves a divergence from a point of origin from one planning period to the next.

The relationship between Planning and Control has been summarised by Higgins (3) in the following diagram:

Figure 1 Planning, Action and Control



It is a truism to state that the future for most, if not all, systems is uncertain and it is this uncertainty that planning systems attempt to combat, either by accurately predicting the future, or by ensuring that a desired future state is brought to pass. Tapeiro (4) points this out by asking:

'Does good planning mean that the future is accurately predicted and adequately prepared for? Or does it mean that an intended future state is brought to pass?'

This illustrates the two aspects of planning which reflect the relationship between the system and its environment. The first where the system cannot affect its environment and where, in this sense, its planning is passive. Here, concern is essentially with predicting the environment so as to set objectives, formulate strategies, modify organisation structure etc., which will enable the organisation to achieve its goals. Such adaption to the environment increases the organisation's tolerance of uncertainty. It is in this context that Contingency Planning plays a role when the future state of the environment is very uncertain. The second aspect is where it is possible for the organisation to modify its environment and is thus, in this sense, active. This is an exercise in attempting to reduce future uncertainty by influencing the environment.

Over the last decade planning processes in organisations have been studied in detail, ref. Argenti (5), Higgins (3), Ackoff (1), Glueck (6), and the concept of corporate planning formalised. For example Tapeiro (4) classifies corporate planning activities as follows:

1. Incremental Planning - this emphasises a short term planning horizon, adjusts adaptively to a changing environment, does not involve much uncertainty, is very flexible, and emphasises short term performance.
2. Long Term Planning - this has long planning horizons and therefore large uncertainties, adjustments to a changing environment are not easy, emphasises stable operating conditions and performance.

3. Intermediate Planning - a combination of 1 and 2 which establishes a sequence of shorter range plans within a long term plan, which will be implemented in the future. Maintains temporal flexibility, reduces the risks of current long term decisions and emphasises both performance and stability.

The classification which Higgins (3) adopts is:

1. Commitment Planning which is used where the system will behave deterministically.
2. Responsiveness Planning which may be used when uncertainty is total and prediction of future events is impossible; it involves designing a structure which will detect and respond speedily to unforeseen events.
3. Contingency Planning lies between 1 and 2 and involves drawing up sets of plans to meet a restricted number of possible futures.

Finally a number of philosophies which underly planning activities have been identified:

1. Satisficing - objectives, i.e. desired future performance, are set at a level that is both desirable and practical and plans are designed to achieve these in an acceptable, but probably not the best, way.
2. Optimizing - here the objective is the highest level of achievement with the plan reflecting the best way of achieving it (this view is reflected in the traditional economists idea of a manager being a rational 'economic man' who will attempt to maximise his expected utility).
3. Ackoff (1) has identified a third possible philosophical base, that of Adaptive Planning, which aims to build responsiveness and flexibility into an organisation. Ackoff's view is that the planning process is of greater value than the plans themselves and that less planning would be required if management and controls were more effective -

> 'the principle objectives of planning should be to design an organisation and a system for managing it that will minimise the future need for retrospective planning - that is, planning directed toward removing deficiencies produced by past decisions'.

Due to the complexity of organisations, the nature of decisions to be made, environmental uncertainty, the time needed to carry out the corporate planning; planning activities are delineated into those which are of a strategic nature and those which are tactical. Tactical planning is concerned more with resource allocation in the short to medium term, typically 1 year to 18 months ahead, in order to meet the organisation's strategic objectives.

A major element in tactical planning is Budget formulation and Argenti (5) has described this as:

> 'In drawing up a budget a manager is being asked "What do you propose to do next year, or for the next few years?" and the budget is a formal quantified answer'.

Managers' individual budgets are integrated within the organisation and cannot be drawn up in isolation. Management by Objectives as a planning and control tool (Humble (7) is one attempt at this type of tactical planning, which widens the objectives from the more obvious budgetary indices to include the personal development of the manager, and to generate more enthusiam and commitment on his part. MbO may be considered to be the process by which corporate objectives are formally translated into departmental and individual objectives applicable to individual managers. However, all budgeting procedures suffer from the same major disadvantage in that they are concerned with planning the use of existing resources and do not encourage managers to think beyong their current operations. Also, because of the emphasis on the attainment of targets in the short term such resource allocation as may be done by the manager may generate long term instabilities.

