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Excerpts from “Man-computer Symbiosis”
IRE Transactions on Human Factors in Electronics, volume HFE-1, pp 4-11 (now IEEE)
March 1960
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Digital Equipment Corporation in Palo Alto, California

Summary
Man-Computer Symbiosis

Man-computer symbiosis is an expected development in cooperative interaction
between men and electronic computers. It will involve very close coupling between the
human and the electronic members of the partnership. The main aims are 1) to let
computers facilitate formulative thinking as they now facilitate the solution of formulated
problems, and 2) to enable men and computers to cooperate in making decisions and
controlling complex situations without inflexible dependence on predetermined
programs. In the anticipated symbiotic partnership, men will set the goals, formulate the
hypotheses, determine the criteria, and perform the evaluations. Computing machines
will do the routinizable work that must be done to prepare the way for insights and
decisions in technical and scientific thinking. Preliminary analyses indicate that the
symbiotic partnership will perform intellectual operations much more effectively than
man alone can perform them. Prerequisites for the achievement of the effective,
cooperative association include developments in computer time sharing, in memory
components, in memory organization, in programming languages, and in input and
output equipment.

1 Introduction 1.1 Symbiosis

The fig tree is pollinated only by the insect Blastophaga grossorun. The larva of
the insect lives in the ovary of the fig tree, and there it gets its food. The tree and the
insect are thus heavily interdependent: the tree cannot reproduce without the insect; the
insect cannot eat witbout the tree; together, they constitute not only a viable but a productive and thriving partnership. This cooperative “living together in intimate association, or even close union, of two dissimilar organisms” is called symbiosis [27]. “Man-computer symbiosis” is a subclass of man-machine systems. There are many man-machine systems. At present, however, there are no man-computer symbioses. The purposes of this paper are to present the concept and, hopefully, to foster the development of man-computer symbiosis by analyzing some problems of interaction between men and computing machines, calling attention to applicable principles of man-machine engineering, and pointing out a few questions to which research answers are needed. The hope is that, in not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today.

1.2 Between “Mechanically Extended Man” and “Artificial Intelligence”

As a concept, man-computer symbiosis is different in an important way from what North has called “mechanically extended man.” In the man-machine systems of the past, the human operator supplied the initiative, the direction, the integration, and the criterion. The mechanical parts of the systems were mere extensions, first of the human arm, then of the human eye. These systems certainly did not consist of “dissimilar organisms living together ...” There was only one kind of organism—man—and the rest was there only to help him.

In one sense of course, any man-made system is intended to help man, to help a man or men outside the system. If we focus upon the human operator within the system, however, we see that, in some areas of technology, a fantastic change has taken place during the last few years. “Mechanical extension” has given way to replacement of men, to automation, and the men who remain are there more to help than to be helped. In some instances, particularly in large computer-centered information and control systems, the human operators are responsible mainly for functions that it proved infeasible to automate. Such systems (“humanly extended machines,” North might call them) are not
symbiotic systems. They are “semi-automatic” systems, systems that started out to be fully automatic but fell short of the goal.

Man-computer symbiosis is probably not the ultimate paradigm for complex technological systems. It seems entirely possible that, in due course, electronic or chemical “machines” will outdo the human brain in most of the functions we now consider exclusively within its province. Even now, Gelernter’s IBM-704 program for proving theorems in plane geometry proceeds at about the same pace as Brooklyn high school students, and makes similar errors. There are, in fact, several theorem-proving, problem-solving, chess-playing, and pattern-recognizing programs (too many for complete referance) capable of rivaling human intellectual performance in restricted areas; and Newell, Simon, and Shaw’s “general problem solver” may remove some of the restrictions. In short, it seems worthwhile to avoid argument with (other) enthusiasts for artificial intelligence by conceding dominance in the distant future of cerebration to machines alone. There will nevertheless be a fairly long interim during which the main intellectual advances will be made by men and computers working together in intimate association. A multidisciplinary study group, examining future research and development problems of the Air Force, estimated that it would be 1980 before developments in artificial intelligence make it possible for machines alone to do much thinking or problem solving of military significance. That would leave, say, five years to develop man-computer symbiosis and 15 years to use it. The 15 may be 10 or 500, but those years should be intellectually the most creative and exciting in the history of mankind.

2 Aims of Man-Computer Symbiosis

Present-day computers are designed primarily to solve preformulated problems or to process data according to predetermined procedures. The course of the computation may be conditional upon results obtained during the computation, but all the alternatives must be foreseen in advance. (If an unforeseen alternative arises, the whole process comes to a halt and awaits the necessary extension of the program.) The requirement for preformula- tion or predetermination is sometimes no great disadvantage. It is often said that programming for a computing machine forces one to think clearly, that it disciplines the thought process. If the user can think his problem through in advance, symbiotic
association with a computing machine is not necessary.

However, many problems that can be thought through in advance are very difficult to think through in advance. They would be easier to solve, and they could be solved faster, through an intuitively guided trial-and-error procedure in which the computer cooperated, turning up flaws in the reasoning or revealing unexpected turns in the solution. Other problems simply cannot be formulated without computing-machine aid. Poincaré anticipated the frustration of an important group of would-be computer users when he said, “The question is not, ‘What is the answer?’ The question is, ‘What is the question?’” One of the main aims of man-computer symbiosis is to bring the computing machine effectively into the formulative parts of technical problems.

The other main aim is closely related. It is to bring computing machines effectively into processes of thinking that must go on in “real time,” time that moves too fast to permit using computers in conventional ways. Imagine trying, for example, to direct a battle with the aid of a computer on such a schedule as this. You formulate your problem today. Tomorrow you spend with a programmer. Next week the computer devotes 5 minutes to assembling your program and 47 seconds to calculating the answer to your problem. You get a sheet of paper 20 feet long, full of numbers that, instead of providing a final solution, only suggest a tactic that should be explored by simulation. Obviously, the battle would be over before the second step in its planning was begun. To think in interaction with a computer in the same way that you think with a colleague whose competence supplements your own will require much tighter coupling between man and machine than is suggested by the example and than is possible today.

