JUDGE_____ FINAL ADJUSTED SCORE_____

create._____plaus._____clarity_____legi._____ TOTAL_____

WILLIAM G. O'FARRELL - SYRACUSE UNIV.

AEROSPACE Booklet Number 00331

What will happen in the future? The modern media are overflowing with the crystal-gazing of "think-tanks" and oracles of varying credibility. With inspiration coming from these sources, as well as from conversations with friends and colleagues, I will attempt to evaluate the likelihood of various predictions.

Many science fiction writers have predicted passenger ships to the moon. This will not come true. The moon will be exploited for its mineral wealth, but the work will be done, not by people, but by robots. The resulting minerals will likely be propelled into moon orbit by a magnetic acceleration track, and brought to earth cheaply by space tugs using electric engines, such as those now under development by NASA. Earth-to-orbit transportation will continue to be energy intensive, since environmental considerations will pre-empt the development of atomic propulsion. Sight-seeing tours of the moon would thus be too expensive to be practical, at least within the next twenty-five years. However, painters and poets will be encouraged to venture wherever manned ships go, and we earthbound will travel vicariously through their art.

High fuel costs will also mean that sub-orbital public transport will not be developed, whereas sub-sonic transport will prosper because of ever increasing fuel efficiency. (Super-sonic travel will remain an expensive alternative for the impatient.) The major advance in public air transport will be in safety. The falling cost of electronic components will mean that even small, private aircraft will be able to be outfitted with sophisticated guidance and control systems which keep aircraft on course and constantly inform computerized air-traffic control stations of velocity and bearing. This will dramatically reduce mid-air collisions and "pilot-error" types of accidents. These devices will not only be able to control take-off, flight and landing, but even runway taxying -- a surprisingly dangerous procedure. Also, computer advances will mean better computer weather models, which will lead to safer flying because of an improved understanding of freak weather changes and wind-shear.

Another popular aerospace prediction will not come true. There will not be giant solar power stations in synchronous orbit above the earth, because the prospect of fusion power makes them unnecessary, and because the suggested method of transferring the energy to earth -- microwaves -- will be regarded as a public health hazard. However, there will be factories in space (probably in low orbit), employing weightlessness in the manufacture of

JUDGE_____ FINAL ADJUSTED SCORE_____

create._____plaus._____clarity_____legi._____ TOTAL_____

AEROSPACE (continued)

everything from ball bearings to baubles (perfect crystals).

The raw materials used by these orbiting industries, as well as the structural components from which the factories themselves are made, will come primarily from the moon. It will simply be more cost-effective to transport matter from the surface of the moon than from the surface of the earth. Once this lunar material has been processed into finished products, it will be "dropped" to earth in one-way re-entry vehicles, which themselves are made in space. With space industry will come space garbage, but most of this will just be dumped out of orbit to burn in the upper atmosphere.

Possibly the most spectacular aerospace development will be in space exploration. Certainly all the planets of our solar system will be visited, although primarily by robot ships. But even more exciting is the fact that interstellar exploration will become a reality. Starships will be built which employ matter/antimatter propulsion, antimatter fuel for these ships being produced using a process similar to current techniques. This method requires a tremendous input of energy (at least 100 times more energy than the resulting antimatter is itself capable of producing), and therefore seems to be an appropriate application for space-borne solar power collection stations. These could be positioned in a hot inner orbit around the sun. Although the production of antimatter is expensive, its propulsion energy per kilogram is so high that it is the most efficient and affordable fuel for starships. (Danger of explosion will make antimatter unsuitable for earth-to-orbit vehicles.)

Where will these starships go? Within twenty-five years robot ships will commence travel to nearby stars. By then many of these stars will have been studied through space telescopes which employ occlusion to make the direct observation of planets possible. In the distant future, ships will take people, not just computers, out of our solar system. Perhaps they will wish to start colonies on alien planets, or perhaps they will regard their ship as their permanent home, wandering from star to star over multiple generations just for the sake of wanderlust.

