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Computer Infrastructure and Artificial Intelligence for the Design Office

Infrastructure informatique et intelligence artificielle dans un bureau d'ingénieurs

Computer-Infrastruktur und künstliche Intelligenz im Bauingenieurbüro

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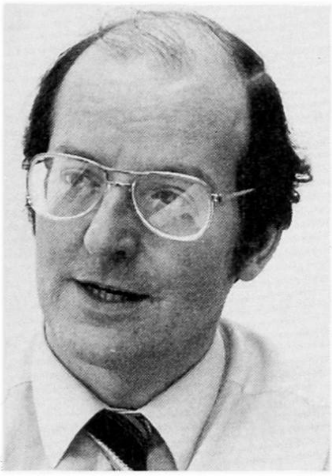


Born 1940, started his civil engineering career as a student with British Railways where he spent five years on a variety of projects. He then moved to the contractor George Wimpey for further site experience before joining a consultant. He has worked with Ove Arup Partnership since 1964, first as a designer then on computer technical support. His responsibilites include policy for Information Technology and hardware acquisition.

SUMMARY
This paper is a transcription of the presentation given by David Taffs who illustrated his talk with numerous slides. It shows the type of work undertaken by a Consulting Engineer and how small a contribution the computer makes to many projects. Other projects are dominated by computer use. The computer infrastructure to support many offices of all sizes is described including communications equipment. A mix of old and new is recommended and adoption of international standards. A direction to future development is given and reference is made to experiences to date with Expert Systems.

RÉSUMÉ
Cette contribution est le compte-rendu de la présentation – illustrée de nombreuses diapositives – de David Taffs lors du Congrès. Elle montre le genre d'activités dans unbureau d'études et la très modeste contribution de l'ordinateur dans de nombreux projets. Dans certains cas la contribution de l'ordinateur est essentielle. L'auteur décrit l'infrastructure informatique et les moyens de communications nécessaires à de nombreux bureaux d'études de grandeur variable. L'auteur est en faveur d'une combinaison d'équipements anciens et nouveaux et souhaite l'adoption de normes internationales. Il indique une direction pour de futures développements et mentionne les expériences réalisées à ce jour avec les systèmes experts.

ZUSAMMENFASSUNG
Dieser Beitrag von David Taffs wurde durch zahlreiche Diapositive illustriert. Er behandelt die Arbeit eines Ingenieurbüros und zeigt, wie bei vielen Projekten der Beitrag des Computers gering ist. In anderen Projekten macht die Rechnerbenützung den wesentlichen Teil aus. Es wird die Rechnerinfrastruktur zur Unterstützung zahlreicher Büros verschiedener Grösse mit den Uebertragungseinrichtungen beschrieben. Eine Mischung von alten und neuen Geräten und die Anwendung internationaler Normen wird empfohlen. Die Richtung der zukünftigen Entwicklung und die Erfahrungen mit Expertensystemen werden ebenfalls beschrieben.

Lecture presented by David Taffs:

Good morning everyone.

The other day I looked in my database and my database is a little box, it has got drawers and hanging files, but it contains information. The older ones of you might call it a filing cabinet, but the computer manufacturers assured me, it's a database. I looked in my database and I found that it was about 10 years ago since you last invited me to speak to IABSE; on that occasion it was in Bergamo in Northern Italy. In about half an hour you will be forgiven for thinking that things have changed very little in 10 years - there is just a little more colour now with our use of computers.

What I am going to do is run through, very quickly, a number of applications just to give you a feel for the way that we use our computers and then go on into the type of hardware that we are using and I hope, if there is time, we finish off with expert systems, artificial intelligence and where we think that is going.

So I start with my first slide which shows highway design and in this particular area of application I don't think anything more needs to be said. It is an obvious area in which to apply computers, we have been doing it for 20 odd years, and I think we are all fairly successful at it. So we do not need to say anything more about it.