3 Need for Computer Participation in Formulative and Real-Time Thinking

The preceding paragraphs tacitly made the assumption that, if they could be introduced effectively into the thought process, the functions that can be performed by data-processing machines would improve or facilitate thinking and problem solving in an important way. That assumption may require justification.

3.1 A Preliminary and Informal Time-and-Motion Analysis of Technical Thinking

Despite the fact that there is a voluminous literature on thinking and problem solving,
including intensive case-history studies of the process of invention, I could find nothing comparable to a time-and-motion-study analysis of the mental work of a person engaged in a scientific or technical enterprise. In the spring and summer of 1957, therefore, I tried to keep track of what one moderately technical person actually did during the hours he regarded as devoted to work. Although I was aware of the inadequacy of the sampling, I served as my own subject.

It soon became apparent that the main thing I did was to keep records, and the project would have become an infinite regress if the keeping of records had been carried through in the detail envisaged in the initial plan.

It was not. Nevertheless, I obtained a picture of my activities that gave me pause. Perhaps my spectrum is not typical—I hope it is not, but I fear it is. About 85 per cent of my “thinking” time was spent getting into a position to think, to make a decision, to learn something I needed to know. Much more time went into finding or obtaining information than into digesting it. Hours went into the plotting of graphs, and other hours into instructing an assistant how to plot. When the graphs were finished, the relations were obvious at once, but the plotting had to be done in order to make them so. At one point, it was necessary to compare six experimental determinations of a function relating speech-intelligibility to speech-to-noise ratio. No two experimenters had used the same definition or measure of speech-to-noise ratio. Several hours of calculating were required to get the data into comparable form. When they were in comparable form, it took only a few seconds to determine what I needed to know.

Throughout the period I examined, in short, my “thinking” time was devoted mainly to activities that were essentially clerical or mechanical: searching, calculating, plotting, transforming, determining the logical or dynamic consequences of a set of assumptions or hypotheses, preparing the way for a decision or an insight. Moreover, my choices of what to attempt and what not to attempt were determined to an embarrassingly great extent by considerations of clerical feasibility, not intellectual capability.

The main suggestion conveyed by the findings just described is that the operations that fill most of the time allegedly devoted to technical thinking are operations that can be performed more effectively by machines than by men. Severe problems are posed by the fact that these operations have to be performed upon diverse variables and in unforeseen and continually changing sequences. If those problems can be solved in such
a way as to create a symbiotic relation between a man and a fast information-retrieval and data-processing machine, however, it seems evident that the cooperative interaction would greatly improve the thinking process.

It may be appropriate to acknowledge, at this point, that we are using the term “computer” to cover a wide class of calculating, data-processing, and information-storage-and-retrieval machines. The capabilities of machines in this class are increasing almost daily. It is therefore hazardous to make general statements about capabilities of the class. Perhaps it is equally hazardous to make general statements about the capabilities of men. Nevertheless, certain genotypic differences in capability between men and com- puters do stand out, and they have a bearing on the nature of possible man-computer symbiosis and the potential value of achieving it.

As has been said in various ways, men are noisy, narrow-band devices, but their nervous systems have very many parallel and simultaneously ac- tive channels. Relative to men, computing machines are very fast and very accurate, but they are constrained to perform only one or a few elementary operations at a time. Men are flexible, capable of “programming themselves contingently” on the basis of newly received information. Computing ma- chines are single-minded, constrained by their “pre-programming.” Men naturally speak redundant languages organized around unitary objects and coherent actions and employing 20 to 60 elementary symbols. Computers “naturally” speak nonredundant languages, usually with only two elemen- tary symbols and no inherent appreciation either of unitary objects or of coherent actions.

To be rigorously correct, those characterizations would have to include many qualifiers. Nevertheless, the picture of dissimilarity (and therefore po- tential supplementation) that they present is essentially valid. Computing machines can do readily, well, and rapidly many things that are difficult or impossible for man, and men can do readily and well, though not rapidly, many things that are difficult or impossible for computers. That suggests that a symbiotic cooperation, if successful in integrating the positive char- acteristics of men and computers, would be of great value. The differences in speed and in language, of course, pose difficulties that must be overcome.

4 Separable Functions of Men and Computers in the Anticipated Symbiotic Association
It seems likely that the contributions of human operators and equipment will blend together so completely in many operations that it will be difficult to separate them neatly in analysis. That would be the case if, in gathering data on which to base a decision, for example, both the man and the computer came up with relevant precedents from experience and if the computer then suggested a course of action that agreed with the man’s intuitive judgment. (In theorem-proving programs, computers find precedents in experience, and in the SAGE System, they suggest courses of action. The foregoing is not a far-fetched example.) In other operations, however, the contributions of men and equipment will be to some extent separable.

Men will set the goals and supply the motivations, of course, at least in the early years. They will formulate hypotheses. They will ask questions. They will think of mechanisms, procedures, and models. They will remember that such-and-such a person did some possibly relevant work on a topic of interest back in 1947, or at any rate shortly after World War II, and they will have an idea in what journals it might have been published. In general, they will make approximate and fallible, but leading, contributions, and they will define criteria and serve as evaluators, judging the contributions of the equipment and guiding the general line of thought.

In addition, men will handle the very-low-probability situations when such situations do actually arise. (In current man-machine systems, that is one of the human operator’s most important functions. The sum of the probabilities of very-low-probability alternatives is often much too large to neglect.) Men will fill in the gaps, either in the problem solution or in the computer program, when the computer has no mode or routine that is applicable in a particular circumstance.

The information-processing equipment, for its part, will convert hypotheses into testable models and then test the models against data (which the human operator may designate roughly and identify as relevant when the computer presents them for his approval). The equipment will answer questions. It will simulate the mechanisms and models, carry out the procedures, and display the results to the operator. It will transform data, plot graphs (“cutting the cake” in whatever way the human operator specifies, or in several alternative ways if the human operator is not sure what he wants). The equipment will interpolate, extrapolate, and transform. It will convert static equations or logical statements into dynamic models so the human operator can examine their behavior. In
general, it will carry out the routinizable, clerical operations that fill the intervals between decisions.

