

Disaster in London The LAS Case study

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Abstract

This case study reviews the system and the processes that led to the botched implementation. The London Ambulance Service have spent the best part of the last fourteen years attempting to computerise their despatch system. (They are still trying). The infamous failure of the second attempt was selected due to the multitude of issues and considerations it raises. The prevailing culture and the financial climate played a major role in shaping the events that led to disaster. This case study highlights how circumstances can gang-up and the resulting implications to the health and safety of patients.

The automation of the despatch of ambulances in London, which was implemented on the 26 October 1992, was subject to very severe problems on the 26 and 27 October, and to total failure on 4 November 1992. In the early hours of the 4 November the system started slowing down and eventually locked up altogether. Attempts to switch off and restart failed. In the absence of a back-up system, the operators were forced to resort to a hastily co-ordinated manual procedure.

LAS Background

The London Ambulance service was founded in 1930 as a direct replacement to the service run by the Metropolitan Asylums Board. In 1965 the LAS was enlarged, as part of the establishment of the Greater London Council, to incorporate parts of eight other emergency services in the London area. In 1974, LAS became a quasi-independent body with its own board, managed by the South Thames Regional health Authority under the control of the National Health Service.

The London Ambulance Service covers a geographical area of just over 600 square miles with a resident population of about 6.8 million people. The day-time population is boosted by millions of commuters and visitors swelling to around 10 million people in the summer months.

This makes the LAS, the largest ambulance service in the world!

The service has 318 accident and emergency ambulances and 445 patient transport ambulances, a motorcycle response unit, and one helicopter. 2,746 staff are based in the 70 ambulance stations divided into four operating divisions. Out of the 318 emergency ambulances, 212 may be rostered to be in use, at any one time. The remainder are relief vehicles or are being serviced.

Some 55 percent of the LAS staff, 40 percent of the vehicles and 76 percent of its annual budget are devoted to the accident and emergency service function.

Volume of work:

The LAS receives between 2,000 and 2,500 calls and transports over 5,000 patients daily. Emergency calls account for 60 percent of the calls and result in roughly 1,400 (of the 5,000) transported patients.

The ambulances attend an average of 1,200 incidents a day. They are controlled from Central Ambulance Control at the LAS headquarters at Waterloo. The staff of the control room handle between 1,900 and 2,500 emergency 999 calls each day (many incidents generate more than one call).

Purpose

During the early 1980s, it became apparent that the emergency dispatch system required upgrading. The establishment of the national 3-minute standard mobilisation time, meant the manual dispatch method was inadequate in terms of prescribed performance. This would become more acute during peak times and large incidents. The LAS became convinced that a computer dispatch system was the only approach that could automate ambulance call outs and ensure the meeting of the dispatch standard.

The original manual system was structured around three major components:

Call taking: Control Assistants at the LAS control centre would write down the details on a pre-printed form. The assistants would then locate the incident co-ordinates in their map book and place the completed forms on a conveyor belt transporting all the forms to a central collection point.

Resource identification: Another assistant would collect the forms, scan the details, identify potential calls, and allocate them to one of the four regional resource allocators. The appropriate resource allocator would examine the incident forms, consult ambulance status and location information provided by the radio operator, consult the remaining forms maintained in the allocation box for each vehicle, and finally decide on which resource (ambulance) to mobilise. The ambulance details would be entered on the form.

Resource mobilisation: The forms would be passed to a despatcher who would then phone the relevant ambulance station (if that is where the ambulance was assumed to be) or pass the mobilisation instructions to the radio operator, if the ambulance was known to be mobile.

This procedure had to be completed within the national three minute activation standard!

Some of the major deficiencies had the potential to further delay the entire procedure. These included:

- a) Manual searching of the map book often requiring a search for a number of alternatives due to incomplete or inaccurate details.
- b) Inefficient movement of paper around the control room.
- c) Maintaining up to date vehicle status and location information as provided by the radio operators and allocators.
- d) Communication procedure and the use of voice communication were slow and inefficient, and could lead to mobilisation queues.
- e) Over-reliance on human ability and memory to identify duplicate calls and avoid mobilising multiple units to the same incident.
- f) Over-reliance on human ability to note and trace all available units.
- g) Call back (caller phoning for second time) which forced the assistants to leave their post to talk to the allocators using up time and introducing physical congestion into the control room.
- h) Identification of special incidents (large or extremely urgent) depended on human judgement and memory.

The proposed system

It was hoped that the computerised system would handle all the major tasks which existed in the manual system. Calling 999 and asking for the ambulance service would connect the caller to a despatcher who records details of the call and assigns a suitable vehicle. The despatcher would select an ambulance and the system would transmit details to the selected vehicle.

The major components:

Computer-Aided despatch system
including the infrastructure hardware and software, incident record keeping system, a radio system and a radio interface system.

Computer Map Display system
including sophisticated mapping software

Automatic Vehicle Location System
with the ability to position units optimally in order to minimise response times and tracking long term asset performance. Also including radio system, radio interface system, and mobile data terminals.

Early History:

In May 1987, after a year of delay, a three year £2.5 million contract was awarded to IAL (International Aeradio Ltd.), a subsidiary of British Telecom, and CGS (Cap Gemini Sogeti) to provide a limited despatch system.