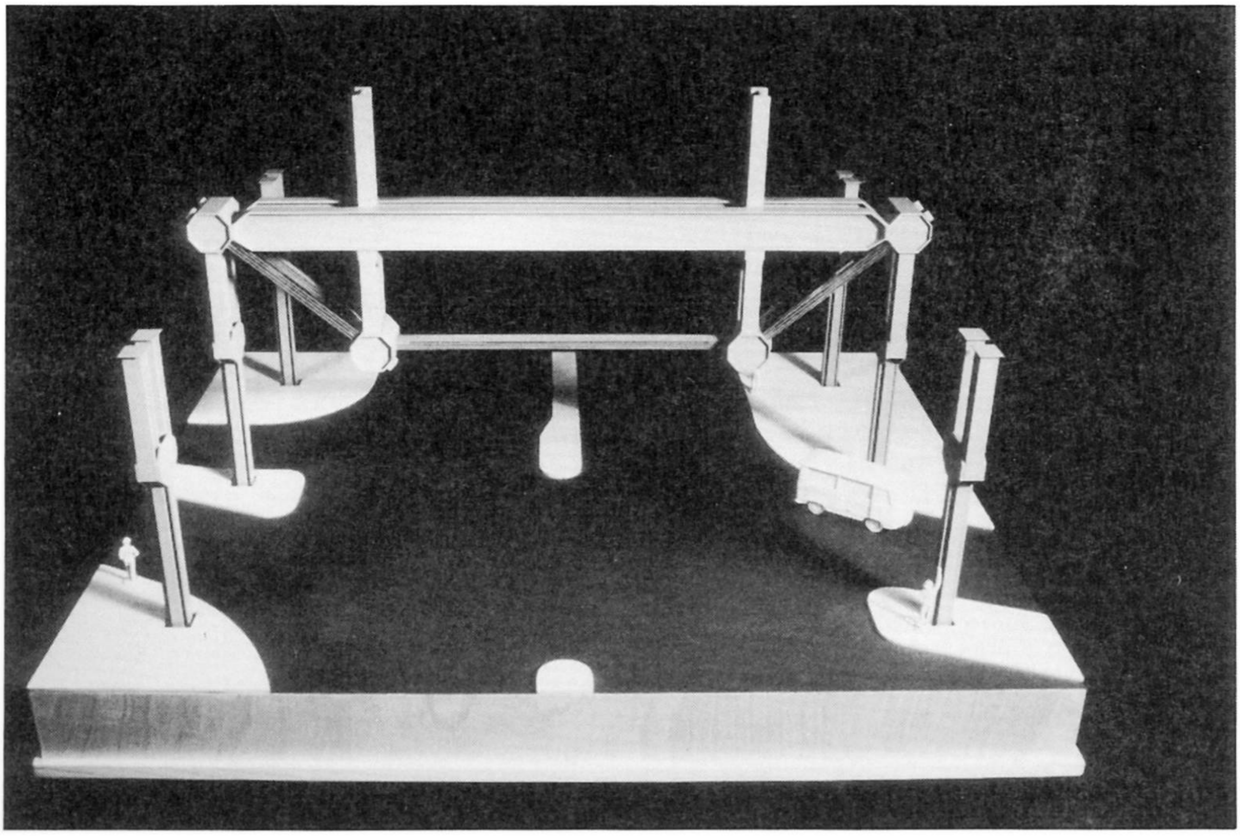
Moving on from highway-design where there is a very clear benefit into an area where we see somewhat less benefit - and that is in site-modelling. But nevertheless, we can model our sites although they may be quite small in some cases. We feed in the data from survey information and then go on and add in, if we wish, the construction sequence for people like contractors to look at the way in which the project is going to be built. This will in turn help the contractor and others to realize how to handle the materials on the site and how best to organize it.

In areas where the structure is very well defined, there is no problem. We can produce computer systems to completely analyse what is there and building a structure such as lattice steel microwave towers, where the dishes at the top may vary in number and orientation, only requires a degree of interaction between the designer and the computer to produce the necessary data which then in turn can be fed through to automatic drawing production.

20 odd years ago we were playing with all sorts of computer applications. Where there is a very well defined system building it is possible to go as far as deciding where the power points are going to appear, where all the services in the project will appear and all of this could be built into the computer system quite happily. Unfortunately, in my particular office we get very few of that type of project to deal with. This (Figure 1) is more representative of the sort of problem we get and I hope, in talking about it in this way, I get across to you how relatively unimportant CAD and computer-tools are to us in our office.

We are looking at the Menil Museum in the United States. The interior lighting was a very important facet of the project and we had to devise ways in which the roof structure would give the correct

1. Ferro cement and ductile iron roof structure of the Menil museum.



2. Transfer structure over six lane highway in London.

lighting and not cast any unwanted shadows within the interior of the structure and so, the design evolved. We came out with a solution where the roof beam bottom cords were in ferro cement and the top cords in ductile iron. Ductile iron has the characteristic of being able to be cast into very fine detail, it is more fluid than other cast irons, so the castings are more accurate. It does not require any heat-treatment, so you do not get distortion. The ferro cement was given a texture that matched with the ductile iron.

Now, the design was by Renzo Piano, the Italian architect, and ferro cement, you would imagine, was very much an Italian material. In fact, we could find no one in Italy who seemed to be able to remember how to construct ferro cement and we had to scour the world looking for people who could do this. It is a fairly convoluted story about how we eventually found an individual or an organisation that could do the work and also ways in which the quality assurance of that structure evolved. No amount of earlier thoughts on CAD systems would have been of very much use in a situation like that. As a consequence of that particular design and project, just the week before last there was another meeting in Italy resulting from an invitation to prepare another museum in the USA. The design team sat around a table, working upon the concept of that design and there was not a computer in sight! I cannot see a situation where that is likely to be for a very long time.

