Panel Discussion

Social Impact of Information Technology & International Collaboration

Chairman:

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Panelists:

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CHAIRMAN: (Karatsu) Ladies and gentlemen, we have two hours allocated for our panel discussion session. I would like to introduce our panelists. Here to this side we have with us from West Germany Professor Siekmann. You have with you the text. On page 143 there are summaries, and I do hope you will refer to those summaries which refer to Professor Siekmann.

To briefly comment on the career or the professional background of Professor Siekmann, he was graduated from Göttingen University and has attended Essex University in Great Britain. He has obtained his Ph.D. degree and now he is engaged in research in the Department of Computer Science at the University of Kaiserslautern.

Next to Professor Siekmann is Dr. Fred W. Weingarten. Dr. Weingarten obtained a Master's Degree from California Institute of Technology and a Ph.D. from Oregon University. Presently he is at the Office of Technology Assessment, U.S. Congress, as a program manager for Computer and Communications Technologies.

To the far end we have with us from the United Kingdom Dr. Timothy Walker. He has studied chemistry at Oxford University, and been engaged in the ALVEY Program. He is presently director of the ALVEY Program.

As for the order of the panelists, I should like to make a general comment first and then would like to ask each panelist to talk for about 25 to 30 minutes, and then following that I would like to once again give 5 to 10 minutes for additional comments to cover whatever has been missed. There should be some time remaining afterwards, and so we can solicit questions or comments from the floor, and then I will make some concluding remarks. This is rather a bountiful task that we have to cover within our discussion session, so I should like to ask for your cooperation.

As you know, the progress of technology is remarkably rapid, in every country. Technology provides the basis for economic development and, therefore, investment in R&D continues to increase. In the last five years the amount of investment by respective countries in large cases was 16 percent, or above 10 percent increment in the respective countries for expenditure in R&D. Especially the private sector here in Japan is eager to invest in R&D. It is said that 15 percent increase in the last five years has been recorded.

The work force in Japan has not expanded in the last five yars but the number of researchers has increased in the last five years with 120,000 engineers being added to the private sector. One after another we see the birth of new technologies, especially information technology. We have the expression "put the fire on crude oil" and it's that kind of a momentum we have here in Japan.

Those from overseas may not know very well, but we have the Japanese word processor here, and it uses Kanji, Chinese or the semantic characters. There are a great number of such characters, and we indicate them to the word processor by entering phonetic characters, which are like an alphabet. When we push a button, the phonetic characters are transformed into Kanji ideographs (semantic characters).

Toward the end of the year, I bought a word processor that cost me ¥100,000. Just one year later I saw a completely new model, so I bought that new one. I had to buy it. With the old model I could write only one line and then had to push the button to transform it, but now with the new model I can input many, many sentences, several lines before I must push the button to produce the Kanji version of the sentence. So the one-year old machine cannot be used any more. ¥100,000 is quite costly and within just one year it is already scrap. It is an amazing age in which we have to live, and the way to successfully utilize such technology is the issue. We cannot keep up with the progress of technology. This concern is expressed by many people.

As you know, already about ten years have passed since robots were first extensively utilized. At the beginning of the robot utilization, especially in the United States and Europe, there was some dispute with labor unions and some delays in the introducing robots into the workplace. Fortunately, in Japan we did not have such conflicts with labor unions, so we very actively introduced the robots into the shop floor. Seventy percent of the total functioning robots of the world are being used in Japan. This is an amazing figure, and the very high productivity of Japanese manufacturing plants has given Japan a competitive edge in these manufacturing sectors.

One of the highlights of such technolgoy is the artificial intelligence. That is to say, the existing computer was engaged in data processing, but the new computer is to do knowledge processing, according to my understanding, at least. This new technology is to be adopted and utilized in the society, in the household, in the public sector, and private firms, and so on. This will constitute our next very important task which will influence the total outcome in the next decade. For that we have to consider four points.

The first is what is realizable through the dependence on technology. Another point is the social environment which would use such new technology, what kind of changes will occur in the social framework. This is one point of the discussion we have to consider.

In Japan and in Europe, the young generation is recording very low birth rates registered. Toward the beginning of the 21st century we will have fewer people in the younger age brackets. How are we to cope with the lack of young population? That is a demographic question.

The third point is that in utilizing the information technology we have a government regulatory framework or the legal statutory aspect, and what kind of changes are expected in this context? This is a very important aspect we have to pay attention to.

For instance, data communication in the United States has attained a very high level of development, but because of political constraints is Japan it is only recently that this sector had been privatized and, therefore, value added networks and their utilization have lagged behind, not due to technological reasons but because of the regulatory aspect. Knowledge processing technology is being newly developed and is progressing, but if the social and the regulatory framework is not a suitable environment to accept the technology, then these new invention will not be utilized.

The fourth issue is that one of the characteristics of information technology is that we will use the communication network which will bring us into contact with one another. A trans-border communication framework will be provided. This is altogether a new possibility which is given to us, and it is up to us to utilize this new possibility.

Based on these four points, I would like to ask the panelists to present their respective situations and express their views. First, I should like to call upon Professor Siekmann.

SIEKMANN: Thank you very much for your kind remarks. My talk is based on a joint paper by Michael McRobbie and myself, and it was originally commissioned by the German Ministry of Technology. It essentially consists of three parts, as the ministry requested (Fig. 1). Its first part briefly describes what are debatably the major areas of artificial intelligence, namely natural language processing, expert systems, automated deduction systems, robotics, and computer vision. After that we proceed to give a prediction for each of these areas, and this was classified into three categories, namely: fairly substantiated short-term predictions (2-5 years), and more or less substantiated medium term predictions (5-8 years) of what is most likely to happen. Of course, this is already guess work, and even more guess work is the third category, long-term prediction (10 years and more), which they explicitly asked for (Fig. 2).

Artificial Intelligence

Perspectives and Predictions

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Fig. 1

(A) Short Term: 2-5 Years
(partially substantiated)

(B) Medium Term: 5-8 Years
(much less certain)

(C) Long Term: over 10 Years
(more or less speculative)

Fig. 2 Timespan of Predictions

I shall not spend too much time on that, as the full paper is to appear in the European AI-Communications. I would rather spend the next quarter of an hour on the final part, namely the future economic development and what this kind of scientific innovation will do to our society. Let me start from the very general and move to some more specific things later on.

Taking a very broad view on society there are at least two major social revolutions that have taken place in the histroy of mankind: one, the agrarian revolution, which is often taken as a good paradigm of what people think is currently happening, particularly Edward Feigenbaum made this view very popular. The general idea which I like very much is this: suppose you had asked the Stone Age man what he was actually doing this year when he made the remarkable invention to save some of his grain for the next year, and why he was doing it. Suppose also you had asked him, what will be the consequences of all this and you had told him, that because of his invention in a few thousand years only 5 percent of the population will be able to feed the rest of the population (Fig. 3). They will therefore have enough time, for example, to develop computers and they will develop the atom bomb and so on. What would his reactions be like? Presumably he would have just laughed and told you that all he wants to do is to have enough food next year. In other words, the idea of this model being that it is just completely impossible for the contemporary to predict what will happen in the long run, in particular in times of deep technological change.

Although I do like this picture, the problem is that we do not know very much about the stone ages and hence it is not particularly helpful. So let us look for a moment at the second major upheaval in our history, the industrial revolution, particularly since we know so much more about the social changes this revolution has brought about and how it actually happend.

There is one central figure by which industrialized nations are characterized, which is often quoted by sociologists: How many percent of a population are neccessary in order to feed the rest? In other words: How large is the section of the society that is working in the agrarian section? Less developed and underdeveloped countries have about 80 to 95 percent of the population in the agrarian section, and industrialized countries like ours and Japan need only 5 to 8 percent of the population that can produce enough food for the rest of the population. In fact, some of the very poor countries even need 99 percent of the population. that is, almost everybody in such societies is still busy with maintaining himself.

The first claim, then, is that there is a similar figure to characterize the post-industrial societies, the transition towards which we are just currently experiencing: Currently in almost all indsutrialized

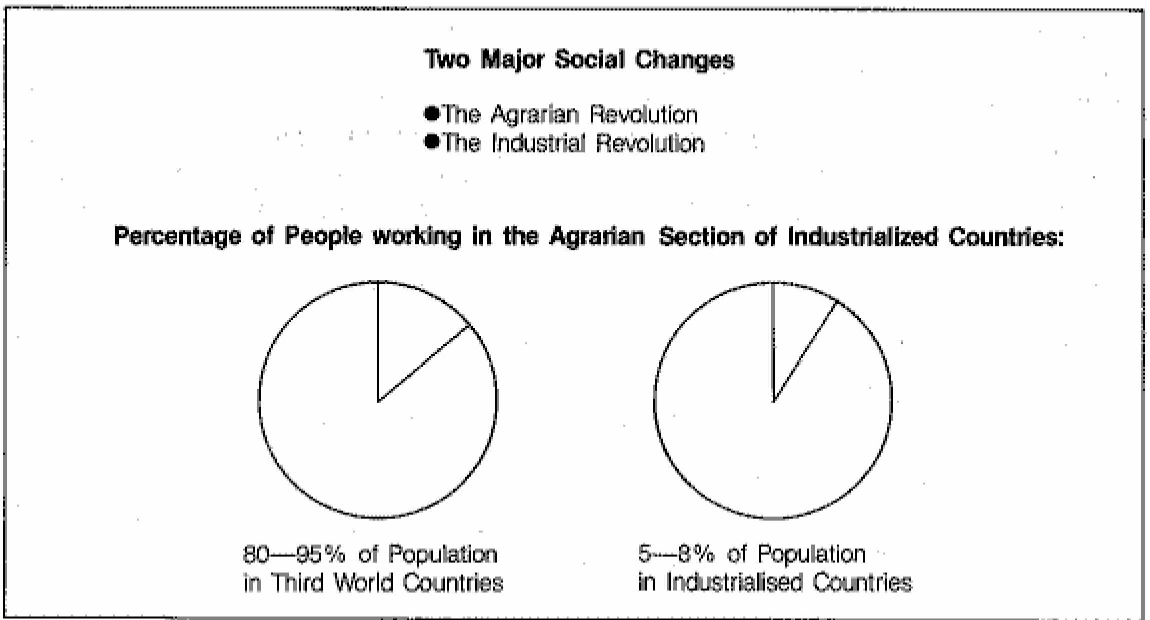


Fig. 3 A Bird's Eye View

countries of Western Europe, Japan, United States and so on, about 50 to 60 percent of the population are working in the production area and in administration. The claim is, that under the influence of computer science in general, artificial intelligence in particular, hence general information technology, this figure will drop to an order of magnitude of the agrarian section, which is, say, 5 to 10 percent (Fig. 4).