Corporate planning, as mentioned above, tends to be discontinuous, that is, plans are drawn up and budgets agreed at fixed intervals of time. During these intervals control may be exercised continuously or discontinuously at the manager's discretion, with control by higher levels of management being exercised only at fixed points in time when the manager is held accountable for the attainment of his plan or budget. These accountability points may correspond to the times when the next plan is formulated and agreed, or there may be a number within a budgetary period, for example quarterly within a 12 month budget period. Obviously within any organisation there exist mechanisms whereby, if managerial control ceases to be effective, say due to some sudden large environmental disturbance, then the planning and control cycle may be aborted. In such a situation contingency plans may be used and planning cycle restarted or modified.

It is possible that unless the system being managed is sufficiently robust the longer term consequences of decisions made by managers in pursuing the short term objectives, as exemplified in the accountability system, may generate serious instabilities that will threaten the system. Such endogenously generated instabilities are, of course, well known at the corporate or industry level, and have long been a source of interest to system dynamicists (Forrester et al). However, decision making at a tactical level has not, possibly due to the wide availability of Management Science techniques specifically orientated towards resource allocation problems. Management Science techniques are, however, notoriously difficult to apply in dynamic, complex, non-linear situations, which generally characterise management decisions making even at the level of resource allocation.

It has been argued that when a manager reviews progress he will, if necessary, alter the objective in response to the progress he is making, this behaviour is possible in a situation where the manager feels he cannot control the process he is accountable for and where he has sufficient autonomy. However, within a formal planning/budgeting system this is unlikely and as Argenti (5) states:

'A questionalbe type of behaviour, more likely the managers boss will decide on the basis of progress whether the objective should be modified or whether more resources should be allocated to the attainment of the original objective'

Managers are, of course, acutely aware of time and in many respects it is one of their most important resources as Tapeiro (4) points out:

'Because time has the characteristics of being irreversible, limited, inelastic and not storable, management must allocate it as other resources are allocated. In practice the timing of management decisions and their effects over time are essential factors in the success or failure of management.'

However, managers usually find it difficult to consider the effects of a decision in time, especially where it affects a complex system.

In conclusion then, it is postulated that too rigid a control system in which control is exercised by higher management at discrete points in time may generate unwanted and deleterious dynamics because of

1. an incorrect time interval between performance appraisals

and/or 2. too rigid an adherence to target attainment by the managers in the face of shocks to the system by the environment, or a gradual change in environmental conditions,

and/or 3. too narrow a choice of targets/objectives specified by the planning/budgeting process, leading to a situation where short term advantages are traded off against long term disadvantageous consequences.

The implication is that MbO or other tactical planning and control systems 'incorrectly' applied or applied under incorrect assumptions about the environment, generate unwanted behaviour and straightjacket a manager.

It has been argued that the planning and control systems described above are basically wrong in principle, for example Stafford Beer (8) argues:

> 'Planning must be adjusted continuously - because rational expectations and probable scenarios are both constantly changing, so that the decision taken yesterday is very probably and ostentatiously wrong today. More information has arrived and 'information is what changes us'.'

This implies that a continuously adaptive planning system, with an all embracing set of objectives or more global indices of performance, which reflect the complex inter relationships within the system, provides a better control system in a turbulent environment, at least at an operational level. This means that objectives must be respecified in more open ended terms. Such an approach is consistent with Ackoff's adaptive planning philosophy mentioned above.

Such a planning and control system should be very responsible to environmental changes, having the capacity to adapt quickly whilst still being able to reconcile this with the long term strategic organisational goals. Stafford Beer (8) maintains that

> 'planning is a continuous act of adaptive decision making that continually aborts.'

and it is interesting that he goes on to state that

> 'tactical planning is a procedure that will continuously detect and damp down instability.'

