UPPEAK REVISITED SIMPLIFIED

Dr.Eur-Ing.G.C.Barney,
Lerch, Bates & Associates Ltd,
LBA Northern, Kendal, Cumbria, LA8 8AP, England.

ABSTRACT
It was once thought that the only way to efficiently service uppeak traffic was to force cars to return to the main terminal after every trip. However, there are a number of techniques (made possible by modern computer technology), which now make this oversimplification invalid. These include uppeak Subzoning (divide the building into two); uppeak Sectoring (give each lift a set of floors to serve) and Hall Call Allocation (find out where passengers want to go, before letting them into the car). A comparison is made of these three techniques and Hall Call Allocation with uppeak subzoning; using the conventional uppeak service regime as a reference.

1. INTRODUCTION

If you asked a traffic designer a short while ago,

"Which traffic control system (despatcher) is best for serving up-peak traffic ?"

the reply would have been

"There is not much in it."

Nowadays, with modern computer controlled systems the answer is not so clear.

All the older conventional collective systems operate by returning cars to the main terminal, after their last passenger had exited. An improvement was achieved by the uppeak subzoning technique offered by most lift makers. Recently computer controlled systems have been introduced, which offer uppeak sectoring (Powell, 1992) and hall call allocation (Schroeder, 1990). The operation of these systems is very complex. Computer analysis shows a wide range of performance (Barney, 1992).

So what is the answer to:

"Which is best ?"

As with most things is:

"It all depends."

2. SPECIFIC ANALYSIS

Consider an example building with the data shown below:

Number of floors [N]	16	Interfloor distance [d_f]	3.3 m
Number of cars [L]	4	Cycle time [T] *	10.0 s
Size of cars (persons) [CC]	21	Passenger transfer time [t_p]	1.0 s
Speed of cars [v]	3.15 m/s		

* Time from instant of doors closing to instant doors 90% open at next adjacent floor.

Suppose now that the five traffic control algorithms:

(i) conventional
(ii) uppeak subzoning
(iii) uppeak sectoring
(iv) hall call allocation
(v) hall call allocation with uppeak subzoning

are installed in the example building in turn. What would be the effect ?

The operation of the conventional and the four other uppeak traffic control systems is illustrated in Figures 1 to 5, where they are responding to the same passenger arrival rate; i.e. delivering the same handling capacity [*HC*]. The figures show cars moving from floor to floor distributing passengers. It will be seen that the conventional system (Figure 1) has many more stops [*S*] than the other four. Also note the subzoning algorithms (Figures 2 & 5) show cars serving their subzones only.

It is important to note that all the four "improved" traffic control systems require more than four cars for justice to be done. Also the subzoning splits and sectoring floor assignments in real systems may be made in different ways. Thus their portrayal in the figures should only be considered to illustrate the spirit of their operation only.

The performance figures for the four "improved" algorithms have been normalised by comparing them to the conventional system. This is accomplished by dividing the conventional uppeak figures into the figures obtained for each of the improved traffic algorithms. So a 70% figure represents a reduction in value of 30%.

Figures 2-5 show that the four uppeak algorithms improve performance by reducing passenger average waiting [*AWT*] and journey times [*AJT*], number of passengers carried [*P*], percentage car loads [%*CC*] and number of stops [*S*]. However, the interval [*INT*] and passenger service interval [*PSINT*], which is the service period the passenger experiences, may not decrease !

3. GLOBAL ANALYSIS

So for a specific system we can see improvements, but the question is still "which is best ?". Computer analysis (Barney, 1992) of over 1000 different parameter combinations (*N*, *L*, *CC*, *v*, *df*, *T*, *tp*) showed that sometimes one system would perform better, but on other occasions it would not.