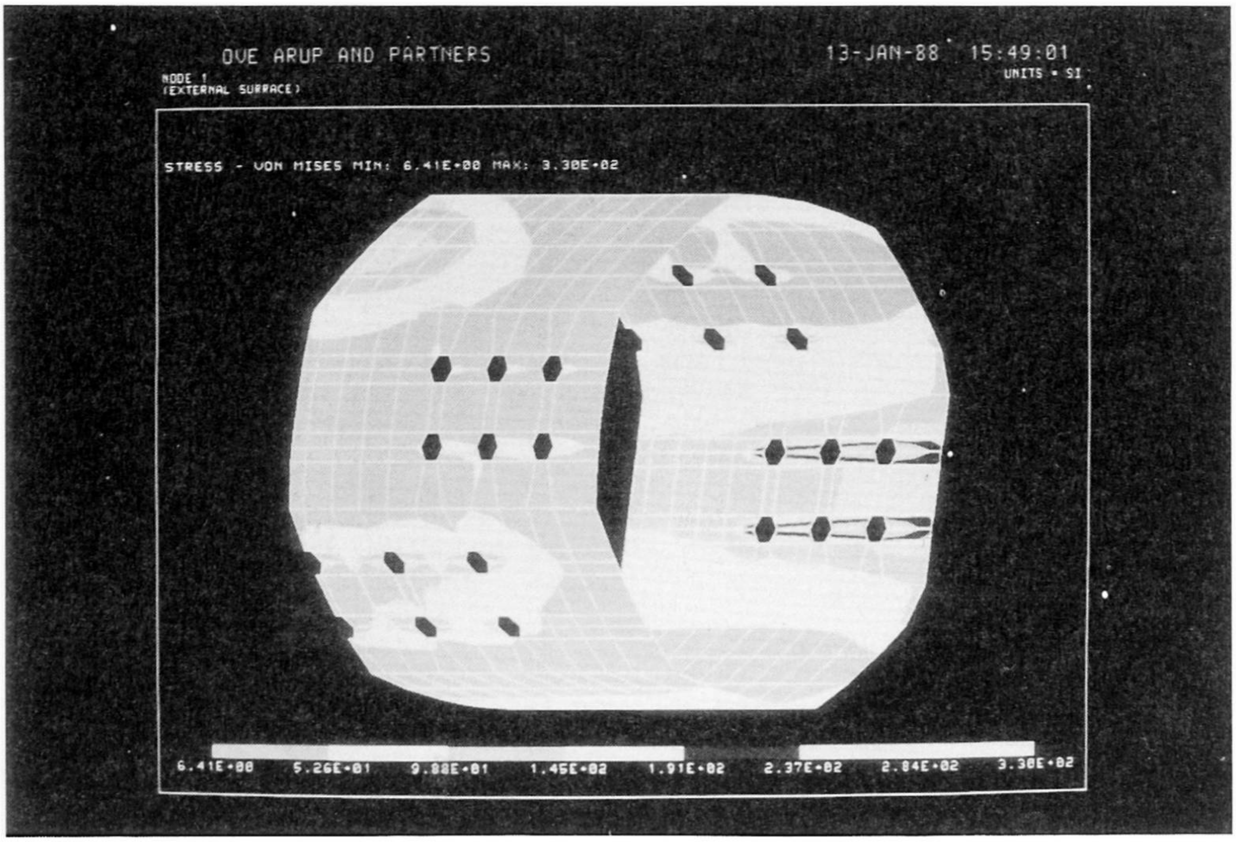
Where we do use the computer, is more in analysis, in particular areas of analysis - and here is a project that is going up in London at the moment (Figure 2). It is an 18-storey-building that fits across a six-lane highway, a dual carriage highway. Here you see the road intersections, and the problem was designing the transfer structure underneath the building. The obvious solution would have been a normal truss but the crossbracing of that truss at the ends, where you have your maximum shear, would have clashed with an area that had to be left clear for pedestrians to walk through. So the design chosen was an inverted truss. The tension members were bars that allowed for take up of tolerances during the construction. We use our computers simply to tell us a little bit about the particular casting that you see in Figure 3 - an analysis of the structure.

Very much the sort of thing that we were seeing in Bergamo ten years ago, but without the colour.