This will bring about major social changes in our society, for example, in the production of consumer goods the fully automated factory, and in administration the paperless office and the automation of administration that will therefore become possible.

Let us look more closely at these transformations. Why will they happen? Are we not just making claims? To answer this, let us take a view from a lesser altitude. What are the driving forces? Why is this going to happen? Why are we in this transition?

There are mainly two forces that drive society in this direction: one is that fewer people are necessary for the production of goods because of increasing automation (Fig. 5). These figures are generally well known so I do not need to quote any. Essentially the percentage of labor to produce our goods decreased exponentially since the last war.

Maybe not as well known is that more and more people are working in research and development, and this figure is also increasing exponentially.

These new societies that are coming about are sometimes called "information society" or "knowledge society." "Wissenschaftsgesellschaft" is a popular German word for it right now among sociologists ("science society" if you want to translate it that way). The idea being that science itself becomes the third and major productivity force. R. Kreibich is one among the German sociologists who is advocating this point of view in his interesting book "Die Wissenschaftsgesellschaft."

These new societies are characterized by the following figure: Only 20 percent of the population are necessary to produce all consumer goods, all food and all administration related to the production of goods, and the rest of the population can do something else.

Is this just a claim, or can we find evidence for this development? Let us become even more specific, and let's look at three areas: the growth of scientific and technical knowledge, the increase of expenditure on research and development (R&D)

Currently: 50—60% of Population in Production and Administration

Postindustrial Society: 5% of Population in Agriculture
10% in Production and Administration

Result: Major Social Changes

- In the Production of Consumer Goods (fully automated factory)
- In Administration (the paperless office)

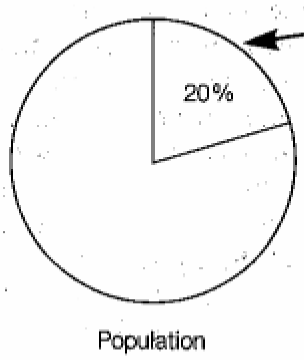
Fig. 4 Characterization of Post-industrial Societies

Two Driving Forces

- ●Less People necessary for the Production of Food and Goods
- ●More People in Research and Development

Result: The new Postindustrial Society ..
Information Society
Knowledge Society
Science Society

The Postindustrial Society:



Population required for the production
- ●of food
- ●of consumer goods
- ●administration

Fig. 5 A View From A Lesser Altitude

Exponential Growth of Scientific and Technical Knowledge

Increase of Expenditure on R+D Activities

Percentage of Population Working in R+D

Fig. 6 Even More Specific

Number of Scientific Journals:	Double Every 15 Years
Number of Books in University Libraries:	Double Every 10 Years
Physics Abstracts:	6 Million per Year 17000 per Day
Number of Scientific Publications:	Double Every 5 Years

- ●90% of all published Scientific Knowledge discovered in the 20th Century
- ●2/3 of which after the 2nd World War

→ Personal Experience of Every Scientist
→ Example: Chemistry Experiments

Result: International Scientific DB's

Fig. 7 Exponential Growth of Scientific and Technical Knowledge

activities and, finally, the percentage of population that is actually working in R&D (Fig. 6).

Let's start with the first point, the exponential growth of sicentific and technical knowledge (Fig. 7). There are a number of sutdies, all of which corroborate that there is an exponential increase. Here are some figures: the number of scientific journals (the first one was an English one, actually, the Transaction of the Philosophical Society) doubles every 15 years. The number of books in university libraries doubles every 10 years. To take an absolute figure of one of the most prolific areas: There are 6 million physics abstracts per year, that is 17,000 publications per day. Taking all publications, the number of scientific publicatons doubles every five years.

This is almost an exact exponential increase, and as with all exponential curves you have strange phenomena. Here is one. Ninety percent of all published scientific knowledge was produced in this century, two-thirds of this knowledge was produced after the 2nd World War.

This corroborates an experience almost every scientist makes; I mean we all know from our everyday life, how hard it is to keep up with the literature and how narrowly we have to focus on sub-fields, sub-fields of sub-fields, sub-fields of sub-sub-fields, and in the end you just have a few mates knowing each other in a very narrow area indeed.

Another interesting area in this respect is chemistry, where certain experiments are conducted on the spot if they cost less than a certain amount. For example, if some new compound is to be discovered, if it costs less than say 10,000 dollars the research company will do the experiment regardless of whether it has been done before, because they know, searching for the appropriate literature will certainly cost more.

The result of all this is an increasing computerization of finding the literature, for example international data banks for scientific articles, elaborate search programs and so on.

Let's look at the second point, the increase of expendiutre on R & D activities. This is the single area that has experienced the *highest* growth rates of all expenditure in all industrial countries. I have taken some figures from Germany: The gross national product increased within 20 years by three times. At the same time, the expenditure on R & D increased by 15 times, and the amount spent on education increased by six times during that period. In other words, the slice spent on R & D and education continually increases and takes up more and more of the cake. Although the increase of expenditure was particularly dramatic in Germany, since after the war, we had to catch up, these figures are nevertheless corroborated from other countries as well. As you can see down here this diagram (Fig. 8) gives approximately the same increase spent on R & D for most of the other industrialized nations.

Finally, my third point, the percentage of the population working in R & D (Fig. 9). Here are the strange phenomena of the exponential curve: 80 percent of all scientists that ever lived on earth live right now in our generation. Some statistics from Germany 1969 to 1981 show an increase of 64 percent of German scientists during this period. The percentage of youths with an A-level, the so called "Abitur" in German (the entry permission into universities, which carries a high societal status) increased from 1960 when we had 6 percent, to 23 percent in 1980.

In All Industrialized Nations Highest Relative Growth Rate

Increase from 1945 to 1965 in Germany

- GNP 3-times
- R + D 15-times
- Education 6-times

Comparison To Other Countries

Bruttoinlandsausgaben für FuE je Einwohner in ausgewählten Staaten, in US$, 1975-1981[1)]

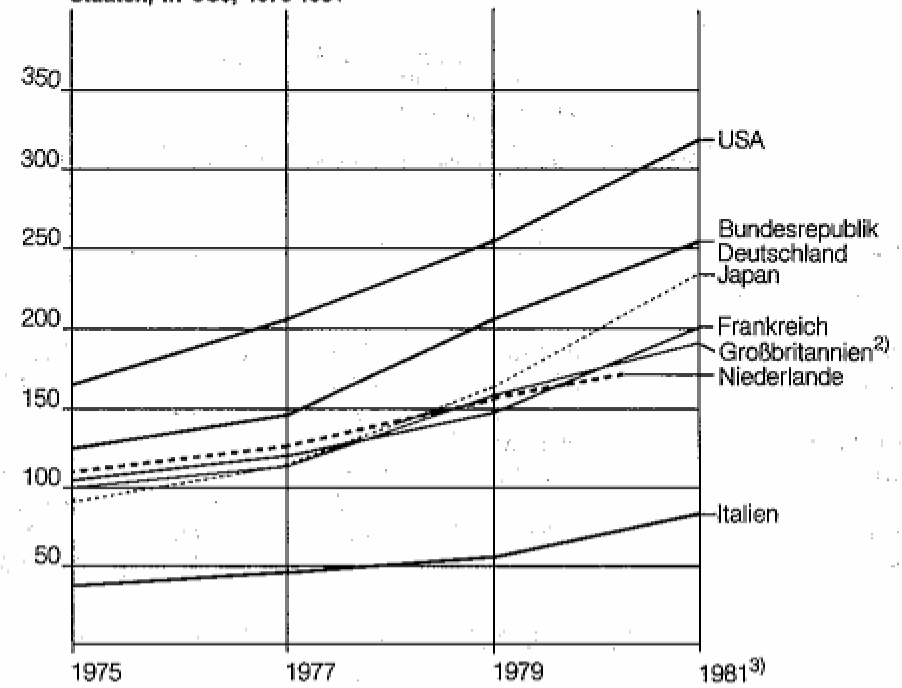


Fig. 8 Increase of Expenditure on R + D Activities

And, as a final point, the increase in expenditure on education doubled in 30 years.

These figures are not just specific for Germany (Fig. 10). These are typical figures for other OECD countries as well, all of which corroborate the same dramatic increase of the population working in R & D (i.e. technicians, researchers, scientists in industrial and government institutions, and so on). The first three columns give the absolute figures, and the last column gives the increase in percent which is between 12, 16 and 20 percent in almost all countries. Let me sum up these three points: Yes, indeed, we can already witness a transition towards the new post-industrial society, which is now characterized by three productivity forces rather than the two traditional forces, capital and labor.

Usually land, capital and labor are considered as the driving forces by political scientists. Well, land is debatable nowadays, but certainly now there is a third pro-

Today: 80% of all scientists that ever lived on earth

Statistics for Germany:
Number of Scientists and Technicians
1969: 240,000
1981: 372,000 Increase: 64%

Percentage of Youth with A-Level (Abitur u.a)
1960: 6%
1970: 11%
1980: 23%

Increase in Expenditure on Education:
1950: 2% of GNP
1982: 5% of GNP

Fig. 9 Percentage of Population Working in R + D

Country	1977	1979	1981	Change abs.	%
West Germany	319,437	363,208	371,548	52,201	16,3
France	222,111	230,766	249,000	26,889	12,1
Italy	97,345	94,643	102,836	5,491	5,6
Great Britain	259,600				
Sweden	36,283	36,434	43,114	6,831	18,8
Japan	564,915	601,192	648,977	84,062	14,9
Canada	55,971	59,080	65,712	9,741	17,4
USA	570,300	626,800	691,400	121,100	21,2

Fig. 10 Statistics For Other OECD-Countries

ductivity force, namely science and technology, and according to some sociologists this is three major one (Fig. 11).

R. Kreibich substantiates this point in his book "Die Wissenschaftsgesellschaft" and claims that the other traditional productivity forces are almost neglegible. Of course, labor is important, but only if educational standards are high enough. Of course, capital is important but in industrial nations there is enough capital anyway. So the really interesting driving force becomes this third productivity force, science and technology, that accounts for the dynamics of modern societies.

