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ELECTRONIC COMMUNICATION Booklet Number 00422

~~A civilization's communication system is analogous to the~~ body's nervous system; the information which is transmitted and received in both maintains their well being, and potential for growth. It is likely that the most noticeable changes in our society will occur as a result of advances in this field. My ~~(conservative) predictions are:~~

The hookup of most homes and businesses to a centralized communications system (analogous to the current telephone system) with fiber optics where the building density is high enough. ~~Satellites will link remote areas. Each location will have fiber~~ optics of various kinds for different applications: less expensive single-mode fibers for data transmission will be developed, and current multi-mode graded-index fibers for audio and visual applications will also be used.

~~Novel services will become available over the improved~~ communications system. Picture telephone service will be economically feasible for the average customer. Immense data bases will be available to those with computers. These data bases will include news, weather, advertisements, government ~~publications, library materials, etc.. Eventually, even the~~ contents of the Library of Congress will become accessible to anyone, anywhere, at anytime. Home and business security could be accomplished with sensors monitoring conditions for fire and burglary, reporting to a specified location when conditions warrant. The responder will be able to check the monitored location with video cameras to cut down on expensive false alarms. ~~Elderly and incapacitated individuals~~ could be equiped with sensors that monitor body parameters like temperature and heart rate. If hypothermia or heart attack happens, an alarm could be ~~broadcast to the individual's home base station. From there an~~ appropriate notice could be sent to a neighbor or the authorities. Such systems are in experimental use now, but 25 years from now they will be common and inexpensive. Three dimensional holographic television may be possible with the increased ~~information transmission rates. In any case, far more channels~~ for music and video will be there for the discerning consumer. ~~Inter-office information transfer will increasingly be in the form~~ of electronic mail. This will reduce needless paper usage. The Postal Service and UPS will not be eliminated, though, since there ~~is always a need to move nonstandard information and goods -~~ cookies and sweaters from mom are hard to send via fiber optics.

~~Education will make tremendous strides under the new~~ communication system. Access to knowledge will be a reality for people no matter how far they are from libraries, schools, and ~~universities. The concept of educational tv will finally bear~~ fruit; with many channels available on fiber optic systems,

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ELECTRONIC COMMUNICATION (continued)

specific topics at high levels will finally be taught. New "universities" of the air will arise.

Cellular transmitters will be more common. This will allow uninterrupted communications for the mobile individual. Increased security of communications will be available. Information will be encrypted to discourage theft, and detection of taps on fiber optic lines will be easier than, say, finding passive receivers of microwave link transmissions today. Authorized agencies will be able to trace calls instantaneously; a great advantage in apprehending terrorists and kidnappers.

Since the available locations for geosynchronous orbits are limited, they must be used efficiently. This will mean ever larger and capable satellites will be launched by the space shuttle. At some point it might become possible that orbit locations will be allocated by a world body like the U.N.. Satellites will be shielded with special materials and equiped with various defense mechanisms to protect them from attack by nations or terrorists.

Many of the requirements of the communications field are the same as for the computer industry. Of necessity, the entire communications system will be computer operated. High speed electrical and optical switches and detectors will be created using GaAs and InAlP. Molecular beam epitaxy and ion implantation (with laser annealing) will play vital roles in device manufacture. The control of the magnetic spins in the nuclei of atoms at low temperatures will satisfy the tremendous memory capacity requirements of many services. This technology will surpass current magnetic storage or laser-burning techniques by at least several orders of magnitude. Polymeric fiber optics (in a crystalline form) may eventually be adapted for specialized wavelength regions because of an increase in strength or reduction in environmental degradation (via stress corrosion or clouding from hydroxyl ions). New semiconducting lasers will be developed to meet the wavelength requirements of the new fibers. Integrated optics will be created. These will consist of optical and electrical components on chips. The laser, modulating circuitry, detectors, amplifiers, etc., will all be on a suitable substate which is sealed into a module with electrical and optical feedthroughs. Their use in severe environments (electromagnetic fields, explosive gases, radioactive areas, etc.) will be common. The coupling of fibers will be simplified so that even home handymen can add components as necessary to their networks.

