LIFT SIMULATION USING PC's

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ABSTRACT
A generalised lift simulation and design suite (LSD) was developed at UMIST some 15 years ago. The program suite allows the traffic design of lift systems to be carried out on a main frame digital computer with the results being viewed graphically. Although the LSD suite has been enhanced by the addition of new control algorithms over the years its structure has remained substantially the same. This paper describes a proposal to transfer the kernal of the suite to an IBM-PC or equivalent with improved input and output facilities.

1 GENERAL

1.1 Calculations, Simulations and Computer Aided Design (CAD)

It is a relatively simple matter to perform a traffic calculation to determine the Round Trip Time, Interval, Handling Capacity and Percentage Population served for an up peak traffic condition (Barney, 1986). The factors evaluated are, however, only related to quantative criteria. Such qualitative criteria as passenger waiting times and journey times can not be easily determined. Worse it is not easy to evaluate other traffic conditions such as down peak and interfloor (Alexandris, 1977).

Complex engineering and scientific systems, such aerodynamical flows and weather forecasting, are often studied in depth using simulation techniques. Here the equations describing the system being studied are programmed onto a computer and subjected to a set of input conditions so that the output responses may be studied. Differential equations normally describe continuous systems and originally were simulated on analogue computers, but are now solved on fast digital computers using continuous system simulation languages (eg ACSL). Difference or logical equations describe discrete systems and they have always been solved using digital computers often making use of discrete simulation languages (eg SIMULA). A lift system falls into the latter class of simulation activities.

Engineers over the last two decades have used computer aided design (CAD) techniques to analyse engineering systems. These techniques harness the power of the digital computer to take the tedium out of such work and improve the accuracy of the results. The engineer is still in control of the design as the computer does not select the final system. Expert systems have been developed recently, where the skills of the expert is captured into the computer program. These systems are of great help in diagnostic situations (eg medical), but do not as yet contribute greatly to engineering design, where inventive and intuative leaps are still the perogative of the human. In the case of lift traffic design a CAD system for lift systems follows the conventional path of most CAD packages and comprises an input module for system definition, a compute intensive simulation module and an output module for system analysis.

1.2 Simulation of Lift Systems

Jackson (1970) wrote "... a real need ... is a computer program to simulate the likely performance of proposed lift systems ... Different numbers, speeds and groups of lifts should be considered, as well as different control systems ... the results would show designers the performance of several proposals ... (and allow) ... rational decisions."

Early uses of digital computers for traffic designs were simply emulations of an advanced desk top calculator. Mostly the simulations were performed in batch mode rather than with the designer interacting with the program. Probably the earliest simulation is by Parlow (1966), who simulated a 2-car group in a 11 floor building. The World Trade Centre, New York comprising 95 cars and 110 floors was simulated by Browne et al (1968) with a specific program for the building. Hitachi (Yuminaka et al, 1973) had a program specifically for their control system. The earliest attempt to produce an on-line interactive general simulation program for all traffic conditions and a variety of control systems was at UMIST in 1972 (Dos Santos). Since then most manufacturers have developed specific systems and other packages following the same lines have evolved (Lustig, 1986).

1.3 Advantages of Simulation for Lift Systems

To simplify up peak calculations a number of assumptions are made:

- (A) All floors are evenly populated.
- (B) Contract speed is reached in a single floor jump.
- (C) Interfloor heights are equal.
- (D) The supervisory control system is ideal.
- (E) "Lost times" (despatch, loading, door dwell times, etc.) are negligible.
- (F) Each car transports 80% of contract capacity on each trip.
- (G) Passengers arrive uniformly with time.
- (H) There is an ideal arrival profile.

Although some of the assumptions do not have a great significance others do. Also it is not possible to calculate easily down peak and interfloor traffic patterns.

The biggest asset of simulation techniques is to be able to gather data and present it graphically in many forms:

- (A) Average and maximum values of passenger waiting times.
- (B) Average and maximum values of passenger journey times.
- (C) Average car loads.
- (D) Average intervals.
- (E) Spatial plots of car movements.
- (F) Listings of data,

  etc., etc.,

The skilled use of simulations for lift traffic design allows various hypotheses and ideas to be tried out and a "best" solution proposed. In addition a simulation suite used in batch mode allows the extensive analysis of a wide range of traffic conditions, control systems and installations.