More debatable, of course, is the problem to isolate those areas that account for this new productivity. Whatever they are, certainly Gene Technology is among them (probably not yet in monetary terms but certainly in terms of its potential). Secondly the invention of new materials in physics and chemistry: we are currently witnessing the substitution of natural materials by artificial substances at an unprecedented scale. In particular the substitution of iron by new materials may mark the end of our "iron age."

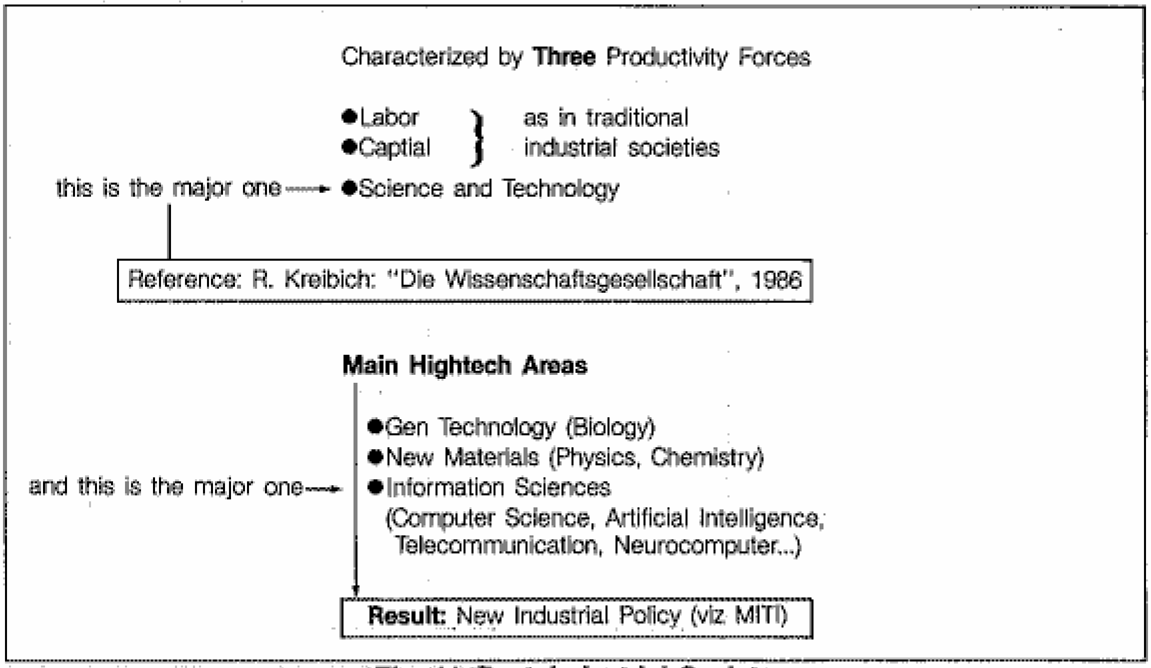


Fig. 11 Post-industrial Society

And, finally, I would endorse the view, that the information sciences, particularly if taken as a whole (i.e. computer science, artificial intelligence, neuro computers, microelectronics and computer based communication) change our society more than anything else.

The result is a new industrial policy towards science and technology in almost all industrialized countries, most notably of course, in Japan.

I would like to move on to the fourth point, with a brief international comparison, from which we can draw some conclusions for the politics of at least the European countries. Comparing the three countries, USA, Japan and Germany (as a representative of the European countries), the essential conclusion is that Germany (as any other single European country, for that matter) cannot compete on its own and we are forced into international collaboration (Fig. 12). There will be a special talk by Dr. Walker on that, so I'll just skip that topic and present the major figure, to demonstrate my point.

This diagram (Fig. 13-1) depicts the amount spent in Germany (Germany is typical for most European countries in that respect, so I have just taken this because I had the figures, but there is nothing specific here to Germany) on science and technology and you can see that it is substantially less than that of the other two competitors, America and Japan.

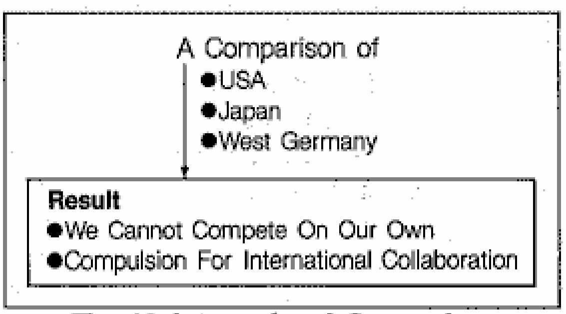


Fig. 12 International Comparison

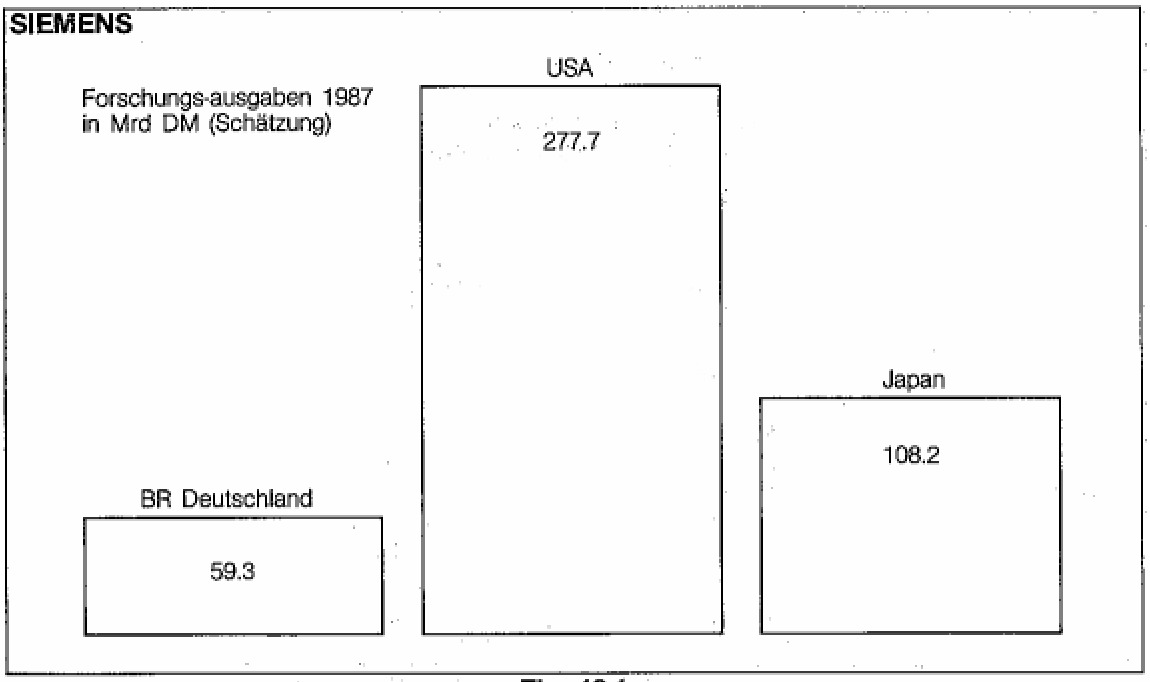


Fig. 13-1

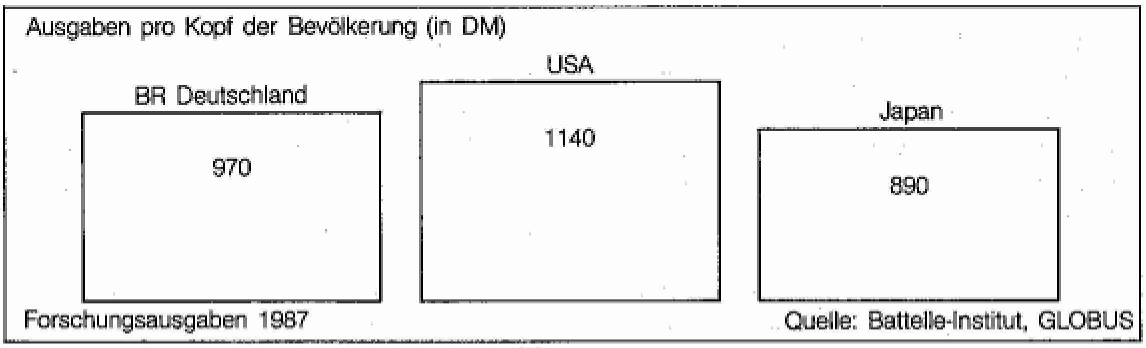


Fig. 13-2

Now could we not just increase our expenditure to the same order of magnitude? Well, the next diagram (Fig. 13-2) shows the relative per capita distribution of what is actually spent and reveals why this cannot be done. Of course, we can increase the amount but not to an arbitrary extent, as we are already spending more, for example, than Japan, and almost as much as America. The problem is, that we are just 60 million people (Japan 130 million, USA 240 million).

So, in the face of this, what is to be done? Currently, at least in Germany there are three major activities (Fig. 14). One is to completely reshape the national R & D activities and to concentrate on the

- Reshape Of National R + D Activities
- European Market And Integration (1992)
- International Collaboration

Fig. 14 Current Activities

important sections. The second is to target for the European market: 1992 is the crucial date most industrial companies and the larger research centers are preparing themselves for, when the huge European maket will be integrated. It is a significant date for the following reason: for the first time, a European company can develop its products for the European market alone, no longer immediately for the world market as it had to be done in the past. It is possible to survive on that market, because of its sheer size in the sense that the research and development costs of new products can be tolerated in view of the potential sale within this market. In the past this was not so: we had to develop a product first for the American or for the international market and only if it was successful there, was it returned back to Germany or Italy or whatever. This is a significant change in economics for Europe with consequences for the research and development sections.

Let me spend now some time on the first point, the reshaping of our research activities (Fig. 15). I'm sorry this slide is in German but it still gives you the general idea, namely that the areas we traditionally spent our money on, the development of nuclear energy and research on transportation, are rapidly decreasing now, whereas the two areas information technology and space research are rapidly increasing.