3.1 Method of analysis

Lift systems are sized for the uppeak traffic pattern by using the following well known formula (Barney & Dos Santos, 1985-p22), in order to obtain the system round trip time (*RTT*), the interval (*INT*) and the 5-minute Handling Capacity (*HC*):

$$RTT = 2.H.tv + (S+1)ts + 2.P.tp \qquad \ldots (1)$$

There are six parameters required to solve Equation (1):

- Number of floors served (*N*)
- Rated capacity (*CC*)
- Rated speed (*v*)
- Interfloor distance (*df*)
- Number of lifts (*L*)
- Cycle time (*T*)

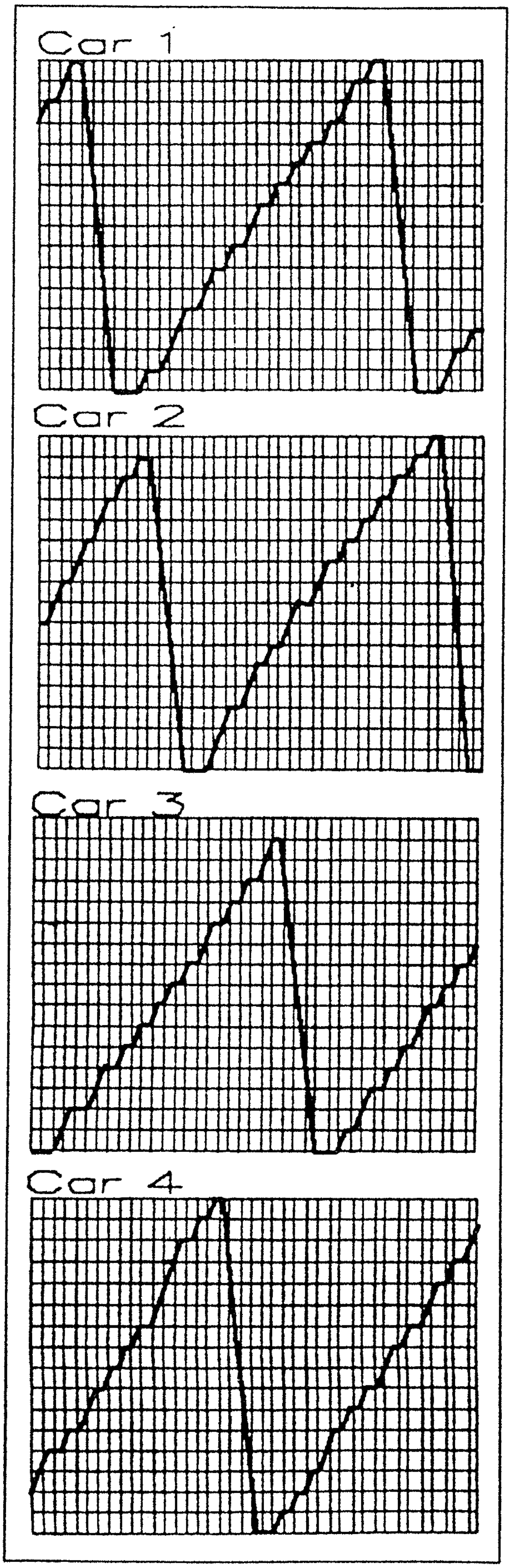

Figure 1: Uppeak Collective Control

(i) Uppeak Collective Control

Operation

Under conventional traffic control: once the uppeak traffic condition has been detected (eg. by load weighing, number of car calls registered, etc.) all cars are returned to the main terminal floor, after the last passenger has exited at the high call reversal floor (*H*). Down landing calls are ignored or serviced on an occasional basis.

Calculation method

Equation 1 is used to calculate the round trip time (*RTT*). From this the interval (*INT*) and handling capacity (*HC*) can be found. The passenger service interval (*PSINT*) will be equal to the interval (*INT*) as each passenger enters the first car to arrive.

Data arising from specific system

Number of stops (*S*)	10.6
Number if passengers (*P*)	16.8
Interval (*INT*)	42.5 s
Passenger service interval (*PSINT*)	42.5 s
Handling capacity (*HC*)	100%
Average waiting time (*AWT*)	100%
Average journey time (*AJT*)	100%
Percentage car load (*%CC*)	80%

Comments

This is the control system, which is available from nearly all maunfacturers. There are a large number of stops, compared to the other four traffic algorithms. Also note that the cars reach a reversal floor high in the building compared to the other algorithms.

The parameters: handling capacity, average waiting time and average journey time are stated as 100%, in order to aid comparison in Figures 2-5. Actual figures can be provided. The other parameter, the car load is shown as 80%, which is the value used when carrying out traffic calculations.

