My Story of Lift Traffic Analysis, Design and Control 1960 – 2020

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Abstract. This paper, relying on the first 60 years[1] of lift traffic design, provides an objective view of the developments in lift traffic design since 1960. The paper will look at the contributions of, amongst others: Alexandris, Barney, Beebe, Closs, Dos Santos, Godwin, Lim, Peters, Port, Schroeder and Strakosch. Lift traffic developments are of necessity intertwined with lift traffic control algorithms and technology, including Call Allocation and interactive lift system simulation during the same period. A view ahead will be indicated. Footnotes indicate sources for their easy reference by readers rather than being in-line text.

1 INTRODUCTION

This story is my story and will be told in a narrative style in the first person as I was and am still there. Rather than run a time line, I will tell this story based on the people that made it, as evidenced by material in the public domain and by personal contact. There will be material in the archives of lift manufacturers and elsewhere that is missing from this story (unknown-knowns). Most of people mentioned are still alive today, some I know personally others only by reputation. Inevitably there will be people and events left out of this story. Additions/corrections to the story are welcome. An example of this is that during the writing of this story a colleague reminded me of a citation in an article to a paper Dos Santos and I published in 1974[2].

GINA (*née* GEORGE) BARNEY

My first encounter with the lift industry was in January 1968, when Michael Godwin (Adrian Godwin's father) came to the University of Manchester Institute of Science and Technology (UMIST), where I was a Lecturer, seeking help with the stopping and levelling of Ward-Leonard drives. This was a technical problem. David Closs, a student at UMIST, was looking for an MSc project. He resolved this technical problem in September 1968. His work pump primed my interest and my near 50 years work in lift traffic analysis, design and control.

Subsequently I was fortunate to work with many clever people as you will see, who sometimes had eureka moments and were gone, but some have become equally enthused for lift traffic analysis, design and control. The work at UMIST continued to 1993, when I retired and since then I have carried on the work independently.

There are four books and a landmark paper that I have authored/co-authored which objectively report my work and the work of others in the field where it is known. They are:

Landmark Books

Book (1) Barney, G.C. and Dos Santos, S.M., 1977, "*Lift traffic analysis design and control*", Peter Pereginus.

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[1] Gray, L., 2017, Lift Traffic Analysis 1890-1960, 7th Symposium on Lift and Escalator, Northampton, 2017

[2] Green, M.F and Stafford-Smith, B., 1977, A survey and analysis of lift performance in an office building, Building and Environment, Vol. 12, pp. 65-72, Pergamon Press

Book (2) Barney, G.C. and Dos Santos, S.M., 1985, "*Elevator traffic analysis design and control*", Peter Pereginus.

Book (3) Barney, Gina, 2003, "*Elevator Traffic Handbook*", Taylor & Francis.

Book (4) Barney, Gina and Al-Sharif, Lutfi, 2016," *Elevator Traffic Handbook*", Routledge.[3]

Landmark Paper

Barney, G.C. and Dos Santos, S.M., 1975, "*Improved traffic design methods for lift systems*", Bldg. Sci.

2 BACKGROUND

2.1 Traffic Analysis and Design

In the beginning from 1890 to 1960 there were many people, who laid the foundations of modern lift traffic analysis and design[4]. This list compiled by Dr Lee Gray for his paper included: Root (1890), Hill (1893), Darrach (1901), Kidder (1904, 1916), Pelham Bolton (1908), Tweedy (1912-13), Ehrlich (1914), Cook (1916 - 1932), Gumpel (1916), Gillette and Dana (1918), Jones (1923 - 1926) Grierson (1923), Marryat (1924), Kinnard (1930), Annett (1935, 1960), Phillips (1939, 1951), Molloy (1941).

In 1968 I was blissfully unaware of this work. My foundations were built on George Strakosch's landmark book published in 1967, which did inform me at least of Bassett Jones.

2.2 Traffic Control

Six "Eras" of traffic control can be identified:

Era	Dates	Traffic Control Type
I	1850–1890	Attendant simple mechanical control
II	1890–1920	Attendant and electrical car switch control
III	1920–1950	Attendant/dispatcher and pushbutton control
IV	1950–1975	Automatic group control: IVa scheduled traffic control to 1960 IVb demand traffic control from 1960
V	1975–1990	Computer based group control
VI	1990 –	Call Allocation group control

The transition from a human pulling a rope to a computer making decisions took nearly one hundred and fifty years. This story starts in Era IVb.

2.3 Traffic Simulation

The early traffic simulations used batch based processing, where paper tape, or cards, or magnetic tape drives provided the input method and line printers produced reams of paper for the output. In between the algorithms were coded, possibly in Fortran, but often in assembly language.

