The Ninth International Symposium on Operations Research and Its Applications (ISORA'10)
Chengdu-Jiuzhaigou, China, August 19–23, 2010

Staffing Model for Scheduling Simultaneous Interpreters under Tight Constraints

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Abstract The Government Secretariat of Hong Kong has seen steady increases in the need of providing simultaneous interpretation (SI) services at various levels of executive, legislative, legal and urban services meetings. The lack of corresponding addition of interpreters has thus presented a tight manpower scheduling situation. Its distinctive feature of difficultly tight constraint requirements brings out the need of workload balancing and *scheduling for equitability*, and to critically examine the issues of feasibility versus optimality in a many-rule setting. The solution must also be able to handle subsequent rescheduling, whenever there is a change of either up or down of manpower level, to stay close to its target equitability, which is a function of various jobs with differing difficulty and responsibility. We approach this problem by optimization modelling with computer implementation for its benchmark scenario. Numerical examples are provided as illustrations.

Keywords Staffing model; Manpower planning; Scheduling application; Discrete optimization

1 Introduction

The background of this study is the determination of staff deployment faced by the central Simultaneous Interpretation (SI) Section of the Hong Kong Government. The administration has seen sharp increases in the need of providing SI services at various levels of executive, legislative, legal and urban services meetings. This coming of age of localization and bilingualism in Chinese and English is due in no small part to the transfer of sovereignty of Hong Kong to China in July 1997. This has also been the view of the distinguished linguist Dr. Eugene Nida, who in early 1995 visited Hong Kong, that "what the territory really needed was many more simultaneous interpreters" [5]. A special team (of under eighteen people as of 2008) termed as the SI Section within the Official Languages Division of the Government Secretariat is solely responsible for providing such SI services for the entire Hong Kong Government. These human resources are in such high demand and valuable that constant recruitments are in effect with successes only scarce and far in between. The reasons are rather simple because SI functions require individuals capable of withstanding the severe work pressure of pace and tension, beside being necessarily sharp, talented and with extremely good mastery of both working languages. The recent increases in workload without the corresponding additions of interpreters have thus presented the management a very tight and difficult manpower scheduling situation.

More specifically, this scheduling problem is important then in at least the following ways.

1. The provision of SI services becomes mandatory as the Government has moved to a bilingual (Chinese and English) *Legislative Council* (LC).
2. The demand of SI services increases drastically consequential to the current implementation of the *District Board* (DB) operations of more localized administration.
3. The continuing and expanding need of SI services at the level of *Urban Council* (UC), which governs urban and suburban regional planning and day-to-day operations such as cultural centres, country parks, refuse collection services.

The construction of a "good" schedule for the SI staff is identified to be urgent because of at least the following issues.

1. The SI Section is in an extremely severe manpower shortage situation. Recruitment is virtually on a standing basis while staff attrition is high.
2. Workload at the SI Section is so heavy that many individual staff are often "doubling up" in successive meetings on one given day. Part-time work (on meetings basis) becomes a frequent necessity, even though it is difficult to manage, monitor and arranged.
3. There are various rules and regulations on the allowable staffing patterns, amid the need for schedules to ensure effectiveness and "maximize" productivity.

It is clear that "good" planning such as provided by a staffing model is required [4]. The complexity of this scheduling problem (being intrinsically combinatorial in nature) is thus set against background of importance and urgency. Here we undertake to approach the problem from an operational (and less so from an administrative) point of view. We seek to construct a rather detailed mathematical model to compute decision support solutions subject to demand and capacity constraints, while catering to the various specific rules-and-regulations requirement. It is shown that such a computer modelling is able to locate such (highly constrained) combinatorial solution schedules that often prove too complex, and thus hidden from, manual scheduling efforts of the SI Section administration at times.