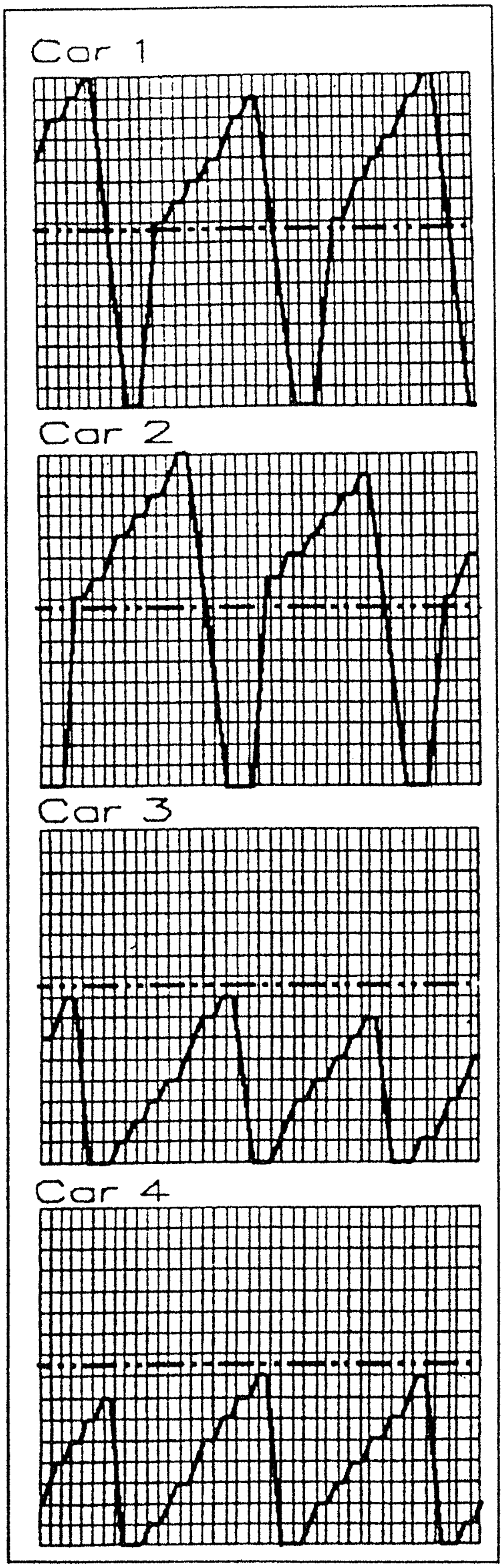

Figure 2: Uppeak Subzoning Control

(ii) Uppeak Subzoning Control

Operation

In subzoning systems, the building zone is divided into two subzones and the lift group is divided into two subgroups for the duration of the uppeak period. The cars are permanently allocated to a subzone and passengers are directed to the subgroup, which serves their floor by illuminated signs. The subzones may not contain equal numbers of floors, and equal numbers of lifts may not serve each subzone, as they do in this example.

Calculation method

Equation 1 is used again. For the lower subzone the method is identical to that used for the conventional calculation except there are less floors to serve and less cars the serve them. The higher subzone is calculated in the same way, except allowance has to be made for the express jump across the lower subzone.

Data arising from specific system

Number of stops (*S*)	6.1
Number if passengers (*P*)	10.9
Interval (*INT*)	27.5 s
Passenger service interval (*PSINT*)	55.0 s
Handling capacity (*HC*)	100%
Average waiting time (*AWT*)	66%
Average journey time (*AJT*)	65%
Percentage car load (*%CC*)	52%

Comments

The number of stops is reduced because only half the floors are in each subzone. The number of passegers carried in the cars is also reduced to two thirds of the number carried by a conventional system. The average passenger waiting and journey times reduce to two thirds of their conventional values. For this building a satisfactory solution.