Interactive computing is relatively recent dating from the late 1960s/early 1970s. Today "Apps" are everywhere. Interactive traffic design only became possible when time sharing computers video display units became available.

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[3] Records 283 references and 32 bibliographic entries of all the people and publications we could find in the field.

[4] Gray, Lee, 2017, Lift Traffic Analysis 1890-1960, 7th Symposium on Lift & Escalator Technologies, September 2017

3 THE BEGINNING – MY FOUNDATIONS – MY MENTORS

BASSETT JONES

Jones, when working for the General Electric Company was interested in sizing lift motors for the duty that they had to meet [5] So he wanted to know the number of stops[6]. He was also interested in drive dynamics[7]. He was not a lift industry member.

GEORGE STRAKOSCH

He worked for Otis and later became a consultant. In 1967 he wrote a landmark book[8] that updated the work of R.S. Phillips'1939 book [9] He gave a traffic design method. This was the first significant attempt to bring traffic analysis into one place. He defined and used the concepts of five minute peaks, handling capacity and interval and established a lift's cycle time as the round trip time.

Strakosch's method was very pragmatic – basically a recipe system – and not at all formulaic. He added the times to open and shut the doors, the time that passengers take to get in and out and the time to move up and down to provide a value for a Round Trip Time.

MICHAEL GODWIN

He is very important to my history. When we met he was Technical Director of William Wadsworth, Bolton. Very innovative and intuitive, he was very much in advance of his time. It was he who suggested putting the call buttons on the landing. I do not know if he had heard of Leo Port (see Port), but sometimes great minds are separated by 12,000 miles.

He and I set up Lift Design Partnership in 1974, which became Lerch Bates Europe, in 1990, when Michael retired. I remained Chairman/Chairman Emeritus until 2002. Besides producing a radically new standardised specification for public housing lifts[10] his main technical innovation was Bush House [11](see Beebe and Lim).

To this day he is interested in linear motor driven lifts. And this is how he met and employed Haider Al-Abadi[12] for nineteen years, currently Prime Minister of Iraq.

JORIS SCHROEDER

Joris Schroeder when reading for his doctorate in 1955 derived a formula for the highest reversal floor H [13].

He was also very brave to produce the first implementation of Call Allocation at Schindler's Ebikon offices in December 1989. This was against strong company opposition and significant industry derision at the time. All the usual ill informed "*No one will use it*", etc. He used the technical specification that Dos Santos and I published in our 1977 book (Book 1). He did not fully implement the specification, such as penalty functions, dynamic uppeak subzoning, adaptive algorithm, etc. Today the industry derision has disappeared to be replaced by over enthusiastic adoption of what is (commercially) called "Destination Control", see David Closs below. Joris sadly passed away before he saw the fruits of his endeavours – a badly missed interlocutor.

Schroeder also published equations for H and S to adapt the RTT equation so that an uppeak

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[5] https://archive.org/details/generalelectricr26gene
[6] Jones, Bassett 1923, The probable number of stops made by an elevator, GE Rev., 26, (8)
[7] Bassett Jones, 1924, Time-velocity Characteristics of the High-speed Passenger Elevator. General Electric Review, Vol. 27, February 1924
[8] Strakosch, G.R., 1967, Elevators and escalators, 1/ed, Wiley
[9] Phillips, R.S., 1939, Electric lifts, Pitman
[10] Godwin, M.,1973, Formulating the specification, Lift, 15, pp141-146
[11] Godwin, M., 1986, Bush House: Lifts of the World
[12] Al-Abadi , H. J, 1980, Disc and linear forms of electronically controlled permanent-magnet claw machines, PhD thesis, University of Manchester, 1980
[13] Schroeder, J., 1955, Personenaufzuege (passenger lifts), Foerden und Heben, 1 (in German)

calculation could be performed for Call Allocation. The variable *k* is the famous look ahead.

4 THE MIDDLE 1960-2017

DAVID CLOSS

In my autobiographical note I mention David Closs as my first MSc student in 1968 and my first PhD student. After completing his MSc, Closs registered for a PhD to research the behaviour of traffic control algorithms[14]. His first analysis considered the best method for a lift to answer a set of landing calls (the "travelling salesman" problem). He concluded the best method was directional collective and elaborated four rules:

> **Rule 1** A car may not stop at a floor where no passenger enters or leaves a car.
>
> **Rule 2** A car may not pass a floor at which a passenger wishes to alight.
>
> **Rule 3** A passenger may not enter a car travelling in the reverse direction to the passengers required direction of travel.
>
> **Rule 4** A car may not reverse direction of travel while carrying passengers.

To which can be added a pragmatic rule:

> **Rule 5** Car calls take precedence over landing calls.