At the same time, carefully monitored by the German Ministry of Technology, they are reshaping the way research is done in Germany—and the same is actually happening in most other European countries as well. The changes currently taking palce are this: Germany was always accused of the fact that the universities are too traditional and although some good science and some outstanding individuals came out of it in the past, the overall picture of technical innovation was rather poor. In particular, there was not enough collaboration with the industrial research labs. Now with

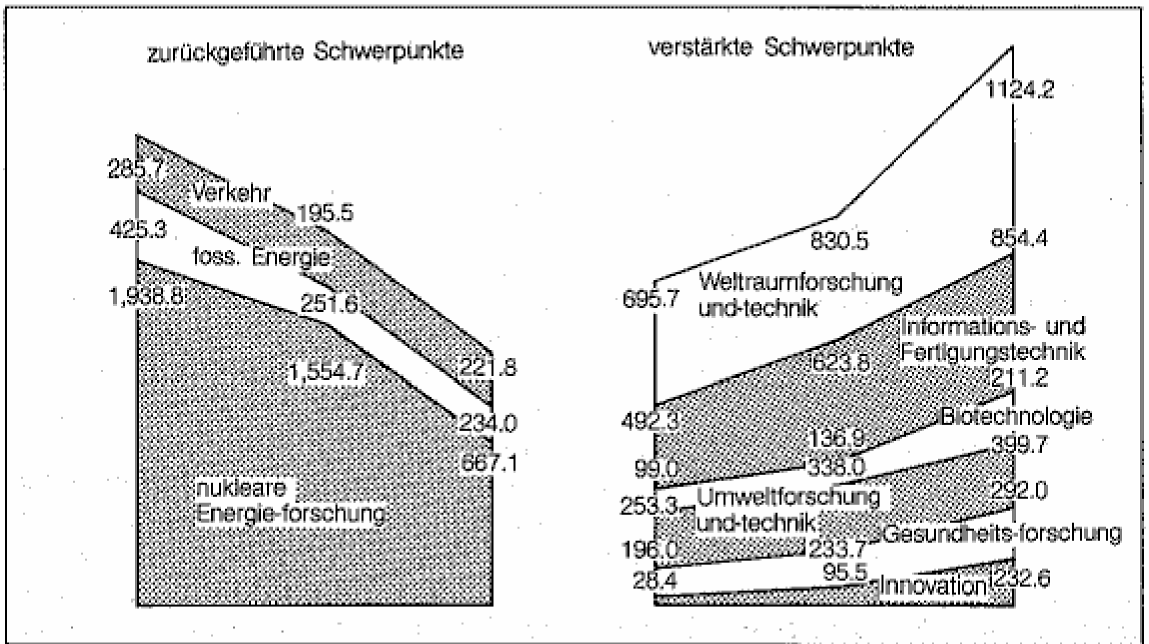


Fig. 15 Umschichtungen im Haushalt des BMFT 1982—1987 (Mio DM)

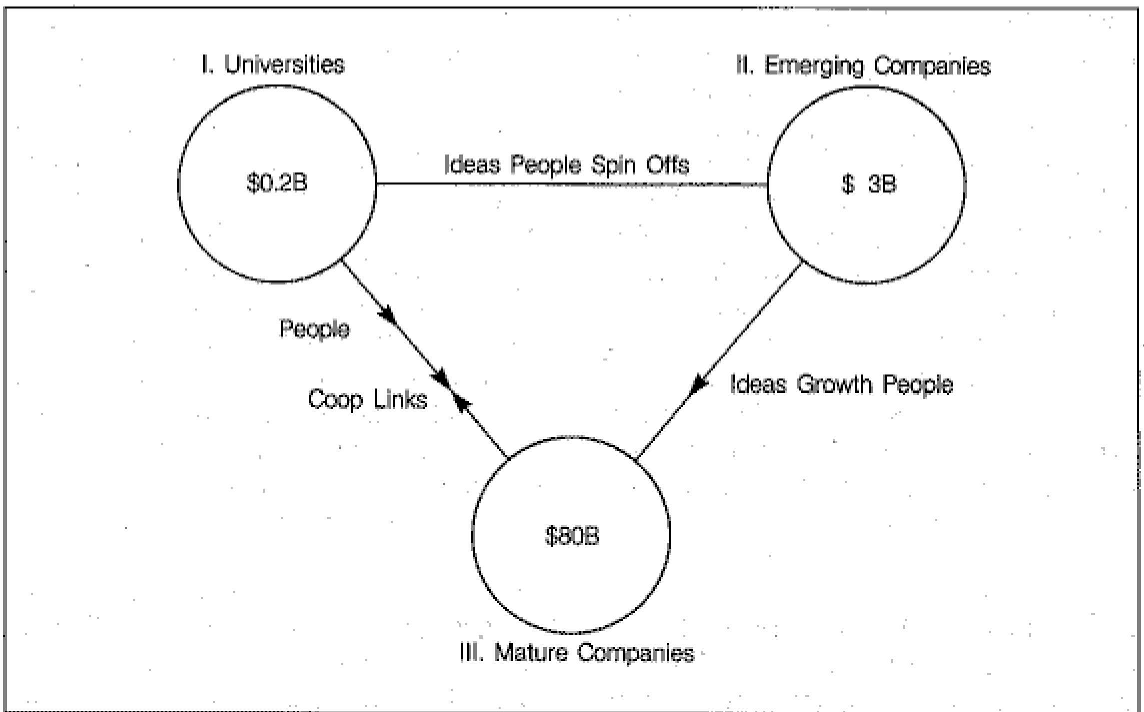


Fig. 16 The Three Wheel Engine of U.S. Leadership in Information Technology

research and technology taking on this new dimension within the society, this is no longer an appropriate model. This diagram (Fig. 16) shows a model taken from America with three spinwheels, namely universities, start-up companies and major companies and their close linkages, the money flow and the flow of ideas. Exactly that is the mode to be implemented in Germany and again in most other European countries as well.

Personally our experience as active scientists is to witness these general changes in the more specific domain of artificial intelligence, the area we originally started with. To sum up let me show what is happening here, but, again, this is not just happening to artificial intelligence, it is a general trend to be witnessed in all major R & D sections vital to the economy. The universities still play their traditional role in educating students and doing basic research, but they are no longer alone and there are very close links now between universities and industrial as well as state financed R & D research institutions. In the case of artificial intelligence it looks like this: There is a national AI center substantially funded by the state as well as by industrial partners, and its objective is to do long-term research spanning about a decade ahead (Fig. 17). It is situated within a university so there are close links to the basic research activities of this university. Below this center, there are more applied AI research centers mainly on the borderline between AI and computer science. They all have close links with the industrial R & D development centers and also to the German National Research Center which is, in fact, monitored by industry itself.

On the topic of international collaboration I want to be brief because that is an important topic to be discussed later on by

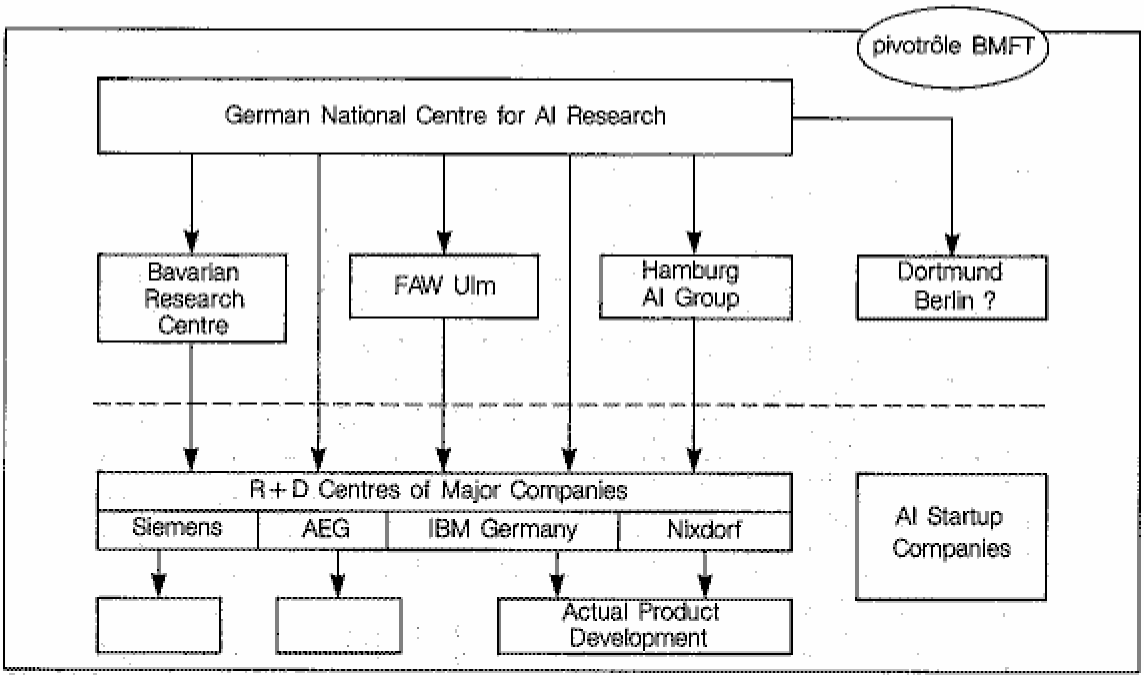


Fig. 17 Artificial Intelligence in Germany: R + D Infrastructure

Dr. Walker. It is important, because most companies are very active in this respect, in the face of the challenges I mentioned before. This diagram depicts the relationships between various companies (Fig. 18). Another good example is the International Institute for Computer Science (ICSI) at Berkeley which is partially funded by German money.

That more or less sums up what I wanted to say and let us just briefly recapitulate: We are saying essentially that our societies are in a rapid transition and this transition will accelerate over the years to come. We have recognized the problem and all seems to look well: Certain sections of the society will become redundant and will move into other sections, mainly research and development.

It seems as if there were no problems ahead. I personally believe that in the long run, yes, this is probably a true picture and appropriate government measures are taken in most industrial countries. But the picutre I have drawn so far completely leaves out one aspect, namely the social dimension. This picture of smooth technological change as an engine for social changes, presupposes two things, first of all, that we live in a rational society which, of course, we don't, and, secondly, that there are no social problems involved in shifting these people. But of course, there are. We have currently 2.5 million unemployed in Germany (about 13 million in Europe), a large fraction of these will probably never find work again in their life. Hence in the short term of the transition period I do not believe in this smooth picture at all. In fact, I think there are major social upheavals ahead.