2 Model Construction

An integer programming model for the staff scheduling is constructed as follows. Let m denote the number of SI staff and b the length (in units of months) of a base-period or *session*, during which time a staff member is fixed to one of the three serving teams of *Legislative Council* (LC), *Urban Council* (UC) and *District Board* (DB). The planning horizon, being the length (in number of sessions) of the whole schedule to be computed, is denoted by n. (There is an integral multiple relationship between m and n, given by $m = kn$ for some positive integer k to be discussed later.) Let $i, i = 1, \cdots, m$, index the staff and let $j, j = 1, \cdots, n$, index the session. A schedule is given by the specification of the binary decision variables of the following types.

$$L_{ij} = 1 \qquad \text{if staff } i \text{ is assigned in session } j \text{ to LC}$$

$$U_{ij} = 1 \qquad \text{if staff } i \text{ is assigned in session } j \text{ to UC}$$

$$D_{ij} = 1 \qquad \text{if staff } i \text{ is assigned in session } j \text{ to DB}$$

In any one session, a staff thus belongs to one of the LC, UC and DB groups, despite occasional "borrowing" of service from the other two groups as needs arise. Based on past statistics and future planning, the relative demands (that is, the number of meetings to serve) lead, in accordance with a general agreed principle of the SI Section, to the relative numbers of r_L, r_U and r_D of required staff in the respective groupings of LC, UC and DB. As these make up a total of m staff, we have

$$r_L + r_U + r_D = m\ , \tag{1}$$

for each session. For each staff, he/she is to provide service capacities (in terms of relative number of sessions) of s_L, s_U and s_D over the whole of the planning horizon of length n. That is,

$$s_L + s_U + s_D = n\ . \tag{2}$$

Additionally, these capacities cannot be chosen arbitrarily, which can be seen as follows. To satisfy the demand patterns specified by r_L, r_U and r_D, these capacities must be such that, for $G \in \{L, U, D\}$,

$$ms_G = nr_G\ , \tag{3}$$

as the LHS of (3) represents the total number of sessions over all staff servicing respectively LC, UC and DB; while the RHS of (3) gives the total number of sessions over the planning horizon required respectively by LC, UC and DB. Since all quantities in (3) must be positive integers, we can have either (a) m is a multiple of n, or (b) n is a multiple of m. Taking into account future staffing instability, a shorter scheduling horizon if possible is definitely preferred and thus case (a) is the resulting stipulation. That is, the *regularity condition* on the length of the planning horizon n for m staff due to the demands r_G and the capacities $s_G, G \in \{L, U, D\}$, is such that $k = m/n$ for some positive integer k. This aggregates into

$$r_L + r_U + r_D = k\,(s_L + s_U + s_D)\ , \tag{4}$$

from the individual conditions of $r_G = ks_G, G \in \{L, U, D\}$.

2.1 Parameter Feasibility

The integral nature of the problem parameters in (1)-(4) above lead to the following determination procedure of the feasible parameters set, which forms the necessary prerequisite of the subsequent existence of any feasible schedules.

Given the demand requirements r_L, r_U and r_D (hence $m = r_L + r_U + r_D$), we consider a parametric increase on *feasible* k starting from 1 to max-$k(= [m/4])$. Feasible value of k refers to the resulting $n = m/k$ and capacities $s_G = r_G/k, G \in \{U, L, D\}$, all being positive integers (with $n \geq 4$). This procedure (easily implemented as a spreadsheet calculation) then limits the scope of search for feasible planning horizons given the demands $r_G, G \in \{L, U, D\}$ on the work force of size m. Such work equalization achieved in capacities $s_G, G \in \{L, U, D\}$ over these n sessions of the planning horizon is the precise property of what we have termed an *equitable scheduling*. A sample calculation is given in Table 1 below for the various cases from $m = 10$ to $m = 16$.

Table 1: Feasible combinations of model parameters for equitable scheduling.

m	r_L	r_U	r_D	max-k	k	s_L	s_U	s_D	n
10	4	3	3	2	1	4	3	3	10
11	4	4	3	2	1	4	4	3	11
11	5	3	3	2	1	5	3	3	11
11	5	4	2	2	1	5	4	2	11
11	6	3	2	2	1	6	3	2	11
12	4	4	4	3	2	2	2	2	6
12	4	4	4	3	1	4	4	4	12
12	5	4	3	3	1	5	4	3	12
12	6	3	3	3	1	6	3	3	12
12	6	4	2	3	2	3	2	1	6
12	6	4	2	3	1	6	4	2	12
13	5	4	4	3	1	5	4	4	13
13	6	5	2	3	1	6	5	2	13
14	5	5	4	3	1	5	5	4	14
14	6	4	4	3	2	3	2	2	7
14	6	4	4	3	1	6	4	4	14
14	7	5	2	3	1	7	5	2	14
14	8	4	2	3	2	4	2	1	7
14	8	4	2	3	1	8	4	2	14
15	5	5	5	3	1	5	5	5	15
15	6	5	4	3	1	6	5	4	15
15	7	6	2	3	1	7	6	2	15
15	8	5	2	3	1	8	5	2	15
16	8	6	2	4	2	4	3	1	8
16	8	6	2	4	1	8	6	2	16

2.2 Constraints on Decision Variables

The scheduling problem is very tightly constrained due to the many requirement and regulatory rules. We first introduce the (simpler) requirement constraints.