In addition, the computer will serve as a statistical-inference, decision-theory, or game-theory machine to make elementary evaluations of suggested courses of action whenever there is enough basis to support a formal statistical analysis. Finally, it will do as much diagnosis, pattern-matching, and relevance-recognizing as it profitably can, but it will accept a clearly secondary status in those areas…

COINING THE WORD CYBORG

Cyborgs and space

Altering man's bodily functions to meet the requirements of extraterrestrial environments would be more logical than providing an earthly environment for him in space . . . Artifact-organism systems which would extend man's unconscious, self-regulatory controls are one possibility

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SPACE travel challenges mankind not only technologically but also spiritually, in that it invites man to take an active part in his own biological evolution. Scientific advances of the future may thus be utilized to permit man's existence in environments which differ radically from those provided by nature as we know it.
The task of adapting man’s body to any environment he may choose will be made easier by increased knowledge of homeostatic functioning, the cybernetic aspects of which are just beginning to be understood and investigated. In the past evolution brought about the altering of bodily functions to suit different environments. Starting as of now, it will be possible to achieve this to some degree **without alteration of heredity** by suitable bio-chemical, physiological, and electronic modifications of man’s existing modus vivendi.

Homeostatic mechanisms found in organisms are designed to provide stable operation in the particular environment of the organism. Examples of three successful alternate solutions provided by biological mechanisms to the body-environment problem with regard to operating temperature are man, hibernating animals, and poikilothermic fish (organisms with blood that take on the temperature of the environment).

Various biological solutions have also been developed for another problem—respiration. Mammals, fish, insects, and plants each have a different solution with inherent limitations but eminently suitable for **their field of operation**. Should an organism desire to live outside this field, an apparently “insurmountable” problem exists.

However, is the problem really insurmountable? If a fish wished to live on land, it could not readily do so. If, however, a particularly intelligent and resourceful fish could be found, who had studied a good deal of biochemistry and physiology, was a master engineer and cyberneticist, and had excellent lab facilities available to him, this fish could conceivably have the ability to design an instrument which would allow him to live on land and breathe air quite readily.

In the same manner, it is becoming apparent that we will in the not too distant future have sufficient knowledge to design instrumental control systems
which will make it possible for our bodies to do things which are no less difficult.

The environment with which man is now concerned is that of space. Biologically, what are the changes necessary to allow man to live adequately in the space environment? Artificial atmospheres encapsulated in some sort of enclosure constitute only temporizing, and dangerous temporizing at that, since we place ourselves in the same position as a fish taking a small quantity of water along with him to live on land. The bubble all too easily bursts.

The biological problems which exist in space travel are many and varied. These are reviewed below. In some cases, we have proposed solutions which probably could be devised with presently available knowledge and techniques. Other solutions are projections into the future which by their very nature must resemble science fiction. To illustrate, there may be much more efficient ways of carrying out the functions of the respiratory system than by breathing, which becomes cumbersome in space. One proposed solution for the not too distant future is relatively simple: Don’t breathe!

If man attempts partial adaptation to space conditions, instead of insisting on carrying his whole environment along with him, a number of new possibilities appear. One is then led to think about the incorporation of integral exogenous devices to bring about the biological changes which might be necessary in man’s homeostatic mechanisms to allow him to live in space qua natura.

The autonomic nervous system and endocrine glands cooperate in man to maintain the multiple balances required for his existence. They do this without conscious control, although they are amenable to such influence. Necessary readjustments of these automatic responses under extraterrestrial conditions require the aid of control theory, as well as extensive physiological knowledge.
Cyborg Frees Man to Explore

What are some of the devices necessary for creating self-regulating man-machine systems? This self-regulation must function without the benefit of consciousness in order to cooperate with the body’s own autonomous homeostatic controls. For the exogenously extended organizational complex functioning as an integrated homeostatic system unconsciously, we propose the term “Cyborg.” The Cyborg deliberately incorporates exogenous components extending the self-regulatory control function of the organism in order to adapt it to new environments.

If man in space, in addition to flying his vehicle, must continuously be checking on things and making adjustments merely in order to keep himself alive, he becomes a slave to the machine. The purpose of the Cyborg, as well as his own homeostatic systems, is to provide an organizational system in which such robot-like problems are taken care of automatically and unconsciously, leaving man free to explore, to create, to think, and to feel.

One device helpful to consideration of the construction of Cyborgs, which is already available, is the ingenious osmotic pressure pump capsule developed by S. Rose for continuous slow injections of biochemically active substances at a biological rate. The capsule is incorporated into the organism and allows administration of a selected drug at a particular organ and at a continuous variable rate, without any attention on the part of the organism.

Capsules are already available which will deliver as little as 0.01 ml/day for 200 days, and there is no reason why this time could not be extended considerably. The apparatus has already been used on rabbits and rats, and for continuous heparin injection in man. No untoward general effect on health was noted when the injector was buried in animals. As long as five years ago, an
injector 7 cm long and 1.4 cm in diam, weighing 15 gm, was successfully buried under the skin of rats weighing 150-250 gm. The photo on page 27 shows a rat weighing 220 gm with an injector *in situ,* 

The combination of an osmotic pressure pump capsule with sensing and controlling mechanisms can form a continuous control loop which will act as an adjunct to the body’s own autonomous controls. These controls can be changed to the desired performance characteristics under various environmental conditions. If these characteristics were determined, such a system would be possible today with the selection of appropriate drugs.

For example, systolic blood pressure may be sensed, compared to a reference value based on the space conditions encountered, and regulated by letting the difference between sensed and reference pressures control administration of an adrenergic or vaso-dilator drug. Of course, any such system presupposes that we would be cognizant of what optimum blood pressure would be under various space conditions. While it is quite difficult to set upper limits to “natural” human physiological and psychological performance, we can take as minimal the capabilities demonstrated under control conditions such as yoga or hypnosis. The imagination is stretched by the muscular control of which even the undergraduate at a Yoga College is capable, and hypnosis per se may prove to have a definite place in space travel, although there is much to be learned about the phenomena of dissociation, generalization of instructions, and abdication of executive control.

