Lecture to the conference on Leisure Opportunities, London 1989

"EXTENDING THE HUMAN EXPERIENCE."

I shall begin by quoting Samuel Johnson, who in 1773 said "All intellectual improvement arises from leisure."
In this presentation I would like to suggest three things:-

Firstly, that **Every human being is insatiably curious**:
Secondly that **Simulation technology is a new, safe and profitable way to meet that human need**:
Thirdly that **you should not consider simulation as a "fairground ride" but as a whole new way of creating enjoyment in the leisure industry.**

The Drive to Explore

We all have a deep-seated and unconscious drive to explore our environment and for most people this is denied them in their everyday work. Leisure time therefore is seized upon as a time to make up for lost opportunity, to break from a routine environment, to explore and to play in the full sense of the word. This is true for every leisure activity; for example leisure travel is a deliberate seeking out of new environments, new sounds, new views, new tastes and encounters with new people. Sporting activities represent constant effort to exceed one's previous best sporting achievements, to set one's self against new people, to employ new techniques and to try one's skill in new environments. The enjoyment of art consists in the seeking out of new sensations, the exploration of new ideas and the finding of new ways of looking at the world around us.

The general public may not be consciously aware of their in-built drive but nevertheless they are always attracted to something new, something which is in some way "better" than they have previously known and they are always attracted to a different presentation, even of old ideas, because they represent in this context "something new".

The fundamental need which every part of the leisure industry sets out to meet is **the need to extend the human experience.** Simulation represents a very powerful way of doing just that.

Why I make Simulators

I built my first simulator 20 years ago. Actually I built two, which were the air intake simulators for Concordes 001 and 002, the French and British prototypes respectively. The significant thing, of course, is that Concordes 001 and 002 did not actually have Air intakes of the type which were used on all subsequent Concordes. The two prototype machines had jet engine intakes which were of fixed configuration, whereas on the later machines the area of the intake and the relative proportion of the intake air which was

fed into the engine at different altitudes and under different flight conditions was variable. On the first Concordes it was not and in order to check out the control systems it was necessary to simulate these air intake mechanisms. I built bits of machinery and electronics which, as far as the Concorde control systems were concerned, behaved exactly as the variable air intake doors were going to behave on future Concordes; the control system could not tell the difference between my air door simulator and a real air door. I created a fantasy air door. I fooled the electronics into thinking that reality was changed. That's what all simulators do.

Ten years later I built a very large and complicated simulator for Marconi at Stanmore which was designed to do a similar thing for various types of electronic warfare equipment. If you do not know what electronic warfare is about then in simple terms I will say that it is a game of Hide and Seek, a sort of chess game played between computers and microwave equipment at extremely high speed and therefore without the intervention of any human being at the time of the (bloodless) battle. Radars and jamming equipment try to outwit each other as an aircraft, for example, comes streaking in across enemy territory whilst the enemy tries to get a fix on the aircraft and fire off guns or missiles to knock it out of the sky. If the jammer wins the battle the aircraft will survive; if it loses the aircraft is doomed. The electronic warfare simulator is used to test to the limits the efficiency of the jamming equipment and the cleverness of the programmers who bury into the software of the computing systems all the strategies which can be adopted against all the counter strategies known to be possible within the physical limits of the enemy microwave equipment.

The problem of course that everything happens at high speed, is very complex and quite invisible and so it is incredibly difficult to follow the simulation, to understand what is happening, who is winning, who is losing, and why. I ask you to remember in any case that the whole thing is imaginary. It is a simulation, and it is designed to convince the software in the equipment under test that it is <u>not</u> sitting in an anechoic chamber in a steel lined building at Stanmore but it is fixed to an aircraft streaking in at Mach 1 50 feet above the ground against a densely defended target thousands of miles away.

The most interesting thing is that everything is invisible and inaudible to the test engineers. I therefore decided that, so that they could have some idea of what was going on as the test proceeds at breakneck speed, that I would transform the signals into visible images which could be shown on a TV screen. In effect I decided to give the test engineers a view of the simulated microwave world seen by the microwave sensors in the attacking aircraft. I used some very large computers for this work, some of which were more powerful than the Cray 1 Super-computer and I made my first encounter with Computer Generated Imagery.

I was astounded at the effect of this simulation on my basic human emotions and the effect on the emotions of RAF pilots and senior military personnel who watched the displays on the TV screen. Clearly, they were fascinated and found themselves caught up in what they saw. I resolved that I would find some way to let the general public experience this sort of fascination.

I left Marconi and set up a company which built its first simulator in 1985. I am pleased to acknowledge the co-operation of my erstwhile colleagues and of the Marconi Company itself in assisting me to make the first Super X simulator a reality.

What is a Leisure Simulator?

