Short Term Manpower Planning: Time Based Simulation vs Systems Dynamics Approach

G I Mould
Department of Business Studies
University of Stirling
Stirling FK9 4LA, UK
Tel: 0786 467317

Abstract

The bulk of the literature on manpower planning models deals with long term planning and strategy evaluation. The most common approach is to use a Markov type model. This can readily model wastage and promotion rates, together with training policy and can be used to evaluate the longer term impact of personnel policies. However many manpower planning problems span a much shorter time period and precise modelling of training and promotion strategies is inappropriate. This paper presents such a problem. Staff planning procedures were required to reduce a large but temporary backlog of work. Two modelling approaches are contrasted: a time base simulation (a decision support system approach) and a systems dynamics approach. The simulation model was encoded in a spreadsheet this enabled management to easily make alterations to the model data. The systems dynamics model presented a graphical representation of the problem which made all the modelling assumptions explicit. Both models could assess management alternatives, the spreadsheet model was able to provide very detailed information, whilst the main strength of the systems dynamics model was its ability to provide more general results for the longer term. With both approaches the cooperation of management was essential for suggesting practical solutions.

Short Term Manpower Planning: Time Based Simulation v Systems Dynamics Approach

Introduction

This paper contrasts two modelling approaches to a short term manpower planning problem. The problem occurred in an agency which processed contract clerical work. The manpower planning exercise originated when the agency was presented with an unexpectedly large batch of work and a backlog quickly developed. Management took the obvious action of increasing staff numbers but this had little effect on the throughput of work. As the situation deteriorated a rapid response was required from management. This meant that only models that were readily accessible for use by management could be considered. Two such approaches were: a systems dynamics approach; and a decision support system approach, which was simply a time based simulation of the situation encoded in a spreadsheet model.

Background

The aim of the manpower planning exercise was to strike a balance between the input of new work and the throughput of completed work. This can be achieved with the aid of reliable forecasts of new work, evaluations of the current work outstanding and assessments of achievable throughput based on projections of staff numbers and likely productivity. Most manpower managers realise that achieving and maintaining an exact balance of work input and output is impossible, but by building in flexibility, the situation can be kept in control. Flexibility in work input can be achieved by allowing a small backlog of work to develop. Flexibility in output is achieved by working overtime, or using temporary or clerical agency staff in the short term and in the longer term, by training schemes, promotion and recruitment policies.

Traditionally manpower planning has been concerned with planning in the longer term, where projections of future staff numbers can be made by applying the promotion and wastage rates observed in the past (Vajda 1978). This is encoded in Markov type models, which can be used to assess the impact of personnel policies. A typical time scale for such a plan would be between 1 and 5 years. The absolute accuracy of planning over this time horizon is often of little consequence as the main objective is a broad assessment of future policy.

Manpower planning in the short term is about scheduling the available manpower resource to meet current objectives. Typically this requires a much more pragmatic approach. Here the few options available to management must be used with great care to bring about the desired outcome. A relatively high degree of accuracy is required as there will be little opportunity to correct inaccurate assumptions. Poor strategies may well compound the problem. Mathematical programming techniques can be useful in deciding the allocation of scarce manpower resources amongst competing activities. However it appears that management seldom use traditional manpower planning techniques (Feuer, Niehaus & Sheridan, 1984). One reason for this may be the lack of understanding of the methods used leading to a lack of confidence in the results produced. It is unlikely that management will have the necessary skills to fully understand and implement the techniques themselves and more pragmatically, they are unlikely to have the skills for running the necessary computer software.

One of the main aims of this study was to produce a solution which was readily accessible to management in an attempt to overcome implementation problems. Venema and Vessels (1988), identified the benefits of adopting a decision support system approach, which gives the end user the freedom to build and evaluate different scenarios of their choosing. Lee and Biles (1988), demonstrated that a spreadsheet based manpower model could be implemented and used by management. Lane (1988) showed that the Systems Dynamics modelling approach had many benefits for management learning.

The problem

The particular problem considered in this paper is that of an agency which undertakes contract clerical work. The bulk of the work can be described as the processing of cases. The agency run a number of different contracts or schemes at any one time for processing particular types of cases. The schemes are operated by two grades of clerical staff: grade 1 and grade 2. Grade 1 staff are usually

inexperienced, all temporary staff are recruited on this grade. All grade 2 staff are experienced in the work of the schemes. On average it takes two years for a person on grade 1 to gain the necessary experience to be promoted to grade 2. When a person is recruited on to a scheme they will generally stay on that scheme for a number of years.

