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1/1996

Information Technology

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EMERGING TECHNOLOGY SERIES

INFORMATION TECHNOLOGY 1/1996

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SIMULATION FOR PLANNING AND OPTIMIZING OF MANUFACTURING ENTERPRISES
by J. Niwinski

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TO OUR READERS

Through a new series of awareness publications on technological advances that incorporates the earlier **Technology Trends Series** and the **Industrial Monitors Series**, UNIDOhopes to better sensitize industry and governments to the need for and requirements of technology assessment and monitoring in the areas of the new and emerging technologies. As you see, the former **Microelectronics Monitor** has now been renamed **Information Technology** and will appear four times a year, as before. In addition, the **Emerging Technology Series** will cover special topics in special issues, such as **Trends in Parallel Processing**, which appeared earlier this year. We hope that our readers will continue to find the coverage of subjects useful, as these emerging technologies play a catalytic role in the development process of the new global pattern of rapid and accelerating technological change, sweeping trade liberalization, far-reaching deregulation of markets (including the privatization of state-owned enterprises and commercialization of R&D), as well as the globalization of international business.

This issue of **Information Technology** presents a lead article on computer simulation. This tool, also called computer modelling, is one of the most promising ways in which computer technology may contribute to the progress of our civilization. Computer modelling is nearly as old as the computer itself (the von Neumann machine) itself.

In many cases, computer modelling is a more powerful tool than the traditional mathematical approach. The difference between the traditional mathematical approach and computer modelling already became obvious in the 1960s. For example, the differences of these two approaches can be found in the modelling of brain neuron networks. It is possible to mathematically describe the electrical activity of a single neuron as a function of time. Then a network of interconnected thousand neurons can be described in the form of a thousand equations. Without mentioning the difficulties in solving such a set of equations, the obtained result would present a snap-shot of a status of such networks at a single moment in time.

In a computer experiment (as already demonstrated by Farley at the Moore School, University of Pensylvania, in the late 1960s), a computer model of a single neuron should be made, then multiplied to a thousand of such models, the interconnections assumed and modelled, and a simulation applied. An observation of the network model may then begin. Only the changes in the number of active modelled neurons divided by the total number of the modelled neurons are to be registered in time. The result (depending on the simulated interconnections) could be similar to records obtained as an encephalogram from the real brain – not as a snap-shot, but as changes in time.

This example illustrates how powerful computer simulation could be in specific applications. With advances in processing speed, and the volumes of memory available, computer simulation will reach more and more complex problems of reality and a limit is hardly forseeable. In my opinion, modelling is one of the most promising computer applications, and this potential should not be overlooked by developing nations.

There are many promising parallel avenues resulting from advances in information technology. The rapid development of this technology from time to time facilitates "short cuts" – a development of essentially new applications without following the pattern of applications prevailing in the developing countries. For this reason, monitoring of advances is crucial for developing countries. Monitoring may bring an answer to a quandary expressed by the cat in a dialogue with Alice in Lewis Carroll's **Alice in Wonderland**: *"Would you tell me, please, which way I ought to go from here?"* Alice asked. *"That depends a good deal on where you want to get to"*, said the cat. Nowadays, there is no technology as versatile as computer modelling, which makes resolving this quandary both difficult and with an enormous impact for the future of a country and its people.

Konrad Fialkowski
Scientific Editor

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A. SPECIAL ARTICLE

SIMULATION FOR PLANNING AND OPTIMIZING OF MANUFACTURING ENTERPRISES

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Abstract

This article is presented by way of an introduction and invitation to simulation, and is aimed at presenting the current status of simulation techniques from the viewpoint of the requirements set by the manufacturing environment. It should not be regarded as a complete overview of simulation technologies, as it only treats selected subjects which are important in understanding simulation problems. The paper attempts to connect available simulation techniques and tools with the issues that arise in contemporary manufacturing facilities. It compares simulation methods with its competition, shows the advantages and disadvantages of simulation techniques and presents a wide scope of possible applications. The importance of simulation techniques for developing countries is also discussed. In general, this paper should give readers a better understanding of simulation; it aims at demonstrating that these techniques are not just computer games or "Star Wars" animation, but that simulation is a serious, useful and very powerful tool, which can and has to be used in the planning, monitoring and optimizing of contemporary manufacturing systems and processes.

Introduction

The introduction of electronic computers has caused huge changes in almost all fields of mankind's activities and may well be compared to the invention of the steam engine at the turn of the 18th century and electric power and the combustion engine at the turn of the 19th century—in fact, computers have initiated a new industrial revolution. In manufacturing, this began with the development and extensive use of computer-controlled machines and manufacturing systems. The use of NC and CNC systems introduced important improvements to the quality and quantity of products, but also caused many new organizational problems at the same time. Machines became faster, more flexible and could be used to manufacture a wider range of different and more sophisticated products. At the time of their introduction, the capabilities of new machines were far ahead of their actual utilization. Computer-controlled machines replaced traditional ones in job shops, but the ways of planning and controlling manufacturing processes remained almost unchanged.

The real challenge came in the 1970s. The oil crisis, declining demand and oversupply forced traditional manufacturers to search for new forms of organization. Market studies showed that those companies with the best chances of gaining an advantage over competitors and staying in the lead were those able to:

- Produce in short series;
- Manufacture a wide variety of product types and variants;
- Produce with short lead and delivery times;
- Offer lower prices than the large series manufacturers;
- Flexibly extend and reduce manufacturing capacities in accordance with the market situation;
- Flexibly extend the product palette;
- Take additional orders and carry them out within a reasonable time and price frame.

Of course, the requirements listed were in many points contradictory. The available hardware (machines and technologies) permitted the fulfilling of all of these requirements, but it had to be done within an acceptable economic frame. Examining the methods that most competitive companies planned, manufactured, delivered and priced their products, shows that solutions to some problems may be found by employing Just-in-Time or "kanban" manufacturing. It is interesting to note that these methods were worked out in Japan, not as a means to gain advantage in the markets, but because they were the only way to survive in the harsh years after the Second World War. The lack of money for raw materials made it necessary to keep stocks at a minimal level and not produce goods that could not be delivered and paid for immediately.

But what was possible and manageable within small, family-oriented companies was not necessarily suitable for the hierarchical structures of most enterprises. Their organization, with the controlling instruments based on filing cabinets, manually constructed flow-charts, calculations, lists and diagrams, could not react flexibly enough to the market and changes in the manufacturing environment.

The dissemination of computers, not only in manufacturing departments, but also in the forecasting, planning and controlling areas, together with progress in simulation and data analysis, laid the foundations for really flexible manufacturing.

What is simulation?

Simulation is an expression, which is well known and used by many people, at least in a general way. *Webster's Unabridged Dictionary* describes the term as:

Simulation — from the Latin "simulatio", a feigning.

1. The act of feigning; pretense.
2. False resemblance, as though imitation.

The *Random House College Dictionary* defines simulation as:

1. The act or process of pretending, feigning.
2. The assumption or imitation of a particular appearance or form.

Dictionary definitions suggest that simulation involves imitation or mimicking, giving the appearance or effect of some elements. It can also be taking on the characteristics of reality, and usually involves a sham object, a counterfeit, a replica, or a model. Simulation brings to mind the idea of pretending, or feigning.

These definitions are perhaps too general, too universal for our "technical" purposes, but they support the initial, basic understanding of the meaning of simulation. As a technical term, simulation will be defined as imitation of the behaviour of a real-world process or system over time. By a real-world system, we mean some part of the real world which is of interest. The system may be natural or artificial, in existence at present or planned for the future. For imitating (simulating) purposes, a model of the real-world system has to be developed and its behaviour analysed under various conditions.

Historical scope of simulation techniques

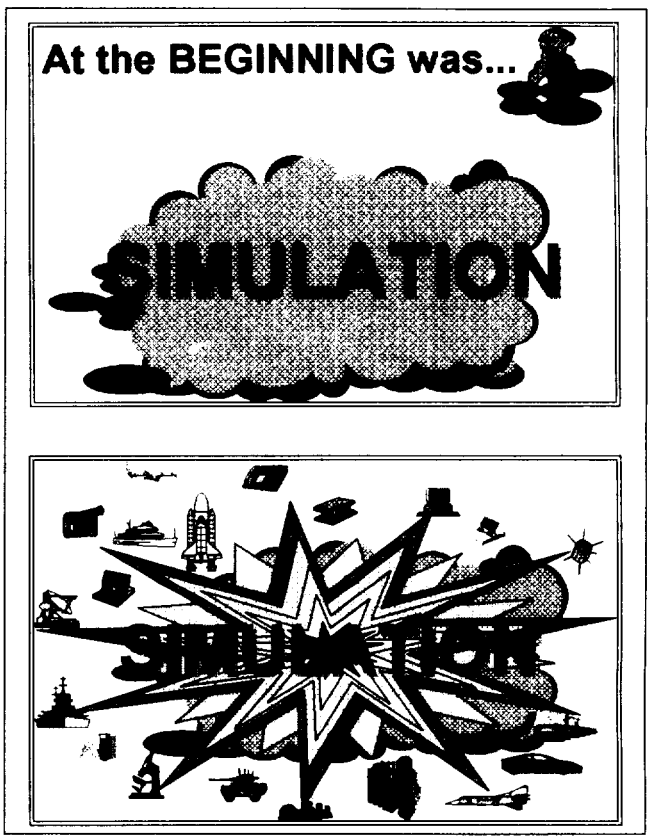
Simulation (imitation) is not a new technique. From ancient times, inventors have tried to apply available technologies to depict physical and even mental processes. Prior to computers, this necessitated applying the state-of-the-art in mechanical techniques. Archytas of Tarentim, Greece (c. 400-350 BC), fabricated a pigeon whose movements were controlled by a jet of steam or compressed air. Even more elaborate automata, including an entire mechanical orchestra, existed at the same time in China. After the studying and entertaining phase, inventors began to develop simulation systems for trade and industrial purposes. Calculating machines, such as Napier's Bones, the Pascaline and the Analytical Engine of Charles Babbage, were early efforts to simulate and extend human computational abilities. The rapid growth in population of the United States in the late 1890s led to the development of a new machine that could handle the census data accurately and in time. Edmund Hollerith's creation of punch cards and an electronic device to interpret encoded information also helped in this activity.

Henry Ford, determined to sell his Model T to average Americans, especially to millions of farmers, needed a plant that could produce his cars more effectively than his Highland Park facility. He believed this problem could be solved only by employing a steady flow of materials and half-products through a manufacturing system.

In planning the great River Rouge plant, which displaced Highland Park in the 1920s as the heart of the Ford system, Ford insisted on having scale models of machine tools, conveyors, windows, pillars and floor space, so that these could be moved around to test ideas concerning production. Between 1922 and 1926 he and his engineers designed and had constructed at the River Rouge site, a coke-oven plant, a foundry, a cement plant, an open-heart steel plant, a motor-assembly building, and several other plants, which created one of the most important industrial complexes of its day.

The huge net of facilities at Highland Park and River Rouge, with well-organized, simulation-tested manufacturing, allowed time and cost effective mass-production of the Model T. In the five succeeding years of increasing production efficiency and savings, he cut the price of the basic car from $900 to $440, well below the price of the nearest comparable automobile. The average monthly number of unfilled orders grew to almost 60,000. In that time the Ford company had a 55 per cent share of the automobile market, and production of the Model T climbed to two million cars and trucks a year.

Figure 1



Simulation of complex missile trajectories was the main reason for developing the first computers. This development, which in the next few years brought immense changes to all fields of social and industrial life, may be called the Third Industrial Revolution, and it opened the information age. It may be said that all the chips used in almost all present-day products, from washing machines to CNC tool machines, telecommunication systems to space shuttles, are the direct results of the need for a capable simulation tool.

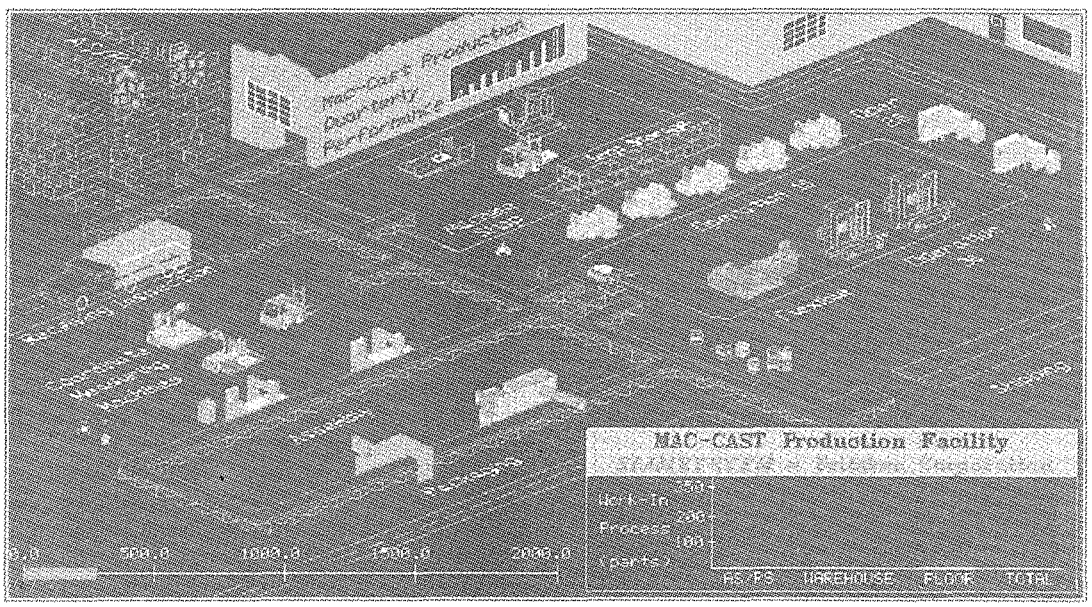
Classification of simulation methods

To bring about a better understanding of the simulation terminology and narrow down the meaning of the term as it will be used in this paper, the following distinctions should be observed:

Dynamic versus static simulation
Space behaviour versus logical relationships simulation
Discrete versus continuous simulation.

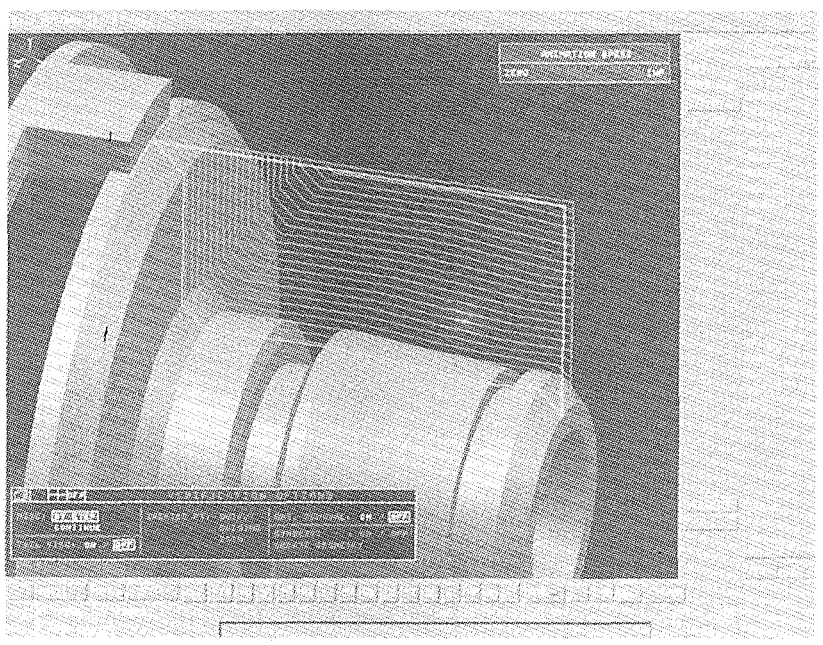
Dynamic simulation describes the behaviour of a system of interest over time. Using this type of simulation, changes occurring in the model can be observed as they take place at different points in time. To this group belong the majority of simulation oriented solutions, such as flight simulators, war games, weather forecasts, robot movement, collision analysis, manufacturing processes, transportation systems, etc. See figure 2.

Figure 2



Source: Pritsker Co. IN

Figure 3



Source: International Business Machines (IBM)

Static simulation describes the status of a system at a given point in time, and represents a marginal part of the simulation field. For the static characteristics of this family of solutions the predicate "simulation" is seldom used. To this class of applications belong CAD systems, urban and building planning, interior design, architectural modelling, and many similar cases, where time-related behaviour has no meaning for the performed analysis. See figure 3.

Simulation of space behaviour allows us to examine three- or two-dimensional space relationships between system elements. Time is usually used as an independent variable. Studies of space behaviour can be seen as an advanced version of dynamic simulation. To deal with the complexity of analysed processes and the necessary computer power, reduced size systems are normally used. In manufacturing, this kind of simulation is represented by robot navigation, robot

off-line programming, robot or transportation system collision examination, assembly animation, etc. In non-manufacturing areas examples such as Spacelab or Space Schuttle simulation, flight simulation, war games, weather analysis, etc., can be mentioned. See figure 4.

Figure 4

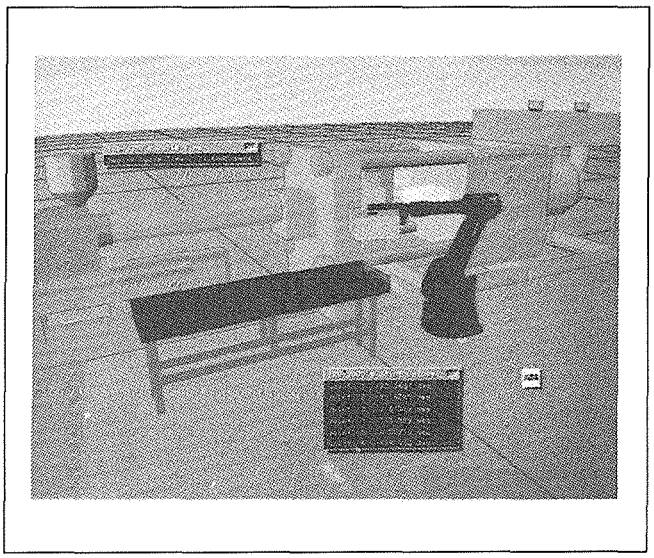


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Figure 5

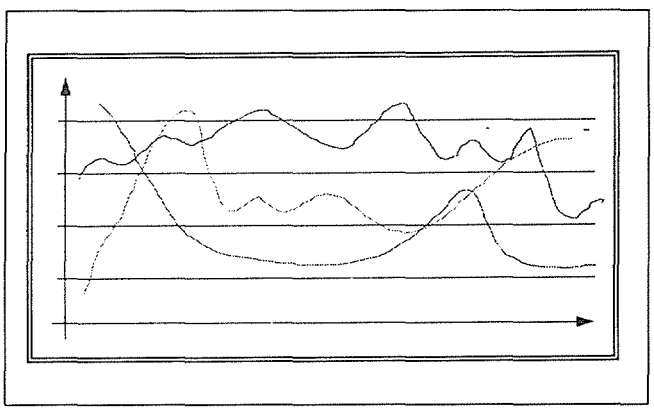
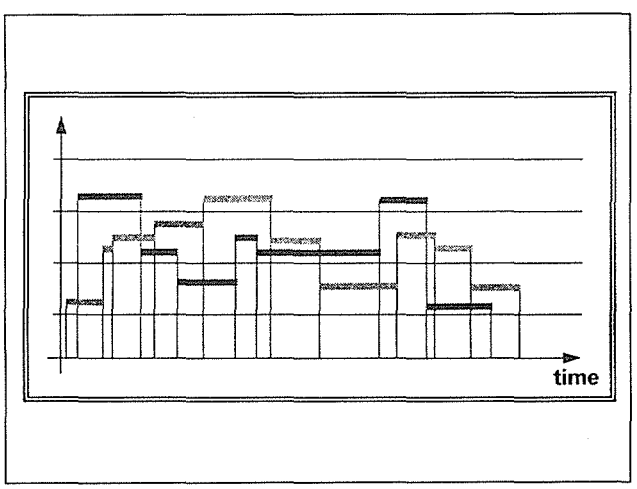


Figure 6



Logic relationships simulation concentrates on observing mathematical, logical or causal relationships between system elements. Spacial relations between elements are usually treated as secondary issues and are not taken into account. Examples of issues being examined within this frame are material flow in manufacturing systems, transportation systems, decision games, flow charts analysis, etc.

Continuous simulation describes systems by means of sets of mathematical equations. These may be algebraic or differential, usually using time as the independent variable. It is often used to analyse fluid-flow, hydraulics problems, ballistics, calculations of satellite orbits, description of continuous manufacturing processes (blast furnaces, petro-chemical plants, etc.). See figure 5.

Discrete-event simulation describes a system in terms of logical relationships that cause changes of state at discrete points of time rather then continuously over time. Examples of such systems are material flow in a manufacturing system, services at the gas station, operation of the transportation networks, etc. Discrete-event simulation assumes the lack of importance of occurrences happening between defined time points of interest. For example, in examining a manufacturing system, we would like to know what happens in the system as an immediate consequence of a product's arrival, freeing a resource and starting an operation, without being involved in the observing status (usually a constant one) between these singular events. See figure 6.

Simulation and the alternative methods

Simulation is just one of many things that can support system analyses. In general, a given system of interest can be examined by means of:

- Experimenting with the real system;
- Experimenting with the physical model of the system;
- Solving a set of mathematical equations describing the system;
- Simulating the behaviour of the system.

The dependencies of the available approaches are presented in figure 7.

The simplest and oldest method of system investigation is by experimenting with the system itself. It is the most natural way, but unfortunately cannot always be used. The disadvantages of using a real system will be discussed later in this paper.

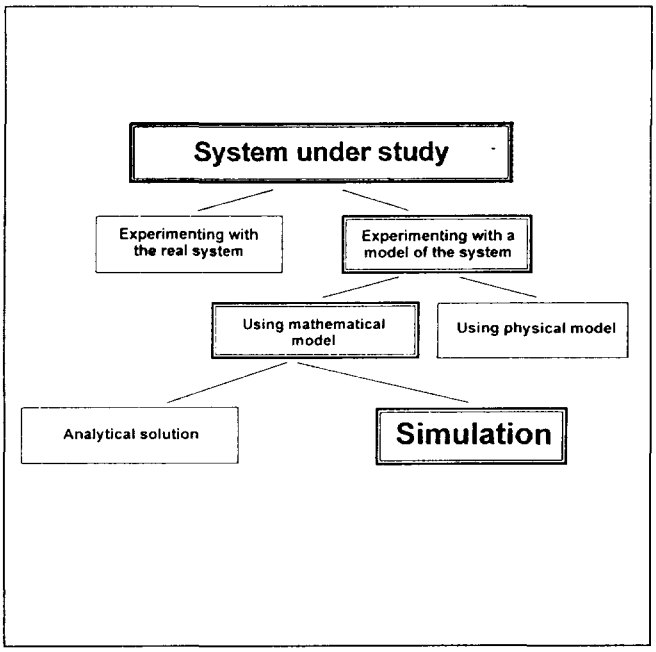
As an alternative to the real system experiments, model-based analysis can be employed. The behaviour of the system is studied by observing the work of the model describing the whole or part of the system of interests. The model of the system can be constructed as a physical one or as an imaginary, mathematical description of its elements. Experimenting with a physical model of the system of interest is nearest to investigating the real one.

Unfortunately, these methods can only be used for a reduced family of issues. In most cases, building a physical model is too expensive and too complicated, and the data obtained do not exactly represent the aspects of behaviour of the system of interest.

The abstract, mathematical description of the system can be realized in two ways:

1. Elements of the system and their behaviour can be described in the form of a set of mathematical equations. The observations of the dependent variables, usually as functions of time, form a basis for the design of equations. This set of methods is often referred to as mathematical programming, which is the most widely used method of this family.

Figure 7



2. A computer simulation model is not based on an equations set, but employs other techniques to describe logical and causal relations among the system's elements. Analysis of the system behaviour is performed by conducting time-oriented experiments and observing the status of the selected model parameters.

In the following sections of this paper, simulation and alternative methods will be compared, showing the reasons why the ranking of the simulation among the methods of system analysis is steadily growing.

Simulation versus experimenting with the real-world systems

Experimenting with the real system is the simplest and the most natural way of studying its behaviour. As a matter of fact, simulation is just a mimicking or feigning of a given system. And the mimic, even the best one, stays just a mimic and can barely match the operation of the real system. Unfortunately, experimenting with a real system is connected to some disadvantages, which in many cases make such examination impossible, or the obtained results inapplicable. In the following, some disadvantages of real-system experimenting are discussed.

The real system must exist before experiments on it can be performed, whereas the objective might be to design a system that does not yet exist. This property of real-system experimenting excludes these methods explicitly from problems involving planning of new, or extension of, existing systems. Of course, experimenting with a system similar to the planned one could be attempted; it would not be experimenting with the real system, but with just an approximation of the system, or its physical model.

The system has to be available for experimenting. Even if the system does exist and is in use, then often for economic and/or political reasons it might not be possible to interrupt its ongoing operations. This paper attempts to concentrate on comparing simulation with its alternatives in industrial applications. For this reason the classical examples, such as experimenting with GAU in a nuclear plant or ecological catastrophe, will not be discussed.

Manufacturing systems, even if they exist, are seldom accessible for full-scale experimenting. It is almost unimaginable that a manufacturing line or cell would be stopped just to perform some investigations, even if these were aimed at facility or process optimization. In addition, the lead times of manufacturing operations are usually long, and in order to collect the necessary amount of data, the facility has to be out of service for at least several days or weeks. Most job shops are facing very tough competition and have to operate with very narrow or no security nets. Stopping manufacturing means losses, and these can be justified only when the improvements are clearly predictable.

No time-scale of the experiments. Even if the real system can be used for experimentation, the lack of time-scale analysis remains one of the biggest obstacles for a proper examination of the system. In many systems, especially manufacturing ones, a system must operate for days or weeks before the necessary amount of data can be collected. This reduces the number of alternatives that can be investigated and diminishes the chances of finding the optimal one. Similar problems occur when the activities in an analysed system are too fast or too complex. It is almost impossible to properly monitor and investigate processes in the manufacture of integrated circuits, where thousands of operations take place every minute. It permits just the observation of some trends, but not the single events.

Unavailability of the data. Many manufacturing systems are so complicated, that defining the data which should be analysed, and preparing the instrumentation for its acquisition create problems of their own. Selecting the data and building the monitoring system takes so much time and can cost so much, that there is not enough left over for the planned experimentation. Additionally, the monitoring elements can change the analysed system to such an extent, that the obtained data cannot be used to analyse the behaviour of the original one.

Real-system experimenting, despite its disadvantages has been used in many cases where the proper planning and prediction of the system behaviour could not be reached by using any other analytical tool. In many cases, experimenting with the real system has been replaced by experimenting with its physical model. This was the way Ford built his River Rouge plants; the elements of the Fisher-Technics allow building manufacturing facilities on the desk top and connecting them with the real controlling systems—this is how architects build their urban projects. Physical modelling was popular in manufacturing until the 1980s and created a kind of bridge between real-system experimenting and "real" computer simulation. Computer simulation, using constantly improving hardware and software platforms, became simpler and cheaper and could successfully replace almost all cases of real-system or real-model experimenting. At the time, real-world experimenting was often used in order to obtain the data to describe unique systems. This data constitutes the basis for further simulation studies.

Simulation versus mathematical modelling

Elegance of the method. Mathematical modelling is a very elegant and scientific method. It allows the description of a system of interests as a clean set of mathematical equations.

Generality of the solutions. Once defined, a set of equations describing a system can be used for various sets of parameters to describe the properties and number of elements in the system. It allows the diverse configurations of the system, as long as they are in conformity with the assumptions of the model, to be analysed without redesigning and reprogramming the base equations.

Optimizing abilities. If the system of interest is described as a set of equations, then an optimum for a given set of parameters could be found. Being able to generalize the sets of equations and the solutions, mathematical modelling supports the finding of an optimum (an absolute one) for any valid set of conditions. It allows the use of mathematical modelling to answer not only simulation questions of "What if ...?", but also delivers solutions for "What will the best in ...?" cases. This characteristic is often named as a deciding factor for employing mathematical modelling to solve various problems.

High grade of abstraction. This attribute of mathematical modelling can be an advantage or a disadvantage of mathematical modelling. The high grade of abstraction allows for the describing of any of the problems through the same or just slightly modified equations. It means a high grade of flexibility of employed methods, but on the other hand it is very sensitive to changes in meaning of the parameters and their dependencies. It permits the same set of equations to be manifoldly interpreted, leading to the possible drawing of false conclusions and recommending of wrong solutions.

Reduced complexity of analysed systems. Mathematical equations only support a description of a reduced set of problems. This means that just a selected spectrum of systems can be adequately described, their behaviour observed and conclusions drawn. Complex systems must be reduced to describable and solvable ones if they are to be analysed by means of mathematical modelling. This is connected to the necessity for a simplification of the problem and reduction of the parameters. However, this can often lead to inaccurate or false descriptions and as a result to wrong predictions of system behaviour. In addition, a high degree of abstraction reduces the readability of the model, impeding the recognition of the syntactic and semantic errors.

Reduced ability to describe discrete systems. Our main field of interest, the manufacturing systems, are mostly discrete systems. This means that their behaviour has to be described by unsteady functions. In addition, the dependencies between system components are also discrete and build a set of triggers for the secondary discrete processes. Such systems can hardly be described precisely by using traditional continuous equation sets. The necessary assumptions and approximations very quickly lead to incorrect descriptions and false results.

Low transparency and the "market value" of the problem description and solutions. Mathematical modelling is a very scientific and sophisticated family of tools. The complex sets of mathematical equations cannot be easily understood and interpreted without profound mathematical studies. For this reason, these methods can only be used by highly experienced personnel or system analysts. The end-user of the results of the analyses, usually the manufacturing engineer, is as a rule unable to interpret the presented description of his problem, and can therefore hardly cooperate in the process of model validation and experiment design. Due to the lack of transparency of the problem's description, it is very difficult to obtain the necessary model credibility and convince the end-user of the results of an analysis. It can also lead to misinterpretation of the aims of the analysis, its methods and outcomes, and result in false conclusions, which could lead to the implementation of wrong measurements.

Advantages of simulation

Simulation, using a computer model to investigate the system of interest, combines the advantages of experimenting with the real system, or its physical model, with those of the scientific methods of mathematical modelling. Some of the most visible advantages represented by this combination are presented below.

Investigating non-existent systems

In simulation studies, experiments are performed using a model, and not the real system. This means that the system does not have to exist. A model can be built based on just ideas, or a description of the planned system. Unlike physical modelling, where the model can hardly be modified or "destroyed" experimentally, computer simulation allows an almost unlimited extendibility and modifiability of the model. It allows for a relatively simple and inexpensive testing of systems design, before the first steps in its realization are carried out. Experimenting with imaginary system environments supports the building of imaginary system extensions only, including interfaces or environmental elements and events.

Realism of experiments

Simulation, especially using animation, performs experiments in a very realistic and easily understandable way. It not only presents the actual status of the system in the form of parameter values and selected statistics, but also shows, in a movie-similar manner, the reaction and interactions of the system elements. This means of analysis allows for the observation and understanding of processes and dependencies which are usually not visible when using numerical outputs. Easy-to-use results come together with the user-friendly model building and experiment control elements, which in turn can be understood and used by non-mathematical professionals. Manufacturing engineers are thereby able to take an active part in simulation study. Such cooperation results in high credibility models that can be easily validated, verified and modified, even at the job shop level.

Conducting experiments in time-scale

Many experiments, which may be able to be carried out using real systems or processes, are very often too fast or too slow to make a proper observation, data collection or analysis. A complex process in a microprocessor with millions of operations and interactions of different elements takes only milliseconds. To monitor a real manufacturing system and collect an appropriate amount of data, an analyser needs weeks or months. Time can be compressed or stretched in simulation experiments. The equivalent of milliseconds and seconds in real system time can be simulated in minutes or hours on a computer. On the other hand, the equivalent of days, weeks and months of real system operation can be simulated in seconds, minutes or hours on a computer. Such flexible handling of the time-scale in manufacturing permits the examining of a large number of alternatives and the finding of the optimal one.

Total control of experiment conditions

In simulation experiments, every parameter describing a system of interest can be artificially held constant. Such "freezing" of parameter values cannot be performed in a real system. This feature allows for the reduction of "noise data" which do not have a direct impact on the results of the experiment, and a step-by-step analysis of the single correlation of the system elements. In addition, every variable, even an artificial one which does not occur in a real system but which has an impact on the understanding and performance of simulation study, can be set up, monitored and collected during experiments, thus improving the results of the analysis.

Reproducibility of the experiment conditions

In a real or imaginary system there are two kinds of events. These are deterministic events which occur in predefined conditions and at points of time, and stochastic events that occur randomly with a given or assumed distribution. Because of the true randomness of events in a real system, it is almost impossible to repeat a real-world experiment with the same characteristics and conditions. In the artificial, mathematical world of simulation there are no true random values or systems. These are replaced by pseudo-random numbers that are generated by using a given mathematical formula. This means they are repeatable. This feature, together with the previously described possibility of freezing selected parameter values, permits the repetition of the same experimental conditions each time, while focusing on different parts of the system. It improves and supports the extensive analysis of complex systems or processes.

Inexpensive training tool

Since simulation is based on feigning, or mimicking of depicted systems, it can communicate with the user by using the language of the simulated system and does not require a high level of scientific sophistication to be employed by the user. This simplifies not only the training of the simulationists involved with the system analysis, but also that of the system users who work daily with the real system. The wide use of simulation in military training (flight simulators, battlefield war games, etc.) can be easily adopted by manufacturing. Simulation offers a huge training potential, for example, in operating expensive and sophisticated machine tools or other elements of manufacturing systems, working out breakdown strategies, planning system maintenance, product, process or order changes, etc. Powerful computers and software tools using graphical user interfaces, multiprocessing and high resolution graphics, deliver reality-similar conditions and very often do not require more knowledge than he or she would need to handle the real system. In this way, after a short introductory period, it is possible to replace costly training using the real-world system or processes by simulation-based training courses.

Simulation as a marketing and presentation tool

Simulation is an ideal marketing tool. It is usually used when elements and terms from the system are being investigated. It builds a common communication level between the system analysist and the customer. On the one hand, if the study is performed together with the client, he or she can be directly involved in the model and experiment development, and an acceptance of the results can easily be gained. On the other hand, when only the results of the study are presented to the client, he or she is more likely to be more receptive to the simulation findings than to the numerical description of the proposed system. As a result, it is much easier to sell a product or idea when the client can quickly understand it and relate to it, than to convince him by just showing flow charts, spreadsheets, two-dimensional drawings, etc., which can always contain some hidden errors and cannot therefore be completely trusted.

Powerful forecasting — insurance — tool

It has been estimated that comprehensive simulation studies designed to work out the characteristics of a proposed system can cost 2 per cent or less of the capital outlay involved in building the system. For example, it might cost $50,000 or less for simulation studies designed to evaluate a manufacturing system involving a capital outlay of $1 million. In this sense, simulation provides an inexpensive insurance against building systems that are underdesigned and so will not perform to specifications, or that are overdesigned and will therefore expensively provide more capacity than is needed.

Disadvantages of simulation

Along with its many advantages, simulation is subject to some disadvantages. Looking at the disadvantages that can be found in the simulation literature more carefully and meticulously, one will notice that these disadvantages are not the disadvantages of the simulation enterprise alone, but are also the disadvantages (and pitfalls) of using any system. This section should be regarded as a kind of polemics on the "disadvantages of simulation", as found in the basic work on simulation "An Introduction to Simulation using GPSS/H" by T. J. Schriber, Professor and Chairman of Computer and Information Systems at the Graduate School of Business, University of Michigan, and published in 1991 by John Wiley and Sons.

Failure to produce exact results

Suppose a system is composed of one or more elements that are subject to random behaviour. In a hospital system, for example, the time required by a doctor to examine a patient may vary randomly. The various times required by a doctor to examine patients influence the waiting-time experiences of other patients waiting to be examined by the doctor. When a simulation is performed with a model of the system, the values of such variables as "the time a patient spends waiting to see the doctor" are recorded by the model, and the averages of these values are given in a post-simulation report. But the average in a sample of observed waiting times only provides an estimate of the expected (or long-run average) time that patients must spend waiting to see a doctor. In this sense, a simulation only provides estimates, not exact results. [Schriber: "Introduction to Simulation using GPSS/H", 1991]

Simulation as a depiction of a given real-world system is only a feigning of the behaviour of that system. This means that in extreme cases it can be the very reflection of the system, but it cannot be better than the system itself. If a real-world system consists of a set of random events, it cannot be predictable. For example, the measurements taken in hospital in month A differ from the measurements taken in month B, and it is impossible to make an exact prediction for month C. The randomness of only one of the system parameters is the cause of the impossibility of making an unequivocal description of the system. Without the exact depiction of the real-world system, there cannot be an exact model of it and the simulation to produce the exact data describing its behaviour.

Lack of generality of results

Simulation results apply only to the situations that were simulated and do not lend themselves to generalization. For example, suppose in a manufacturing system, that the manufacturing resources include three machines of Type A, five machines of Type B, and two machines of Type C. Suppose that a simulation study is performed on this basis, and the resulting manufacturing rate is estimated, what manufacturing rate will result if there is one less Type B machine or if one of the Type B machines is replaced by another Type C machine? The results from the simulation study already performed cannot be used to answer these questions. Instead, the model has to be modified to correspond to these changed conditions, and then simulation studies must be performed with the modified models to estimate the resulting manufacturing rates. If, as stipulated in the contract, a mathematical model has

been built to express the manufacturing rate as a function of the number of Type A, B, and C machines in the form of an equation or equations, then this model could be evaluated quickly and easily for all combinations of Type A, B, and C machines that might be of interest. [Schriber: "Introduction to Simulation using GPSS/H", 1991]

Generalization in manufacturing is a very sensitive problem. Through the considerable complexity of manufacturing systems and manufacturing processes, a slight change in parameters can have a large impact on the system's performance. For example, reducing the number of Type A machines that are causing a bottleneck in a system can lead to a manufacturing disaster, while changes to the over-dimensioned Type B machines may have a slight impact on the system's work. In this case, the lack of generality can be seen as an advantage of simulation, without permitting the drawing up of false conclusions. Changing the number and kind of resources (machines) in a previously described manufacturing system can lead to completely new manufacturing configurations and can often be complicated. Changing a model does not have to be so complex. By defining machines as "independent" modules, we can simply replace one by another.

Mathematical modelling can seldom describe the complexity of manufacturing systems with all its dependencies, not only between the machines and other hardware systems' components, but also between those elements and products that have to be produced on a modelled facility. Additional problems are created during the description of jobs, part priorities, time dependencies, and from it follow the waiting queues and manufacturing sequences.