There are some workers[15] today who suggest that Rules 2 and 4 can be violated for the convenience of the traffic algorithm. This defies Closs.

Closs went on to analyse what he called "Call Allocation" [16], ie: to give the control algorithm a passenger's destination and not just their direction. This meant putting the destination call buttons on the landing not in the car. His analysis showed the promise of this idea.

After graduating in 1970, Closs did not stay in the industry.

SERGIO dos SANTOS

He is responsible for the major developments of: the derivation of the RTT equation; interactive simulation; the analysis of various traffic conditions and control algorithms; and most importantly a full definition of the Call Allocation traffic control algorithm in two forms: Hall Call Allocation and Adaptive Call Allocation. Sergio dos Santos took Closs' work further on.

Interactive Simulation

In May 1972 he registered for an MSc with me. By 1972 it was obvious that we would not get anywhere unless we could emulate or model a lift system in some way. In May 1972 I defined a basic simulation program comprising an input module, a control and simulation module and an output module. I gave Dos Santos this specification and went to Argentina for three months. When I got back Dos Santos had done it and had also coded a simple full collective algorithm as Closs had defined it into a fully interactive program[17]. We had LSD (Lift Simulation and Design) simulation[18] program! Dos Santos agreed to read for a PhD on this topic.

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[14] Closs, G.D., 1970, The computer control of passenger traffic in large lift system, PhD thesis, UMIST

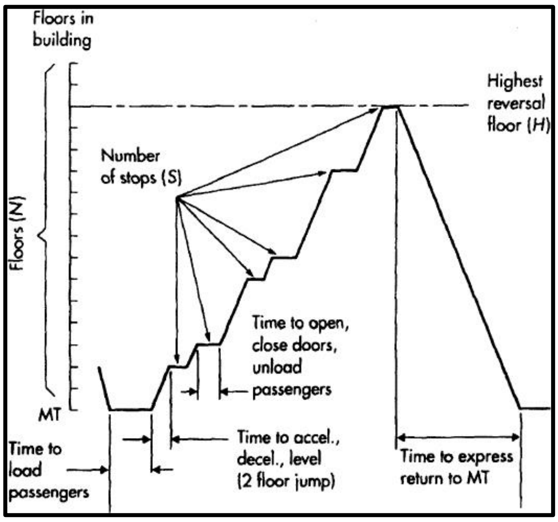
[15] Gerstenmeyer S., Peters R. D., 2014, Reverse Journeys and Destination Control, Proceedings of the 4th Symposium on Lift & Escalator Technology

[16] Sometimes called "Destination Control", which is ambiguous, it is the user that determines the destination not the traffic control algorithm! Destination Control is the commercial name for Call Allocation.

[17] In the 1970s must computers operated in batch mode.

[18] Dos Santos, S.M., 1972, Lift simulation, MSc dissertation, University of Manchester Institute of Science and Technology

Round Trip Time Formula



In the course of the programming the LSD program, it was obvious that the Strakosch "recipe" method of sizing could better be described mathematically. We defined the now classical *RTT* equation in the period of Dos Santos' work and published the first version of it in our 1975 paper as:

$$RTT = 2H\,t_1 + (S+1)\,t_2 + 2Pt_3$$

This is the basic equation and obeys Closs' rules. It can be adapted for other conditions than uppeak (not given here). The equation presentation has changed little over the last 42 years, except to make it more understandable to the mathematically challenged and now looks like:

$$RTT = 2Ht_v + (S+1)(T-t_v) + 2Pt_p$$

This equation is simple in concept and it is worth explaining.

Three independent variables (t_v, t_s, t_p) and three dependent variables (H, S, P).

The first term is for the time a lift is moving, ie: a travel distance of H floors with a time between floors of t_v.

The second term is S times (+1) the time consumed in stopping, ie: for door operations, drive control.

The third term is what the passengers do, ie: get in and out of cars taking a time of t_p.

The middle term is the most significant, as a second added here may reduce the handling capacity by 5-10%.

The variables H, and S are dependent on the number of passengers (P) in the car, when it leaves the main terminal and the number of floors above the main terminal (N).

So there is really only one independent variable and two dependent variables! And these are evaluated by Bassett Jones (1923) for S and Joris Schroder for H (1955).

Dr Lee Gray in his paper highlights George Hill's search for a "*uniform law*" for lift traffic analysis[19]. The two equations above (the only two in this paper) might do it – 82 years later?