Thus what is required of a tactical planning and control system is adaptability and continuous planning as well as continuous control; incorporating target states or criteria which adequately reflect the complexity of the system, the means to prevent instabilities, and compatibility with the long term strategic aims of the organisation.

3. The colliery system

Evidence may be drawn for the arguments put forward above, by considering the basic operating unit of the National Coal Board, the colliery. In a colliery coal is mined from a number of separate coal faces which progress through a panel of coal. A coal face has a life dependent on the size of the panel of coal being extracted and the rate of extraction. At any one time the faces producing coal will be at different points in their life cycles. Before coal can be produced from a face is must be prepared, or 'developed', and thus at the same time coal is being produced new faces must be in preparation to replace exhausted faces.

A colliery has a limited number of men employed on coal extraction, organised into machine shifts. A machine shift is the basic production unit, there being a possible maximum of 3 machine shifts per face, per day, each machine shift requiring a minimum number of men to operate the coal extraction or face development machinery.

It is rarely the case that all faces and developments will be operating at the maximum number of shifts, since spare capacity, in the form of unworked shifts, is needed to act as insurance if a face stops; i.e. the shifts from that face may be redeployed so that the men are not underutilised and production is maintained.

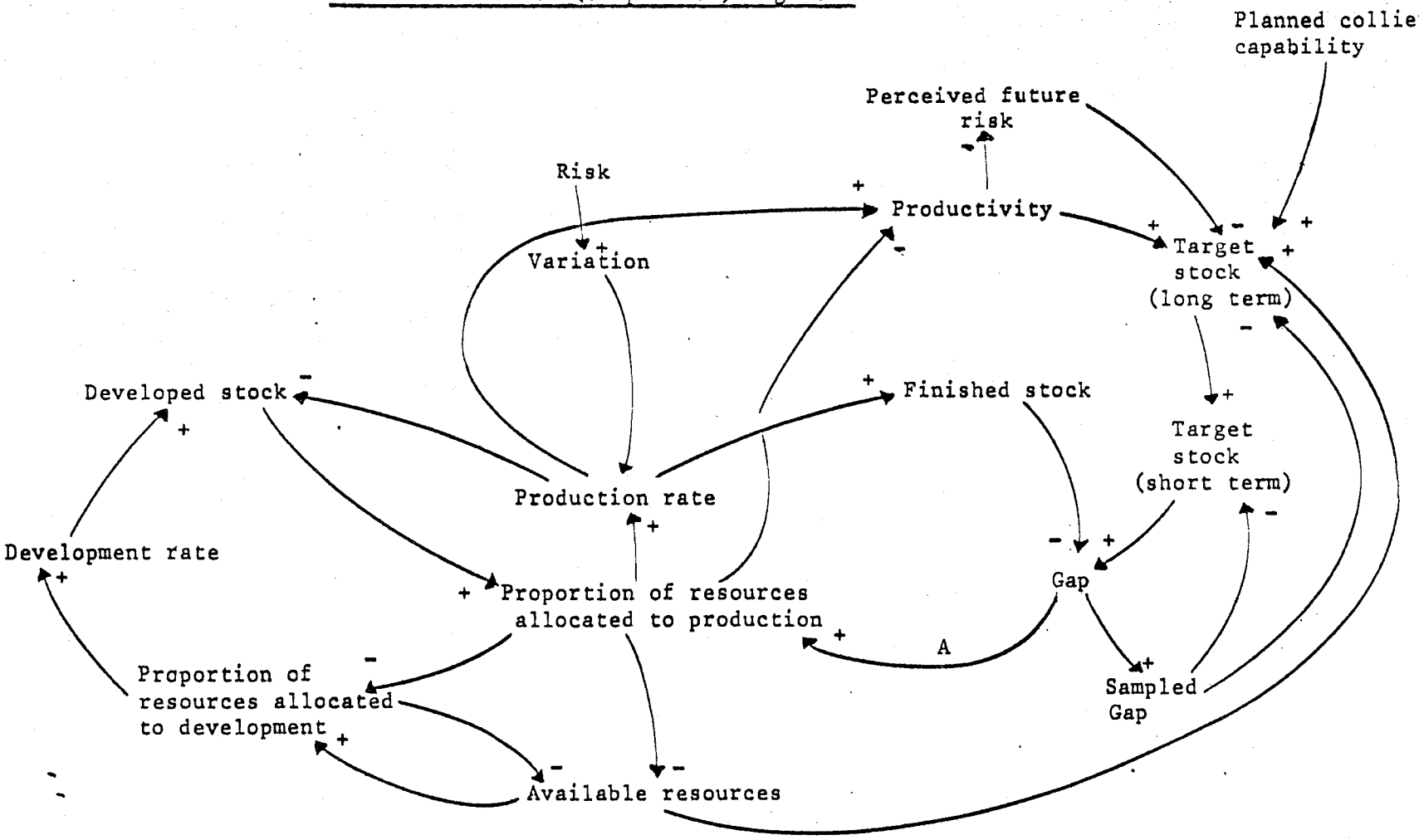
A colliery manager has thus a resource allocation problem in allocating machine shifts between production and development, and between the various production faces. Normally the required allocation is specified in an Action Programme which is an 18 month plan updated every three months. However, due to the highly unpredictable nature of the mining system environment, that is primarily geological conditions in the coal bearing strata, the Action Programme is frequently obsolete as soon as it is updated. As it is only a guide for the manager the Action Programme may be ignored as the manager has the freedom and authority to change the machine shift pattern as he wishes