Failure to optimize

Simulation is used to answer the questions of the "what if" type, but not of the "what is the best" type. In this sense, simulation is not an optimization technique. Consider the type of manufacturing system question posed earlier: "What combination of product should we produce if the objective is to maximize profit subject to the following machine, manpower and marketing constrains?" Simulation can be used to estimate profit that will result when a given combination of products is produced. That involves a "what if" situation. In other words: "What if we produce this combination of products? What profit will result?" But simulation cannot be used to indicate which combination of products among all feasible combinations results in the maximum profit. This would involve a "what is the best" situation. In other words, "What combination of products is best in the sense of maximizing profit?" In simulation, the only alternatives considered are those that are directly investigated. Simulation does not generate solution; it only evaluates those that have been proposed. If six alternative combinations of products are investigated, then that alternative among the six considered which maximizes profit can be identified, but it is quite possible that one or more of the alternatives not considered may result in larger profits than the best of the six that are considered. [Schriber: "Introduction to Simulation using GPSS/H", 1991]

Simulation alone is not an optimizing tool, but it can be part of an optimizing system. In our example, we are looking for optimal product combinations for a given manufacturing facility, and a simulation experiment will be conducted using a sequence of products to be made as input. After the experiment, the input sequence, together with the output parameter, such as system utilization, lead times, manufacturing costs, etc., are analysed by an optimizing tool. This results in generating a proposal for a new product sequence for the next simulation experiment. The new experiment will be performed, followed by the analysis. Such a loop, consisting of simulator and analysing (optimizing) algorithms, can lead to the production of a very good solution for the stated problem. Finding the real optimum for a usually very complicated manufacturing system is in most cases a Sisyphus task. We would therefore prefer to speak of a very good, a reasonable, or a satisfactory solution. The term "optimal" as used in this paper, always carries one of the aforementioned meanings (very good, reasonable, or satisfactory).

Long lead times

A simulation study cannot be conducted over a weekend. Months of effort may be required to gather data; to build, verify and validate models; to design experiments, and evaluate and interpret the results. A simulation effort should be started well before the results are needed. In practice, unfortunately, the results of simulation are usually needed "yesterday". A simulation study may not be authorized until the project involving the system to be simulated becomes an urgent priority, and then there may not be adequate time to complete the study before the results are needed. [Schriber: "Introduction to Simulation using GPSS/H", 1991.]

A simulation is a long process. It uses data to describe a system, builds a model of it, performs a couple of experiments and analyses the results. To build a model, simulation professionals need data about a modelled system. In many cases, that data is not available. In many cases, companies do not work on reliable data but very often on the experience and "feelings" of their staff. There is never enough time to carry out measurements, and to complete and marshall the data. The analysis of the system has to be done, and logical connections and operation times have to be determined. All the data should be available a long time before the simulation study begins. But usually this is not the case. Searching for data becomes part of the simulation study and prolongs its lead time. Another very important factor of a simulation study is the cooperation with the system operating staff. In many cases, supporting the simulation team is only an ad hoc duty, with the corresponding results. It is very difficult to define a simulation goal, obtain data and check the model with the real system if there is no appropriate collaboration with company staff. This same problem arises during analysis of simulation results. What is important for the company, which parameters do not match reality, etc.? It is difficult to answer these questions as an outsider. The bottom line is that the long lead time is not a peculiar version of the simulation, but it is more the result of a falsely prepared and conducted study on the part of the supervisors of the company or systems being examined.

Costs for providing a simulation capability

Establishing and maintaining a simulation capability involves making a major and ongoing commitment with concomitant personnel, software, hardware, training and other support costs. Many smaller organizations cannot afford to maintain a simulation capability. Some organizations may have one or two people who work on simulation projects from time to time, but these people may have to be supplemented by outside consultants on occasions when simulation projects are to be conducted. Other organizations may simply contract their occasional simulation projects out to consultants or firms specializing in simulation. They will then pay a premium to have a simulation study carried out and may wind up in a position of dependency and relative inflexibility if follow-on simulation efforts are required. [Schriber: "Introduction to Simulation using GPSS/H", 1991]

Every small or medium-sized company lives within a web of dependencies. It is very rare that a firm is truly independent. There is always a network of suppliers, dealers, contractors and subcontractors. If a company wants to introduce a new product, it hires a consulting company to carry out a market research to examine what chances the product has. Product design is often done by a specialized company with experience in three-dimensional design (it is too expensive to maintain a staff of designers with appropriate hard- and software). Marketing campaigns are almost always done by external marketing specialists. Taxes and payments are supervised by external experts and lawyers. All the external companies a firm employs to carry out jobs create a dependency relationship, and employing a consulting company to perform some simulation studies will not endanger the client situation.

Misuse of simulation

There are many facets to a balanced and comprehensive simulation study. As a result, a person should be educated in a variety of areas (e.g., analysis of input, experiment design, analysis of output, etc.), before becoming a simulation practitioner. This fact is sometimes ignored, resulting in situations where people who only know how to build simulation models and make runs with them are cast in the role of simulation professionals, even though their education and training may not have prepared them adequately for this designation or responsibilities. Such people may not be in a position to conduct balanced and comprehensive simulation studies. As a result, the studies may be incorrectly performed, may be incomplete, or may fall short in other ways, perhaps resulting in a failure of the simulation effort. [Schriber: "Introduction to Simulation using GPSS/H", 1991]

Simulation is not a game, it is a serious tool that can have a huge impact on decision-making. People are used to machines, but nobody would be given the job of a machine operator without the appropriate knowledge and experience. Virtually nobody is hired as a manager without references and research into past experience. Therefore, why should a simulation tool be employed by staff without the corresponding knowledge? If simulation is used by the wrong people it could lead to disaster. Yet the same, or a similar disaster could take place if complicated and expensive machinery is exploited by the wrong people, or when an organization is directed by the wrong managers. It is not only in simulation that misuse is a disadvantage, it is a disadvantage in any system when it is wrongly used.

In conclusion, simulation is not a panacea. It offers powerful advantages, but these advantages can only be utilized through a proper utilization of this tool. Simulation has its own disadvantages, as does every system. Fortunately, most of the disadvantages connected with system performance and usefulness diminish in importance during the course of time, thanks to improved simulation tools, methodology, education and computer performance, and decreasing computing costs. On the other hand, many of the disadvantages attributed to simulation alone, are simply shortcomings related to wrong usage or misuse of the system.

Simulation application fields

Defining the fields where various simulation based techniques are used is a complicated task. By defining simulation as imitating, this term can be used for almost all the activities in which mankind or a system is involved. While reading a book we imagine (simulate) in our minds the scenarios described. Going to the movies or watching TV, we live the lives of screen characters, partake of their emotions, problems, stresses and thrills. Philosophically, it could be said that we are simulating our lives in a simulated world. In technique and science the scope and use of simulation is very wide and is steadily growing. This expansion is caused by the increasing complexity of the problems faced, which can hardly be solved by using other means. In addition, progress in both hardware and software has made simulation tools more powerful, flexible and user friendly. Table 1 presents some of the fields where simulation techniques are widely used.The use of simulation is not restricted to the classes shown in table 1. This table is presented to demonstrate the versatility of simulation and the possible range of applications, and although indicative, it is by no means exhaustive.

Simulation in manufacturing

With the growing importance of simulation in almost all areas of mankind's activities, it has also become an integral part of manufacturing enterprises. Four main factors may be mentioned as reasons for such rapid growth and the omnipresence of simulation based tools:

- The extent of the problems faced overshadows the possibilities offered by traditional planning and analysing tools.
- The steady growth of sophistication and sinking prices of the offered simulation packages and computer systems allows access and utilization of these tools even to small and medium-sized companies.
- Generational changes in manufacturing has created a new class of engineers who are not restricted to purely mechanical solutions and who are willing and accustomed to use computer based tools.
- Growing competitiveness has forced manufacturing companies into quick, flexible and economically acceptable responses to market changes.

As a result, the following areas have emerged, where simulation has become an integral part of the facility life cycle:

- Planning of new manufacturing facilities
- Planning of manufacturing processes
- Extending and optimizing of existing manufacturing systems
- Monitoring the manufacturing processes
- Product design (CAD)
- Robot control

This study has been aimed at discussing the tools for analysing manufacturing logistics. For this reason, only the first four of the above-listed fields will be discussed. Computer Aided Design (CAD) and robot control represent quite different approaches to manufacturing and simulation methodology and are better presented in a separate paper.

Simulation in facility planning

Facility planning was the first family of applications, where simulation techniques were widely employed and for which the first commercial simulation systems were developed. In facility planning the simulationist assumes that a defined set of workpieces, described through manufacturing processes and a defined demand (number of parts to be produced in a given period) is given and treated as a constant. As the goal of a simulation study, the working out of a manufacturing system layout is defined, containing a detailed description of machines, transport systems and their positions, tools, calendar, shifts, required staff, etc. The number of variables a system analyst works with is relatively small, simulation runs are usually long, and the changes of model parameters does not require extensive user interaction. Facility planning usually takes place far from the job shop floor

Table 1

1. Aerospace — military — undersea	
Space system reliability	Equipment replacement policies
War games/strategies	Armed forces recruiting strategies
Search and rescue strategies	Equipment distribution
Space defence system	Satellite positioning
Combat vehicle training	Flight simulators
Radar and communication	Ballistics and missile systems
Navigation systems	Undersea cable development
Undersea vehicles	
Weather	
2. Health care	
Health care planning	Emergency room design
Organ transplantation strategies	Hospital staffing
Disease control strategies	Drug interaction control policies
Hospital admissions	Blood bank management
Diet management	Ambulance crew scheduling
	Emergency situation planning
3. Urban-social	
Emergency-response vehicle location	Garbage collection routings
Traffic lights	Educational planning (schools, buses)
Mass transportation systems	Population planning
Air pollution control	Weather
Air traffic control	Airport and its environment design
Urban development and dynamics	
4. Services and communication	
Fast food facilities and nets	Fleet scheduling
Local area networks	Harbour planning
Supermarket planning	Bank teller scheduling
Telephone systems	Facility location and environment
Highway toll collection	Parcel service
Communication networks	Telephone switching
Airport networks	Freeway traffic
5. Politic and administration	
Political redistricting	Political campaign strategies
Economic condition	Business games
Insurance and risk management	Auditing strategies
Labour planning	Negotiation strategies
6. Industrial	
Facility planning	Process scheduling
Manufacturing optimizing	Inventory management
Repair and maintenance scheduling	Distribution channels design
Machine and tools monitoring	Process and product safety testing
Quality control	Staff scheduling
Robots collision examination	Staff training
Off-line programming	Power plant emergency strategies
Control system design	Robot navigation
8. Education and science	
Heat and mass transfer	System dynamics
Hydraulics	Cell grow simulation
Cardiovascular systems	Genetic
Sonar systems	Isotope separation
Soil and water systems	Vibration
Chemical processes	Propulsion systems
Training	Educational simulators

Source: Budnik, McLeavey, Moyena (1988). *Principles of Operation Research for Management*, Richard D. Inwin, Homewood, IL, USA.

and is performed by people already used to working with computers and sophisticated mathematical methods. In the past, such a configuration enabled a conflictless use of simulation tools that were initially difficult to understand and to handle. Industrial engineers were usually just confronted with the results of the studies and were not directly involved in a simulation process. This did not result in comfortable user interfaces being regarded as one of the most important features. The growing popularity of simulation studies resulted in firms trying to carry them out on their own, using company staff. This has brought about a new breed of simulation systems that make extensive use of graphical user interfaces, animation and languages to solve problems. The new simulation system "talks" with the analyst, using terms such as shift, machine, operation, breakdown, maintenance, off-shift, etc. These communication rules are employed not only to model building and conducting of experiments, but they are also applied to all communication, optimization and analysis modules, enabling work to be done with the simulation tools without the necessity of additional theoretical studies. The concurrent developments in hardware design permit a comfortable performing of extensive simulation studies with on-line databases, optimizer or external interfaces, even on personal computers.

Simulation in process planning

The way that simulation is used in process planning is in general very similar to its application in facility planning. While in facility planning the goal is defined as working out a facility layout, taking as given the processes and the manufacturing objectives, in process planning various process alternatives are analysed, assuming that the facility shape and the manufacturing objectives stay constant. This change of perspective brought about a rapid increase in the number of variable system elements (the number of parts, number of manufacturing processes, number of singular operations, etc.). Their frequent changes caused a sophisticated system interface to become an urgent necessity. The already implemented user friendly interfaces had to be extended by interfaces to databases, MRP (MRP II) and data collection systems, improving not only the handling of the experiments, but also the analysis speed.

Simulation in dynamic optimizing of existing manufacturing systems

The employment of simulation tools in process planning was certainly an important step towards extending the range of simulation applications, but they were still embedded in large series manufacturing. As in facility planning, where simulation was used just once to establish the layout of analysed manufacturing systems, process planning employed simulation just once to define a suitable configuration of the manufacturing processes. Once implemented, the system of interest was seldom reanalysed or changed. The sluggishness of traditional large series manufacturing ensured that the changes were not only too complicated to implement, but were also enormously expensive.

The introduction of short series manufacturing with a wide product diversity, low inventories, and short lead and delivery times, also initiated new requirements and new qualities to the field of simulation. The changes in product demand should cause an almost instant adaptation of the manufacturing environment, an adaptation that would comprise the introduction of new products, a dynamic adjustment of manufacturing capacities, on-line design of new processes and manufacturing plans, etc. The traditional methods of manufacturing planning and controlling are not able to deliver appropriate solutions for such environmental conditions, but a remedy can be found in the new generation of simulation based systems. The already existing features of graphical user interfaces, animation and connection to the other manufacturing systems prepared for extensive facility and process planning could be used as a basis for more dynamic and sophisticated purposes. By becoming part of the JIT planning and controlling system, simulation lost its independent, local character.

One use of simulation methods is in intelligent schedulers, even if the word simulation is not emphasized. An intelligent scheduler takes as input the facility equipment, personnel, inventories, processes, orders, shifts, delivery terms and generates quickly and more or less automatically detailed plans for future manufacturing. Simulation is the means for taking data from the database, files or on-line interfaces, feeding the model, "manufacturing" the defined amounts of products, "delivering" them and analysing the outputs. The most advanced schedulers are extended through optimizing elements. The scheduler answers not just the simple question "what if?", it combines a series of such questions into the process of finding the "which is the best?". Such schedulers do not take the predefined input data as an absolute constant. They are allowed to change them within predefined boundaries in order to find an optimal configuration of the manufacturing conditions.

Simulation in monitoring of manufacturing processes

Simulation is a means by which we are allowed a glimpse into the future and the wherewithal to predict the consequences of predefined (scheduled or random) events. The first simulation systems delivered the results of experiments in the form of lists and tables, which were later extended through animation. Some of these animation modules were designed to be used with any output data, not necessarily simulation originated. Such animation tools connected to data collection systems offer very flexible and inexpensive ways of analysing past manufacturing. A controlling system can additionally write out events, which could be of interest to external files. These can be read by the animation module, making possible movie-similar presentations of past events. This sort of animation allows for the zooming in on selected facility areas, repetition of chosen situations at various speeds and the analysis of interconnections of just realized processes. The same tool can also be used for on-line monitoring of the facility status, building an inexpensive alternative for complicated and costly monitoring systems offered by machine and control system manufacturers.

In the last few years, simulation has steadily gained importance in manufacturing enterprises and has become an integral part of all sectors of the manufacturing facility life cycle. The low price of software and hardware, together with a growing performance and user friendliness of the offered system, enables it to be employed in small and medium-sized companies. Acceptance is fairly slow, but the same process was observed in the past with introduction of NC, CNC, CAM/CAM, AGV, MRP and other computer oriented manufacturing tools. Nowadays, nobody thinks of doing without them. Studies have shown that by the year 2000 simulation will replace spreadsheets as the analytical tool of choice for system analysis.

Application examples

In this section, we would like to give some examples of applications where simulation has been successfully used.

Case studies seldom contain detailed descriptions of the benefits reached using simulation techniques. The reasons are manifold. When a company "takes the risk" and employs simulation to solve a given problem, that same problem has seldom been approached using other methods. In such cases, it is difficult to make comparisons and give figures (time, money, manpower, environment, flexibility) that show the advantages of a simulation based solution. On the other hand, a typical manufacturing system is characterized by a steady shortage of time and the piles of work that should have been accomplished "yesterday". In such an environment the simulation team has barely enough time to undergo the "unproductive" work and prepare an analysis and comparison of the methods employed. In addition, such analyses are often not desirable. It reveals to competitors which methods are being used and what results have been obtained, thereby reducing any advantages gained. It is typical that companies openly discuss simulation at the introductory stage. They use external experts and discuss their situations and plans with universities. After the simulation study is completed, analyses carried out and the results implemented, the whole subject vanishes from open discussion. New installations are purchased directly from the vendor, only absolutely independent consultants are involved, and all the information connected with the simulation is treated as classified.

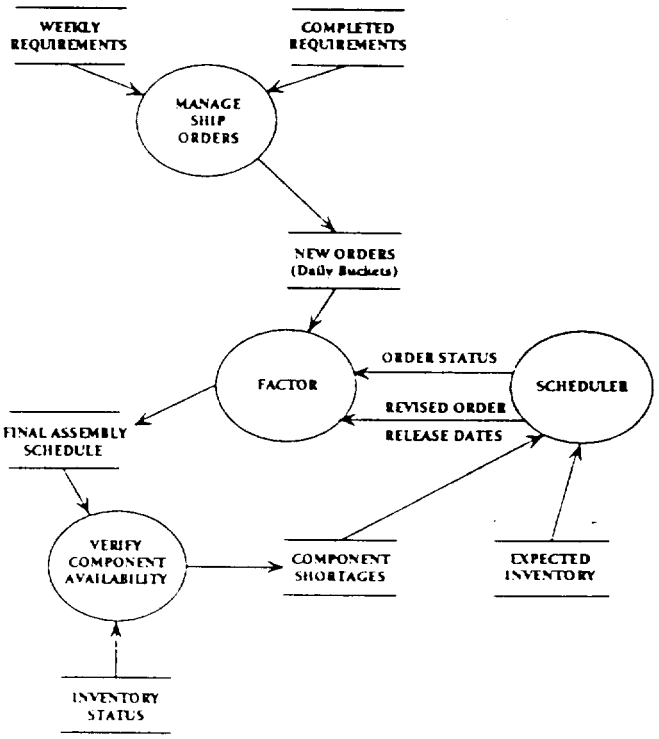
Final assembly scheduling for automotive engine cooling units

One of the division's of a major automobile producer uses simulation tools to bridge the gap between existing planning systems that provide assembly requirements in weekly buckets, as well as the operational necessity of meeting daily customer shipping requirements. The division manufactures about 75 different engine cooling units, which are assembled by a crew of 18 to 24 assemblers who perform serial operations. There are usually 100 to 150 different orders in a system for a given week. Missed shipments can result in assembly plant downtime, incurring costs of about $100,000 per hour. Minimal amounts of finished goods inventory can be held, so a missed shipment date will require the use of premium shipping modes, costing the division as much as $100,000 per month. The simulation schedules are driven by the daily-bucketed customer shipping requirements. The task of scheduling the final assembly area is further complicated by the transition of the facility from a traditional assembly line layout to a more flexible cellular assembly configuration. The original three assembly lines are being replaced with 18 assembly cells, leading to a level of complexity that requires the computer-aided decision support provided by simulation. The primary objective is to provide scheduling decision support that enables the scheduler to produce achievable, capacity constrained schedules that:

- Meet customer requirements on shipment dates;
- Minimize final assembly inventory levels;
- Maximize final assembly throughput.

A simulation based scheduling system was developed to provide a sequence for each final assembly resource (cell or assembly line). The sequencing logic of the system evaluates the trade-offs between due date performance and changeover costs (as measured by the time required to make changeovers). The system captures all key constraints on assembly activities to ensure that feasibility schedules are produced. Final assembly schedules are produced with a one day (four shift) horizon and a full week horizon for distribution to the shop floor. Reports of component part requirements for departments that supply final assembly are generated by the

Figure 8



system as well. Anticipated benefits from implementing a simulation based planning system include:

- Improved performance to customer shipment date;
- Reduction in finished goods inventories;
- Improved communication between manufacturing and production control;
- Added visibility, via the simulation's "what if?" capability, of the impact of alternative scheduling decisions.

The final assembly schedule is run through a bill of materials explosion that provides a report of the components' parts (motors, screws, etc.) that are required to support the final assembly schedule. These requirements are automatically cross-referenced against the component inventory level to lag orders that cannot be run due to the unavailability of component parts. The scheduler can then modify the FACTOR orders accordingly and re-run the schedule to ensure feasibility.

Printed circuit board planning and scheduling

Circuit Center, Inc., implemented the simulation based scheduling system in order to set realistic, achievable order due dates, as well as to analyse the impact of premium order acceptance. Furthermore, the project allowed more effective management of order releases to the shop and provided detailed production schedules that were capacity constrained and coordinated to improve due date performance.

The manufacturer provided express services to customers by using a "launch and expedite" operating strategy. As demand grew and capacity remained relatively fixed, it became clear that improved planning and scheduling methods were required. The sales force was finding it increasingly difficult to assess the impact of accepting premium ("hot") orders. The production control department had little or no visibility of the effects of upstream sequencing decisions on

downstream finishing operations, including the shipping of completed orders. The facility operates mainly as a make-to-order shop with a small number of repeat designs, with sufficient flexibility to generate new routings as orders are accepted. The material flow overview is shown in figure 9. The facility consists of about 15 departments. The complexity of the boards usually manufactured at this facility ranges from 10 to 30 operations. Almost all design work is done by the customer and supplied along with the order. There are normally 250 open orders at any time for quantities ranging from 1 to 50 boards. The average order size is 20 boards. Average order delivery time is five days, but one- or two-day service is available at premium rates.

The simulation (scheduling) study was aimed at:

- Visualizing the effects of accepting premium orders;
- Predicting order completion times for setting promise dates;
- Producing achievable manufacturing schedules that improve performance to due date

The scheduling system was implemented in two steps. The first step included a high-level facility model developed for sales analysis of premium orders, impact and estimation of completion date. The model could also be used as a tool for:

- Analysing of decisions to be taken at key points;
- Generating gross level production schedules to define the launching of new orders.

The initial model was designed as a stand-alone solution, without connection to the other elements of the manufacturing system: development and procurement.

The second step led to the building of a more complex production model. This provided detailed workstation level schedules and was connected to work-in-process tracking, order entry and other systems developed and integrated during the first step of the scheduling system design.

Short-term capacity planning in a paper plant

One of the major producers of paper products suffered from a lack of planning and communication as a result of geographically distributed yet interdependent operations. The manufacturer is divided between three facilities, or mills, separated by as much as 160 kms. Each of the three mills has unique production capabilities required by orders originating at another mill. The company produces several product lines, each with a variety of specific products. The company is largely
"make-to-order", with some "make-to-stock" to shorten lead times during high seasonal demand.

An order begins with a base paper, which is coated, embossed, topcoated or printed, and then sheeted or slit. Order sizes vary from only a few hundred metres to tens of thousands of metres. An order requires only a few hours of machine time, but has a lead time of two to four weeks. There are 100 to 1,500 orders in the system at any time.

Because of the physical separations, each facility had little warning of what demand other facilities had for its resources. This lack of visibility often resulted in the need for overtime or premium labour. The typical response was to carry work-in-process inventory to shorten the apparent lead time for a product, making it easier to satisfy the customer due date.

To solve these problems arising in the company, a scheduling system was developed and implemented, which was aimed at:

- Improving on-time delivery;
- Limiting work-in-process inventories;
- Reducing premium labour.

The system employed FACTOR, and performs short-term capacity planning. It captures the constraints of three mills, illustrating the effects a decision at one mill has on the other two mills, and on the company as a whole. A report from FACTOR showing the expected utilization for each work centre is also available to help identify potential capacity problems.

The FACTOR scheduling system produces a schedule for each workcentre at the three facilities. The schedules show only start and end dates for each order in the system; to encourage "real-time" sequencing, no times are listed. The scheduling personnel in each facility are responsible for providing feedback to a central FACTOR analyst who incorporates their decisions in the FACTOR model. Through this process, the demand across facilities is communicated, and priorities and responses are negotiated. The scheduler is integrated with an MRP system, which provides production routings, new orders and in-process order status. FACTOR schedules are distributed to the shop floor and are used as a list of jobs to be completed each day. Within a department however, the supervisor has the flexibility to sequence the order as necessary, providing the day's demand is met.

Through implementing of a simulation based scheduler the following benefits were gained:

- Better performance to due date, resulting in improved customer satisfaction.
- Improved communication among the mills, reducing the need to expedite late orders and requiring less premium labour.
- Visibility of the impact of work-in-process inventory levels on due date performance and utilization. Reducing inventory results in lower carrying costs and shorter lead times.
- Day-to-day shift of operational focus from "local optimums" to more global, company-wide objectives.
- Increased discipline regarding management of capacity, without the loss of flexibility needed to respond to changes in the production environment.
- Added visibility and communication, which help to keep "hot" orders from becoming overlooked.

Analysis of robotic palletizing alternatives

A customer, being one of the major consumer products manufacturers, needed to choose a robotic palletizing system for one of their warehouses. The required system is presented in figure 10.

Cases of the product enter the warehouse on a conveyor. Up to 12 different products may be present on the conveyor at any one time. The cases are spaced out evenly by the metering belt and then palletized by the operator at the appropriate pallet cell. If space is not available at the required storage spur, the case will circle around on the conveying loop for another attempt. Once a pallet has been filled completely, it is either conveyed automatically from the cell or removed by a fork lift truck and taken to storage.

The system was required to handle a recent increase in production while meeting cost guidelines. The company management arrived at three alternative configurations, from three different robot vendors, and chose simulation to help decide between the systems. The performed study had three main objectives:

- Evaluating the ability of each system to service the design load condition;
- Using the model to fine tune several of the system parameters; and
- Determining the material handling limits of each design.

Figure 9

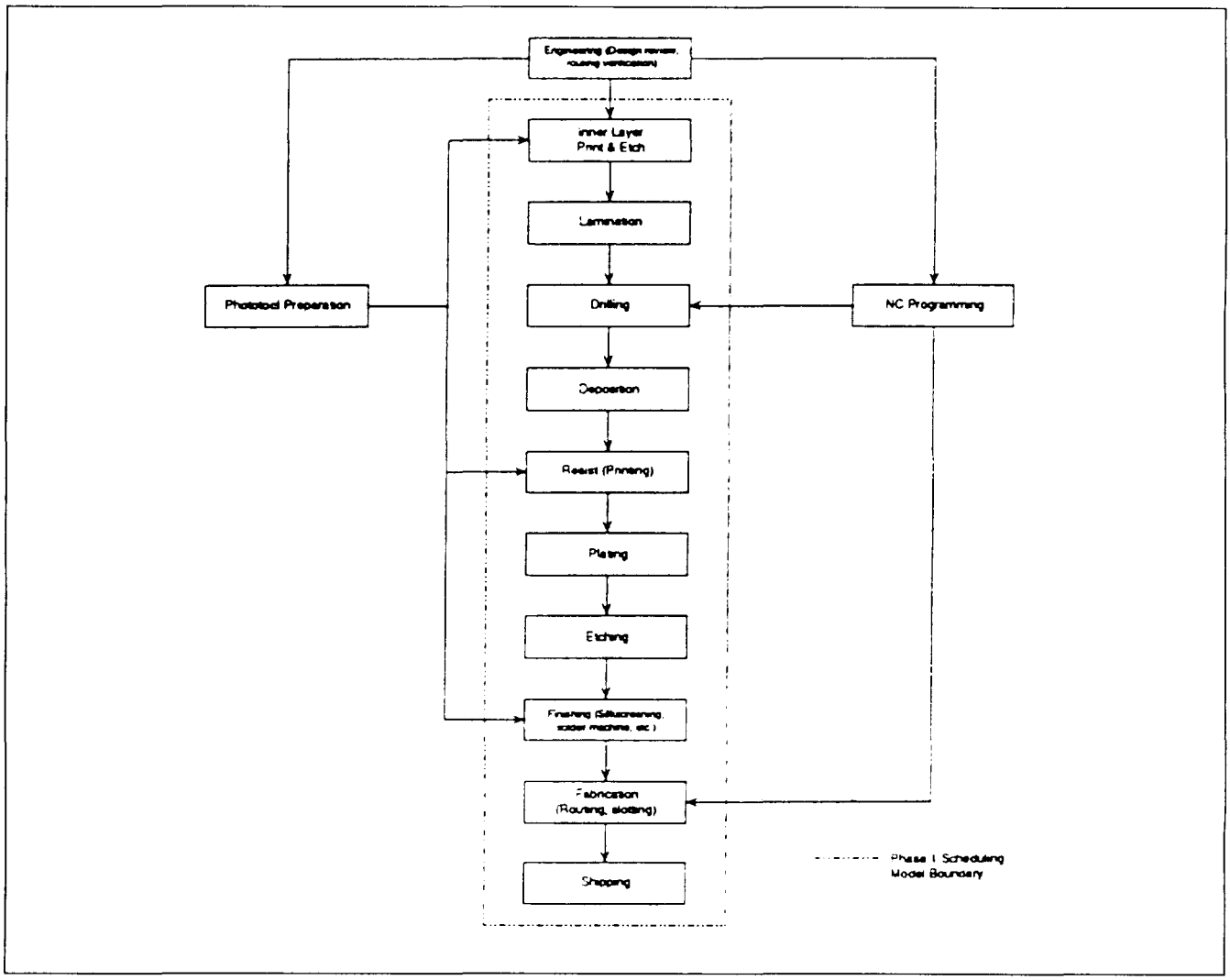
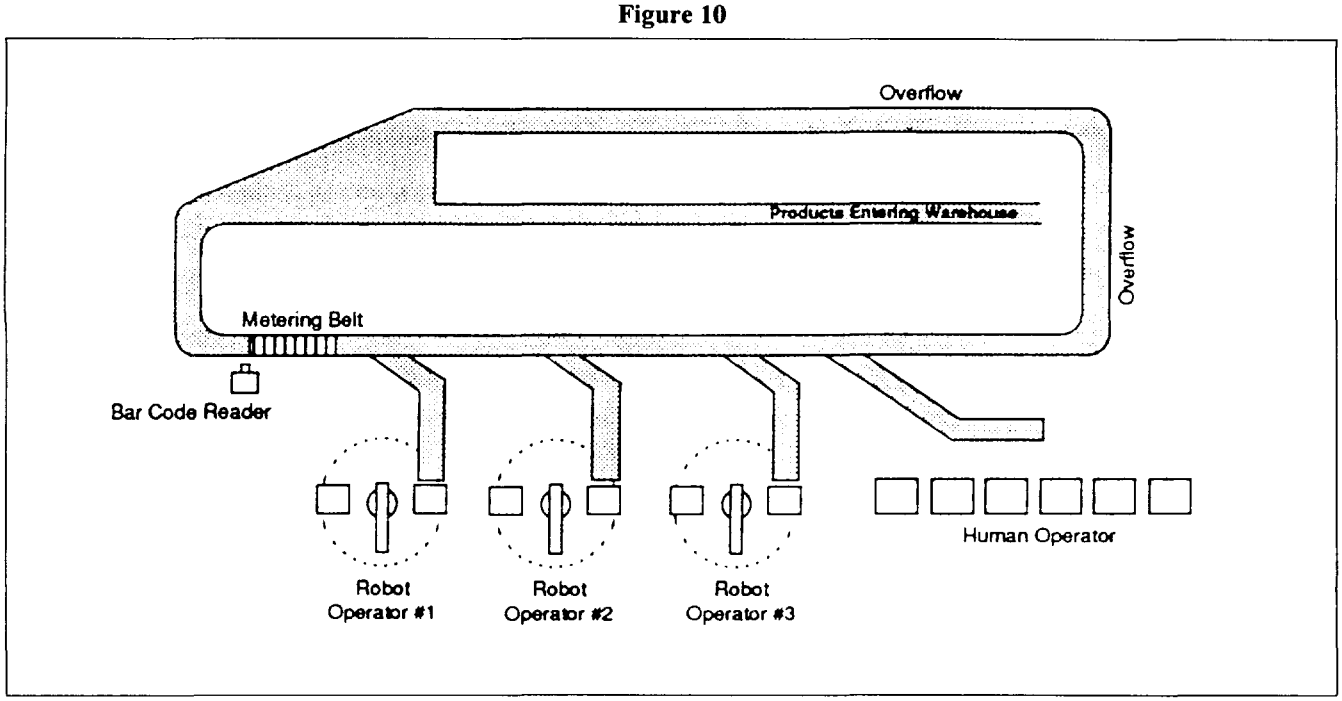


Figure 10



The SLAM II model showed that configuration with three robots and one human operator would meet both production and cost requirements. A cost ceiling dictated that one human operator be used along with three robots instead of implementing a four-robot system.

The model was also successful in fine-tuning system parameters such a robot cycle times, palletizing strategies and case diversion logic. Because of the initial success of the model, it was used for further analysis of the system parameters and logic.

Total capacity management using simulation at Pratt & Whitney

In a project at Pratt & Whitney, a compressor blade manufacturing area that makes more than 50 parts was scheduled using a simulation system. The area consists of a cropper, six extruder lines, nine forge lines, seven broachers and other stations that perform intermediate operations, such as machining, heat treat and surface finishing. Material handling and storage is accomplished through integrated AS/RS and AGV systems. Altogether, the process includes 15 operations, with a manufacturing lead time of 8 to 12 weeks. The broach is the bottleneck operation; its setup takes from one day to two weeks and is a key consideration in production planning. Lots for the broach are usually sized at 10,000; whereas lots for the extrude and forge operations usually run around 2,000 to 2,500. The smaller lot sizes are designed to reduce inventory levels, while ensuring the bottleneck operation has materials when needed.

The objectives of the scheduling project were:

- Automation of routine scheduling decisions;
- "What if" capabilities to evaluate scheduling decision alternatives;
- Extend the scheduling horizon for manufacturing support organizations, tooling in particular;
- Provide a capacity to evaluate reactions to unplanned events;
- Provide a single coordinated schedule of all departments.

Tooling was one of the manufacturing area's largest problems. Even though large tool inventory was carried out, tool-related production interrupts (wrong tools on hand) were experienced. Part of the long-range strategy is to provide sufficient forward visibility in the production schedule to support tool planning and scheduling. Purchased and fabricated tooling have lead times ranging from one week (expedited) to six months. In addition, forward visibility could benefit material purchasing, since titanium stock lead time is about 16 weeks.

The blade area scheduling strategy used a combination of manual and computer-based steps. Each quarter, a schedule was manually developed for the broach based on orders from the corporate MRP system. The plan horizon is 18 months, and accounts for part sequences and setups. From this, an 18-month cropper release schedule is manually prepared, using an appropriate setback.

The simulation based scheduling system is used to develop a 30-day schedule for the remaining operations. Scheduling for the two forge and two extrude operations required the consideration of a large number of capacity and operation constraints, and involved logic relations to intelligently sequence operation and plan changeovers. The 30-day schedule is regenerated daily, using current status information from a CIM database. The production control department reviews the schedule to ensure tool availability and makes changes as appropriate. The schedule is then reviewed at the daily production meeting, where further revisions may be made. Once accepted, the schedule is released to the production floor. Further adjustments are made manually. A simulation based scheduling system incorporates these decisions in the next run. The 30-day schedule provides information to expedite needed tools within the 30-day window.

The next step is to expand the model-based 30-day schedule into the disk manufacturing and experimental blade area and work out a generator for an 18-month broad schedule.

Validation of assembly plan design

An automobile manufacturer was preparing to retool one of its assembly plants for a new type of car. Design engineers were preparing bid packages for equipment vendors and needed to validate the proposed assembly conveyor system.

The simulation study addressed three specific questions:

- Can the proposed conveyor systems support the production objectives?
- Can any excess conveyor capacity be eliminated?
- What production rates would be required for key assembly operations to meet production objectives?

The simulation model identified that, in order to meet the goal of 72 jobs per hour, part of the conveyor system would have to be increased. These increases were necessary to cover operations during breakdowns. The model also showed that other accumulation buffers were over-designed to cover operation breakdowns.

The simulation model showed that modifications to a proposed conveyor system for a redesigned body shop were needed to meet the shop's target production goal. The analysis also identified an excess number of carriers in the system. By eliminating these carriers alone, approximately $225,000 could be saved.

Analysis of semiconductor wafer fabrication facility

Simulation has been used to solve problems in a large semiconductor wafer fabrication facility. Due to the high level of complexity in the manufacturing process, an accurate method to identify capacity constraints in advance of their occurrence did not exist. Also, when bottlenecks occurred there was no method to accurately analyse the problem and identify the most cost-effective solution. Often, very expensive equipment, to the tune of more than $1 million, would be purchased to solve a capacity problem. Because the proper tools were not available to properly analyse the cause of the problem, decisions were made on the basis of very limited information. Frequently, the equipment that was purchased did not solve the problem.

To solve these problems a simulation tool was implemented. It now provides a productive way of analysing the various areas within the wafer fabrication facility. By using it, production personnel can now:

- Predict production performance relative to expected demands; and
- Test the results of decisions (i.e. equipment purchase) before committing capital and resources.

With the help of simulation, highly accurate, complex production flow analysis is completed in a matter of minutes, bottlenecks are identified and "what if" analysis is performed to identify the most cost-effective solution.

The simulation tool implementation has provided the manufacturer with the visibility and ability to make better decisions involving capacity planning and short interval scheduling and sequencing. Large cost savings have been realized due to avoiding the purchase of several very

expensive pieces of equipment. Several bottlenecks were minimized due to the ability to identify potential problems in advance and test the result of a proposed solution before committing capital and resources.

The implementation of the simulation tool has resulted in increased production throughput; decreased capital expenditures; and improved resource utilization.

Simulation is being used to help a large semiconductor manufacturer reduce costs by providing the ability to identify capacity constraints and test proposed solutions before committing capital and resources. A simulation model has been integrated into Consilium's COMETS to provide on-demand analysis. The model is currently being extended to provide daily production schedules.

Consolidating production sites of Fortune 500 company

A Fortune 500 manufacturer wanted to consolidate production from multiple sites into one optimized facility. The existing sites processed 300 different product types, each in various packaging configurations. Major consolidation issues revolved around feasibility design and scheduling questions. Could all the products be run on the same site? Which packaging lines could be configured to run from which processing operations? Could lines be staffed to satisfy demand without building up excessive inventories? To address these issues the company, together with a consulting partner built "Extend+Manufacturing" based models incorporating:

- Hierarchical sub-models that could be connected in various configurations to evaluate total operations. This approach enabled the modellers to quickly explore alternative configurations at the system level without having to access the lower level details.
- Control logic that determined material movement after querying the database of materials and equipment information. Specific aspects of a product (such as the moisture content) of equipment (i.e., tank cleaning time) were integral to how the product would be run.
- A custom built scheduling module for quick preparation of sequences of product runs. This provided a means to apply an heuristic system, which sorted and arranged the product runs to satisfy demand, minimize changeovers, and achieve smooth loading across weeks. The data for the schedule was read from an Excel file and was used to drive the simulation. Separate schedules determined crewing levels and calculated utilization, idle time and overtime.