JUDGE_____ FINAL ADJUSTED SCORE_____

create._____plaus._____clarity_____legi._____ TOTAL_____

00331

COMPUTERS Booklet Number _____

In twenty-five years time there will be more computers in the Western World than there are people. Virtually every middle-class home will have a general-purpose system, in addition to having perhaps several processors built into household appliances. And although there will not yet be an affordable domestic mechanical anthropoid, industry will have become dependent upon all manner of robotic devices. As these machines become more and more sophisticated, they will take on such jobs as bus driver, telephone receptionist, and manual laborer. Spurring this growth will be advances in artificial intelligence (AI), as well as the ever increasing speed and decreasing cost of computer hardware.

Sophisticated AI computers will be developed -- the so-called fifth generation. They will serve as robot "brains", and as professional assistants in law, medicine, etc. The tremendous amounts of computation required by AI will be provided through exploitation of the parallelism that is inherent in logic programming (programming in first-order predicate logic), which will become the dominant AI technique.

The development of non-silicon logic gate technologies (such as gallium arsenide) will make for faster machines, but the most significant influence in the speed-up of AI-type computation will be much lower prices for silicon-based random-access memory (RAM). For various reasons, applications written in logic programming languages tend to be very address "vagrant," and thus unsuitable for paged virtual memory computers. This means that very large amounts of "real" memory will be required to efficiently execute the huge AI applications of the future.

In fact, paged virtual memory systems will dissappear within the next twenty-five years. They will be unnecessary because the low price of RAM will enable all programs to be completely resident in main memory. Magnetic media, such as disks and tapes will become obsolete. Archival storage needs will be met by optical media (such as "laser disks"), and the kind of intermediate storage now provided by magnetic disks will be redundant in large RAM systems. Instead, RAM will lose its reputation as being a dynamically shared resource, and sizable chunks of it will be dedicated to individual applications within a system -- programs far too immense to be transferred in and out of memory except for back-up purposes. It is also likely that associative caches will become orders of magnitude larger then they are now, and much faster too, probably

create._____plaus._____clarity_____legi._____ TOTAL_____

COMPUTERS (continued)

being implemented in non-silicon technologies.

Paralleling the evolution of AI computers, will be startling advances in scientific computation. Unlike AI, scientific calculations do not usually require colossal amounts of memory, and so engineers will concentrate on providing very fast components and circuits for the arithmetic-logic units (ALUs) of scientific computers. Also, these engines will not use associative caches. They will have only extraodinarily fast RAM. For a few years speed enhancements will be achieved primarily by using faster logic packed in ever smaller boxes (in efforts to minimize speed-of-light limitations). In twenty-five year's time the raw speed of a general purpose scientific computer will be directly proportional to its physical size, with logic-gate delays being near their theoretical light-transit-time limits. In fact it is likely that future scientific computers will not even be electronic, but will employ light waves as the logic medium.

There will arise an interesting connection between scientific and AI computing. It is already a fact that AI is being applied to the design of computer circuits. It is also true that some scientists, being presented with problems well beyond the capabilities of current general-purpose computers, are finding that special-purpose computers, custom-designed for their application, can provide great computational speed-ups. However, designing these machines is very time-consuming, and would seem to be a task that AI could eventually handle. Such a system would need a "starter-kit" of pre-designed circuits to use as building blocks, and would have to incorporate some of the design principles that are used currently, but have not yet been codified. In twenty-five years, a scientist may typically be able to describe a class of problems to a computer, and have it produce machine-readable plans for a calculating engine which can solve such problems very efficiently. These plans would then be transmitted to a custom-computer factory where robots would fabricate and assemble the new device.