The new system was not required to include any mobile data capability.

In 1989, the design specification was altered to include mobile data in addition to voice transmission..

In October 1990, the project was terminated after two tests investigating peak load performance failed. In addition to abandonment, an independent assessment of the systems requirements, sponsored by the LAS chief executive, recommended that, if possible, the system should be replaced with a bespoke system.

By the time it was cancelled, the project was already severely behind schedule with the accumulating costs having escalated to £7.5 million.

The cost overrun, at cancellation represented a figure of 300% !!!

The LAS attempted to seek damages from the prime contractor, claiming that the prime vendors did not understand the requirements. The vendors counter-claimed by blaming the LAS, their constantly changing specifications, and the lack of clarity and ambiguity in their initial request. An out of court settlement was eventually reached.

Estimation

The independent assessment of the early failure, conducted by Arthur Andersen, recommended that the system should be replaced with a turnkey system. If such a system were available, the study asserted, that the LAS would need to spend £1.5 million and 19 months to field it.

The report clearly sets out that If no suitable packaged solution could be found, the cost and time involved in developing a new system from scratch would be significantly higher. (The independent assessment referred to the original statement of requirements produced prior to the first failure and therefore excluded mobile data and vehicle location systems.)

While numerous operating despatch packages were examined (including the ones operated by the ambulance services in the West Midlands, Surrey, and Oxford), none was deemed an acceptable foundation to build upon as they all suffered what the LAS perceived as major limitations.

New requirements:

Once it became clear to the LAS, that the despatch system project had to be re-initiated, they began an effort to write a new system requirements specification for a new despatch system.

The specification was written by a project committee taken from LAS management and the systems team without any input from the ambulance crews or consultation with the unions. At the same time, a new LAS senior management team was being appointed.

The new proposed system would go further than the original and would represent the state-of-the-art in despatch systems. The 'thinking' ability incorporated into the new system would free the operators and despatchers from all manual tasks, but, more revolutionary it would also free them from making decisions.

The controllers would feed the information they receive from callers into the system, and leave the system to take over. The despatch system would allocate and mobilise ambulances, interact with crews, and track and monitor actual performance and positions.

Exception messages would only be generated in extreme cases of failure when no free ambulances were available for at least 11 minutes. Only under these exceptional conditions will human intervention be required.

The new system would show the location of each patient and the nearest three ambulances.

The system would also be in charge of all communications with the crews in the field. Alarms would sound if the selected vehicle did not acknowledge or went the wrong way. The ambulance would report to base on its way to hospital and when free for next assignment.

The LAS were fully aware that this extremely ambitious system represented a quantum leap in technology. The previous attempt which was essentially a much simpler system, became a failure when the supplier failed to understand the complexity inherent in the environment. Combining the sophisticated allocation, tracking, and monitoring, without human intervention with judgement and decision making aspects necessitated a major intellectual and technical effort.

The expected benefits (regardless of feasibility) sounded very promising, and in order to maximise them, it was decided to opt for a big-bang implementation. Rather than phase the system in over time, a single shot implementation encompassing full functionality would be used over night.

Pre- History

The new software development specification document was being developed with an eye to saving costs and perhaps more crucially, time. Insiders, report a sense of urgency that pervaded meetings, attitudes, and decisions relating to the computer system.

Hardware components from the failed attempt were incorporated into the proposal as a means of saving time and capitalising on a previous investment.

The implications of the new system for staff working practices were so immense that new guidelines had to be published. This was conducted without any co-operation from the ambulance crews, the control room operators, or indeed the unions.

All allocations would be handled by an 'objective' computer. No longer would staff be able to decide which ambulance to take, or stations decide which vehicle to mobilise. Ambulances would thus, be allocated to incidents away from their home stations and could spend the rest of their shift covering unfamiliar areas further increasing the distance to their home base. After the end of the shift, crews would be forced to drive back to their home station, often confronting heavy traffic on their way. Controllers, despatchers and radio operators would no longer need to communicate with ambulances by voice-based radio or with the stations by telephone as the computer system would be handling all communications.

Successful implementations often report that users feel they 'own' and benefit from the system. In this case there was no attempt to sell the system to the users or even reduce the resistance to change, despite the fact that the new system was bound to introduce anxiety and possibly conflict due to the severe implications on working

practices. Based on recent history of industrial conflicts and attitudes towards structural change within the LAS, there was every reason to assume that another major change to the organisational culture would require tact and careful management. User involvement often provides the most effective mechanism for overcoming organisational or cultural resistance. In a 'quantum leap' where the stakes are high this can be a most critical ingredient.

The new specification document was completed by early February 1991 (some 3.5 months after the decision to abandon the old system). The majority of the work was completed by a contract analyst and the systems manager. The document was highly detailed and extremely prescriptive, containing a high degree of precision on how the system was intended to operate, yet, leaving little opportunity for the suppliers to incorporate their own ideas, use their experience, or optimally utilise their technology.

One of the constraints in the new document calls for the operational system to be available by January 8, 1992, thus allowing a mere 11 months for the development of this new concept in despatch systems.

The standing instruction from the Regional Health Authority is to put all new systems to tender. An advertisement seeking interest in the development and building of a despatch system for the LAS appeared in the *Journal of the European Communities* on February 7, 1992. 35 companies expressed an interest in bidding and were sent the newly developed statement of systems requirements.

