Hybrid Lift Group Control Systems

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Abstract. Over recent years destination control systems have been embraced by all of the major and independent manufacturers having sat at the margins of the industry with only one company actively promoting its use.

As the use of destination systems has risen the known benefits of providing an up peak booster have become a major factor in their being specified. However with the use of destination systems there has been a recognised perception that whilst providing benefits for up peak performance they are not as efficient at handling two way and inter floor traffic. This has resulted in some manufacturers offering hybrid group systems whereby destination control is used to dispatch lifts from the main lobby but uses a conventional two button system to call lifts on the upper floors with active car call buttons to select the destination floor.

This paper compares the efficiency of hybrid systems with dedicated destination control systems across a variety of office building applications. It also looks at the human factors that present barriers to hybrid systems.

1 INTRODUCTION

The purpose of this paper is to try and establish if the use of hybrid systems is more efficient in dealing with two-way and inter floor traffic than destination systems, and if so are there any penalties in terms of service provision. In addition it seeks to explore the barriers and perceptions of building users when confronted with a hybrid system and how these might be addressed.

This paper looks specifically at the use of hybrid group control in modern office buildings and does not consider their application in other environments such as hotels, hospitals and other public buildings.

2 CONVENTIONAL CONTROL

From the outset it should be considered that the use of conventional two button control and hybrid systems have limitations in terms of their application. The main areas of limitations are:

a) For groups of up to 4 cars in a single line. Maximum 8 car group (four cars opposite four).
b) Where all lifts do not serve all floors in the building.

Taking each of the above in turn;

a) Conventional/hybrid systems are really only practical for groups where the maximum number of lifts in a single line does not exceed four. This obviously means that the maximum number of lifts in a group should not exceed eight, four lifts opposite four. With a lobby length of 11.250m, for a 4 car single line of lifts, and a distance between the centres of adjacent lift doors of 2.850m, adding a further 2.7m to the length of the lobby has a significant impact, given the average walking speed of between 1.25m/s and 1.6m/s, see Figure 1. Once you move beyond a line of four lifts crowded lobbies become too long for people to navigate effectively and difficulties arise with accessing lifts within reasonable walking times. This is especially difficult for those with visual and mobility impairment and obviously has an effect on the systems efficiency as door dwell times are increased and lift performance is reduced.

With long lobbies the question of lift arrival indication is also an issue as a more prominent form of signage is required with high levels of audibility for arrival gongs. While flag type or raised direction arrows may be acceptable, highly audible arrival gongs can be obtrusive, especially where lifts open directly into occupied accommodation.

Add to this the undemocratic way in which people access the lifts, i.e. those nearest can board first while those perhaps waiting the longest may be left at the lobby and the limitation become apparent.

b) Where buildings are designed such that not all lifts in the group serve all floors conventional systems may require special landing call buttons and services to cater for passengers travelling to floors served by fewer lifts. In some cases the arrangement is extremely complex, as in figure 2, and it becomes almost impossible to provide an effective service with conventional control systems. Even with less complex configurations there is an adverse impact on lift performance in terms of handling capacity and waiting times to the floors served by fewer lifts. In these circumstances destination systems are far better at managing traffic to such floors.