This case will concentrate on one section of the agency's work where two categories, say A and B of case are processed. Some of these cases contain arrears, either because of the time it has been waiting for processing or because there has been a delay in the claim coming to the agency. This will add to its processing time. Category B cases with arrears are more complex than category A. It can take several days for a grade 2 member of staff to process a category B case with arrears, whereas category A, and category B cases without arrears will require little more than 30 minutes attention from a relatively inexperience member of staff. The nature of the work is temporary in that it is envisaged that all cases will occur within the next two years. After that the routine work will be largely handled by computer, with only a skeleton staff to respond to ad hoc queries and instances of change in circumstances.

The agency is required to allocate its working time between category A and B work roughly in proportion to the number of each type of case on file. At the present time approximately 60% of cases are type A. However, this does not reflect the time required to process the cases. If this balance of work were adopted then type A work would account for significantly more than 60% of the processed cases owing to the expected shorter processing time. The agency has tended to revers this ratio, spending 60% of its time on category B work, with the resulting balance (A: B) in terms of numbers of cases processed being approximately 3:2.

The work has been progressing for a number of years and management has had the situation well planned and for the most part under control. The agency has received reliable information as to the number of new cases to expect each year. Estimates of the numbers of staff required for each section have been good. Consequently the work of the agency has progressed smoothly with few delays. The backlog of work has been kept to a size that could be cleared by working overtime for a week or two if it was so desired. In fact a small backlog of work was desirable as this gave management some flexibility, and ensured that staff were always fully occupied.

Problems arose when there was a huge influx of unexpected work. At the start of the year work was progressing normally, however the number of new cases began to increase in the early spring. By April more than the total number of expected new cases for the year had been received, and cases were still arriving at a considerable rate. A sizeable backlog of work had built up and management felt they were losing control of the situation.

Management's solution

Management's first action was to recruit more staff on short term contracts. It was possible for the new staff to start work within a few weeks of the decision to recruit. These new recruits had to be trained and this required the time of the more experienced staff, consequently taking them off the job. The situation deteriorated. This was partly due to the loss of the time of experienced staff, and also due to the build up of arrears on the outstanding cases. Hence the new staff had little immediate effect on the situation. However, within a few weeks the new recruits were able to process routine cases of type A and B, but little could be done to reduce the backlog of category B work with arrears. This backlog was in fact increasing due to the reduction in the available working time of grade 2 staff, who were now busy training the new grade 1 recruits. A second alternative of working overtime was tried, this was not popular amongst the staff, but it was a way of increasing the working time of grade 2 staff. It could provide at the most a 10% increase in work time, but owing to its unpopularity, a 5% increase was more usual. In time the new recruits became more effective, but many of them left, usually for other permanent positions elsewhere within the organisation. When this became apparent management added a condition to all new temporary contracts that they could not apply for other internal posts for the first six months of there employment. Nine months after the original surge in work, the backlog of work was sizeable and if anything still increasing. It was at this point that management requested help with staff planning.

Modelling Approaches

The modelling approaches considered had to meet the main objective of modelling the processing of cases and evaluating strategies for reducing the backlog of work. In addition there were two other considerations. The first was that a solution had to be found quickly since the situation was deteriorating daily. The second was to provide a solution that was readily understandable and accessible to management for the evaluation of alternative future scenarios. These requirements ruled out the use of Markov or LP type models as they were judged to be too complex for the situation. An additional reason for rejecting these modelling methods was that the multiple objectives of management were represented by attempting to quantify the trade offs between the different alternatives (Ackoff, 1960). This sort of methodology limited the potential of management to investigate a full range of possible solutions. An LP approach embedded within a decision support system had proved successful elsewhere, (Weigel & Wilcox, 1993), (Hegde & Tadikamalla, 1990), though this type of approach would require considerable effort to develop a robust interface between the LP and the decision support system. Time pressures effectively eliminated this approach. Byrne and Davis (1991) demonstrated the use of a systems dynamics approach for modelling manpower strategy.

Decision support approach

It was decided adopt a decision support system approach for the reasons of flexibility as identified by Verbeek (1991). An interactive model was built in a spreadsheet medium. This essentially provided a simple time based simulation of the problem. The spreadsheet medium (Quattro Pro), facilitated changes to the data, and allowed the presentation of results in a readily comprehensible graphical form. Management could assess the impact of different options, such as: varying the number of temporary staff recruited; and changing the amount of overtime etc.