(subject to operational constraints such as Union agreement), even if there are no major difficulties such as a shut down face.

Because of the need for coal as an energy source in the U.K. subsequent to the OPEC oil price increase in 1973/74, the long term strategic objective of the N.C.B. has been to increase production (as set out in the Plan for Coal (9)), and this has coloured the setting of objectives and production targets. There has been a great emphasis on reaching production targets and this has meant that managers have been held accountable on this basis through the medium of annual budgets set via an annual planning cycle which corresponds to the tactical planning situation outlined earlier. The Action Programme being a scheduling aid which in theory reflects these target production requirements. Formal accountability meetings are held regularly to monitor progress within this budgetary period when control is exerted by higher management. This has led to the situation where, if the mining environment deteriorates, a manager is tempted in the short term to sacrifice development for the sake of production, in order to meet his target, which will lead to an imbalance between production and development and a possible consequent long term loss. The manager's rationale for this being the hope that the difficulties encountered are transient and that the necessary development work will be achieved before the production face is exhausted.

The system in its general form as a causal loop diagram, is shown in Figure 2. The colliery system has been researched in more detail as part of a larger research project (15), and Figure 2 is a simplified version of a more complex model.

Generalised Model (simplified) Figure 2



With reference to Figure 2 the finished stock is the sum of coal produced in the accountability period which is the same as the coal sold in that period. It is possible for the manager to stock coal but this quantity is small compared to that actually delivered to the customer so that over a three month period the coal sold is an accurate measure of his production. At present within the accountability period, day to day production figures are inaccurate due to the way the information is collected and the lack of any accurate way of measuring the coal produced. The manager will know the number of skips wound up the shaft per shift and there will be estimates of the volume of coal produced from the faces from survey work, but because of underground bunkerage and density variations an accurate continuous figure of tonnes produced is impossible. Thus on a day by day, week by week basis it is possible by manipulating stock levels and density estimates for a manager to iron out actual minor production fluctuations by his reporting to ensure an adequate performance which will satisfy the informal control which Area Management tries to continuously enforce. Such game playing is well known but because of its nature the extent of the practice is difficult to ascertain and there is no accurate way of determining short term production fluctuations.

However, through experience, knowledge of geological conditions and weekly sales figures a manager can assess the likelihood of meeting his production target for the accountability period and it is at this point that he will change his resource allocation policies (via link A), that is exercise tactical decision making. Deteriorating environmental conditions which reduce his production and prompt those decisions, and yet which are not severe enough to instigate contingency planning, are not recognised by the system until the end of the budget period when the annual target (long term) is reset and even then these environmental effects may not be adequately catered for. During this time, the manager, to keep

his production up, will have made these short-term tactical decisions which may have undesirable longer-term consequences. For example, in this simple case by diverting resources to production the development rate is reduced and thus the developed stock will become depleted. Dependent on the imbalance between the production and development rates the developed stock will become exhausted sooner or later, thus causing the production rate to stop completely until the developed stock can be replenished. This catastrophic production failure is obviously a situation the manager hopes to avoid but which he is forced to risk by the emphasis on achieving the short-term target. A more detailed version of Figure 2 could provide a manager with knowledge as to the possible outcome of his actions but the pressure to make these decisions would still be there.