Call Allocation Traffic Control Algorithm

Working with Closs' skeleton derivation of the Call Allocation traffic control algorithm, Dos Santos developed a full specification of the two variations of the algorithm. The first was Hall Call Allocation. The second was Adaptive Call Allocation. There were many features: penalty functions, dynamic uppeak subzoning, adaptive algorithm, etc. all described in his thesis[20] and in our jointly authored book Lift Traffic Analysis Design and Control in 1977 (Book 1). By putting this specification into the public domain by prior publication of Closs' and Dos Santos's PhD theses in 1972 and 1974 it prevented it being patented by a manufacturer (one tried and failed) and could be offered to all. The specification has never been fully implemented by any manufacturer although Schroeder was close to it. And Peters has a closer representation of HCA, but not ACA in Elevate.

Analysis of Traffic Conditions

Dos Santos and I realised that having an interactive program (LSD) meant we had a powerful tool to analyse all traffic patterns and any control systems. At the time LSD was being developed the traffic control systems were based on relays and some electronics. They were not simple. The main ones

[19] Hill, George Hill, 1893, Some Practical Limiting Conditions in the Design of the Modern Office Building, The Architectural Record, Vol 5, 445-468 (April-June 1893)

[20] Dos Santos, S.M., 1974, The design, evaluation and control of lift systems, PhD thesis, UMIST

were fixed bidirectional sectors, eg Otis VIP 260, fixed time based sectors, eg: Express Mark 4 and dynamic sectors, eg: Schindler Aconic.

The question is how do they affect actual performance?

Dos Santos programmed these algorithms into LSD and ran over 2000 simulations and produced a series of graphs for uppeak, down peak and interfloor traffic. To do this he invented traffic profiles, which you can see today as "templates". This work enabled some rules of thumb to be developed and these fed back into the design process.

Alongside this work Dos Santos also programmed the Hall Call Allocation algorithm and analysed it. During this work he developed Adaptive Call Allocation (ACA), which switched the cost function (*aka* performance index) from journey time to waiting time for low loads.

Dos Santos did not stay in the lift industry but went on to be the Rector of the Universidade do Minho, Portugal from 1985-1998.

LEO PORT

Port proposed, what we all accept now, taking the pushbuttons out of the car and putting them in the hallway/lobby/foyer/landing. It was the first proposal for Call Allocation, which is what Closs called it. Port patented[21] it as PORT–El in 1961, which he let expire in 1977. He had two implementations, one in the Law School at the University of Sydney[22] and the other was in the Australian Milk Marketing Board offices. Both installations were low rise and only had two or three lifts. Port did not have any computing power so he programmed the lifts to always go to the same floors using simple fixed logic.

He became Lord Mayor of Sydney in 1975 and died in office in 1978.

In retrospect Call Allocation traffic control systems should be called Port-El systems to honour someone, who changed the whole scene of lift traffic control.

PETER TREGENZA

The formula derived by Jones and Schroeder used the simple probability distribution function (pdf), often known as a rectangular or constant pdf. What this represents is people arriving with a constant interval between them. But do people arrive like that? It is thought that a Poisson pdf was more likely, see Alexandris. Tregenza in 1972 accepted this and developed relationships[23] for the variables S and H.

Dos Santos was subsequently able to show that a Poisson pdf gave smaller values for S and H and hence a more optimistic design than the constant pdf. This allowed the simpler formulae and processes to be the chosen procedure.

NICOS ALEXANDRIS

Alexandris was a mathematician and registered for a PhD[24] with me. Out of intellectual curiosity he was set the task to prove mathematically what had been discovered by the Dos Santos simulations, hence the title "*Statistical models in lift systems*". His first task was to survey buildings to determine the arrival process. He found it to be (probably) Poisson. By queuing theory he was able to show the 80% loading factor to be the interface between a good system and a poor system. Along the way he developed a general analysis[25].

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[21] Port, L.W., 1961, Australian patent specification 255218, 1961
[22] Port, L.W., 1968, The Port elevator system, University of Sydney, June, 1968
[23] Tregenza, P.R., 1972, The prediction of passenger lift performance, Archit. Sci. Rev
[24] Alexandris, N.A., 1977, Statistical models in lift systems, PhD thesis, UMIST
[25] Alexandris, N.A., Barney, G.C., Harris, C.J., 1979b, Derivation of the mean highest reversal floor and expected number of stops in lift systems, Applied Mathematical Modelling, Volume 3, August 1979

BRUCE POWELL

The story of random behaviour would not be complete without mentioning Bruce Powell. Powell is a long time contributor in the application of mathematical modelling to lift design and control systems. I first came across his work ca1972[26] and it might well have influenced Alexandris and Dos Santos. He shaped some of the theory we use today.

After university his career was in the lift industry initially at Westinghouse, where he was involved in coding simulation software ca1967. He later moved to Otis and in 2002 reached the inevitable destination of becoming a consultant. In 2005 he was one of the "Four Doctors".