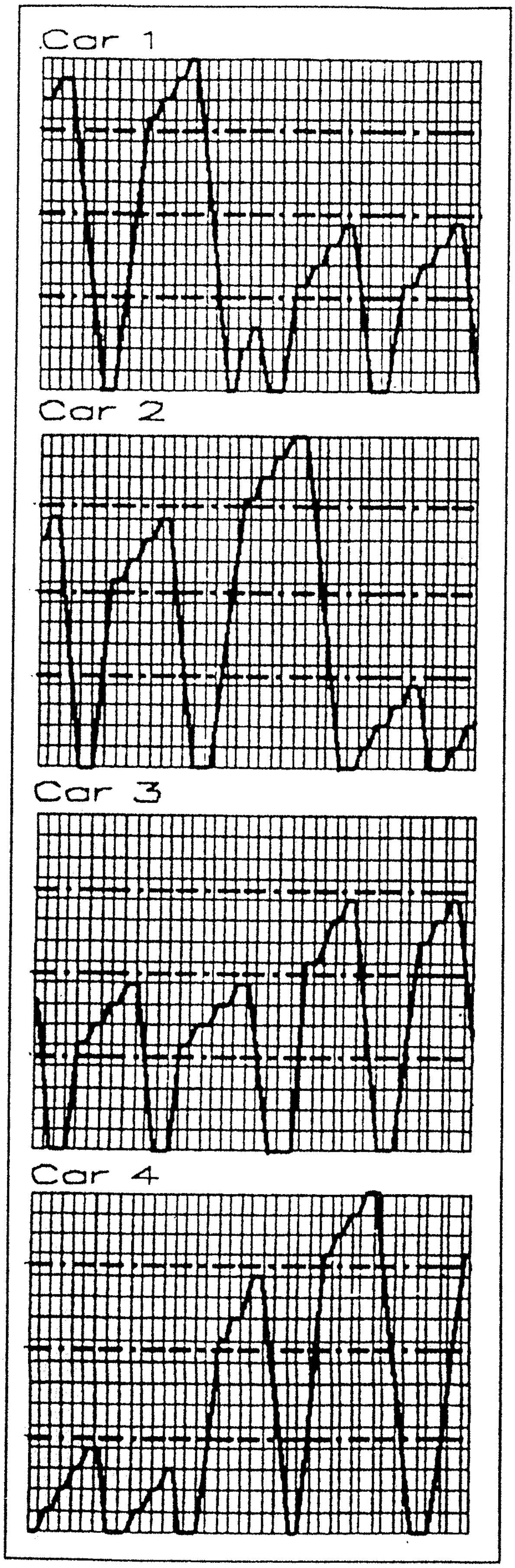

Figure 3: Uppeak Sectoring Control

(iii) Uppeak Sectoring Control

Operation
Uppeak subzoning can be extended by dividing the building into more than two subzones or sectors. The number of sectors can be made equal to (or slightly less than) the number of cars. Cars are not permanently assigned to a sector. As cars arrive at the main terminal floor, they serve the sectors in a strict "round robin" fashion. Passengers are directed to cars serving their floors by destination signs above the cars. The passengers in this example, who just miss a car serving their sector, will have to wait for the fourth car to arrive.

Calculation method
The method assumes a sector, containing an average number of floors, situated exactly halfway up the building. The round trip time, etc. for this sector are calculated using Equation 1. This technique calculates average values for all sectors. In the example the average number of floors is four and the sector will be placed between floors 7-10.

Data arising from specific system

Number of stops (*S*)	3.6
Number if passengers (*P*)	7.6
Interval (*INT*)	19.3 s
Passenger service interval (*PSINT*)	77.0 s
Handling capacity (*HC*)	100%
Average waiting time (*AWT*)	86%
Average journey time (*AJT*)	57%
Percentage car load (*%CC*)	36%

Comments
The number of stops is reduced (obviously) as each lift now only serves a potential four floors (in this example). The number of passengers carried in the cars is much reduced to about one half of the number carried by a conventional system. The average passenger waiting and journey times reduce to 86% and 57% of their conventional values.