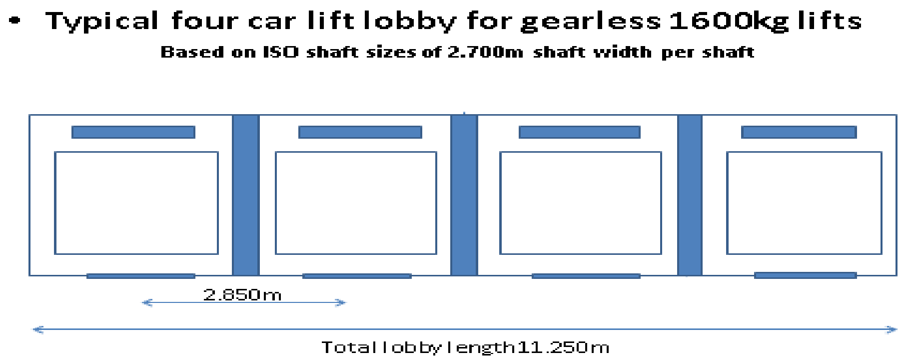

Figure 1

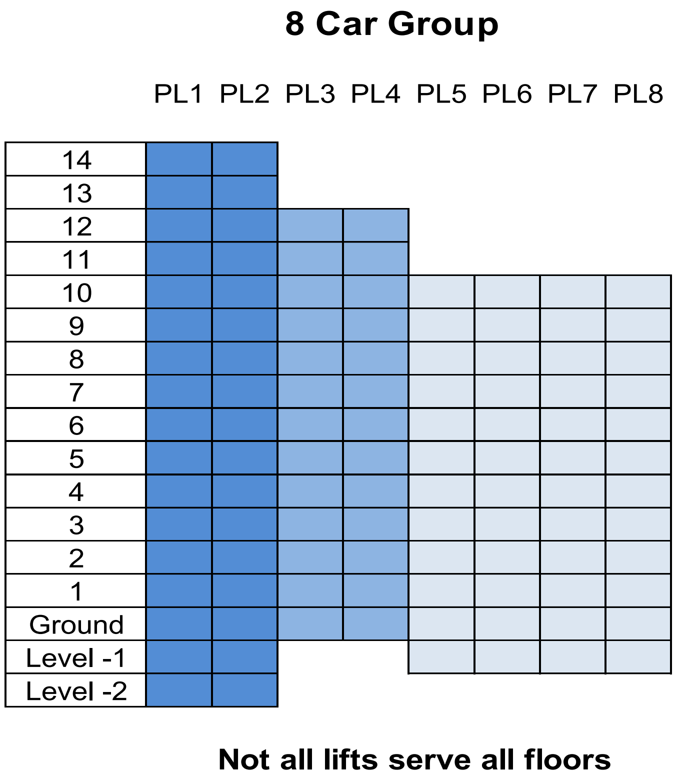

Figure 2

3 DESTINATION CONTROL

The use of destination control as a means of proving improved performance during the up peak period is now well established. With higher saturation points, compared to conventional systems, they are ideal as a ‘booster’ for the up peak period. These tangible benefits are seen in terms of better passenger management at the main lobby together with shorter journey times and a reduction in the number of stops before reaching the final destination. This all equates to shorter round trip times and increased handling capacity.

All of these features are seen as positives and this has resulted in the use of destination systems as the almost default group control system in large office buildings with multi car groups. All major manufacturers and many third party suppliers of lift control systems now offer destination control as a standard option.

There is however the question that whilst providing an enhanced up peak performance destination systems are not as effective at managing two way and inter-floor traffic. The basis of this is that whilst it is easy to group passengers travelling to the same destination at one point, in the main lobby, this is far more difficult to achieve when passengers are located on different floors and fewer in number. The perception is that longer waiting times are experienced by those passengers moving between floors as the destination system constantly tries to match passengers on different floors to common destinations. The dynamic of upper floor traffic is constantly changing between two way and inter floor and the system needs to be able to respond to these changes while providing the user with an almost instant car allocation.

The ability of some destination systems to effectively manage the dynamics of upper floor traffic, within the constraints of the basic destination template, is difficult. The system is inflexible in terms of call reallocation, something discussed later, and the system constraints limit the ability to provide the most responsive service levels. This leads to a reduction in handling capacity accompanied by increased waiting times.

4 HYBRID SYSTEMS

Hybrid systems appear to offer the best of both worlds, with destination dispatching from the ground floor and the benefits of conventional control in the upper part of the building. With some manufacturers of hybrid systems destination dispatching is available from more than just the main lobby. This arrangement appears ideal for buildings with restaurant, amenity and perhaps function floors located on the upper levels.