We are now working on a new preparation which may greatly enhance hypnotizability, so that pharmacological and hypnotic approaches may be symbiotically combined.
Psycho-Physiological Problems
Let us now turn our attention to some of the special physiological and psychological problems involved in space travel, and see how Cyborg dynamics may help achieve better understanding and utilization of man’s natural abilities.

*Wakefulness.* For flights of relatively short or moderate duration—a few weeks or even a few months—it would appear desirable to keep the astronaut continuously awake and fully alert. The extension of normal functioning through the use of that group of drugs known as psychic energizers, with adjunctive medication, for this purpose is a present-day reality. In flights lasting a month or two, no more than a few hours a day of sleep would be required in the normal environment if such drugs were employed. Tests indicate efficiency tends to increase, rather than decrease, under such a regime, and extended usage appears entirely feasible.

*Radiation Effects.* One subsystem of the Cyborg would involve a sensor to detect radiation levels and an adaptation of the Rose osmotic pump which would automatically inject protective pharmaceuticals in appropriate doses. Experiments at the AF School of Aviation Medicine already indicate an increase in radiation resistance resulting from combined administration of aminoethylisothioronium and cysteine to monkeys.

*Metabolic Problems* and *Hypothermic Controls* In the case of prolonged space flight, the estimated consumption of 10 lb a day for human fuel—2 lb of oxygen, 4 lb of fluid, and 4 lb of food—poses a major problem. During a flight of a year or longer, assuming that the vehicle was operating satisfactorily, there would be little or no reason for the astronaut to be awake for long periods unless some emergency arose. Hypothermia (reduction of body temperature) would appear
to be a desirable state in such long voyages in order to reduce metabolism, and thus human “fuel” consumption. The use of external cooling, reduction of the temperature of the blood in an arterio-venous shunt, and hibernation (through pituitary control), alone or in combination with pharmaceuticals, all seem to offer possibilities in attempting to obtain and maintain such a state. Control of the temperature by influencing the heat regulating center would be more desirable than changing the reference level.

** Oxygenization and Carbon Dioxide Removal.** Breathing in space is a problem because the space environment will not provide the necessary oxygen, and respiration eliminates needed carbon dioxide and involves heat and water losses. An inverse fuel cell, capable of reducing CO2 to its components with removal of the carbon and recirculation of the oxygen, would eliminate the necessity for lung breathing. Such a system, operating either on solar or nuclear energy, would replace the lung, making breathing, as we know it, unnecessary. Conventional breathing would still be possible, should the environment permit it, discontinuing the fuel-cell operation.

** Fluid Intake and Output.** Fluid balance in the astronaut could be largely maintained via a shunt from the ureters to the venous circulation after removal or conversion of noxious substances. Sterilization of the gastrointestinal tract, plus intravenous or direct intragastric feeding, could reduce fecal elimination to a minimum, and even this might be reutilized. **Enzyme Systems.** Under conditions of lowered body temperature, certain enzyme systems would tend to remain more active than usual.

In the same manner, selected atmospheres of other types could be investigated.
Vestibular Function. Disorientation or discomfort resulting from disturbed vestibular function due to weightlessness might be handled through the use of drugs, by tempo- rarily draining off the endolymphatic fluid or, alternately, filling the cavities completely, and other techniques involving chemical control. Hypnosis may also be useful for controlling vestibular function.

Cardiovascular Control. The application of control-system theory to biology has already yielded sufficiently fruitful results in studies of the multiple homeostatic functions of the cardiovascular system to indicate the possibility of altering the system by the Cyborg technique. Administration of presently available drugs, such as epinephrine, reserpine, digitalis, amphetamine, etc., by means of Rose injectors, offers one possibility of changing the cardiovascular functions so as to fit them for a particular environment. Alteration of the specific homeostatic references within or outside the brain, and electric stimulation, either as a means of regulating heart rate or affecting selected brain centers in order to control cardiovascular functioning, are other possibilities.

Muscular Maintenance. Prolonged sleep or limited activity has a deleterious effect on muscle tone. While reduction of body temperature and metabolism may reduce the magnitude of the problem, further investigation of the chemical reasons for atrophy appears necessary to develop adequate pharmaceutical protection to help maintain muscle tone on prolonged space voyages.

Perceptual Problems. Lack of atmosphere will create markedly different
conditions of visual perception than those with which we are familiar. Attention should be given to providing a medium which would recreate some of the distortions to which we are accustomed, and to which the astronaut could become acclimated before takeoff. Part of the problem would come from searching for an adequate frame of reference, and in this regard the factors which influence autokinesis (and illusory movement) may have an influence on space perception problems. Investigation of whether pharmaceuticals would influence autokinesis is therefore desirable.

*Pressure.* Under pressure lower than 60-mm Hg, man's blood begins to boil at his normal body temperature, Therefore, if he is to venture out of his space vehicle without a pressure suit, some means must be found of reducing his normal operating temperature to a point where the vapor pressure of his fluids is no greater than the internal tissue pressures. This is another reason why lowering of body temperature is essential to avoid the use of constricting pressure suits.

*Variations in External Temperature.*

While man will require the protection of a space ship or station at the real extremes of temperature, there are also likely to be intermediate conditions within or close to the limits of human tolerance. By controlling reflection and absorption by means of protective plastic sponge clothing plus chemicals already in existence which produce changes in pigmentation and provide effective protection against actinic rays, it should be possible to maintain desired body temperature. Needed is a light-sensitive, chemically regulated system which would adjust to its own reflectance so as to main-
tain the temperature desired.

*Gravitation.* A change in the ratio of gravity and inertia forces to molecular forces will alter mobility patterns, among other things. Body temperature control and other uses of pharmaceuticals could possibly improve functioning under conditions of greater or lesser gravitation than that on earth.

*Magnetic Fields.* Chemicals and temperature alteration might also act to retard or facilitate the specific effects of magnetic fields in space.

*Sensory Invariance and Action Deprivation.* Instead of sensory deprivation, it is sensory invariance, or *lack of change* in sensory stimuli, which may be the astronaut's bugaboo. In most of the sensory deprivation experiments to date, it has been sensory invariance which has produced discomfort and, in extreme circumstances, led to the occurrence of psychotic-like states. Of even greater significance may be action invariance, deprivation or limitation, since in many such experiments subjects have mentioned a "desire for action." The structuring of situations so that action has a meaningful sensory feedback should reduce these difficulties. Here again drugs could play a useful role in reducing resultant tensions. Action without demonstration that such behavior is purposeful or sensory stimuli without opportunity for appropriate response are both highly disturbing.