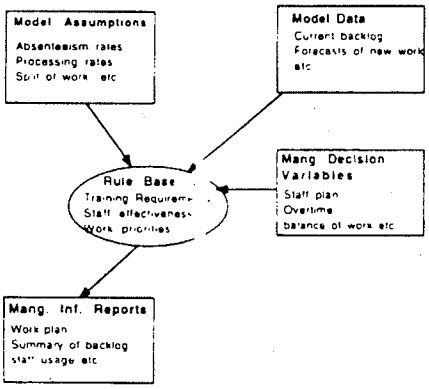

Figure 1. Manpower Model Structure
Decision Support Approach

	Grade 2				Grade 1			
	leaving	current	new or promoted	Maximum overtime	leaving	current	new	Maximum overtime
Jan		15		5%		11		5%
Feb		15		5%		11		5%
Mar		15		5%	1	10	1	5%
Apr		15		5%		11	1	5%
May	1	14	1	5%	1	11		5%
Jun		15		5%		11	1	5%
Jul		15		5%	1	11		5%
Aug		15		5%		11	1	5%
Sep		15		5%	1	11		5%
Oct		15		5%	1	10	2	5%
Nov		15		5%		12	1	5%
Dec	1	14	1	5%	2	11		5%

Figure 2. Staff Plan

There were essentially four categories of data: model assumptions, model data, management decision variables and management information reports. The structure of the model is shown in Figure 1. The model assumptions were established from the analysis of past work patterns, examples of these are: processing rates; absenteeism rates; split of work by section. The model data consisted of details of the current situation and forecasts of new work. Management's decision variables reflected the tools that management had available to solve the problem. For example, the staff plan (as shown in Figure 2), the amount of overtime worked, the allocation of staff to a particular section. The results from the model are in the form of management information reports. These included a detailed work plan which gives details of the backlog, new work and processed work, for each type of work, on a monthly basis; a monthly summary of the backlog of work, expressed in terms of the numbers of cases outstanding and also in terms of mandays, as shown in Figure 3, the latter form provides a better basis for comprehension and comparison. The backlog in terms of mandays is presented graphically, Figure 4, here the categories of work are simplified to type A, B and complex type B (type B cases with arrears). The final management information report is the usage of staff by grade as shown in Figure 5, this gives useful information on the amount of overtime employed and any unused staff time.

	Section 1 Backlog + new work (No. of cases)					Backlog (mandays)		
	Category A		Category B			Cat. A	Category B	
	Routine Queries	New Claims	Routine Queries	Simple Claims	Claims + arrears Claim months	Queries & Claims	Queries & Claims	Claims + arrears Claim months
Jan	5257	100	3504	4	1288	303	243	322
Feb	4986	100	3292	4	1707	288	229	427
Mar	5271	101	3544	4	2278	304	246	570
Apr	4954	217	3504	121	2534	297	256	634
May	5640	217	4191	121	2997	335	304	749
Jun	6268	217	4967	122	3500	373	360	875
Jul	6491	101	5522	4	3326	373	383	831
Aug	5955	101	5684	5	3005	347	398	751
Sep	6362	101	6498	5	2822	367	451	706
Oct	6367	126	7181	30	2548	371	505	637
Nov	5391	126	7237	30	2101	319	513	525
Dec	4744	126	7512	30	1700	278	527	425

Figure 3. The Backlog of Work

The model was designed so that an acceptable situation could be sought by changing the decision variables. Once this had been found, slight adjustments could be made to model assumptions to test the robustness of the proposed solution. The forecasts of new work were revised three monthly, at this point the model data could be updated and if so desired, the performance of the model monitored over the preceding period.