2 DESIGN OF THE LIFT SIMULATION AND DESIGN (LSD) SUITE

Most CAD suites follow the structure given in Figure 1.

It can be seen that an Executive module controls access to all the other modules and deals with ensuring correct data is available at all stages. (For instance it prevents the output module being entered before a simulation has been carried out.)

The Input module allows the system data to be entered and checks that all data are valid and produces error messages if not. (For instance that sensible numbers of floors are entered.) The module also offers values for flight times for specified contract speeds and informs the designer of

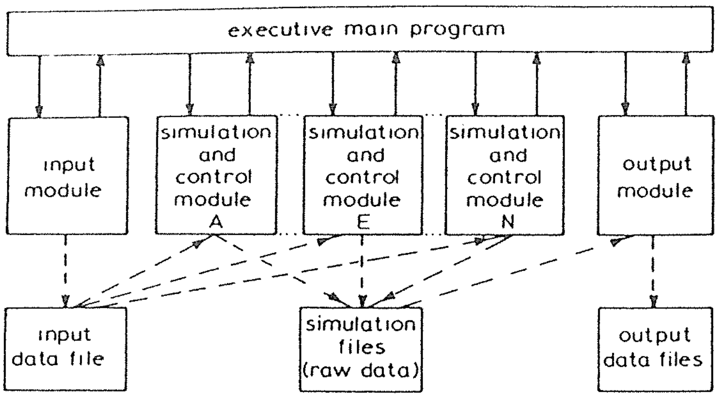

FIGURE 1: Structure of LSD suite

Question: WHICH MODULE TO RUN NEXT?

Help message: TYPE:

(a)

INP	:	TO RUN THE (INP)UT MODULE
SIM	:	TO RUN THE CONTROL AND (SIM)ULATION MODULE
OUT	:	TO RUN THE (OUT)PUT MODULE
L	:	TO (L)IST THE INPUT DATA
E	:	TO (E)ND THE PROGRAM SUITE
H	:	TO GET THIS (H)ELP MESSAGE

Question: WHAT NEXT?

Help message: THE POSSIBILITIES ARE:

(b)

(I)NPUT	:	TO RUN ALL THE MODULE, ENTERING ALL THE DATA
(L)IFT	:	TO EDIT DATA CONCERNING THE LIFT SYSTEM
(A)RRIVAL	:	TO EDIT DATA CONCERNING THE ARRIVALS
(P)ARAMETER	:	TO EDIT THE BUILDING PARAMETERS
(R)ATE	:	TO EDIT ONLY RATES OF ARRIVALS
(C)AR	:	TO EDIT ONLY THE NUMBER AND CAPACITY OF CARS
(T)IME	:	TO EDIT ONLY THE CAR OPERATING TIMES
(S)UPERVISORY	:	TO EDIT ONLY SUP. SYSTEM DATA
(B)IAS	:	TO EDIT BIAS
LOA(D)ING	:	TO EDIT PASSENGER TRANSFER TIME AND LOADING INTERVAL
(E)XIT	:	TO EXIT TO THE MAIN PROGRAM
(H)ELP	:	TO GET THIS HELP MESSAGE

Question: MODE?

Help message: THE POSSIBILITIES ARE:

(c)

TG	TO PRODUCE PSEUDO DISPLAYS ON CHARACTER TERMINAL
T	TO (T)YPE INFORMATION
G	TO DISPLAY WT AND JT
S	TO DISPLAY WT FOR (S)ECTORS
FW	TO DISPLAY WT FOR (F)LOORS
FJ	TO DISPLAY JT FOR (F)LOORS
S/A, FW/A, FJ/A	AS MODES S, FW, FJ BUT WITH (A)UTOMATIC SCALING
R	TO DISPLAY (R)OUND TRIP INFORMATION
BUN	TO DISPLAY (BUN)CHING OF CARS
C	TO DISPLAY (C)AR TRIPS
PER	TO DISPLAY (PER)CENTILES
L	TO (L)IST INFORMATION, CALLS "PRINT" AND CAUSES EXIT FROM THE PROGRAM SUITE
E	TO (E)XIT TO THE EXECUTIVE
H	TO GET THIS (H)ELP MESSAGE