*Psychoses.* Despite all the care exercised, there remains a strong possibility that somewhere in the course of a long space voyage a psychotic episode might occur, and this is one condition for which no servomechanism can be completely
designed at the present time. While an emergency osmotic pump containing one of the high-potency phenothiazines together with reserpine could be a part of the complete space man’s kit, the frequent denial by an individual undergoing a psychotic episode that his thought processes, emotions, or behavior are abnormal, might keep him from voluntarily accepting medication. For this reason, if monitoring is adequate, provision should be made for triggering administration of the medication remotely from earth or by a companion if there is a crew on the vehicle.

Limbo. The contingency of possible extreme pain or suffering as a result of unforeseen accidents must also be considered. The astronaut should therefore be able to elect a state of unconsciousness if he feels it to be necessary. Prolonged sleep induced either pharmacologically or electronically seems the best solution.

Other Problems

There obviously exists an equally large number of medical problems amenable to pharmacological influence which have not been discussed here for lack of space. Among these are such conditions as nausea, vertigo, motion sickness, erotic requirements, vi-bration tolerance, etc.

However, those selected for discussion offer an indication as to what the Cyborg can mean in terms of space travel. Although some of the pro-posed solutions may appear fanciful, it should be noted that there are references in the Soviet technical literature to research in many of these same areas. Thus we find the Russians proposing prior oxygen saturation as a solution to the problem of respiration during the first few minutes after space vehicle launchings; reporting on alterations of the vestibular function both by drugs and surgery; studying
perception and carrying out research on the laws of eye motion in vision; finding
that lowering of temperature can aid in solving pressure problems; etc.
Solving the many technological problems involved in manned space flight by
adapting man to his environment, rather than vice versa, will not only mark a
significant step forward in man's scientific progress, but may well provide a new
and larger dimension for man's spirit as well.
Excerpts from “The Cyborg Manifesto: An Ironic Dream of a Common Language for Women in the Integrated Circuit” By Donna Haraway

...A cyborg is a cybernetic organism, a hybrid of machine and organism, a creature of social reality as well as a creature of fiction. Social reality is lived social relations, our most important political construction, a world-changing fiction. The international women's movements have constructed 'women's experience', as well as uncovered or discovered this crucial collective object. This experience is a fiction and fact of the most crucial, political kind. Liberation rests on the construction of the consciousness, the imaginative apprehension, of oppression, and so of possibility. The cyborg is a matter of fiction and lived experience that changes what counts as women's experience in the late twentieth century. This is a struggle over life and death, but the boundary between science fiction and social reality is an optical illusion.

Contemporary science fiction is full of cyborgs—creatures simultaneously animal and machine, who populate worlds ambiguously natural and crafted.

Modern medicine is also full of cyborgs, of couplings between organism and machine, each conceived as coded devices, in an intimacy and with a power that was not generated in the history of sexuality. Cyborg 'sex' restores some of the lovely replicative baroque of ferns and invertebrates (such nice organic prophylactics against heterosexism). Cyborg replication is uncoupled from organic reproduction. Modern production seems like a dream of cyborg colonization work, a dream that makes the nightmare of Taylorism seem idyllic. And modern war is a cyborg orgy, coded by C3I, command-control- communication-intelligence, an $84 billion item in 1984's US defence budget. I am making an argument for the cyborg as a fiction mapping our social and bodily reality and as an imaginative resource suggesting some very fruitful couplings. Michael Foucault's biopolitics is a flaccid premonition of cyborg politics, a very open field.

By the late twentieth century, our time, a mythic time, we are all chimeras, theorized and fabricated hybrids of machine and organism; in short, we are cyborgs. Thus
cyborg is our ontology; it gives us our politics. The cyborg is a condensed image of both imagination and material reality, the two joined centres structuring any possibility of historical transformation. In the traditions of 'Western' science and politics-- the tradition of racist, male-dominant capitalism; the tradition of progress; the tradition of the appropriation of nature as resource for the productions of culture; the tradition of reproduction of the self from the reflections of the other—the relation between organism and machine has been a border war. The stakes in the border war have been the territories of production, reproduction, and imagination…

…From one perspective, a cyborg world is about the final imposition of a grid of control on the planet, about the final abstraction embodied in a Star Wars apocalypse waged in the name of defence, about the final appropriation of women's bodies in a masculinist orgy of war (Sofia, 1984). From another perspective, a cyborg world might be about lived social and bodily realities in which people are not afraid of their joint kinship with animals and machines, not afraid of permanently partial identities and contradictory standpoints. The political struggle is to see from both perspectives at once because each reveals both dominations and possibilities unimaginable from the other vantage point. Single vision produces worse illusions than double vision or many-headed monsters. Cyborg unities are monstrous and illegitimate; in our present political circumstances, we could hardly hope for more potent myths for resistance and recoupling...

…Communications technologies and biotechnologies are the crucial tools recrafting our bodies. These tools embody and enforce new social relations for women world-wide. Technologies and scientific discourses can be partially understood as formalizations, i.e., as frozen moments, of the fluid social interactions constituting them, but they should also be viewed as instruments for enforcing meanings. The boundary is permeable between tool and myth, instrument and concept, historical systems of social relations and historical anatomies of possible bodies, including objects of knowledge. Indeed, myth and tool mutually constitute each other.

Furthermore, communications sciences and modern biologies are constructed by a common move - the translation of the world into a problem of coding, a search for a common language in which all resistance to instrumental control disappears and all
heterogeneity can be submitted to disassembly, reassembly, investment, and exchange.
In communications sciences, the translation of the world into a problem in coding can
be illustrated by looking at cybernetic (feedback-controlled) systems theories applied to
telephone technology, computer design, weapons deployment, or database construction
and maintenance. In each case, solution to the key questions rests on a theory of language
and control; the key operation is determining the rates, directions, and probabilities
of flow of a quantity called information. The world is subdivided by boundaries
differentially permeable to information. Information is just that kind of quantifiable
element (unit, basis of unity) which allows universal translation, and so unhindered
instrumental power (called effective communication). The biggest threat to such power
is interruption of communication. Any system breakdown is a function of stress. The
fundamentals of this technology can be condensed into the metaphor C31, command-
controlcommunication-intelligence, the military's symbol for its operations theory.