The *uniqueness* of staff-session assignment yields

$$L_{ij} + U_{ij} + D_{ij} \; = \; 1 \; , \qquad (i = 1, \cdots, m; j = 1, \cdots, n) \tag{5}$$

which lead to mn rows, $3mn$ non-zero constraint coefficients and mn non-zero constant coefficients.

The *relative demand requirements* are written as

$$\begin{aligned} \sum_{i=1}^{m} L_{ij} &= r_L\,, \qquad (j=1,\cdots,n) \\ \sum_{i=1}^{m} U_{ij} &= r_U\,, \qquad (j=1,\cdots,n) \\ \sum_{i=1}^{m} D_{ij} &= r_D\,, \qquad (j=1,\cdots,n) \end{aligned} \tag{6}$$

which require $3n$ rows, $3mn$ non-zero constraint coefficients and $3n$ non-zero constant coefficients.

The *relative service capacities* are similarly given by

$$\begin{aligned} \sum_{j=1}^{n} L_{ij} &= s_L\,, \qquad (i=1,\cdots,m) \\ \sum_{j=1}^{n} U_{ij} &= s_U\,, \qquad (i=1,\cdots,m) \\ \sum_{j=1}^{n} D_{ij} &= s_D\,, \qquad (i=1,\cdots,m) \end{aligned} \tag{7}$$

which add $3m$ rows, $3mn$ non-zero constraint coefficients and $3m$ non-zero constant coefficients.

Next are the class of regulatory constraints. These imposed restrictions mainly centre around the LC assignments due to their significance (over those of UC and DB). These are initially stated rather imprecisely as “operational requirements” as given below.

1. A staff is to work continuously for half a year once he/she is on the LC team.
2. These six months on the LC team should be either the first or second half of a year due to workload balancing consideration for different times (or seasons) of the year.
3. It will, however, be too strenuous for a staff to work more than six months in a row in the LC team. Some work on the UC and/or DB team in a year should be the norm.
4. There is less restriction on the duration of UC and DB team, but each staff should spend no more than half of any year on one of these two teams. (This comes about since the demands for LC service accounts for just about half of the total demands for three services put together.)

At first sight, there is no a priori justification for the consistency of these rules needed for the existence of a feasible schedule. The key observations that these rules (being followed as closely as possible even with the manual staffing roster) can be made consistent in the sense of our parameter feasibility stipulated earlier are (a) the team size of LC should not exceed half the total staff size, or $r_L \leq [m/2]$, and (b) any LC assignment should be a block of six months. A convenient choice is to have our previously mentioned base-period (or session length) $b = 3$ months, thus translating the six-month LC rule into *double session*

($= 2 \times b$) LC-block requirement. And it suffices to have UC and DB follow the base-period (=b) session length. The following groups of constraints have therefore been able to capture all of those "operational requirements". (For notational simplicity, we treat below only the case of n being even.)

The *double-session LC requirements* are written as

$$L_{ij} - L_{i,j+1} \;=\; 0\,, \qquad (i = 1,\cdots,m; j = 1,3,\cdots,n-1) \tag{8}$$

for a total of $m(n-1)/2$ constraints.

The *six-month LC requirements* are given as $m(n-4)/2$ constraints

$$\sum_{j \in J_k} L_{ij} \;\geq\; 1\,, \qquad (i = 1,\cdots,m; k = 1,2,\cdots,[n/2]-2) \tag{9}$$

where the index set $J_k \equiv \{2k-1, 2k+1, 2k+3\}$ picks out moving windows of 3 double sessions (or $3 \times 2 \times b = 18$ months) to require at least one LC service during each. (The subtle reason behind not using windows of whole years is due to the planning horizon n not being necessarily whole years in length.) Table 2 in the next section gives an illustration of J_k for the case of $n = 10$.