The planning system in operation with the NCB has been operating now for a number of years and conforms with the generally accepted models of corporate planning and leans more towards the Commitment Planning and Long-Term Planning as mentioned earlier, with recognition of the need for Intermediate Planning. The underlying philosophy tends to be satisficing although there is a desire to optimise performance. Most nationalized industries in the UK have a statutory requirement to operate at least strategic planning if only to appraise the government of their future investment. Ref. Harris and Davies(10).

The pattern of tactical planning and budgeting is a necessary consequence of the corporate planning cycle. That is information on past performance and potential future capability is passed upwards from colliery to Area to National Management with consequent aggregation. Plans are upgraded and objectives reset in the light of this information and estimates of future demand given the pricing decisions which are also carried out at National level. These objectives are then disaggregated to finally generate the manual production budget for a colliery (long-term target stock, Figure 2). Such a budget is simply pro rated to give the quarterly production targets

against which a manager's performance is measured at the formal accountability meetings mentioned above. (short-term target stock in Figure 2). Because of this structure it is difficult to see how an alternative continuously adaptive planning and control system could be implemented at a tactical level given the accuracy and availability of information presented in the past. A schematic diagram concentrating on the colliery/Area level is shown in Figure 3.

With the introduction of microprocessors and mini computers coupled with the development of accurate and durable sensors for underground installation it is now feasible to obtain vastly improved data, which should not only improve operational control, but also provide management with information making it possible to implement better real time control at the tactical level. This new technology application has been given the name MINOS (MINe Operating System) and it is envisaged that its installation will improve the efficiency of the coal extraction process and thus help in achieving the long-term strategic aims of the industry as set out in the Plan for Coal (9). There has been much written regarding this information retrieval system, for example Hartley (11),(12) and Thomas and Chandler (13). It is perceived in the main that it will provide real time, on line information for control of operations. For example: quicker and more accurate notification of breakdowns, full bunkers, etc., the automatic control of certain machinery, such as for coal clearance; its other main function is simply that of monitoring the environment, for example methane and dust levels, an essential task for safety reasons. A much less publicised role for the equipment lies in the provision of management information. It is in this area that the role of the equipment is much less well defined and where in the long run it may have a more influential impact due to its effect on the colliery planning system at the tactical level.