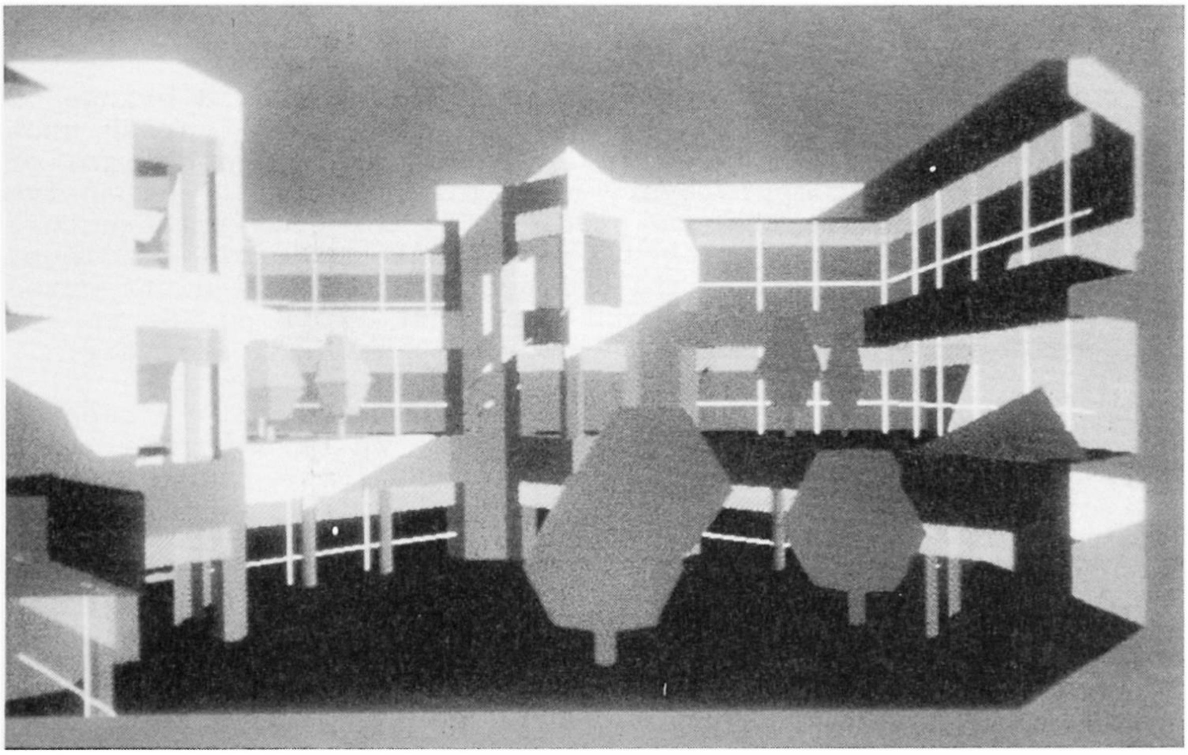
One pleasing aspect of this particular project was that we could use the computer to produce drawings and those drawings in turn were passed to an artist called Ben Johnson. He is well-known in the UK and specializes in painting mechanical objects and building structures. Having been suitably inspired by some of the work we were doing on this scheme he produced a painting some three metres high, of the transfer structure steelwork. So that to me is one of the more pleasing uses of CAD.

Visualization is where we see computers used quite often at the moment. Actually the cost benefits are very debatable but the results look quite attractive. In Figure 4 you see a courtyard in the middle of a hospital complex. In other cases you are looking at larger landscapes and bringing in existing buildings.

Interior shots as well, these are popular, generating images quite quickly. We do find that we need particular types of computer



3. Stress diagram of a node in the transfer structure.



4. Visualisation of courtyard in a hospital complex.

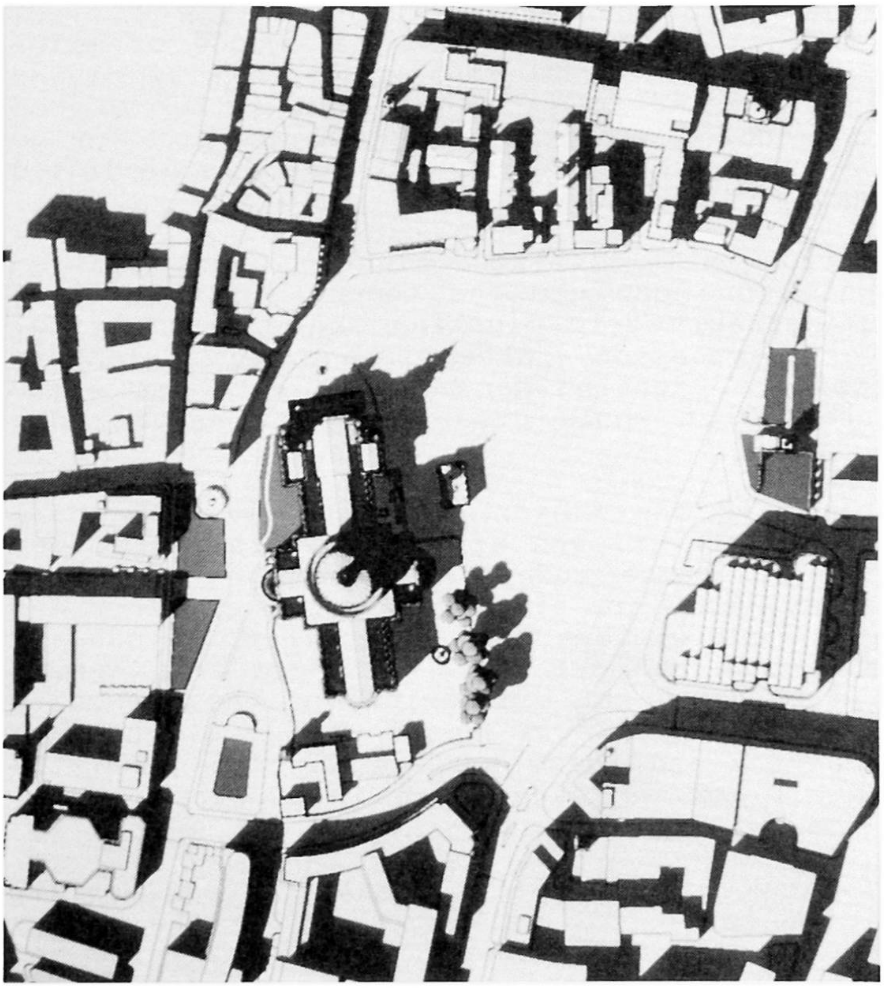
graphics software in order to generate the information we need within the timescale we are given for the project. There often is not time to sit down and drive an elaborate graphics system. It is also very surprising how often we get caught out when we look at the proprietory systems. One of the first slides I showed you on highway design was generated on a system that is very strong in the UK in the motor industry. Therefore, we thought if we bought it we ought to have no problem considering the complexity of some of those motor engineering structures. But in fact we hit a limit - as soon as we started to work on the system, we hit a limit in terms of the file sizes it could hold and it is remarkable that we keep coming up against these problems. I tend to think of ourselves as being fairly modest in our demands on CAD and we hear of all these other wonderful things that are happening and yet, every time we dabble, we hit limits of one sort or another and these systems cannot cope. I would like to mention our 3D-work. We find we need particular pieces of software, particular techniques to get the information we need fast enough. Having built a 3D model, analysis that can be either lighting or thermal analysis and things like this flow from it.