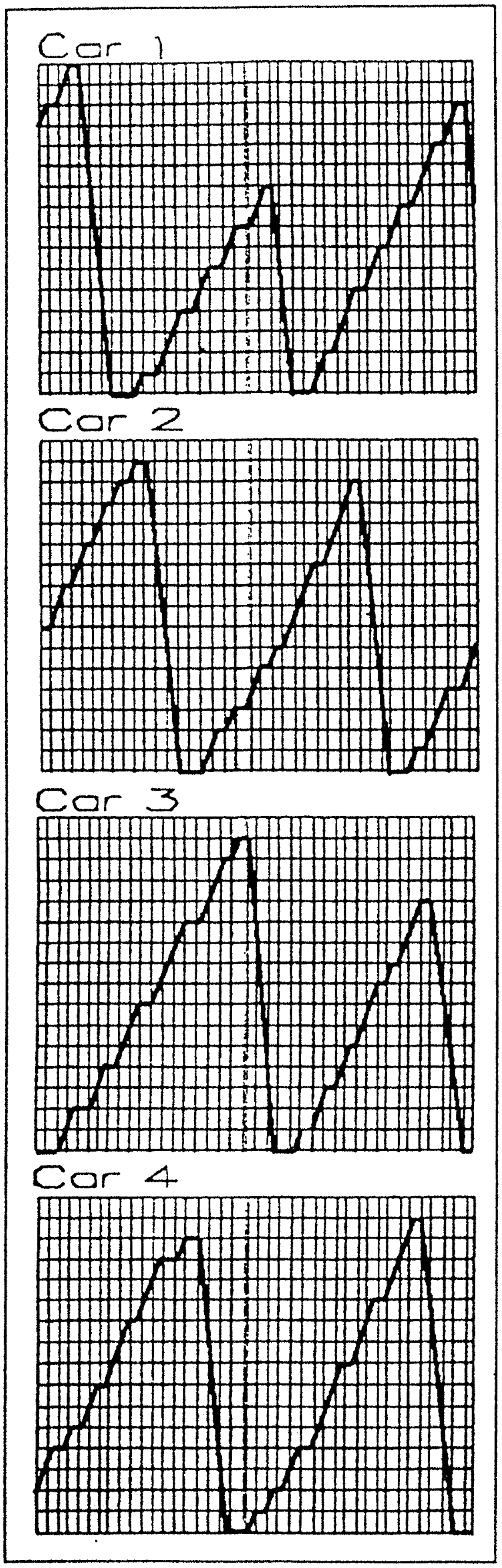

Figure 4: Hall Call Allocation Control

(iv) Hall Call Allocation Control

Operation

If a keypad is provided, at the main terminal floor, so that passengers can register their destination floor, before they enter a car, a more efficient allocation can be made. Cars are not permanently allocated to specific floors. Passengers are notified (on the keypad), which car will take them to their destination, immediately they have registered their call.

Calculation method

Equation 1 can be used again, provided the formulae to determine H and S are modified. The formula for S involves considering a "look ahead" factor (k) equal to the number of cars to be considered in each allocation. (Imagine a large car equal in size to k cars serving the building.) Values of k=2 usually suffice. The formula for H involves replacing the parameter P by the calculated value for S, as the number of stops is determined by the algorithm and hence the highest floor which is reached.

Data arising from specific system

Number of stops (*S*)	6.4
Number if passengers (*P*)	12.2
Interval (*INT*)	30.8 s
Passenger service interval (*PSINT*)	61.5 s
Handling capacity (*HC*)	100%
Average waiting time (*AWT*)	82%
Average journey time (*AJT*)	72%
Percentage car load (*%CC*)	58%

Comments

The lifts serve all the building with a reduced number of stops (about 60% of the conventional). The car loading is reduced to about two thirds of the conventional loading. The passenger waiting and journey times reduce to 82% and 72% of the conventional. Performance in this case about the same as subzoning.