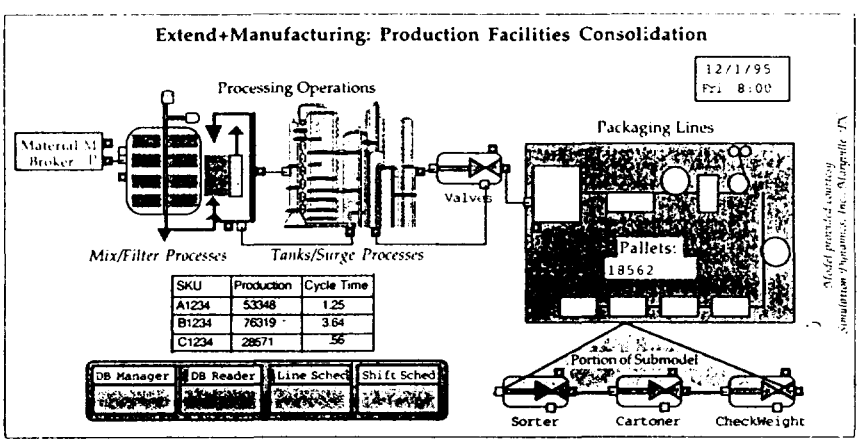
Apart from promoting confidence in the consolidation strategy, the simulations determined the optimum buffer size between processing and packaging for each production line and convinced the company that the crewing schedules envisioned prior to the simulation study were unrealistic. In addition, the company avoided unnecessary and overly expensive production line changes. For example, the models were used to determine a better layout after one configuration was shown to cause severe long-term quality problems requiring a $4 million retro-fit.

Based on the success of this project, modellers at the consolidated plant are now also modelling supply operations and the company has adapted the model for use in other plants world-wide. The scheduling portion of the model continues to be used for crewing allocations for this and similar operations. The "Extend" graphical user interface allows modified models to be used for training crew in the production and packaging areas.

Simulation for developing countries

Developing countries possess the lion's share in human and natural resources. For various reasons their economies rely mostly on selling raw materials and importing industrial goods. The changes in demand/supply trade-off resulting from growing inventories, the application of substitute materials, new material processing techniques, and the

Figure 11



Source: Simulation Dynamics, Inc. IN

emergence of new suppliers, causes a steady decrease in capital earned. At the same time, expenditures connected to growing needs and increased prices for industrial products, bring about a substantial growth in expenditures. To stop this development some steps into extending local manufacturing capacities have to be taken. It would add value to the exported domestic products and cut down import quotas. Additionally, a trend towards a wider openness of international markets offers new emerging economies many chances. Even if it is not visible at the first glance, developing countries have a lot of advantages.

- The natural resources, which are presently exported, are cheaper than in other countries;
- The domestic demand for industrial products is steady growing;
- Labour costs are usually lower than in developed countries; and
- The education level is usually high enough to establish and run various enterprises.

These advantages are also recognized by international companies, which are likely to cooperate with the local enterprises and authorities to utilize the existing potential. Such partnerships bring necessary means, such as capital, technology, machinery, organization, experience, distribution channels, etc. But the presence of multinational companies not only brings opportunities. It also brings competition. Local companies, if they want to stay in the lead have to cope, not only with the new products, but also with the new economic conditions created by the opening of the market. They have to:

- Produce in short series;
- Manufacture a wide variety of product types and variants;
- Produce with short lead and delivery times;
- Offer lower prices than the large series manufacturers;
- Flexibly extend and reduce manufacturing capacities in accordance with the market situation;
- Flexibly extend the product palette;
- Take additional orders and carry them out within a reasonable time and price frame.

The best enterprises will be rewarded, not only by domestic sales, but also by delivering to the world markets.

In addition to the above advantages that the newly emerging economies have, they can also make use of each others' very valuable assets. They can learn from the mistakes made in the course of time in other countries and companies. They do not have to go through the loop of sequences - "build, try, fail, analyse". They can pick up the simplest and most effective method that has been worked out and employed all over the world. To find new ways, simulation can be used. The last few years have brought a huge advance in this area. New, highly sophisticated hardware and software platforms and tools have been developed and disseminated. What has still to be done? Appropriate tools have to be selected, the necessary training undergone and the created capabilities employed. This process should be supported by institutions and organizations involved in overall country development programmes. It includes government-sponsored chambers, professional societies, universities, research centres, and others, together with such international organizations as UNIDO, UNDP or the World Bank.

In the next few years simulation is expected to be omnipotent in almost every process and development, saving time, money and resources. This dissemination should take place not only in great companies, such as General Motors, Ford, IBM or Siemens, but also in small and medium-sized enterprises all over the world, as a planning, monitoring, controlling and optimizing tool.

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B. NEWS AND EVENTS

Global software scene: an overview

The information technology industry is the fastest growing global industry. The combined business of computer hardware, telecommunications, software and related support services already exceeds one trillion US dollars. The growth prospects and high profitability of these high technology industries, and perhaps more important, the strategic importance of the core technological competencies associated with producing and applying IT, have attracted the attention of both industrialized and developing countries. It is increasingly used by organizations for productivity and value added enhancement. It is also extensively applied to reduce transaction and coordination costs in product design, manufacturing and marketing activities.

Information technology has been perceived by OECD countries as a major opportunity to modernize traditional "low tech" industries such as textiles, apparel and footwear. There are profound implications of IT-based product design and manufacturing on the competitiveness of key industries in developing countries. For example, the advantages gained by users of computer numerical controlled (CNC) machine tools are such that the market for conventional capital goods produced by developing countries is declining. The impact of IT on the clothing industry has also been dramatic in terms of quality and responsiveness to the market. The organization and economics of automobile assembly have been transformed by exploiting IT-based systems in product development and engineering, procurement and supplier integration, flexible manufacturing, distribution and marketing. The unit cost, quality and lead time advantages gained from the adoption of these technological and managerial innovations are so substantial that other OECD manufacturers and the newly industrialized countries (NICs) are being forced to adopt similar practices in order to survive.

Information technology diffusion is influencing the flow of foreign investment and trade, as it changes both the production and governance functions, particularly of the multinationals. It tends to decentralization and specialization of the production function, by lowering the minimum efficient size of production units. Among the salient features of growing usage of IT are: increased access to multi-sourcing, globalizing the procurement function, niche strategy based on differentiation, electronic subcontracting, on-line reinforcement of quality control of subcontractors, increased coordination between engineering, manufacturing and marketing accelerated product life cycle, reduced delivery time and strengthened financial controls and corporate management systems. The overall result of such forces, generated by the introduction of IT, is a growing trend towards developing a new form of organization, called the network organization.

Although there are examples of advanced and effective uses of computing and communication technologies in industries in developing countries such as India, Pakistan and Bangladesh the examples tend to be limited to a few large firms and have little downstream linkages with local suppliers and the rest of the industrial sector. There is limited information, or awareness about the opportunities of IT adoption and hardly any government programme to promote or facilitate the introduction and diffusion of IT applications.

IT in public sector management

Public administration is by its very nature highly information intensive and transaction driven. Not surprisingly, mainframe computers were first used in the public sector, and until now, public administration remains the largest investor in information and communication systems in almost all countries. OECD countries continue to invest in the computerization of social security, tax administration, customs, public procurement, financial and personnel management, budget and treasury management, patent records, ports, aviation and many large transaction systems. Most of these applications have become essential to public administration and the running of government. They support internal management functions and the automation of existing services to increase efficiency and contain the growth of the civil service.

During the 1980s, the advent of micro-computers and electronic networks substantially expanded the opportunities to apply IT in public sector management. These applications are intensifying the use of information for policy-making, planning and budgeting, monitoring service standards, delivery of new services and accountability and control.

The benefits of such applications are substantial but not automatic. Experience in industrialized countries, where these applications are most advanced, suggests that the full benefit of IT is achieved only when an organization applies it to information (analysis) in addition to automating (processing).

Many developing countries are automating their critical systems such as the national budget, tax administration and treasury management. The challenge is to begin to use information systems applications to support planning and decision-making, to improve coordination, to facilitate decentralization and accountability, to provide superior extension and support services, and in general, to improve the quality of policy and programme management. Realizing the full benefits from these applications requires new levels of training and motivation currently uncommon in developing countries. (Contributed by K. Fialkowski, UNIDO 1996)

Technology 1996

What a time this is for electrotechnology! As the sector's stocks climbed to new heights in 1995, systems and scientific disciplines that were once independent found a need to communicate. The vision of a world in which information flows unchecked among a diversity of systems has caught everyone's imagination.

Even within communications, disparate elements are converging. No longer do purveyors of broadcast media, telephone services and data transmission play in separate arenas. Today, broadcast and cable companies—and power utilities, too—talk of using their wires to provide data services, including Internet access, to the home. Internet providers plan to compete with telephone companies, and telcos aspire to offering television programming. All these once-distinct industries plan a radical reform of how wires and airwaves bring people information and entertainment—not least by allowing feedback through interactive services that have never before been possible.

While Windows 95 and Windows NT had the most impact on the computer field in 1995, a debate that may reshape the personal computer industry in the years to come was sparked by developments in communications. A number of computer companies have begun suggesting that PCs are not the right tool for the future. They suggest that a less

expensive device that draws on the computing power of a network may be the better way to go.

Communication issues are certainly shaping the top consumer product: the television set. (In 1997, though, it may come second to the home PC.) The last nails are being hammered into a standard for high-definition television in the United States, but doubts remain as to whether anyone will broadcast in HDTV format. Broadcasters may prefer to use the greater capacity of a digital system for extra channels, not extra quality and use them to deliver more data.

Those who apply the latest technologies to communication systems, computers and consumer products can thank progress in semiconductor technology. Growing integration of functions on a single chip is enhancing performance while reducing costs for the end-user. The system-on-a-chip is virtually a reality.

Microsoft Corp. is giving its own twist to software engineering, with the Win32 application programming interface becoming a de facto standard. No other software supplier can offer an application programme interface (API) that will stand up to it, so the tools of software engineering may well have to cling to Windows developments like a velvet glove to an iron hand.

More surprisingly, Microsoft is the underlying theme in engineering software applications. Unix is their traditional base. But Windows NT's move into the workstation world has fostered the rise of tools that will run on the latest high-performance PCs.

Advances in circuit testability and self-test techniques are as ever playing catch-up to the greater speeds and functionality of ICs and boards. The density has elicited a new type of wafer prober capable of 13,000 contacts per square centimetre.

Year after year, global warming seems more of a certainty. Consequently, efforts are intensifying to moderate the effect on the environment of CO_2 emissions from energy production. More efficient coal and gas combustion techniques are helping to reduce emissions of greenhouse gases. But the future of fusion and fission remain doubtful.

In the case of electronics production and consumption, efforts to lessen their environmental impact focus on policies that would make manufacturers take back and recycle products at the end of their useful lives. Design for Environment strategies are also picking up steam with the development of computer-aided design tools that flag environmentally troublesome products.

Air travel will be safer when differential global positioning systems are installed at air traffic control facilities across the USA. Now under development, these systems will give the correction signals broadcast to aircraft a precision of 15 metres instead of 100 metres. Automated positioning and guidance systems are also coming into use for trains, ships and cars.

At higher elevations, the US space Shuttle docked with Mir, the Russian space station, for the first time ever in June 1995. Current efforts of the National Aeronautics and Space Administration include developing an unmanned Reusable Launch Vehicle for transporting supplies to the International Space Station. Construction on the space station is to begin in 1997.

Closest to the hearts of men and women are the many advances in medical technology. Implants for pain control, Lou Gehrig's disease, and diabetes now in limited testing may relieve sufferers from those illnesses. Software to aid in medical diagnosis is becoming epidemic.

Power electronics will benefit from insulated-gate bipolar transistors that can cope with 1,200 A and MOS-gated thyristors for applications above 2,000 V. Security systems may one day benefit from the union of neural networks and optical techniques to store facial images on an ID card for comparisons with those of the bearers.

At the frontiers of science, researchers have realized a new state of matter: Bose-Einstein condensation, which exists at billionths of a degree above absolute zero. Much closer to the horizon, investigators are making rapid progress with plastic transistors. Others are looking at novel ways of storing digital data three-dimensionally. (Source: *IEEE Spectrum*, January 1996)

Engineering "megaprojects" are making a comeback

Electronics is essential to the latest Wonders of the World. The first Seven Wonders of the World, catalogued 23 centuries ago, comprised massive piles of cut stone that marked the dawn of civil engineering. Even a 1930s list of Modern Wonders honoured such civil engineering feats as the Empire State Building and the Golden Gate Bridge.

Today, electronics is indispensable to these Wonders, which consume such massive quantities of labour, money and resources that we call them "megaprojects". A post-modern Pharaoh building a pyramid would employ computer-aided design, laser-guided stone-cutting machinery, electro-optical survey transits, and, of course, cellular phones to call the limestone quarry.

However, as large investments are seldom premised on untried technologies, the use of leading-edge electronics was not a criterion for candidacy. Some project managers, in fact, choose to avoid risk by using off-the-shelf electronics.

Such choices are part of the challenge of executing a megaproject. Technology moves so fast, and lets us change designs just as fast, that configuration control boards must lock designs in place and at times keep engineers from using the latest tools, to prevent design and redesign from entering an infinite loop. Glory, even so, is transitory or even elusive because the next design team can contrive something bigger—or the Pharaoh might change his mind. Project Apollo spanned 11 years, less time than it took to build a pyramid. (Source: *IEEE Spectrum*, October 1995)

Secure tick plan for Web buying

International credit card organizations Visa and Mastercard will introduce a technical specification for secure electronic financial transactions, including payments made over the Internet.

The new standard, to be called Secure Electronic Transactions, is expected to raise confidence among parties that engage in electronic commerce, and speed up the public acceptance of smartcards.

Until now, Visa and Mastercard have individually worked on bringing out such a standard, each in cooperation with a different technology firm. Visa was associated with Microsoft developing the STT system and Mastercard with Netscape developing the Secure Corner standard.

Their third partner in the EMV initiative, Europay, was cooperating with IBM in the development of the Internet Keyed Payment protocol. (Source: *Electronics Weekly*, 7 February 1996)

Digital TV system spec from DVB

Europe's progress towards the terrestrial broadcasting of digital television before 1997 continues with the publication of the first system specification from the European DVB Project.

The specification gives details on the adopted scheme, based on coded orthogonal frequency division multiplexing (COFDM), and the possibility of using 1,704 or 6,818 individual carriers to transport the data.

The UK is still on the road to an early introduction of terrestrial-DVB and it may adopt the 1,704-carrier transmission scheme. Spain, however, may be one of the countries which will opt for the 6,818-carrier scheme, to be used later on.

The DBV Board has also agreed on the specification for a digital broadcasting system using Multipoint Video Distribution Systems (MVDS). This system can potentially be the most important means of delivering a large number of DVB channels to households, especially where cable cannot be used. (Source: *Electronics Weekly*, 31 January 1996)

International DRAM venture under way

IBM, Siemens, Toshiba and Motorola have announced plans for a four-way alliance to develop future generations of highly advanced semiconductor chips, including a 1 Gb dynamic random access memory (DRAM). Motorola researchers are expected to join the development teams from IBM, Siemens and Toshiba, who have been working on high-density memory-chip development for several years at IBM's Advanced Semiconductor Research and Development Centre in East Fishkill, NY.

According to plans unveiled by the four companies, the new alliance team will continue to develop and enhance existing 64 and 256 Mb chips and cooperate on next generation 1 Gb DRAMs.

The alliance is the outgrowth of separate long-term relationships among the companies. IBM and Siemens work together in 16 Mb DRAM manufacturing. Toshiba and Motorola have a manufacturing joint venture for 16 Mb DRAMs in Japan. IBM, Siemens and Toshiba are collaborating on a next-generation 64 Mb device, and IBM and Toshiba recently announced plans to build a wafer facility in Manassas, VA to manufacture the device. Toshiba and Siemens have been collaborating in various semiconductor areas, including 1Mb DRAMs, standard cells and gate arrays. IBM and Motorola are involved with Apple Computer Inc. in a joint technology development alliance for PowerPC microprocessors, and a joint venture between IBM Japan and Toshiba manufactures advanced flat-panel computer displays. Siemens and Motorola also just announced plans to build a joint facility to manufacture DRAMs. (Reprinted with permission from *Semiconductor International Magazine*, December 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

Incompatible DVD plans hit consumers in the pocket

The consumer is set to be the loser as DVD player manufacturers compromise on a technical solution for the surround-sound element of the video disc standard. The US and Europe are pursuing incompatible schemes, leaving the consumer to pay extra for a dual-standard player if he wants to be able to play all the discs on the market.

Discs with films for NTSC playback will have home cinema sound in Dolby's AC-3 format, whereas films for PAL playback will have home cinema sound in the MPEG Musicam format.

This means that users will have to pay for two decoders if their machines are to play any DVD film disc. The only redemption is that all DVD films will carry standard two-channel 16-bit "CD" sound as well.

The two formats, AC-3 and Musicam, have been championed by different players in the DVD group of companies.

DVD is the high data density CD-sized optical disc standard for video, audio and data. The DVD companies are split into two camps. One includes Philips and Sony and the other, the so-called "grand alliance", includes Toshiba, Panasonic, Time-Warner, Pioneer, JVC, Hitachi and Mitsubishi. (Source: *Electronics Weekly*, 17 January 1996)

Cleaning firm may make memory breakthrough

Philadelphia firm Sub-micron Systems, a semiconductor-cleaning-equipment maker, may have found a way to make denser ferroelectric memories. Instead of the standard liquid spin-on method, Sub-micro is reported to use chemical vapour deposition, resulting in more uniform material films. The company claims this could lead to denser, higher-reliability memory arrays with longer lifetimes for FRAMs. (Source: *Electronics Weekly*, 15 November 1995)

Japanese join for submicron

Japanese chip and chip equipment makers are banding together to evaluate submicron processes and 300 mm wafer equipment to avoid duplication of effort.

In a departure from similar previous efforts, findings will be swapped with overseas groups, in particular Sematech of the USA.

Sematech and Japanese industry are said to be looking to set up 300 mm research ventures. The Japanese version is likely to be supported by Japan's ten biggest chip companies who will spend between $40 and $50 million a year evaluating equipment. (Source: *Electronics Weekly*, 8 November 1995)

Trans-European Network

The Trans-European Network (TEN) concept was first articulated in Title XII of the Maastricht Treaty. Telecoms TENs sit alongside Europe-wide networks for transportation and energy, and are seen as forming the backbone of European Community initiatives to attack structural unemployment within the member States. New telecom operators and potential new entrants are trying to convince the European Commission that only a fully competitive network of networks will lead Europe into the next millenium. They are countered by PTOs who say that they are the national leaders due to their experience in switching calls and their already installed infrastructure. Yet both camps have focused on voice provision rather than broadband multimedia and information services.

According to the Commission, network capabilities are to be based on Euro-ISDN, with subsequent migration to broadband in order to offer high-speed file transfer and real-time video. Once the infrastructure and service provision comes into being, they will host applications ranging from teleworking to air traffic control to city information highways. All of the infrastructure funding will be driven by the private sector with the Commission only providing catalytic funding when beneficial to the Information Society. However, it is felt that the well-intentioned TENs concept faces a tough future if it is to become reality. Like so many aspects of European telecoms, it is above all dependent on an open and competitive framework being established. It is worrying then to find a monopolist movement made up of PTOs attempting to hijack the TENs movement for its own ends. (Source: *Communicate*, October 1995)

IT—a glimpse of the future

The costs associated with maintaining the lifestyle taken for granted in developed societies—those of materials, energy and transport—are so great that it is unreasonable to imagine they could be sustained for the entire world. An information-based society could realize substantial savings in each of those cost areas. Bringing such a society about, however, would entail considerable investment in the information infrastructure, and the money for this can only come at the expense of established industries and modes of operation.

Innovation in computing and telecommunications has to date had its most profound impact in the workplace. Within the next decade, however, it will enter the home in the form of new, integrated entertainment and information systems, which will revolutionize our concepts of work and play. Already, many organizations are becoming geographically dispersed as its members work from home or satellite offices. It has been estimated that the amount of office space empty at any given moment in North America is equivalent to the total space available (in use or not) in San Francisco.

New capabilities will emerge to make possible further developments in this direction. The most pressing and immediate need is for enhanced user interfaces to computer and communication systems to replace the present bewildering variety of cumbersome ones. We may expect to see new applications of artificial intelligence, virtual reality and telepresence which will make possible easier and more effective interaction with these systems.

The major challenge presented by such changes will be in humanizing them, making them acceptable to people everywhere. (Source: *Aslib Proceedings*, October 1995)

Putting digital in the picture

Broadcasters and digital television system providers are in great turmoil over testing digital video signals that will make digital TV picture quality quantifiable.

Parameters that apply to analogue signal interfaces such as luminance/chrominance, K factors, gain/delay, noise, overload margin, audio/video delay and coding delay do not necessarily apply to digital signals. Their test and measurement is typically achieved by slotting an insertion test signal (ITS) into the analogue signal waveform's vertical blanking interval (VBI). And as VBI is not used in digital signals, due to it not adding objectively to the picture quality, then such measurement appears impractical.

Another problem lies in the nature of the digital video signal, which is compressed. MPEG typically works by comparing adjacent picture frames and compressing out static information. If ITS was to be inserted into the signal, the compression process would effectively remove it.

So broadcasters resort to subjective testing, which remains the only reliable way to assess picture quality and, it appears, will remain so until proven correlations between test parameters and picture quality can be found.

As the digital era becomes increasingly established, broadcasters and academics are not giving up on finding the right methods of digital picture assessment. One such project that focuses on the matter is a European Race called Mosaic, which formulates study methodologies where digital impairments can be assessed and subsequently measured. (Extracted from *Electronics Weekly*, 8 November 1995)

Joint Ericsson/Linköping University A/D converter minds its Is and Qs

An example of the integration benefits promised by CMOS is the 120 MHz A/D converter performing in-phase (I) and quadrature (Q) demodulation developed by Ericsson Microwave Systems and Linköping University in Sweden.

The need to convert a complex envelope signal from RF to baseband, to form in-phase and quadrature components is a common requirement for radar and communication applications. Traditionally, cosine and sine heterodynes are used to separate I and Q components before being digitized using matched A/D converters.

Use of DSP techniques has profoundly affected this classical receiver structure resulting in several alternative configurations. These trade off various system parameters by altering the analogue/digital boundary placement.

Ericsson and Linköping University 120 M samples/s A/D converter digitizes I and Q values to an accuracy of 10-bits. The device has been designed for a radar application although it is appropriate to any carrier frequency system. The device has also been used to reconstruct to baseband an FM formulated modulated 450 MHz carrier mobile telephone signal.

Rather than use I and Q mixers followed by matched A/D converters, the design is founded on a single mixer, single A/D converter architecture that operates higher that the Nyquist rate. In particular, if the intermediate frequency (IF) signal of interest is located at a quarter of the sampling rate, the digital mixing is simplified to "multiplication" with values 1, 0 and -1. Since the I and Q samples do not exist at the same instance, a Hilbert filter is used to interpolate odd Q samples to form even ones.

The device designers have further adapted the architecture by using a dual filter approach that moves the phase of I by +45 degrees and Q by -45 degrees instead of the single Hilbert filter. According to Jan-Erik Eklund at Linköping University, using filter coefficient values having a small spread, the filtering can be implemented within the sampling circuitry of the device. However, two A/Ds are now required.

The conversion to baseband is done by decimation. Here a number of samples are weighed by the filter coefficients before being converted to a single digital one. Multiplication with the filter coefficient is done at the sampling stage where the voltage is converted to a current representation, the size of the sampling capacitor representing each coefficient.

Testing the A/D for an IF of 30 MHz and sampling at 120 MHz, the mirror signal, harmonics and inter modulation products are all below -64 dcBc achieving the desired 10-bit accuracy. The device consumes 270 mW and operates at 5 V.

According to Eklund, the architecture offers an alternative to existing I and Q detection approaches for applications such as radio and radar. "At the moment it exists as a test chip only but it has great development possibilities. Implemented in CMOS it can be easily integrated within a DSP." (Source: *Electronics Weekly*, 14 February 1996)

And there's Moore ...

Gordon Moore, founder of Fairchild Semiconductor and Intel, has given $15 million to the University of California at Berkeley for the University's "New Materials Initiative". The programme involves manipulating atoms to create new materials which are stronger, lighter and longer-lasting that any yet known. Goals are to produce synthetic material harder than diamonds and to produce new magnetic materials for high density information storage. Moore, chairman of Intel and grand old man of the semiconductor industry, invented the planar MOS process. Under his direction Intel invented the DRAM, SRAM, EPROM, EEPROM and microprocessor. He also devised "Moore's Law", the projec-

tion for the progress of the chip industry which predicted the increasing capabilities of chips for 30 years. Moore has 5.6 per cent of Intel's stock worth over $2 billion. (Source: *Electronics Weekly*, 24 January 1996)

Internet on a chip architecture

LSI Logic's recent announcement of its Internet on a Chip architecture is just the first in a number of electronic components and systems that are intended to produce cheap PCs designed for surfing the Internet.

The world's growing fixation with the Internet information highway ensures that enthusiasm for dedicated terminals is high. Wobbles in the PC demand curve may force suppliers into a search for the next killer application. What is less clear is whether the "dumb" Internet terminal is that application. Will consumers want what would essentially be scaled-down PCs with limited functions?

Sun Microsystems, Netscape Communications and Oracle are at the forefront of popularizing what they call a new computing paradigm in which an Internet World Wide Web browser such as Netscape Navigator is the user interface and programs are downloaded from remote servers as the user needs them rather than storing them on the user's hard drive. Such a platform relies on additional technologies such as Sun's Java computer language which could be used to create downloadable applications.

The compelling advantage of such a platform is that it is essentially hardware independent, it does not require the Intel/Microsoft technologies and can run on virtually any microprocessor. All it requires is a 32-bit operating system, which can be a small, kernel based operating system and 32-bit microprocessor which can be a cheap Risc-based chip. Without the need for large system memory and large hard drives, such systems might be sold for as little as $500.

LSI's Internet on a Chip architecture proposes using LSI's Mips Risc processor-based NetCore blocks which include digital signal processing cores, modem communications cores, and MPEG and audio decompression cores plus bus interface cores such as PCI local bus. LSI says it can combine its NetCore blocks in various combinations capable of 100Mips processing to provide custom chips for as little as $50 each for system builders developing such Internet PCs.

LSI is not the only chip manufacturer that hopes to capitalize on the Internet. VLSI Technology is working with Acorn Computers subsidiary Online Media to integrate the ARM7500 into a similar product to top that of LSI's Internet on a Chip offering.

On the software side, Silicon Graphics, Sun and Netscape said they will merge their technologies to provide platform independent software that would support Internet PCs. The companies will work on a set of application programming interfaces for Silicon Graphics' Virtual Reality Modelling Language, Sun's Java and Sun and Netscape's JavaScript languages.

Creating a platform independent computer architecture has been a dream of many electronics companies for many years and the Internet with its platform independent technologies now offers an opportunity to create such computers. Sun's Java, for example, defines a virtual hardware platform which means that applications written in Java will run on almost any platform implementing the Java Virtual Machine specifications.

While there is plenty of industry enthusiasm for Internet PCs, what is not yet clear is how much consumer interest there is. A poll by the US trade magazine PC Week found little demand from corporate customers for cheap $500 Internet PCs or terminals. And in the home PC market, consumers have been choosing powerful Pentium-based systems with large hard drives rather than cheaper systems.

It is conceivable that Internet "PCs" would become adjuncts to more powerful desktop PC systems rather than trying to replace them. They could even find use in schools and mobile applications.

In order to try and replace desktop PCs, they would require much faster network connections so that they could rival hard drive speeds, but more significantly a cultural shift among PC users. Few PC users are likely to be happy with storing their private files on a remote server somewhere.

Are we witnessing the birth of a new computer architecture, a platform independent architecture that will bring computers to a wider audience at much lower prices? If so, it may be just what the PC industry will need in 1996. (Extracted from *Electronics Weekly*, 13 December 1995)

Global positioning systems

From being an expensive navigational aid for ships and yachtsmen, global positioning systems (GPS) using the NAVSTAR constellation of satellites are becoming consumer items.

Because of the good old microelectronics learning curve—the electronics for GPS receivers can now be compressed into two or three chips. Whenever that happens—as with calculators, pocket TVs, digital watches, mobile phones, electronic cameras, organizers, etc.—the result is a consumer-priced item.

For instance the US-made Magellan range of handheld GPS receivers has, at the bottom of its range, the 2000 model costing $199 in the US.

GEC-Plessey has a $50 three chip chip-set (plus micro) called GPS2000 and is thinking about squeezing it into two chips; Rockwell is the only other company with an integrated chip-set on the market.

Philips, SGS-Thomson and Motorola will be making bids for the GPS market with two chip, sub-$50, chip-sets. Motorola has a chip-set now but it is not on the merchant market.

SGS' all-silicon chip-set will use the transputer-based ST20 core, and Philips—developed in collaboration with the US telecoms company Ashtech—will have a silicon bipolar front end and CMOS baseband processing chip for introduction in Q3. However the caution of the big firms could be because they see the mega-market as not GPS on its own but GPS incorporated with a wireless communications capability.

For instance, a GPS/GSM combination in a hire car will tell the hire company where it is; in a cellular phone or a laptop computer it will tell the owner where they are when they are stolen; people engaged in hazardous pursuits will be able to be instantly located in the event of accidents; boats can be instantly traced.

Unlike in the hand-held market, which has hit consumer pricing levels already, there is plenty of opportunity to make money in automotive GPS all the way down the learning curve—systems currently cost $2,000.

What everyone involved in GPS is now looking for is a big boost to the market's potential from a dramatic impending improvement to the accuracy of the fix obtainable under the NAVSTAR system.

At the moment NAVSTAR GPS is accurate to ±100 m, but this is an artificial constraint imposed for strategic reasons by the Pentagon which pays for and runs the NAVSTAR constellation and allows people to use it for free.

By removing the built-in inaccuracy, the NAVSTAR system's true accuracy down to ±30 metres could be realized. Some think that the Pentagon is now prepared to relinquish the built-in inaccuracy called "selective availability".

Even stuck with selective availability, it is possible to refine the current positional accuracy by conventional triangulation techniques using a ground station reference. Using this, GEC-Marconi are reporting accuracy to within two to three metres. If all else fails there is an alternative constellation—the Russian GLONASS satellite system—which gives accuracy to ±30 metres. This is available to commercial users but adds complexity to the chip-set front-end because each satellite uses a different frequency.

There are a lot of pointers suggesting that market take-off is imminent. It has been a long time gestating. It all began six years ago when the US Department of Defense was persuaded to make its developing GPS satellite-based timing and ranging system available to commercial users.

For a while systems were so expensive to build that the main commercial use was in surveying. However, with the launch in 1993 of the final satellite in a constellation of 24 needed to offer high accuracy longitude and latitude positioning, the GPS receiver manufacturers at last became able to develop widely usable commercial products.

Triangulation techniques using signals from a minimum of four NAVSTAR satellites are used to calculate the fix. At least four satellites should be visible above the horizon at any one time and typically between six and ten are visible.

However, there can be problems in cities with what is called the "urban canyon"—i.e. large buildings on either side of the road with a narrow strip of sky visible.

Having located its minimum four satellites, the GPS receiver then determines its distance from each satellite by calculating the time taken for a time signal to travel from the satellite to the receiver. Each satellite carries an atomic clock allowing it to transmit extremely accurate time signals. The time of travel is computed by comparing this to a synchronized time signal in the receiver.

All the GPS receiver then needs to know to find its own position is the exact position of the four satellites. The satellites are tracked by control stations which compute their precise individual flight paths and transmit this data up to the satellite which then broadcasts it to all receivers.

The receiver must also compute out the propagation delays due to atmospheric effects and clock errors. This is achieved by making separate calculations for four satellites, the intersection being the receiver's position.

The satellite data is transmitted on a 1575.42 MHz carrier. This is modulated with two signals: the first is a precise code (P-code) at 10.23 MHz and the second is the coarse acquisition (C/A) code at 10.23 MHz.

The high accuracy P-code is encrypted for military use and cannot be accessed by commercial receivers. The accuracy of the commercial system is limited further by a modulation on the C/A code signal, to provide the degradation for selective availability.

An important parameter for the GPS receiver is the time it takes to calculate its first position, starting from cold. The data rate from the satellites is only 50 bit/s, which means it can take 70 seconds to position each satellite, if five satellites are being tracked then first accurate positioning will take around six minutes. This can be reduced by retaining satellite position and almanac data in non-volatile memory in the receiver.

In situations where the last fix was recent, then it may only take 30 seconds to calculate position. If the position has moved a few hundred miles since the last fix then the calculation may take 4-5 minutes.

The RF receiver must be sensitive enough to track the 1.57 GHZ satellite signal down to -160 dBW. The GEC-Plessey chip-set uses a silicon bipolar downconverter device (GP2010) to convert the 1575.42 MHz, L1-band spread-spectrum signal to the binary data stream from which the timing information is extracted.

By using silicon, GEC-Plessey can make a front end for less than half the cost of using gallium arsenide, which is Rockwell's current practice.

With learning curve pricing now hitting the GPS market, the pressures will be on to get everything into silicon, preferably into CMOS, and into fewer chips. If the Pentagon does loosen up on selective availability then the market will be galvanized and the day of the single chip GPS receiver will not be long off. The shirt pocket GPS will not be far behind it. (Source: *Electronics Weekly*, 22 November 1995)

The myth of electronic publishing

The latest fad is usually technological and one of the latest for managements around the world is "Publishing via the Internet" as against "electronic publishing" which was a fad in the late 1970s when Viewdata first got going. Viewdata was going to replace paper publishing; it did not, nor will the Internet.

The trouble is that when it comes to putting material on the Internet, it all looks fantastic from the publisher's end. First there are the new storage technologies like CD- ROM or DVD which allow vast amounts of data of all types—text, audio and video—to be stored in a small physical space. Moreover, the capacity of the storage media doubles up every year—a rate of progress that is set to dramatically increase.

Second there is new processing technology—the speed of the Pentium microprocessor has doubled every year since it was introduced. The rate of progress in micros should also increase.

So the storage and processing of information is now incredibly cheap. A year's copies of a weekly magazine can be put on a DVD (including the photos)—and find a reference in it using a modern micro in a few milliseconds.

Moreover, you can easily mix and match the various data types—stripping in video along with text, audio along with graphics.

It is a beguiling idea for those who collect, process, and package multi-media wonder products for dissemination to the world but then they have to think about how they are going to deliver them. It is then that they come against that hoary old horror—bandwidth.

The awful thing is that the little telephone wires which come into our homes have only 4 KHz of bandwidth capable of transferring data at a maximum of 28,800 bits per second.

If you are going to send a copy of a newspaper to people's homes along a telephone wire—and the average text content of a daily newspaper would be around 800,000 bits—the time it would take to transfer it would be 27 seconds—and with compression less than 9 seconds—that is no problem. But if you are going to send the photographs—there is a problem. With photos the number of bits in a newspaper goes up to 16,000,000,000 bits and to send that at 28,800 bits per second takes 154 hours—that is a problem even when you use compression and reduce it by 70 times to two hours and 12 minutes.

Video is more impracticable. A frame in a video needs two million bits to store it and there are 30 frames for every

second of storage. So every second of screen time devours 60 million bits of storage. Ninety minutes of video needs 324,000,000,000 bits of storage which, transmitted at 28,800 bits per second would take about 150 days or— compressed 100 times as you can with video—a day and a half.

If you are downloading off the wireless networks— as in all those nice videos of the future when you work from your laptop while sitting on the beach—bandwidth constraints limit you to 9,600 bits per second.

You could still download the text of your newspaper in half a minute, but if you also want the photos it would take six and a half hours and a 90-minute video would take four and a half days.

Furthermore, anyone with a grain of sense prefers a highly portable paper-based newspaper than having to carry around 6 lb. of laptop computer to read their daily paper.

Of course you do not have to download. You can log on to a Web site and browse around it. But anyone who has browsed around the Internet knows what an unconscionable amount of time is takes to find what you want. And telephone charges are expensive.

Technologies are around which can solve the bandwidth problem—for instance ADSL (Asynchronous Digital Subscriber Line) will increase the transmission capability over the little wires into our homes (the local loop) to six megabits per second, but judging by the history of ISDN (Integrated Services Digital Network), it will be ages before it is implemented.

ISDN is a technology that has been around for ten years and it boosts the transmission capability of the local loop to 144,000 bits per second. (Source: *Electronics Weekly*, 24 January 1996)

C. NEW DEVELOPMENTS

Matsushita reveals PC plans for photo discs

Matsushita Electric Industrial has revealed plans to introduce photo disc (PD) equipment for PCs in early 1997 that will have DVD-ROM functionalities.

This product will be followed by a PD2 system that will incorporate DVD-ROM and DVD-RAM functions.

Both systems, the PD1 and PD2, will be based around a PD hardware combined with CD-ROM drives and high-speed read/write devices.

Many magnetic tape makers are finding the idea of re-writable compact discs financially attractive and are adapting to optical technology. TDK is one such company and plans to start printing and packaging rewritable CDs in Europe and the US in 1996, followed by their in-house manufacture in Japan and Luxembourg. TDK reckons demand for CDs will reach 17 million units world-wide during 1996.

With such an increased demand for CDs, Sony is to set up yet another plant for optical pickups to be used in CD/DVD players. It will employ more than 1,600 people in its second plant in China, which is expected to become operational in January 1996. Its output will be 2 million optical pickups a month.

Philips is working on highly integrated MPEG1-encoding ICs that will be used in DVD consumer recorders. Only a few companies offer expensive MPEG-1 cards. (Source: *Electronics Weekly*, 13 December 1995)

Philips lets radios be seen as well as heard

In an intriguing move Philips Semiconductors has developed a module and a set of components that let PCs receive and decode RDS (radio data system) broadcasts, displaying the information on the screen.

Dubbed the Smart-Radio module, Philips claims it provides the first high-quality radio reception for PCs, superseding previous solutions that relied on chips developed primarily for car receivers.

RDS broadcasts are widely used throughout Europe to transmit the station's identification, traffic bulletins, weather and other information alongside the normal FM signal. In the US the Electronics Industries Association (EIA) is supporting the RDS standard and has launched a campaign to install hardware encoders in the top 25 radio markets across the US. The EIA's plan is to equip several radio stations with the encoders, allowing RDS signals to reach 85 per cent of the US radio audience.