One of the key factors and benefits of conventional control systems is the ability to reallocate landing calls. When a landing call is registered the call is allocated to a car that the system computes will provide the fastest response time. If the allocated car is delayed at any point the call can be reallocated to a different lift. While this process is taking place within the group control system the waiting passenger is unaware of any change of allocation and is informed of the lifts impending arrival only when the hall lantern illuminates as the car approaches the floor.

This is in contrast to destination systems where the almost instant allocation of a lift is fixed. Once the passenger is directed to a particular lift then it is expected that the lift will arrive. However if the lift is delayed there is no mechanism to inform the passenger the call has been reallocated. In these circumstances the frustrated passengers tolerance expires and they re-enter their call only to be directed to a different lift or worse, back to the original lift again. This has a negative impact on the user's perception and view of the service being provided and is one of the major difficulties encountered with destination systems.

From the above we can start to see some of the benefits of the hybrid system. Management and grouping of passengers at the main lobby and the elimination of the call reallocation problem on the upper floors, although it should be appreciated this can still happen at the main lobby or any floor where the destination facility is available. However this approach appears to offer the best of both systems and carries a certain degree of logic in terms of a group system operation.

5 HYBRID AND DESTINATION SYSTEMS COMPARISON

In examining the use of hybrid systems it is necessary to try and understand the benefits and drawbacks of each system both technically and in terms of the 'user experience'.

5.1 Destination Control

For:-

- Identifies number of travelling passengers
- Groups passengers according to destination
- Shorter round trip times during the up peak
- Improves waiting time at the main lobby*
- Efficient use of lifts
- Improved up peak handling capacity
- Better allowance for passengers with disabilities (DDA passengers)
- Manages people in the lobbies

* Especially if passenger demand is close to or exceeds handing capacity of conventional systems.

Against:-

- Relies on all passengers entering their destination
- Passengers have no control within the car
- Passengers have to move to the landing to change their destination floor
- Ghost calls reduces efficiency

- Does not signal call reallocation
- Unpopular with some users
- Perceived inefficiencies in handling inter floor traffic
- People try to beat the system – repeated call request or group call function used.

5.2 Hybrid system

For:-

- Identifies number of travelling passengers at the main floor
- Groups passengers according to destination at the main floor
- Provides up peak booster feature
- Manages people at the main lobby
- Good inter floor traffic handling
- Allows space for DDA users from the ground floor.
- Can use hall call allocation on upper floors with heavy traffic (restaurants, meeting floors, etc.)
- Allows call reallocation for lifts responding to upper floor landing calls.
- May carry a cost advantage over a full destination system

Against:-

- May be confusing for users
- Different landing fixtures at ground and other floors
- Car buttons active/inactive at different times
- Not as effective at allowing for DDA use from upper floors
- People try to beat the system. Entering the car and waiting for the COP to become active
- Up to 8 car groups only
- Doesn't know how many passengers are to be transported from upper floors
- Passengers may experience more intermediate stops than destination control
- May not be suitable in groups where all lifts do not serve all floors.

6 SIMULATIONS

In addition to understanding the benefits and drawbacks the relative performance of each system is assessed through simulation in identical applications. The results, using set criteria and performance standards, are set out below for a theoretical building with a typical service requirement.

For the purposes of this paper a 10 floor building of 250,00 sq/ft with a space utilisation of 80% and population density of 1:8m² is considered. Utilisation is the expression of occupied space on each floor with 20% floor space being used for circulation, cabinets, photo copiers, etc.

The selected measurement criteria are:

a) Up peak traffic

b) Lunchtime traffic

c) Two way traffic; 50% incoming and 50% outgoing

d) Intense inter floor traffic; 10% incoming, 10% outgoing and 80% inter-floor

The two way traffic in 'c' above represents a building with a diversified tenancy where there is no inter floor traffic. Conversely criteria 'd' represents a consolidated tenancy with high levels of inter floor traffic. The criteria used in both 'c' and 'd' is not based on any guidance references but is purely a means of comparing the performance delivery of each system. In both 'c' and 'd' the lifts are operating outside of the up peak and lunch time period.