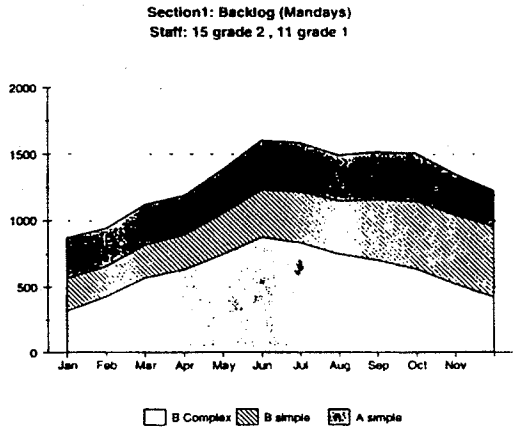

Figure 4. The Backlog of Work

	Category A				Category B					Total		Total			
	Routine Queries		New Claims		Routine Queries		New Claims		Claims arrears	Over-time used	(Days)	Days Redundant		Balance of Work	
	grade 2	grade1	grade 2	grade1	grade 2	grade1	grade 2	grade1	grade 2	grade 2	grade1	grade 2	grade1	A	B
Jan	124	94	5	-0	38	141	0	-0	154	15	11	0	0	0.4	0.6
Feb	102	79	5	-0	32	118	0	-0	129	13	9	0	0	0.4	0.6
Mar	119	90	5	-0	37	135	0	-0	149	15	11	0	0	0.4	0.6
Apr	79	71	10	-0	21	106	6	-0	107	11	8	0	0	0.4	0.6
May	79	67	10	-0	21	101	6	-0	107	11	8	0	0	0.4	0.6
Jun	88	78	10	-0	24	116	6	-0	117	12	9	0	0	0.4	0.6
Jul	113	87	5	-0	35	130	0	-0	142	14	10	0	0	0.4	0.6
Aug	78	65	5	-0	24	98	0	-0	99	10	8	0	0	0.4	0.6
Sep	90	69	5	-0	28	104	0	-0	113	11	8	0	0	0.4	0.6
Oct	116	96	6	0	35	144	1	0	146	15	11	0	0	0.4	0.6
Nov	99	91	6	0	30	136	1	-0	126	13	11	0	0	0.4	0.6
Dec	68	56	6	0	21	84	1	-0	89	9	7	0	0	0.4	0.6

Figure 5. Use of Staff by type of work

Systems Dynamics approach

The systems dynamics model of the situation identified three distinct aspects of the problem: staff planning; case processing and staff assignment. Initially models were developed for staff planning and case processing, the staff assignment model was used to link these models together.

The staff planning model

The staff planning aspect was concerned with modelling the recruitment, promotion and wastage of staff. This was the first model to be built, it is shown in detail in Figure 6 below. It modeled staff movements through the system, using the observed wastage rates and current promotion requirements. The model was initially used with data from the current situation: actual and planned number of staff in each grade, the latter was used as a factor to drive recruitment. The current promotion requirement of 2 years experience in grade 1 before promotion to grade 2, and the high wastage rate of 20% p.a. for grade 1 staff. The model produced some interesting results. It demonstrated that this system could not produce the required number of both grades of staff. Only by increasing the desired number of grade 1 staff to 16 could a staff level of 12 be guaranteed. Increasing the desired number of grade 2 staff had no effect, 11.6 staff seemed to be the theoretical maximum. The model demonstrated that there were insufficient grade 1 staff available for promotion to grade 2 to achieve the desired number of grade 2 staff. This could be accounted for by the high wastage rates of grade 1 staff and the long experience requirement before promotion to grade 2. This was an important result for management. Further runs varied the experience requirement. This had to be dropped to 18 months before a stable level of 15 grade 2 staff could be attained. Hence the model had demonstrated that the with the current wastage rates the number of grade 2 staff could not be maintained.

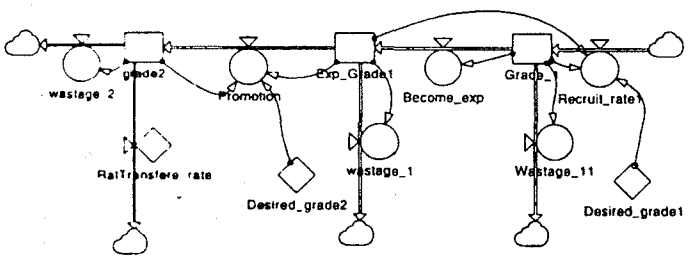

Figure 6. Staff Planning Model with results.

The case processing models

The case processing models were concerned with the flow of work through the system, diagrams of each of these models are shown in Figure 7 below. As in the decision support approach there were essentially three types of case: A, B and complex B. Types A and B were similar in their processing time requirements, however it was necessary to model them separately because of the different rates of new work inflow and the need to monitor the proportion of time spent on each type of case. Complex type B cases can only be processed by Grade 2 staff. In addition the processing time for a case depends on its arrears. The arrears have a compounding effect on the time required to clear a case, this increases with every month of delay. The arrears on complex B cases were modelled by using the array facility of Powersim. The flows and levels relating to these cases had two dimensions: one for the number of cases; the other for the average amount of arrears on the cases. All the case processing models were tested independently before inclusion in the full model.