The present generation of Super X machines consists of small cinemas in which a group of people watch a projected television display and listen to a soundtrack whilst the whole cinema moves on a hydraulic motion base. It sounds simple but I am pleased to say that it is not; there are many critical subtleties which have to be learned and rigorously applied before the simple concept comes to life. My financial backers, the Leading Leisure Group, have supported a very substantial investment in Research and Development and in Production Engineering for these machines.

If you have seen a simulator working from the outside you will see that it weaves and dodges about through small angles of pitch and roll and it also bobs up and down a few inches in a seemingly - random combination of movements. I assure you that when you get inside the effect is quite extraordinary and without giving away too many secrets about how the trick is done I can say that it is highly dependent upon the total exclusion of the external world. From then on it depends upon Einstein's First Principle of General Relativity. This says that, in a closed environment, it is impossible to tell the difference between gravitational and inertial forces - in short, you do not know which way up you are if you get lots of other signals to your senses which tell you that "down" is not in the direction you thought it was. Finally, simulation works because your body is designed so that it ignores a steady speed in any direction and it even ignores a steady acceleration after the first fraction of a second. All these things taken together make it possible for computers programmed by a trained "simulation choreographer" to persuade the occupant of a simulation capsule which moves a few inches that he/she is swooping violently around the sky, racing around the Isle of Man on a motorbike, Skiing in the Alps, Rushing through a canyon on a raft, or sailing gracefully about in a microlight aircraft.

Lessons from the prototypes

Of course I read all the books and talked to all the experts in the business before I built my prototypes but nevertheless I learned many things the hard (i.e. very expensive) way. For example:-

Technology is not attractive. I was very proud of my gleaming prototype, its hydraulic valves, its sophisticated electronics, its very expensive software and so on. Billy Chipperfield of the famous Chipperfield family leant over the fence to me one day after watching the machine for a while and said, very helpfully, that as far as he and his friends and relatives in the fairground trade were concerned at least they did not mind the technology just so long as the machine always started on the button, was easy to maintain and just kept going! To me a well designed piece of mechanism is a thing of beauty but I do take Billy's point that the technology is not actually what I am selling.

Reality is not wanted. Using the vast computing resources available to Marconi I was able to produce my first simulations accurately synchronised to a very detailed and exact computation of the necessary movements of the simulator to reproduce correctly the sensations of flying in the actual aircraft which was "flown" in the simulation - in this case a T45 Hawk flown with locked rudder.

Within a very few days of putting the Super X into operation the general public forcibly informed me that, the sensations were definitely not what they wanted. When the general public is flying an imaginary plane which banks to the left they insist on feeling the sensation of slipping downwards to the left, for example. You and I know that when the aircraft which we are flying for business or pleasure banks to the left we decidedly do not want to slip down to the left and our cup of tea (or glass of champagne) does not fall over and the surface of the liquid remains parallel with the top of the glass. This is because the aircraft flies in a properly-banked turn, in which the centrifugal force which throws the aircraft outward in the turn is always directed vertically downwards through the floor of the cabin and keeps us firmly in our seats and our drinks firmly in our glasses. My logical and reasoned explanation to the dissenting public was swept aside and I remembered, of course, that the customer is always right. The customer now gets what he wants in my simulators even if it isn't the world of Euclid, Newton, Einstein et al, to all of which I have previously learned to give the highest respect.

Reliability means money. Just under 25 years ago I designed the Burner Control Systems for all the boilers in several of Britain's oil burning and coal fired power stations, including Fawley, Pembroke, Isle of Grain, Eggborough, Ironbridge and so on. I seem to remember that I was very impressed that if, due to a fault in my control system, a six hundred megawatt boiler was out of action unnecessarily, it cost the CEGB £25,000 an hour in lost revenue. If one my simulators is out of action today it costs the operator £200 an hour but that is cash, "real" money and the man whose pocket it should be going into gets very angry. I therefore use the old rule:-
"When in doubt make it stout, out of things you know about".
We do push the technology all the time but we make things as simple as possible and

as strong as they need to be and then some.

Everybody wants a story. The general public does not just want a few minutes of exciting reality or even a few minutes of reality as they think it ought to be. The pseudo-reality has to have a story with an unexpected twist here and there. My very first little simulation, using an aircraft carrier, a bit of a shoot-up and a very eventful landing attempt back to the aircraft carrier, was scripted and constructed in two weeks flat but it still one of our most popular experiences because everyone can relate to the story. Stories must have a beginning, there must be a satisfying end, and something interesting has to happen in the middle.

Music sets the mood. Reality doesn't have any background music but simulated reality is not good enough unless there is some music of the right type at the right time. I am fascinated by the psychological effect of background music and we even have one experience which the public like for the music first and the simulation second. This is our microlight experience filmed in the Autumn of 1987 over the Marlborough Downs and it is this Experience which the Prime Minister and her party rode in Australia last year. The music adds a definite sense of enjoyment to what might otherwise be an unexciting ride. Microlight aircraft, after all, are not rated for their high G aerobatics.