Most potential bidders questioned the tight deadline constraint to be told that the date is nonnegotiable. Seventeen companies provided proposals for all or part of the system. A number of the vendors proposed an alternative timescale whereby a basic version can be supplied by the January 8, 1992 deadline, with a fully functional system available in early 1993.

The initial screening by the LAS, eliminated all proposals that did not explicitly state January 8, 1992 as the deadline for the full system.

The handful of remaining contenders were evaluated using price (lowest tender) as the primary criteria. While an explicit set of criteria were used as a checklist (including resilience, functionality, flexibility, and response times), team members concentrated on the cost factor. The quality of the proposed solutions was not considered as it was felt that financial instructions governing government procurement should be rated on a cost basis.

The internal 'secret' figure targeted by the LAS was £1.5 million. There is no clear rationale as to how this figure was arrived at. It is probably safe to assume that this is based on the previous figure supplied by the independent assessment of the previous failure. This figure is

predicated on the assumption that a suitable package could be found and that the original assumptions hold.

In practice, no such package was deemed suitable and an additional requirement for mobile data and vehicle location systems was added to the requirements. Each of these factors should have resulted in a serious re-evaluation of this cost. It would appear that the group used the initial price, which was taken out of context, and with the wrong set of assumptions as their anchor. Decision makers often use the first figure offered as an anchor and adjust subsequent values in small increments. In the context of group decision making, where all members were part of the management function, it became easy to home in on the initial value, and use groupthink and group dynamics to defend it.

The previous attempt at a less challenging computerisation was a failure and exceeded its initial budget of £2.5 million by a factor of three. This project would have been a more ambitious undertaking, with more sophisticated components and a tight and inflexible time-frame, yet the internal tag of £1.5 million was never challenged. The early commitment to a figure, albeit an irrelevant one, and the apparent homogeneity of the group could have blinded them to the relative danger of fixing to an initial price before evaluating the quality and strengths of the incoming bids. By applying collective rationalisation, coupled with the illusion of invulnerability, group members are often able to persuade themselves to ignore outside information and alternatives. In the absence of dissenters, groups adopt an internal structure which feeds on the inherent self-censorship mechanism and the illusion of unanimity to adopt 'unchallengeable' and often indefensible positions.

As the initial failure lasted for almost 3.5 years before it was scrapped, at the cost of £7.5 million, forcing a fixed timeframe of 11 months on a more demanding 'quantum leap', would necessarily have required more than was actually spent on the aborted project. Looking at either the time or the cost factor with the benefit of hindsight from the previous failure, it is extremely difficult to defend the teams' rationale.

Using this financial criteria, the clear winner was the bid for £937,463 for the complete system. The nearest competitors come in at £1.6 million and £3 million. The implicit, internal figure of £1.5 is exceeded by all but one of the bids. With the additional incentive of assessing bids by price rather than quality, the race was already won.

The bid of £937,463 for a system to be completed by the mandated deadline, was put forward by a consortium led by Apricot computers. The bid was hardware driven with Apricot Computers (a UK hardware supplier owned by Mitsubishi) supplying the networked PC's and fault-tolerant file server system as the hardware platform. Systems Options (a small UK software house) would supply the software for the despatch system which was based on their Wings Geographical Information System. Datatrak would supply the Automatic vehicle Location System, while the Radio Interface Systems and Mobile

data terminals would be supplied independently by Solo Electronic Systems (The equipment from Solo, was used in the previous abandoned information systems).

The quoted price of the software component of the despatch system, the main hub of the system, was £35,000. The core of the system, the software that makes allocation decisions in place of humans was being offered as a throw-in in a hardware deal. The price represented less than 4% of the overall price of what should have been a software intensive system, a gross mis-estimation of the expected functionality and inherent complexity. It would appear that the LAS became concerned about the software experience and balance within the consortium. The LAS advised Systems Options that the failure of the previous system was largely due to the supplier's software house not taking on board the complexity of the system. While Apricot were the consortium leaders, they refused to assume project leadership as the success of the entire system clearly depended on the quality of the software provided by Systems Options. During later negotiations, under severe pressure from the LAS, Systems Options, reluctantly agreed to take over from Apricot as the consortium and project leaders. It later emerged that System Options had been reluctant to bid for the system in the first place, but were persuaded to do so by Apricot. A similar bid by the two companies for a far more basic service at the Cambridgeshire Ambulance Service was rejected due to the lack of technical understanding exhibited in the bid. The significance of the software component was clearly visible to all participants.

The requested despatch system was significantly bigger and more complex than anything any of these companies have handled previously. The new leaders, Systems Options, with their software experience, were only accustomed to smaller, simpler systems. Their main field of expertise was in developing government administrative systems. They had no experience in developing real-time, safety-critical, command and control systems. The LAS were reassured by the fact that Systems Options had delivered systems for police and fire services. In actuality, these were administrative systems with no critical components.