There is a project that is currently being tackled in London (Figure 5). You see an area around St. Paul's Cathedral in the centre and our interpretation of St. Paul's. Those of you who are avid readers of the magazine CAD/CAM will recognize that we are on the front cover of this month's issue. The cover shows a view of structural steelwork of a project, again in London, which is called Broadgate, a very massive fast-track project. The model of the steel was created through the CAD-system to enable the architects to play with different configurations of steel and to get a fair idea of what the final product would look like.

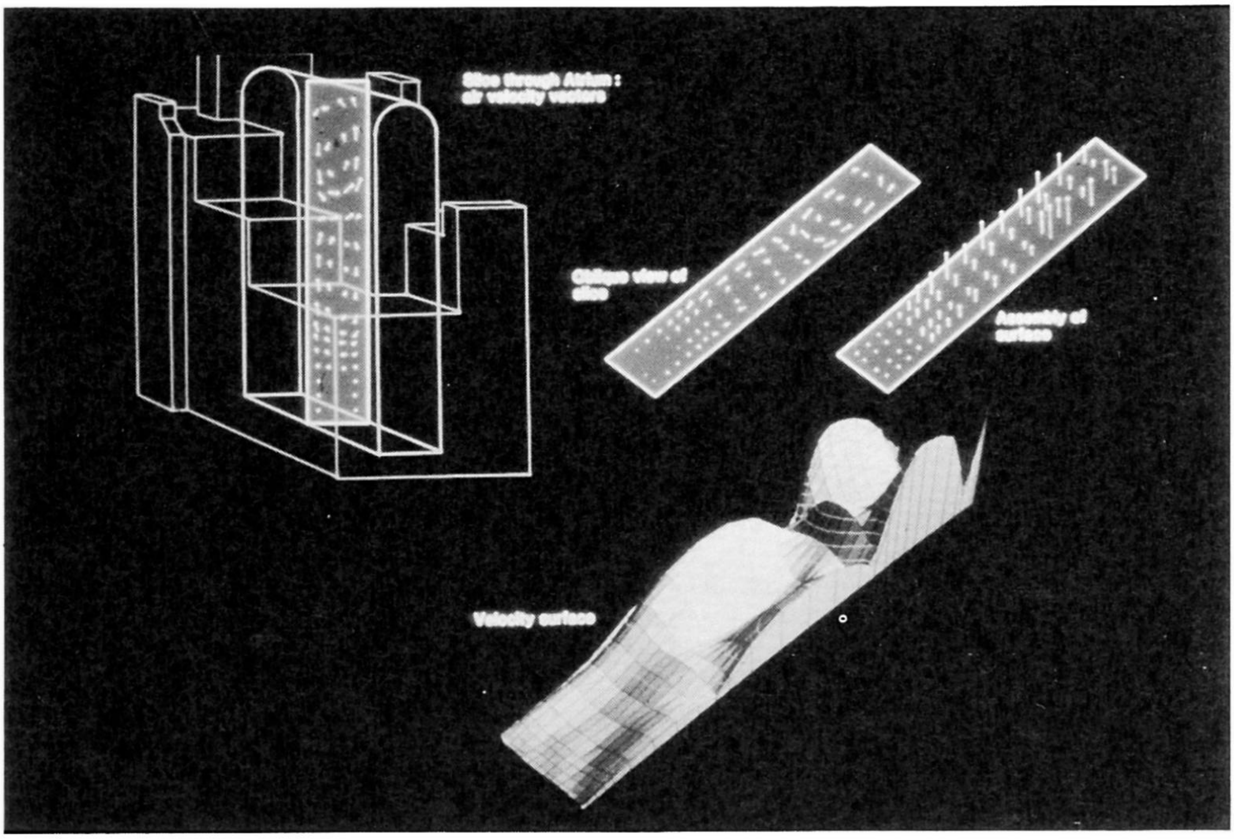
In your company today I thought I should at least show a bridge or two, perhaps a cable stay bridge. Alternatively a more garish shot for bridge engineers who are colourblind. But in bridge design, of course, we do use the computer very much more for numerical analysis, for getting the data that we need. Being the complex structure it is, we have construction stages to consider, variable loadings, the automatic positioning of vehicle loads or uniformly distributed loads, use of influence surfaces and this sort of thing. So we are using the computer in the traditional way of numerical analysis.

Light weight structures, of course, lend themselves to this because of the amount of geometrical calculation that we have to deal with and it is not only just for the stressing up of the fabric within those light weight structures but also for producing the cutting patterns for making the structure afterwards. So these are all by-products of the visualization.