The performance measurements assessed are Average Waiting Time, Time To Destination and Average Stops per Round trip.

Note - The simulations for up peak and lunchtime are based on the criteria as set out in the Draft BCO 2014 Guide. The profile is constant traffic with a one hour simulation period. All simulations have been carried out using Elevate, Version 8.17 software. For destination control simulations the 'Destination Control (ACA)' dispatcher has been used and for the hybrid simulations the 'Mixed Control (Enhanced ACA)' dispatcher has been used.

It must be recognised that the use of Elevate software provides a set of results that may well be at variance to those achieved by a suppliers own simulations. For the purposes of this paper however the simulation results achieved using Elevate provides the basis of discussion.

The data matrix below details the building and lift criteria applied in the simulations

Building Details

	Area Sq Ft NIA	Sq M	Utilisation 80%	Population 1:8
10	25000	2323	1859	232
9	25000	2323	1859	232
8	25000	2323	1859	232
7	25000	2323	1859	232
6	25000	2323	1859	232
5	25000	2323	1859	232
4	25000	2323	1859	232
3	25000	2323	1859	232
2	25000	2323	1859	232
1	25000	2323	1859	232
Ground				
	250000			2323

Lift data

No of Elevators	SPECIFIED	8
Capacity (kg)	SPECIFIED	2000
Car area (m²)	AUTO	
Door Pre-opening Time (s)	SPECIFIED	0
Door Open Time (s)	SPECIFIED	1.8
Door Close Time (s)	SPECIFIED	2.9
Speed (m/s)	SPECIFIED	2.5
Acceleration (m/s²)	SPECIFIED	0.8
Jerk (m/s³)	SPECIFIED	1.2
Start Delay (s)		0.5
Levelling Delay (s)		0

Results

Traffic Criteria		Control		AWT	ATTD	Stops per round trip
85/10/5 in/out/inter @ 12%	Up peak	Destination		23.3	64.7	3.8
85/10/5 in/out/inter @ 12%	Up peak	Hybrid		22.2	72.8	4.6
45/45/10 in/out/inter @ 13% HC	Lunch time	Destination		30.3	70.5	4.6
45/45/10 in/out/inter @ 13% HC	Lunch time	Hybrid		30.4	81.9	6.3
50/50 in/out @ 13% HC	Two Way	Destination		24.5	62.1	3.5
50/50 in/out @ 13% HC	Two Way	Hybrid		26.6	75.3	5.2
10/10/80 in/out/inter@5% HC	Interfloor	Destination		28.9	62.1	10.7
10/10/80 in/out/inter@5% HC	Interfloor	Hybrid		16.0	46.7	9.2

The results show there is a significant reduction in waiting times and times to destination with a hybrid system when catering for a high level of inter floor traffic.

In the other traffic patterns, up peak, lunchtime and two-way the waiting times are not too dissimilar between the two systems, however the time to destination is longer with the hybrid system as a result of the increased number of stops experienced during the round trip. This suggests that the hybrid is working harder as it is achieving similar waiting times with increased numbers of stops reflecting a higher handing capacity.

The general results show that a hybrid system does mean shorter waiting and journey times for inter floor traffic. The results of the up peak and lunchtime simulations show the destination system performs better in terms of time to destination and fewer intermediate stops while waiting times are similar to the hybrid.

With respect to the passenger's experience of intermediate stops it is important to distinguish between the numbers of stops the lift makes and the number of intermediate stops experienced by each passenger. With passengers entering and leaving the lift at different floors the number of intermediate stops experienced is not the same for each individual. To arrive at the average it is necessary to apply a weighting based on the number of passengers who start the journey together and those who leave the lift at each stop. This will obviously show that the number of intermediate stops experienced by each passenger is different but the average is less than the number of intermediate stops made by the lift. This is an important factor when assessing the 'passenger experience' and is a key element in the marketing of buildings. To effectively arrive at the average number of stops passengers experience it is necessary to track each individual from start to finish of their journey.