Imagination needs time. I tried a number of simulators completely unthemed in the earlier days and these were a complete flop. I now know that it is necessary to build up a sense of anticipation in waiting crowds by a number of means, so that when they finally enter the simulator they are primed to expect the pseudo-reality of the simulation. It is my view that the queue for the simulator should move through a narrowing tunnel which gradually obliterates outside reality and builds up an expectation of the new "reality" which will shortly be experienced.

Key technical developments

My early calculations of the power which would be required to move a simulator properly were very conservative. They were based on the gentleness of true reality. It turns out that the general public actually want a more violent reality which uses up about twice as much power. I was also interested to find that if I pursued the development of the precision of the machine simultaneously with its power handling capability, I could achieve the most extraordinary effects on the human psyche.

I found that in order to be comfortable in this more violent environment I had to improve the quality of the seating and of other furnishings within the capsule and that this improvement in quality and lighting also added to the feeling of security and enjoyment of people entering a simulator for the first time.

Finally, I found that there is a constant pressure to enhance the sound and visual quality of the experience and that this reflects on the technical capabilities of the audio and video equipment used. I do not expect this pressure to ease until high definition television systems are commonly available and low enough in cost to be used in my

simulators.

Some Interesting discoveries

For simulation to work the following features are critically important:-

Complete isolation is necessary. As I have earlier explained, it is vital that the person who is within the simulator has no idea of his orientation relative to the gravitational vector and it is therefore necessary to shut off the outside world completely. There must be no windows and no possibility of seeing the ground outside from peripheral vision. Actually it goes a lot further than this; no chink of light must be allowed to penetrate the capsule to provide any clue as to the nature and type of movement which is really being experienced. I also found that any reflecting surfaces inside the capsule interfere with the illusion that the occupant is part of the picture on the screen. The moving cinema is matt black to every possible extreme to remove every sensation of edge and distance other than those seen on the screen.

Tiny movements are essential. It is not the big heave, pitch and roll movements, which can be seen by the outside observer, which cause the most profound effect on the human psyche. It is the tiny movements (some of them only about a millimetre in stroke) which are synchronised to the fine grain of the picture and represent things like the road surface or the scrunch of the snow. These really convince the occupant that he is no longer connected to the ground but moving swiftly into the picture on the screen.

Dark rides work. Having toned down any sensation of the real world as described above and produced an excellent sound track we found that it is possible to produce an exciting dark ride with just a few glimpses of something mysterious on the screen from time to time to stimulate the imagination. I personally found this very interesting, since it is part of the deception process to link small movements of the simulator with much larger visual cues. However in the case of the dark ride there are hardly any visual cues and the occupant has to interpret his sensations in relation to an alternative reality which has only been very vaguely described! We are looking into this!

There is a threshold of credibility. Starting from some fairly wimpish and unrealistic movements, if the degree of power and precision of the simulator motion is gradually increased and locked to pictures of better and better quality there is at some stage a "flip" in the mind of the occupant. Up to a certain degree of precision the occupant is conscious of being in a simulator. Above this degree of precision something like a survival instinct or a sense of balance kicks into action and takes over the thought process, concentrating the mind intensively on the picture on the screen. The motion is not perceived as being additional to the picture any more but the picture itself suddenly becomes very important. Any criticism of the quality of this picture (e.g. any sense of the TV lines and their unreality) is also suspended and the occupant acts as though in a survival situation.

I think this is just what is required of a good simulation - a sense of real fear in an absolutely safe environment.

The balance of fantasy and reality

I have earlier referred to the basic human need to explore and to play. It is also a basic human drive to imagine, to fantasise and to escape from reality if only for a short time. An intellectual will express this drive in an interest in the Arts, in reading and in contemplative thought; but even the least intellectual of persons enjoys TV, Cinema and lurid literature. Everyone needs a way into fantasy and simulators are designed to achieve this.

I don't know how many of you have thought about the psychology of the design of shopping malls. With the present trend to integrate leisure and retail activities, perhaps most of you have.

There are two ways of looking at the concept. Obviously where a crowd has gathered for the serious business of shopping there is an opportunity to take more income from the provision of leisure activities. Similarly the leisure environment prolongs the dwell time near the retail outlets and the relaxed atmosphere reduces the resistance to the sale of luxury goods.

But there is, I think, a much deeper significance to the design of shopping malls. Every effort is made to promote the sensations of cleanliness, airiness, spaciousness, richness, warmth and general pleasantness. The customer is made to feel safe and welcome to stay as long as he/she wishes. Restaurants provide food. There are many kinds of entertainment; large malls even include a chapel. Only "decent people with money" are allowed into the mall complex. In short the mall is a futuristic fantasy world, an artificial reality, an escape from the inconvenient real world outside.