The procurement team fielded by the LAS was small and inexperienced in terms of both technical knowledge and acquisition procedures. Procurement guidelines for the Regional Health Authority stated that the lowest tender should be accepted unless there are 'good and sufficient reasons to the contrary'. No attempt was made by the team to question the differential in bids, the price which was below the internal target price, or even the difference by almost an order of magnitude between their favoured bid and the next cheapest. The prime responsibility for the evaluation of the bids rested with the contract analyst and the systems manager. The systems manager was an ambulanceman who had taken over responsibility for ambulance service systems on the understanding that he would be replaced by a qualified systems manager at some point. The contract analyst had five years experience with the LAS, largely as a result of his

involvement in the failed original project. The decisions were thus being made by a manager expecting to become redundant and a contractor who was a temporary addition to the organisation.

The letters of reference regarding Systems Options, suggested that the company was overstretched on its current contracts and had been having trouble delivering (the much simpler and less demanding) software on time. A letter from the Staffordshire Fire and Rescue Service expressed grave concerns over the ability of Systems Options to cope with the project. These claims were not investigated or even acknowledged by members of the LAS procurement team.

As is the practice in the public sector, LAS higher management conduct an audit of the selection process before awarding a contract to the party recommended by the internal procurement team. The audit and the external assessor indicated that the process was risky and required close management attention, yet, the decision was approved.

The major management restructuring was finally completed during April 1991. Senior and middle management ranks were slimmed by 20%, and the LAS was reduced from four divisions to three. The restructuring resulted in a large number of experienced staff leaving the organisation and the reported creation of a great deal of stress for those who remained. The internal climate was influenced by a minimal investment in staff or managerial training, and little scope for career advancement. The remaining managers were unmotivated, stressed, anxious, and oppressed by job security prospects.

The rapid changes eliminated any stability within the organisation. To compensate for the loss of the highest-calibre managers, others were promoted or shifted sideways to new positions (rising to level of incompetence syndrome?). The directors were left with a great span of responsibility and power.

In the absence of consultation with employees and the unions, industrial relations deteriorated, resulting in resentment, lack of trust, low staff morale, and increased absenteeism. An earlier national industrial dispute over pay and conditions, left relations strained with little communication between management and workers. (The subsequent appointment of a new Chief Executive Officer with a reputation for 'sorting out' troublesome employees and interfering trade unions did not help.)

On May 28, 1991, (with just over seven months to the deadline), the LAS Executive Board endorsed the decision to award the contract to the consortium. As a safety procedure, the LAS required the consortium to provide a complete systems design specification detailing how the final despatch system will operate. The document was viewed as an assurance that the consortium truly understood the needs of the LAS and could provide an adequate solution. (This no doubt represented their need

for reassurance following the perceived failure of the previous vendors).

A small starter contract was awarded to the consortium to develop the design specification document. The document was developed during June and July (count down to the fixed deadline was now five months for the full development!)

Design issues

In order to allow the complex allocation algorithm to run, extreme processing power was needed. The greater the distance between the incident and the ambulance resource, the longer the time needed to calculate the resource allocation due to the need to identify the most appropriate resource. At busy times when the number of incidents increased and the number of resources not already dealing with other incidents decreased, the entire system would slow down due to the volume and complexity of the calculations.

The consortium decided at an early stage to perform a tradeoff between ease-of-use and performance in order to facilitate a user friendly interface. The consortium opted for Microsoft windows 3.0 for the user interfaces and Visual Basic as the development tool for the creation of the screen dialogues. This was not specified in the proposal submitted to the LAS..

Project management

While the design specification document was being developed, The LAS was trying to figure out its management strategy in relation to the project.

The concerns that were noted and minuted but never followed up included the facts that:

- * No full time LAS staff member had been assigned to the project
- * The draft project plan left no time for review or revision
- * The 6-month schedule was somewhat shorter than the 18 months that other municipalities need for less complicated despatch systems.

The LAS director of support services invited one of the losing bidders to perform independent quality assurance on the project. This proposal was rejected internally as it was felt by the project team that quality assurance was the contractor's responsibility and not their concern. Rather than have external quality assurance (incorporating risk assessment and audit features), the team devolved all quality assurance activities to Systems Options, the software developers.

Additional concerns included the lack of clarification of how PRINCE was to be applied to the project and the lack of a formal programme project group and review meetings.

The PRINCE project management methodology was selected to guide the development effort. The suppliers had little experience of project management and have not come across the methodology before. As the staff in the LAS had no experience of applying this methodology either, a special course was arranged for the project team to acquaint them with the methodology. Very little use was ever made of this knowledge and nor was any alternative methodology or computer tool adopted in its place.

Official project launch:

The contract was awarded to the consortium on August 8, 1991, following The LAS's approval of the design specification. (Leaving exactly 5 months for the project). There was no formal sign-off of the design specification which contained omissions and undeveloped sections (such as the interfaces with other components and systems).

Project meetings were scheduled at regular intervals. During the meetings it became clear that Systems Options were not planning to project manage the entire effort as they were struggling to manage their own software effort. It was quickly acknowledged that there was no experienced project manager among the team members.

The contract analyst employed by the LAS, and the LAS Director of Support Services were forced to add managing the overall project to their list of duties.

Systems Options Did not perform any formal quality assurance on the system, or even on their portion of the code. Changes that were agreed during the project, were not recorded, or tracked in any way.

No formal configuration management was applied. No test plans existed. No integration tests were ever planned. The consortium did not perform any project management activities. The only scant attempt at project management was performed, by default, by inexperienced members of the LAS.