RICHARD PETERS

I have known Richard Peters since he was an undergraduate (1986) and I and Lutfi al-Sharif were pleased to examine him for his doctorate[27]in 1997. Amongst other things (the list is long), working from first principles, he derived the Generalised Analysis method[28] which improves on Alexandris' work by providing a more extensive method of analysing any peak traffic flow, not just uppeak.

However, his most significant contribution to lift traffic analysis, design and control, by far, is the implementation of interactive computer simulation programs.

His interest in lift traffic simulation began whilst employed at Ove Arup and when he set up his own company in 1997 - Elevate was born. I worked with Peters, for five years from 2002, to develop simulation technology. That is why many of the graphs and tables resemble LSD and PC-LSD [29].

Peters' simulation has done what I never achieved by becoming a worldwide industry standard, applied by more lift professionals than any other traffic design software. LSD only achieved 20 sales – but it was programmed in FORTRAN 4, and ran on machines the size of a transit van. It could be said LSD lives on in a different guise.

I and my students have used simulation as a powerful research tool. Peters has followed this route and developed a number of dispatching concepts and design ideas in a similar manner to Dos Santos, when using LSD. As an adjunct to this work, Peters has carried out surveys on lift traffic and lift performance for research, and as a basis for making decisions about the benefits of modernisation. This work has proved that the area based traffic design method is the correct approach and validated my work.

His many contributions can be seen in the CIBSE and BCO guidance. In the former he has published a number of traffic templates based on buildings surveyed.

Peters has always been a friendly, but robust challenger of my work. The why's and the where fore's in many a profound debate. In particular my concept of sizing a lift by area and not mass. He was a sceptic until his surveys showed design by area was the more realistic scientific approach. Area based design has been in his software since 2010 and now is used by the vast majority of designers worldwide for lift selection. See Gina Barney (encore).

LUTFI AL-SHARIF

Al-Sharif worked for a lift manufacturer in Jordan. He became my PhD student in 1989[30]. In work for his doctorate he evolved a predictive method called the inverse *S-P* of deducing the number of passengers from the number of stops. It is interesting to note that Bassett Jones used this formula to determine the variance of *S* from its expected value *E(S).*

[26] Gaver, D.P. and Powell, B.A., 1971, Variability in round trip times for an elevator car during uppeak, Transpn. Res.
[27] Peters, R.D., 1997, Vertical transportation planning in buildings, Eng.D. thesis, Brunel University
[28] Peters, R., 1990, Lift traffic analysis: Formulae for the general case, Building Services Engineering Research & Technology, 11(2), 1990
[29] These can be seen in Book 3.
[30] Al-Sharif, L., 1992a, Predictive Methods in Lift Traffic Analysis, Ph.D. Thesis, Oct 1992, UMIST,

Another lift control problem that Al-Sharif investigated was bunching[31]. This phenomena is very destructive of lift performance.

After a brief excursion on escalators for London Underground and consultancy, he returned to the University of Jordan. He is currently very active in lift research and education.

As a result I am pleased he has joined me as co-author in the second edition of the *Elevator Traffic Handbook*, Book 4.

In the book he makes a new suggestion that he calls the HARINT plane. This is a visualisation of the conventional iterative process to balance the two design parameters handling capacity and interval. This method provides a route to determine the necessary value of *P*, which is the number of passengers a car must accommodate.

He hopefully can ensure a continuing life to the *Elevator Traffic Handbook* (Book 4).

He has moved Manchester, England to Amman, Jordan.

SINHO LIM

S.H.Lim was another one of my PhD students[32]. Observations by Lim of legacy controlled lift systems had indicated that the response times to answer landing calls follow an exponential curved shape. This distribution curve has a large number of calls answered in zero time or during the first time band. However, there is a long tail to the distribution with some calls waiting very long periods of time. He developed a new traffic control algorithm called Computer Group Control (CGC). The full text was published in Book 2 in 1985[33].

The intention of a CGC Traffic Control System is to provide an even service to all floors, where every landing call is given a fair consideration. This means that the landing call that has been waiting the longest should be given the first consideration for service. To achieve this egalitarianism, landing calls are considered to form a queue and will generally be served in the order of their waiting time. The intention of the CGC algorithm design was to bring the tail closer to the average and to sacrifice the "instant" collection of some calls by moving the exponential away from the origin to a Gaussian shape similar to the Rayleigh Distribution curve. Jon Halpern (see Acknowledgements) subsequently extended this concept and he analysed a number of other distributions[34]-[35].

JONATHAN BEEBE

Jonathan Beebe was my PhD student in 1977 and graduated in 1980. In 1980 Lift Design Partnership were appointed to modernise the lifts in Bush House (home of the BBC World Service at that time). Beebe first of all worked on the single car controller and was later joined by Lim to implement the CGC algorithm. A unique feature of the Bush House implementation was the ETA and actual time displays on the landings.