The results indicate that hybrid systems are better suited to buildings with a single tenancy where inter floor traffic levels are likely to be higher than perhaps a diversified tenancy building. This obviously poses a question related to the future proofing the building.

7 PROGRAMME MODES

Historically conventional group control systems have sought to manage demand based on responding to the traffic pattern. Up peak, down peak, two way traffic (balanced) have been familiar terms in lift programme language, with the group control system monitoring demand and applying a preprogramed response to the pattern of usage.

The usage was detected by monitoring landing and car calls together with measuring the car load. However the response could be somewhat clumsy and relied on high levels of maintenance to ensure the systems functioned correctly.

This changed somewhat with the advent of lifts working in ‘zones’ throughout the building. Up peak was retained as a ‘programme’ to respond to the morning traffic but once this subsided the lifts would revert to a ‘zoning’ operation whereby the lifts were driven by demand within the zones.

The introduction of microprocessor technology changed the approach to group control whereby call allocation was introduced and greatly improved performance and response times. This was achieved by the use of greater computing power to assess a much wider level of information and to start to match response to demand. Coincident car and landing calls, assessing the ‘allocated workload’ of each car and knowing accurately the exact position of each car in the shaft allowed systems to operate at a far higher level and provide a much better level of service to building users. ‘Relative system response’ became a key measurement of performance.

The concept of using different operating modes or programmes is still used in modern microprocessor based systems with the ‘up peak’ used on conventional systems the most obvious. However the ability of systems to have a completely flexible and seamless response to changing traffic patterns would appear to offer the best solution in terms of system response, given any ‘programme’ is operating within the parameters of a pre-defined criteria, however flexible that may be. By extension destination systems provide the better means of control given their ability to understand the pattern of demand before passengers enter the lift. This is of course conditional on all passengers entering their destination.

Any destination system, even those working within modes or programmes, is still constrained by the basic principle of the system. This is to group passengers going to the same floors together, whether the demand is for up peak, two-way or inter floor traffic.

8 USER INTERFACES

While the use of hybrid systems provides advantages in terms of waiting times for inter floor traffic patterns the key obstacle is the user’s perception of the system based on the interfaces they are confronted with.

The use of different landing fixtures at the main and upper floors together with the car buttons (COP) being active at varying times is perceived as being difficult for building users to understand and comprehend.

There are means of mitigating some of these concerns but if we look at current hybrid systems then we can see that the main issues is with the COP and the points at which it is either enabled or inhibited.

With some current hybrid systems the car operating panel button will illuminate when the destination is selected from the ground floor landing call station. This gives the user the impression the button has been pressed and provides the comfort of knowing the call has been registered and the lift is destined for their floor. In fact all of the car call buttons are inactive and anyone entering the lift who hasn’t placed a call from the landing call station is unable to register a car call.

On the upward journey the car buttons are inhibited until the car responds to a landing call. At this point the car panel is enabled and the boarding passenger can register their car call. In theory there shouldn’t be a problem with this approach as those who boarded at the main lobby also have their call registration illuminated. However for those people who do not understand the operation of the system, probably the majority, this appears odd and incomprehensible.

To try and address the problem and provide clear indication as to when the COP is enabled/inhibited a better form of indication would appear to be required. One approach could be that the car operating panel is in fact a touch screen. The screen is blank, or carries other information, when the lift is at the ground floor and the 'next stop' indicators located in the lift entrance reveals or floor indicator screen provide the comfort for passengers of knowing they are in the right lift to reach their destination. If the lift stops in response to a landing call then the screen becomes active and illuminates as a conventional operating panel allowing passengers to enter their calls. In this situation it could also show destination floors selected at the main lobby as already 'registered'. In addition the smart use of voice announcements could inform passengers of the status or what to do, 'Your destination has been preregistered', 'Please enter a car call' provide information and may help improve the 'user experience'. There is the matter of DDA access to overcome with touch screens but this approach may be considered less confusing than having something 'not working' such as a set of fixed inoperative buttons.