FIGURE 2: Help messages

the number of passengers likely to arrive for specified arrival rates. Help messages are available (Figure 2) to guide the designer, if unfamiliar with the suite, or when a little used proceedure is entered.

The Simulation and Control module can simulate systems of:

8 cars
25 person capacity
25 floors per zone
12 supervisory control algorithms

During the actual simulation a graphical output is displayed showing the queue length at a specified floor. This has the value of indicating rapidly whether the simulation is proceeding satisfactorily or not.

The Output module provides a wide range of output plots as listed in the help message shown in Figure 2(c). A selection are given in Figure 3.

3 THE PC VERSION OF LSD

3.1 History

The first version of LSD was produced in 1972 and contained basic Input and Output modules and only the collective algorithm for the supervisory control system. Since that time the Input module has been improved and the Output module extended. The most significant changes have occured in the Simulation and Control module, where the number of control algorithms (proprietry and research) that can be simulated have been increased considerably.

The LSD suite has been used to analyse in depth and extend the knowledge of how lifts operate under many conditions (Barney and Dos Santos, 1985). In addition it has been employed by Consultants and Architects to examine and/or confirm designs for difficult and unusual circumstances. Versions of the package have been purchased for use in Canada, The Netherlands and the United States of America.

It has only been possible to use the LSD suite on main frame mini digital computers (DEC system 10, DEC-VAX, PRIME 50, etc.) to date, owing to the demands of the compute intensive simulation part of the suite. (To have used the suite on smaller machines would have resulted in unacceptable turnaround times.) The appearance of IBM-PC/s and clones (-PC, -XT and -AT models) now found in large numbers in the office enviroment (where they are used for spreadsheet, database, accounting, wordprocessing, draughting and design calculations) has made it possible to consider the transfer of the work to these smaller (physical and inexpensive machines. Tests have shown that the processing power of the PC-AT is adequate to achieve an acceptable turnaround compared to the multi-user use of a timesharing digital computer. Later, when the 386 based and IBM PS2 machines are more available, power will not be a problem. An additional advantage is that the package price can be lower owing to the larger potential market.

3.2 Design for PC-LSD

3.2.1 Input module

The original Input Module of the LSD suite comprises a question and answer sequence, with:

Extensive error checking of input data
Help messages for guidance

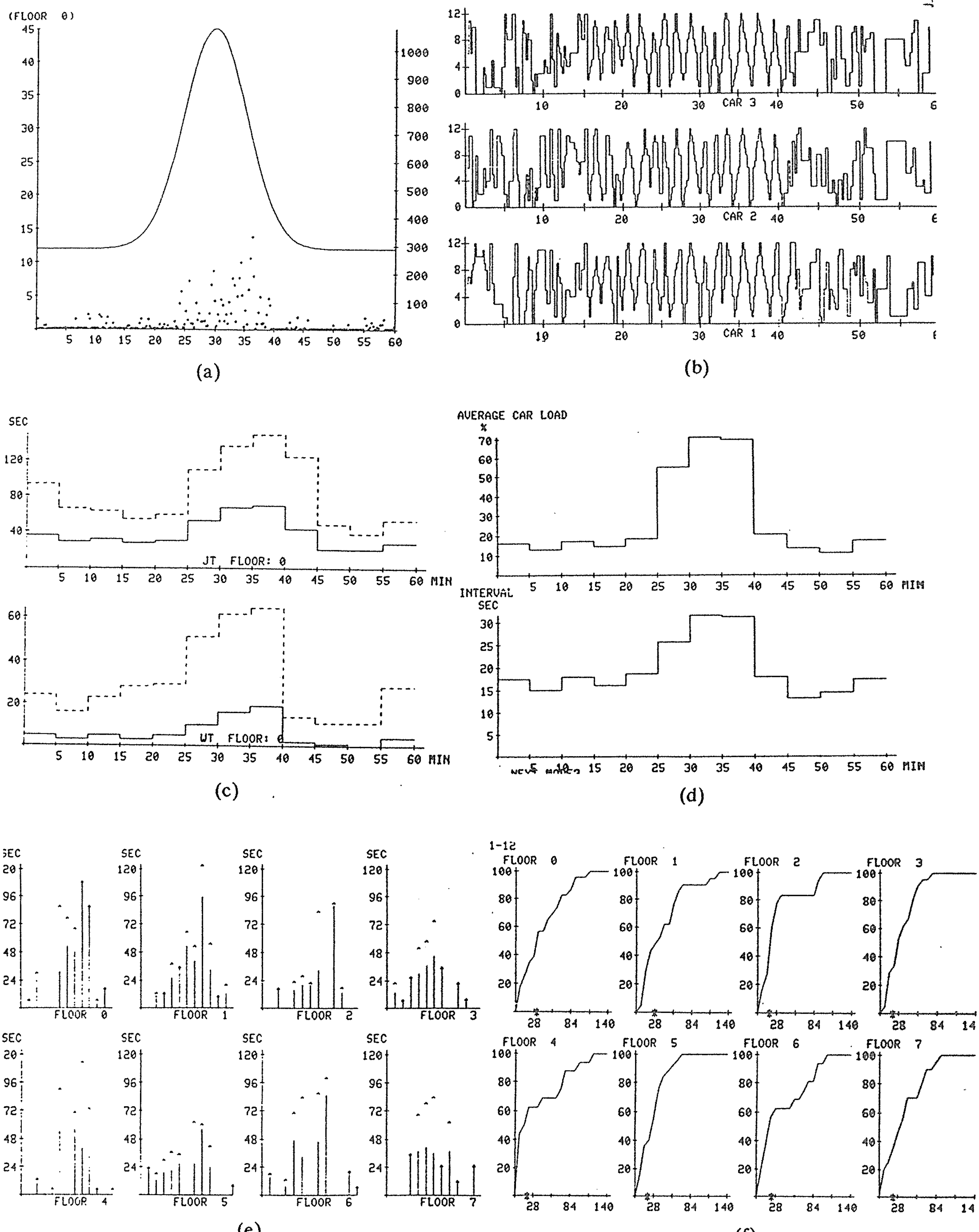

FIGURE 3: Some graphical outputs

(a) Output during simulation (b) Spatial plot of car movements (c) Car load and interval (d) passenger waiting and journey times (e) multi-floor passenger waiting times (f) percentile curves.

On-the-fly calculations of various factors
Mnemonic based responses

These attributes should be retained, as they have been found to most be acceptable to users, but they can now be modernised by the use of a screen template. This will allow the whole of the input data to be viewed simultanously and allow rapid editing, removing the need for the editing switches of LSD. Some of the new features are:

A. Where a selection is to be made eg:

Pattern profile? Standard [ ] Step [x] Sloped [ ]

On selection the screen would show:

Pattern profile: Step

B. Where an error is made eg:

Number of floors = 31

The bell would sound and a message would appear in the error box at the foot of the screen viz:

ERROR: Number of floors 1 to 24

C. Where there is a large amount of data associated with a parameter a summary only will be shown eg:

Supervisory control system: FSO

To examine the details the box "View [x] would be selected viz:

Supervisory system: FSO			
Sector	1	2	3
Number of floors	1	6	7
Floor identification	MF	1-6	7-13

D. Where a user is in doubt as to the correct response to a data field a help message will "pull down" if the user presses the "help" key eg. with the cursor on "loading interval" the message would be:

Permissable values of loading interval are from 0 to 10 seconds.

3.2.2 Simulation module

This module presents a display of queue length at a specified floor as the simulation proceeds. One improvement here is to scale the right hand 'y' axis in calls/5 minutes not calls/hour. A function key should allow the simulation to be stopped part the way through, if it is not proceeding satisfactorily.