After the Bush House handover in 1984, Beebe continued to work on lift monitoring equipment. In 1989, Beebe stopped working full time in the lift industry, but maintained an interest in applying current techniques for the modelling and development of software systems to lift management.

As a result of Lim's work on CGC being published (in Book 2) the Bush House code was taken up by a continental lift company and in 1994 Beebe assisted their commercial implementation. Subsequently, from about 2007 Beebe has been continuing the development of CGC and other cost function (*aka* performance index) based algorithms. It is not known if CGC is embedded in other

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[31] Al-Sharif, L.R. 1993, Bunching in lift systems, Elevator Technology 5, IAEE Publications

[32] Lim, S.H. 1983, A computer based lift control algorithm, Ph.D. thesis, UMIST

[33] Barney, G.C. and Dos Santos, S.M., 1985, Elevator traffic analysis design and control, Peter Pereginus

[34] Halpern, J.B., 1992, Variance analysis a new way of evaluating elevator dispatching systems, Elevator World, September

[35] Halpern, J.B., 1993, Variance analysis of hall call response time, in Elevator Technology 5, proceedings of Elevcon '93, Vienna, Austria, November 1993, pp 98 – 106

company's products.

In 2003 Beebe published the Standard Elevator Information Schema[36], which in 2005 was applied in the design and prototype implementation of a city-wide remote monitoring system to be used on to all new and refurbished lifts in government buildings in Hong Kong. He continues to be active in retirement on the integration of lift systems into the Internet of Things and open standard information modelling.

MARJA-LIISA SIIKONEN

I first met M-LS in 1993 at ELEVCON, Rome, when she was awarded best paper. She worked closely with Roschier and Kaakinen[37] at Kone, Finland. She has over 50 lift papers. She instigated the "Four Doctors"[38] meeting in September 2004 to develop lift traffic definitions, which still stand today.

Over the years we have debated many things robustly. And she has 23 references in Book 4 after Peters with 26 and myself with 29. She out ranks me on Google Scholar with 803 citations to my 653. She and Peters are the only two people formally acknowledged in Book 4. Her work has centred on traffic design and traffic control systems and her group at Kone have greatly contributed to the survey data vault.

Recently she has been Convenor of ISO/TC178/WG6/SG5 revising ISO 4190-6: 1984 (to be known as ISO 8100-32).

ANA LORENTE

Computer simulation is a very powerful research tool to inform a design process. This was particularly true in recent work on the energy efficiency of lifts. I met Ana as the Spanish (AENOR) delegate to ISO/TC178/WG10 in May 2009. WG10 was developing the ISO 25745 series of energy standards. She was researching life cycle analysis for a doctorate and not making much headway. On joining WG10 she gained a purpose. To populate the equations being developed by the Working Group, values of load, distance travelled and balance factors had to be obtained. Ana volunteered to find these. She knew little about lift traffic design, but soon did and carried out thousands of simulations using Peters' simulation. The Convenor of WG10 said "*These simulations have helped accelerate the development process of these (ISO 25745) standards and provided invaluable scientific input on which to develop the classification for lifts*"

She decided to include this work in her LCA thesis and she became my latest doctoral student. She graduated in 2013[39].

Ana has illustrated the power of simulation.

GINA BARNEY (*encore*)

The forgoing relates much of my involvement in lift traffic design and control. This autobiographical note relates to my recent independent work. This is to do with the sizing of lift cars.

I became conscious of the anomaly between the stated passenger capacity (in persons), displayed on the in-car rating plate and the actual number of passengers observed in a car. In the mid1980s, I struggled with the notion that according to the BS 5655-1/2 standard of the time a 450 kg car with a platform area of 1.2 m^2 could accommodate 6 persons (ie: 0.21 m^2/person) and a 2500 kg car with a platform area of 5 m^2 was rated at 33 persons (ie 0.15 m^2/person). The former occupancy would be

[36] Beebe, J.R., Standard Elevator Information Schema, http://www.std4lift.info/, 2003-8

[37] Roschier, N.R. and Kaakinen, M.J. 1980, New formulae for elevator round trip time calculation, Elevator World, August 1980. – 7.4.1, A1

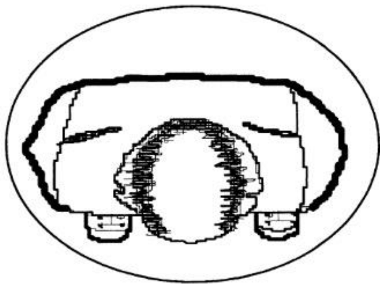
[38] Barney, G.C., Peters R.D., Powell, B.A. and Siikonen, M.L., 2005, Towards agreed traffic definitions, Elevator World: February 2005 (pp 108), Elevatori, 1/2005, Elevation, Issue 42

[39] Lorente, A.M., Lifts Life Cycle Analysis Modelling, Classification of Lifts Energy consumption and Rules for Environmental Statements, Doctoral Thesis Centro Politécnico Superior. Universidad de Zaragoza, 2013

comfortable, but the latter somewhat like the London Underground during rush hour.