The heart of Philips' strategy is the OM5604 module, which is the FM radio tuner and preamplifier. The module is carefully shielded to isolate it from the noisy PC electrical environment and is prealigned.

It uses the TEA5757H tuner IC designed by the Philips team for this application. The tuner IC uses twin frequency locked loops to provide speedy scan tuning and tuning to up to 99 frequency presets.

The module is completed with a preamplifier providing 900 mV line audio outputs and an I^2C bus controller chip. The module is programmed and controlled via this bus.

PC and PC card makers can then augment this module with the SAA6579 RDS demodulator and the CCR921 RDS decoder chips.

Philips engineers have developed a prototype PC plug-in card based on the OM5604 module and have written a Windows software utility to control the radio from the screen.

The card and the software are for demonstration purposes and it is unlikely Philips will sell either on the PC user market. (Source: *Electronics Weekly*, 22 November 1995)

LAN speed record

Scientists at BT Laboratories claim to have broken the telecommunications world speed record by transmitting data at a rate of 100 Gbit/s down a length of single mode optical fibre. The data rate achieved is the equivalent of 50 full sets of the Encyclopaedia Britannica being transmitted in one second. The technique uses optical signal modulators, optical switches and narrow line laser transmitters to generate the optical signal on a single wavelength. According to BT, wavelength-division multiplexing, allowing a number of signals to be transmitted together on a single fibre, could theoretically provide at least a 10-fold increase in the 100 Gbit/s data throughput. (Source: *Electronics Weekly*, 29 November 1995)

NatSemi claims world speed record with VIP

National Semiconductor has introduced an op-amp that has a slew rate of 4,100 V/μs which it claims is the world's fastest voltage-feedback operational amplifier.

The LM7171 is indicative of the trend in which innovative amplifier front-ends and high performance processes allow voltage-feedback op-amps to encroach on current-feedback territory, tempting engineers who are ignorant of current-feedback techniques to design high- speed circuits.

The LM7171 has a 4,100 V/μs slew rate and a bandwidth of 220 MHz (Av=2) at a supply voltage of ±15 V. With a ±5 V supply the figures are 950 V/μs and 140 MHz.

The maximum output current of the amplifier is 100 mA and has been designed with stability in mind. This allows the op-amp to drive heavy, capacitive loads like video cables with claimed low distortion producing high-quality images. Supply current is typically 6.5 mA and offset voltages down to 200 μV are available.

The chip is produced using National's proprietary VIPIII bipolar process. This allows vertically integrated pnp transistors to be made with performance similar to nearby npn transistors. the third generation of the VIP process produces npn and pnp transistors with f_ts of 3 GHz and 2 GHz respectively. (Source: *Electronics Weekly*, 29 November 1995)

Novel superconductor

Pennsylvania State (College Park) researchers report a copper-free superconducting thin film having the same layered perovskite structure as high-temperature oxide superconductors. The material, a strontium-ruthenium oxide, is superconducting at around 1 K. Existing materials that superconduct at temperatures higher than the boiling point of nitrogen are perovskites containing copper oxide layers. While the ruthenium material is only superconducting at low temperatures, the researchers say it could lead to insight into the mechanism of high-temperature super-conductors. (Source: *Chemical Week*, 13 December 1995)

Formation of new large piezoelectric $La_3Ga_5SiO_{14}$ single crystal

Prof. T. Fukuda and his research team of the Institute for Materials Research, Tohoku University, jointly with Tokyo Denpa Co., Ltd., have succeeded in forming a large

piezoelectric $La_3Ga_5SiO_{14}$ single crystal (langasite). the crystal has a 2 inch diameter, which has paved the way to establish the technology for mass production of crystals of 3-4 inch diameter.

The new single crystal was formed in air by using a commercial frequency induction heating furnace with an output of 60 kW and a 50 mm platinum crucible. To form large single crystals of 2 inch diameter, an iridium crucible with a diameter of 100 mm was used under argon combining a small amount of oxygen.

The new crystal is transparent with an orange tint, an overall length of about 130 mm, a diameter of roughly 50 mm, and is synthesized by the typical CZ growth method. Professor Fukuda earlier synthesized langasite crystals with lengths of about 80 mm and diameters of 23 mm, but succeeded in synthesizing larger single crystals, this time by optimizing the growth conditions.

The piezoelectric crystal is vital for producing electronic components such as filters and oscillators for communications equipment. Piezoelectric crystals are used to produce the SAW filters for handy telephones and lithium tantalate crystals for television and VTR filters.

When used as a filter material, the piezoelectric crystal features an excellent characteristic of being highly resistant to temperature changes, but the waveband characteristic is rather narrow. Lithium tantalate features a broad frequency characteristic but is rather vulnerable to temperature changes.

Langasite is a piezoelectric crystal with characteristics lying in between these two types of crystals, and when used as a filter material, enables the bandwidth to be expanded to about three times that of ordinary crystals, while the temperature change of its frequency characteristic is much less than that of lithium tantalate.

Further details from: Institute for Materials Research, Tohoku University, 2-1-1, Katahira, Aoba-ku, Sendai City, Miyagi Pref. 980. Tel.: +81-22-215-2100; Fax: +81-22-215-2101; E-mail: atfukuda@lexus.imr. tohoku.,ac.jp (Source: *JETRO*, November 1995)

Record fuel-cell output

A research team at Siemens Corp. has exceeded its previous record in the development of high-temperature, solid-oxide fuel cells for power generation. By arranging a stack of 80 bipolar metal plates in a window configuration, the team (at Erlangen, Germany) achieved an output of 10.7 kW, while operating on hydrogen and oxygen at 950° C. That is six times better than the previous international record of 1.8 kW, achieved by Siemens in 1995. The stack also produces recoverable waste heat that can be used to generate additional electric power. When used on a large scale, plant efficiency levels are expected to reach 70 per cent. (Source: *Industry Week*, 22 January 1996)

Stray capacitance

IBM has patented an idea that in retrospect appears obvious: reducing stray capacitance in on-chip inductors by raising them off the substrate. Researchers at IBM's T.J. Watson Research Centre have made spiral inductors using the upper metallization layers of a multi-layer process. The lower one or two layers are not used, and are filled with the dielectric that supports the upper layers. The other way to raise Q is to use a semi-insulating substrate like GaAs. But these III-V materials are likely to remain more costly than silicon. The IBM inductors have a Q of around 10, compared with around four for inductors made directly on silicon substrates. Qs of around 30 are needed for narrow band filtering applications. (Source: *Electronics Weekly*, 8 November 1995)

The photon strikes back

A device from Northwestern University, Illinois, called a photonic wire laser is in reality a semiconductor microdevice developed to study spontaneous emission and lasing in nano-fabricated structures.

Physically it is a tiny semi-conductor optical waveguide made into a ring-shaped cavity 9 μm across. The waveguide is 0.4 μm wide and 0.2 μm high and is built with layers to form a series of quantum wells.

Lasing occurs first in the inner ring cavity. The lasing photons then tunnel across a 0.3 μm air gap into the outer U-shaped waveguide, which guides the light out.

The laser is made from InGaAsP material and emits light at the optical communication wavelength of 1.5 μm.

About 70 per cent of the light emitted by atoms in the ring is captured into the lasing beam. This is due to the use of low dimensional photonic and electronic structures. These structures, in this case photonic wire, change the way atoms emit due to the quantum effect of atom-photon interactions. A smaller version of the photonic wire laser with a 4.5 μm ring diameter also lases. It has a cavity volume of only 0.27 μm^3 and is made from 1 μm^3 of semiconductor material. (Source: *Electronics Weekly*, 8 November 1995)

Adaptive digital filter advance

A methodology for implementing parallel adaptive filter structures is being investigated by the Graz Institute of Electronics in Austria.

Adaptive digital filters have characteristics which vary with time. They are suited to environments where signal characteristics are not constant.

Typically the output of an adaptive filter is compared to a reference signal. The difference measure is used to then compute updated filter coefficients so that the filter output more closely matches the reference.

The aim of the work is to identify how the performance of quite complex filter structures can be boosted. The work makes use of a development system employing four Texas Instruments TMS-320C40 DSPs.

Three adaptive filter structures have been investigated: the popular least mean square (LMS), recursive least squares (RLS) and least squares lattice (LSL).

To identify where parallelism can be employed for each filter type, data-dependency analysis has been used. This is applied in a top-down fashion.

Not surprisingly mapping a data-dependency graph onto multiple C40s requires data partitioning in an efficient way with communications between processors kept to a minimum.

The performance improvement has been correlated with filter length, assuming various processor-to-communications ratios.

For the LMS and RLS algorithms computation efficiency can be further improved by enlarging the filter size and by reducing the communications overhead. The LSL in contrast achieves near perfect scaling efficiency. (Source: *Electronics Weekly*, 1 November 1995)

High-Q on-chip inductor ahead

IBM claims to have developed a high-Q on-chip inductor for use with silicon substrates that will ease the design of RF circuits for mobile communications ICs.

Conventional on-chip inductors are made by laying a spiral of metallization on the surface of the chip.

Semi-insulating substrates, like GaAs, do not suffer from capacitive loading. This allows the manufacture of higher Q components, but at a far higher cost.

IBM's solution to reduce the Q-sapping capacitance is to make an inductor that is mechanically supported above the substrate. It uses a conventional BiCMOS process with four metallization layers.

The inductor is fabricated as matching spirals, one above the other, on layers three and four (furthest from the substrate). The two layers are connected in parallel with multiple metal vias to reduce resistance, further boosting Q.

An under-bridge is constructed on layer two to bring out a connection to the spiral centre. Layer one is unused, maximizing the separation between the substrate and inductor.

Different structures with, for instance, three spiral layers and a bridge on layer one, have also been tried.

Results on an inductor 200 μm across show that a 2 nH inductor with a Q of 9.3 that will work at 2.4 GHz can be constructed. (Source: *Electronics Weekly*, 1 November 1995)

World's first 26- and 40-inch colour plasma display panels for TV

Matsushita Electric Industrial Co., Ltd. has developed the world's first 26- and 40-inch colour plasma display panels (PDPs) designed for use in televisions, under the direction of NHK (Japan Broadcasting Corp.) and in collaboration with DuPont Company of the USA and Texas Instruments (TI) Japan Ltd. Production technology was developed within the Matsushita Group.

The 26-inch PDP samples for use in conventional televisions will be available in October 1996. Forty-inch samples, designed for use in HDTV, are scheduled to reach the market in June 1996.

The panels were developed through a joint international programme in which NHK proposed the basic technology under the auspices of the PDP Consortium, an organization that is centred around the Science and Technical Research Laboratories of NHK.

Matsushita will begin development of television monitors and wall-hanging TVs that incorporate 26-inch and 40-inch TV PDPs. In addition, Matsushita will begin developing these units into consumer products, with 1996 for availability of 26-inch models and 1997 for the 40-inch models.

Further details from: Matsushita Electric Industrial Co., Ltd., Tokyo Publicity Centre, 1-1-2, Shiba-Koen, Minato-ku, Tokyo 105. Tel.: +81-3-3578-1237; Fax: +81-3-3437-2776. (Source: *JETRO*, November 1995)

Superhigh-intensity X-ray beams generated to investigate microstructures of substances

The National Research Institute for Metals of the Science and Technology Agency and Rigaku Denki Co., Ltd., a manufacturer of analysis equipment, have jointly developed a system to generate the intense X-ray beams required for investigating the microstructures of substances.

This system was developed to establish the measurement and analysis technology XAFS for analysing the structures of substances on the atomic level, and enables data to be obtained in as little as 40 minutes. X-ray beams that include a wide wavelength domain are ideal for analysing the structures of diverse specimens, from biological organisms to semiconductors, but has until now been unavailable. The new system is expected to prove highly beneficial for the development of new electronics elements and catalysts and also for the analysis of biological reactions.

The new system consists of an electron gun using a filament made of lanthanum hexaborate and an anode of 10-cm diameter made of molybdenum. The hot electrons from the filament are bombarded against the anode at high speed to generate X-rays of various wavelengths continuously. A large tube current of maximum 1,100 mA can be passed, by which X-ray beams about 2.7 times more intense than those produced by conventional systems can be generated.

X-ray tubes generally use electron gun filaments made of tungsten, but tungsten adheres to the surface of the anode, and the resultant X-ray beams are known to obstruct accurate measurements. In addition, since the new system is operated at a low tube voltage of 10-30 kV, the noise generated by the higher-order X-ray beams is extremely low. Analysis of the same specimen with the new system and a conventional type of SOR system confirmed that the new system achieves data quality and measurement time comparable to those of the SOR system.

The XAFS technology is a sophisticated technology in which X-ray beams are irradiated on the target substance while changing the wavelengths. The beam absorption is measured to analyse the structures and the states surrounding specific types of atoms. XAFS is usable for analysing virtually all kinds of solid, liquid and gaseous substances, and is also applicable to the analysis of amorphous substances (non-crystalline structures), as well as superparticles.

Further details from: National Research Institute for Metals, Science and Technology Agency, 1-2-1, Sengen, Tsukuba City, Ibaraki Pref. 305. Tel.: +81-298-53-1199; Fax: +81-298-53-1005. (Source: *JETRO*, November 1995)

System for automatic visual inspection of LCD filters

Technos Japan Corp., a manufacturer of sensors, has ventured into the liquid crystal display (LCD) inspection systems business by developing a system for the visual inspection of filters before assembly into panels, and has started marketing the new inspection system to LCD manufacturers.

This new system (LC9000) resolves a filter into as many as 5,100 million points for detecting colour disparities and microscopic foreign substances. The company plans to market the new visual inspection system as a product for replacing the method of visual inspection with the human eye.

LC9000 is a system that automates the work of visual inspection of LCD filters, which used to be performed by human visual inspection. The angle for inspecting the filter is adjusted with an actuator to detect infinitesimal defects at a high resolution: a filter can be inspected in about 2 seconds. The filter is divided into sections consisting of 20 million points and each point reads out accurately with a brightness consisting of 256 graduations. Inspection is performed over the entire filter surface, with superfine defects detected to the order of a few micrometres and colour disparities detected at a very high accuracy that is about 10 times that of a colorimeter.

The system also incorporates a navigation function that enables the entire production process to be assessed on a single display screen, and can read out the specific strip number from which a defect was discovered out of a maximum of 8,000 strips.

Further details from: Technos Japan Corporation, 5-26-12, Minami-Oi, Shinagawa-ku, Tokyo 140. Tel.: +81-3-3767-9111; Fax: +81-3-3764-2575. (Source: *JETRO*, November 1995)

Touchless switch unit with colour liquid crystal graphic buttons for equipment operation

Tietech Co., Ltd., a manufacturer of computer and electronics products, has developed a Touchless Switch Unit.

This switch unit uses a 5-inch colour liquid crystal panel to display an array of colour graphic operation buttons and employs a special type of lens mounted over the liquid crystal panel to create the illusion that these graphic operation buttons are floating in the air. Two lines of detection sensors are arranged above the lens in both vertical and horizontal directions, respectively. When a user pushes one of the graphic buttons floating in the air without touching the switch unit (Touchless Switch Unit), the sensors detect the location and make the corresponding switch work. Since the display of a graphic button on the liquid crystal panel can be changed, one button can be used for various different functions and purposes. Such a switch unit is an ideal operation switch for medical equipment and foods manufacturing equipment, and is also usable for amusement equipment, such as game machines and so on.

Further details from: Tietech Co., Ltd., Head Office, 2-13-1, Chikama-dori, Minami-ku, Nagoya City, Aichi Pref. 457. Tel.: +81-52-824-7373; Fax: +81-52-811-473795-11-002-03*. (Source: *JETRO*, November 1995)

Three-dimensional concentrator for photovoltaic modules

Researchers at Tokyo University of Agriculture and Technology have developed a three-dimensional lens that concentrates light on a solar cell as part of the MITI's New Sunshine Project. Concentration of sunlight allows a solar cell to produce more electric power per unit area. The experimental lens achieves a doubling of the photovoltaic output of a solar cell. This may be a promising approach to reduce the cost of producing electric power with solar cell modules. The research team is planning to make a prototype 10 W, A4-size concentrating solar cell module.

The solar cell module increases power output when the cell receives more light. Naturally, a larger cell captures a greater quantity of light, but this does not achieve cost reduction. The present solution is to collect more light by a lens instead of enlarging the cell. By concentrating the light, the same size of solar cell can produce more power, which will lead to a reduction in the cost of power generation.

The research team made the solar cell lens of acrylic resin. The 36 x 45 x 27 mm lens had an optical concentration ratio of 2:1. The module is composed of the concentrator lens and a solar cell attached to the planar bottom of the lens.

The model lens was designed empirically and made by a machining process, so that the cost was considerable. However, when the lens is mass-produced by a die process, the price will be sufficiently low for use. The design of the lens can be refined, and theory predicts that the optical concentration ratio could be nearly 3.0.

Further details from Tokyo University of Agriculture and Technology, Faculty of Technology, 2-24-16, Nakamachi, Koganei City, Tokyo 184. Tel.: +81-423-81-4221; Fax: +81-423-85-9055. (Source: *JETRO*, November 1995)

New techniques used to fabricate gigabit memory cells

Researchers from Mitsubishi have fabricated experimental memory cell arrays with a unit cell size of 0.29 μm^2 (0.38 μm x 0.76 μm) using three advanced technologies: X-ray lithography, MOCVD-grown BST and ECR etching.

Mitsubishi's synchrotron ring facility and a Canon XFPA Stepper were used to generate X-rays with a wavelength of 0.69 nm. The minimum feature size patterned was 0.14 μm, with an overlay error of less than 0.08 μm. The X-ray masks were made of stress-free W-Ti absorbers on a silicon carbide substrate.

Films of (Ba, Sr)TiO_3 (BST), a high dielectric constant material, were grown by a two-step MOCVD method on Ru-metal electrodes, providing a step coverage of ~75 per cent. The storage electrodes were fabricated by depositing a thick Ru film by an rf sputtering method and patterned with magnetically enhanced reactive ion etching. The etch selectivity of Ru over a SiO_2 mask was more than 20. The researchers said any additional barrier metal would be degraded by the BST film deposition, and is unnecessary due to low interdiffusion between Ru and Si.

The 0.14 μm-wide WSi_2 (50 m)/polysilicon (50 nm) transfer gate on the 8 nm thick gate oxide was etched by ECR discharged plasmas. The etch selectivity of polysilicon over the gate oxide was more than 50. Storage node contacts holes of ~0.1 μm gave an aspect ration of about 5 with a contact resistance of 3 kΩ at the Ru/polysilicon interface. The researchers also developed a size-independent etching technique by means of beam plasmas generated by a gas puff plasma source. (Reprinted with permission from *Semiconductor International Magazine*, 19 November 1995. Copyright 1995 by Cahners publishing Co., Des Plaines, IL, USA)

Wet preclean key to selective tungsten CVD

A precleaning method that uses hydroxylamine sulphate solutions to remove native metal oxide prior to selective tungsten deposition has been developed by Taiwanese researchers from the National Chiao Tung University and the Taiwan Semiconductor Manufacturing Co. (TSMC), both located in Hsinchu, Taiwan. Selective tungsten CVD was the focus of intense research a number of years ago for contact and via hole fill, but problems with selectivity loss caused the industry to adopt a more complex approach of blanket tungsten deposition, followed by an etchback. The new cleaning technique is said to effectively address the selectivity loss problem.

There are two possible reasons for selectivity loss in selective WCVD, noted the Taiwanese researchers. One is the polymers that form on the sidewall of the via hole during the via etching process, which after resist stripping exist as metallic oxides. These oxides act as nucleation sites for tungsten on the sidewall, leading to a phenomenon known as "creep-up". For good selectivity, it is preferable to have the tungsten nucleation limited to the bottom of the via hole.

Another possible cause of creep-up is the *in situ* plasma etching step used to remove metal oxide from the aluminium surface prior to tungsten deposition, the researchers noted. During the plasma etching, the sputtered aluminium oxide and aluminium can be redeposited on the sidewall of the via and on the surface of the dielectric layer, and again as nucleation sites.

In experimental studies, the researchers compared two precleaning techniques: a wet clean in a hydroxylamine sulphate solution [$(NH_2OH)_2 \cdot H_2SO_4$], and an *in situ* BCl_3 plasma clean. They found that the hydroxylamine sulphate solution was capable of removing the insoluble metal oxide around the bottom of the via, leading to improved selectivity, while the BCl_3 step resulted in creep-up and selectivity loss. (Reprinted with permission from *Semiconductor International Magazine*, November 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

Polymer blends enable full visible range of colour LEDs

Researchers at Princeton University (Princeton, NJ) have developed a series of polymer blends that could span the full visible colour range of polymer light-emitting diodes (LEDs), which may eventually find use in thin film electroluminescent devices.

In electroluminescent displays, a typical polymer LED is formed by spin-coating the polymer on an indium tin oxide (ITO)-coated glass substrate, followed by the evaporation of a top metal contact. A common problem is that a good luminescent polymer does not necessarily have good electron and hole transport abilities. Various approaches have been adopted to overcome this problem, including the use of reactive low work function metal electrodes and the incorporation of carrier transport layers to form a multilayer device structure.

The Princeton work made use of polymer blends composed of the luminescent conjugated polymer Poly(3-*n*-butyl-*p*-pyridyl vinylene) (Bu-PPyV), a hole-transporting polymer poly(9-vinylcarbazole) (PVK), and an electron-transporting material 2-(4-biphenyl)-5-(4-tert-butyl-phenyl)-1,3,4-oxadiazole (PBD). All materials are mixed as a blend in a solvent and then deposited in a single step. The researchers say the blends enable them to optimize the optical and electrical properties of the polymers in ways not possible with pure materials, resulting in improved efficiency and reduced operation voltage. The blends were used to obtain colours from purple to green to red.

The researchers—all with the Advanced Technology Centre for Photonic and Optoelectronic Materials at Princeton—said the main advantage of the blends is that they reduce the interchain interaction of pure Bu-PPyV, which leads to the formation of excimers between BuP-PyV chromophores. The excimer emission is red and has low radiative efficiency. Diluting Bu-PPyV with higher energy-gap PVK and PBD in the thin film eliminates the formation of Bu-PPyV excimers and thus recovers the monomer emission (green) and its much higher radiative efficiency. (Reprinted with permission from *Semiconductor International Magazine*, November 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

Consortium to develop 16-in. wafers

A consortium of nine silicon wafer manufacturers from Europe, Japan and the USA has been formed to develop 16-in. wafer production. The technology will be needed for mass production of 1 Gbit DRAMs expected to start about 2003. The five-year $94 million project will commence in March 1996 involving Wacker Siltronic (Germany), Shin-Etsu (Japan) and MEMC Electronics Materials (US). (Extracted with permission from *Semiconductor International Magazine*, November 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

IIR filter probe

Strathclyde University's signal processing division is investigating the use of infinite impulse response (IIR) digital filters for applications such as ADPCM compression, teleconferencing and active noise control.

Dr. Bob Stewart at Strathclyde said adaptive IIR filter research has been sporadic during the last 20 years with finite impulse response (FIR) filter structures being used predominantly for adaptive applications.

Adaptive filters are used where the signal characteristics vary with time.

The benefit of using IIR filters is that they promise systems with better modelling performance yet use fewer filter weights.

Strathclyde has already developed a 20/20 pole/zero adaptive filter for highly reverberant teleconferencing environments that matches the performance of a 400-tap FIR structure. (Source: *Electronics Weekly*, 15 November 1995)

APT develops holographic verification system

Advanced Precision Technology has developed a fingerprint biometric verification system based on holographic technology, which it believes will aid Mondex in raising the security of its electronic purse. The system, named APrinT, is designed to automatically capture fingerprint images, and store them as holograms, unlike most currently available systems which work with coded information of the gathered parameters. APrinT consists of a reader where a fingerprint image is captured by a CCD camera. This image is processed by a laser-based optical system, which transforms it into a hologram. The hologram is compared to the one stored on the smart card with the whole process taking less than five seconds. The APrinT fingerprint capture device is expected to be commercially available by April 1996 for less than $600. (Source: *Electronics Weekly*, 13 January 1996)

New diode developed

Scientists in Japan have fabricated a diode only 2.5 nm across using a synthetic protein molecule. The molecule has been made by Mitsubishi Electric and is a combination of the natural protein cytochrome C552 and the vitamin flavin. Under an electric field an iron atom in the cytochrome can be persuaded to release an electron to the flavin. Conversely, a similar electric field in the other direction cannot push an electron to the cytochrome. Forward voltage drop is reported to be 900 mV at 70 pA and 10,000 of these devices would fit onto a diode made with leading edge 0.25 μm semiconductor technology. Like most of the current wave of molecular electronics, it is still in development and requires a great deal of specialist equipment to make it work. To operate the molecule, a scanning tunnelling microscope is used to select one of a number of the molecules that has been laid down on a metal substrate. The substrate is then the cathode and the microscope the anode. (Source: *Electronics Weekly*, 21 January 1996)

Base widths scaled down to sub-100 nm

Collaborative German work between Siemens AG (Munich), the Fraunhofer Institute for Solid State Technology (Munich) and the Hochschule der Bundeswehr (Neubiberg) has demonstrated direct-write electron beam lithography for the downscaling of a novel lateral bipolar structure. Base widths have been successfully scaled down into the sub-100 nm region.

The substrate material was SIMOX (Silicon Isolation by Implanted Oxygen) wafers with a top layer thickness of 120 nm. The workers used a reactive ion mesa etch technique to provide device isolation and grew a screening oxide to passivate the silicon surfaces. They employed a blanket double boron implantation to create the p-doped base. Emitter/collector n+-doped contact regions and p+based contact regions were defined by resist masks and subsequent implantations. A 100 nm thick TEOS layer was deposited and tungsten metallization formed with a Ti/TiN barrier layer.

The group employed direct-write electron beam lithography with a PMMA resist. The resist masked the p-doped

base against a phosphorus implantation. Single lines of under 100 nm were realized with the 1:10 aspect ratio required for adequate ion stopping power of the resist layer. Rapid thermal annealing was used to repair implantation damage.

The group stated that their work is a novel approach to downscale a lateral bipolar transistor on SOI by direct-write sub-100 nm electron beam lithography. This work was described at the Micro- and Nano-Engineering Conference at Aix-en-Provence, France. (Reprinted with permission from *Semiconductor International Magazine*, January 1996. Copyright 1996 by Cahners Publishing Co., Des Plaines, IL, USA)

Matsushita explores use of nickel-zinc ferrite thin films

Matsushita Electrical Industrial Co. Ltd. has applied a newly-developed laser ablation technology in a low temperature-forming technology for permeable nickel-zinc (NiZn) ferrite thin films.

NiZn ferrite has an electrical resistance about 10 times greater than permeable alloy-based materials. Because it has no overcurrent losses and offers high magnetic permeability, it is being considered as a promising material for use in microwave band devices. Conventional fabrication techniques like plating and sputtering, however, are unable to provide sufficient permeability in thin films.

The process applies laser ablation technology. The laser beam is split into two, with one beam directed at the target and the other at the substrate. Coupled with control of the reaction atmosphere, this allows the formation of a thin film with a weak (1.4 Oersted) coercive force, or less than 1/10 that of normal thin films. Because laser ablation allows thin film formation at relatively low temperatures (400°C or less), it means an increase in the range of substrates supported and facilitates integration with other functional components. The thin films developed through this new technology can be utilized in inductors, transformers and magnetic heads to provide small, more efficient communication components such as high-frequency devices and thin film magnetic heads. (Reprinted with permission from *Semiconductor International Magazine*, January 1996. Copyright 1996 by Cahners Publishing Co., Des Plaines, IL, USA)

Observing atoms in motion

A technique to watch individual atoms in motion is now in use at Sandia National Laboratories (Albuquerque, NM). The technique can work at elevated temperatures and can potentially be used to watch corrosion and crystal growth—the leave-taking or adding of an atom—as it occurs. Understanding an atom's travels at different temperatures, as well as its ultimate incorporation into surfaces, will be crucial in making smaller, faster, smarter electronic structures in the future, in which the omission or misalignment of even a few atoms will wreck a circuit and ruin a chip.

For several years scientists have been able to observe atoms at rest on a crystalline lattice. By programming the needle-like sensor of a scanning tunnelling microscope (STM) to ride the atom's high point, no matter where it moves, the atom can now be observed in motion. Lateral electronic feedback from a surface's atomic topography is used to supplement the vertical feedback ordinarily provided by an STM. The additional information tells the perched sensor if it is sliding down the sloping sides of a moving atom and provides directional guidance as to which way the sensor should move to regain the high ground. The technique is sensitive enough to see a pair of bonded atoms change their configuration at a single lattice point and to measure how much energy it takes to pull an atom off or stick it onto the surface. The scanner achieves its speed—about a thousand times faster than the usual STM imaging time interval—by declining to scan the entire image field. Instead, it sticks to a selected atom. In a short video sequence, a moving dot of red light demonstrates the path taken by an atom as it hops along over a background STM image. Should an already embedded atom be displaced by the moving atom, the sensor switches "horses" and follows the evicted atom. (Reprinted with permission from *Semiconductor International Magazine*, January 1996. Copyright 1996 by Cahners Publishing Co., Des Plaines, IL, USA)

Atomic "light" microlithography thought possible

A new form of microlithography that uses neutral atoms instead of light to write patterns on silicon has been demonstrated at NIST by scientists from Harvard University and the Commerce Department agency. The new method offers the future promise of manufacturing ICs about 10 times smaller than is currently possible with light-based lithography methods.

Briefly described, this method involves directing a beam of metastable argon atoms through a copper grid or screen with holes about 10 μm across. The atoms were used to write patterns on a gold surface covered with a resist. This resist is a self-assembled monolayer made of organic molecules known as alkanethiolates. Wherever the metastable atoms hit this experimental resist, they release their energy and break hydrocarbon bonds. After development of the exposed resist, the resulting gold line is a few micrometers wide, which then can be chemically transferred into the silicon. (Reprinted with permission from *Semiconductor International Magazine*, January 1996. Copyright 1996 by Cahners Publishing Co., Des Plaines, IL, USA)

Micromachine advances

For a decade or longer, scientists have been fascinated by the potential of micromachines—devices so small that some of the components are invisible to the naked eye. Although potential applications have only begun to be conceived, the range of possibilities includes:

- Tiny micromedical pumps implanted in the human body to drive internal drug-delivery systems.
- Low-cost, high-performance gyroscopes for use in automobile or aircraft navigation systems.
- Miniature devices capable of manipulating individual cells in microsurgical procedures or DNA research—or, perhaps, removing micron-size particles from the surface of a computer chip.

Applying fabrication methods similar to those used in the production of integrated circuits, various research teams have pursued the development of micromachines and "micro-engines" to power the tiny devices. Until recently, most of the work has been limited to the development of single-level structures. However, a team at Sandia National Laboratories, Albuquerque, has found a way to produce more complex devices—including interconnected motors and gears—using micro-electronic fabrication methods.

The Sandia micromotor and external gears are etched on the same silicon-wafer substrate, using a repetitive photolithography process, with multiple layers of silicon dioxide sandwiched between layers of polysilicon.

The research, undertaken as part of a defence programme initiative to improve locking mechanisms on nuclear weapons, has considerable commercial potential.

A videotape produced by Sandia offers a greatly magnified view of the micromachine in operation: A motor

consisting of two tiny silicon combs with a shuttle between them generates 0.5 microwatts of power. Energized by on-off electric voltages, the stationary combs take turns pulling the shuttle, using electrostatic attraction. An attached shaft turns a minuscule drive gear—which is 30 microns across, *less than the diameter of a human hair*—one quarter of a rotation. A second comb-drive engine, at right angles to the first, causes the next quarter turn. By alternating forces, the two engines convert reciprocating motion into rotary motion.

The small gear has teeth that mesh with those of a second gear that is 30 times larger, causing it to turn. In one application, the larger gear—which has two holes— serves as an optical shutter because a beam of light can pass through the openings in some positions but not in others. Development of the optical shutter is expected to have military application as well as significant potential for telecommunications switching devices.

A major challenge for the team was to devise a way to fabricate components capable of interacting in a three-dimensional framework.

The first level contains the engine, the second the gears, and the third the linkages connecting the engine to the gears. Moreover, the Sandia devices also accommodate a fourth level for electrical interconnections.

Alternative micromachine fabrication methods require steps such as plating and assembly, whereas the Sandia approach accomplishes the entire process using photolithography and silicon etching, much the way micro-electronic circuits are manufactured. The significance is that the devices can be made relatively inexpensively with large-volume batch-production methods—perhaps in facilities that once produced microprocessor chips such as Intel's 286 or 386.

In the commercial arena, one potential application is in optical switches for telecommunications systems based on fibre optics. Micromachines able to reposition tiny mirrors could function as optical switching devices.

Longer-term, the technology might be used to fabricate minuscule gyroscopes for automobile navigation systems. Coupled with tiny accelerometers—which have already been made with micromachining methods—the gyros would help track the position of a car and relay the information to a dashboard display. (Accelerometers measure linear distance, while the gyros detect a change in direction—such as turning a corner.)

Perhaps the real importance of the work of the Sandia team is that it may lead to new discoveries in the future. (Extracted from *Industry Week*, 18 December 1996)

Brain computations

The Institute of Neuro-informatics, recently established in Zurich, has set itself the task of understanding the computations of the brain.

The Institute is developing its brain model using a hybrid architecture based on digital and analog circuits. According to Kevan Martin, one of the Institute founders, the process of computation is fundamentally limited by noise, requiring the restoration of signals during the execution of complex computations.

Digital computers overcome the problem by restoring the binary values at each stage of the computation. The digital approach also requires a sufficient number of bits to be used to effect the necessary precision.

The brain, in contrast, uses a completely different, yet highly effective, strategy to tackle system noise.

The brain seems to be able to restore the analog signals based on the collective action of the neuron building blocks, organized into populations. One goal of the Institute's work is to use its physical model to shed more light on this collective behaviour.

The hybrid system under development is being used to investigate the visual cortex—the part of the brain that processes images from the eyes. It will be applied to problems including stereo vision and image understanding. By adding a motor system, the eventual aim is for the brain model to move around, learning its environment.

The system comprises a silicon retina chip, the analog output pulses of which are routed to analog VLSI neural network devices using a digital processor.

The silicon retina device already exists from earlier work performed at the California Institute of Technology. The device converts the incoming light image into neural signals much in the way of a biological retina. It encodes small changes in image intensity around an average value while handling ambient light levels covering a vast 10 orders of magnitude.

The system uses a single high bandwidth channel to communicate the analog pulses to the silicon neurons instead of attempting to emulate the millions of links used in the brain.

At present work is concentrating on the design of the neuron devices. The plan is to create a system comprising 10,000 such neurons connected to the retina device.

This will enable synthesis rather than just analysis work to be performed. (Source: *Electronics Weekly*, 13 December 1995)

Chemistry cracks open memory limits

Innovative but relatively minor changes in silicon-processing techniques could open up a threefold reduction in the area required for capacitive components in micro-electronic devices. Electronics experts are welcoming the advance as allowing further miniaturization of memory devices which would otherwise soon hit capacitance limits using conventional methods.

The basis of the breakthrough announced by researchers at AT&T Bell Laboratories is an increase in the dielectric constant of Ta_2O_5, tantalum oxide, by addition of 8 per cent TiO_2 titanium oxide.

Ta_2O_5 is known to form high-quality thin films, though its dielectric constant is low at around 35. Addition of TiO_2 boosts that figure to 126.

Ta_2O_5 and TiO_2 are already well used and understood in electronics, unlike many of the more exotic compounds that have been suggested in the past to increase the dielectric constant. This allows the area of capacitors to be reduced.

The exact reason why the TiO_2 boosts the dielectric constant of Ta_2O_5 is not yet wholly clear. So far TiO_2 seems to be unique in its effect.

However, the researchers say that at around the 8 per cent TiO_2 level, the new material is likely to be processable with very similar conditions to those currently employed to make pure Ta_2O_5 films.

As well as the area reduction, the workers say that the material could eliminate the need for complex three-dimensional capacitor geometries often resorted to, to yield acceptable capacitance in small-area components. (Source: *Electronics World*, January 1996)

Plastic lasers break through performance boundaries

Sealing laser modules in plastic can provide several operational advantages. But such modules have rarely demonstrated good operating characteristics and so far

reliability has been uncertain. However, three researchers from NTT Optoelectronics Laboratories in Japan are claiming to have built a device that could make plastic moulding practicable, heralding the next stage in laser module fabrication technology for optical fibre transmission.

The lasers are Fabry-Pérot type 1.3 μm-band bulk or strained MQW BH devices. They have no facet coatings and are mounted on silicon heat sinks with a fibre guide. The heat sinks are then bonded on a TO18 stem usually used for compact disc lasers.

In the fabrication process, the laser is manually mounted so that the light-emitting region can be set at the centre of the fibre guide. In this way, the Japanese team reports optical coupling can be obtained without alignment by inserting the fibre along the guide. Distance between the laser facet and the fibre end (optical input port) is a few tens of micrometres.

The entire laser-mounted stem and fibre can then be covered with epoxy resin and cured. Refractive index of the resin is set at around the value of the fibre core.

Results show that good modulation characteristics can be produced, and the 3 dB bandwidth under sinusoidal wave modulation is more than 3 GHz at a current of 30 mA.

Following tests, life is estimated at over 105 h—even at 70°C and a constant output power of 5 mW.

The researchers say that the work proves the feasibility of plastic pigtail lasers and demonstrates a practical low-cost method for optical transmitter production. (Source: *Electronics World*, January 1996)

New technology combines lithography, doping and annealing

Ultratech Stepper (San Jose, CA) has teamed with government and industry partners to develop a technology that could produce ultrashallow transistor junctions for use in sub-0.25 μm device technology. The proposed method could reduce the number of process steps currently used, providing IC makers a lower manufacturing cost.

The method is dubbed P-GILD or projection gas immersion laser doping. P-GILD merges photolithography, doping and annealing technology into a single wafer-processing tool that could prove viable in future IC generations.

Initial evaluation of P-GILD was funded by the US Governments's Advanced Research Project Agency (ARPA), SEMATECH and Ultratech Stepper; participants also included Lawrence Livermore National Laboratory and "two dominant US-based chipmakers", according to Ultratech Stepper officials.

The next phase of research will be a joint development effort between ARPA and Ultratech Stepper. This work will investigate the commercialization of P-GILD and manufacture a beta system. A subsequent third phase will embark on creating a production-ready system. (Extracted with permission from *Semiconductor International Magazine*, January 1996. Copyright 1996 by Cahners Publishing Co., Des Plaines, IL, USA)

System measures total organic carbon

According to Anatel Corp. (Boulder, CO), total organic carbon (TOC) has been identified as one of the critical contaminants in wafer cleaning. Currently, facilities require <10 ppb TOC. TOC indicates only the organic carbon content and does not measure the contribution of other atomic species to the total organic mass. For example, if a methanol (mw 32) solution was measured, 100 ppb as C of TOC would be equivalent to 266.7 ppb of actual methanol (methanol contains a single carbon; the mass ratio of methanol to carbon is 32:12).