The contract with Solo Electronics for the communications hardware was not signed until September 16, 1991 (four months before the delivery deadline, and some three months after the award of the system design contract). The essence of the contract was to salvage key features from the earlier abandoned project. Software deliveries were all late. Systems Options blames the delays on the two months needed to develop the systems design and the delay in signing the contract for the communication equipment their software needed to interface with.

The LAS hired a new systems manager in October, who promptly arranged a formal project review for November.

The LAS senior management, were informed of the results. The key finding of the review were that:

- a. Little time had been set aside for review
- b. Increased quality management was needed
- c. Troubling technical problems were cropping up.
- d. The January operational date should be maintained if only to keep pressure on the suppliers.

The publicity and external pressure had resulted in questions put forward to the Health Minister. The reply was that in the Governments' view, the consortium was fully qualified for the task at hand. Senior management of LAS decided to take no action.

As mid-December approached it was becoming clear that the January 8, 1992 deadline was not achievable. With three weeks left the despatch software was incomplete and untested, the Radio Interface Systems was yet to be delivered, the design and position of the data terminals in the ambulances required changing, the vehicle location tracking system was not fully installed, and according to some reports, the data provided by the tracking system was neither accurate nor reliable. In addition, no training of ambulance crews or control room operators had been initiated.

Phase two

By late December, it was agreed that the despatch system would not be delivered on time. A new schedule for a three increment delivery strategy was agreed. The increments would be rolled out over the subsequent ten months. Final delivery was scheduled for October 26, 1992.

Phase 1, was to feature the call taking function. The details and location of calls would be recorded and printed. These print-outs would then be used within the old manual procedure.

Phase 2, was to focus on improving the resource allocation function. The allocators would be issued with terminals that will contain call information. Ambulance locations would be automatically tracked by the system, which would also notify ambulance crews of incidents, eliminating the use of voice despatch. The actual identification and mobilisation of resources would still be orchestrated by the resource allocators as before.

Phase 3, would deliver the fully automated system. All identification and mobilisation duties would be handled by the software. Ultimately resource allocators would become surplus to requirements

A chief implication of the phasing effort was that temporary measures would have to be introduced in order to enable certain operations. During phase 1, the need to print-out call details required the introduction of printers that were not part of the "paperless" office envisioned by the LAS. The addition of printers introduced a number of new problems including screens locking up, server failures, and the accidental loss of calls in February,

when a printer was switched off and the contents of its buffer memory erased.

Live trial versions of Phase 1 and phase 2 were delivered in irregular fashion throughout the three LAS divisions offering different versions of the partially automated despatch system. As they were being delivered, changes and enhancement were being made to the packages delivered to the different divisions. In some cases unrecorded changes were made to code that had already been tested and was assumed to be final and correct. In the absence of a baseline and of a configuration management function, the despatch systems delivered to the different divisions were not functionally or operationally equivalent. This led to immediate software errors, equipment failures, inaccurate or missing vehicle tracking information, and poor radio communication. The lack of training of ambulance crews and control room operators added to the chaos and misery.

Meanwhile, a staff attitude survey, commissioned by the LAS and carried out by Price Waterhouse in January 1992, revealed that only 10 percent of staff felt they knew what the LAS plans were for the future. 13 percent of staff believed that the LAS was providing a quality service, only 8 percent believed that management listened to them. Similar sentiments were expressed by ACAS (Arbitration Conciliation and Advisory Service), three years earlier when they remarked that "the great majority of staff felt the service was deteriorating and that pressures at work were increasing... on-going and relenting [pressures] which gradually wore them down."

March 1992 was the deadline for releasing the finalised version of phase 2. This was marked by a major system crash, resulting in: a 30 minute delay to emergency calls, delayed ambulances, and lost incident reports. Some LAS local area officers ordered a switch back to radio systems until the computer was able to match their performance. The area officer for the ambulance union, NUPE, called for urgent public enquiry. An LAS spokesman reassured the press that these are "normal teething problems and no one has anything to worry about".

A new review conducted by the LAS systems manager revealed that:

- a. The radio interface system was failing almost daily;
- b. No volume testing of the whole communications infrastructure had been done;
- c. There was no way of tracking changes to the system; and
- d. Ambulance crews and control room staff were not trained.

No recommendation as to the future progress or cancellation of the project was made in the review report, which did not elicit any response from LAS senior management.

A number of letters from computer consultancies and safety experts warning about the inadequacy of the system, had reached the LAS and Government ministers.

A number of letters from safety-critical specialists argued that the system was 'totally and fatally flawed'. In April, hundreds of callers failed to get through to the ambulance service. LAS management blamed the public for calling too much and clogging the line. The LAS board were presented with a formal vote of no confidence in the system by staff from one of the three divisions.

Additional complaints and concerns throughout the rest of the year were quickly brushed aside by the LAS executive management. Phased trials, it was explained, were used to highlight problems and there was therefore no need to panic as the final system would obviously work.

Some new problems began cropping up at this stage. These included:

- * Occasional locking up of terminals
- * Overload of communications channels
- * Inaccurate location information provided by the Vehicle location system.
- * Crews using different ambulances to the ones allocated by the system.
- * Slowness of the system.
- * The inability of the system to identify the nearest available ambulance
- * Failure of the Vehicle Location System to Identify every 53rd vehicle in the fleet.