Simulation is another area and in this particular case we are looking at the design of a flask for carrying radioactive waste. The client was very concerned about quality assurance and as a consequence we ran a number of simulations. Although we dropped this flask from great heights and it had not broken, someone came up with the idea that if it fell across a railway track and at a particular angle across that track, it would be at its most vulnerable state if it were then hit by a high speed express train. So we ran through a computer simulation of that particular event. Then the client did something unusual. He sat all the design team down on



5. Computer model of development area around St. Pauls in London.



6. Simulation of air movements in atrium of the Lloyds building in London.

seats, on a ramp, rather like yourselves, and placed the flask across the track. An express train was started a couple of miles further down the track so that it would get up to full speed and the whole of the design team had to sit and watch whether or not their analyses were correct. Fortunately, few of us have to go through that experience. Thankfully, it all worked out as predicted so there was not too much to worry about.

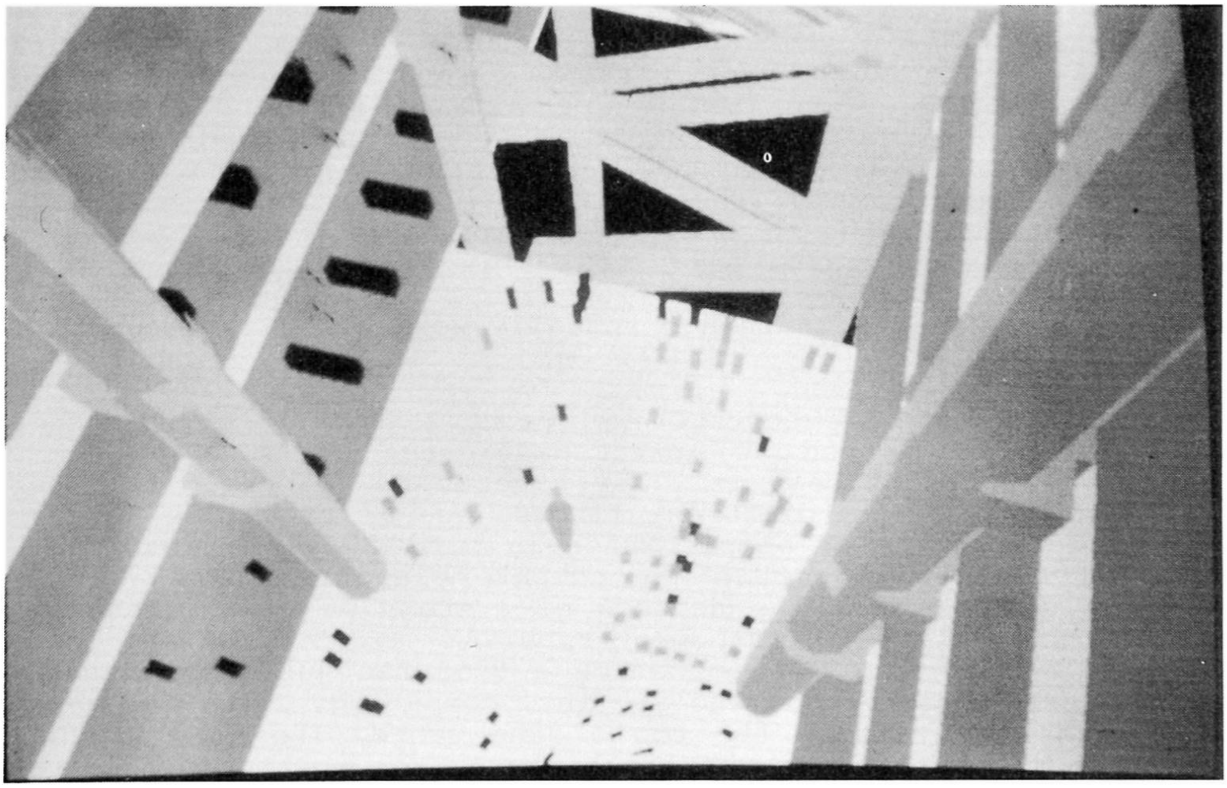
Another area of application is in lighting. Lighting design, interior lighting and, again, one can use the computer for handling different types of luminaires, strip lighting and spot lighting. There is quite a lot of calculation, rather like a very intensive finite element analysis. The lighting can also be not just simulated for individual rooms but whole areas and with natural day lighting as well.

Another project in London is the Lloyds Building. In the centre there is a very high glass atrium, and off to the sides are open plan offices, where the insurance underwriters sit and do their trading throughout the day. They are sitting on the open floor and there was concern that in our winters very cold air would cascade down the side of this atrium and perculate to where the traders were sitting. So we had to carry out simulations of the air movement. So we set up a model of the atrium itself (Figure 6) and then carried out various analyses and these surface diagrams show the peaking of velocity of air movement and where it occurred at the different sections of the building.