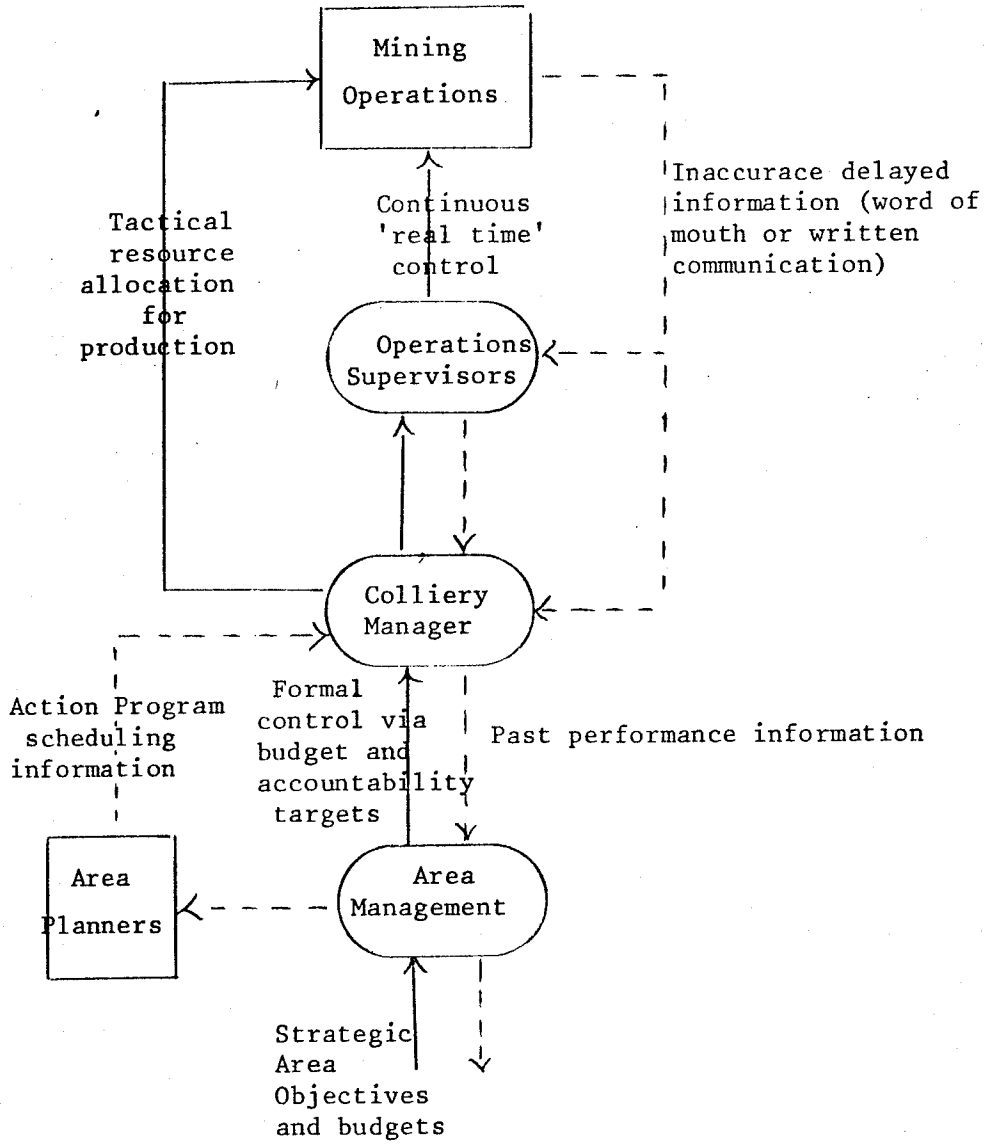
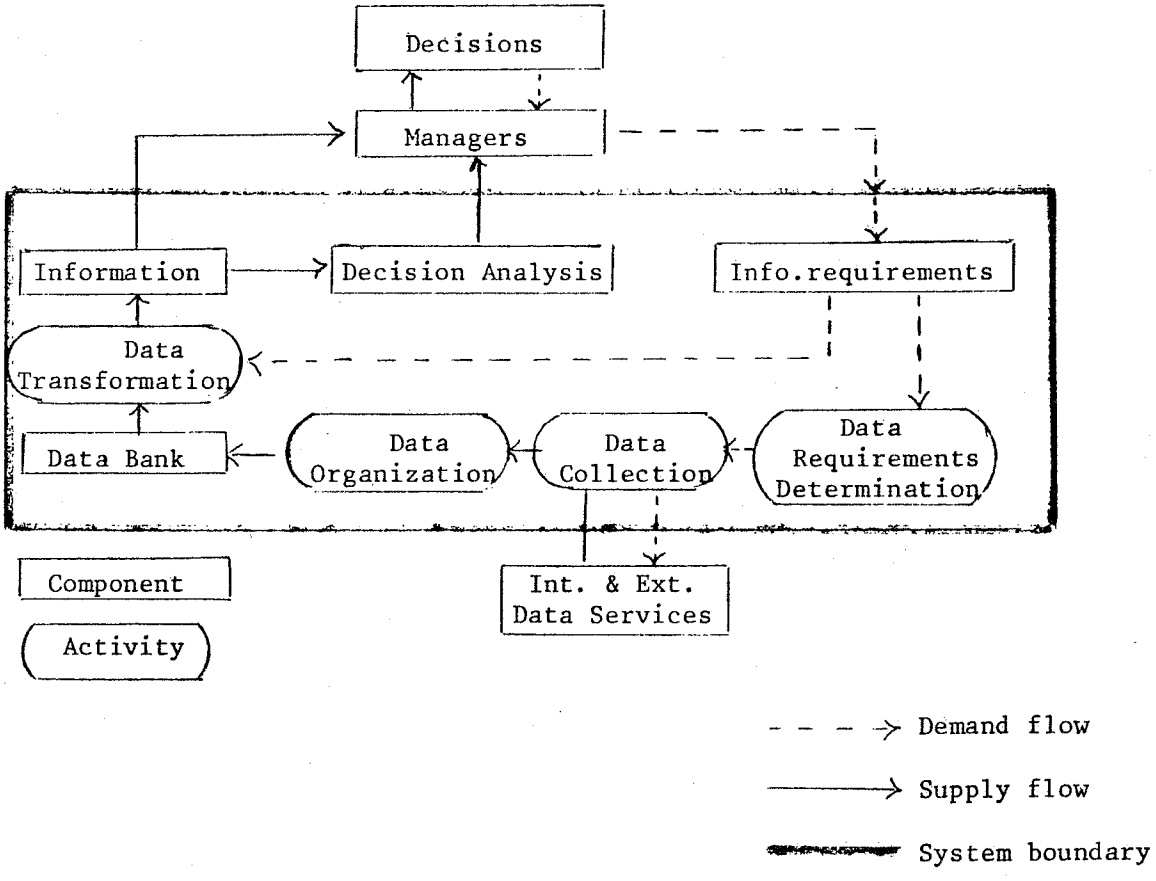