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AEROSPACE Booklet Number 00422

Advances in this field are allowing humanity increased mobility on the planet, and will lead to exploration of the universe on a scale unknown in the history of man. My predictions for the future of aerospace are:

New manufacturing processes will lead to higher performance, greater safety, and reduced costs for aerospace components. Increased use of polymers, composites, and ceramics are guaranteed. Nonflammable and nontoxic plastics in the cabin interior of aircraft will prevent the spread of fire and smoke, saving lives. Composites of metals and polymers will lead to high strength, low weight structural components. Adhesive technology will permit bonding of components with greater ease and strength than rivets. Laser and electron beam fusion bonding of metallic components will result in stronger welds. Ceramics like Si_3H_4 and ZrO_2 will play important roles in jet engine technology. Their use in turbine blades and rotors will allow higher operating temperatures and greater corrosion resistance. Design and manufacture of components will be done by computers and robots. Quality assurance will be maintained by extensive use of ultrasonic testing, X-ray and neutron radiography, electromagnetic methods, and laser interferometry.

Aircraft will use satellites for more accurate navigation and better communication. Passengers will soon be able to make routine audio, video, and data transfer while flying. Pilots will have real time infrared and radar images, converted by computer to three dimensional holograms, at their disposal for all weather flying safety. Head up instrument displays will be common, projecting vital information on the cockpit windshield. The monitoring of all air traffic by satellites will lead to fewer midair collisions. Ground control radar will be installed at all airports to guide planes in safe takeoffs and landings. On board computers will monitor aircraft conditions and respond to emergencies faster and more accurately than human control.

Binary fuel systems, nonflammable liquids or gases until activated at the engines, will reduce explosions and fires. These fuels will also burn more efficiently and cleanly in the engines, giving higher thrust and less pollution. Sonic transducers at the engine exhaust, or suitable combustion process control, will reduce engine noise. New aircraft design will reduce the sonic boom "footprint" of supersonic aircraft to acceptable levels.

Continuously manned bases will be established in earth orbit and on the moon. A manned mission to Mars will be undertaken. Orbiting unmanned observatories will be placed around each of the

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AEROSPACE (continued)

planets of the solar system. New instruments for the detection of radiation and particles will be placed in space, and will provide fascinating knowledge of the universe. Mapping of the earth's resources will be completed, both for exploitation and conservation purposes. Neutrinos, with their long mean free paths, may be supplied by the sun and somehow measured by satellites to give a compositional or structural profile of the earth.

The manufacture of new materials will be afforded by the environment of space. Single crystals of silicon and germanium more than 10 inches in diameter will be possible. Also, since one doesn't require a crucible in space, contamination of the crystals by impurities like carbon and oxygen will be eliminated. A very good vacuum will be available for various processes. Ion implantation of these crystals with selected dopants might be accomplished by using the earth's own Van Allen belts as the accelerator. Biological products will be made in space; for reasons of purity of the product, and isolation of any hazardous organisms from the earth's environment.

Energy for habitation and manufacturing processes will be supplied by solar cells or small fusion reactors. Deep space probes will use fusion reactors, drawing on interstellar hydrogen for fuel, and ion rockets to explore the universe. An offshoot of the technology used to develop large solar arrays would be orbiting mirrors. They would reflect infrared or visible light to reduce frost damage to crops, and illuminate the scene of rescue operations.

Since most manufacturing processes and exploration expeditions could be computer operated, many of the space bases will be established for reasons requiring human beings. An example would be orbiting hospitals, in which weightlessness plays a vital role in the treatment of disease or injury. The uniqueness of the space environment may cause the development of hotels or condominiums by the private sector to cater to the desires of a particular segment of society. It is likely that private spacelines will develop to satisfy the transportation requirements. Advertizing will also take to the heavens, and one will probably see occasional gimmicks involving tremendous visual displays promoting various products. These displays could be in the form of laser-generated images. Of course, world opinion will eventually try to regulate this activity by entrepreneurs. We will also start to see the use of space by a new generation of stuntmen. Perhaps a new sport involving the atmospheric reentry of a spacesuited individual on a ceramic "surfboard" equiped with a high altitude parachute? We will know in only 25 years.