The reason for this was that the standard calculated the number of 75 kg passengers that would be needed to fill the car to the rated load. A safety matter. It was unfortunate that architects, developers, lift companies and consultants, including me, believed this as real life.

So what should the occupancy be for traffic design?



In the USA, circa 1920s, a 150 lb (68 kg) person stood on two square feet (0.186 m^2). This equates to a 75 kg person occupying a space of 0.2052 m^2. Fruin[40] drew a person template with a body ellipse of 600 mm by 450 mm, which is also 0.21 m^2.

Strakosch in his 1967 book observed the loading of lift cars did not meet the assumed loading based on weight.

As the result of my research work in the late 1980s, I published an actual value for passenger capacity in Table 3.4 of the 1993 edition of CIBSE Guide D based on a body ellipse of 0.2 m^2 and a 5% reduction for handrails, etc. But I did not apply it properly to my designs.

Surprisingly the ISO Technical Report ISO/TR 11071-2, 1996[41] said:

> "*While the entire subject of capacity and loading has historically been treated in safety codes as one and the same, it might be more meaningful in the future writing of safety codes to cover loading as a separate issue from capacity. One refers more appropriately to the traffic handling capacity, whereas the other refers to the maximum carrying capacity which has a direct bearing on safety*."

My ideas were also expressed in the many editions of the Elevator and Escalator Micropedia from 1997[42]. But no one took any notice. The change from mass to area based lift car sizing was fully recommended in the 2000 edition of CIBSE Guide D.

In 2001, Peter Day[43,44] made a number of supporting observations and confirmed what many had reported.

The Elevator Traffic Handbook published in 2003 (Book 3) continued to inform the concept and although only 800 copies were sold it reached the people who needed it. In 2006 the ISO Technical Report ISO/TR 11071-2[45] repeated its 1996 text.

My strong stance in Guide D: 2000 alerted Richard Peters to the concept. At first Peters doubted the concept, but on confirming it for himself by on-site observations, finally introduced it into his proprietary software design program in 2010. Book 4 (with Al-Sharif) uses a wholly area based selection for lift car sizing.

The latest editions of the British Council of Offices guidelines[46] recommend area based car selection.

In conclusion it is important to size lifts to fit people, not to weigh them. That is, a method based on providing the personal space, which is comfortable for a person to occupy. This method has replaced the previous method using weight (mass) over a period of evolution commencing in the 1990s and

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[40] Fruin, J.J. 1971, Pedestrian planning and design, Metropolitan Association of Urban Designers and Environmental Planners

[41] ISO/TR 11071-2:1996, Comparison of worldwide lift safety standards - Part 2: Hydraulic lifts

[42] Barney, G.C., Cooper D.A. and Inglis, J. 1997, Elevator & Escalator Micropedia (reprinted 1998, 2001, 2006)

[43] Day, P. 2001a, Passenger comfort - Are you travelling comfortably? *Elevator World*, April. 2001

[44] Day, P. 2001b, Lift passenger comfort have we got it right?, Elevatori, September 2001

[45] ISO/TR 11071-2:2006, Comparison of worldwide lift safety standards - Part 2: Hydraulic lifts(elevators)

[46] British Council for Offices Guide for Specification, 2014

which became almost fully established in the 21st Century.

In the future all designers will use area based selection so that *P* passengers can be comfortably accommodated in a lift car.

5 THIS IS NOT THE END – IT IS JUST THE BEGINNING

"*If you can look into the seeds of time, and say which grain will grow and which will not, speak then unto me."* --William Shakespeare

Will we ever reconcile calculation and simulation?

One of the perennial problems that the lift industry has long grappled with is the reconciliation between the design of a lift system using calculation and the corresponding results obtained from such a system under simulation. It has always been disconcerting to find that lift systems designed using the conventional calculation techniques do not produce the same results, when simulated.

But why don't calculations and simulations line up? One obvious answer is that calculations can consider non integer numbers of passengers whereas in simulation they must always be whole numbers! There are many other reasons (see 17.2 of Book 4).

Why Calculate?

Simulation is a powerful research tool. Dos Santos *et al* has shown this for lift traffic design and control and Lorente has shown it for energy calculations. Simulation has been able to inform the calculation theories and has enabled them to be improved.