In modern biologies, the translation of the world into a problem in coding can be
illustrated by molecular genetics, ecology, sociobiological evolutionary theory, and
immunobiology. The organism has been translated into problems of genetic coding and
read-out. Biotechnology, a writing technology, informs research broadly. In a sense,
organisms have ceased to exist as objects of knowledge, giving way to biotic
components, i.e., special kinds of information-processing devices. The analogous moves
in ecology could be examined by probing the history and utility of the concept of the
ecosystem. Immunobiology and associated medical practices are rich exemplars of the
privilege of coding and recognition systems as objects of knowledge, as constructions of
bodily reality for us. Biology here is a kind of cryptography. Research is necessarily
a kind of intelligence activity. Ironies abound. A stressed system goes awry; its
communication processes break down; it fails to recognize the difference between self
and other...

...Microelectronics mediates the translations of labour into robotics and word processing,
sex into genetic engineering and reproductive technologies, and mind into artificial
intelligence and decision procedures. The new biotechnologies concern more than human
reproduction. Biology as a powerful engineering science for redesigning materials and
processes has revolutionary implications for industry, perhaps most obvious today in
areas of fermentation, agriculture, and energy. Communications sciences and biology are constructions of natural-technical objects of knowledge in which the difference between machine and organism is thoroughly blurred; mind, body, and tool are on very intimate terms. The 'multinational' material organization of the production and reproduction of daily life and the symbolic organization of the production and reproduction of culture and imagination seem equally implicated. The boundary- maintaining images of base and superstructure, public and private, or material and ideal never seemed more feeble.

I have used Rachel Grossman's (1980) image of women in the integrated circuit to name the situation of women in a world so intimately restructured through the social relations of science and technology. I used the odd circumlocution, 'the social relations of science and technology', to indicate that we are not dealing with a technological determinism, but with a historical system depending upon structured relations among people. But the phrase should also indicate that science and technology provide fresh sources of power, that we need fresh sources of analysis and political action (Latour, 1984). Some of the rearrangements of race, sex, and class rooted in high-tech-facilitated social relations can make socialist- feminism more relevant to effective progressive politics...

...The new technologies seem deeply involved in the forms of 'privatization' that Ros Petchesky (1981) has analysed, in which militarization, right-wing family ideologies and policies, and intensified definitions of corporate (and state) property as private synergistically interact. The new communications technologies are fundamental to the eradication of 'public life' for everyone. This facilitates the mushrooming of a permanent high-tech military establishment at the cultural and economic expense of most people, but especially of women. Technologies like video games and highly miniaturized televisions seem crucial to production of modern forms of 'private life'. The culture of video games is heavily orientated to individual competition and extraterrestrial warfare. High-tech, gendered imaginations are produced here, imaginations that can contemplate destruction of the planet and a sci-fi escape from its consequences. More than our imaginations is militarized; and the other realities of electronic and nuclear warfare are inescapable. These are the technologies that promise ultimate mobility and perfect exchange-- and incidentally enable tourism, that perfect practice of mobility and
exchange, to emerge as one of the world's largest single industries.

The new technologies affect the social relations of both sexuality and of reproduction, and not always in the same ways. The close ties of sexuality and instrumentality, of views of the body as a kind of private satisfaction- and utility-maximizing machine, are described nicely in sociobiological origin stories that stress a genetic calculus and explain the inevitable dialectic of domination of male and female gender roles. These sociobiological stories depend on a high-tech view of the body as a biotic component or cybernetic communications system. Among the many transformations of reproductive situations is the medical one, where women's bodies have boundaries newly permeable to both 'visualization' and 'intervention'. Of course, who controls the interpretation of bodily boundaries in medical hermeneutics is a major feminist issue. The speculum served as an icon of women's claiming their bodies in the 1970S; that handcraft tool is inadequate to express our needed body politics in the negotiation of reality in the practices of cyborg reproduction. Self-help is not enough. The technologies of visualization recall the important cultural practice of hunting with the camera and the deeply predatory nature of a photographic consciousness. Sex, sexuality, and reproduction are central actors in high-tech myth systems structuring our imaginations of personal and social possibility.

Another critical aspect of the social relations of the new technologies is the reformulation of expectations, culture, work, and reproduction for the large scientific and technical work-force. A major social and political danger is the formation of a strongly bimodal social structure, with the masses of women and men of all ethnic groups, but especially people of colour, confined to a homework economy, illiteracy of several varieties, and general redundancy and impotence, controlled by high-tech repressive apparatuses ranging from entertainment to surveillance and disappearance. An adequate socialist-feminist politics should address women in the privileged occupational categories, and particularly in the production of science and technology that constructs scientific-technical discourses, processes, and objects…

…Cyborg imagery can help express two crucial arguments…first, the production of universal, totalizing theory is a major mistake that misses most of reality, probably
always, but certainly now; and second, taking responsibility for the social relations of science and technology means refusing an anti-science metaphysics, a demonology of technology, and so means embracing the skillful task of reconstructing the boundaries of daily life, in partial connection with others, in communication with all of our parts. It is not just that science and technology are possible means of great human satisfaction, as well as a matrix of complex dominations. Cyborg imagery can suggest a way out of the maze of dualisms in which we have explained our bodies and our tools to ourselves. This is a dream not of a common language, but of a powerful infidel heteroglossia. It is an imagination of a feminist speaking in tongues to strike fear into the circuits of the supersavers of the new right. It means both building and destroying machines, identities, categories, relationships, space stories. Though both are bound in the spiral dance, I would rather be a cyborg than a goddess.