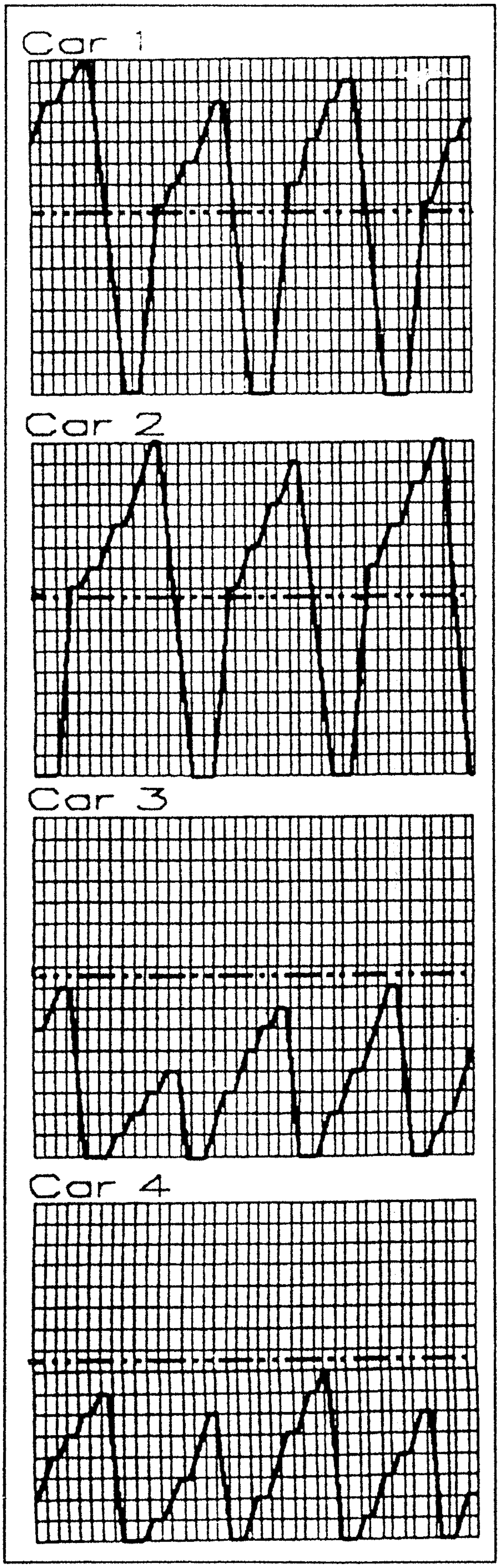

Figure 5: HCA with uppeak Subzoning

(v) HCA with Uppeak Subzoning Control

Operation

A variation to combine uppeak subzoning with Hall Call Allocation. The system operates in the same way as simple Hall Call Allocation, but because the algorithm has less floors to consider in each subzone, improved efficiency results. The subzones are fixed, but can be varied if required, as the passengers would be unaware of the actual boundaries.

Data arising from specific system

Number of stops (*S*)	3.5
Number if passengers (*P*)	8.2
Interval (*INT*)	20.4 s
Passenger service interval (*PSINT*)	81.7 s
Handling capacity (*HC*)	100%
Average waiting time (*AWT*)	91%
Average journey time (*AJT*	59%
Percentage car load (*%CC*)	39%

Calculation method

This will be the same as that employed for simple Hall Call Allocation, but with a reduced number of floors. In the case of the higher subzone account must be taken of the time to cross the lower subzone.

Comments

The number of stops are about 30% of the conventional. (Do not forget that each car only serves half a building.) The number of passengers carried is reduced to about one half of the number carried by the conventional system. The journey time at 59% ranks equal with uppeak sectoring. The passengers wait about the same time as the conventional system.

Using *N* and *CC* it is possible to obtain values for *H* (highest reversal floor) and *S* by calculation or from tables for the number of passengers (*P*) to be carried. The parameter *tv* is obtained from the expression (*df/v*) and the parameter *ts* is obtained from the expression (*T-tv*). It was decided to set:

- The passenger transfer time (*tp*) to an average value of 1.0 s,
- The interfloor distance (*df*) to 3.3 m,
- The transit time (*tv*) to 18/N (to simplify the programming).

As the analysis is concerned with office buildings, the range of likely configurations determined the range of values for *N*, *CC*, *L* and *T* as:

- *N*: 10 to 25 floors;
- *CC*: 16, 21, 26 persons;
- *L*: 4, 6, 8 cars;
- *T*: 8, 10, 12 s.

A suite of BASIC programs were written (REVISIT; SECTOR; HCALL; HCALLSS), to obtain the handling capacity (*HC*), passenger average waiting time (*AWT*), passenger average journey time (*AJT*) and percentage car load (%*CC*) during the uppeak traffic condition for four "improved" lift traffic control systems.

The results were normalised against the conventional collective control system. For each configuration the values for *HC*, *AWT* and *AJT* were calculated for 80% car loadings. These numerical values were then used as the divisor for the results from the other four control systems to give a performance ratio. Thus the simple collective system was used as a benchmark comparator.

The calculations for the Collective, uppeak Subzoning and uppeak Sectoring systems used Equation (1) and the Hall Call Allocation systems used a modified Equation (1).

4. DISCUSSION

Figures 6 to 8 provide a graphical representation of the results of this analysis for the four "improved" control systems, normalised against the collective control system. Thus a ratio of unity (1.0) indicates a par value.

The legend identifies the different bars. Note also the range of variations possible for each characteristic, shown grey in a dotted box; and the average value shown as a bar in the grey box.