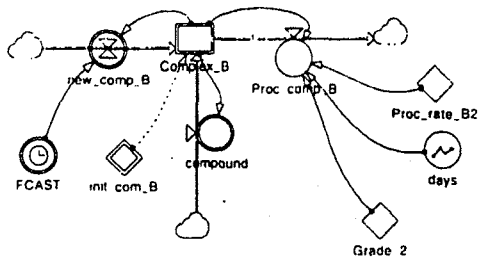

Figure 7. Case processing model for Complex B cases

The staff assignment model

The staff assignment was concerned with allocating staff to the different types of work. This was used to allocate the available staff as calculated by the staff planning model to the different types of case as predicted by the case processing models, this effectively formed the join between the two types of model, as shown in Figure 8 below. The assignment model took the numbers of available staff in each grade and allocated them to the three types of work according to the proportions specified by management, any staff not fully employed on a particular type of work were classed as spare and redeployed to another category of work. This reallocation reflected management's work priories. The number of cases processed was arrived at from the following factors: the number of staff; the available working days each month (after adjustments for absenteeism); the amount of overtime worked; and the average processing time recorded for that grade of staff on that type of work.

Results

Both modelling approaches were used to test out the effects of different personnel strategies on the backlog of work, the most usual strategy being to look at the effects of different recruitment policies over time. In addition, further runs were made altering the forecast work load, this could be increased, decreased, brought forward or delayed. These alternative strategies were compared in terms of their effect on reducing the backlog of outstanding work. Once an acceptable solution had been found, its robustness was tested by setting processing rates at either a pessimistic, expected or optimistic level.

The results from the decision support model are shown in Figure 4. This shows the outstanding backlog of work after a year when a maximum of 5% overtime was allowed. Increasing the number of inexperienced staff had no effect on the backlog of type B complex work, however it did reduce the backlog of simple work. No further benefit was gained from employing more than 15 grade 1 staff. If up to 10% overtime is allowed, then there is some reduction in the backlog of complex type B work, in this case no additional benefit is gained from having more than 14 grade 1 staff on the section. It is clear from these results that the number of temporary staff recruited does not have any effect the size of the backlog of complex type B work. Some benefit can be gained from increasing the proportion of overtime worked, though it was thought not to be possible to sustain an overtime rate of more than 5% for any significant period of time. The only means of reducing the backlog of complex type B work was to substantially increase the proportion of grade 2 staff time allocated to this task, only when 95% of all grade 2 staff are allocated to category B work does the backlog decline, as shown in Figure 9. This alternative is probably not feasible in practice, as grade 2 staff are also required to perform a supervisory role for the routine work of the section.