As a result, calls were getting lost in the system, while others failed to reach ambulances - Vehicles were being assigned incorrect codes, while others were missing from the system - Call waiting queues as well as the ever multiplying exception message queues would scroll off the top of the screen.

At no time before phase 3, was the system either stable or operational across all three LAS divisions.

In the background meanwhile intense governmental pressure was being applied on the LAS to reduce its seriously overspent budget. In order to reduce its expenditure, it was decided that planned capital improvements and preventive maintenance on emergency vehicles would have to be delayed.

Up and running

Phase 3, was scheduled to come on line at 3 A.M. on Monday, October 26, 1992. by 7 A.M. the new system was meant to be fully operational.

The move to the final phase required a move from the existing divisional structure to a centrally controlled 'pan London' approach within a unified control room. The control room had to be reorganised and all temporary equipment and temporary solutions, such as printers, dismantled and removed. Once the control room was cleared up, similar groups, such as radio operators, controllers and allocators, could be united and positioned in different parts of the room.

Prior to the release, the system software had two known errors that could cause severe service degradation in which the system would not function and 44 errors that could cause operational problems that could affect patient care. 35 more minor problems were also known to exist, giving an overall total of 81 outstanding 'issues'. No stress testing had been done on the full system. No backup plans were in place in case of system failure. The LAS did not have their own network manager having relied on the contractors to rectify all previous problems.

By mid-morning it was known that ambulances were arriving late and doubling up on calls. Callers were waiting in excess of 30 minutes to get through while some calls simply appeared to vanish from the system. The map system refused to recognise certain roads, forcing operators to scramble for maps and despatch ambulances by telephone unbeknown to the system.

Error messages were appearing on all terminals, and warnings that ambulances were not meeting their arrival deadlines were flooding the system. It appeared that ambulances were either arriving late, not arriving at all or turning up two at a time. Operator screens and mobile data terminals simply locked up.

Staff were under instruction to minimise voice communication. When wrong allocations were made, many felt too threatened to attempt to rectify the problem by voice communication.

Overload problems

New calls wiped old calls off the screen.
(even though they have not been dealt with)

An overloaded system would only display the latest batch of calls, losing calls that had been received and not responded to.

The system was slow at logging acknowledgements, therefore, creating many spurious alert messages.

Alert messages also wiped old calls off the screen without a trace
(these calls were totally lost)

The system design ignored the limitations of radio-based systems in urban areas. The system relied heavily on radio for data feeds on ambulance location and status. The information had to be perfect at all times. But, there had been no attempt to test the system's response to incomplete or incorrect data

These imperfections led to an increase in the number of exception messages... which in turn led to more call backs and enquiries... thus contributing to the overload problem.

The LAS continued to run the system for the next 35 hours as chaos reigned. By Monday night new emergency calls were overwriting undealt calls thus, hiding an

increasing number of unanswered calls within the system and generating new exception messages. The exception queues were growing at a rapid pace and slowing the system down. In an ill-advised attempt to speed up the system, which resulted in a new spiral of delays, the exception queue was cleared of its contents erasing all references to calls!

Ironically, while the system was in a state of total chaos, a team of public relations experts were busy promoting the new technological efficiency of the service.

At 2 P.M. on Tuesday, October 27, 1992, a decision was made to take the phase 3 system down and replace it with the semi-manual phase 1/2.

More ambulance crews and control room staff were brought on duty in attempt to cut the backlog. In the backroom, the computer people were attempting to regroup, investigate the errors, and try to relaunch the system.

Up to 46 emergency patients may have died prematurely over the two days due to the lack of emergency system according to some sources [Charette 1995, The Times, The independent]. Nupe, the public employees' union suggested that 20 patients may have died. - These claims were hotly disputed by the LAS. The breakdowns forced some patients to wait as long as 11 hours!

On Wednesday morning the LAS claimed that no serious disruptions were caused by the computer system. By Wednesday afternoon, the LAS chief executive resigned. It was later argued that he was under extreme pressure to improve performance by the end of that year and was thus forced to rush the computer implementation.

Following intensive pressure from families of patients, the unions, and a stormy session in Parliament on Thursday evening, the Health Secretary called for an official inquiry into the affair. The trade unions called for the system they described as a "lethal lottery", to be shut down in the interest of patients. Their plea went unheeded.

The LAS received over 900 complaints about its service during those 36 hours.

Excuses and causes:

LAS management claimed that an excessive number of calls were made on October 26 and 27 thus contributing to the systems problems and lowering service to patients.

The inquiry report revealed that the total number of patients transported on these two days was less than the daily average for October. The adjusted number of calls was only 6 percent above the average for October. Due to the lack of response, the number of call backs (people calling again) was up for that period. Yet, even allowing for the call backs, the total number of calls was within the upper limit of predicted calls.

LAS management claimed that ambulance crews deliberately sabotaged the system.

This was shown to be erroneous. Despite losing the personal touch of having a familiar human voice despatcher, crews seem to have accepted the initiative, albeit reluctantly, and co-operated. Crews had to use a sequence of six buttons in the right order. Datatrak, the primary contractor for the vehicle location sub-system, stated that resistance at the LAS was no greater than that experienced by them at other organisations and did not seem to have played a part in complicating the operation of the system as a whole.