Malls are very popular. I believe they betray a natural wish to enjoy an entirely-artificial environment as a deliberate experience. I believe that the use of simulation technology to create a large-scale centre of otherwise-inaccessible experiences follows as a logical extension of the shopping mall phenomenon. There will be Simulation Centres.

The application of Simulators

I would like to suggest a number of ways in which simulator technology can be put to profitable use in leisure projects. They can be used:-

1. **To draw a crowd to a particular area - as an attraction.** They can be used at exhibitions and they can be used to bring "life" to a quiet area of any site.
2. **To extract money from a crowd which has gathered for another purpose.** They can be used in the waiting areas of airports, on railway stations, show grounds, shopping malls etc.
3. **For amusement purposes.** They are an ideal extra choice in fairs and amusement parks, where their unique attraction appeals to all the family at the same time.
4. **For advertising.** The machine itself is an attraction which can be decorated with advertising and the captive audience within the machine is receptive to advertising on the video screen.
5. **For Education purposes.** They can be used in museums to illustrate clearly and in an interesting way aspects of travel, animal behaviour, the local environment and so on.

The important thing to note is that simulators are equally attractive to persons of all ages and all ages can ride the machine simultaneously.

Potential Sites.

Simulators can be used in a large number of different locations. These are:-

1. Piers and funfairs
2. Theme Parks
3. Museums
4. Stately Homes and Safari parks
5. Amusement parks
6. Caravan parks and camping sites
7. Exhibitions and promotions
8. Hotel complexes and resident holiday centres
9. Zoos and Aquaria
10. Shopping malls
11. Leisure facilities and sports centres
12. Mobile machines for seasonal events and shows
13. Airports, railway and coach stations
14. Ferry Terminals
15. Motorway service areas
16. Special indoor attractions at city centre sites
17. Groups of simulators may be sold in themed 'simulation centres' as a totally new form of entertainment attraction.

Training Applications

Simulators are not all "Cinemas on hydraulics". The technology which has been developed for leisure applications is already being extended into that of serious training. For this to be possible it is, of course, necessary for the simulation to become interactive - that is to say, what happens to the participant is strongly determined by the previous actions of the participant. Instead of sitting in a machine which moves into a fixed sort of artificial reality, showing for example a film of an aircraft flight or a motor race, the new generation of simulators will use high quality computer-generated pictures which show the view of an entirely imaginary situation according to the precise actions of the occupant. Such simulators are a sort of "video game you get into" and I would like to suggest two or three possibilities:-

1. **Golf.** It will possible for a golf driving range to show to each striker the view forward from the position of the last fall of the ball on any golf course. For example, one person may tee off to number one and the computer will calculate that he will find himself in the rough, so that his screen changes to show the view towards the hole from the rough. His next door neighbour might have hit the ball well and be up near the green; he will have a view from that position; his next neighbour may have bunkered himself so he gets that view. This applies to all 20 or so people on the range at any one time and they will each move at their own pace through the golf course experience without interfering with each other, in any weather and at any time of day.
2. **Hang Gliding.** It is conceivable that a complete novice can be initiated into the techniques of hang gliding by mounting the hang gliding rig on (or rather hanging it from) a hydraulic motion base whilst the person under instruction tries to fly through an artificial air space which is visually presented on a screen in front of him. The motions of the simulator will respond to air turbulence and the like, as appropriate to his attempts to fly the hang glider. The trainee can also be taught how to respond to difficult situations without putting him in real danger.
3. **Skiing**. A trainee Skier may be placed on a ski slope belt which is itself mounted on a hydraulic motion base. The skier's view is that of a television projection of an appropriate skiing course. According to his skill the difficulty of the course may be increased and it would even be possible to provide some automatic and entirely objective measurement of his skiing expertise as his skill develops.

Any other interactive and skilful leisure occupation can be simulated.

Medical Applications

Simulators have a strong relevance to the medical treatment of phobias of all types. Phobias consist of an irrational and uncontrollable emotional response to a particular set of environmental circumstances. Because these circumstances may be simulated

and the degree of strength of the simulation may be varied, it is possible to lead the phobic person into their irrational situation step by step and in the case of emergency to move instantly from simulation back to reality. This 'trains' the phobic person to experience that which is most feared and restores the mental balance.

The coming revolution

My company is founded on the conviction that simulators as you see them today are but the merest hint of a rapid and extraordinary development in the interface between computers and human beings. Computers will be used to manufacture in simulation an extensive variety of sensations, of inputs to the human sensory system, coordinated to represent a range of alternative realities, of fantasy worlds, with which the human being may interact. Simulation, professionally applied to the consumer market is a powerful attraction to the general public of all ages because it fulfils the fundamental compulsion to extend human experience.

Phillip Denne. October 1989.