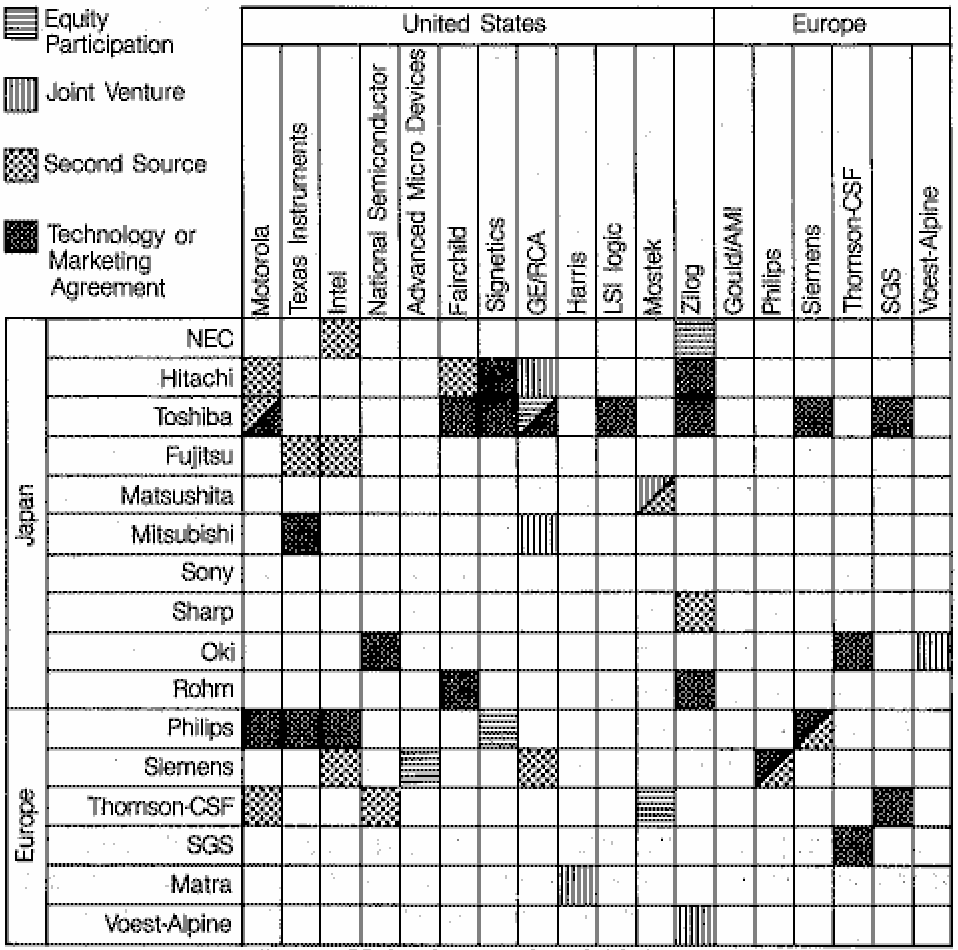


Fig. 18 Major International Linkages

CHAIRMAN: Thank you very much. We'll continue with the next speaker, Dr. Weingarten.

WEINGARTEN: Professor Karatsu, thank you for inviting me to join you on this panel. I'm certainly honored to speak to such a large and august assemblage but, at the same time, in addition to being honored I'm also quite humbled. I come as a futurist whose job is to advise the United States government on how technology is moving and how it's changing the kinds of policies that the government has to consider and make over the next several years.

Over the last seven years that I have been in this job, we published over 30 reports consisting of over 5,000 pages on the subject, and both my staff and I think we've just started to understand what's happening. So you'll pardon me if in these few minutes I just summarize what we've found.

It has also shown us how difficult the problem is of understanding how technology and society interact. The subject tends to be oversimplified, particularly in political debate. Those who create the technology tend to have boundless optimism and enthusiasm for what they're doing—we all do for our jobs—and have high hopes. The critics tend to have boundless pessimism. They see nothing but problems. They see the pitfalls but not the opportunities.

Somehow, when working for the government and advising on policy, we have to steer a middle course. OTA is often accused of having too many hands. We say "on the one hand" and then "on the other hand," and the Congress threatens to cut off one of our hands if we don't stop talking like that.

Any futurist who studies the impacts of information technology has to deal with three types of limitations on the work. First, any particular kind of technology, such as fifth generation system, does not exist in a vacuum by itself but exists as part of a matrix, a complex assembly of technologies that govern how it's used and how it's implemented. To study the implications, one must understand that matrix.

Secondly, information technology is created and provided and used by people. It's used in institutions. It's used to accomplish their purposes, and so its effects are influenced by those human goals and actions.

Finally, the uses and effects of information technology are influenced both directly and deliberately and accidentally and indirectly by the values that we all hold and express in our societies by law, by rules, by regulations, by custom or even by ethical standards regarding its use.

The impacts of technology are, therefore, the intended or unintended consequences of our own choices and our own actions. Technology is not an uncontrollable force, an unknowable force, descending on us from above. It's our creation.

So the most valuable contribution of a futurist is not to predict the future but to try to understand what our choices are and what the consequences of those choices are. How can we realize the benefits of the technology and either avoid the problems they cause or somehow ease the pain of transition?

We certainly know it's critically important to think about these issues particularly with respect to information technology. Historians argue that the printing press, by replacing handwriting and script, created a revolution in culture, economics and politics. It changed the way people create, use and exchange information, and because of that changed our basic institutions and society, and can we doubt that the movement from print to a global information network based on electronic technology will have equally profound implications for our society?

So I am going to discuss each of these three points. First, I want to talk about the matrix or the web of technology in which these systems sit. Secondly, I'm going to briefly give some illustrations of what I mean.by the social or institutional context of how technologies are used, and then, finally, I'm going to propose some of the great social choices that we all, as well as our governments, have to make. I propose them using a term that has become popular in the United States in the scientific community. They talk these days about "grand challenges." Grand challenges are major scientific problems that are currently unsolved and unsolvable but, hopefully, will be addressable with the next generation or the next generation beyond that of computer systems. I'm going to propose social "grand challenges" that we all need to address. First, something about the technological matrix. Fifth generation machines standing by themselves will undoubtedly be powerful tools for problem solving, but I think their major impact will be as part of a worldwide combination of information technology that I've labelled "the global information network." That network is going to amplify the effects of any particular piece of technology within it.

For example, a fifth generation machine in an office may help a business manager to make better decisions within his job within that office; but the global information network, that would include fifth generation technology, will completely change the structure and nature of business, the relationship between firms, the relationships within the entire international economy that is being reshaped by these technologies.

Similarly, a machine in a classroom may help a teacher teach and may help improve the quality of education of any student that uses the machine within that room; but the global information network is changing basically our idea of what education means, what we need to encompass in education, who should receive it, when they should receive it, how and what way and what location it should be delivered.

So what is this network and why is it so powerful? I see four technological trends that shape it. The first technology is the distribution of inexpensive machine intelligence. That's what we're here to talk about this week. Here in Japan and in laboratories all over the world researchers are designing entirely new generations and forms of computers, far more specialized and sophisticated than the simple structures of the past. The systems will manipulate symbols, ideas, logic and perform mathematical calculations at speeds much greater than current technologies allow. Coupled with declining costs and size, this means that fifth generation machines, as well as all these other specialized, extraordinarily powerful devices, will be all around us, potentially affecting every aspect of our daily life.

The second technology is a worldwide digital communications network. We now have the capacity to build this network. The system can connect together any two points on the earth, can carry in digital form information of any type at extremely high speeds—computer data, images, electronic mail, voice, music, virtually anything that can be converted to digital form (meaning virtually any kind of information) can be communicated on this network.

The third technology is really a collection of technologies, that I call the "electronic storehouse of knowledge." Basically, knowledge is moving from paper to electronic form. It doesn't mean that paper is disappearing. In fact, paper is increasing also, but most of the information available on paper is also available electronically. When it is available electronically in digital form, it can be accessed over that global network I referred to. It can be available anywhere, whether it's stored in a large central data bank, in distributed regional databases, or available individually to each of us on an optical disk. The individual can have nearly instant access to all the published knowledge in the world, and eventually will finally realize electronically the ancient dream of Alexander the Great when he established the great library at Alexandria in which he had hoped to accumulate all the codified knowledge of the humans.

The fourth technology is the humanized interface. The greatest barrier to realizing the potential of any of the other three technologies I referred to is to make them useful and effective to human beings, and much research and development is along those lines, including here at ICOT the research involving the fifth generation project. One of its goals has been to develop computer systems that assist more directly human thinking and problem solving.

Machine speech and graphics, voice understanding systems, pattern recognition, all of these technologies aid in communicating to the computer and receiving information from the computer in a way more directly useful. I refer again to the scientific community. One of the exciting new areas of work in science is called "visualization." It's the use of very powerful computer technology to convert what used to be reams of data into pictures. A picture is a much more direct and intuitively expressive of what is happening in the physical system that is being studied.

A major unsolved problem for artificial intelligence is to develop tools that will allow ùs to move freely through the huge library of electronic information I referred to earlier. It's one thing to have the information available. It's quite another thing to have the tools and ability to search for the information needle within that haystack.

These four technologies—computers, communications, storage and human interaction technology—all combine together to form the global information network, but that network is also being designed and used by institutions within society. It's an inseparable part of those institutions that create and deliver it and those that use it. If we are to understand the social impacts we must understand those institutions and how they work. Because of that, for instance, it is surprising to some people that the majority of the staff in my program at OTA are not just technologists. They are social scientists, economists, political scientists, lawyers, librarians, people who need to understand how institutions and human beings work with information.

Let me offer two examples of the institutional forces that shape technology. Most of us have heard of, and Professor Karatsu referred to the deregulation of the telecommunication system in the United States. In the U.S. we have completely changed the institutional structure of the telephone system over the last decade. We have broken up AT&T, the telephone monopoly, we have introduced competition in many areas of telecommunication service, we have eliminated some, although not all—that's important to keep in mind—regulation, all with the hope that by doing that we are going to accelerate the rate at which new technologies will be created, developed and made available. There is still a great deal of debate about whether in fact that will be the effect, but there can be no doubt that the changes in the institutional structure of the telecommunication system in the United States will have an enormous effect on how the technology is made available and how it's going to be developed. It will have far more effect than will the development of new telecommunications technology in and of itself.

My second example is on the user side. It's in the automation of the stock market, a subject which my program is now studying. A purely technological analysis might focus on how an expert system or other kinds of computer system could improve the investment decisions of a broker or improve the efficiency of an investment firm. However, a deeper analysis shows that the entire network of information technology is becoming embedded in the basic operation of the markets. In other words, the market, itself, resides within the technology. The technology is no longer the tool for those who operate the market. The technology is the market. It has become the institution, and so it's fundamentally changing how securities markets operate, how investors relate to them, how the brokers relate to them, and how governments regulate them, if governments can still regulate them. Money and transactions in this system are now nothing but electronic signals.