LAS management claimed that users and crews had not been trained in how to use the system.

The inquiry team concurred with this assertion. Staff training was provided by a combination of internal LAS staff and Systems Options trainers. All training was scheduled to be completed by the original implementation date of January 8, 1992. Control room staff were subjected to a two day familiarisation exercise, while crews had trained separately. At a meeting shortly after this date, staff representatives protested over the inadequate training. The long delay (10 months) before the final introduction of the system coupled with the continual changes that continued to beset the system during development resulted in inconsistent, incomplete, and in some cases irrelevant training.

Several critical flaws later emerged from the Inquiry report. these included:

- a) The need for perfect information for the allocation and monitoring algorithms to perform satisfactorily
- b) Poor interface between crews, terminals and the system. A list of some eleven reasons for lack of perfect information was produced including black spots, failure to press correct buttons, noise corruption, wrong call signs, and too few operators. No consideration had been given to the possibility of violating the assumption of perfect information.
- c) Frequent "locking up" of screens during trials prompted an instruction to staff to simply re-boot their screens.

The design flaws and inattention to the implications of imperfection directly led to delayed and duplicated allocations. This resulted in a build up of exception messages requiring personal attention from operators and preventing them from answering new calls. As the messages and lists were building up the system slowed down. The lack of operators who were engaged in resolving exceptions, led to a backlog of calls. Concerned patients and relatives were forced into calling back initiating new exception messages. The cascading effect simply overwhelmed the system and its operators.

The complete system had never been load tested to predict its performance under-pressure, extreme conditions, in a disaster scenario or with incomplete or contradictory information. (The first system was scrapped in 1990, following its failure to pass either load test. This could explain the LAS's implicit attempt to forego load testing despite frequent smaller scale failures. Similar attitudes and fears of disconfirming information have been reported in other safety critical failures, such as Bhopal, Three Mile Island, Challenger, Chernobyl, and even Pearl Harbour, where decision makers rejected all evidence which threatened their group). The possibility of operator errors or the behaviour, volume, and response to exception messages was not considered or challenged. The overall effect of exception messages on system performance and the problems concerning the interaction of the different sub-systems, were similarly neglected. The operators were inexperienced and poorly trained and could not be relied upon to spot problems or be able to override them.

The cost reduction programme indicated earlier, was responsible for more ambulances than normal being unavailable for duty due to degradation and lack of repairs. The less than optimal complement of ambulances was therefore already stretched and experiencing delays, resulting in additional call backs and exception messages.

The final Chapter:

The reduced functionality system was working for the next ten days. On November 4, 1992 the system started slowing down considerably and finally locked up altogether at 2 A.M.

Operators attempted to apply the 'magic' solution of rebooting the system, to discover that it was still frozen. The automatic back up system failed to come on-line.

The LAS made the decision to revert to the manual methods of the 1980's. Voice tapes had to be replayed to log calls manually. Following the shift to the manual system, all mobilisation, activation and arrival categories recorded dramatic improvements (most by a factor of two).

And then...

The LAS system manager asserted that the computer did not fail, although he did not know what did.

An LAS software specialist defended the choice of the consortium, and stated that no other company could have done better in meeting London's requirements.

Systems Options declined to comment.

Technical problems

The inquiry team discovered that a programming error by a Systems Options programmer caused the software to fail to release file server memory after each ambulance

mobilisation and gradually consumed all available memory. The small piece of code was left had inadvertently been left in the system. Over a three week period all the available memory was used up causing the system to crash.

The backup system did not come on-line because of the way the system had been re-configured after the failure of phase 3. The back-up system was designed to operate as part of the completely paperless system. The printers were used as a stop-gap introduced prior to the actual implementation. The effect of the introduction of additional components, albeit temporary, on the overall system were never tested. The potential failure of the (temporary) printer-based system was not even considered.

Systems Options admitted to the inquiry team that many of its programs could have benefited from fine tuning. Most of the code was written in visual basic, a language more suitable for the rapid delivery of prototype systems. The performance of visual basic programs is rather slow, thus, filling the screens with such programs can easily take several seconds. To overcome this, ambulance control room staff pre-loaded all the screens likely to be needed at the beginning of a shift and used the Windows software to transfer around as required. The implication of this is the excessive demand on the memory available within the workstations, which degraded performance and led to extra 'clutter' on controllers' screens.

Aside from being an inefficient and the most unsuitable tool for a safety-critical system Visual basic was also a new development tool. Systems Options were using a new and unproven tool, without experience or knowledge for a command-and-control safety-critical system. The tradeoff of impressive user interfaces against reduced speed and systems performance should have been carefully evaluated.

While the inquiry report indicated that Systems Options "rapidly found themselves in a situation where they became out of their depth", it also stated that "Within the time constraints imposed on the project and the scope of the requirements, no software house could have delivered a workable solution."

Overall, The technology leap, attempted by the LAS was too great, and they didn't really look first.

Reports:

The government inquiry report released on March 1, 1993 was one of the most scathing government reports ever released. The report described the chaotic management and total lack of planning and technical oversight which led to the disaster and called for the complete re-vamping the LAS and the way it conducts its business.