Figure 3. Schematic showing 'traditional' control structure in a colliery.

Normally, when a Management Information System is set up it is defined by the type of information needed to make a decision, as shown in Figure 4.(14), To a certain extent this has occurred with MINOS in regard to operational decisions but the tactical decisions of resource allocation have been ignored. (Presumably because resource allocation is defined in the Action Programme it is assumed that the manager will not need to make these decisions).

Figure 4. (14)



The place of MINOS may be seen in Figure 5, and the effect of the new information on tactical decision making may be felt in a number of ways. Because information may be provided direct to Area Management the colliery manager may no longer be able to mask small instabilities by the distortion of manually acquired information of known inaccuracy transmitted via himself to Area (i.e. game playing). This will cause the manager to become more responsive to the informal control so that he will be tempted (because of the asymetrical emphasis on production of this control) to make more short-term resource allocation decisions. Whereas before he may have waited until the last minute before transferring resources hoping that the events beyond his control (say deteriorating geological conditions) would correct a production deficit before the accountability meeting (i.e. a tolerance of a relatively large gap in the application of link A in Figure 2) he may now be tempted to reallocate resources more often. This would of course disrupt development and affect the smooth transfer from an exhausted face to a newly developed one as before, and also because of the discrete nature of the resource allocation process (change in the number of shifts on a face) this would cause over-compensation and unnecessary and distuptive oscillations in the finished stock level. Even if the manager ignores this informal control the extra information does not alleviate the problem of the system being driven by the target level and the consequent overemphasis on meeting short-term production goals. Even the provision of an S.D. model on which to test tactical decisions will not basically affect this although it may persuade a manager to accept a lower performance if meeting the target would result in system failure in the immediate future.

To obtain the full benefit of the MINOS system and the application of Systems Dynamics it is necessary to consider the system as a whole. The simplified model shown in Figure 2 indicates the dangers of concentrating on one