The *relieving from LC requirements* are similarly given as $m(n-2)/2$ further constraints

$$\sum_{j \in J_l} L_{ij} \;\leq\; 1\,, \qquad (i = 1,\cdots,m; l = 1,2,\cdots,[n/2]-1) \tag{10}$$

where the index set $J_l \equiv \{2l-1, 2l+1\}$ picks out moving windows of 2 double sessions (or $2 \times 2 \times b = 12$ months) to limit any LC service not to exceed a year. Table 3 in the next section is an illustration of J_l for the case of $n = 10$.

The above completes the rules on the LC service. The *duration of UC and DB* services are limited respectively by the $m(n-2)$ constraints

$$\begin{aligned} \sum_{j \in J_t} U_{ij} \;&\leq\; 2\,, \qquad (i = 1,\cdots,m; t = 1,2,\cdots,[n/2]-1) \\ \sum_{j \in J_t} D_{ij} \;&\leq\; 2\,, \qquad (i = 1,\cdots,m; t = 1,2,\cdots,[n/2]-1) \end{aligned} \tag{11}$$

where the index set $J_t \equiv \{2t-1, 2t, 2t+1, 2t+2\}$ picks out moving windows of 4 individual sessions (or $4 \times b = 12$ months). Again Table 4 in the next section gives an illustration for the set J_t.

2.3 Feasibility vs Optimality

The equitable staffing model then consists of the structural constraints given by (5)-(11) above. As we have seen before, the consistency of the model input parameters depends on the earlier conditions (1)-(4). Any feasible solution in fact yields a schedule with well-balanced workload among the individual SI staff members. The objective function to be used in such an optimization modelling approach in this case turns out to be only of secondary importance. To speed up (0-1 integer linear programming) computation, a constant value of zero can perfectly be used for its objective function. This is the one

Table 2: An illustration for the index set J_k for $n = 10$.

$k = 1$	1	3	5		
$k = 2$		3	5	7	
$k = 3$			5	7	9

Table 3: An illustration for the index set J_l for $n = 10$.

$\ell = 1$	1	3			
$\ell = 2$		3	5		
$\ell = 3$			5	7	
$\ell = 4$				7	9

we have used to obtain the numerical results given in the next section. Alternatively, certain specification of an objective function can be adopted to reflect some further staffing consideration. For example, if staff number m is relatively junior and inexperienced in LC work, he/she would preferably be assigned to the LC team as late as possible. An objective function of the form

$$\text{Min} \quad 3L_{m1} \; + \; 2L_{m3} \; + \; L_{m5}$$

could then be used for such a purpose.

3 Numerical Illustrations

We provide in this section numerical examples to illustrate the sort of (equitable) schedules computable from our staffing model. The first one is for the case of $m = 10$ staff members for the given relative demand specification ratios of $r_L = 4, r_U = 3$ and $r_D = 3$. The feasible combination parameters are determined to be $k = 1$, $s_L = 4, s_U = 3, s_D = 3$ and $n = 10$, thus a planning horizon of $nb = 30$ (months). This is the first case as shown in the first row of Table 1 in the last section. This scenario was also the actual situation when we first started our current project initiated by the SI Section of the Hong Kong Government back in the late 1990s. Tables 2 to 4 gives the indices contained in the index sets J_k, J_l and J_t for the respective sets of constraints in (9), (10) and (11).

Table 5 is the final equitable schedule as all the relative demands r_L, r_U, r_D and the relative capacities s_L, s_U, s_D can be easily checked to be satisfied, as well as the "operational requirements".

Only slightly over one year after the start of our study, we were facing a new situation of having $m = 12$ staff members and requiring a different relative demands of $r_L = 6, r_U =$

Table 4: An illustration for the index set J_t for $n = 10$.

$t = 1$	1	2	3	4						
$t = 2$			3	4	5	6				
$t = 3$					5	6	7	8		
$t = 4$							7	8	9	10

Table 5: Equitable schedule for $m = 10$ with $r_L : r_U : r_D = 4 : 3 : 3$.