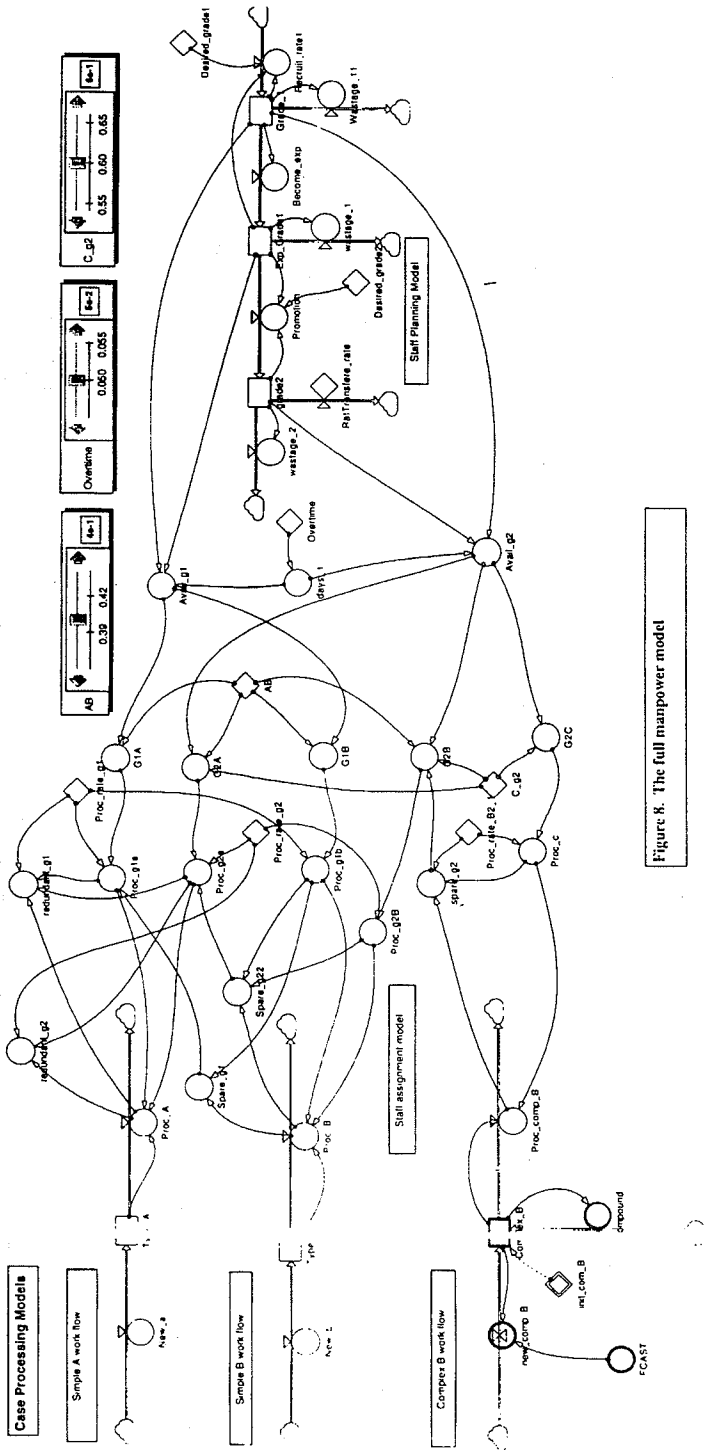

Figure 8. The full manpower model

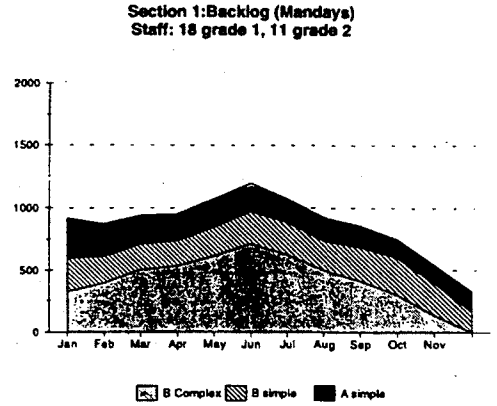

Figure 9. 95% of Grade 2 Staff on Cat. B work, 18 Grade 1 staff

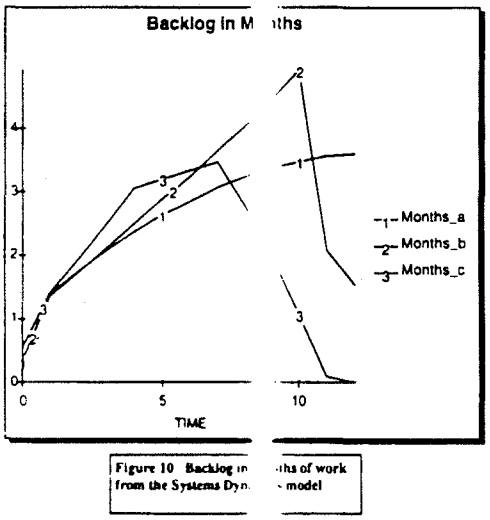

Figure 10 Backlog in ıths of work from the Systems Dyn. - model

The Systems Dynamics model produced similar results though in a different format, as shown in Figure 10, here the backlog is shown in terms of months of effort. With this model there were fewer grade 2 staff available hence the backlog is much greater. This model provides much less detail but none the less highlights important aspects of the problem. The main conclusion is that the situation cannot be remedied with the present staffing policies. There were some difficulties with this approach when modelling over a short period of time. Some aspects of the problem took longer than the modelling period to reach a steady state, for example the staff model. These problems were remedied by establishing the steady state values on a separate run and then using these for the initial conditions in subsequent runs.