However my mantra is "*Calculation first – simulation second*". I can get close to a final design by simple spreadsheet calculations. Why should I waste time doing endless simulations when I can get there quickly by calculation? Simulation gives reassurance and gilds the reports in a commercial exercise.

Will Call Allocation Group Control Spell the End of Building Sectoring?

It has been long accepted that lift traffic systems installed in buildings with more than 20 floors should be sectored or zoned. It is recognised that having a dedicated bank of lifts for each section of the building can prove to be wasteful, especially if the peaks of the traffic of the different section of the building do not coincide.

Call Allocation group control systems are becoming more widely used in new lift installations, often inappropriately. One of the main advantages of using Call Allocation group control systems is the fact that they are able to group passengers such that the number of stops are reduced, and hence the passenger travelling time is kept below specified values.

It is suggested that the lifts within different groups could be combined into one group and controlled by Call Allocation group control. This will probably force the use of the dynamic sub zoning algorithm missing in current implementations of Call Allocation.

Will Call Allocation Ever be Used Properly?

First there are no full implementations of Call Allocation as specified in Book 1. Peters' simulation program is close.

Second to achieve an advantage there needs to be at least four lifts in a group. Many installations use Call Allocation as a sales gimmick.

The answer is probably not.

Better Educated and Training of Lift People

More complex control algorithms will require a new level of skill and understanding on the part of traffic design engineers. The area of traffic design skills rest with a small number of people and needs to be propagated to lower level staffs (sales staff, consultants, etc.) maybe by intelligent design engines implementing the algorithms inculcated by the true experts. Peters and I have developed a simple car selection table using an expert system[47].

Information sharing is a great opportunity to introduce a new generation of creative and imaginative engineers into the industry and thereby enhance its profile in the public perception.

Will the Paternoster Come Back?

Peters and Gerstenmeyer[48] have suggested a modern form of the Paternoster with rope less linear motor drives and have derived traffic design methodology. There are two problems: safety and security of service. Presently the Essential Health and Safety Requirements of the Lifts Regulations would not permit such a system. And if they did meet the EHSRs, then service resilience is dependent on an unobstructed shaft (broken down lift ahead).

Information Sharing

How long have I been asking for open data? Ever since BRE awarded UMIST a contract to data log lifts back in 1975.

Smart buildings, smart cities, Internet of Things, BIM Level-3, etc. require the sharing of all sorts of operational information with building owners and users. Hopefully, the ancient reticence (obstinacy-*sic*) to disclose any information about lift operation will be overcome by the realisation of the new and valuable business opportunities that greater interconnectedness opens up.

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[47] Available on request
[48] Gerstenmeyer, S. and Peters, R., 2016, Proceedings of The 6th Symposium on Lift & Escalator Technology

… and many more people - too many to mention - who I have been stimulated by, worked with, supervised or have influenced.

AUTOBIOGRAPHY

Born 1935, Dr Barney left school at 16. She has the technician qualifications of ONC (1954) and HNC with distinction (1956); the graduate qualifications of BSc with honours (1959), MSc by research (1962)[49] and PhD (1965)[50]. She has the professional qualifications of CEng, FIEE and HonFCIBSE (for exceptional services to the Institution).

Following the award of her doctorate she moved to connecting particle physics analysing equipment to IBM computers and after joining UMIST designing and creating a hybrid computer for control research. Dr Barney founded a research group at UMIST into all aspects of lift systems in January 1968, whilst a lecturer and senior lecturer in the Control Systems Centre, University of Manchester Institute of Science and Technology (UMIST). From 1985 – 1990 she was Director of (computer) Networking at Manchester University retiring fully from academic life in 1993 to work full time as a consultant.

Dr Barney has authored, co-authored or edited over 20 books and over 100 reviewed papers. Notable of these are Books 1-4 indicated in the Introduction.

Gina is Technical Editor and Contributor to CIBSE Guide D: 2000, 2005, 2010 and 2015. She is a Member of BSI – MHE/4 Committees, delegate to ISO/TC178 WG6 and WG10 working groups, BRE Associate, Member of CIBSE Lifts Group and CIBSE Professional Conduct Committee, English Editor of *Elevatori*, Freeman of the City of London, Liveryman of the Worshipful Company of Engineers. Expert witness. Currently she is Principal of Gina Barney Associates.

She still finds time for ballroom, Latin, sequence and Scottish Country dancing, gardening and driving a fast car. Trustee of several Sedbergh Town charities.

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[49] The stability of controls systems containing cascaded nonlinearities University of Durham, MSc, 1962. {Control theory}

[50] The magnet control of the Birmingham Proton Synchrotron, University of Birmingham, PhD, 1965. {Control practice}