	$j = 1$	$j = 2$	$j = 3$	$j = 4$	$j = 5$	$j = 6$	$j = 7$	$j = 8$	$j = 9$	$j = 10$
$i = 1$	DB	DB	LC	LC	UC	UC	LC	LC	DB	UC
$i = 2$	DB	DB	LC	LC	UC	UC	LC	LC	UC	DB
$i = 3$	DB	UC	DB	UC	LC	LC	DB	UC	LC	LC
$i = 4$	LC	LC	UC	DB	LC	LC	UC	DB	UC	DB
$i = 5$	LC	LC	UC	DB	UC	DB	DB	UC	LC	LC
$i = 6$	LC	LC	UC	UC	DB	DB	LC	LC	DB	UC
$i = 7$	LC	LC	DB	UC	LC	LC	UC	DB	DB	UC
$i = 8$	UC	DB	LC	LC	DB	UC	UC	DB	LC	LC
$i = 9$	UC	UC	LC	LC	DB	DB	LC	LC	UC	DB
$i = 10$	UC	UC	DB	DB	LC	LC	DB	UC	LC	LC

4 and $r_D = 2$. Our model generator was re-run to generate an MPS format file as input to our Lindo system [7]. (Most of our cases of these comparable sizes have taken only a few minutes CPU time on a PC.) The particular result of this new case is shown in Table 6. For the sake of illustration and comparison, the other three cases for $m = 12$ with $\{r_L = 6, r_U = 3$ and $r_D = 3\}$, $\{r_L = 5, r_U = 4$ and $r_D = 3\}$, and $\{r_L = 4, r_U = 4$ and $r_D = 4\}$ are also given respectively in Tables 7 to 9. Each of Tables 6 to 9 represents an equitable schedule with respect to its given relative demands ratios.

4 Concluding Remarks

In many ways, our study on the staffing model as described and illustrated in previous sections has the background of a rather classical operations research problem [4],[6]. It is one of our recent series of manpower planning projects for various institutions in Hong Kong such as in [1][2][3]. However, it has its own distinctive features of difficultly tight

Table 6: Equitable schedule for $m = 12$ with $r_L : r_U : r_D = 6 : 4 : 2$.

	$j=1$	$j=2$	$j=3$	$j=4$	$j=5$	$j=6$	$j=7$	$j=8$	$j=9$	$j=10$	$j=11$	$j=12$
$i=1$	DB	DB	LC	LC	UC	UC	LC	LC	UC	UC	LC	LC
$i=2$	DB	UC	LC	LC	UC	UC	LC	LC	UC	DB	LC	LC
$i=3$	LC	LC	DB	DB	LC	LC	UC	UC	LC	LC	UC	UC
$i=4$	LC	LC	DB	UC	LC	LC	UC	UC	LC	LC	DB	UC
$i=5$	LC	LC	UC	DB	LC	LC	UC	UC	LC	LC	UC	DB
$i=6$	LC	LC	UC	UC	LC	LC	UC	UC	LC	LC	DB	DB
$i=7$	LC	LC	UC	UC	LC	LC	DB	DB	LC	LC	UC	UC
$i=8$	LC	LC	UC	UC	LC	LC	DB	DB	LC	LC	UC	UC
$i=9$	UC	DB	LC	LC	DB	UC	LC	LC	UC	UC	LC	LC
$i=10$	UC	UC	LC	LC	DB	DB	LC	LC	UC	UC	LC	LC
$i=11$	UC	UC	LC	LC	UC	UC	LC	LC	DB	DB	LC	LC
$i=12$	UC	UC	LC	LC	UC	DB	LC	LC	DB	UC	LC	LC

Table 7: Equitable schedule for $m = 12$ with $r_L : r_U : r_D = 6 : 3 : 3$.

	$j=1$	$j=2$	$j=3$	$j=4$	$j=5$	$j=6$	$j=7$	$j=8$	$j=9$	$j=10$	$j=11$	$j=12$
$i=1$	LC	LC	DB	DB	LC	LC	DB	UC	LC	LC	UC	UC
$i=2$	LC	LC	UC	UC	LC	LC	DB	DB	LC	LC	UC	DB
$i=3$	LC	LC	DB	UC	LC	LC	UC	UC	LC	LC	DB	DB
$i=4$	LC	LC	DB	DB	LC	LC	UC	DB	LC	LC	UC	UC
$i=5$	UC	UC	LC	LC	UC	DB	LC	LC	DB	DB	LC	LC
$i=6$	LC	LC	UC	DB	LC	LC	UC	UC	LC	LC	DB	DB
$i=7$	DB	DB	LC	LC	UC	UC	LC	LC	UC	DB	LC	LC
$i=8$	LC	LC	UC	UC	LC	LC	DB	DB	LC	LC	DB	UC
$i=9$	DB	DB	LC	LC	DB	UC	LC	LC	UC	UC	LC	LC
$i=10$	UC	UC	LC	LC	DB	DB	LC	LC	DB	UC	LC	LC
$i=11$	DB	UC	LC	LC	UC	UC	LC	LC	DB	DB	LC	LC
$i=12$	UC	DB	LC	LC	DB	DB	LC	LC	UC	UC	LC	LC