To analyze these impacts, then, we have to ask not how brokers work but how markets work, and it turns out that we don't understand that very well. We know how individuals work. We don't know what happens in the international securities market.

Nobody is automating the entire system. We are automating the pieces, but the pieces are growing together. We are unintentionally changing the entire system, and it's reasonable to ask whether this is for the good, are there new problems being created? Do securities markets still serve the same purpose? We must understand the social context in which the technology is being used.

Finally, let me move to what I mean about choices I call "grand challenges" that I see ahead of all of us. Sometimes we don't know we're making these choices. Sometimes we don't predict well the results of the choices we make, and sometimes the choices are made by people we don't even know or we don't know about. Perhaps because of that, it may seem that the technology is an outside force having uncontrollable effects on us.

However, my assumption is always that the social impacts of technology are at least partially shaped by human choice, and I also believe that information technology is confronting us with several critical choices that will determine whether we will gain the benefits they seem to promise. I propose them as five grand challenges. Those challenges are not just for governments. They are for all of us, for private firms, for individuals.

The first challenge is building and managing the global information network I referred to before. It's a constantly growing and changing assemblage of technologies. I think it's already the most complex system ever built by human beings in terms of numbers of components, numbers and complexity of the interconnections, and in terms of how it's used. But it's being built and managed cooperatively by different nations, by different organizations within the nations, all of them working from very different assumptions, different value systems, and different national goals. No one is in charge (and no one should be in charge). The work is done cooperatively, usually.

Somehow those parts, though, must all connect and work together as an integrated whole. The first grand challenge for us all is to make that network work, to see that it does not disintegrate into competitive and non-connectable pieces.

The second grand challenge is to assure access. Information technology is no good to us if we can't gain access to it. The challenge, then, is to see that it can be used, accessed and used by nations, by institutions and by individual people.

Several types of barriers to access may exist. Of course, there are physical and technological barriers—if you can't plug the plug into the wall because it's incompatible, or if the wires don't extend to an office or home or to a nation, for that matter. Certain types of computers and computer systems or data banks are kept locked up. The systems are incompatible. We clearly can't make use of the technology.

Access to technologies also carry a cost and, of course, inability to pay that cost can be a barrier.

Finally, and most importantly, I think, although we don't normally think of it as a barrier, is the inability of people to use information technology even when it is physically available and affordable. That depends on their education, their literacy level. At OTA we usually define "literacy" to mean not just reading and writing but the ability to participate fully in the important information flows in society whatever their form, electronic or paper. That means that education and training itself becomes a major policy to assure access.

Clearly, then, to achieve the benefits of information technology, a grand challenge will be to see that as many people as possible have access to it.

The third challenge is preserving information values. Information has always been a vital resource to society, even to primitive societies, and we hold deep values because of that regarding its use. As technology changes the form of information, it threatens some of those values. It throws some of those values into conflict.

For instance, we value privacy, the ability to control what information about us is known and how it is used, who knows it and what they do with it. We value some kinds of information as a public resource. For that we establish libraries, we establish public education systems. We have free television. All of these express the value that certain kinds of information and certain amounts of information flow within the society are critical. But we also protect some information as property. We try to give it a tangible value. We protect it through intellectual property laws, and we allow treatment as property things like programs, books, songs, plays, even performances, something that can be created, bought, sold and owned.

The third grand challenge, and one that consumes a lot of our efforts at OTA,then, is to study how to preserve those values and when they come into conflict, for instance the conflict between information as a public good or public resource and information as a property, how to resolve those conflicts within a reasonable balance and protect both of them at the same time.

The fourth grand challenge is managing an automated economy. Few experts doubt that information technology is transforming the economic structure of the world. As I said earlier, one can expect that fifth generation machines in the global network will change it further. It's globalizing the world's markets and economies. It's changing the nature of business and management. It's changing and will change more in the future the nature of work. It's changing the type of jobs available, the skills required to do them, the working environment, the relationship among employees and between employees and employers. Perhaps it will create unemployment, perhaps it will create dislocation. Regardless, there are enormous social problems that need to be resolved, and navigating the world's and the nations' economies through these profound changes is going to be the fourth grand challenge.

The fifth, due to the international nature of the technology, is to accommodate international stresses. Probably nothing is more central to a nation's cultural, economic and political identity than the information flows within that nation, and much government policy is directed at protecting and enforcing the cultural and social values with regard to those flows.

The global information network, by interconnecting national systems, tends to create international tensions in many policy areas that have traditionally been handled domestically—intellectual property, communications regulation, banking law, laws that regulate securities markets and so on. The globalization of markets and production creates international pressures on nations' economic policies. Broader access to information across borders can create cultural conflicts and political conflicts.

On the other hand, many of the most important problems that we hope fifth generation and other information technology will solve are global. The environment, Third World development, public health, all of these great social issues cross national boundaries.

So the fifth grand challenge is to balance the protection of important national values with the growing pressures and opportunities resulting from the internationalization of information technology.

In conclusion, I would like to say that we cannot depend solely on the existence of powerful new information technologies to create a more humane society and solve some of our great social problems. Technology alone cannot do it. We need to incorporate it into our social and political institutions so that working together with the technology we can be wiser and more creative human beings. Mere information, a flood of information, is not enough. We can become buried in it.

The 20th century poet T.S. Elliot wrote: "Where is the wisdom we have lost in knowledge? Where is the knowledge we have lost in information?" The impacts of these marvelous technologies will result not from the technologies themselves but from our own social choices. We can choose to develop technology that will help pull the world together or further divide it, close the gulf between the developed and the lesser developed nations of the world, or to perpetuate or even increase the vast gulf that exists between them.

If information technology can really help make us wiser people rather than just better informed, perhaps it's with these choices themselves that it must help us first.

Mr. Chairman, thank you very much for letting me have this time.

CHAIRMAN: Thank you very much. Thank you for giving us a very broad perspective. Now we will hear from the last panelist, Dr. Walker, who is involved in the ALVEY Program.

WALKER: The previous speakers have dealt more with the impact of IT on society. I shall deal more with the implications of international collaboration, which is the other part of the title of this afternoon's session. Even this is a very large topic, and in the time which Professor Karatsu has given me I can only touch on a small part of it, but the one which is I believe of interest to this audience, that is pre-competitive R&D. I speak from some personal experience having started as an academic but having within government both run a national program, helped to run a European program, and being involved in other international collaboration, including with Japan. I shall use this talk to review this experience briefly and then to ask a few questions which may provoke discussion later.

I shall start by admitting that I have never been able to find a good definition of pre-competitive R&D, although I think most of us can recognize it when we come across it. My predecessor, Brian Oakley, used to say that it was any research on which people wanted to collaborate. I doubt myself whether any research is really pre-competitive. My memory of the academic world is that it displays all the hallmarks of extreme competition. Moreover, most, although not all, collaboration involves cooperation with a restricted group of partners, and that implies a degree of competition with others, either nationally or internationally.

I suppose that there are two chief elements to pre-competitive research—cooperation between companies and cooperation between industry and academia. The second of these has usually been regarded as common in the U.S., although rather less so in Europe and Japan. The first has become identified with Japan largely through the variety of MITI-sponsored programs. Many argue it was the fifth generation program itself that stimulated or perhaps frightened Europe and America to start programs of the same kind, although reflecting the particular cultural and business backgrounds of the countries concerned.

Before going on to the social aspects of this cooperation, it may be worth speculating a little on the reasons for this rush into collaborative R&D. It is, of course, not new. There has been collaboration between companies for many years both in cartels and between users and suppliers. This has, however, not usually been organized by or under the auspices of a government, nor have the arrangements had a particularly high public profile. They have also tended to concentrate on joint ventures or production agreements rather than R&D.

I think, however, that there is a clear reason for this growth of collaborative R&D. It stems from the increasingly global nature of the IT market, coupled with the nature of that market, a shorter product life cycle with increasing scale and risk of the necessary R&D, and the tendency especially in the IT and electronics area for product development but to be influenced on heavily by recent scientific results. This produces obvious pressure to reduce the risks both of R&D expenditure and the very downstream investment. This pressure can often be increased further by the absence of international accepted standards.

For some time, therefore, business school texts have included pieces on collaboration as an element of corporate strategy.

I want to confine myself to a personal review of the social implications of those involved, whether its researchers or as managers. This is perhaps a fairly restricted interpretation of the title of this afternoon's session, but it is one that is only rarely explored and one where I suspect there are large differences between countries. It is, however, one well worth the time because many companies, at least in Europe, are spending up to 20 percent of their budget for longer term R&D on collaborative projects. This is bound to mean a greater mutual dependence as well as a tendency to greater specialization.

The first change as a result of cooperative programs in Europe is a much greater contact between the executives of various companies. My understanding is that when Viscount Davignon called together the chief executives of the top 12 European IT companies to create the roundtable, it was the first time they had met. Now they know each other well.

Moreover, the fact that researchers from their companies collaborate on projects means that not only will there be contact at this level but as those industrial research workers move up their companies the big change is that they will already know their opposite numbers. By the time they become chief executives they will have known their peers in other European firms for 20 or 30 years, and this will normally, perhaps not always, make cooperation much easier. It will definitely improve their knowledge of what is going on in Europe.

This greater degree of contact is of particular importance in Europe where for too long the firms in individual countries have had insufficient contact with or knowledge of each other. Working together on R&D also provides a means to building up relationships in other areas often closer to the market. Indeed, this is one of the major ways in which ESPRIT and other programs of its kind support the development of a single European market. It is these commercial considerations, rather than just the desire to do more research, that provides the motivation for the involvement of many of the companies and underlies their approach to the formation of the particular collaborations.

This is also true of national programs in the U.K. which have brought together representatives of the IT supplier companies as well as drawing users and suppliers closer together. It is possible, indeed, that this may have contributed to a number of the takeovers and rationalizations which have taken place in the last year or so. Many industrialists have told me that one of the aspects of collaborative programs which they value most highly is the means to meet their peers, to get to know them better, and to be able to discuss issues with them in a neutral forum. The fact that a government-run collaborative program is necessary to achieve this may come as a surprise particularly to our Japanese colleagues because if the myths were to be believed there is constant contact between the different Japanese companies. It is also different from the U.S. where prior to initiatives like MCC and the recent relaxation of anti-trust legislation, there is a danger that the Justice Department would presume that a meeting of chief executives of computing companies could have taken place only for the purpose of arranging an illegal cartel.