Excerpt from "Interface Fantasy" by Andre Nusselder

1.2.2 Technology beyond conscious intentions

Social constructivism received important criticism in an influential article
by Langdon Winner (1991), who used it as an umbrella term for the body of ideas of a variety of thinkers such as Steve Woolgar, Trevor Pinch, Wiebe Bijker, and Bruno Latour. Winner’s critique concerns social constructivism’s lack of consideration for the deeper structures that govern technology: it does not pay attention to the power struggles and the political dimensions that underlie the so-called construction of technology by social groups. It also ignores the influence of the broader cultural context on the shaping of technology. Philosophers of technology such as Marx, Mumford, Heidegger, and Ellul, who reflected on the broader patterns of technology, can thus too easily be pushed out as old-fashioned. Social constructivism seems to reduce the reason that permeates technology to its instrumental version. It cannot, I would say, understand technology as a construct of the “diseased animal” (as Nietzsche put it).

Furthermore, when it makes the role of social actors in the construction of technology absolute, it seems to tumble into the same trap that it wanted to avoid in the first place: this is the trap of determinism, for it considers everything to be the result of social interaction. It therefore neglects typically human factors, like the meaning that people give to things and the (sometimes strange) reasons and motives they have for performing certain actions—not to speak of the ambivalence toward the openness of the future: the desire for certainty and for the impossible (Nusselder 2008).

According to Winner, social constructivism also disregards the social consequences of technical choice, the social groups that are not included in the construction and the evaluation of technology. I would add to this list the element of nonreflexive intentions: desire. For social constructivism considers the social construction of technology as the outcome of rational choices and strategies. A simple example might show the limitations of this approach. Was the development of the flying machine solely the result of the rational intentions of the actors and groups that were involved in its production? What about the pioneers of aviation who willingly took the risk of flying the first flying machines, with the chance of crashing right away—was that simply a calculated risk? Probably not. It was also an (unreflected) act, for they did not know what the
outcome was going to be.

The question of whether the human “will” is primarily a conscious affair returns in the discussion of technology. This fourth conception of technology, as a kind of willing or volition, is subject to different interpretations. An encyclopedia entry on the philosophy of technology—which commends the value of a social constructivist conception of it—replaces the volitional conception of technology, for instance, with the idea of technology as a social process (Kroes 1998). In this case the conscious intentions of social groups that produce technological artifacts determine the outcome of the process. Unconscious aspects of the human “will” are left out of consideration. This interpretation of technology as a social process thus emphasizes the determination of technology by the rational aims, choices, and preferences of social groups.

Considering technology from the perspective of desire—the term that I will use from now on to specify one domain of volition, namely the Lacanian Eros—apparently entails from the beginning a noninstrumental consideration of technology. Instrumentality strives for an exact knowledge of our intentions during the technological process, while the approach from desire points to the deficient transparency of those intentions. Human intentions are partly unconscious, which is what psychoanalysis takes a close look at. This limitation of self-consciousness is probably not absent with regard to human “use” of technology. The philosopher of technology Ivan Ilich speaks paradoxically of “unintended intentions” (Mitcham 1994, p. 183). And William Mitchell of MIT’s Media Lab adds: “Tools are made to accomplish our purposes, and in this sense they represent desires and intentions. We make our tools and our tools make us: by taking up particular tools we accede to desires and we manifest intentions” (Mitchell 1992, p. 59). From the perspective of the technological Eros, technology involves more than the rational use of means. And technology as volition is more than the “conscious” intentions of individuals and social groups.

1.2.3 Technology: From means to media of desire
In philosophical anthropological studies, one considers technology in relation to the human position in and toward nature. The “classical” position holds that humans are defective animals that need technology in order to survive. As deficiencies and shortcomings characterize humans on the biological plane, technology is a means to substitute for these shortcomings. The essence of technology is then its ability to compensate or substitute for biological or natural needs (Gehlen 1980). This dominant conception of technology defines its meaning completely in terms of our needs: technology is a means to transform or manipulate nature in order to fulfill human needs. It is a form of teleological or purposeful action that satisfies utilitarian or practical functions and goals. Or, to quote a training institute, technology “begins with a need and ends with a solution.”

We must nevertheless ask the question whether technology is something that (instrumentally) helps us to exist in this world, or whether it (substantially) creates a world: is it merely a means or is it a medium? Do we use technology only in order to safeguard our biological survival, or do we also apply it in order to transform our environment—and ourselves—according to our desires? In order to stress my volitional approach to technology, I mention here that several philosophers of technology make note of this idea of technology as led by a will to transformation. The existentialist analysis of Ortega y Gasset grounds technology in a willed self-realization. Hannah Arendt considers modern technology as an answer to old cultural dreams, as a realization of the desire to leave the earth and its conditions (Mitcham 1980, pp. 243–249). For the French philosopher Jean Brun, “technology grows out of Western ontological aspiration to merge subject and object” (Mitcham 1994, p. 249). Heidegger—both in Being and Time (1927) and in his later important discussion of this subject in “The Question Concerning Technology” (1949–1950)—also rejects the common idea of technology as pure means: technology is, instead, a revealing or disclosing of what is. As Carl Mitcham points out: “Although Heidegger does not use the term ‘volition’ and ‘will’ frequently, Being and Time presents technology as object, knowledge, and activity as fundamentally related to volition” (Mitcham 1994, p. 256).
In the conceptualization of the computer as an instrument, “usability” is the central term: the question is which interface design is most effective in helping the user to perform her job. However, the computer has functioned increasingly as a medium since the design of the graphical user interface (GUI), designed in the 1960s at Xerox PARC. Together with Douglas Engelbart’s invention of the mouse, the

GUI was successfully introduced by Apple in the 1980s on the Macintosh computer. The graphical user interface gave, for the first time, a spatial dimension to data objects, so that the computer could appear as an environment that the user could travel through. With the boom of the Internet in the 1990s, this notion of the computer as a medium became very influential. The crucial difference between the computer as an instrument and as a medium holds for information technologies in general. Technologies often start as instruments, and later on they frequently become media as well. Computer technologies often reach the general public when they are applicable to communication, marking the transition from information technologies (IT) to information and communication technologies (ICT).