Table 8: Equitable schedule for $m = 12$ with $r_L : r_U : r_D = 5 : 4 : 3$.

	$j=1$	$j=2$	$j=3$	$j=4$	$j=5$	$j=6$	$j=7$	$j=8$	$j=9$	$j=10$	$j=11$	$j=12$
$i=1$	DB	DB	LC	LC	UC	UC	LC	LC	UC	DB	LC	UC
$i=2$	DB	DB	LC	LC	UC	UC	LC	LC	UC	UC	LC	DB
$i=3$	DB	UC	UC	DB	LC	LC	UC	DB	LC	UC	LC	LC
$i=4$	LC	LC	DB	UC	UC	DB	LC	LC	DB	UC	LC	UC
$i=5$	LC	LC	DB	UC	LC	LC	UC	UC	LC	DB	DB	UC
$i=6$	LC	LC	UC	DB	DB	UC	LC	LC	DB	LC	UC	UC
$i=7$	LC	LC	UC	UC	LC	LC	DB	UC	DB	UC	LC	DB
$i=8$	LC	LC	UC	UC	LC	LC	DB	DB	UC	LC	UC	DB
$i=9$	UC	DB	LC	LC	DB	DB	UC	UC	LC	LC	UC	LC
$i=10$	UC	UC	DB	DB	LC	LC	UC	UC	LC	LC	DB	LC
$i=11$	UC	UC	LC	LC	UC	UC	DB	DB	LC	LC	DB	LC
$i=12$	UC	UC	LC	LC	DB	DB	LC	LC	UC	DB	UC	LC

Table 9: Equitable schedule for $m = 12$ with $r_L : r_U : r_D = 4 : 4 : 4$.

	$j=1$	$j=2$	$j=3$	$j=4$	$j=5$	$j=6$	$j=7$	$j=8$	$j=9$	$j=10$	$j=11$	$j=12$
$i=1$	DB	DB	LC	LC	UC	UC	DB	DB	LC	LC	UC	UC
$i=2$	DB	DB	UC	UC	LC	LC	UC	UC	DB	DB	LC	LC
$i=3$	DB	UC	LC	LC	UC	UC	DB	DB	LC	LC	UC	DB
$i=4$	DB	UC	UC	DB	LC	LC	DB	UC	DB	UC	LC	LC
$i=5$	LC	LC	DB	UC	UC	DB	LC	LC	UC	UC	DB	DB
$i=6$	LC	LC	DB	UC	DB	UC	LC	LC	DB	UC	UC	DB
$i=7$	LC	LC	UC	DB	UC	DB	LC	LC	UC	DB	DB	UC
$i=8$	LC	LC	UC	UC	DB	DB	LC	LC	UC	DB	DB	UC
$i=9$	UC	DB	LC	LC	DB	DB	UC	UC	LC	LC	DB	UC
$i=10$	UC	DB	LC	LC	DB	UC	UC	DB	LC	LC	UC	DB
$i=11$	UC	UC	DB	DB	LC	LC	UC	UC	DB	DB	LC	LC
$i=12$	UC	UC	DB	DB	LC	LC	DB	DB	UC	UC	LC	LC

constraint requirements, which bring out the explicit need of *scheduling for equitability* and to critically examine the issues of feasibility versus optimality in a many-rule setting. Most operational rules are designed to balance the workload among individual staff members performing various jobs with differing difficulty and responsibility. (The three main job types are those dealing with the legislative council, the urban councils and the district boards. Others exist such as press conferences.)

Under such a scenario, our project goal has been set to apply mathematical modelling techniques to "optimize" by way of computer modelling for equitable (and in a limited way, adaptive) manpower scheduling. The current results, we are pleased to able to report, appear to be very useful to the management that close to immediate applicability can be readily computed from the computer with minimal effort.

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