AI will also change the nature of computer programming, but will not eliminate it. Humans will still have to formulate specifications for computer tasks, and (as software engineers know) this is at least as demanding a task as actual programming. Nor will computer engineering be eliminated by automated design systems. Such systems can only mechanically manipulate existing ideas; they can never mimic the knack humans have for creating something new which is greater than the sum of its parts.

create._____plaus._____clarity_____legi._____ TOTAL_____

SOCIETAL IMPACT Booklet Number 00331

In what kind of world will our children live? Perhaps in many ways it will not be much different than our own. People will travel for pleasure as often as they do now, since the price and speed of air transport will be about the same. Most personal letters will still be handwritten, even if there is a "personal" computer in every home, connected electronically to every one else's. Computers are just not personal enough for some applications. In business, however, electronic communication will be used in lieu of travel to such an extent that there will be an overall decrease in air miles logged.

The maturing of space industry will contribute to the overall growth of the economy, and will help improve the quality of life on earth with such advances as longer-lasting automobiles (super alloys and more spherical ball bearings), better health care (medicines made in space), and perhaps even safer streets, owing to improved night-lighting provided by giant parabolic solar reflectors in space. But in the next twenty-five years, the instrument of greatest social change will be the computer.

The widespread purchase of personal computers by concerned parents (as illustrated by the 1983 Christmas season) will guarantee computer literacy for the next generation of middle-class children. It will also mean a revolution in education. The computer encourages a much freer way of thinking about the world than does traditional education. A computer user can write a program fragment, test it, and modify it accordingly. Entire systems can be built-up this way, without going through the methodical pre-planning process which current structured education promotes. Of course, there is a place for structure, and not all students are adapted to the experimental approach. But the educators of tomorrow, who will have grown-up with computers, will better realize that structure is more a method to be learned, than it is a learning method.

Although schools are now beginning to acquire computers, few schools currently have the funds (or even the motivation) to acquire enough computers to provide children with daily, personal access. But such substantial exposure is required for an enduring educational benefit. Richer children will receive their computer education at home, but poorer children, whose families cannot afford their own computers, will not. To lessen this very serious educational disadvantage, charitable organizations will mount "give a child the gift of computer literacy" campaigns. As a consequence, urban "computer day camps"

create._____plaus._____clarity_____legi._____ TOTAL_____

SOCIETAL IMPACT (continued)

will be established during the summer, and permanent neighbourhood computer activity centers will be set-up in poorer districts.

Widespread computer literacy will not lead to an entire generation of professional computer programmers, no more than widespread linguistic literacy has led to an entire generation of professional writers. However, the children of today will become a generation of computer managers. As robots become cheaper and more advanced, most unskilled, and many semi-skilled, jobs will be eliminated, both in factories and in offices. As a result, there will be a great shift in the demography of employment, from labor to management. In twenty-five year's time the least skilled job a young person could expect to obtain would be analogous to that of a junior-level manager, although he/she would be managing computers, not people. Labor unions will eventually disappear, or will at least lose the right to strike. It would be too dangerous in a time of enormous worker productivity; a strike by a small group could paralize the nation.

As automation is introduced, there will be some additional unemployment. In a few years, however, there will develop a shortage of workers. By then all the baby-boom children will have entered the workforce, and they themselves are having fewer offspring. Unemployment will therefore not be a long-term problem, and can be minimized in the short term by intelligent and humane contracts between management and labor. For instance, layoffs can be avoided if a policy of attrition is agreed to. In the end, automation will give workers greater job satisfaction, more leisure time, and greater employment flexibility. In many cases there will be no need for employees to be physically present at a plant, giving them the freedom to work at home terminals if they wish. This may solve child-care problems for a large number of families. But legislation will be required to guarantee the employment rights of home workers.

Computers will never replace all workers. The public will not permit positions of enhanced responsibility to be filled by machines. Even if a computer is developed which is demonstrably more proficient at medical diagnosis than any human doctor, that computer is nevertheless not a responsible being, answerable for its actions. A doctor may use a computer to diagnose a patient, but the doctor's signature will be on the final diagnosis report, and it is he/she who will be sued if the report is wrong. Such is the justice that people will demand.