There are 12 supervisory control algorithms available in LSD. Some of these are now obsolete or variations of other algorithms. It is time to rationalise the available control systems to:

1. Collective algorithms, with timers and load detection (MCO).
2. Nearest car algorithm (THV)
3. Fixed priority timed algorithm (FS4)

4. Fixed bi-directional algorithm (FSO)
5. Dynamic sectoring algorithm (DS)
6. Self tuning ETA algorithm (CGC)
7. Adaptive call allocation(ACA)

3.2.3 Output module

Figure 2 shows the help message used on LSD for the available output displays. For the new PC-LSD some of these outputs can be dispensed with or modified.

A. Type (T) and list (L) can be merged into a new format.

B. Pseudo displays (used for printing terminals only) can be removed.

C. The automatic scaling outputs (S/A, FW/A, FJ/A,) have not been found to be useful and can be removed.

D. The sector display (S) can be removed as it does not apply to all control algorithms.

E. The coarse distribution of waiting times sub-mode (PER-B) can be removed as it has been rarely used.

The remaining displays have been retained and have been enhanced by the use of highlighting, filling, etc. The use of colour is being considered.

4 CONCLUSION

The original LSD has stood the test of time since 1972, but it has taken technology until now to provide adequate computing power in an easily affordable digital computer of sufficient popularity to make a change. PC-LSD still retains the independance of proprietry control algorithms and allows the definition of most building configurations. The PC-LSD suite meets the criteria stated by Pinfold (1965): "... [a simulation program] must be completely open so that it applies to any traffic situation or by feeding in the performance characteristics of a particular installation will reveal the range of experience of the user at any floor or at any time according to traffic demand." It is to be hoped PC-LSD can serve the industry as well over the next one and a half decades as the past one and half decades.

5 REFERENCES

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6. BIOGRAPHICAL NOTES

After some years in the electronics industry Dr. Barney read for his B.Sc. and M.Sc. degrees at Durham University. He obtained his Ph.D. in 1965 for the development of a four quadrant thyristor power supply for the Birmingham University proton synchrotron. In 1967 he joined UMIST as a lecturer and was promoted to senior lecturer in 1971. Dr. Barney has been working on lift systems for over 20 years and has authored over 50 papers and written or edited four books. He is Chairman of the International Association of Elevator Engineers Steering Committee. His current appointment is with the University of Manchester as Director of Networking.

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                          INPUT  SCREEN
*************************************************************
   PC-Lift Simulation & Design suite (PC-LSD)
  [© LSD Barney & Dos Santos 1972, © PC-LSD 1988; Lift Design Partnership, 061 439 4042]
-------------------------------------------------------------
RUN No.:  21   DESIGN NAME:      High House EZ

Serves:                          All the building
Number of levels above MF        = 11
Distance (MF→top floor)[m]       = 36.3
Number of cars                   = 3
Contract capacity [persons]      = 13
Entrance width [mm]              = 1100

Contract speed [m/s]             = 1.6
Door opening time [s]            = 1.5
Door closing time [s]            = 2.5
Acceleration [m/s2]              = 0.9
Flight times [jump]  1     2     3     4     5     6     7     8
               [s]  7.0   9.0  11.0  13.0  15.0  17.0  19.0  21.0

Control system:                  FSO
     Sector 1 [floors]           = 4
     Sector 2 [floors]           = 4
     Sector 3 [floors]           = 3

Arrival pattern:                 UPP
Arrival profile:                 STAND
     Peak [% 5min]               = 15
     Base [% 30min]              = 24
     Double base time [min]      = 20
Building population [persons]    = 500

Passenger transfer time [s]      = 1.2
Loading interval [s]             = 8
Floor bias:
Floor:  1    2    3    4    5    6    7    8    9    10    11
       10    0  -20    0    0    0    0    0  -20   -30   -50
-------------------------------------------------------------
f1=change       f3=enter        f5=view        f7=help
-------------------------------------------------------------
```

FIGURE 4: Screen template.