Because the conceptualization of the computer as a medium closely connects to the representation of data objects on all sorts of displays, it may be a useful metaphor for my approach to cyberspace. Although we must not overlook the fact that cyberspace probably is a combination of several different metaphors—both on the level of the producer and that of the user; in design and in reception—the metaphor of the medium has a particular interest when one focuses on the “volitional” aspect in which the computer—unconsciously—creates a world.
Excerpts from Poe’s “The Man That Was Used Up”
(general warning- racist language)

...The bust of the General was unquestionably the finest bust I ever saw. For your life you could not have found a fault with its wonderful proportion. This rare peculiarity set off to great advantage a pair of shoulders which would have called up a blush of conscious inferiority into the countenance of the marble Apollo. I have a passion for fine shoulders, and may say that I never beheld them in perfection before. The arms altogether were admirably modelled. Nor were the lower limbs less superb. These were, indeed, the ne plus ultra of good legs. Every connoisseur in such matters admitted the legs to be good. There was neither too much flesh nor too little,- neither rudeness nor fragility. I could not imagine a more graceful curve than that of the os femoris, and there was just that due gentle prominence in the rear of the fibula which goes to the conformation of a properly proportioned calf. I wish to God my young and talented friend Chiponchipino, the sculptor, had but seen the legs of Brevet Brigadier General John A. B. C. Smith. But although men so absolutely fine-looking are neither as plenty as reasons or blackberries, still I could not bring myself to believe that the remarkable something to which I alluded just now,- that the odd air of je ne sais quoi which hung about my new acquaintance,- lay altogether, or indeed at all, in the supreme excellence of his bodily endowments. Perhaps it might be traced to the manner,- yet here again I could not pretend to be positive. There was a primness, not to say stiffness, in his carriage-a degree of measured and, if I may so express it, of rectangular precision attending his every movement, which, observed in a more diminutive figure, would have had the least little savor in the world of affectation, pomposity, or constraint, but which, noticed in a gentleman of his undoubted dimensions, was readily placed to the account of reserve, hauteur- of a commendable sense, in short, of what is due to the dignity of colossal proportion.

The kind friend who presented me to General Smith whispered in my ear some few words of comment upon the man. He was a remarkable man- a very remarkable man- indeed one of the most remarkable men of the age. He was an especial favorite, too, with the ladies- chiefly on account of his high reputation for courage....
… It was early when I called, and the General was dressing, but I pleaded urgent business, and was shown at once into his bedroom by an old negro valet, who remained in attendance during my visit. As I entered the chamber, I looked about, of course, for the occupant, but did not immediately perceive him. There was a large and exceedingly odd looking bundle of something which lay close by my feet on the floor, and, as I was not in the best humor in the world, I gave it a kick out of the way.

"Hem! ahem! rather civil that, I should say!" said the bundle, in one of the smallest, and altogether the funniest little voices, between a squeak and a whistle, that I ever heard in all the days of my existence.

"Ahem! rather civil that I should observe."

I fairly shouted with terror, and made off, at a tangent, into the farthest extremity of the room. "God bless me, my dear fellow!" here again whistled the bundle, "what- what- what- why, what is the matter? I really believe you don't know me at all."

What could I say to all this- what could I? I staggered into an armchair, and, with staring eyes and open mouth, awaited the solution of the wonder.

"Strange you shouldn't know me though, isn't it?" presently resqueaked the nondescript, which I now perceived was performing upon the floor some inexplicable evolution, very analogous to the drawing on of a stocking. There was only a single leg, however, apparent.

"Strange you shouldn't know me though, isn't it? Pompey, bring me that leg!" Here Pompey handed the bundle a very capital cork leg, already dressed, which it screwed on in a trice; and then it stood upright before my eyes.

"And a bloody action it was," continued the thing, as if in a soliloquy; "but then one mustn't fight with the Bugaboos and Kickapoos, and think of coming off with a mere scratch. Pompey, I'll thank you now for that arm. Thomas" [turning to me] "is decidedly the best hand at a cork leg; but if you should ever want an arm, my dear fellow, you must really let me recommend you to Bishop." Here Pompey screwed on an arm.

"We had rather hot work of it, that you may say. Now, you dog, slip on my shoulders and bosom. Pettit makes the best shoulders, but for a bosom you will have to go to Ducrow."

"Bosom!" said I.

"Pompey, will you never be ready with that wig? Scalping is a rough process, after all;
but then you can procure such a capital scratch at De L'Orme's."

"Scratch!"

"Now, you n****r, my teeth! For a good set of these you had better go to Parmly's at once; high prices, but excellent work. I swallowed some very capital articles, though, when the big Bugaboo rammed me down with the butt end of his rifle.""Butt end! ram down!! my eye!!"

"O yes, by the way, my eye- here, Pompey, you scamp, screw it in! Those Kickapoos are not so very slow at a gouge; but he's a belied man, that Dr. Williams, after all; you can't imagine how well I see with the eyes of his make."

I now began very clearly to perceive that the object before me was nothing more nor less than my new acquaintance, Brevet Brigadier General John A. B. C. Smith. The manipulations of Pompey had made, I must confess, a very striking difference in the appearance of the personal man. The voice, however, still puzzled me no little; but even this apparent mystery was speedily cleared up.

"Pompey, you black rascal," squeaked the General, "I really do believe you would let me go out without my palate."

Hereupon, the negro, grumbling out an apology, went up to his master, opened his mouth with the knowing air of a horse-jockey, and adjusted therein a somewhat singular-looking machine, in a very dexterous manner, that I could not altogether comprehend. The alteration, however, in the entire expression of the General's countenance was instantaneous and surprising. When he again spoke, his voice had resumed all that rich melody and strength which I had noticed upon our original introduction.

"D-n the vagabonds!" said he, in so clear a tone that I positively started at the change, "D-n the vagabonds! they not only knocked in the roof of my mouth, but took the trouble to cut off at least seven-eighths of my tongue. There isn't Bonfanti's equal, however, in America, for really good articles of this description. I can recommend you to him with confidence," [here the General bowed,] "and assure you that I have the greatest pleasure in so doing."

I acknowledged his kindness in my best manner, and took leave of him at once, with a perfect understanding of the true state of affairs- with a full comprehension of the mystery which had troubled me so long. It was evident. It was a clear case. Brevet Brigadier General John A. B. C. Smith was the man- the man that was used up.