Figure 7 represents the condition when each system is called upon to handle the same number of arriving passengers ie: equal handling capacity (*HC*=1.0). This was the condition studied in the specific example. All passenger journey times and car loadings reduce in value with uppeak Sectoring performing well. However, when considering passenger average waiting time, and taking into account the range of variations, all systems except uppeak Subzoning perform badly. Passengers have to wait longer for service, although they do reach their destinations more quickly.

Figure 6 indicates the maximum handling capacity that each system can produce. This is indicated by noting that the car loads are fixed at 80% (*CC*=0.8) of rated load. Here the uppeak Sectoring system can provide over twice the handling capacity, that can be provided by the collective algorithm. However the price, which is paid, is that passengers may wait over three times longer than with the conventional system. Hall Call Allocation is very similar. The uppeak Subzoning and HCA with uppeak Subzoning produce very similar results.

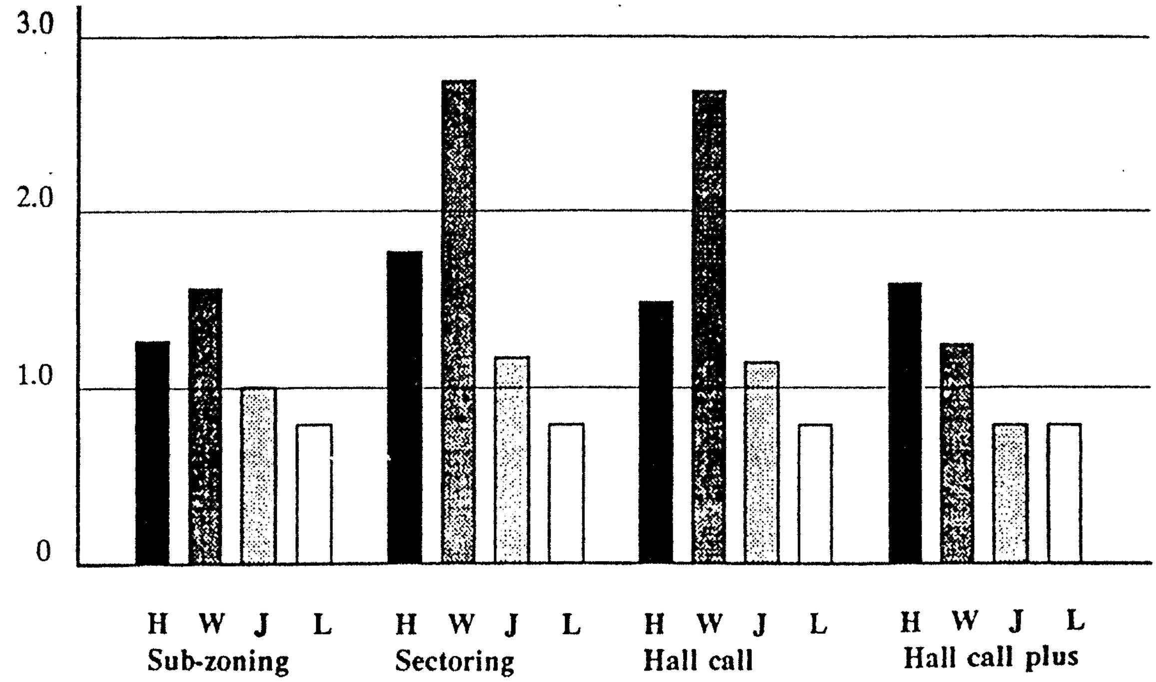

FIGURE 6 Maximum handling capacity

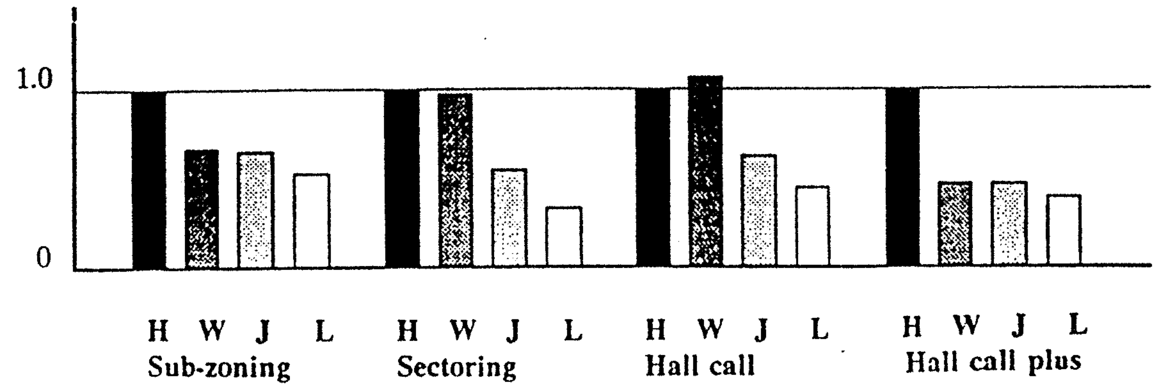

FIGURE 7 Equal handling capacity

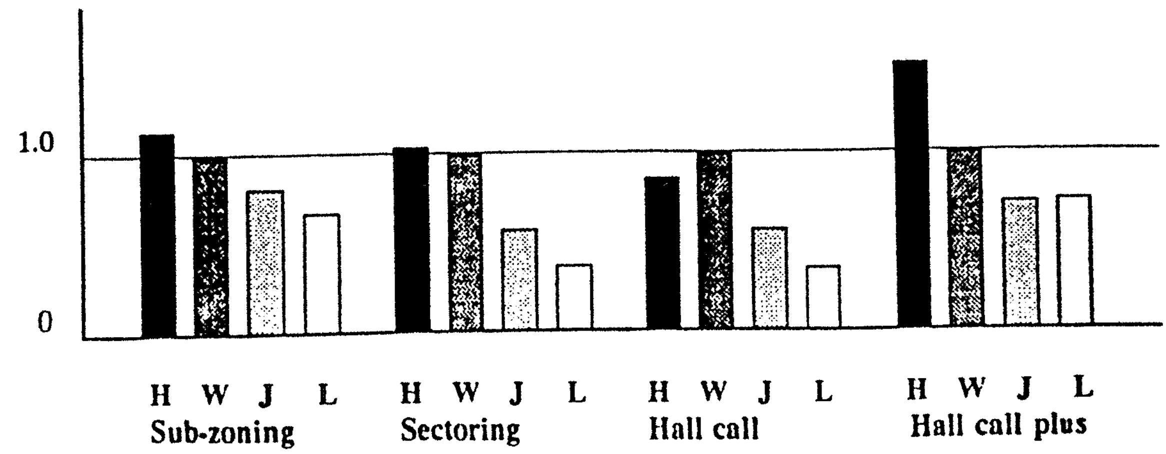

FIGURE 8 Equal passenger waiting time

The third figure (Figure 8) shows what happens, when passengers are asked to wait the same amount of time for service (*AWT*=1.0) as they would in the conventional system. This is indicated by noting that the passenger average waiting time bar is set to unity. The clear winner here is HCA with uppeak Subzoning.

5. CONCLUSION