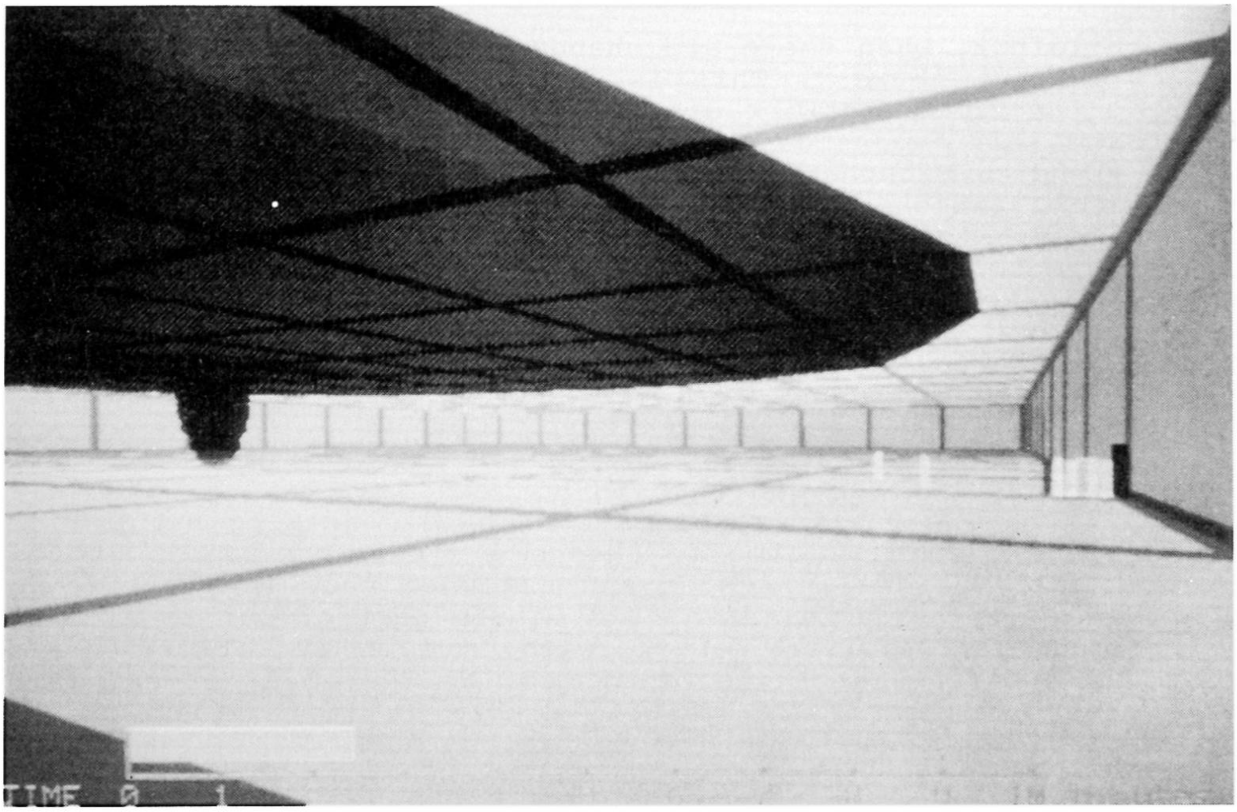
The view in Figure 7 is looking down into the base of that atrium, but the very fact that we see people walking about at the bottom tells me that we are looking at a different type of analysis, and that is one of fire. With fire engineering we are talking about the movement of people within buildings. Typically, with a very large building you are looking at the speed of evacuation of people from those spaces and at all the constraints that are imposed in terms of rate of exit, distance to travel and the different speed of travel of the people. So one can produce a simulation of people moving at different speeds according to their abilities or disabilities and seeing how long it takes to evacuate the building. So one starts a fire in the computer model, you see a few flames at the bottom there and you see the smoke starting to billow up and then, watching that smoke spread and again watching the time it takes for that random sample of people to evacuate the building (Figure 8).

I want to tell you that I have yet to find a need in our particular work to carry out 3-dimensional modelling of building services. I often hear it said how important it is to carry out modelling and I have yet to find the need for it. It normally takes longer to produce the model and there are so many factors which the model cannot sensibly take into account that it is not worth the effort.

Let us take a quick look at a trend that is growing, and that is into intelligent buildings. By intelligent buildings I do not mean cabling of buildings. Invariably, when people talk about intelligent buildings today, they talk about more cabling, special cabling in buildings. That is not what we mean. We are talking about computer control of buildings and its environment. This is a new development and there are very few examples in existence. The other new



7. View of floor of Lloyds atrium taken as part of fire simulation exercise.



8. Smoke cloud advancing over members of public exiting to the right.

area of development is facilities management. What I mean by facilities management is where clients are asking for the computer data to be passed on to them to enable them to carry out maintenance and subsequent planning of the structure after completion.

Right. So let's look now at the computer infrastructure behind these applications to give you some idea of what we are currently using. We are interested in what we can make work today. Typically, one would hear about these marvellous things 10 years ago in conferences but I am talking about struggling today to make the things that we heard about 10 years ago actually work. That is the difference.