Clearly there is a need to look at the car panel issue but with people becoming very familiar with the technological approach to so much in everyday life the use of a touch screen in the car, albeit with DDA issues to overcome, may offer a way forward for building users to be less confused.

With landing fixtures there is the opportunity to align the design of the ground floor destination panel with the two button fixture used on the upper floors. These can be architecturally similar in design and have the same configured appearance to the user. The use of either touch screens or key pads should be consistent and be seen by the user as similar.

The use of touch screens, both within the car and on the landings, has major advantages in terms of flexibility especially when considering the use of the lifts with special services such as an Imminent Catastrophic Event (ICE) or fire evacuation. Clear graphic signs and information that is only displayed at the time of use have a significant advantage over fixed signage that is only applicable in certain situations.

Listed below are some of the features a hybrid system could employ to improve the user interface and reduce any confusion.

Overcoming the obstacles:-

- The same style of touch screens or key pads for all landing fixtures
- Touch screen COP that is only illuminated when active
- COP only active for inter floor and main floor travel
- Common graphics for all screens, main landing, upper floors and COP.
- The use of 'smart' announcements.

9 CONCLUSION

The assessment of pure performance shows that there are advantages to hybrid systems in terms of service delivery for buildings with high levels of inter floor traffic. This derives from the increased handing capacity of the system as lifts pick up landing calls in the direction of travel irrespective of the passengers destination.

The case for hybrid systems in the up peak and lunchtime, based on Draft BCO 2014 guidance, is not convincing given the waiting times are similar but the time to destination is longer. This raises the question: is it worth the additional time to destination in the up peak and at lunchtime for the benefits of reduced waiting and travel time for inter floor traffic?

In considering the question it is necessary to factor in the obstacles to be overcome with user interfaces. From the author's visit to an occupied building in Manchester with hybrid systems the users and facilities management were very comfortable with the systems and how to use them. This suggests that the interfaces did not present a significant barrier to users and that this part of the question is perhaps one of people being adaptable in what they have to do to reach their destination. Refinement of the interfaces would only help to improve the user experience of a system that requires different inputs at different points.

It appears that many people are not comfortable with the fact there are no car buttons with destination systems and that the element of control they had previously is now removed. Couple this to the issues associated with ghost calls, the need for all passengers to register their destination and inability to reallocate calls and a case could be made for hybrid systems in a general sense.

With most of the main manufacturers offering hybrid systems the industry obviously sees they have an advantage in terms of improved service, although one major supplier is stressing that car buttons provide user 'comfort' as part of their marketing approach.

The question of system selection based on performance is subjective based on who thinks what is better; shorter waiting times for inter floor traffic or consistency of user input, notwithstanding the drawbacks of destination systems. Factors such as building tenancy and future proofing could be a major consideration in determining which system is best suited.

From the users perspective the benefits of quicker inter floor service with the hybrid will not be fully appreciated or recognised. The one thing the user is acutely aware of though is waiting time and in the overall performance comparison the hybrid scores better when high levels of inter floor traffic are being catered for.

With ever increasing pressure on buildings to work harder any improvement in lift performance is to be welcomed. Hybrid systems do offer increased performance in one key area and for this reason deserve to be considered.

REFERENCES

BS ISO 4190 -1:2010

CIBSE Guide D: 2010

Draft BCO Guide: 2014

BIOGRAPHICAL DETAILS

Len Halsey spent a major part of his career with Otis before joining Canary Wharf Contractors in 1998. Appointed Design Manager for Vertical Transportation Systems in 2002 he is responsible for directing Architects, Consultants and Engineers on VT related design matters to meet Canary Wharf and clients standards. He is a member of CIBSE and holds the post of deputy chair of the CIBSE lift group.