Each system performs better than the collective control system for a wide range of designs. Only analysis of specific designs can lead to a decision, as to which system is best for a specified building. There are also other matters to consider, such as the cost of the more advanced traffic control systems and the changes needed in the passengers' perception (user friendliness) of the signalling arrangements.

For further study of this topic read Barney (1992). The Author will also send to any interested researchers, a copy of the programs used in this analysis, plus the technical appendices to Barney (1992), on receipt of two 3½ inch (virus free) formatted discs.

REFERENCES

Barney, G.C. & dos Santos, S.M.: *Elevator traffic analysis, design and control*, Peter Peregrinus, 1985.
Barney, G.C.: *Uppeak revisited*, Elevatori, 5/92.
Powell, B.A.: *Important issues in uppeak traffic handling*, Elevatori, 6/92.
Schroeder, J.: *Advanced dispatching: M10*, Elevator World, 3/90.

ABOUT THE AUTHOR . . .

George Barney has the degrees of B.Sc. and M.Sc. from Durham University and a Ph.D. from Birmingham University, the latter for work on four quadrant thyristor power supplies. Joining UMIST in 1967, Dr.Barney has carried out research into many aspects of lift systems. An energetic writer, he has authored, co-authored or edited some 15 books and 80 papers on a variety of topics. Currently his activities include: Chairman of Lerch, Bates & Associates Ltd.; Visiting Senior Lecturer, UMIST; English Editor, Elevatori; Chairman of the Board of Executives of the International Association of Elevator Engineers; a Member of the British Standards lift committee MHE/4 and Principal of OutReach College.

[1513]