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SOCIETAL IMPACT Booklet Number 00422

The impact of the predictions I made for communications and aerospace will be dramatic. It must be remembered that they will occur incrementally over the next 25 years. Some people will not even be aware of the total advances being made at the time, much as today many don't realize the role of current satellites in, say, a long distance call from Boston, MA to New York City. Public reaction and acceptance may be slow in several respects, but the underlying changes will have been made for them, and dramatic effects -both welcome and unwelcome- will be manifested at various points in their lives.

The communications revolution will lead to a quantum increase in the ease with which information is processed and distributed. This could be a road to freedom or imprisonment. For individuals able to perform creative work at home the prospects are tremendous. Already many artists, musicians, and authors create their works at home. If the format of the final product is compatible with the state-of-the-art in data transfer (as is music and text currently) why couldn't the musician or author remain at home and send their works to their publisher without ever leaving home? In all likelihood many will in the future. For others, increased communication may not directly translate to working location freedom. Many jobs simply require individuals to be at centralized locations to work. Scientists in laboratories, steelworkers constructing a new building, and doctors in a hospital are three examples. An additional factor is that human beings like to associate with each other at work. Thus, increased communication won't cause them to run home to work. It will, however, let them interact with others not as close geographically. In any case, better communication will lead to greater efficiency, productivity, and job satisfaction.

A danger of increased communication flexibility is that incorrect information will be input in the system faster than currently possible. This could be a negative factor in the case of, say, false early warning signals for a nuclear attack. Information on individuals (credit, health, political viewpoints, etc.) may be distributed so easily some people may be totally destroyed by an unintentional or intentional mis-entry of data on them to public agencies, creditors, and possible employers. Safeguards of personal rights, with respect to the aforementioned problems, and prevention of unauthorized intrusion (via the future's form of wiretapping) must be instituted to insure our freedom under the Constitution. Of course, not all infractions against individuals will come from Big Brother, and it is likely the common criminal element will learn to use the communications explosion to plan and perpetrate their criminal acts.

To some, the prospect of total mobility with communication is an ideal. Being able to drive, sail, fly, walk, or run and still be in touch may be desirable for corporation presidents,

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SOCIETAL IMPACT (continued)

policemen, or the local restaurant owner. Others may resent the fact that someday it may be possible for almost anyone to contact them anywhere - Bo Derek, watch out!

The aerospace improvements of the next 25 years will lead to increasing use of the airlines for pleasure rather than business. Presumably, a great deal of today's travel by business managers could be accomplished via computers and communication linkups at a far lower cost than, say, shipping a 170lb executive vice president 3300 miles form New York City to San Francisco, CA. In fact, one might see more business travel by lower level employees because of the necessity of actual contact; like a skilled repair technician travelling to a customer's facility to fix a broken piece of electronic machinery, or a salesman visiting a university and making a sale on the basis of his or her interpersonal skills. Surely the decreased cost and increased safety will induce those people who don't presently fly to consider the prospect.

The decreased noise and air pollution of future aircraft will enable airports to maximize their efficiency. Many airports must curtail their hours of operation to comply with noise regulations of the communities which have grown up around them. If engine noise and sonic boom noise can be eliminated one will probably see the return of supersonic transport as an economically viable form of transportation. Reduced air pollution will be beneficial for all aircraft, especially 10 mile high SSTs and the ozone layer. One might even be able to see a clear blue sky again (without 9 contrails hazing it up, as is currently the case).

The advances in space will have immediate influence on our lives. The increased communications load carried by satellites is the most evident. Resource mapping will help humanity exploit yet, hopefully, conserve its limited store.

The current attempts at the militarization of space should be blocked now (except for reconnaissance satellites to insure compliance with established treaties). The placement of nuclear, particle beam, and laser weapons in space must not be allowed to insure the survival and growth of all.

The habitation of space, in particular by private groups, could be the forerunner of colonization, with the inevitable result. Eventually, groups of people would seek autonomy from the earth in their own artificial environments. As the earth's entire surface has already been carved up into nations, space is the logical extention of a people's quest for autonomy from present political systems.

As always, the coming of the future will be a remarkable and unstoppable event. It will leave humanity with a combination of joy and sorrow. Together we can make it more of the former.