TOC increases can occur without noticeable changes in the resistivity level. The rinse-down characteristics of an ion exchange resin clearly show that the resistivity values are acceptable long before TOC.

Anatel's A-1000 TOC monitor measures TOC over a temperature range of 0-100°C, eliminating the need for heat exchangers. Its operating the range for measuring resistivity is 0.01 to 18.20 Mohm-cm. Its operating range is 0.05 ppb to 9,999 ppb for carbon, with a repeatability of better than 0.05 ppb at <5 ppb, and better than 1 per cent at >5 ppb. (Reprinted with permission from *Semiconductor International Magazine*, January 1996. Copyright 1996 by Cahners Publishing Co., Des Plaines, IL, USA)

Unravelling nanotubes

Some of the most sensitive microscopes use a beam of electrons from an electric field—called field emission—to scan materials atom by atom. Now US researchers claim the opened tips of carbon nanotubes may be the ultimate atomic-scale field emitter.

Carbon nanotubes are good candidates for individually mounted probes for scanning microscopes because they are mechanically stiff and electrically conductive. Researchers from Rice University in Houston and Michigan State University have discovered that field emission of electrons from nanotubes is dramatically enhanced when the tips are opened by laser evaporation or oxidative etching. Most surprisingly, they report that the field emission is more intense when the tip is at room temperature than when it is heated to 1,500°C.

The team concludes that the emitting structure is a linear "atomic wire" of 10-100 carbon atoms pulled out from the open edges of the nanotube wall by the force of the electric field, like a sleeve unravelling. "They may turn out to be excellent coherent points sources of monochromatic electron beams and to have wide applications as probes, emitters, and connectors on the nanometre scale", they say.

The researchers dismissed another explanation that the dangling bonds of the exposed wire had reacted with background gases such as water, hydrogen, oxygen, carbon monoxide; these species are better field emitters than carbon atoms. They found that when they increased the level of these gases, the field emission was quenched.

The team believes that the wire consists of double bonded carbons which facilitate the transport of electrons from the negatively charged nanotube down to the wire's end. The delocalized cylindrically symmetrical π-bonding along the chain concentrates the electric field to extremely high values at the end of the atom on the tip of the chain, they explain. The result is that high-current field emission is obtained at low voltage at room temperature. (Source: *Chemistry & Industry*, 18 September 1995)

Two-way chip-and-nerve cell link

Although prosthetic surgeons dream of replacing severed limbs with mechanical surrogates controlled directly by the living nervous system, the creation of "bionic" hybrids remains purely imaginary. However, a team of German biophysicists has now taken a small step towards mating man and machine by opening a two-way communication link between a silicon chip and a leech's nerve cell.

The achievement, by Dr. Peter Fromherz and his research team at the Max Planck Institute of Biochemistry at Martinsried, near Munich, was described in a paper in the journal *Physical Review Letters*.

The group reports that it has built a new type of junction between a microscopic spot on a silicon chip and a corresponding spot on a leech neuron. A novel feature is that no

electric current passes from the chip to the neuron; the chip stimulates the neuron to "fire", or respond, by inducing an electric charge inside the leech cell. Leech neurons were used for convenience, but the technique can presumably be adapted to human nerve cells.

Dr. Fromherz has devised a way to send a signal to a nerve cell using capacitive stimulation, in which electric charges are rearranged without a flow of current. Voltage applied to the interior of the chip produces an electric field that induces a charge inside the cell. When this charge reaches a certain level, the cell fires, initiating the electrochemical sequence by which nerve cells communicate.

The accomplishment thus established a signalling channel between a nerve cell and a silicon chip that works in both directions—a requirement for any future prosthetic limb controlled by the brain through a living nervous system.

Dr. Fromherz said in an interview that his group had worked with neurons dissected from leech ganglia, or nerve bundles, because leech nerve cells are relatively large and therefore easier to manipulate than the nerve cells from most other animals.

Even so, a leech neuron is only about 50 microns long, about half the diameter of a human hair. Although some of the necessary operations can be done by hand under a microscope, others require computer-controlled micromanipulators.

The mere creation of a communication link with a neuron does not in itself open the way to building bionic limbs, he said, noting that capacitive coupling, or "hyperpolarization", as he has named his laboratory technique, is not how living cells communicate. Neurons transmit their messages by chemical changes at their synapses, or joining points.

One obstacle to integrating a silicon chip with a living nervous system, he said, will be maintaining intimate contact between the chip and the neurons. (Source: *International Herald Tribune*, 24 August 1995)

British fabricate 200 nm FETs

A British collaborative research group has used an economical benchtop laser plasma X-ray source to produce photoresist linewidths down to 130 nm. The system fabricated functional silicon field effect transistors (FETs) with 200 nm gate electrodes and peak transconductance values of 220 mS/mm (n-channel devices) and 100 mS/mm (p-channel devices).

The group includes the department of electrical engineering from the University of Edinburgh, Scotland; the central laser facility and the central microstructure facility of the Rutherford Appleton Laboratory (RAL) Oxfordshire; the department of physics at King's College in London and Leica Lithography Systems in Cambridge. The work was performed to evaluate the potential of the RAL laser plasma pulsed 1 nm X-ray source for the future production of 1 Gbit and 4 Gbit circuits.

The X-ray masks were fabricated using 200 nm silicon nitride membranes etched into 75 mm diameter silicon wafers. E-beam lithography, using a single layer PMMA resist and conventional lift-off, was used to pattern gold absorber features to 300 nm thickness with line-widths down to about 150 nm. A Leica VB6HR lithography system was used for the e-beam procedure.

X-ray lithography was performed with a 1:1 system using an X-ray mask held in close proximity to the substrate by a 12 μm mylar spacer. The AZPF514 chemically amplified negative tone resist (sensitivity 20 mJ/cm^2) required about four minutes' exposure at 125 mm from a source generating 100 mW of X-ray average power in 2π steradians. The exposure field was 20 mm x 20 mm. Conventional optical lithography was used for all stages except for the gate level.

Gate sidewall spacers were used to implement source/drain extension structures. A 200 nm doped polysilicon gate electrode was defined by X-ray lithography over a 5 nm thermal gate oxide at the centre of the device structure. Inter-device isolation was achieved with a 200 nm conventional LOCOS thermal field oxide. Threshold adjustment and punch-through suppression were set by dual B+ implants. Source-drain extensions were formed by Sb+ (n-channel) and In+ (p-channel) implantation. A gate sidewall spacer, 300-400 nm wide, was formed by conformal oxide deposition and etch-back. The source and drain junctions were formed with As+ (n-channel) and BF_2+ (p-channel) implants. The devices were annealed and contacts were formed.

The RAL source currently has no precision mask-to-wafer alignment system, which created a problem as the gate level had to be aligned relative to the previously-patterned device isolation level. This alignment problem was solved during X-ray lithography by patterning arrays of gratings across all device sites (150 nm lines on a 1.5 μm pitch). The following optical lithography step autoselected the gate structures that were best positioned over each device site.

The X-ray gate level was implemented using device wafers with a three-layer MOS stack (100 nm electron cyclotron resonance oxide over 150 nm doped polysilicon over 5 nm thermal oxide). The gate patterning involved X-ray lithography with the grating mask over a resist coated device wafer, pattern transfer of the X-ray image into the ECR oxide by RIE, optical lithography to print the auto-select level, an RIE step to remove all unwanted ECR oxide lines and RIE of the gate polysilicon to etch vertical sidewalls in the polysilicon with high etch selectivity to gate oxide. The performance of devices with both polarities was similar to those of devices fabricated by e-beam methods. (Reprinted with permission from *Semiconductor International Magazine*, December 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

Fastest transmission speed attained with 0.15- μm CMOS chip

Toshiba Corp. has attained the fastest transmission speed with a complementary metal oxide semiconductor (CMOS) of 0.15 μm gate length. A single-gate structure was introduced for the first time to attain this high-speed transmission level, by which the delay time per gate of 15.4 picosec has been attained that is comparable to that of a 0.1 μm CMOS chip.

With 0.1 μm CMOS chips, the general practice had been to introduce the dual gate structure of N-type and P-type polysilicon for the NMOS and PMOS gate electrode materials, respectively. However, the process becomes complicated and the cost increases in the stage of mass production, while the problem of boron diffusion is also encountered where impurities from the gate electrode pass through the oxidized film and penetrate the wafer.

To cope with this problem, the ULSI Research Laboratory of Toshiba Research and Development Centre introduced the single gate structure using N-type polysilicon for both NMOS and PMOS, which enabled the attainment of a high-speed performance comparable to that of 0.1 μm semiconductors. The adoption of the single-gate structure not only solves the boron diffusion problem but also improves the current drive force, since the PMOS becomes an embedded channel-type MOS FET.

The single-gate structure of 0.1 μm level could be introduced because the depth formed by the embedded channel is extremely shallow and is only 0.05 μm from the wafer surface. With the embedded channel type PMOS, the generation of leakage current makes switching to an OFF state difficult and readily generates the so-called short-channel effect. The company introduced the lamp annealing technique for creating a uniform high temperature of 1,000°C in a few seconds by irradiating the beams of several halogen lamps at once. Controlling the distribution of impurities in the channel domain enabled the short-channel effect to be suppressed.

The conventional lithography technique could be applied to the stage of mass production of 0.15 μm CMOS, so it will be possible to manufacture high-speed semiconductors at a low cost by process simplification.

Further details from: Toshiba Corporation, Public Relations Office; 1-1-1, Shibaura, Minato-ku, Tokyo 105. Tel.: +81-3-3457-2105; Fax: +81-3-3456-4776. (Source: *JETRO*, November 1995)

Mitsubishi laser diode achieves 11° spread angle

Mitsubishi Electric Corp. has developed a laser diode with a laser beam spread angle of only 11° through the use of an integrated waveguide lens.

The use of an optical communication system between subscribers' homes will require smaller and less expensive optical communication modules. These optical communication modules will require optical beam axis alignment of 1 μm or better between the laser diode and the optical fibre, which would increase costs. Mitsubishi addressed the problem by eliminating the lens used to couple the laser diode to the optical fibre and integrating the lens into the laser diode itself. This move also decreased costs.

The lens function was implemented by forming a dielectric mask on the substrate and then using selective epitaxial growth, with the growth speed suppressed within the mask area. The layer was thickened where laser oscillation gain was needed, and in the lens portion the layer thickness was gradually tapered out to form a waveguide. The thickness of the tip of the active layer at the front edge is about a quarter of the thickness of the rear laser active layer. Oscillation results in a beam spread angle of 27° at the rear, but only 11° at the front. Because the beam is focused, when coupled directly with optical fibre, connection loss improves from the usual 8.3 dB to 3.3 dB, which allows the permissible beam axis offset to be increased form 1.5 μm to 3 μm.

The diode has a stable operating temperature range from -40°C to +85°C, and can transmit up to 50 km in the 4 GHz modulation waveband at 622 Mbps. (Reprinted with permission from *Semiconductor International Magazine*, December 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

E-beam format for 256 Mb DRAMS

E-beam supplier Lepton (Murray Hill, NJ) and data preparation company Transcription Enterprises (Los Gatos, CA) will support a new data format for Lepton's EBES4 electron beam lithography system. To handle pattern data for 256 Mb DRAMs, the new format supports variable-sized macro-cells, one level of cell hierarchy and e-beam proximity effect correction. The initial release of the "CATS" module that supports the new Lepton format is expected to be available before the end of the year.

Advanced reticle applications like 256 Mb DRAM and masks with optical proximity effect correction require very high pattern fidelity. When these new features have been incorporated into CATS software, reportedly the EBES4 system will have the most cost-effective solution for mask applications requiring both high resolution and address grids below 50 nm. (Reprinted with permission from *Semiconductor International Magazine*, December 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

A noble method of lithography exposure

Scientists have come up with a new form of microlithography that exposes resist with neutral atoms. This is the work of researchers at the US Commerce Department's National Institute of Standards and Technology (NIST) and Harvard University. Funding has come from these two organizations and the Alexander von Humboldt Foundation of Germany.

Briefly described, the new technique uses metastable, noble gas atoms to pattern a high-resolution resist made with a single layer of molecules. When noble gas atoms are excited to a metastable state their electrons carry stored energy. Upon impact with a surface, the atoms release their stored energy to break chemical bonds. One of the advantages of this type of exposure is that metastable noble atoms are "gentler" than other advanced lithography exposure energies from X-rays, electron beams or ion beams. Furthermore, the wavelengths of metastable atoms are less than 0.01 nm, enabling tremendous resolution advantages.

The resist used in the Harvard-NIST method is a self-assembled monolayer of organic molecules called alkanethiolates that are adsorbed on the surface of the gold.

The research group's experiments involved directing a beam of metastable argon atoms through a copper grid with holes 10 μm across. When the metastable atoms hit the self-assembled monolayer resist, they released their energy and broke hydro-carbon bonds. The result was a grid of gold lines a few micrometres wide with less than 100 nm roughness. Subsequently, the gold features were used to pattern the underlining substrate.

Looking at continued development work, the research group plans to replace the physical screen with an interference pattern created by standing waves of laser light or possibly by a laser hologram. Already they have used a laser to selectively quench or turn off metastable atoms; the laser energy releases a metastable atom's stored energy before it reaches the resist surface. (Reprinted with permission from *Semiconductor International Magazine*, December 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

NEC cracks gigabit thorn

NEC claims it has cracked one of the thorniest problems associated with manufacturing gigabit DRAMs and would sample the device in 1998.

The main problem is that of shrinking the size of the capacitor while retaining sufficient capacitance. NEC says it can make stacked capacitors as small as 0.2 μm with cell capacitances of 25 fF in an area of 0.125 μm^2 using 0.3 μm high storage electrodes.

NEC's 1 Gbit DRAM process will use an internal cell contact technology that forms self-aligned pads that can reduce cell area by 36 per cent. Capacitor contact depth is reduced to one half, lateral overgrowth of the pads is controlled to less than 50 nm. Interfacial contact resistance is reduced to a fifth and leakage current is comparable with conventional technology.

A key NEC development that allows fabrication of 1 Gbit DRAMs is a low contact resistance metallization technology for making deep contact holes with an aspect ratio greater than six.

The first 1 Gbit DRAMs will be made at NEC's Sagamihara plant in which $480 million is being invested. The company plans to sample the chip in 1998 and to start mass production in 2001. It will be made on a 0.18 μm process. (Source: *Electronics Weekly*, 13 December 1995)

Colour sensor chip

Edinburgh publicly quoted camera-on-a-chip company, Vision, has launched its long-awaited colour sensor chip, claimed to be the world's first.

The IC is in a camera for Vivitar, the first product to use the colour sensor.

Aimed at PC videoconferencing, the camera plugs into the PC's parallel port and offers a 320 x 240 pixel resolution for still images and a 160 x 120 resolution for video at 15 frame/s. The lower video resolution is limited by the data throughput of the parallel port and not the sensor.

Colour is achieved through a 2 x 2 matrix of RGB filters over the sensor's pixels (there are two green filters since the eye is most susceptible to this colour). An off-chip DSP restores full colour to each pixel by interpolating between colours.

The colour sensor is a breakthrough for Vision, which has been promising to deliver colour technology for the past two years. (Extracted from: *Electronics Weekly*, 17 January 1996)

Non-linear route to image processing

What is claimed to be the first analog implementation of a morphological image processing device, suited to such applications as machine vision, has been developed by the Georgia Institute of Technology in Atlanta.

Morphological image processing is a non-linear way of processing an image, the regions of which fall within distinct sets, to perform object detection and image segmentation.

Morphological processing is founded on two fundamental operations: erosion and dilation. As the name suggests, erosion is used to remove image pixels from a region's border, whereas dilation adds pixels to a border. The removal and addition operations are determined by a structuring element which acts as a mask-like image filter; for the circuits being developed at Georgia, the structuring element includes any combination of pixels within a 3 x 3 mask.

For example, take a dilation operator acting on a binary image comprising two sets of pixels. With dilation the set of pixels equal to one is expanded in different directions, depending on the size and shape of the structuring element. The expansion comes about by equating each output pixel value to the peak value that falls under the mask.

The analog VLSI circuits under development at Georgia integrates the processing circuitry locally with each photodetector. The result is a parallel array of smart pixel elements that executes morphological operations on grey scale images. The parallel array architecture promises a processing performance of 1,000 frames per second.

The advantage of an analog implementation is that it results in a relatively compact circuit design, with each photodetector converting the intensity to a current. For a digital processor implementation, this current then needs to be converted to a digital value.

The group has already built an 8 x 8 dilation test array using a modest 2 μm CMOS process, resulting in a pixel dimension of 187 x 187 μm.

An erosion processor is now under development as is the analog circuitry required for image storage. By including analog memory, the group plans to implement general purpose, 128 x 128 programmable morphological image processors. (Source: *Electronics Weekly*, 6 December 1995)

D. MARKET TRENDS AND COMPANY NEWS

Market trends

VLSI research forecasts a peak in capacity in 1997

The semiconductor industry has been scrambling to eradicate the shortage of ICs by announcing new fab additions, expansions and upgrades. VLSI Research Inc., a market research firm based in San José, CA, forecasts that capacity announced in 1994 and the first half of 1995 will generate annual revenues of roughly $120 billion before the year 2000, which it said is enough to meet the demand of today's semiconductor industry.

Not surprisingly, the largest investors are also the largest semiconductor suppliers. Motorola, the largest investor, accounted for 9.6 per cent of all announcements. Intel was second with 8.7 per cent, while Samsung and Mitsubishi tied with 7.7 per cent of the announcements. The top 10 investors in new fabs account for 58.2 per cent of the total, according to VLSI Research.

Geographically, America is the leader in announced capacity, with Japan trailing closely. South-East Asia is not far behind, outspending all of Europe. South-East Asia's investment levels are mainly due to the splash being made by Taiwan, as it is committed to becoming a major global player by the end of the millennium.

What most concerns individuals outside the industry is the possibility of excess capacity. The latest findings at VLSI Research indicate that the capacity impact of newly announced semiconductor fabs will peak in the second half of 1997 when the accumulation of these new additions steeply drives up production. Therefore, the earliest signs of a capacity-driven slow-down would occur in 1998 if price erosion in DRAM markets starts to occur. However, announced investments in 1994 and the first half of 1995 of $42.5 billion in DRAMs will generate $53.2 billion in annual revenue—less than 80 per cent of VLSI Research's DRAM forecast in 1998. (Reprinted with permission from *Semiconductor International Magazine*, January 1996. Copyright 1996 by Cahners Publishing Co., Des Plaines, IL, USA)

16 Mbit under pressure

After the market glut of DRAM in the final quarter of last year, US market research firm Semico Research predicts that there will be a world-wide shortage of 16 Mbit DRAMs this year.

The company says that demand will exceed supply by about 7 per cent. The market for 16 Mbit DRAMs will double this year to reach $40 billion while the 4 Mbit DRAM market will be about the same as last year at $20 billion, says Semico. This estimate is well above that of analysts Dataquest which project the 1996 DRAM market at $50 million.

Semico reckons that supplies of 4 Mbit DRAMs will diminish as manufacturers switch to 16 Mbits. The shortage is also likely to put a halt to the fourth quarter drop in DRAM prices, which have caught several major companies. (Source: *Electronics Weekly*, 31 January 1996)

DRAM market 1995-1999

Samsung, the world's largest DRAM producer, predicts the market size and ASP (average selling price) for DRAM for the rest of the decade. The projected pricing levels will do little to improve PC manufacturers' margins.

DRAM market 1995-1999

Item		1995	1996	1997	1998	1999
4 MDRAM	Market size	1 315	1 062	812	434	209
	Av. price $m	13.21	12.99	10.45	7.75	6.95
16 MDRAM	Market size	312	724	1 090	1 145	918
	Av. price $m	51.77	48.95	36.10	26.70	23.00
64 MDRAM	Market size	0	4	60	279	596
	Av. price $m	394.65	309.85	244.57	118.49	82.25
255 MDRAM	Market size	0	0	0	1	10
	Av. price $m	0	0	0	710.94	575.38

(Source: *Electronics Weekly*, 14 February 1996)

IT spending and business success

By the year 2003, successful companies will be spending 40 per cent of their total IT budgets on externally focused investments, up from less than 10 per cent in 1995, reports Forrester Research Inc., Cambridge, MA. "Smart companies will recast all IT investments—data management, data access, middleware, development tools, and base infrastructure—based on revenue generation instead of traditional cost containment," says the report. (Source: *Industry Week*, 5 February 1996)

US computer shipments will be moderate in 1996

Computer and office equipment shipments have exhibited double digit growth levels since 1992. In 1994 shipments neared 20 per cent before receding to a still astounding 15.7 per cent. 1995 shipments have held on as business investment buoyed and consumers have been captivated with Pentium PCs.

Cahners Economics expects a 14.9 per cent decrease over the year rate of change in 1995. As domestic business investment and personal consumption gradually ease, US orders for computers and office equipment will begin to slow. Declining prices and increasing export opportunities will keep shipments up 11 per cent in 1996.

PC sales slowed in the second quarter of 1995, which may be the effect of consumers and businesses postponing purchases until the release of Windows 95. The latest round of price cuts on computer equipment (August 1995) is intended to clear out existing inventories and aid manufacturers in capturing a larger share of the cost-conscious consumer market. Following these cuts, there is little speculation that PC manufacturers will experience anything less than a strong holiday season.

Shipments have yet to feel the effects of the swell in orders in 1995, because production has been hampered by capacity restrictions in the input markets. Over the first half of 1995, shipment rates remained fairly steady, seeing declines of slightly more than 1 per cent. Backlogs soared to 50 per cent over the year and inventory growth sank to 2.2 per cent in this segment of the electronics industry alone.

The consumer market has been expanding rapidly over 1995, stimulated in large part by declining prices. Climbing consumer debt will make expensive computer equipment a harder sell in 1996. Slower US growth coupled with a high installed base forces computer manufacturers to look for new markets in which to expand.

As the economies in Europe and the Asia-Pacific region rebound, sales in these regions will begin to accelerate. European, Japanese and Chinese markets offer manufacturers phenomenal growth potential in business investment and personal consumption over the long run. Foreign markets in 1996 will comprise an increasingly larger percentage of equipment shipments. (Reprinted with permission from *Semiconductor International Magazine*, January 1996. Copyright 1996 by Cahners Publishing Co., Des Plaines, IL, USA)

Semiconductor growth

Over the past four years, strong demand in the US market has been the foundation for celestial semiconductor industry growth, straining semiconductor manufacturing and supply lines in 1995. Some portion of the 1995 gains in semiconductor orders were due to speculative ordering caused by expectations of increasing future demand and fear of capacity constraints and shortages. In 1996, as new manufacturing equipment comes on-line, speculative ordering will diminish. Expect 1996 growth rates for semiconductors to exhibit a more pedestrian pace than in years past. Total industry sales should expand 12.6 per cent reaching $159.4 billion, substantially less than the 39 per cent gains in 1995.

This industry has maintained its strength up through 1995 in part as a result of favourable global market conditions and technological advancement in end-market products. Semiconductors have more frequently replaced less advanced passive components as a result of digital technology and high-level IC integration, offering lower- cost means to faster, more powerful OEM products. As fewer substitutions remain, expect long-run growth rates to reflect increasing levels of market saturation. (Reprinted with permission from *Semiconductor International Magazine*, December 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

Boom time forecast for world smart card market

The international smart card market is to grow $1.2 billion each year by 1998, according to Semiconductor International. In 1994 the smart card global market was valued at $270 million with the revenues mainly derived from Europe, the largest smart card market.

Although Europe holds around 90 per cent of the world-wide market, industry predicts a decline of 25 per cent in Europe, which will be compensated by the growth in South-East Asia and Japan with shares of 15 and 12 per cent respectively.

Annual unit production of smart cards is around seven million but this figure is expected to change to more than one billion by 1998. (Source: *Electronics Weekly*, 15 November 1995)

Dataquest sees shortage of polysilicon round corner

US market research firm Dataquest is predicting a shortage of polysilicon as semiconductor demand continues to grow and production capacity lags demand.

The shortage is predicted to hit semiconductor manufacturers in mid to late 1996 and could last as long as 10 months. However, new polysilicon market capacity is expected to come on-line in 1997, which will let it catch up with demand.

Dataquest also predicts a shortage of 200 mm wafers as companies prepare new fabs that use the larger format size. The 200 mm wafer shortage will begin in 1996 and will continue for much of the rest of the decade, peaking in 1997 and then again in 1999.

The firm estimates that 1995 demand for 200 mm wafers world-wide is 1.280 million wafers a month. This demand will almost double in 1996 to reach 2.206 million wafers and the industry will require 5.213 million wafers a month by the year 2000. However, the industry will only be able to supply 1.956 million wafers next year and 3.894 million wafers a month by the end of the decade. Dataquest points out that there is a mismatch of supply and demand. This has created a shortage of 100 and 125 mm wafer sizes, which should soon be solved. (Source: *Electronics Weekly*, 13 December 1995)

Trends in the workflow software market

BIS Strategic Decisions has predicted that the North American and European markets for production, collaborative and administrative workflow software will increase from $235 million in 1994 to $1,100 million in 1998, a

compound annual growth rate of 47 per cent. Basic workflow functionality will be incorporated into next-generation messaging products, putting workflow systems onto many more desktops. Competitive pressure is expected to drive down the "cost per set" for workflow software tools.

The forecasts were based on end-user surveys, supplier information and secondary market research. The end-user research involved a postal survey with 600 respondents and a telephone survey of 150 workflow software users.

Critical success factors for the market as a whole will include ease of use, ease of development (end-users want to write their own applications), reusability of custom tasks, ease of administration, integration of mail and shared database platforms, client platform independence and ad hoc functionality.

The European market is expected to offer higher growth and margins than the North American one. This is due to a number of factors, including the smaller size of the current installed base in Europe, the anticipated influx of North American products into the European market and the relatively lower level of price competition in Europe. Although current products are perceived as relatively untried, expensive and potentially disruptive, European businesses are looking hard at ways of improving efficiency and remaining competitive. (Extracted from *Information Management & Technology*, 28(6) 1995)

Emerging market information

When it comes to researching the emerging markets of Central and Eastern Europe there is no shortage of news. Services such as OMRI, CET and Prague Financial Monitor can be found on the Web, or delivered direct to your e-mail bus, free of charge.

One example, Internet Securities (IS) can be accessed via the World Wide Web. Access to the bulk of the data is password controlled, but there are free demonstration files which give you an idea of the wide range of information that is available. The service covers Russia, Poland, the Czech Republic and the Baltic States. Russia and Poland are covered in most detail with news, company financial statements, industry data, analyst reports and country macroeconomic data. Approximately 75 per cent of the information is not available on-line anywhere else.

For Russia, news is supplied by Open Media Research Institute (OMRI), AG News, Broadfax, Russia Portfolio and Skate-Press, all well known and respected providers of information in this area. The bad news is that Skate-Press is not only in Russian but also in Cyrillic script, as are the reports on Daily Financial Indicators. The other resources for Russia include stock quotes and histories, company profiles, and extensive reports on the Russian stock market.

For Poland, there are ten news services, including an exclusive English translation of *Gazeta Bankowa*. On Polish companies, there are brief company profiles, detailed financials of the major corporations, stock quotes and analysts' reports on individual companies, as well as industry sectors. For anyone monitoring the restructuring and privatization programme in Poland the reports from the Gdansk Institute for Market Economics are especially valuable. There are detailed macroeconomic statistics from GS, the State Statistical Office, but the headings in the tables are in Polish. (Extracted from *Information World Review*, November 1995)

'Net shakeout

At a New York press conference, the Yankee Group, a Boston-based consulting firm, predicted a major shakeout in the fast-growing Internet marketplace, with telecommunications companies emerging as the clear winners. Analysts predicted the old Ma Bells and long distance carriers will soon begin offering competitive rates for packaged content and navigational help for consumers; connectivity and directory services—such as the World Wide Web "yellow pages"—for businesses; as well as providing general access and enabling secure electronic commerce. Indeed, this may signal an end to the entrepreneurial frenzy feeding start-ups that provide comparable services. (Source: *Industry Week*, 8 January 1996)

Is there life after 95?

Whether you like Windows 95 or not, it has become the de facto standard for user computing.

Who will the short-term winners and losers be in the 95 paradigm shift? Memory manufacturers are the biggest winners: 95 limps badly on a 386 or 486 with only 8 Mb of memory. Modem manufacturers are also big winners: 95's connection to the Internet will induce most 95 users to buy a high-speed (28.8 kilobaud) modem.

Office suite vendors other than Microsoft are the biggest losers: Microsoft Office 95, released the same day as Windows 95, runs a good deal faster than any of the Windows 3.1 application suites from Lotus/IBM or Novell, neither of which has a 95-specific product ready to ship. So Microsoft Office will gain more market share.

Who will be the long-term winners and losers? Long-term winners will use their existing skills to make money in new markets that 95 has opened but in which Microsoft has as yet no products. Stac Storage and Communications, for example, is applying its data compression technique to reducing the bandwidth required to move information over telephone and network cabling. Long-term losers will continue to compete head-to-head with Microsoft. (Source: *IEEE Spectrum*, November 1995)

Technology stock market

For much of 1995 shares in firms producing everything from software to semiconductors soared. "Technology" was the hottest investment theme in an already febrile American stock market. No longer. Shares in high-tech companies that produce disappointing results are now dumped unceremoniously.

An index of 35 leading high-technology firms run by Morgan Stanley, an American investment bank, fell by 6.4 per cent—its biggest ever one-day drop.

Now, however, the Morgan Stanley index is around 19 per cent below the high it reached in November 1995. The roots of today's decline lie in yesterday's excesses. From late 1994, investors became increasingly excited about the Internet. So excited, in fact, that a few months after its flotation in August 1995, Netscape, a firm that makes software for users of the world-wide computer network, had sextupled in value, to around $7 billion.

The hype had already spilled over to computing and electronics firms in general (biotechnology and medical technology firms are usually excluded from the "tech stock" label). Some 500 companies make up these stock market sectors in America. At the end of 1995, their market value was around $1 trillion, or twice their annual revenues—and equivalent to some 12 per cent of America's total market capitalization.

During the boom, few questioned the logic of treating "technology" as a single investment theme. Received wisdom held that computers, memory chips and software were becoming the backbone of an economy dominated by

information and its management. Technology firms of all sorts would benefit as their wares became ubiquitous, even to the extent that their production cycles would diminish or disappear.

Few investors are quite so sanguine today. Recent events have reminded them that not all high-technology companies are alike. In 1995, for instance, many software firms nearly doubled in value; the value of the average personal-computer market fell.

Nor is it clear that the cycle is dead. Although some chip makers try to limit the risk of overcapacity, they cannot much influence the overall level of investment in their business. Expensive chip plants are sprouting like mushrooms, particularly in Asia. So it would be dangerous to assume, as many seemed to in 1995, that semiconductor firms' earning will rise predictably in coming years.

Moreover, the perceived linkages between different types of technology firm are now being closely scrutinized. A mainframe software firm such as Computer Associates might benefit if sales of mainframes rise sharply. But it can also do perfectly well simply by serving the existing stock of machines.

There are cases, however, where the fortunes of firms in different businesses are linked. For instance, Windows 95, a software launched by Microsoft in August 1995, is credited with sufficient clout to influence demand for memory chips. The more of these memory-hungry programs that are sold, the more powerful chips their users will buy.

But industry analysts say this type of direct impact across businesses is harder to detect as the technology sector becomes larger and more diffuse.

This raises the issue of how to distinguish between the two.

As the technology industry develops, it is becoming even harder to judge shares' value. For instance, the sector's once predictable seasonality has broken down, possibly because individual consumers are helping to smooth the effects of more cyclical business demand.

Finally, high-technology industries are, by their nature, difficult to predict. Product cycles are usually short, and technology is changing so rapidly that it is difficult for firms to establish long-term franchises. (Source: *The Economist*, 20 January 1996)

Current practice in information management

Consulting company Touche Ross has released a report entitled "Information Management: A Survey of Current Trends and Practices 1994". This survey was compiled from questionnaires circulated to UK users and suppliers of information management tools and techniques. About 300 organizations responded across a range of private and public sectors, and the report contains a detailed analysis of their response. One of the main findings of the survey was a divide between small and large companies. Smaller companies, classified as having fewer than 50 employees, relate information management to clerical procedures, use of databases, spreadsheets and the company library. Large companies of over 5,000 employees focus on information technology, records policy, and data management. It seems that the larger the company the greater the problem finding information. Seventy-five per cent of respondents have the problem of information being in the correct form for decision-making.

Trends that are emerging are the popularity of voice mail, which 38 per cent of respondents have already implemented, and workflow systems that route packages of information from one participant to another according to structured procedures. Multimedia on the other hand has stalled. Although there are enthusiastic users, large numbers of companies do not know what to do or have no plans. Business Process Reengineering (BPR) is also slow in taking off, with only 20 per cent of respondents currently using BPR and over 52 per cent unsure whether they would ever use it. (Extracted from *Information Management Report*, October 1995)

Company news

How companies make IT decisions

Where does the IT decision-making power reside? In a survey of more than 2,000 senior executives, almost 90 per cent of their companies describe it as a shared responsibility, says IBM Corp., White Plains, NY. Its study, "Aligning your Business for Growth", found that 37 per cent of the companies reported that functional managers decide strategy, while IT managers make technical decisions. Slightly more, 42 per cent, say that IT and functional managers have shared responsibility for all decisions. Only 8 per cent say that IT managers set guidelines and functional managers make decisions. The study reveals that more than one in three companies today are pursuing strategies of revolutionary, not evolutionary change. The study also relates client/server strategies to customer-focused objectives. (Source: *Industry Week*, 22 January 1996)

First rad-hard MCM to receive US certification

Honeywell's Solid State Electronics Center (SSEC, Plymouth, MN) was the first to receive certification from the US Defense Department for its radiation hardened MCM production line. Honeywell received Qualified Manufacturer Listing (QML) from the Defense Electronics Supply Center (DESC). QML certifies the package's radiation hardness for military and space-based applications. DESC certified Honeywell's Generic VHSIC Spaceborne Computer (GVSC), a five-chip, RH-1750 processor.

This year, the SSEC will produce hundreds of the GVSCs for another Honeywell division. The 200-lead MCMs are 2.1 x 2.1 inch and use an epoxy die attach, aluminium wire bonds and a ceramic substrate. The two-year effort consisted of DESC certifying the design and manufacturing process and completing the product qualification. The Government audited SSEC's CMOS wafer fabrication, assembly, screening and testing to ensure a reliably-built GVSC. Then Honeywell built parts, subjected them to a battery of tests and submitted a report detailing the MCM-packaged GVSC's ability to withstand radiation and other environmental stresses. (Reprinted with permission from *Semiconductor International Magazine*, January 1996. Copyright 1996 by Cahners Publishing Co., Des Plaines, IL, USA)

Advanced Photonix Inc. awarded NASA grant

Advanced Photonix Inc. (Camarillo, CA) has been awarded a Phase I Small Business Innovation Research (SBIR) grant by the National Aeronautics and Space Administration (NASA). The grant will be used to develop a near-infrared version of the company's large area avalanche photodiodes (LAAPDs). Advanced Photonix was one of 304 small businesses to be awarded the grant out of 1,947 proposals. If the initial research is successful, the work may lead to a Phase II proposal and grant of approximately 10 times the Phase I value. NASA intends to use the new infrared version of LAAPDs to map the Earth's surface from planes and satellites.

In announcing the award, James W. Ward, chairman of the board of Advanced Photonix, noted "This announcement will help position the LAAPD as the detector of choice in a wider range of applications. Silicon has inherently broad detection capabilities, and this award should extend the large area APD capability and perform over the detection range better than any other silicon detector."

During the current fiscal year, the company has been awarded three other LAAPD-related development contracts. Advanced Photonix says its LAAPDs are more sensitive than other solid-state detectors when operating at higher signal speeds with weak amounts of light. They also offer advantages over the conventional photomultiplier tube (PMT), such as ruggedness, compactness, immunity to magnetic fields and sensitivity to a wider variety of light intensities without distortion.

One of the most promising commercial applications of this near-infrared enhanced LAAPD is collision avoidance. Industry analysts predict that collision avoidance systems, based on light detection and ranging, will appear on automobiles within five years, and may employ a solid-state light detector like the LAAPD for its sensitivity and ruggedness. (Reprinted with permission from *Semiconductor International Magazine*, January 1996. Copyright 1996 by Cahners Publishing Co., Des Plaines, IL, USA)

Atmel starts 8 inch European fab facility

Atmel Corp. has started construction of a fabrication facility (Fab 7) in Rousset, France, that will have the capability of producing 5,000 8-inch wafers per week. Located approximately 10 miles east of Aix-en-Provence, the new fabrication site is near the company's existing fabrication and design facility. The new facility will be capable of producing semiconductor wafers with 0.35 μm, dimensions. The facility is expected to come on-line in the third quarter of 1996.

In April 1995, Atmel purchased a majority interest in this French manufacturing, design and sales organization from European Silicon Solutions, ES2. The organization has been renamed Atmel ES2. In 1995, Atmel invested approximately $30 million enlarging and upgrading the original ES2 fabrication facility, now called Atmel Fab 6. An additional $50 million is slated for the Fab 6 project in 1996. When completed, the two Atmel ES2 fab facilities will almost double the company's silicon production capability. (Reprinted with permission from *Semiconductor International Magazine*, January 1996. Copyright 1996 by Cahners Publishing Co., Des Plaines, IL, USA)

Fujitsu/AMD plan 2.7 V 8 Mbit flash chip push

In a bid for half this year's world flash memory market, Fujitsu and AMD are to start production of the only 8 Mbit flash chip which can be programmed, erased and read at 2.7 V.

The chip will be made at the two companies' joint venture fab in Aizu-Wakamatsu in Japan. This has a current capacity to product 10,000, eight-inch, half-micron wafers a month.

A second module at Aizu-Wakamatsu is being equipped to add 10,000, eight-inch, 0.35 μm wafers a month capacity by the end of this year. If all goes well with bringing up the second module, the companies expect to get 20 million 4 Mbit chips (or 4 Mbit equivalents) from the module.

So the combined total from Aizu-Wakamatsu this year could be 100 million 4 Mbits (or 4 Mbit equivalents) worth $1 billion at current pricing.

That should be half the value of the 1996 world flash market if Dataquest's projections turn out correct. Dataquest reckon that the 1995 world flash market was worth $1.4 billion and that the 1996 market will be worth $2 billion.

In 1995, half the world's flash market was supplied by Intel, with AMD taking 30 per cent and Fujitsu 10 per cent.

AMD, which has other flash fabs besides Aizu-Wakamatsu, says it will outship Intel this year.