Nevertheless, at least in the U.K. there do appear to be considerable advantages from government organizations holding the ring of these kind of discussions. The ALVEY Program had also developed the relations between U.K. industry and the academic world. Five years ago there was, with notable exceptions on both sides, too little contact and too little understanding of what the other had to offer. Now industrialists have a greater appreciation of the relevance of academic research, while academics recognize the considerable intellectual content of industrial research. This has a significant impact on teaching. Not only the students observe their professors working with industry but course materials start to use examples taken from industrial experience.

Within the U.K. the research community is now much better developed in a number of areas and provides scope for much better communication over a wider range of interest. It has also stimulated greater mobility of researchers, which is perhaps the best way of securing technology transfer.

I believe there have been corresponding developments as a result of other national programs in Europe and that the U.S. programs have also stimulated greater contact of this nature.

The effects on the society of the IT researchers depends a little on the geographic nature of the cooperation. The U.K. has normally preferred to have collaborative projects arranged on a distributive basis with researchers remaining in their parent organization. While this may be because we recognize a lot of success in winding up laboratories which have fulfilled their usefulness, it does have the advantage of facilitating technology transfer back to the participating organizations.

On the other hand, MITI has often chosen to establish a central laboratory such as ICOT for the fifth generation or the corresponding laboratory for optoelectronics to which partners second staff, and MCC has taken the same line in the U.S.A.

However, one of the most interesting examples is in Europe with the formation of ECRC by the three mainframe companies, ICL, Bull and Siemens. This is a joint research laboratory for the three companies located in Germany with a French director, Hervé Gallaire, who is here today and whose working language is in English.

There have, therefore, been substantial results and alterations within the IT community as a result of these programs. I suspect that the largest changes have taken place in Europe where the fragmentation of the Community between the different countries has been reduced. There has also been greater contact with Japan particularly on the part of European academic workers, and contact with the U.S. has been at least maintained, although traditionally this involves very little direct government involvement on either side. It has been claimed that England and the U.S.A. are two countries divided by the same language.

The economic and commercial pressures are likely to result in a continuation of this increased contact between different parts of the Community. Within Europe I believe there will be increasing concentration of the industrial structure, particularly in the software field, and that this will be facilitated by the greater social contact that has developed over the last few years. In time, the more that companies become genuinely European, rather than regarding themselves as from a particular country, the more we can expect increased interchange between the European IT research community. This will also be helped by the free movement of researchers and the mutual recognition of professional qualifications which has recently been agreed.

However, there are a number of issues that arise from these developments. The first, and perhaps the most crucial, relates to whether these programs are part of a movement to carry out IT R&D on a genuinely international basis, or whether they are part of what might be characterized as intellectual protectionism.

Most of the collaborative programs are concentrated on a particular country, or in the case of the European programs on a group of countries. While most academic programs remain international, not all the more industrially oriented programs welcome or acquiesce in the involvement of multinationals from other countries.

While there are programs which have been prepared to develop relationships with other programs, others have not. One might argue that because the reason for the programs in the first place was to develop or protect a commercial advantage for the organizing country, it will make no sense to collaborate with other programs.

Alternatively, the structure of a program will have been drawn up to reflect the particular needs or position of the industry in that country, and these both make it more difficult or inappropriate to accept foreign participants. Both of these are understandable arguments, but to my mind it will be a pity if they resulted in the collection of programs which were too inward looking. After all, no one can believe that any one country or group of countries can do all the R&D necessary for its own IT development.

This need, or at least the degree of openness, is being recognized. ESPRIT has allowed the participation of companies from non-Community European countries, and together with a number of European national programs permits the involvement of multinationals, provided the research is carried out in the country concerned. There are also links between ICOT and other countries, but I must still admit to a certain unease about the dangers of the research equivalent of a trade war. I hope I am wrong, and it would be interesting to hear the comments of other delegates later.

Perhaps it will be helpful to illustrate these issues and the opportunities they provide by looking at two of the decisions that will have to be taken in Europe. At the moment, many ESPRIT projects contain universities in one country and firms in another, and there is undoubtedly significant cooperation between them. However, most industry-academic cooperation still tends to be within the same country and universities are usually brought into a consortium on that basis.

However, after 1992 when the single market comes into force, it may be more appropriate to think in terms of European companies and European universities. Thus, the U.K. may want to encourage its companies to collaborate with the best European university, not just the best U.K. institution, and correspondingly with the universities. This would have considerable implications for the way the U.K. operates its support for research in universities in IT because it will be important to make sure that enough of our universities were of European stature. At the same time, our companies would need to become more aware of the European academic world than they are at the moment. And, of course, I would expect our French, German, Greek, Spanish and Portuguese colleagues to be doing exactly the same. This could have a significant effect on the structure of collaboration or the development of a genuinely European IT community.

The other example is the industrial analog of the first but is also a key question for governments in Europe. It is how does one decide what kind of projects should be done in a national program and what kind of project in a European program.

At present, there are few clear answers, although my impression has been that companies tend to enter European programs for reasons of commercial strategy rather than purely to do research.

I show here a number of examples of collaboration going on at the moment, the number of national programs, bilateral programs, the MEGA project between the Netherlands and West Germany, multilateral programs in Europe, ESPRIT and EUREKA. In the U.K. we have been giving some initial thought on how we make the choice between European and national programs. For European programs we think there are three kinds of criteria. The first is those projects whose exploitation will require very substantial investment in production or marketing, for example whole processes for LSI or new parallel processing architectures. Here the investment must be made on the basis of at least the European, if not the world, market. It makes no sense for every European country to develop its own.

Next is the development of standards. For example, the portable common tool environment for engineering or ANSA in computer architectures.

The third area is projects where there already is some European collaboration, and we would obviously wish to encourage that.

For national programs we think they are more appropriate for work which is becoming interdisciplinary for the first time. It is difficult enough to get the people from different disciplines to work together without making it international as well, also longer term speculative research which will prepare the U.K. or another European country for European programs in the future or preliminary work on standards. Alternatively, small scale additions to work on European projects. For example, while the portable common tool environment may be developed in ESPRIT itself, individual tools compatible with that could be developed in national programs.

As the last topic areas where the U.K. already has a comparative advantage, e.g. natural language, where it might be claimed that our natural use of English gives us an advantage.

Now, those criteria do not provide a complete answer to the problem, but they are a starting point and they allow us to begin to discuss the relationship between the two programs and between the research communities, but I must admit that we are ready to start to think about these issues, and it is by no means clear where they will lead. It will be a pity if the variety of initiatives within the Community was to make Europe inward looking, and I hope that we will be able to maintain and develop links with programs in countries outside Europe as well as with individual companies and with institutions.

It is, however, clear that we need to develop answers to the question of how a company, university or government decides whether to pursue particular research topics within its own country, within a program like ESPRIT which involves a defined group of countries, bilaterally with another European country like MEGA Project, bilaterally with Japan, with the U.S.A., or with another country outside Europe or, indeed, by collaboration with different international programs. This is an embarrassing range of possibilities but the answers we produce and the choices all of us make will define not just the social structure of the IT research community but would also be of great significance for the commercial structure of the industry. It is perhaps too much to hope that we will get the answers right, but I hope we can avoid being too wrong.

Thank you, Mr. Chairman.

CHAIRMAN: Thank you very much, Dr. Walker. So far we have listened to three speakers who presented their broad perspectives. I would like to attempt to make a summary.

When I was listening to Professor Siekmann's presentation I thought the audience here is very lucky in that he assured us that the future ahead of us is so promising and presents so much potential opportunity, but in order to make full use of that opportunity there are many problems that we have to solve.

Dr. Weingarten, who has been engaged in technical assessment in Washington in the United States, clearly presented those problems, and he again and again used the term "grand challenge" and he predicted innovative changes in various fields of the society and elaborated on them with specifics, which included some technical problems as well as labor relations and international relations.

He was followed by Dr. Walker, who talked about international cooperation, and now I would like some questions, some controversial questions maybe. Of course, it is important to point out the necessity of international cooperation, but when I was listening to the presentation I had an impression that international cooperation in the private sector would be easier because interests there are so clearly presented, but when it comes to cooperation between governments, there are sometimes conflicting interests. So there should be a limit to such international collaboration. In my view, international collaboration sounds very beautiful and nice, but in reality how can we realize international collaboration? The integration of the European Market starts in 1992, and the countries in the rest of the world are trying to preempt the best position in that market. Collaboration is going on and at the same time the competition has intensified, and that situation was described by Professor Siekmann as well. Because the United States is separated by the ocean from the continent, that kind of feeling may be less intensely felt, there.

The same situation can be observed in Japan. Although the media coverage about the integration of the European Market in Japan is increasing, the Japanese don't take the integration of the European Market seriously, and so this is the first point that I wanted to ask about international collaboration, whether it is really possible.

The second question is related to the motivation that drives humans. It is not only the rationality that motivates us. A computer may be driven by rational forces, but what about the human? It was not clearly elaborated, so I want to ask that second question. And so as the first question I would like to ask concerns the possibility of international collaboration. Can I invite comments from the speakers about international collaboration? I wonder who would lead off the discussion. Dr. Walker?

WALKER: Mr. Chairman, your question was whether international collaboration is possible. It is clearly possible. It happens both in Europe. It happens between American companies and European companies, and it happens between Japanese companies and European companies as well, and it seems to me a natural strategy for companies to adopt, and I don't see anything necessarily wrong with it. I don't think that it is the answer to all questions, and there clearly has to be a balance between a collaboration where it is in the interest of those who collaborate and competition where they perceive that to be in their interest. I think the question for individual companies is to decide where the border lies in particular cases, but I think over the last ten years in electronics and IT we have seen more and more cooperation between companies both in the same country and in different countries.

WEINGARTEN: I would like to just make a couple of general comments. In the first place, I think the U.S., perhaps not driven by necessity as is the European Community, but has certainly been experiencing some of the problems of internationalization and the linkages of economies in its negotiations with Canada. In fact, the recent Canadian election has brought some of those difficulties and problems to the surface.

On international cooperation, I would

like to interject a note here based on the study we published sometime ago. It may be that overt government-directed collaboration internationally is in fact sometimes difficult, sometimes raises political symbolism and resistance, but in fact science and technology is an international activity. Scientists have collaborated and shared their results across national borders for hundreds of years, and so in some sense international collaboration and cooperation is not only possible, it is probably inevitable and unstoppable within vast portions of the scientific and technical community. They find it unnatural in fact to think that national borders define their activities.