We have networks of computer systems. We have about 16 buildings in London. There is a need to intercommunicate. Design groups are split as new projects come in. They have to be relocated together in different buildings, different floors, and all the time we have this dynamic movement of people which in turn means, moving equipment to allow them to get to the computers and use them as they need to be used. Within the network of systems we have a range of computers. There is a DEC-10 computer, a VAX II/785 computer. There are a couple of Primes, one of which a 9755 has just been changed for a 6350. To those of you who are into computing, I say its amazing that we keep hitting the top of the range. The 6350 when we bought it a few months ago was the biggest, the most powerful system that Prime had. For the little bit of work that we do, to find ourselves having to use the biggest and the best that they have, I find staggering. What, I wonder, is the rest of the world doing.

Within buildings, when there are changes, we have to reanalyse the segments of the network. This is done by somebody working on a PC-system. He has a network diagram in front of him on a screen. Over to the left hand side here, you see some fairly thick cables. That is standard Ethernet cabling, where a trial is being conducted between a PC (which is the Apricot-PC), through the little grey boxes which are the transceivers which take the input from the PCs, and another computer. We are down to things like speed and concurrency of movement of the data and the data-transfers, of course, always turn out to be far less than the rated data-transfer speed. Ethernet we are told is 10 megabits a second. We are still looking for the manufacturer who can deliver that.

Behind the scenes of course you have got archiving, masses of data to store and look after and that is no mean feat having to do all of that. We have database machines that handle nothing but a Pick database. Again when we came to choose a system we looked at the financial institutions in London and saw what they were using. To us, handling our financial data is a minute part of our total processing load. The suppliers came forward, saw our specification and offered us a particular style of system. We looked at it and said that sounds quite good, but we will double it in terms of power. They said you won't need that, it is far too much. We insisted they doubled the size of their offering and within months we soaked it to the point where it was hardly able to run. What I am showing you now is the latest machine that has just arrived. It is again the biggest available, the latest technology. It is the first one that McDonald Douglas have supplied in the world and which gives us, they claim, performances of 24 to 30 mips of power, just to handle one small part of our activity. And again I put the question: What

9. Testing data transfer speeds through Ethernet cables (visible to the left).

10. Design office hardware from CAD to programmable calculators.

is the rest of the world doing? If we in a small part of our data processing have to get the biggest models, where does that leave the financial institutions? Are they maybe just playing with their computer systems? I don't know. - That's a question for later maybe.

With our level of computing activity we need back-up and all sorts of other things. You are looking at a UPS-system (uninterruptable power supply). Now the point I want to make here is, as you become more dependent on the computer systems, you do not have the time to fall back onto manual systems of any sort and, therefore, you have to have all the support services in place and this is a big headache for us, to achieve all of this.

Constantly playing with wiring, with cabling, with autodial-modems, the ability to go out and communicate with offices across the world - all of this requires extra effort and support. You get very congested cabling if you go for mini computer technology with multiple colour work stations. Line analysers are needed to install and check out RS232-type of communication or whether you are into much faster Ethernet. You need different analysers for the different networks, go- faster boards and graphics boards and all sorts of lovely things.

I should tell you about telephone systems as well because the telephones have to be reprogrammed every time people move about and every time we want to introduce a new feature. We keep statistics on their use, so we know who is doing what and where extra line capacity is needed. We are also expected to exchange data with all the other systems our clients are using. For this we use various devices and always some bespoke programming. We also have a continuous training programme on all topics, which is a constant headache to us.

We have quality assurance to worry about in software, making sure that the software is correct. There are even mistakes in chips. Those of you that may well be using an early Intel 386-chip should be aware, if you have not already heard, that for a while there was a basic error in the 386-chip logic. So if you have done a lot of calculations with a 386-chip, I hope you are feeling comfortable at the moment. If you want to check with Intel they will tell you the serial numbers affected. They are printed on the chip and are easily visible.

Another subject is documentation. We help our quality assurance by paying attention to documentation. Distribution of software is a problem. We have set up a system for distributing our software with an automatic machine for copying and verifying disks. The endless supply of equipment requires staff to deal with the demand and the packing and unpacking and all the insurance requirements that we have.

And then, finally, into our offices and the sort of set-up you see: PCs, laser printers, little dot matrix printers. For the heavy specification production we get dedicated word processing systems. For the design office we have CAD-stations and more CAD-stations. I think this is an important slide to note (Figure 10). You see little programmable calculators, where software is being stored. They do not change, they are just laying about there, people will grab the particular calculator they want. So every scale of computing has its place.

Onto colour output and a particular SUN workstation. We are using the 386i workstation as our standard now and that has again only just been announced. The operating system software still has bugs, but we are working on that, and hoping to get better.

Quickly, then, I have about one minute I think, on expert systems. An expert system has been set up by a UK government body which is spending a lot of money and wanting reassurance about the way that money is being spent. So they commissioned an expert system.

We are the consultants who are advising the government body on the project which is about stabilising old limestone mineworkings. The idea is to get corroberation of our recommendations. Our knowledge was fed into the knowledge base. Not surprisingly now, the expert system tells the government body that what we are advising them is correct. So those of you who understand these systems, may not be impressed by the exercise.

In other areas of expert systems practical applications are a long way off. Simple operations with expert systems we find are taking hours and hours, very much longer than it would take to simply phone up an expert and seek advice.

I have run out of time. Thank you.

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