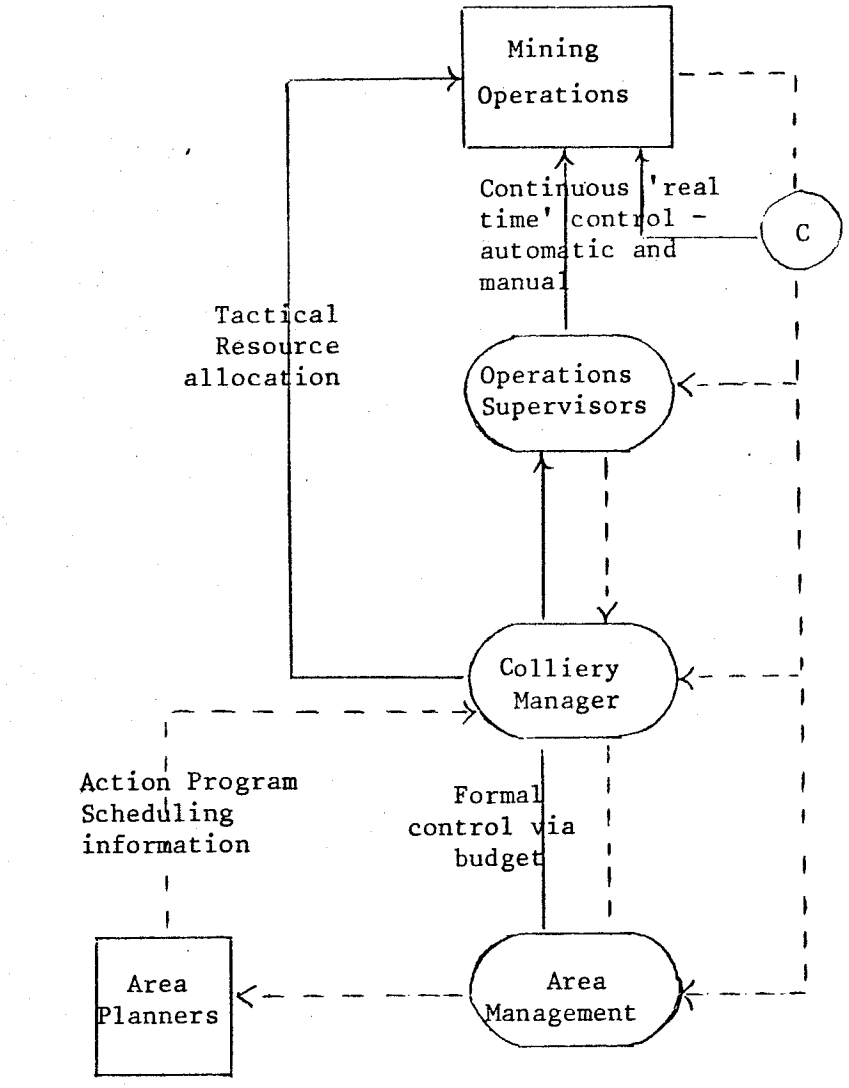


Figure 5. Schematic showing 'traditional' control system incorporating the MINOS computerised information system.

link and can provide the insight into the complex interrelationships needed to reformulate the system objectives and performance indices in a way more suited to continuous adaptive control. These would conform more to the units of measure described by Stafford Beer (8) of:

'actuality, capability and potentiality - and the indices arising therefrom: productivity and latency'

They would reflect the effectiveness of the system as a whole in producing coal in such a way as to make the best use of its resources whilst at the same time mitigating the effects of changes in the geological environment. Because of the availability of these measures on a real time b asis by means of the MINOS computer transforming the raw data, policy decisions may be made on a real time basis and may indeed be automated as they correspond to managerial policies.

This restructuring of the planning and control system will mean that the formal budgeting cycle is irrelevant and may cause problems in the reconciliation of this new system within the strategic planning cycle. Also this has implications regarding the autonomy of the colliery manager. By creating a flexible and adaptive system the manager must be more responsible and independent, there will be a greater element of negotiation in his dealing with higher management.

4. Conclusions

To summarise the above the relatively rigid, cyclic planning and control system with its emphasis on a very narrow range of performance indices is counter productive in its application at the colliery level. This is indicated by the use of a System Dynamics method of analysis and the use of such an analysis as a planning tool leads to the initial restructuring of the planning and control system as envisaged by Acheoff in so far as it will minimise the future need for retrospective planning at the colliery level.

The implementation of MINOS now makes the possibility of the changes indicated being implemented a more practical proposition, by the provision of information for the global performance indices needed on a real time basis.

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