The results from both models were disappointing as they demonstrated that a sizeable recruitment plan would have little effect on the backlog. While the backlog of simple work could be easily eradicated, the problem of the complex cases with arrears remained. The models demonstrated to management that the options under consideration were not capable of resolving the situation. In addition the Systems Dynamics model highlighted the fact that the numbers of grade 2 staff could not be maintained in the long term. Pressure to find a solution quickly was increasing. The only option that had any effect, working overtime, was unpopular with grade 2 staff. It was now obvious that a more radical plan was required.

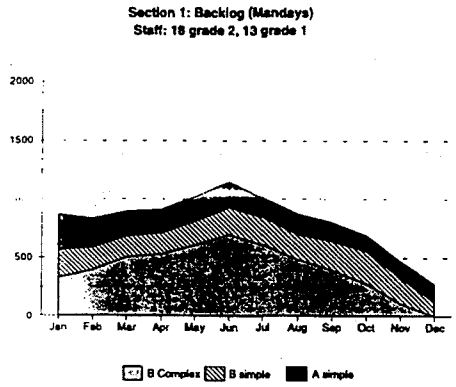

Figure 11. The effect of 3 additional Grade 2 Staff

The agency operated a number of similar schemes to the one described here, these were not operating under such pressures at the time. One such possibility was to take grade 2 staff from other schemes working on different but related work and retrain them for this scheme. Meanwhile the other schemes would be able to make effective use of some temporary grade 1 staff, if the work was organised for them to handled the routine tasks. This option provided a far better solution than had been previously obtained. With the additional effort of 3 grade 2 staff making a total of 18, it was possible to eliminate the backlog of complex category B work by the end of the year. With this arrangement, 13 grade 1 staff were required to reduce the backlog of routine category A and B work to an acceptable level. This adjustment could be easily made to both models. The number of grade 2 staff in the staff plan in the spreadsheet model was increased. An inflow of grade 2 staff was incorporated in the Systems Dynamics model These results are shown in Figure 11. Further increases in temporary staff had little effect on the situation. After obtaining this general set of results management were then able to vary other model assumptions to test the robustness of the solution.

Comparison of the two methods

The two models produced similar results in different formats with differing amounts detail. The systems dynamics model gave pictorial representation of the situation, but was not able to provide the same level of detail as the spreadsheet model. However the systems dynamics approach highlighted other problems ignored by the spreadsheet approach, for example the inability of the system to produce enough home grown grade 2 staff. Both models met the projects requirements of providing a rapid response, however it is thought that management would feel more at home making changes to the spreadsheet model, once they trusted that the model was a true representation of the situation. The diagram (Figure 1) explaining the main structure of the model was useful here. The structure of the Systems Dynamics model was readily understood by management, though the staff allocation model seemed complex. The modelling medium was a new concept for most management, and lack of familiarity proved to be an obstacle in its use. The addition of slide bars to vary some model parameters was useful as management generally lacked confidence to change parameters from the object set-up screens.

Conclusions

Both the Systems Dynamics model and the spreadsheet model were able to provide good representations of the situation presented in the case and for the most part produced similar results. The comparison of the two modelling approaches illustrates the strengths and weaknesses of both methods. The Systems Dynamics approach was most useful for gaining an overview of the situation, but when fine detail was required the spreadsheet approach proved the most flexible for evaluating alternative solutions and for developing precise recommendations.

References

Ackoff, R. L. 1960). 'Unsuccessful case studies and why'. Opls Res. vol 8, pp 259-263.

Byrne, M. Davis, A. 1991. 'Stella modelling process for a manpower strategy'. Systems Dynamics '93. pp 73-81.

Feuer, M. J, Niehaus, R. J. and Sheridan, J. A. 1984. 'Human resource planning: a survey of practice and potential'. Human Resource Planning. vol. 7, pp 85-97.

Hegde, G. G, Tadikamalla, P. R. 1990. 'Interactive workforce management on a PC'. Eur. J. Opl Res. vol 48, pp 275-280.

Lane, D. C. 1989. 'Modelling as learning'. Proceedings of the European Simulation Congress.

Weigel, H. S, Wilcox, S. P. 1993. 'The army's personnel decision support system'. Desion Support Systems. vol 9, pp 281-306.

Vajda, S. 1978. Mathematics of Manpower Planning. Chichester, Wiley.

Verbeck, P. J. 1991. 'Decision support systems - an application in strategic manpower planning of airline pilots'. Eur. J. Opl Res. vol 55, pp 368-381.