Intel is bringing up a "30,000-ish" six-inch fab in New Mexico and is moving another flash fab to 0.4 μm from 0.6 μm, while its flash partner Sharp is also moving to 0.4 μm. All these moves should allow Intel to grow shipments by two thirds this year—faster than the market growth projected by Dataquest. (Source: *Electronics Weekly*, 31 January 1996)

Siemens and Motorola to build DRAM plant

Siemens AG and Motorola Inc. have signed a memorandum of understanding to build a joint facility in the US to manufacture the latest generations of Dynamic Random Access Memories (DRAMs). The plant, in which the partners will have equal stakes, will require an initial investment of about $1.5 billion. Construction is planned to start in mid-1996, with initial production in early 1998.

Motorola and Siemens already are working together on the development of advanced memory chips as members of a technology alliance with IBM and Toshiba. DRAMs produced in the joint venture factory will be based on the 64 Mb and 256 Mb DRAMs jointly developed within the alliance.

The site is being conceived as a fully integrated facility for chip production (wafer fabrication), assembly and test.

As part of its long-term strategic plan to boost capacity for covering growing market demand, Siemens is opening an advanced chip production facility in Dresden, laying the cornerstone for a new plant in Newcastle, UK, and making major investments to expand its semiconductor operations in both Villach, Austria and Regensburg, Germany. Underscoring its global orientation, the company will also be adding capacity to its semiconductor facilities in Singapore, Malaysia and Indonesia. Motorola's strategy for DRAM production is centred on joint-venture partnerships, and this new relationship with Siemens significantly enhances that strategy. Motorola currently supports its DRAM customers through a joint venture with Toshiba. This facility in Sendai, Japan is now in its third phase of expansion and is shipping 16 Mb DRAMs in volume. (Reprinted with permission from *Semiconductor International Magazine*, December 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

Korean trio puts massive investment into memory

Unfazed by projections of an over-supply of DRAMs, the Korean Big Three chip manufacturers have announced that they intend to spend over $6 billion on new memory capacity in 1996.

Samsung, the world's largest DRAM manufacturer, is to spend $3.5 billion, Lucky Goldstar is to spend $3.4 billion and Hyundai says it will spend $1.3 billion— all on new DRAM capacity this year.

Part of Lucky Goldstar's expenditure is on extending its six-year DRAM collaboration with Hitachi of Japan. The two companies are setting up a joint venture to build and operate a $1.3 billion wafer fab in an industrial park near Kulim, Malaysia, to produce 16 Mbit and 64 Mbit DRAMs on 0.3 μm technology. The long-term aim of Hyundai is to be among the world's top five chip producers—in 1995 it was

number 11—and to get there it says it will spend between $1.2 and $1.9 billion on new capacity every year until the end of the century.

Hyundai has its third Korean-based 16 Mbit DRAM plant about to be completed and a fourth is being built in Oregon, USA. (Source: *Electronics Weekly*, 17 January 1996)

The future of material handling

Just what are the benefits of integrating manufacturing, robotics, and material handling into one process? In Osaka, Japan, Sharp Corp. was able to achieve three times the production capacity with two-thirds less operating staff at a new automated plant producing room air conditioners. That integrated network of material-handling systems was provided by Daifuku Co. Ltd. Other benefits are in cycle-time and inventory reduction. (Source: *Industry Week*, 4 December 1995)

Hitachi says LCD to replace CRTs

Hitachi is making a bid for world leadership in the large flat panel display market by building a new TFT factory at Mobara in Japan. The company aims to sell the displays as replacements for CRTs in computers, says the company's general manager for LCDs, Zenzo Tajima.

Tajima is projecting a sharp drop in the price of a 10.4-inch panel to $500 in 1996—less than twice the price of a 14-inch CRT—which Tajima reckons will allow LCDs to compete for design-wins in the 5 million unit-a-year desktop computer market.

The new factory will make 100,000 TFTs a month—doubling 10.4-inch TFT production at Hitachi. Its current plant at Mobara makes 100,000 10.4-inch and 13.3-inch panels a month and, in addition, the company's large-size colour STN (dual-scan) plant makes 120,000 panels a month.

Although Hitachi has a smaller portion of the overall LCD market than Sharp, DTI (Toshiba/IBM) and NEC, it is one of the biggest players in the 10.4-inch colour LCD segment: the market focus for Hitachi.

The new Mobara Plant will start making 10.4-inch and 13.3-inch panels but will be equipped to handle larger sizes. From 1997, it will make 15-inch panels and larger. By the end of the century, Tajima reckons he will be making 20-inch TFTs. Tajima believes the CRT's heat and weight will be unsupportable in the future. (Source: *Electronics Weekly*, 29 November 1995)

"Printing" 3-D objects

3-D Systems Corp., the company that marketed high-precision stereolithography in 1986, is offering a new network peripheral for CAD workstations. Called Multi-Jet Modeling, the equipment uses inkjet technology to quickly create a three-dimensional prototype using a thermopolymer. "Engineers can conceive their idea, design it via CAD, and without leaving the CAD workstation, build a physical model of their concept as easily as creating a paper print plot", says Charles W. Hull, the company's president. The company says the technology is intended for low-cost object printing, where speed and ease of use are critical. (Source: *Industry Week*, 8 January 1996)

Business intelligence

Now one can order up-to-date company profiles compiled on demand and delivered via e-mail or fax within two hours. The service is available on the World Wide Web, courtesy of Avenue Technologies. The service, which charges $40 per report, tracks relevant financial data and the latest news on about 25,000 US and international public and private companies. For more information, e-mail rick@avetech.com or view a sample document at the Avenue Web site: http://www.avetech.com/avenue/. (Source: *Industry Week*, 8 January 1996)

ICI optoelectronic team goes it alone

A team of specialists in polymer-based optoelectronic components from ICI is planning to expand into new markets after separating from the multinational in a management buy-out.

Four members of the effects polymers team, based at ICI's Wilton research centre on Teesside, UK, have established their own independent company, Epigem, to develop the business.

Currently providing contract R&D services in optoelectronics and related technologies, the new company plans to expand its manufacturing activities to supply components for the telecoms, datacoms, avionics and other markets.

By becoming an independent business, the company will be better able to finance such developments.

Remaining on the Wilton site, Epigem is to continue purchasing services from ICI research and manufacturing groups. (Source: *European Chemical News*, 4-10 December 1995)

AMD and NexGen

The merger of Advanced Micro Devices (AMD) and NexGen is the first sign of a shakeout in the Intel compatible microprocessor market and a testament to Intel's aggressive business strategy, which makes it increasingly harder for competitors to survive.

The merger brings together two companies with complementary strengths and weaknesses and should ensure that AMD retains some of its credibility as a supplier of Intel compatible microprocessors. AMD gains access to NexGen's Pentium-class microprocessors and its next- generation Nx686 microprocessor after major development problems with its own K5 microprocessor which is delayed until the second half of 1996.

In return, NexGen gains manufacturing capacity in AMD's state-of-the-art fabs and will not have to rely on IBM to manufacture its devices. NexGen also benefits from AMD's distribution network and its global customer base which should help it recover from lower than expected sales of its low-end microprocessors.

AMD said that it will shelve its K6 development in favour of NexGen's Nx686 microprocessor which offers an impressive performance relative to Intel's Pentium and Pentium Pro products. However, AMD will continue with its K5 product, shipping it in the second half of 1996 along with the NexGen Nx686 which will be renamed the K6.

AMD faces the onerous prospect of spending huge sums in development and production capacity and ending up with a next generation device which it can sell for not much more than its current high-end 486 parts. However, the NexGen merger will give it a short-cut to the sixth generation microprocessor market where it will be able to charge a premium and try to recoup some development costs. (Extracted from *Electronics Weekly*, 1 November 1995)

E. APPLICATIONS

Japan firms race for glass LCDs

Japanese companies are competing to come up with lower temperature polysilicon TFT processes, all of which are designed to make it possible to use glass instead of quartz in flat panel displays.

Sanyo Electric came up with a polysilicon TFT process that operates at 600°C, Sharp came up with one that works at 500°C and Sony has now announced a 400°C process.

The importance of sub-1,000°C processing in polysilicon TFT manufacturing is that it makes the technology commercially competitive with competing TFT display technologies such as amorphous silicon.

This is because the lower temperatures allow ordinary glass to be used instead of the much more expensive quartz. The value of using polysilicon instead of the conventional amorphous silicon is that the higher mobility of electrons in polysilicon allows the display's driver chips to be incorporated in the display's polysilicon substrate instead of having to be mounted on the glass.

Sharp reckons that by incorporating the driver chips in the display it will be possible to make TFT panes 35 to 40 per cent cheaper than amorphous silicon TFTs. (Source: *Electronics Weekly*, 24 January 1996)

Superconducting improves cellular phone voice quality

Superconducting technology is being used in the US to improve the noise performance and voice quality of cellular phones.

Ameritech Cellular Services reported excellent results from the use of a cellular system RF filter incorporating superconducting devices from Illinois Superconductor. Ameritech said that use of the filter at the cell site improved voice signals by more than a third and was 10,000 times more effective at eliminating interference and signal noise.

The SpectrumMaster filter also allowed more cellular phone users to access the system and increased the receive path range. There were also fewer dropped calls and an increase in the number of usable channels. Ameritech said that the filter is especially effective at cell sites that have problems from interference, either from buildings or from other radio signals. If other cellular phone system providers adopt the filter, it could open a major new market for superconducting materials and help drive the development of other superconductor-based technologies.

High-temperature ceramic superconductors continue to operate above the boiling point of nitrogen (77 K). (Source: *Electronics Weekly*, 31 January 1996)

Smart card security improved

A manufacturing technique developed at Motorola's East Kilbride, Scotland facility will provide an additional level of security for microcontrollers. This development, which will be especially important in the smart card market, allows test circuitry built into smart card chips to be removed by a precision sawing process after the completion of quality testing.

The new technique will be used first on devices to be manufactured on the company's specialized production lines at East Kilbride.

Motorola will start producing smart card microcontrollers with a 0.65 μm double-level metal process at East Kilbride. The second level of metallization will help to increase the security of smart card products. Work is also under way at Motorola to adapt existing 0.5 μm processes for smart card application.

Motorola plans to increase its smart card chip production three times over the course of this year. The company expects to produce over 500 million smart card devices per year by the turn of the century, some 10 times more than its current capability, by which time it estimates the world market will be $1 billion per year. (Reprinted with permission from *Semiconductor International Magazine*, January 1996. Copyright 1996 by Cahners Publishing Co., Des Plaines, IL, USA)

When less is more

In Germany a group of library and information leaders has been meeting to carve out a new "role" for one-person librarians. In another development, and one related to the Berlin activity, the Solo Librarians Division of the Special Libraries Association (SLA) has climbed to over a thousand members in less than four years. Although headquartered in the USA, SLA is an international association, and if there is any one spot where SLA is international, it is in this group.

What made the difference? According to the author, it is because of management policy. In almost every organization that is looking for excellence in information delivery, the policy has become to reduce the large libraries and other stand-alone information operations to departmental or divisional units, and put information delivery responsibility in the hands of one well-trained, highly efficient, highly effective information practitioner. As long as the organization needs information and as long as there is an expert information provider available to the organization to get it for them, there will be work for that librarian.

Today's managers want an information specialist who can identify what the information customers' needs are, who can find out how to address those needs, and who can cut through the layers and throw out what the customers do not need and what impedes good information delivery. They want librarians who think like one-person librarians think, who recognize that their time is limited, that their energies and their resources are limited, and yet still have a commitment to providing the highest levels of service at the highest levels of quality. (Extracted from *Library Manager*, 11 October 1995)

Path opened for ultra-high-speed optical switches

Hitachi Ltd., in cooperation with Hitachi Europe and the Cavendish Laboratory of the University of Cambridge, has announced success in electron coherent erase, making possible the creation of ultra-high-speed optical electronics operating with on/off rates of 100 fsec.

Conventionally, a light pulse is output to a device to generate an electron-hole pair, with on/off implemented through natural decay. The Hitachi test makes use of electrons' wave-like flow to control decay by amplifying the waves with a second optical pulse.

During the test, an optical pulse was divided in two, passed through separate circuits, and output to a test GaAs substrate. The timing of the arrival of the two pulses was adjusted to allow either a matching phase or an opposite phase with the generated pair. Path length adjustment was handled with a piezoelectric device capable of control in steps of several nm, and a proprietary optical path length stabilization technique. The group succeeded in erasing 70 per cent of the pair waves at 100 fsec in the test. Resulting

applications could include optical switching at the 1 fsec level, opening the way to ultra-high-speed, high-capacity optical communications. (Reprinted with permission from *Semiconductor International Magazine*, December 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

Ink dot removal using UV-ozone-heat

When a machine or operator error causes wafers to be improperly tested, a cassette full of wafers can very quickly be generated which have dies with ink dots that do not belong there.

The most common way to remove the ink dots, if they have not been baked or dried, is to use a solvent, which results in a dirty solvent to be disposed of. If the dots have been baked, there is no recourse.

A technique for removing baked dots introduced by Samco Inc. (Sunnyvale, CA) uses only oxygen and nitrogen and produces no hazardous wastes. This system, accomplished in five minutes, requires UV, ozone and heat. It involves mounting UV lamps with output at 185 and 254 nm above the wafer platen. The light at 185 nm provides the energy necessary to produce ozone, and the light at 254 nm provides the energy to dissociate an oxygen atom from the ozone molecule. The atomic oxygen then combines with the organic materials in the ink to produce CO_2 and H_2O which is then exhausted from the system. Samco's model UV-300H incorporates UV lamps, ozone generations, and a heater for the wafer platens. Because the method uses three mechanisms for removing ink dots, there is flexibility in setting up the process; for example, the UV light can be turned off during EPROM cleaning. According to Samco, this stripper/cleaner removes baked phenolic or epoxy ink dots in about five minutes without using chemistry that requires special handling for disposal. (Reprinted with permission from *Semiconductor International Magazine*, December 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

Software giant joins with Consilium to provide integrated software

At a November gathering of semiconductor industry executives in Santa Clara, CA, Oracle Corp. announced a five-year alliance with Consilium Inc. to give manufacturers integrated client/server-based software that links corporate headquarters, regional field offices and manufacturing sites. The two companies are combining Oracle's enterprise resource planning (ERP) software with Consilium's software, which is a manufacturing execution system (MES) geared to the semiconductor industry.

In the first year of their cooperative agreement, Consilium and Oracle plan on accomplishing basic information transfer between the ERP software and Workstream DFS. Afterwards, programmers will work on deeper levels of integration, new applications and enhancements to existing applications to fulfil a total supply chain management system. Engineering teams have worked on product development plans and integration project software releases should debut throughout 1996.

Since the companies are taking existing applications and finding ways of making them work together, the capital outlay required for the software modules will be reduced. If the customers already use Workstream DFS or Oracle products, the upgrade costs for the new releases will be part of their software maintenance contracts. New software modules will be created that contain increased functionality and these might be sold as discrete products. (Reprinted with permission from *Semiconductor International Magazine*, December 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

ASM introduces deep UV machine

ASM lithography, the wafer stepper maker in which Philips has a 57 per cent stake, has brought out a high throughput deep UV (DUV) machine and entered an agreement with Nissei Sangyo to sell it in Japan.

ASM has also entered a collaboration with the UK's Rutherford Appleton Laboratories to develop narrow wavelength (193 nm) DUV steppers to take chip technology up to the 0.13 μm level suitable for making 4 Gbit DRAMs, which are four memory generations away.

Although DUV steppers are only a tiny part of the stepper market—which is dominated by i-line machines—ASM believes DUV will be used for critical layers in commercial logic devices at the 0.35 μm level and in memories at the 0.25 μm (256 Mbit) level

The difference is because costs are more critical in memory manufacturing than in logic. According to Steve Wittekoek, executive scientist at ASM, it costs 50 per cent more to make a chip using deep UV than it does using i-line.

The bulk of the market now is for i-line steppers but, by the end of the decade, DUV is expected to be half the market. (Source: *Electronics Weekly*, 17 January 1996)

Low-cost, handy, high-performance specific low-power radio

Japan Storage Battery Co. Ltd. has developed a specific low-power radio GRX 100 featuring a data transmission function.

This radio enables wireless transmission of data with an RS232C interface used for personal computer connection. The volume is 229 cm^3 and it can be carried in a pocket. Compared with an ordinary specific low-power radio working in the 400 MHz band, the data transmission speed of 9,600 bit/s is doubled.

The specific low-power radio set is cordless and is most convenient for the transmission of data and information. The company has been engaged in the development and manufacture of batteries and chargers for various radio equipment. Further details from: Japan Storage Battery Co., Ltd., Corporate Affairs Department, 1, Inobaba-Cho, Nishinosyo, Kisshoin, Minami-ku, Kyoto 601. Tel.: +81-75-312-1214, Fax: +81-75-316-3005. (Source: *JETRO*, November 1995)

GPS plan takes fab to 0.25 μm

GEC Plessey Semiconductors (GPS) has unveiled its technology road map coinciding with potential fabrication capacity down to 0.25 μm. In 1996 it anticipates having its first silicon germanium chips on 0.35 μm technology.

By 1997 the company will prototype 0.35 μm CMOS production with a 3.3 V, 0.35 μm process scheduled for 1998. A 2.5 V, 0.25 μm CMOS process is expected by the end of the decade.

GPS is to pursue a more aggressive track in bipolar with 0.5 μm, 5 V and 3.3 V, triple metal layer processes in production in 1996.

The company will sample a 0.35 μm SiGe process next year with production scheduled for 1998. By the end of the decade GPS could have a 0.25 μm SiGe process. (Source: *Electronics Weekly*, 29 November 1995)

Matsushita doubles energy capacity of NiMH batteries

Matsushita is developing a nickel-metal hydride battery with a claimed energy capacity twice that of normal NiMH cells. The battery stores 300 Whr/1 compared to conventional NiMH cells which offer around 170 Whr/1.

NiMH cells offer higher energy densities than Nicads and have a lower environmental impact. They are appearing in portable products such as mobile phones and laptops, but there is some debate as to whether they will be overtaken by lithium technology secondary cells.

Lithium ion cells have higher energy densities, around 280 Whr/1 with 360 Whr/1 predicted. The Matsushita battery, if it proves to be mass-producible, brings NiMH strongly back into the fray.

AER Energy Resources of Columbus, GA, is claiming a 50 per cent increase in the capacity with a 78 per cent hike in output power for its rechargeable zinc- air batteries. AER makes batteries that fit under popular laptops, increasing their run time to over 12 hours between charges. (Source: *Electronics Weekly*, 22 November 1995)

Salford ion implanter for 1 Gbit use

Salford University has unveiled a low-energy ion implanter which will enable it to develop silicon material for 1 Gbit DRAM memory devices.

The implanter has been developed as part of a collaboration between the universities of Salford and Loughborough, and US equipment supplier Applied Materials. It will be used by the university to create advanced semiconductor processing technologies for the development of electronic devices such as microprocessors and memories.

The significance of the implanter, which is used for doping silicon prior to the lithography process, is that its extremely low (less than 5 keV) ion beam capability will fabricate the semiconductor junctions necessary for 256 Mbit and 1 Gbit DRAMs.

However, the low energy implanting technique could be an alternative to traditional e-beam epitaxy wafer fabrication for 1 Gbit DRAMs. (Source: *Electronics Weekly*, 22 November 1995)

Fax acts as scanner for PCs

Why waste all that good digital scanning and printing hardware just sitting in a fax machine? With the pocket-sized quarter-kilogram ProSX-101 from Faxmate Inc., Rolling Hills, CA, the fax acts as a scanner for any personal computer with a fax modem (phone cables are included). The scanned document, fed into any fax machine to which the unit is affixed, can then be manipulated to your heart's content—saved, edited, e-mailed, or manipulated with software for optical character recognition.

On the output side, the device can be used to replace a portable printer, say, so that rather than sending documents stored on a portable PC to an often-hoarded printer, they can be sent to a fax machine, which almost everybody has on-line and is easily accessible.

The ProSX-101, and all necessary cables, sells for $79.95. Contact: Faxmate Inc., 904 Silver Spur Rd., Suite 425, Rolling Hills, CA 90274. Tel.: 310-514-8322, Toll-free: 800-514-9337, Fax: 310-514-1333. (Source: *IEEE Spectrum*, January 1996)

Sorting out graphics for low-cost PCs

Fujitsu has revealed details of its 3-D computer graphic rendering device, developed to address the cost-conscious PC market.

The MB86271, dubbed the advanced graphics processor (AGP), performs 3-D rendering operations on geometrically transformed data. The AGP is a 1.1 m transistor device clocked at 60 MHz. It has two execution units—a microprocessor core and a computer graphics pipeline.

The core handles the AGP's main control functions. It also has two computation elements that operate on 40-bit data and share a 256 word store. The graphics pipeline performs computationally intensive 3-D graphics calculations like rendering positions, colour data, texture coordinates, alpha blending and texture mapping.

The AGP interfaces to a host processor and three distributed memory stores—a local, texture and frame buffer. The local and texture memory have a synchronous DRAM interface while the frame buffer uses video RAM.

The AGP can process 445,000 Gouraud-shaded (25 pixel) polygons a second and 15 million texels (textured pixels) a second. The AGP has been announced in Japan but has yet to be unveiled in Europe. (Source: *Electronics Weekly*, 8 November 1995)

Slow down, you talk too fast

Hitachi has introduced a Risc-based pocket-sized device that replays speech at a slower speed than it was captured at without changing its pitch. The device can aid comprehension of speech for people with hearing difficulties or for people learning languages.

In tests on 58 elderly people, 32 claimed it helped their comprehension.

The portable device is based on a 10 Mips 32-bit SH7034 Risc device and comprises a 10 bit A/D converter, 64 kbyte of EPROM, 4 kbyte of RAM and 8 Mbit of DRAM storage.

The DRAM acts as a ring buffer, storing between one and two minutes of speech. The Risc time scales the speech in software and has three speech speeds, expanding its duration by factors of 1.25, 1.33 and 1.5.

The speech is sampled at 16 kHz and stored in the DRAM buffer. The sampled data is processed frame by frame, each frame being 64 milliseconds long (1,024 samples).

To expand speech, its pitch (fundamental frequency) is detected first using the auto-correlation technique. For men the pitch is between 70 and 120 Hz. For women it varies between 100 and 300 Hz.

To expand the duration of the speech, segments of the captured signal are weighted by a triangular window function and added together. The duration of the triangular window is altered to be twice that of the speech's pitch. The overall speech is formed by adding the weighted segments. It is the ratio, in integer pitch periods, of the weighted speech segments to the summed output signal duration that achieves each of the three restrained speech speeds. (Source: *Electronics Weekly*, 8 November 1995)

What is a thyristor?

Thyristors are sometimes called silicon controlled rectifies, or SCRs. The simplest thyristor structure is a four-layer sandwich of alternating P and N type silicon. The top three layers form a PNP transistor and the bottom three form an NPN transistor. Because the middle layers are shared, the base of each transistor is inherently connected to the collector of the other.

If the cathode is made positive with respect to the anode the device behaves like two reverse biased diodes in series and does not conduct.

If the anode is made positive with respect to the cathode a thyristor will exist in one of two states, either on or off. When the anode is initially made positive no current flows in the thyristor because the centre diode junction is reverse biased. The device is off.

A third terminal, connected to one of the inner layers, is provided to allow some current to be injected into one of the transistor bases. When sufficient current flows in this terminal the associated transistor conducts, pulling current through the other transistor's base, turning it on. Current through the second transistor reinforces the base current of the first and mutual saturation occurs, turning the thyristor on.

Current through the third terminal is now irrelevant and the thyristor cannot be turned off without removing the voltage applied between the anode and cathode. The same effect is achieved by restricting the current flow between the anode and cathode to such an extent that the transistors' base currents are insufficient to hold them on.

Thyristors are made with a wide variety of current and voltage ratings, from 1 A to 6,000 A and 50 V to 8,000 V. Physically, these vary from tiny surface mount packages to 100 mm diameter hockey-puck shaped monsters.

There was a time when the thyristor was the only solid-state component capable of switching at mains voltages and its supremacy extended from watts to megawatts. Now all of the lower ground and much of the middle ground has been usurped by IGBTs and power FETs. But the venerable thyristor still holds sway as a low- cost motor controller in domestic electrical appliances and in "real" power control applications above 2,000 V.

Views differ on its future. Growth in sales is low enough for certain large manufacturers to switch to more profitable lines, others champion it as a practical solution to simple problems, while a small group of firms vie to serve the high-power market.

Thyristors and GTOs are also used for process control in mines and big mills like those making cement, paper and steel. (Extracted from *Electronics Weekly*, 24 January 1996)

DSP catches the PCI bus

The PCI local bus is a long overdue standardized solution to the PC I/O bottleneck, which has implications for DSP systems on the PC bus, and VMEbus platforms.

Unlike previous attempts to remove the bottleneck, PCI looks likely to gain universal acceptance and become as ubiquitous as the PC itself. PCI will then become the technological driving force both for new and old applications in the PC environment.

For signal processing the PCI local bus will enable a new generation of products that integrate the man-machine interface more closely with the signal processor.

For video signal processing PCI is the key enabling technology. Outside of the signal processing devices themselves, PCI will become one of the more important parts of the complete image and signal processing design.

The key benefit that PCI local bus offers is high performance: it supports 32 bit wide data transfers at a rate of 33 MHz. This translates to a peak bandwidth of 132 Mbyte/s. The specification also caters for the future using an optional 64-bit extension (offering 264 Mbyte/s peak transfer rates) and specification for 3.3 V operation as well as 5 V. PCI local bus can be used across a wide variety of host computers, and was originally designed to support high-performance computer and peripheral add-ons.

Designers have quickly spotted its potential to support massive data throughput, allowing them to use digital signal processing (DSP) to penetrate new applications. PCI local bus has other attributes, such as burst data transfers and access based arbitration. These are attractive for implementing real-time applications, which form a large proportion of the market for DSP-based products. The nature of the tasks to which DSP has been applied have helped to establish its reputation as a performance-hungry technology. (Extracted from *Electronics Weekly*, 6 December 1995)

High-temperature superconductivity gets wired

Fascinating the scientific community since its discovery in 1911, superconductivity has fallen short of its commercial promises in part because the original class of superconductors require cooling to temperatures approaching absolute zero to exhibit their magical properties. In 1986 IBM Corp. scientists in Zurich identified unique copper oxides that exhibited superconductivity at temperatures that could be achieved with liquid nitrogen or mechanical refrigeration, dubbed high-temperature superconductors (HTS). As brittle ceramics, however, they could not be easily formed into the most basic tools of electricity and magnetism management: wires.

Enter American Superconductor Corp. (ASC), Westborough, MA, and its fettucini-like composite HTS wire. Crowning eight years of composition and processing refinement, the technology blossomed in early 1995 to yield wire that provides superconductor performance in a form that is flexible enough to be wound into coils for motors, generators, transformers, and more, while at the same time strong enough to allow mechanical stranding into long cables for power transmission. Capitalizing on this new HTS wire technology, ASC realized significant achievements in 1995:

- Twenty thousand feet of HTS wire were delivered to Italian partner Pirelli Cavi S.p.A., to machine weave an electric power transmission cable conductor 100 feet long—by far the longest ever made and the first ever stranded by a machine. The wire was woven around a hollow tube that will carry liquid nitrogen for cooling. Successful commercialization of this type of cable could alter power transmission for all time, considering HTS wires can carry 100 times the current density of copper wires.
- ASC created an HTS-wire coil exhibiting a magnetic field 50 per cent higher than had ever been reported (electricity running through a superconductor creates a super magnetic field). Los Alamos National Laboratory is investigating the technology for remediation of earth contaminated at nuclear test sites, since radioactive waste has a slight magnetic moment and can be separated with super magnetism.
- ASC filled its first commercial order, an HTS current lead for an electric power grid-stabilization device designed by Babcock & Wilcox. Designed to carry large amounts of electric current, the lead achieved a world-record capacity of 16,000 amps. The device itself allows electric current to circle around without loss of energy in a low-temperature superconductor (LTS) coil, like an aeroplane in a holding pattern. It draws off current during surges and releases energy during sags to level out current flow. The HTS lead carries the electricity in/out of the coil without the attendant heat rise associated with resistance, which would increase insulation requirements of the LTS coil.
- Using ASC HTS wire for the windings, Reliance Electric Co. demonstrated a 5 hp electric motor. Forecast are HTS-based motors of more than

1,000 hp that will be half the size and weight of copper-based motors, with lower operating cost. For instance, at 5,000 hp, an HTS-based motor will save users about $170,000 in the first two years of operation because of reduced power requirements.

- ASC HTS wire was shipped to Asea Brown Boveri Group for windings in a transformer scheduled to go on line at a Geneva substation in 1996. Also, an ASC HTS wire coil was delivered to the US Air Force for a 1 MW generator prototype, and Southern California Edison/Lockheed Martin demonstrated a prototype substation-size current limiter—essentially a large industrial surge protector—based on ASC HTS wire and coil technology.

ASC is on target for introduction of its line of HTS-based CryoPower AC/DC power converters in 1997, in a market currently valued at $200 million. Supplying HTS wire to its partners for transformer launch in 1999 challenges a $3 billion market with technology that could cut the weight of these 300 ton behemoths in half, facilitating siting, transport, and manufacture. A 2,000 hp motor launch via partner Reliance Electric—in a market worth more that $1 billion based on today's technology—is scheduled for century end, as is the underground power transmission cable launch with Pirelli. Currently the underground cable market is valued at $700 million, but 99 per cent of existing cable is above ground. (Extracted from *Industry Week*, 18 December 1995)

Tagging

From automobiles to animals, prisoners to packing cases, electronic tagging is being used for identification, invoicing and inventory control.

Many types of tag (transponder) are available. All communicate using some kind of electromagnetic radiation. The variety of tags can be partitioned by frequency, programmability and power source.

Low-frequency tags work at around 100 kHz and operate through magnetic fields. To create the magnetic field, readers and tags have either a loop or ferrite rod antenna. The low-frequency operation of these tags and the need for resonant operation mandates high inductance coil antennas. To fit in the many turns needed, makers have resorted to wire 6 μm in diameter.

High-frequency tags work at several gigahertz and use printed aerials.

Earlier tags were not programmable; they could only be read. That is to say, their response to reading was fixed.

Now more sophisticated tags are available that can be written to as well as read. Contactless smart cards are sophisticated read-write tags.

Tags are either active or passive. The power source in an active tag is a battery.

This tag type has a longer range—up to 50 m or more, and a higher data rate.

The battery constrains the tag to a finite lifetime, but in some cases this is as long as 10 years. Most road tolling systems use active tags although passive types for this application are becoming available. Passive tags are powered by the interrogation signal. Range is generally around a metre, but Norwegian company Micro Design offers a passive tag that has a range of up to 8 m.

Passive tags can be further split into half-duplex and full-duplex types. A half-duplex tag stores a pulse of interrogation energy in a capacitor, then transmits its data using the stored charge. A full-duplex passive tag absorbs a continuous flux of interrogation energy and retransmits on a different frequency, often half the incoming one. Tags are available with anti-clash circuitry to let a number of tagged items be scanned at once. The British Technology Group's Supertag has this and can be read at the rate of 50 per second.

Some tags are very small. AEG makes a passive read-only tag 12 mm long and 2.2 mm in diameter.

Only slightly larger is Texas Instruments' passive read-write tag which is 33 mm long and 4 mm in diameter. Both are chemically inert.

They can be moulded into robust packages for mounting on structures or hidden inside things like antiques, guns and bicycles. Some of these small tags can be injected into live animals. Larger tags tend to have better antennas and consequently longer ranges. (Source: *Electronics Weekly*, 17 January 1996)

The mobile industry dilemma

The rush to buy mobile phones is creating a dilemma for the cellular telephone network operators and frequency planners. Where can we go in the radio spectrum to accommodate all these users?

The usual response from network operators like Cellnet and Vodafone is to apply to the Government for more radio channels. But cramming more and more users into the 900 MHz GSM band is getting more problematic. So the availability of higher frequency radio bands at 1.9 GHz is seen as the way forward in many countries. Most notable is the UK's licensing of the 1.8 GHz for personal communications network (PCN) services, which is being repeated in many European countries particularly Germany and most recently France.

In the US the 1.9 GHz band is being licensed for the next generation of PCS digital mobile phone networks, as it is in Japan. In addition, the two emerging digital cordless telephone standards—European DECT and Japanese personal Handyphone system—both use the same 1.9 GHz band.

Inevitably the world will not harmonize on a single-frequency band for mobile communications, just as it seems incapable of fixing on the one speech coding protocol for all cellular telephone networks. One result of this is that radio frequency (RF) circuit designers are busily looking into the practicalities of multiple-frequency systems.

A mobile telephone working on GSM at 900 MHz and DECT or PCN at 1.9 GHz is the next product for most mobile phone makers.

The digital circuits developers are already well along the route towards a programmable baseband processor design that can adapt to the various speech and radio channel encoding protocols. But switching the radio frequency is not so straightforward.

One circuit element of the mobile phone's RF front end is the IF/RF converter, which converts the call signal contained in an intermediate frequency (IF) carrier into an RF signal for transmission over the radio channel. The frequency synthesizer creates a stable oscillator signal source. There are also the signal switches, needed to switch between the transmit and receive data paths when design requires sharing of the IF and RF circuits. And there are the power amplifiers.

Combining the GSM cellular phone with a DECT cordless handset seems to be less attractive to manufacturers than a dual standard and frequency cellular telephone. A GSM handset which will work on DCS1800 microcells in urban areas could be a solution to capacity problems in areas of high usage.

The first commercial dual-mode handsets are likely to be GSM 900 MHz and DCS 1,800 MHz.

GEC Plessey Semiconductors' approach is to combine two synthesizers in the one IC. The NJ88C50, which uses a fractional-N interpolator letting the phase detector in the phase-locked loop run at different multiples for the required channel frequency, can be used to generate 900 and 1,800 MHz signals for a dual-mode GSM.

Duplicating elements of the RF circuits, particularly the power amplifiers, may seem like clumsy design, but it seems to be the only practical option for the next two years.

Another level of integration would be possible using a single 1,500 MHz synthesizer which can be switched between the GSM and DCS 1,800 frequencies. But essentially the RF transmitters will remain separate, making it difficult for manufacturers to keep the cost of the first generation dual-mode phones down.

The pressure is likely to build in the market for dual-mode handsets as plans for mobile satellite phone systems start to take shape. The frequencies allocated for the satellite phone service by the World Radiocommunications Conference in 1992 were 1,980 to 2,010 MHz for the up-link and 2,170 to 2,200 MHz for the downlink. One operator, the Motorola-backed Iridium Group, which plans to start launching its first satellites this year, intends to base its service on dual mode GSM/satellite handsets.

The logic of the mobile phone that will work on any network irrespective of frequency is clearly attractive to the cellular phone industry. It is possible that all the RF chip designers require is a nudge to make it happen. (Source: *Electronics Weekly*, 17 January 1996)

F. SOFTWARE

Microsoft in Satcom interface

The exchange of files between shipboard PCs and office networks ashore is set to be transformed following the development of a new wireless interface. It will link wireless communication networks with electronic mail (e-mail) products from the world's leading producer of software for personal computers.

The Inmarsat Wireless Messaging Technology (IWMT), developed by global satellite communication provider Inmarsat in conjunction with the UK's Paragon Software and Telesis North of Canada, provides a simple and effective interface between Microsoft Exchange and a number of wireless networks. It has been fully endorsed by Microsoft.

In essence, IWMT is a set of tools for software developers. It will allow their products to incorporate "seamless" communication between mobile Microsoft Exchange users and the local area network (LAN) Microsoft Exchange mail servers in their offices. The communication can take place across a variety of mobile data networks, including the global Inmarsat-C service, cellular radio and packet radio.

The advantage for software developers, says Inmarsat, is that the IWMT allows them to build a communication facility into their products that overcomes the problems inherent in wireless networks without themselves having to acquire a specialized knowledge of these networks.

For end-users of IWMT-based software, this is likely to result in the ability to exchange files and messages easily between remote PCs and office LANs, using the same simple procedures for each wireless network, regardless of its particular characteristics.

End-users will simply select the appropriate network "driver" and the IWMT-based software will automatically prepare, address and send the communication in the correct manner.

In addition to Microsoft, three key communication companies—Motorola subsidiary ARDIS, AT&T Wireless Services and Vodafone Group subsidiary Vodata—have endorsed IWMT. More than one million people throughout the world currently use the mobile data transfer services provided by these three companies.

The first software product to incorporate IWMT has been launched by Paragon Software, one of the companies responsible for the development of the technology.

Paragon says that Precis Link brings remote transport support to applications written to the Microsoft application programming interface. It offers in-built features that greatly reduce network traffic and associated costs, such as remote control of viewing and re-routing messages and the removal of all non-essential data prior to transmission. (Source: *Ocean Voice*, January 1996)

Document management system

Document management systems with their ability to track information means that they are taking on a key role within businesses. However there is still some resistance to their implementation, as people still maintain that they like the feel of paper. It is no good attaching a document management system to an existing network without considering the heavy burden that graphical images make on a system compared to simple word processed files. Indexing and the use of OCR packages in the retrieval process and then free text searching can slow down the system even more.

Large corporate businesses use a variety of information systems according to the nature of the information. MR-Data is a service supplier which has long been involved with the transfer of mainframe information to microfiche (COM) and now also to laser disk (COLD). Their disaster recovery facility with 24-hour operation and one-hour turn-around for City users is proving popular. Clients can have direct on-line access to their files. COM is still seen as the ideal long-term retention medium with a guaranteed lifespan of 150 years. Microgen offers a similar range of services and fast demand publishing.

For medium-sized companies, Principal Communications aim to assist in making businesses more effective. Not only do they market the Minolta MIMS 3000 image management system but also assist with the implementation of work-flow procedures. Canon, a pioneer in document imaging for the small business are now marketing the Canonfile 510. The latest version of its CF-File+ software includes networking and it can be integrated with existing databases via Dynamic Data exchange. SimpliFiler from Bell Howell is another entry level system. It costs £12,000 including PC and scanner. Panasonic, Fujitsu and Lanier UK also provide small systems. IMI Computing, specialists in office automation, working with business partners in the fields of workflow and document management, offers a range of services where document management forms only part of the solution. (Extracted from *Business Equipment Digest*, September 1995)

Optical character recognition

Optical character recognition (OCR) software expands the range of tasks which can be achieved with a computer, and is now available in a number of price/capability bands, aimed at different categories of user. This article reviews six OCR packages.

EasyReader Classic (£199), from the French company, Mimetics, was fairly fast and performed well. It had a built-in dictionary, could identify all printed or typed document formats and character sizes between 6 and 72 point. *EasyReader Elite* (£399), in addition enables scanned text to be saved in one of more than 50 word processing formats with their original layout and attributes.