During a press conference marking the publication of the official report, Paul Williams, a member of the inquiry team commented that the LAS "went through every mistake in the book".

Following the publication of the report the chairman of the LAS resigned saying “We caused a considerable amount of anguish to the people of London. We failed to deliver the service we could.”.

Systems Options lost their contract for the administrative system they developed for the Staffordshire Fire and Rescue Service (used as proof during the LAS tendering stage). Staffordshire’s Assistant chief officer stated that “the ability of Systems Options to support their system had declined and its capability to meet the demands placed on it had not come up to expectations”

Further incidents resulting from the reintroduced manual system and lack of adherence to performance standards may have led to further deaths over the ensuing couple of years.

A further report, commissioned by the Secretary of State for Health, following the death of an eleven year old girl listed a long set of steps necessary in order to speed up progress and quieten the public outcry

The case of Nasima Begum’s death followed in the footsteps of the LAS fiasco. The public outrage following intensive media coverage forced an official government inquiry into the handling of 999 calls and the London Ambulance Service.

Nasima Begum, aged 11, suffered from a kidney condition known as relapsing nephrotic syndrome. Nasima died of pulmonary oedema after her family had telephoned four times for an ambulance and had waited for 53 minutes. Her doctors at the Royal London Hospital revealed that the girl required treatment within twenty minutes, “Nasima could have been saved had urgent treatment been more forthcoming”. The ambulance that should have saved Nasima was redirected to treat a patient with a sore toe.

The events leading up to Nasima Begum’s death were investigated by a cross-party committee of MPs which reported that “lives may have been lost as a result of failings in the London Ambulance Service”. The report described the system as ramshackle and undermined by absenteeism, ‘blame culture, cumbersome processes, lack of trust between management and staff, and lack of technology. The MPs went on to accuse the Regional Health Authority and The National Health Service executive of a complete ‘failure of nerve’ following the 1992 crash, which itself came after a decade of serious under-performance.

The NHS issued a detailed set of guidelines governing the procurement of computer systems. POISE, Procurement Of Information Systems Effectively focused on a standard procurement process, a set of stages and tools, and guidelines on best practice.

In the wake of the failure, RES ambulance services were offering a guaranteed service to south Londoners for an annual fee of £37.50 per household. The teams were

made up of disgruntled and disillusioned ex-LAS crew members.

Personal views of a disaster:

S.B., an operator, was on duty when the system was first switched on, “Until the day we only saw parts of it ... Nobody knew what the whole lot was like together... We started at 7.00, by about 10.00 we started to lose control, by lunch time we lost complete control.”

Another operator remembers that “the stress level were unbelievable and there were furious bust-ups between operators.”

Others contribute their recollections “The aim was to get a call activated in three minutes, but sometimes it was as long as 18 minutes before an ambulance was sent.”

“Everything that could go wrong did.”

“The computer was supposed to recognise the first four letters of a road name, but often it just couldn’t.”

“It was also supposed to work out the quickest route, but it would frequently end up directing crews down a high street on a busy Saturday morning”

M.H. from East London, watched his GP arrange a bed and order an ambulance for his mother, suffering from heart attack, at 3.45 P.M.. He was promised an ambulance within the hour. Six hours later concerned that she might lose the bed, M.H. arranged a bed in a van and transported his mother to hospital. At 1.45 A.M., The phone rang, it was the ambulance service ringing to check if the ambulance was still required. (10 hours later).

A disabled woman was trapped in her chair by the body of her collapsed husband. She called the LAS every 30 minutes, to be told each time that there was no trace of an earlier call. The ambulance finally arrived 2.75 hours after the initial call, by which time the husband had died.

Crew members reported long delays to the press giving specific details of people that could probably have been saved had it not been for the system. Cases included an 83 year old who collapsed in Wembley and died while an ambulance took 90 minutes responding to a 999 call because the computer could not find the address, and a 14 year old asthma patient who waited 45 for an ambulance.

M.B., a control assistant recalled that “It was chaotic, incredibly stressful and a disaster from the minute I arrived for my shift”. “There was a four-hour backlog of calls and my colleagues and I just looked at each other and said “Where on earth do we start?” ... The computer was failing to give us the message that an ambulance had picked up an emergency, so we had to ring back the 999 caller and ask if the vehicle had arrived, Not surprisingly, they would then give us abuse.”

In one heart attack case, the reply was “I called for an ambulance two hours ago and someone has just died here”

“The following day we decided to revert to partial automation to clear the backlog and take control of the

mess... The problem was there was no back-up system. We were just left with a computer that did not work.”

P.W., an ambulance driver said that both days were chaotic. “The control room had completely lost us and could not give us any calls. They found us in the end, but by then delays were running at about 90 minutes. Many people we went to pick up had made their own way to hospital ... Some on the bus.”

In a number of incidents, ambulance crews were greeted with a ‘nice of you to arrive’ greeting by the police and fire brigade.

The Southwark coroner, Sir Montague Levene, described the ambulance control as ‘totally and absolutely inadequate’ [The health service Journal, November 5, 1992].

A.S. , an experienced radio operator was forced to deal with angry crews questioning why it took three hours to get them to incidents. “In one occasion, a distraught crew were asking why the undertakers were there before the ambulance crew”

Acknowledgements:

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