In 1994, Caere merged with Calera, so *OmniPage Pro 6.0* (£595) and *WordScan Plus 4.0* (£495) now come from the same source. The former first appeared in 1988, and it is probably the world's best-selling OCR software. New features include Direct Input, providing integration with word processors, and a new Page Parser, which improves the identification of text and graphic regions within a document. *WordScan* features a new recognition engine which works with whole words rather than individual characters, giving a claimed 40 per cent improvement in accuracy.

Readiris 3.05i (price not available) is supplied by Florida-based Image Recognition Integrated Systems. Designed as a low-cost product, it is frequently bundled with a range of hard- and software packages, such as the free-text database *AskSam* and low-priced scanners. It is fully-featured, but did not perform well with poor text.

TextBridge Pro 3.0 (£349), from Xerox, is easy to use, powerful, fast and probably the best buy in terms of price and performance. (Extracted from *Personal Computer World*, November 1995)

Security first for digital networks

US firm, Scientific Atlanta, has become the first broadband communications product supplier to license powerful data encryption techniques for digital network security enhancement.

Scientific Atlanta has licensed from RSA Data Security its public key cryptographic techniques, and from Cylink a licence to use such methods. The use of cryptography is seen as paramount if interactive network services are to be established.

The technology is to be used by Scientific Atlanta for its Powerkey conditional access system. Powerkey will be used in set-top terminals, head-end components and network management software to enable the confidential delivery of broadcast and interactive services.

Using the public key approach, network operators can exchange securely subscriber details such as credit card details, while authenticating a sender's identity and guaranteeing the integrity of the message.

For other network service applications such as digital video transmission, the Powerkey system will use secret key algorithms. These will provide data security at a higher speed of operation. (Extracted from *Electronics Weekly*, 17 January 1995)

Maths and display software

DSP Development has made freely available a student edition of its DADiSP mathematical and display software on the World Wide Web. DADiSP is a menu-driven graphics-based package that allows the user to mathematically manipulate such data items that include matrices, images, waveforms and signals and view the results much like a spreadsheet. For signal analysis, the student edition offers nine windowing functions for data weighting, and can analyse vectors up to 1,000 samples long. The software can be accessed at: http://www.dadisp.com (Source: *Electronics Weekly*, 17 January 1996)

Microsoft changes operating system

Microsoft is planning major changes to its operating system design that will enable computer companies to develop a wide range of powerful systems at lower costs and could challenge Intel's Native Signal Processing technology.

According to reports, Microsoft will produce new versions of its Windows 95 and Windows NT operating systems based on a software architecture called the Simply Interactive PC.

The architecture is designed to make it easier for PCs to become information appliances, to run games software, and to improved communications features for Internet applications.

The Simply Interactive PC design does not mean that Microsoft will scale down its operating systems; rather, it will simplify the system software design so that it unites Windows 95 and Windows NT. (Source: *Electronics Weekly*, 17 January 1996)

EDI software made simpler

In a step to make the Internet a secure alternative to traditional electronic data interchange (EDI), Premenos Technology Corp., Concord, CA, has joined forces with UUNet Technologies, Fairfax, VA, one of the premier Internet service providers in the USA. The alliance combines Premenos' popular "Templar" EDI software suite, which enables confidentiality, data integrity, user authentication and built-in security—all necessities for secure, end-to-end transmission over open public networks—with a range of UUNet's business-class services, including network access and customer support.

For more information, visit the Premenos WWW site at http:///www.premenos.com. (Source: *Industry Week*, 4 December 1995)

Video rolls onto the Internet

Today, downloading video from the Internet is tedious, taking as long as 30 minutes to capture a one-minute snippet of video—if you have the right software. But VDOnet Corp., Santa Clara, CA, claims its new "VDOLive", technology circumvents bandwidth limitations and will make desktop video broadcasting commercially viable. Based on a compression technique that shrinks digitized video and communications protocol that preserves its data integrity, VDOLive is able to run real-time video at speeds of 10 to 15 frames per second using a 28.8-baud modem.

For information: E-mail *infoVDOLive.com.* (Source: *Industry Week*, 4 December 1995)

How to chart and graph like a pro

DeltaGraph 3.5 Pro is a state-of-the-art charting and graphing package for Microsoft Windows and Macintosh platforms. The company behind it, DeltaPoint, claims it is the most comprehensive charting package available for business and scientific applications.

The package's chief selling point is its wide variety of charting styles—notably, over 60 two- and three-dimensional types. Several are intended for scientific users, among them being radar, contour, statistical, vector, and assorted 3-D surface and scatter plots. A number of other scientific features, such as nine types of curve-fits, six error bars, and logarithmic scaling, are also available.

All told, these charts and features form a flexible and powerful environment for putting together technical presentations. DeltaGraph 2.0 users will find many worthwhile improvements in version 3.5. The most noticeable is the redesigned user interface, where an added command bar now provides shortcuts to many of DeltaGraph's features. Page layouts have also been added to organize charts, text, title and graphics automatically into a single page. Favourite custom layouts, together with a collection supplied with DeltaGraph, may be stored in a library for later use.

Data can be entered by hand, imported from files, or linked from other programs into an interface that is much like a standard spreadsheet. The software now supports Microsoft OLE 2 (object linking and embedding), so that dynamic links may be established with a database or spreadsheet or a similar data source.

To spruce up a presentation, graphic images can be imported for illustrations or backgrounds or else used directly to represent data in a pictographic format. Most of the standard graphic formats are accepted. Furthermore, DeltaGraph supports a cross-platform compatibility, so that charts and graphics can be shared between Windows and Macintosh platforms without needing any translation.

In sum, DeltaGraph 3.5 Pro is a powerful and flexible charting and graphics package with many features tailored to the scientific user. That means considerable power for the reasonable retail price of $195.

Contact: DeltaPoint Inc., 2 Harris Court, Suite B-1, Monterrey, CA 93940. Tel.: 408-648-4000; Fax: 408-648-4020. (Source: *IEEE Spectrum*, December 1995)

Software piracy

According to the Business Software Alliance (BSA), 43 per cent of the software used in the UK in 1994 was pirated.

In Turkey and Central Europe, piracy rates exceed 90 per cent. Software publishers claim that their losses in Europe alone in 1994 amounted to $6,000 million. As a result, BSA has launched an aggressive campaign aimed at raising awareness of the problem.

As part of this, it established a freephone "Crimeline", inviting informers to report the use of illegal software in their organizations. About 400 calls have been received. BSA and its lawyers "raided" the Trowbridge premises of Cow & Gate, discovering almost a hundred illegal programs in use on the site. Normally, however, BSA puts its allegations in writing and invites the organization to accept an audit.

Although some individuals believe they are entitled to make copies, the commonest reason for the use of pirated material is lack of management control. At the London Borough of Tower Hamlets, for example, 204 illegal copies of software were discovered across several sites. The organization has now introduced an automated software inventory system and new auditing procedures.

Recently, Microsoft introduced a free auditing program, *Legal Ware*, which enables users to check which programs are in use on the network. Some critics of the software industry, however, point out that little or no effort is being made to simplify the complex procedures involved in software licensing. Agreements come in a variety of forms and are constantly changing, making compliance with legal requirements more difficult. Another positive action, they aver, would be to offer more generous discounts for the purchase of multiple licences. (Source: *Management Today*, November 1995)

Some guidelines for creating World Wide Web home pages

The World Wide Web has become an important resource of timely information for the information professional. It has also brought the concept of electronic publishing within reach of any person who has browser access to the Internet navigator and thus allows the information professional to take part in the publishing process by creating and maintaining a home page on the Web.

The first step is to establish a goal or objective for a specific home page. Examples of these could be to provide a well-marked, logical point into the organization's information; clearly, accurately and attractively provide an organization's presence or corporate image on the Internet; provide a multi-media presentation about the nature and business of an organization; or to provide access routes to other information resources such as Gopher, Archie and WAIS.

Sound planning is also key in developing a good home page environment for a specific organization. By studying other existing examples of home pages, incorporating good qualities and avoiding bad ones, the home page author can find substantial ideas to follow. The needs of the potential user of the home page must always be kept in mind and a feedback mechanism such as a fill-in form should be included to guarantee timely and consistent feedback from visitors to the home page. The home page also conforms to certain interface standards, which include requirements about the use of colour, graphics, motion and text. (Source: *The Electronic Library*, 13(4) August 1995)

Dynix's NetPublisher: Web publishing for libraries

NetPublisher is an integrated World Wide Web document editor, server and monitor developed for libraries by Ameritech Library Systems. The Editor allows you to design the overall structure of a publication and organize the information into a hierarchy. Management of the hypermedia links between the different parts of the document is facilitated with a Windows drag and drop interface and integrated image map management software for creating and editing clickable images. Catalogue information may be attached to any document or resource within the publication.

The server listens for incoming requests from the network, checks the port from which the request came and interprets the request based on the protocol assigned to that port. The server retrieves the information and sends a response back to the user using the same protocol. World Wide Web, Z39.50 and Gopher protocols are all concurrently supported. The server also maintains a log of transactions. The monitor controls the server, configuring the server parameters and displaying the status of the server and the server transaction logs.

NetPublisher provides a number of major benefits when preparing and managing a publication of substantial size. Firstly, a list of items which are available to the publication are maintained in alphabetical order on the left-hand side of a vertically-split screen. Items may be added to the list by dragging and dropping from the Windows NT file manager. Secondly, the structure of the publication is represented on the right hand side of the screen by a directory structure of folders and icons which will be familiar to users of Windows or Windows NT. (Source: *Vine*, 9 June 1995)

Scholarly foraging and network discovery tools

A huge variety of information sources is available to modern scholars by electronic means. Recognition of this fact prompts questions as to how they discriminate between sources, and in particular, why they select some and not others. The essentially disorganized nature of the World Wide Web suggests that scholars are likely to adopt what is termed a "foraging" strategy in order to retrieve information. They will select different areas at different times for different purposes, and search them with varying levels of intensity.

Such an approach is not best served by tools devised to exploit the orderly, structured world of conventional (commercial) on-line databases. Concepts such as recall and precision are no longer necessarily valid. Whereas commercial databases tend to be highly focused, those on the Web are broad, diffuse, fluctuating and even unstable. The search strategy must perforce be characterized by attempts to *manage* this breadth and diversity.

We might expect scholars to seek novelty—new concepts and insights—to stimulate their own researches. If this is the case, there are implications for the design of the search tools to be employed. Specifically, the emphasis must shift from matching to "foraging". Tests using *WebCrawler*, however, were disappointing as regards the generation of *useful* novel associations with search terms. More research needs to be done in such areas as defining "patches" where foraging takes place, the manner in which it is undertaken, and the mechanisms necessary to make novel items available to scholars. Only then are more relevant search tools likely to appear. (Source: *Journal of Documentation*, 51(4) December 1995)

Subject searching for information

Unlike commercial on-line databases, the Internet does not offer access to structured and indexed collections of information. The difference between the two systems may be expressed in terms the technologies employed: commercial on-line databases provide a content and retrieval facility, the Internet does not. On-line databases reside on a central host

accessed by dumb terminals: on the Internet all computers are equal as regards communications.

The differences extend to the quality of the information provided. At present, there are no systematic procedures for validating the material offered, nor are any guarantees made that the information will be available on a continuing basis. Commercial data tends to be presented as a structured database, accessed by an (often proprietary) query language. Material on the Internet tends to be unstructured text with no classification or organizing system applied.

Network browsing tools such as *Archie*, WAIS, VERONICA and JUGHEAD provide only rudimentary facilities for retrieving information by means of keyword searches. Similar tools—described using terms such as *spider*, *web wander*, *worm* and *robot*—are appearing for searching the World Side Web (WWW). One of the better ones if ALIWEB, which enables the user to specify a query profile which incorporates AND/OR operators and other conditions.

Since 1991, librarians have established a number of working groups to examine the possibility of cataloguing networked resources systematically on the basis of cataloguing rules and standard representational formats. (Source: *The Electronic Library*, 13(5) October 1995)

Virtual instrument package for Visual Basic

National has developed a collection of 32-bit virtual instrumentation add-on controls and libraries for Visual Basic 4.0. Called Component Works, the tool set is compatible with multiple development environments and does not suffer from the array-handling limitations of Visual Basic extensions (VBX).

ComponentWorks comprises four major functional components: drivers for IEEE-488 instruments; data-acquisition (DAQ) controls; analysis libraries; and graphical user interface (GUI) controls for creating meters, knobs, real-time graphs, and so forth. For maximum flexibility, the OLE controls and data-linked libraries (DLLs) can be combined with 32-bit OLE controls from other vendors.

The IEEE-488 drivers are standard 32-bit DLLs for more than 70 instruments from Hewlett-Packard, Tektronix, Keithley, Fluke, Wavetek and others. They are based on National's Lab-Windows/CVI driver library, the standard established through the VXI-plug&play Systems Alliance.

The data-acquisition controls are strictly for controlling National Instruments' data-acquisition hardware. As might be expected when the hardware and software come from the same vendor, the controls make DAQ programming particularly easy. All that is required is assigning a set of DAQ properties. When the hardware data buffer is full, the control simply passes the data array to a Visual Basic application for processing.

Two different analysis libraries are offered. The standard Analysis Library, which comes with the Component Works Base Package, calculates basic statistical quantities such as the mean, standard deviation, maximum, minimum, and so forth of an array. The advanced Analysis Library comes with the Full Development System. It does signal processing, curve fitting, signal generation, complex algebra, matrix operations, fast Fourier transforms, filtering, and so on.

The Base Package sells for US $495; the Full Development System goes for $895. Contact: National Instruments Corp., 6504 Bridge Point Parkway, Austin, TX 78730-5039. Tel.: 512-794-0100; Fax: 512-794-8411; Toll-free: 800-433-3488; E-mail: info@natinst.com; *url*: http://www. natinst.com. (Source: *IEE SPECTRUM*, January 1996)

RF/Analog simulation library

Users of SystemView, the Microsoft Windows-based visual simulator for signal electronics, now have available a library containing models of analog circuits and components. With it, for example, users can generate Bode and root locus plots with a single mouse click.

The library includes fixed and variable amplifiers, op-amps, several types of power splitters and combiners, couplers, and diodes. It also makes available resistor-capacitor differentiators, resistor-inductors, low-pass and high-pass R-C and L-C filters, PLL filters, LC tank and quad circuits, and coupled resonator pairs.

The host application, SystemView, supports mixed-mode (analog and digital) multirate systems, parallel simultaneous systems, and internal or external data sources and sinks. Graphical templates can be used for design of analog-digital filter, discrete linear time, and continuous-time Laplace linear systems. Modifications to the design can be displayed in the time, frequency or phase domain.

SystemView, at $2,450, requires a minimum of 4 MB RAM and 3 MB disk-space on a 386 or higher computer running Windows. The RF/Analog library costs $525; other libraries for communications, DSP and logic are also available. Contact: Elanix Inc., 5655 Lindero Canyon Rd., Suite 721, Westlake Village, CA 91362. Tel.: 818-597-1414; Fax: 8181-597-1427; E-mail: elanix@elanix.com; *url*: http://www. elanix.com (Source: *IEEE Spectrum*, January 1996)

Debugging Windows 95 applications

Windows 95 lets application vendors build their wares from pre-constructed software components. But the use of components to build code can also have a drawback: the difficulty of isolating the ultimate cause of bugs in programs built from them.

Debugging a Windows 95 application is even harder than debugging most code because it may use both 16- and 32-bit components. These components may include 16-bit Visual Basic eXtensions (VBXs), 32-bit OLE Component eXtensions (OCXs, essentially 32-bit VBXs), dynamic-link libraries (DLLs), and other Windows 95 executables (EXEs).

What developers of Windows 95 applications need is a system-level debugger—one that in effect understands the subsystems and commands of the operating system but works independently of its system code. Such tools function in much the same way as a hardware debugger (for example, an in-circuit-emulator, or ICE) that collects data about a program as it executes without interfering with that execution.

Fortunately for developers, Nu-Mega Technologies Inc., Nashua, NH, is now delivering just such a debugger—the first for Windows 95. Soft-ICE for Windows 95 contains utilities for reverse engineering the VBXs, OCXs, DLLs, and EXEs called by a developer's prenascent application so that a component's precise operations become visible.

Thus, when the application interacts with a component, the developer can see how the two work together and thereby isolate a bug's cause. This is the software equivalent of an ICE's bond-out processor, which adds extra leads to the interior circuitry of an ordinary processor so users can see what occurs inside the processor as the software executes. Contact: Nu-Mega Technologies Inc., Box 7780, Nashua, NH 03060-7780. Tel.: 603-889-2386 (Source: *IEEE SPECTRUM*, January 1996)

Visual programming

Graphical interfaces running on a powerful computer are the basis for Rapid Application Development (RAD) environments, which reduce the time required to complete the initial top-down development phase of program development.

Of these graphical interface techniques, visual programming is one of the most promising. Pointing and clicking a mouse is enough to select and connect the icons of already existing programming modules. A visual application builder converts the icons into a program framework, which is then stored as source code or even as compiled code.

The first RAD programming tools were meant for use by part-time programmers. Novell Inc.'s AppWare, for example, was introduced as a point-and-click tool for graphically constructing simple network applications. The tool proved so effective that Novell plans to create another version of AppWare, one that will build both desktop and network applications using components in the Novell Office and in AppWare.

RAD tools are also being developed for professional programmers. IBM Corp. introduced the first RAD product for C++ programmers when the VisualAge C++ compiler for OS/2 arrived in stores in July 1995. With VisualAge, C++ programmers can build entire SQL database applications without writing a significant amount of code.

The biggest drawback of visual programming is the sluggish performance of the applications. AppWare runs at a crawl (as it were) on a 25 MHz 386 computer with 4 MB of memory; AppWare developers need at least a 33 MHz 486 computer with 8 MB of memory. VisualAge is almost unusable on a 33 MHz 486 computer having 16 MB of memory: VisualAge developers need at the least a 90 MHz Pentium with 24 MB of memory. For AppWare, contact Novell Inc., 2180 Fortune Dr., San Jose, CA 95131. Tel.: 408-473-2300; For VisualAge C++ for OS/2, contact IBM Corp., 1133 Westchester Ave., White Plains, NY 10604. Tel.: 800-342-5572 (Source: *IEEE Spectrum*, November 1995)

Electronic pay-per-piece information is coming to the corporate desktop

Electronic information floods corporate PCs, sweeping away money and time in an endless stream of digital data. Peter Sprague, the former chairman of National Semiconductor Corp., swam his share of information distribution channels—CD-ROMs, on-line services, the Internet and databroadcasting. He disliked the search for information and the associated costs. So in 1988 Sprague formed Wave Systems Corp., New York, and developed an electronic metering system, WaveMeter, for the distribution and retrieval of electronic information on a pay-per-piece basis. WaveMeter, he says, provides a cost-effective option for gathering precise information and, for information providers, an automated electronic collection mechanism that could be a prototype toll booth for the Internet.

WaveMeter consists of software and a patented integrated circuit built into a PC card, PCMCIA adapter, or motherboard, and uses the Data Encryption Standard to lock and unlock information that comes to a PC.

To get that information to the desk-top PC and to a WaveMeter, Wave Systems is targeting CD-ROM, the Internet, and databroadcasting delivery.

Pay-per-piece access, says Sprague, makes available information that was as a whole cost-prohibitive. Wave Systems has conducted beta tests with both Dun & Bradstreet and Standard & Poor's for delivery of their research materials. An agreement with Harvard Medical International, a subsidiary of the Harvard Medical School, will result in the creation of a medical library by Wave Systems. The library, in traditional form, would consist of 600 volumes of medical and biomedical journals and cost more than $100,000. The proposed digital form will be a few compact disks or accessed by need off the Internet, costing on average $200 per year, projects Wave Systems.

Sprague says WaveMeters will also be able to track pay-per-use software from CD-ROMs and other digital media. He says this application will strengthen software copyrights by giving corporate users a legitimate and affordable means to obtain limited-time usage of software programs instead of fraudulently passing existing, expensive applications to additional users.

WaveMeter logs data usage and sends the information to WaveNet, a processing centre that manages transactions, data encryption, credit and royalties. For CD-ROM data, WaveMeter users initiate the WaveNet connection via modem; with databroadcasting it is periodical and transparent. (Internet delivery and fee processing to WaveMeter should begin this year with the distribution of the medical library.)

Network News uses Verity Inc. software to full-word index and tag all wire stories. The complete newswire feeds with tags will be databroadcast to corporate-site software built on a Windows NT platform and distributed to PCs over a local area network. The feeds will be filtered at corporate sites in real time against user-set profiles and relevance rankings. Stories above the predetermined relevance ranking will be immediately purchased and filed, and the user notified.

Sprague says WaveMeter data-broadcast technology costs $6,000 to $8,000 to install (server, software, satellite dish, and CD-ROM carousel), and users pay monthly connect, story and Verity annual service fees. Network News projects these costs to be as low as one-tenth of competitors' pricing. (Source: *Industry Week*, 22 January 1996)

PROductivity From Information Technology (PROFIT)

The PROFIT Initiative is based at the Massachusetts Institute of Technology's Sloan School of Management. Its key objective is to study the use of information technology in both the private and public sectors to enhance productivity in many areas ranging from finance to transportation, and from manufacturing to telecommunications.

Research at MIT shows that the likelihood of success in utilizing information technology to increase productivity is a function of several technical and non-technical factors. To attain success, there are three prerequisites—a careful determination of strategic applications, an intelligent selection of technologies, and an ability to incorporate appropriate changes in the organizational structure. The absence of even one of these factors will lead to failure.

In spite of all the technological advances that have occurred during this century, white-collar workers still spend a large amount of their time retrieving information from various sources in order to perform their respective jobs. Some pieces of the information reside on computers of different makes and types; other pieces exist on paper and other traditional media; and still other pieces must be accessed through personal interactions. With growing complexity of applications, the overhead involved in managing and integrating relevant pieces of information is a major barrier to enhancing productivity.

One of the original objectives of the PROFIT Initiative was to define new business processes required in gaining productivity from information technology. The consortium was also expected to develop key technologies for the support of these new business processes and make data a truly valuable corporate resource. It is increasingly clear that business success through the use of information technology requires a careful and delicate interplay between the three components that represent the basis for this: Strategic Applications, Technology and Organizational Research Initiative (SATORI; Webster definition: "a state of enlightenment").

Strategic issues

The strategic uses of information technology include the identification of new business opportunities and the enhancement of value to the customer. The potential diversity of applications ranges from the ability to create just-in-time distribution networks (that can be tailored to respond to a sudden surge in demand) to the creation of new cross-product markets (e.g., a financial institution uses credit card information to encourage buyers to increase their insurance after the purchase of new jewellery). The PROFIT Initiative has analysed the creation of such opportunities and the development of systematic methodologies for monitoring enhancements in technology and the corresponding impacts on overall profits.

Organizational issues

Information technology can enhance productivity only when the organizational structure is modified to benefit fully from the new technology. Research shows that different organizational and sub-organizational units possess dissimilar goals and strategies, and it is unrealistic to make the assumption that they will participate and cooperate to the extent necessary to attain success. This makes it necessary to identify the optimal set of roles and responsibilities of the key participants, along with a delineation of their rights, privileges, and liabilities in areas such as proprietary information and ownership of data. The PROFIT Initiative has analysed the methodology of focused standards and other issues concerning the process of making controlled changes in complex organizational environments.

Technical issues

Productivity from information technology requires improvements in the data gathering, quality analysis, integration, and aggregation stages.

Data Gather: A considerable cost and effort is incurred in many organizations to gather necessary data. New technologies provide opportunities to dramatically mitigate this problem. For example, the advent of new image-oriented techniques provide the ability to scan and interpret information directly from source inputs. A prototype application for reading amounts on bank checks, developed at MIT, shows the potential for dealing with the large set of data required by management that does not currently reside on computer media (e.g., letters, memos, drawings, annual reports); a patent application is currently being processed by the US patent office.

Data Quality: A parallel initiative on Total Data Quality Management (TDQM) methodology is looking at techniques required to analyse, measure and improve data quality. Results from TDQM are incorporated into the PROFIT Initiative, as appropriate, to mitigate the problems caused by erroneous and incomplete data.

Data Interpretation and Aggregation: The effective integration of information from disparate sources (e.g., dissimilar hardware, software, data syntax and semantics) to create new knowledge is a key area addressed by the PROFIT Initiative. The Composite Information Systems Tool Kit, an integration framework developed at MIT to demonstrate advanced techniques in connectivity and context knowledge in interchange, has been enhanced. Further, techniques to move information from one environment (i.e., context) to another continue to be merged with existing data repository and warehouse technologies to provide productivity gains in large-scale operations.

PROFIT Initiative membership

The original target of the PROFIT Initiative was to attain a research base of $950,000 per year by the end of 1995; this target was attained in July 1994. New organizations can still join PROFIT, provided they commit at least $95,000 per year, or $250,000 for a three-year period.

Charter members are eligible to: (i) attend PROFIT seminars and symposia organized at MIT and elsewhere; (ii) serve as study or test sites for PROFIT research activities; (iii) receive the PROFIT discussion papers; (iv) utilize the knowledge gained from this program in their respective organizations; (v) have access to prototype software developed by the PROFIT research team; (vi) gain from valuable interactions with PROFIT research team members and other charter members of PROFIT; (vii) gain from interactions with members of the PROFIT Advisory Committee and directors of PROFIT.

For more information, please contact any of the following members of PROFIT:

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(Source: *Communication from MIT*)

G. COUNTRY NEWS

China

China — A vast electronics market on the horizon

The US market, which carried the electronics industry over the past several years, is headed for a slower rate of growth, causing manufacturers to re-evaluate investment and expansion opportunities abroad. As China begins to open its borders and markets to the outside world, electronics have emerged as the leading industry. Manufacturers are looking to China, a virtually untapped market, for investment and growth opportunities well into the next century.

China's policy of economic reform has been in effect for the past 15 years, gradually allowing the world into its markets. This policy has resulted in China achieving the most aggressive growth rates in the global marketplace—an average annual growth rate of 9 per cent over the entire 15-year time span. The electronics market has been the primary engine propelling this astounding growth, averaging over 20 per cent annual growth in the 1990s.

As a result of this performance, the Chinese Government has looked to its electronics industry as a cornerstone of the national economy. Thus far, consumer electronics have taken centre stage. However, communications and computers have taken a strong foothold, increasing rapidly over the past five years.

The communications market has grown 40 per cent over the past five years, as additional types of communications equipment evolve. The cellular arena has attracted enormous attention, with 1.57 million cellular mobile users by the end of 1994. By the year 2000, projections estimate there will be eight million cellular phone users.

While the Chinese Government has recently established a company to specialize in the design and production of mobile phones and systems, Motorola had captured 80 per cent of the phone market, and Ericsson 70 per cent of the base installation market, by the end of 1994. The expansion potential for foreign telecommunications companies is tremendous. Projected investment of $41.8 billion over the next five years would only increase the installed base to eight users per 100 people in the entire country.

The Chinese computer market has also been experiencing astounding growth, with exorbitant potential over the next 10 years. From 1991 through 1994, PC sales increased 6.1 times, for a total of 718,000 units in 1994. In 1995, growth rates are projected at 25 per cent, as PC sales approach one million units.

Opportunities are further created for foreign manufacturers of electronic components as Chinese manufacturers have been gearing up for domestic production of personal computers. The evolution of this industry has increased the Chinese demand for ICs and components by 60 per cent from 1990-1994. Demand for foreign supplies should increase by 20-30 per cent annually. Currently, 1.7 billion chips are used per year in Chinese production, and chip demand is projected to escalate to three billion pieces by the year 2000. Chinese manufacturing capacity is expected to be able to produce less than one billion pieces at that time, offering an enormous surplus to foreign competition.

Currently, foreign manufacturers hold approximately 80 per cent of the production/distribution of electronics products in China. In response to these expansive growth opportunities, manufacturers have begun to establish a presence in the Chinese market, both as joint ventures and foreign direct investment. (Reprinted with permission from *Semiconductor International Magazine*, January 1996. Copyright 1996 by Cahners Publishing Co., Des Plaines, IL, USA)

Siemens in China

Siemens says it will have invested $1 billion in China by the end of the decade and will have sales there of $10 billion in the year 2000. It already has 30 joint ventures under way in the country with 20 more under review. By the year 2000, it expects to employ 30,000 people in China and 50,000 in Asia as a whole.

Siemens is expecting that Asia will contribute 20 per cent of the company's sales revenues by the year 2000—up from 10 per cent this year.

Siemens is anticipating a 15 to 20 per cent sales increase in Asia over the next five years. (Source: *Electronics Weekly*, 22 November 1995)

France

Titanium silicide deposition research

CNET (Centre National des Études de Télécommunications, the R&D section of France Telecom, Grenoble, France) has entered a joint development agreement with Applied Materials' High Temperature Films Division. The agreement covers process development work on titanium silicide deposition to be performed in CNET's laboratory. The aim is to develop alternatives to existing titanium silicide processes for use at the base of the contact structure of CMOS devices and the process chamber hardware. The work is part of the GRESSI (Grenoble Submicron Silicon) programme. (Reprinted with permission from *Semiconductor International Magazine*, January 1996. Copyright 1996 by Cahners Publishing Co., Des Plaines, IL, USA)

Germany

Research into polymer blends

The German Federal Ministry for Education, Science, Research and Technology has provided DM 4 million ($2.8 million) funding to a research project into high performance polymer blends being pursued by BASF in cooperation with two Japanese universities. The three-year cooperation focuses on the development of production technology for new types of high temperature resistant blends for use in the electronics industry. BASF will carry out synthesis of the basic polymers, including polyether sulphone, polysulphone and polyamide and blends. The Japanese partners, Tokyo Institute of Technology and Kyoto University, will have the responsibility for characterization of the blends. (Source: *European Chemical News*, 4-10 December 1995)

Italy

Biochip island

A research laboratory could turn the tiny island of Elba into a hotbed of bioelectronics. The laboratory, named Technobiochip, is the brainchild of Claudio Nicolini, a bio-

physicist at the University of Genoa. In 1989 Dr. Nicolini convinced five companies to invest together in a laboratory that would do research in the fledgling field of bioelectronics. Carefully, he chose firms that were not direct competitors, such as SGS Thomson, a micro-electronics company and Raggio Italgene, an Italian biotechnology company.

Technobiochip has a budget of about $6 million a year for some 20 researchers since it opened in 1991. The result is an extremely well-equipped laboratory. Although much of research carried out there is very long-term, the industrial involvement puts pressure on the researchers to develop devices that are useful at present. One example is a biosensor that can detect the minute amounts of recombinant DNA used to make drugs. Such applications have commercial value.

The original venture has now split into two. Technobiochip Manufacturing will further develop the most marketable ideas. To complement Technobiochip's activities, the "National Bioelectronics Pole" has been opened in the town of Marciana. Among its research preoccupations are neural networks.

There are plans to convert a fourteenth century fortress into the Elba Foundation, dedicated to more fundamental research in bioelectronics and supported by the Italian and Russian Governments as well as several American foundations. The Russian connection has already proved fruitful for Technobiochip, supplying the laboratory with well-trained scientists, hired on short-term consultancies to keep overheads to a minimum. Together, the various institutes will form the Elba Science and Technology Park, one of 13 such parks being built throughout Italy. (Source: *The Economist*, 9 September 1995)

Malaysia

Malaysia's first wafer fab planned

A new project designed to propel Malaysia into the ranks of Pacific Rim countries like Taiwan and Singapore that provide leading-edge semiconductor manufacturing technology has been announced by the Government of Malaysia and Sarawak and the Sarawak Ministry of Industrial Development (MID), in tandem with banking and other private investors. The goal of the project is the development of InterConnect Technology, billed as the country's first state-of-the-art semiconductor manufacturing facility.

Interconnect will be the largest high-technology investment in Sarawak, requiring $1.3 billion in construction and development costs. The Sarawak MID has devised an aggressive economic restructuring programme to focus State funding on the acceleration of the electronics industry. This policy includes a conducive environment for high technology companies, including competitive prices for industrial land, tax incentives, a skilled workforce and a government-funded training programme.

Funding for this project will be a concerted effort among state and federal Governments, quasi-governmental groups such as Sarawak Economic Development Corp. (SEDC), the Malaysian private sector, US banking partners and technology and customer partners. (Reprinted with permission from *Semiconductor International Magazine*, December 1995. Copyright 1995 by Cahners Publishing Co., Des Plaines, IL, USA)

United States of America

Foreign firms aim to enter US Sematech

Europe's big three semiconductor companies, Philips, Siemens and SGS-Thomson Microelectronics are negotiating an entry into Sematech, the joint industry/government semiconductor R&D consortium in Austin, Texas.

European companies have been lobbying to get into Sematech ever since it was founded in 1988. The Americans have consistently rejected participation, arguing that by receiving US taxpayers' dollars they could not be seen to be delivering benefits to non-US concerns.

Now, Sematech has formed a separate legal entity to pursue a project which is not taxpayer funded: the conversion from 8- to 12-inch wafers.

This is potentially so expensive that Sematech probably wants foreign participation. So far only six American companies have signed up to it.

The big three Korean companies, Samsung, Hyundai and LG Semiconductor, also plan to join the 12-inch project, dubbed the International 300 mm Initiative (I300I).

In addition, a Taiwanese company is expected to join. The project will start at the end of March 1996 and last 18 months. A continuation programme to the year 2000 is envisaged. (Source: *Electronics Weekly*, 6 March 1996)

US frequency cash to help start-ups

The vast sums of money raised by the auctioning of frequencies in the US is to be used to help entrepreneurial start-up companies in the US telecommunications industry.

The money comes from interest earned on payments sent to the US Federal Communications Commission (FCC) by the auction winners for frequencies and operating licences in particular geographical areas. The sums involved are huge.

In the next 10 years, it is expected that the sale of frequencies and licences will generate over $10 billion. This will make available funds for entrepreneurs of over $1 billion a year. A federal fund has been set up to handle the money, already amounting to over $100 million.

It is expected that the first payments from the fund will be made within three to six months. (Source: *Electronics Weekly*, 28 February 1996)

US launches microwave programme

The US Department of Defense's Advanced Research Project Agency (ARPA) has launched the Microwave and Analog Front End Technology (Mafet) programme.

The project follows the success of the recently completed ARPA project addressing microwave and millimetre wave monolithic integrated circuits (MIMICs), a seven-year endeavour that advanced considerably the design and manufacture of RF integrated circuitry.

The three-year Mafet programme is designed to focus on the next level of assembly and will address the development of EDA tools for the design of multi-chip assemblies. Here, each analog function is implemented in the most appropriate process technology before being integrated within a module. (Source: *Electronics Weekly*, 17 January 1996)

H. STANDARDIZATION AND LEGISLATION

Standardization

Chip makers battle for DRAM in PC standard

A battle is on to see who will define the standard for the DRAM used in PCs for the rest of the century. The DRAM makers, the PC makers, JEDEC and Intel are all involved.

Intel has mooted a standard to the DRAM makers and Fujitsu has counter-proposed one to Intel. JEDEC—the standards body—has yet to choose any particular route.

In the meantime NEC and Samsung—the world's two largest DRAM makers—have said they will standardize on NEC's synchronous DRAM standard called SDRAM Lite.

The two companies plan to harmonize about 30 specifications, including set-up and hold times, by the summer. NEC says that the current cost of SDRAM—about 10 to 15 per cent more expensive than conventional DRAM—is expected to come down to the same level as conventional DRAM next year. NEC is completing development of its third-generation SDRAM with samples expected in the second quarter.

NEC and Samsung, with a quarter of the world DRAM market and half the world SDRAM market between them, hope they have the clout to establish a standard. However, they are up against Intel, which is proposing a cut-down version of 16 Mbit SDRAM to avoid much of the expense of testing, so reducing the price of SDRAM to that of conventional FPM DRAM.

Fujitsu is said to have offered its own standard to Intel on a sole supply basis and Samsung is said to be talking to Intel about a sole source supply deal on the Intel standard. (Source: *Electronics Weekly*, 24 January 1996)

Rivals sound out DVD standard

The competition to become the dominant multichannel audio standard shows no signs of a winner as industry experts question the validity of the latest round of tests.

The main protagonists are Dolby with AC-3 and the MPEG group with MPEG-2 and its Musicam variant.

The current battle ground is DVD, where a compromise solution is being discussed, but the prize will be domination of the whole market in the same way that VHS is the dominant video tape format.

AC-3 is being recommended for the US version of HDTV, but MPEG-1, with which MPEG-2 is backward compatible, is already installed in many multimedia computers.

The last time the two systems, and others, were formally tested against each other was by the BBC and Deutsche Telekom in 1994. Tests were performed at a bit rate of 320 kbit/s, lower than the 384 kbit/s allowed in US HDTV and DVD's 448 kbit/s. AC-3 and MPAC from AT&T were declared "statistically better" than several MPEG variants, but none of the systems tested were judged to be of broadcast quality.

Late last year the Advanced Television Service Advisory Committee, which is choosing the audio system for US HDTV, is reported to have declared the AC-3 system to be "transparent". This means that its output is indistinguishable from the original unprocessed programme material. Dolby has not been slow to announce these results, but industry experts continue to have significant reservations over the test method.

Both Dolby and Philips, who co-designed MPEG-2, have much to gain from licensing their system and both claim to have better, fully acceptable, quality at 384 kbit/s.

Technically AC-3 is a simpler system if only multichannel audio is considered. The five channels (or "5+1" if the low rate bass channel is considered) are independently compressed. The bit streams are dynamically fitted into the allotted bandwidth and either stored or transmitted as required.

On reception or playback the five channels are extracted from the bitstream and separately decompressed.

If a Dolby stereo (like that from conventional videos) is required, the bitstream is run through a Dolby Surround Sound encoder matrix to generate the two channels. These two can then also be fed into a Dolby Pro-Logic decoder matrix to produce four channel surround sound.

The MPEG-2 system is more complex. The 5+1 channels are processed by a matrix to form modified signals before compression. Two of these, which are akin to normal stereo, are processed by an MPEG-1 encoder to produce MPEG-1 audio similar to that used in PCs. The other signals are encoded in an MPEG-2 extension encoder to make an auxiliary bit stream that is added to the MPEG-1 stream. The resultant stream is then stored or broadcast.

Decoding this bitstream is performed by a conventional MPEG-1 decoder and an MPEG-2 extension. These regenerate the intermediate audio signals, which are converted to the original 5+1 audio streams by a further matrix.

When a full blown 5+1 system is required, the MPEG system has the disadvantage that it has two matrix operations that AC-3 avoids. The advantage is that acceptable stereo, which is likely to be what the vast majority of users want initially, can be extracted with an MPEG-1 decoder. These are in production and are fitted in many home computers already.

Assessment of competing systems is difficult. Certainly laboratory tests for bandwidth can be made. But traditional "quality" measurements like those for total harmonic and intermodulation distortion (THD and IMD) are irrelevant. This is because of the large amount of sub-audible information discarded during encoding. Therefore testing relies on listening tests.

The International Telecommunication Union—Radio (ITU-R) lays down strict criteria for listening tests. These require the test subject to compare a known reference source with two mystery sources. One of these is again the reference while the other is the reference source which has undergone the process under test. The listener is required to determine which of the mystery sources is which. If no difference can be detected, the process is declared "transparent" by the listener. Further to this the listener can grade the processed sound on a five-point scale between "very annoying" and "imperceptible".

To test the listener, some deliberately degraded sounds are introduced into the sequence of tests.

An industry expert said "Last year's tests are questionable because the listeners passed the deliberately distorted signals as transparent as well."

The criterion for broadcast laid down by the International Telecommunication Union— Radio (ITU-R) is that artifacts and distortions in the programme material may be "perceptible, but not annoying". (Source: *Electronics Weekly*, 24 January 1996)

Intel and Microsoft back new standard

PC technology suppliers Intel and Microsoft have put their backing behind the industry standard T.120 PC videoconferencing protocol, a move which represents a change of heart for Intel.

Intel had been championing its own videoconferencing standard before changing its plans to support the T.120 International Telecommunication Union standard. Intel and Microsoft will join in interoperability tests scheduled for later this year that will make sure that desktop videoconferencing products from different vendors will work together.

The companies believe that open standards will increase the number of desktop videoconferencing users and that users and vendors will benefit. As many as 250 companies have been invited to take part in the tests. Interoperable solutions are critical to the widespread deployment of conferencing capability.

Intel is working with Microsoft and industry leaders to enable customers to use interoperable conferencing to solve the real-time decision-making requirements of business. (Source: *Electronics Weekly*, 31 January 1996)

Handy standard for PCS market

Pacific Bell Mobile Services, Ericsson, Nokia, Hewlett-Packard, IBM and BellSouth Personal Communications have said they will collaborate on creating standard application program interface (API) standards. This will ensure that PCS 1900 customers have a standard method for wireless access to faxes, e-mail, information services and corporate computer systems.

The companies will release the recommendations in advance of the commercial introduction of PCS 1900 services in mid-1996. The PCS 1900 communications networks are based on a higher frequency and higher quality flavour of the European GSM cellular system.

The companies involved in standardization efforts believe that the current lack of a standard API is an obstacle to the development of PCS services which will attract consumers. Market research company Frost & Sullivan predicts that the US wireless market, which includes PCS, will grow to $92.5 billion by 2001. (Source: *Electronics Weekly*, 31 January 1996)

Wireless LAN hopes rest with US standards body

Early in 1996, the IEEE, the US standards body, is expected to give the wireless LAN market an important boost when it finalizes the long-awaited 802.11 wireless LAN protocol. The 802.11 specification supports 2 Mbit/s data rates over a radio link in the unlicensed 2.4 GHz band, called the ISM band in the US, using spread spectrum radio technology.

The move will allow manufacturers to lower the cost and improve availability of wireless LAN products just as the technology is under attack for its lowly 2 Mbit/s data rate. The LAN market, which takes 10 Mbit/s Ethernet as its baseline and is moving to 100 Mbit/s technology for multimedia applications, provides the biggest barrier to widespread wireless LAN use. (Extracted from *Electronics Weekly*, 6 December 1995)

Computer quartet to standardize fast fibre channel interconnect

Western Digital, Compaq, Sun Microsystems and AMP have joined forces in order to standardize high-speed fibre channel interconnect used in computer applications.

They are jointly developing a set of specifications to be made available early in 1996.

Based on this specification, Western Digital is currently sampling an optical-to-electrical transceiver module, the OE1063SW, that supports data rates of up to 1.062 Gbit/s. This module implements the fibre channel physical layer—to the ANSI standard—which allows OEMs to take advantage of lowpower and higher reliability for clustered and switched applications. (Source: *Electronics Weekly*, 29 November 1995)

Sharc spawns module interface standard

The Sharc Floating-point DSP from Analog Devices has gone the way of the transputer and the TMS320C40 in having its own module interface standard. The module, called Sharcpac, is the result of collaboration between Ariel, Analog Devices, Bittware Research Systems and Ixthos.

A combination of DSPs, memory and I/O modules can be accommodated on the module. Bittware already offers a range of Sharcpac modules including single, dual and quad Sharcs, SRAM and DRAM modules.

The Sharcpac interface comprises 48 bits of data, 32 bits of address, eight interrupts, eight flags, 16 link ports and four serial links.

The Sharcpac standard will be made available to developers at http://www.analog.com (Source: *Electronics Weekly*, 1 November 1995)

System-level design gets IC specification

After two years' passage through numerous technical committees, an IC modelling specification for system-level design has finally been standardized. The Input/Output Buffer Information Specification (IBIS) was ratified as EIA standard 656, opening the way for easier signal-integrity analysis across a system.

EIA 656 formalizes IBIS version 2.1, encapsulating enhancements to version 1.1, which was released to the public domain in 1993. EIA 656 is compatible with the original version.

IBIS describes the analog characteristics of an IC's I/O buffers. Using this information, engineers can then perform accurate signal-integrity analysis of the interconnection network using one of the many Spice simulators.

The manager for Intel's microprocessor group and chairman of the IBIS committee, says "there is no question" IBIS will become widely used. The process of generating a model has been automated from Spice decks. IBIS is supported by a growing number of IC vendors including Intel, Motorola, National Semiconductor, NEC, Texas Instruments and VLSI Technology.

IBIS models are capable of any level of accuracy and Intel's experience has shown the effort needed to build them is not "inordinate". (Extracted from: *Electronics Weekly*, 6 December 1995)

Legislation

Legal structure of the Internet

The fact that no single person or organization owns or controls the Internet means that in the event of any grievance, there is no single person against whom legal

action can be brought. A well-understood predecent, however, does exist which helps to explain how law might apply on the Net.

An analogous situation is that which prevails in containerized shipping, where no single firm is responsible for the entire process. Rather, there are owners of containers, ships, delivery vehicles, cranes and so on. In similar fashion, information may be published on the Internet by one person and "handled" or distributed by many organizations.

Given this, it is a fallacy to speak of the Internet as being unregulated. Fraud, for example, is still fraud, whatever the medium used to perpetrate it. Moreover, much of the technology used by the Internet has been available for decades, and its application understood in legal terms. Copyright law, for instance, has adjusted to the introduction of computer-based systems, although admittedly problems such as those of "virtual copying" on the Internet do present novel questions.

The issue of trade marks raises a number of concerns, relating to the impact on existing licensing agreements and more specifically on Internet "domain names". Trade marks are frequently licensed for a specific geographical territory, so problems would arise if they appeared on the Net, which recognizes no boundaries. Domain names are a related but different concern: they are allocated on a first-come, first-registered basis, without reference to existing intellectual property rights. This could give rise to a domain name being registered which resembled an existing trade name. There are, however, possible legal remedies under existing legislation. (Source: *Aslib Proceedings*, 47 (11/12) November/ December 1995)

New developments in intellectual property rights protection and access for electronic documents (EC projects)

The European Commission is funding two new projects into managing access and protection for intellectual property. IMPRIMATUR (Intellectual Multimedia Property Rights Model and Terminology for Universal Reference) will be led by the Authors' Licensing and Collection Society in London. It is a horizontal project with a wide perspective. A network server will be established, based in Italy. It will aim to prove that rights can be dealt with in a networked environment and will use Lotus Notes and copyright management software. Every message passing through the system will be treated as a type of intellectual property right, paid for through one of the partners. There will also be a World Wide Web site, with information about the project and reports on progress, regularly updated.

The second of the two projects, COPEARMS (Coordinating Project for Electronic Authors' Right Management Systems), will be investigating cooperation with EC-funded vertical projects. Led by Brussels-based Bureau van Dijk, one of the major aims of the project is to develop the CITED (Copyright in Transmitted Electronic Documents) project and to work on standardization to allow interoperability of electronic copyright management systems (ECMS) and to transmit design experience to the information industry at large.

Other copyright-related projects already under way include COPICAT (Copyright Ownership Protection in Computer Assisted Training). COPICAT-protected material is held in a wrapped form. In order to unwrap and read the material, unwrapping keys are needed, held securely within an electronic licence. COPICAT protects material in transit and is able to provide protection while the material is in use. (Source: *Information Management Report*, December 1995)

Using technology to protect intellectual property

The increasing use of networks brings the possibility of unauthorized copying of material made available over it. A number of systems are under development intended to monitor usage and charge accordingly.

Infosafe Systems, for example, is developing an external device which will reside between the network (LAN or WAN) and whichever device is making use of the information content, whether this is remote or local. The first application of this is Design Palette, a CD-ROM library for the graphic design market. This contains 30,000 items of clip-art, fonts and stock photographs from twenty-six suppliers. Those leasing the disc pay $39 a month, plus usage charges for individual items.

Wave Systems employs an internal device, a chip known as the WaveMeter, supported by the transaction processing network, WaveNet. A modem is used to transmit data to the clearing house or individual publisher. The company has also established the Network News Corporation to distribute newswire services, again charged for on a per-item basis.

EPR Electronic Commerce Technologies is trying to develop a general purpose management system which is not dependent upon hardware. Each document will have a series of usage rules attached to it, which will determine whether it can be copied or printed. The system should be very flexible, although it would be complex for both publishers and users to administer.

ICL has developed an electronic publishing system, Commands, for use on the World Wide Web, which features rights control and payment systems. Other systems include Ç-Dilla and Ivy.

The main problems facing all such systems are commercial rather than technical. They will have to gain the confidence of publishers and be accepted by users. (Source: *EPJournal*, 9(5) October 1995)

TRW files patent on satellites

TRW has made the first move in its battle with Inmarsat by getting its intermediate Earth orbit satellite system design patented in Germany.

The issuing of three "utility models" by the German patent office is a significant move towards TRW's first full European patent. Such a patent if granted could affect the plans of UK-based satellite operator Inmarsat which plans to launch its own mobile phone service using intermediate Earth-orbit satellites.

The three aspects of TRW's design covered by the action include the use of three orbital planes below 10,000 nautical miles where at least one satellite is visible to the mobile phone at a minimum elevation angle of 10 degrees. TRW has similar patents in the US, and is filing for patents in Japan and China as well as Europe.

TRW's US patent covers the concept of medium Earth orbit (MEO), describing a communications satellite from 5,600 to 10,000 nautical miles above the Earth's surface.

The altitude of the satellites is crucial to the technical design of the proposed global mobile phone services. Geostationary satellites have been ruled out because of the unacceptable 360-390 ms delay introduced on calls.

Low Earth orbit satellites offer the shortest delay at around 150 ms, but large numbers of LEO satellites, as many as 66, are required to offer continual coverage. MEOs are attractive because they strike a balance between delay, at 200 ms and the numbers of satellites required which could be as low as 10. (Source: *Electronics Weekly*, 29 November 1995)

I. RECENT PUBLICATIONS

Is electronic publishing viable?

Most publishers view the future for electronic publishing as uncertain, not because they cannot see the potential of the technology, but because they are unsure of the extent of acceptance of electronic information products in the marketplace. In assessing the viability of electronic publishing it is important to consider all costs and to view the electronic product in its context as part of a publishing portfolio. Costs associated with the production of electronic and print products can be viewed as falling into three categories: database costs, distribution media costs and overhead costs. Database creation is often common to both the printed product and any equivalent electronic products. The costs associated with database creation, editing and processing tend to be fixed costs that depend upon the size of the database. Output costs are different for the different distribution media. For print, the cost depends partly on the length of the document, while the creation of a CD-ROM incurs costs associated with the creation of the master and then per-copy costs for each copy. Whereas print costs rise with the number of volumes, CD-ROM costs remain the same. Lastly, there are overhead costs associated with running a publishing operation, which can be allocated to two activities: commissioning and editing, and marketing.

Strong recovery in the world engineering industries in 1994 and 1995. New study published by UN/ECE

The world engineering industries are in the phase of recovery. In 1994, they came out of a deep recession which had its trough in 1992—in the United States the trough occurred in 1991, while in Europe it did not arrive until 1993. Engineering production surged by over 6 per cent on a world-wide basis, by 10.5 per cent in the United States while in Europe it stopped at 4 per cent. The engineering industries in Europe were harder hit by the recession than in other regions. Between 1990 and 1992, production fell by 4.2 per cent per year and by 6.4 per cent in 1993. The United States, on the other hand, has had booming growth in the engineering industries since 1992.

In periods of recession the engineering industries normally show less growth than manufacturing as a whole. This, however, is more than compensated for during recovery when the engineering industries expand significantly faster than the rest of manufacturing.

These are some of the conclusions made in a new UN/ECE publication, *World Engineering Industries and Automation: Performance and Prospects 1994-1996.*[*] This publication analyses the development of gross output, value added, employment, investments, R&D and trade for over 40 countries based on time series data starting in 1986. Part II of the publication presents detailed statistical data on production and trade for 20 major engineering product aggregates as well as on the financial performance of the world's major companies producing these products.

[*] *World Engineering Industries and Automation: Performance and Prospects 1994-1996.* Sales No. E.96.II.E.5, New York and Geneva, 1996, United Nations Sales Section, Palais des Nations, CH-1211 Geneva 10, Switzerland. Price: US$75. For more information about the publication contact: United Nations Economic Commission for Europe (UN/ECE), Industry and Technology Division, Palais des Nations, CH-1211 Geneva 10, Switzerland. Tel.: +41-22 917 3285; Fax: +41-22 917 0178.

Re-engineering the elephant: Organizational alternatives for accelerating Internet access in Africa (by Chambliss Neil, Lee W. McKnight, and Richard J. Solomon, Massachusetts Institute of Technology, Center for Technology, Policy, and Industrial Development Research Programme on Communications Policy, 16 May 1995)

This is a white paper prepared for the United Nations Development Programme in cooperation with the World Bank, the US National Aeronautics and Space Administration, the US Agency for International Development and the US Department of State.

The report sets out organizational alternatives for accelerating Internet access in Africa through enhancing cooperation among donors and service providers. First, the authors outline the technologies on which the Internet depends. Second, they review the economic context for developing networks. Thirdly, they identify and briefly describe major considerations affecting development of the Internet in Africa on the part of Africans and of donor organizations. Finally, the authors identify three alternative organizational arrangements accelerating Internet development and recommend the creation of an African Internet Forum. This new organization, consisting of representatives of African Internet service providers and donor organizations, would be a loose association that would establish a cooperative to buy international transmission, offer technical support to African service providers, and offer a meeting place for those providing services and those wishing to invest.

World Telecommunication Development Report 1995

The barriers that once separated the three sectors of the information industry—telecommunications, computing and audiovisual—are breaking down, so that each sector can now process and exchange information in digital form. Technological convergence is creating a new range of multimedia products and services. Public computer networks, such as the Internet, are becoming the basis for new forms of electronic interaction between individuals and companies. The talk is of fibre-based *Information Infrastructures* which will herald a new era of information access and electronic entertainment. The 1995 *World Telecommunication Development Report* examines the way telecommunications network operators, service providers, Governments and users around the world are preparing for a multimedia future. The report has been written from the perspective of the telecommunications sector. For that reason, it is concerned primarily with the way in which multimedia services are likely to be communicated and networked, rather than the equally interesting aspects of software, content and hardware. While firms active in the audiovisual and computing sectors may find much here to interest them, the aim of the report is to focus on the implications for telecommunications service providers.

The report is structured around specific themes. *The Information society* examines the transformation of the world economy from industrialization to informatization and the economic impact of the information industry, both in its own right and as a catalyst for other industries. The implications of information infrastructures for trade and employment are examined, as is the relevance of advanced communications facilities for developing countries. *Information industry convergence* provides an overview of the world-wide communications market and the forces bringing the telecommunications, entertainment and computing industries closer together. *Visions of the information superhighway* reviews different national policies aimed at promoting an information society. *Corporate strategies* examines telecommunication company strategies in light of growing competition and diversified services. *Building information infrastructures* looks at technologies for switching, transmission and interacting with geographically dispersed multimedia resources. *From voice to multimedia* covers the likely applications that will be available over information infrastructures. *Regulation in a multimedia world* looks at new regulatory issues emerging in the construction and operation of information infrastructures, including reconciling the different regulatory regimes for telecommunication, broadcasting and computing, and resolving the international disputes that are likely to arise. *Hype or reality?* examines how ready the world is for multimedia, when it might be here, and who will be the likely winners and losers.

The World Telecommunication Indicators forms the second part of the report and presents the latest comparable data available on the development of communications services in some 200 economies world-wide. As well as providing the traditional range of telecommunication indicators, this section has been extended for this edition to cover other communication statistics such as cable television, personal computer markets and Internet access.

Copies may be obtained from ITU Sales Department, International Telecommunication Union, Place des Nations, CH-1211 Geneva, Switzerland. A World Wide Web version can be found at the Internet address http://www.itu.chp/WTDR/95.

TECHNOLOGY AND INVESTMENT OPPORTUNITIES

TECHNOLOGY REQUESTS

COMPUTER AIDED DESIGN
An engineering and management consultancy organization is seeking to introduce computer aided design and drafting, software and hardware to improve quality and speed of delivery of their services. The estimated total project cost is US$ 450,000 and 80 per cent of their work is directed towards the domestic market.
Specification of technology requirement: Know-how, training, equipment and managerial skills.
Proferred mode of cooperation: Joint venture, sub-contracting and equipment supply.
Year established: 1991
No. of employees: 10
Annual turnover: US$ 200,000.

(For futher information, please contact:
Mr. Matthew B. Munyagi, Managing Director, EM Consultants Ltd., P.O. Box 5579, Dar-es-Salaam, Republic of Tanzania; Tel. +255-51-30215; Fax: +255-51-112-754)

HYBRID CIRCUITS AND SURFACE MOUNT ASSEMBLY
Technology relating to the manufacture of hybrid micro circuits and surface mount assemblies for printed circuit boards is required. A new project in a high market growth area with an estimated project ost of US$ 4 million. Planned output is 2,250,000 units at 80 per cent capacity by the third year. A feasibility study has been completed.
Year established: 1948
No. of employees: 1,102

(For further information, please contact:
Mr. K. N. Hari Kumar, The Printers (Mysore) Ltd., No. 75 M.G. Road, Bangalore 560 001, India; Tel: +91-80-558899; Fax: +91-80-5587096)

PRINTED CIRCUIT BOARDS
Technology for the manufacture and processing of printed circuit boards is required to replace manual operations. A high demand market with substantial levels of imports and an estimated project cost of US$ 345,000.
Type of cooperation: Joint venture
Year established: 1989
No. of employees: 17

(For further information, please contact:
Mr. Victor P. George, Victor Process, II490, Erattayal, Kodumbu P.O., Palakkad, Kerala, India; Tel: +91-491-28544/538464; Fax: +91-491-29522)

AUTOMATIC TEST EQUIPENT FOR PCBs
Technological help required for the production of automatic test equipment for populated and unpopulated printed circuit boards for incporporation into air, water and noise pollution measuring, monitoring and control instruments.
Type of cooperation: Investment, joint venture, sub-contracting, licensing, turnkey project, equipment supply
Year established: 1960
No. of employees: 180

(For further information, please contact:
Mr. D.V.S. Raju, Managing Director, Elico Ltd., 309 Model House, 6-3-456/A/1, Punjagutta Hyderabad 500 082, India; Tel: +91-1111140-22222.7265; Fax: +91-40-31.9840)

TELECOMMUNICATION EQUIPMENT AND SYSTEMS
A wide range of this equipment is sought, including: SDH optical communication equipment; wireless in local loop (WILL) products; CDMA systems; radio trunking systems; higher order multiplexing equipment; digital multiple access rural radio systems; microwave communications equipment; and V-SAT terminals. All the equipment is needed to meet the estimated requirements for the Indian telecommunications market in the year 2000 (telephone density estimated to increase from 1 to 5-6 per cent of the population). Local investment currently available is US$ 3,563,000.
Type of cooperation: Investment, joint venture, sub-contracting, licensing
Year established: 1985
No. of employees: 317

(For further information, please contact:
Mr. P. Kailasnath, Senior Manager, Karnataka Telecom Ltd., KSCMF Bld. (annex), 8 Cunningham Road, Bangalore 560 052, India; Tel: +91-80-225.3428/7026; Fax: +91-80-2253208/8520965)

EXPERT SYSTEMS IN A CONTROL ENVIRONMENT (MacDonald Dettwiler)

Expert systems will play a major role in the next generation of control decision-making (intelligent) systems. Expert systems have been developed for use in a wide variety of applications: planning, fault detection and rectification, integration and testing. These systems are all based on a commercial shell and are developed using the same rules, methodologies and processes for translating human knowledge into data. The product would be a generic expert system directed towards system control. It could be tailored towards a specific economic sector with base expertise built into the shell. The service would be the provision and implementation of an expert control system to perform specific tasks/decisions in a mid-sized manufacturing facility.

Main use: The most likely target markets would be suppliers of products to the resource industry sectors. Services would be required by mid-sized firms or in sectors that are historically not large users of advanced information technologies.

Main advantages: This technology could be used by systems integrators and suppliers to several sectors of the economy in which intelligent control is just becoming recognized as a useful system specification. (For example, forestry, mining, agriculture and manufacturing). Generic expert systems could be developed for each of these sectors, coupled with a defined rules engined to allow human expert knowledge to be included. They could be coupled with the sensor integration/control technology to produce a next generation of intelligent control.

Degree of development: Laboratory or prototype

Know-how available: Yes

Available for license

(For further information, please contact:
Mr. Pierre Herbert, Manager, Industrial Development, Canadian Space Agency, 6767 route de l'Aeroport, Saint-Hubert PQ, J3Y 8Y9 Canada; Tel: 514-926-4456; Fax: 514-926-4448; E-mail: herbertp@sp-agency.ca)

CD-ROM MULTIMEDIA TRAINING PACKAGE FOR WORK TEAMS

This 12-hour computer-based CD-ROM multimedia training package is aimed at introducing the "work team" concept to the public sector and private corporations. This project is now ready to be marketed.

Main use: This project has resulted in the creation of a template that can serve as the framework upon which to build other management training material. The company expects to be able to produce two more projects based on this technology by the end of 1995.

Degree of development: Production

Know-how available: Yes

Type of license sought: Joint venture

(For further information, please contact:
Mr. Nick Bakyta, President, Tinsel Media Productions, 6838 – 82 Avenue, Edmonton AB ,T6B OE7 Canada; Tel: 403-465-0811; Fax: 403-466-8399)

GEOGRAPHIC INFORMATION SYSTEM (GIS) SOFTWARE

The core of the company's strategy is the concept of building a simple open system of spatial data management. This approach extends GIS well beyond traditional applications by simplifying its use and leveraging client investment in existing software tools and sources data such as autocad graphics and database information from such industry standards as Oracle, R.Base, dBase, etc., by combining PC host databases, graphics and imaging technology, client server architecture and multimedia together within a sophisticated spatial database.

Main use: Linking traditional database management systems to industry standard autocad graphics to create applications for municipal infrastructure information systems, public utility systems, water and wastewater treatment facilities, real estate and asset management or related demographic analysis.

Main advantages: Uses industry standard autocad and database management systems in a PC-based environment. Includes leading edge features such as dynamic segmentation, network tracing and polygon processing not normally found in PC-based technology. Use of industry standards allows for less expensive training costs. Open architecture linkage-based software provides simpler integration with existing application specific software products.

Degree of development: Production, appropriate for developing nations

Know-how available: Yes

Available for license

(For further information, please contact:
Mr. Len Exner, Manager, Corporate Relations, Kanotech Information Systems Ltd., 575 Park Street, Regina SK, S4N 5N2 Canada; Tel: 306-721-2362; Fax: 306-721-2474)

SOFTWARE PRODUCTS IN AGRICULTURE, LAND RESOURCE MANAGEMENT AND ENVIRONMENTAL ASSESSMENT

A software system integrated with air photo images, farm, field or soil landscape maps and global positioning system with full editing and data import capabilities. FarmView MIS(c) – a crop production record keeping system with graphical map presentations. LandView Fertilizer (DSS(c) – A farm fertilizer analysis, recommendation and

decision support system. Includes: air photo and map presentations, soil landscape attributes mapping, field sampling and laboratory communications module, fertilizer blending calculations, fertilizer order form and an economics module.
Main use: Fully integrated tools for information and records management, planning and decision support in land resource management and environmental sustainability applications in the agricultural energy sectors. The systems manage spatial information with a realistic and visual presentation.
Main advantages: The products may be used as a market advantage in marketing other mainline products and services.
Degree of development: Production
Know-how available: Yes
Joint venture sought

(For further information, please contact:
Mr. Paul Barlott, Director, BCL Landview Systems, No. 600, 10665 Jasper Avenue, Edmonton AB, T5J 3S9, Canada; Tel: 403-448-7476; Fax: 403-421-1270)

PROGRAMMING AND CONTROL ENVIRONMENT
A hierarchical control architecture has been developed for industrial automation work cells. This control architecture allows the integration of robots, vision systems and force sensors. The architecture is PC based and is structured to accommodate communications with Programmable Logic Controllers and servo-motor control boards. The control architecture is modular, thereby allowing the same core software to operate with different peripheral devices. For example, if a different robot were required, the user need only replace low-level configuration and translation files while the higher-level code would remain unchanged. Similarly, different vision systems can be accommodated through generic communications protocols.
Main use: Manufactureres with variable work environments (e.g. frequent retooling non-uniform or random parts) would benefit from this technology. Also, system integrators would benefit from the relative ease with which peripheral devices could be included within the environment.
Main advantages: Because TSL contains implicit vision commands, uncertainties in object pose are resolved with a great degree of autonomy. This feature makes the aarchitecture well suited to flexible manufacturing environments.
Degree of development: Laboratory or prototype
Know-how available: Yes
Technology available for license.

(For further information, please contact:
Dr. Glin Sincarsin, President, Dynacon Systems Inc., 5050 Dufferin Street, Unit 222, Downsview ON, M3H 5T5 Canada; Tel: 416-667-0505; Fax: 416-667-0709; E-mail: dynacon@gpu.utcc.utotonto.ca)

PROCESS CONTROL AND MATHEMATICAL MODELLING
CANMET's Western Research Centre is developing advanced new process control technologies and instrumentation to meet the current and future needs of the energy industry. (1) Modelling complex energy processing schemes to improve performance; (2) Developing technology tools to optimize energy processing, and (3) Devising and testing new instrumentation technologies for on- and off-line monitoring and control.
Main use: On-line process control.
Main advantages: Expert services to both large and small companies in the energy, minerals and manufacturing industries.
Degree of development: Laboratory or prototype
Know-how available: Yes
Technology available for license.

(For further information, please contact:
Mr. Bruce Stewart, Director, Western Research Centre, CANMET Natural Resources Canada, P.O. Bag 1280, Devon AB, T0C 1E0 Canada;Tel: 403-987-8615; Fax: 403-987-8690)

PARTS POSITIONING IN 3D SPACE
The technology developed is related to the positioning of parts in 3D space for assembly purposes, using machine vision inputs to robotic controllers. It is an essential building block of what is called "Fixtureless Assembly". The company intends to introduce a flexible assembly work cell, comprised of stereo camera based machine vision sensors, coupled to a computer readout, containing the mathematical transforms required to determine 3D object position in space of one or more objects from datum points on their surface. While initially developed for sheet metal car body parts, and the like, it is generic to a wide range of potential other applications.
Main use: In the near term, these products will only be sold to developmental laboratories. Some are to be built into major R&D programmes being put forward in Canada, Japan and the USA.
Main advantages: The technology leads to a far more flexible factory environment, in which product changes can be more rapidly made. It is a key enabling item of several major thrusts, including the Intelligent Modules for Assembly Thrust of the Japanese Intelligent Manufacturing Systems Programme, as well as the US National Center for Manufacturing Systems Flexible Assembly Program Area (FAPA).
Degree of development: Laboratory or prototype
Know-how available: Yes
Technology available for license

(For further information, please contact
Mr. Tim Pryor, President, Sensor Adaptive Machines Inc., 6360 Hawthorne Drive, Windsor On, N8T 1J9 Canada; Tel: 519-944-6641; Fax: 519-944-1928)

EXPERT SYSTEM APPLICATIONS FOR REMOTE DIAGNOSTICS FOR OFF-LINE OR REAL-TIME OPERATION

The institution has expertise in the process and methods used to acquire knowledge from various sources (e.g. human experts, reference files) and to represent and organise that knowledge within an expert system using both rules and a model of the problem domain. The knowledge in the expert system is applied to input data obtained from various sources (sensors) to analyze system performance, detect and isolate failures and to suggest solutions. A packaged generic expert system could be developed specifically for distributed system control/data collection, e.g. hydro power generation or distributed oil pumps. A supplier to such users, particularly with SCADA experience would be a good potential technology recipient.

Main use: Markets for such systems could be large, particularly if a retrofit system could be developed. Continuous monitoring of performance and process control in areas such as product manufacturing, agriculture and electrical power plants offers a wide market for suppliers. It is well known that Canadian companies are world leaders in the application of SCADA technologies; the application of expert systems technologies is a natural extension of this expertise.

Main advantages: Expert systems operating in a remote mode will become an important feature in many distributed systems of the future. This technology can provide the means to analyze remote performance and propose appropriate control modifications, where prudent. Communication to the central control can be through the use of any convenient commercial communications highway.

Degree of development: Laboratory or prototype
Know-how available: Yes
Technology available for license

(For futher information, please contact:
Mr. Pierre Hebert, Manager, Industrial Development, Canadian Space Agency, 6767, route de l'Aeroport, Saint-Hubert PQ, J3Y 8Y9 Canada; Tel: 514-926-4456; Fax: 514-926-4448; E-mail: hebertp@sp-agency.ca)

HEAT MANAGEMENT

The Energy Heat Management Group specializes in and actively develops new heat management technologies that have proven potential for specific applications that will deliver the highest cost-benefit ratio to its clients. A full range of services, including modelling, simulation and technology development is available.

Main use: Modelling, simulation and optimization of industrial thermal systems or processes.

Main advantages: Not only do these technologies save energy and protect the environment, they also result in tangible economic benefits to both manufacturers and end-users.

Degree of development: Laboratory or prototype
Know-how available: Yes
Technology available for license

(For further information, please contact:
Mr. Pierre Boyer, CANMET – Natural Resources Canada, Energy Diversification Research Laboratory, 1615 Montee St.-Julie, P.O. Box 4800, Varennes PQ, J3X 1S6 Canada; Tel: 514-652-4376; Fax: 514-652-0999; E-mail: boyer@cc2smtp.emr.ca)

AUTOMATED CONTROL EQUIPMENT

Revolutionary controller system that combines innovative user interface with functionality and affordability.

Main use: Products are dual-axis and multi-axis controllers that utilize computer intelligence to operate manufacturing tools and processes.

Main advantages: The units will incorporate a leading-edge technology that enables the system to modify predetermined operating parameters as it encounters regularly occurring changes. The ability of the system to quickly adapt to changing conditions, without manual intervention, provides significant advantage over traditional technologies that operate exclusively within predetermined parameters.

Degree of development: Production
Technology available for license

(For futher information, please contact:
Mr. Mike McLaren, President, Steady State Automation Ltd., 6157 – 6th Street S.E., Calgary AB, T2H 1L9 Canada; Tel: 403-253-7760; Fax: 403-253-7762)

PARAMETRIC CONTROL DEVICE FOR ROBOTIC MANIPULATOR AND OTHER DYNAMIC SYSTEMS

This technology provides a novel means to control complex dynamic systems such as multilink robotic manipulators, traffic signals networks, manufacturing processes or local economies. The concept is inspired by the approach taken by a human brain when controlling many muscles in even the simplest movement. The experimental evidence shows that aimed human hand movements have an associated pattern, individually characterized by scaling parameters. The parametric control device uses similar principles. It involves an innovative use of an artificial neural network in conjunction with dynamic scaling.

Main use: The technology has been demonstrated in conjunction with a robotic system. Manufacturers of robotic systems are therefore most likely to be interested in the capability. However, the technology is generally suitable as the new means of control in various other control applications, including chemical processes, local economies, etc.

Main advantages: It allows the transfer of parameters of the system from an initial into a desired final state and thereby facilitate parametric control means that are both effective and efficient.

Degree of development: Laboratory or prototype
Know-how available: Yes

Technology available for license

(For further information, please contact:
Mr. K.P. Aspila, Director, Patent Administration Department of National Defense, 1423-1 (D Pat A) 10 North Tower, 101 Colonel By Drive, Ottawa ON, K1A 0K2 Canada; Tel: 613-992-3800; Fax: 613-995-5111)

RTAP/PLUS SOFTWARE FOR ENTITY-WIDE PROCESS AND DISCRETE, HYBRID APPLICATIONS

RTAP/Plus was designed to be fully compatible with open standards and to assist the value-added and end-user customers in accelerating the development of new systems.
Main use: RTAP/Plus enables customers to take advantage of the multi-user, multi-tasking and multi-solutions capabilities inherent in today's high performance RISC workstations.
Main advantages: To date, over 70 per cent of RTAP/Plus sales are exported worldwide to a diversity of sectors including oil and gas, chemical processing, discrete manufacturing, electrical utilities, facilities management, food processing, pharmaceuticals, telecommunications, transportation, and water and wastewater management.
Degree of development: Production
Know-how available: Yes
Technology available for license

(For further information contact
Mr. Gerhard Schmid, General Manager, Hewlett Packard (Canada) Ltd., Calgary Product Development Center, 100, 3030 – 3rd Avenue N.E. ,Calgary AB, T2A 6T7 Canada; Tel: 403-235-2400; Fax: 403-272-2299

CERAMIC HYDROGEN ION CONDUCTOR AND ITS PROPERTIES

A two stage process for manufacturing a solid ceramic compound (hydronium beta double prime alumina) with a superior conductivity for protons. The first stage produces a dense potassium beta double prime alumina that is ion-exchangeable to hydronium beta double prime alumina, thereby avoiding costly vapour exchange steps. This solid ceramic proton conductor can be used to improve the performance of hydrogen fuel cells.
Degree of development: Laboratory or prototype
Know-how available: Yes
Technology available for license

(For further information contact:
Mr. Steve Samson, Licensing Advisory Officer, NRC Intellectual Property Service, Office Building M-58, Montreal Road, Ottawa ON, D1A 0R6 Canada; Tel: 613-991-6980; Fax: 613-952-6082)

SENSOR INTEGRATION AND CONTROL INCLUDING PRIORITIZING CONTROL

A sensory input controller receives analog and digital inputs (for SED a satellite ground station, but not necessarily), processes these input signals and then provides control through analog digital outputs. The sensors are generally commercially available products. The controller is the core component because it allows the user to prioritize activities, process and store information, and to change programmed execution based on input information and its analysis. Expert system capability can be added to the control from SED capabilities. This technology could best be exploited by selecting a generic system targeted towards a particular application area (e.g. developers of manufacturing cells and farm machinery), and making it available to a broad range of suppliers to such sectors. The know-how could also be used to source a consulting service to such suppliers.
Main use: Most next generation complex machinery will include multi-sensor integration and control, independent of its targeted market. Therefore the market is broad, but generally dispersed.
Main advantages: All advanced systems require status information from sensors and must have control capabilities to ensure operation within allowed limits preset for individual system sensors. Information can be provided regarding sensor selection, integration techniques and control methodology, all based on a high level of fail-safe engineering. The technology could also be expanded to provide inputs into neural nets, expert systems, fuzzy logic controls, etc.
Degree of development: Laboratory or prototype
Know-how available: Yes
Technology available for license

(For further information, please contact:
Mr. Pierre Hebert, Manager, Industrial Development, Canadian Space Agency, 6767 route del'Aeroport, Saint-Hubert PQ, J3Y 8Y9 Canada; Tel: 514-926-4456; Fax: 514-926-4448; E-mail: hebertp@sp-agency.ca)

ICE SERVICES INTEGRATED SYSTEM (ISIS)

ISIS will provide servers for data acquisition, processing, storage and dissemination. It will provide dual-headed workstations for softcopy display of imagery and graphics, and tools for data analysis, integration and information product development. ISIS will employ a client/server architecture and a framework based on a distributed Oracle database using ARCStorm spatial database manager, object oriented methodologies and distributed computing environment. It will utilize off-the-shelf modules for data rectification, image display and analysis, and for the geographical information system industries.
Main use: Marine operators, shipping, oil and gas, environment and GIS industries.
Main advantages: The Ice Services Integrated System (ISIS) will provide full capabilities for data acquisition and processing, display and analysis chart and product production, information storage and dissemination. Furthermore, ISIS will provide a data browser (image, graphic and

alphanumeric) and data catalogue for data review, selection and loading.
Degree of development: Laboratory or protoype
Technology available for license

(For further information, please contact:
Mr. Pierre Meloche, I.P. Exploitation Manager, National Research Council Canada, Intellectual Property Services, Office Building M-58, Montreal Road, Ottawa ON, K1A 0R6 Canada; Tel: 613-990-3646 Fax: 613-952-6082)

MULTIPURPOSE ACOUSTIC OCEANOGRAPHIC MAPPING SYSTEM

This invention provides an improved method of oceanographic mapping which greatly increases the speed with which mapping can be accomplished. Conventionally, oceanographic mapping is done through the sending and receiving of an acoustic pulse, from which the echo time reveals depth and the beam orientation indicates angular position. This invention improves the speed of mapping by transmitting a series of pulses, rather than a single pulse, and transmitting these pulses before the echo from the previous series has been received.
Main use: Oceanographic mapping of water body floors or of underwater objects.
Main advantages: This method of mapping is faster than single pulse and unlike other multipulse systems, can be used on steep slopes.
Degree of development: Planning
Know-how available: Yes
Technology available under exclusive license

(For further information, please contact:
Mr. Harry Davis, President, Innovation and Development Corporation, University of Victoria, P.O. Box 1700, Victoria BC, V8W 2Y2 Canada; Tel: 604-721-6500; Fax: 604-721-6497)

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A UNIQUE OPPORTUNITY FOR INVESTMENT AND TECHNOLOGY

Investment in Tanzania has been on the upward trend with the backing of the Government, particularly in the private sector. To capitalize on the positive trend of the Tanzanian economy and the renewed interest of foreign investors towards business opportunities in the country, the Ministry of Industries and Trade, the United Nations Industrial Development Organization (UNIDO) and the United Nations Development Programme (UNDP) are organizing an international investment and technology forum to bring together Tanzanian entrepreneurs with foreign partners from all over the world to discuss, develop and conclude business partnership agreements. The projects presented at the forum will cover:

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* Tourism
* Mining
* Infrastructure (BOT)

To enhance the transfer of technology, especially for small- and medium-scale enterprises, stands and booths are available to display products/samples and provide information to technology seekers. Investment support organizations and banks will also be represented.

For further information, please contact:

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