We also find, looking at corporations where research is in fact appropriated and controlled as property, that even there as the economy internationalizes, as markets internationalize, technology transfer agreements are made between firms, and scientists move across borders and carry their knowlege with them, that there is a level of international cooperation and collaboration that is far beyond the ability of any government to stop it even if they wanted to. So the question I think only refers to specific overt government-sponsored attempts at collaboration.

SIEKMANN: I'm becoming increasingly restless with our over-optimistic pictures. Yes, of course, there is increasing collaboration but, as you said, that was always the case among scientists. What is new, is that this international collaboration is almost entirely in the interest of economics, certain economic interests. Take for example, the ESPRIT Project, which was very well presented by Dr. Walker. But why is it there in the first palce? It exists because we Europeans are just scared stiff that we will not survive on the international market unless were organize ourselves and have a market similar in size to, say, the United States of America. That is the driving force behind it. That is the reason why the ESPRIT Project is currently operating, and the goals of the ESPRIT Project are not in the first approximation geared to the advance of science. Yes they are that as well, but they are primarily geared towards the economic interests of the participating countries in Europe. To overstate the point, I usually tell the joke at this point that certain laboratories in America are no longer open for Japanese scientists, but they are still open for us—which tells you something about Germany (we have become some sort of rabbits, no longer a challenge for anyone), but in particular it tells you something about the political dimension of todays scientific business: why it is that some have the privilege to participate in the international scientific community whereas others have not? That has never happened before in science: even in the "dark" medieval ages, there were excellent relationships and communication among those (few) scientists.

MCC, for example, was one of the first institutions that actually put restrictions on its freedom to publicize. Exactly the same issue is currently debated in the German National AI Institute. For the first time (Germany has one of the oldest traditions in academic life, paralleled only by Great Britain), for the first time we discover that we may no longer be able to publish our results. So, of course, this kind of internaitonal scientific collaboration is geared to economic interests. Let me put up a slide which I brought along because I expected this coming up, anyway:

It shows you the life cycle between the invention of some typical pieces of tech-

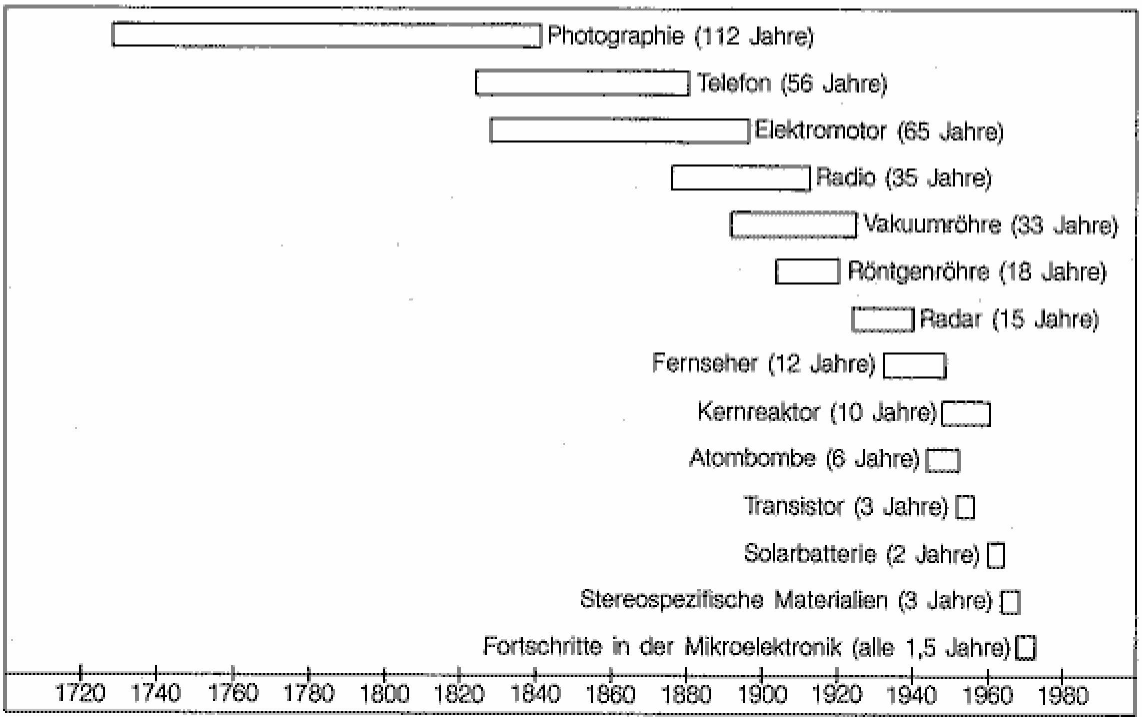


Fig. 19 Die Geschwindigkeit des Technologischen Wandels: Intervalle zwischen Entdeckung und Anwendung in den physikalischen Wissenschaften

nology and its final marketing (Fig. 19). As it is in German (the important buzzwords are international, however), let me remark on some entries: The first one gives the life cycle of photography which took 112 years between the invention and the marketing. The telephone took 56 years. The electric engine 65 years and moving down,the vacuum tube 33 years, the ray tube 18 years, radar 15 years, television 12 years, atom bomb only 6 years, the transistor 3 years and finally, pieces of microelectronics only 1.5 years. Microelectronics has now exceeded the most dynamic field so far, namely chemistry, which used to have the fastest turnaround time.

Now it is only 1.5 years—and the race for the first megachip (now the 4 mega chip) between two European companies and the Japanese competitor is probably well known in this audience: it was a matter of months! This situation explains the interest of the large companies into our research and why they spend so much money now in key technologies. This is a far cry from the good old liberal thinking that we are all good scientists and that we should internationally collaborate towards the best of mankind.

CHAIRMAN: Dr. Walker, do you have comments?

WALKER: There is no doubt that, as I mentioned in my talk, the shorter product life cycle is likely to encourage people to collaborate. I agree, too, that there are potential problems in information being restricted. I think history tells us it's usually rather difficult to do that.

CHAIRMAN: Thank you very much. What I am referring to is the coexistence within the collaboration is indispensable for the new technology to advance. How can we go about the coexistence within the collaboration? This is such a huge question that we cannot resolve here among ourselves, but without the competition we cannot expect the advancement of the technology. Competition is the mother of invention, but too much competition will inevitably cause problems, so coexistence within competition has to be properly coordinated. Coexistence within competition, this is something that the government and other sectors concerned should seriously consider.

After asking the second question I would like to open the discussion to the floor. We didn't touch on the Third World issue in this session. The relation between high technology and the Third World, do you have any comments? Does anybody have any comment about the relation between the Third World and high technology?

WEINGARTEN: I will refer back to my comment on access as one of the grand challenges. In fact, one of the areas I was thinking specifically of was Third World access to these technologies. It would be very easy to unintentionally allow this global network that I referred to to evolve in such a way that access by the Third World would become either prohibitively expensive or even technically impossible.

Secondly, in the area of choice it's not so clear that the people who are not involved directly in developing the technologies are having much voice in its forum on how it is to be used.

CHAIRMAN: Professor Siekmann?

SIEKMANN: Well, I seem to become the "advocatus diaboli", so let me play this role once more. This optimistic picture that if all scientific and technical information was generally available we could all participate and there would be an equal society and genuine collaboration between the poor and the rich countries—I don't believe in this optimistic picture at all, certainly not in the short term and probably not even in the long run.

Take the situation in America: Do you really think that anybody who lives in the Bronx or in Harlem could participate in this brave new world of shared information technology? That is just silly. Do you really think that anybody in the Third World could seriously compete and take advantage of the kind of scientific knowledge that we are producing at this conference? Well, he can't, and if anything—i.e. if it is not just neutral—it will divide that gulf.

WALKER: I think, Mr. Chairman, there is a very important issue here of intellectual property and making it both available and being able to protect it. And, of course, within the GATT at the moment intellectual property is providing quite a problem area where the Third World countries and industrialized countries don't always take the same view of what is the right balance between making things available and protecting them.

CHAIRMAN: When the network becomes global, well, you can access the database or the knowledge base from any point in the world, and you would have to I believe offer payment as a consequence. If we neglect this remunerative payment, then it will present a problem. Suppose if you receive information, then how you use it will depend on the amount of information you already have. Information given to a person who does not know anything about the information becomes useless. In case of the Third World, I think this kind of aspect enters into our consideration. When we discuss the things on the level of the developed, advanced countries, the information that we all have is somewhat equally distributed. We all have a similar type of information, so the issue of intellectual property arises. But if you access the information from a different point of view, the person receiving the information will not know how to utilize it, and I think we can handle this issue from many different perspectives, but the time remaining is only 15 minutes. I would like to turn the handle and navigate toward a different direction, so allow me to go into a different direction.

Floor is open to questions from the audience. We have a microphone, and if you like to ask a question or make a comment please indicate so by raising your hand. Please state your affiliation and your name before you express your view.

QUESTION (Floor): Dr. Karatsu, first I would like to compliment the very articulate remarks on social impacts but, on the other hand, since I am from the U.S.A., we grey-haired people in this audience have certainly heard for at least ten years similar discussion on the social impacts to be expected of the information society. One could cite the fifth generation project itself since 1981, the Masuda book on the information society, some projects in the United States. We always learn of the expected impacts. Is not the real problem to be discussed how we will deal with these impacts? I wonder what the panel feels about that.

CHAIRMAN: Is there any comment? Well, then, on behalf of the panelists, let me respond. When you discuss a thing as the impact, it's like you are being hit by a bullet and things suddenly become different and change. That's the kind of impression we receive. But what I conceive in my mind is that, for instance, the condition ten years ago and the way we handle our business today, either in the office or in manufacturing plants, workshop or in the household, things have changed so much because of the information technology, and I'm sure you are aware of that. For instance, in downtown Tokyo there are many shop floors and to these shop floors the parent companies have traditionally given a pencil drawn draft of drawings, but now what they do is incorporate it into a floppy disk or tapes, because the parent company has done it with a CAD system and is not using the pencil any more. No manufacturing plant does designing by pencil. It is done by CAD. Therefore, it comes out as output on the floppy disk or tape, and this is placed in the machine and automatically produces the expected product. This is a reality now.

You may think this is just a matter of course, but in terms of the production either going up or down, this is very flexible. Flexibility is being provided for. In one instance when the production exceeds its capacity, then the same floppy disk or the tape can be brought to a different location of the plant, and then the same thing can be produced. This is factory automation. It is well known. What's there say about it?

But ten years ago, in no plant was this possible, and also here when you come to Japan, you have flown to Japan, and the seat reservation system is extremely convenient now. The reservation system has been in existence already for 20 years, but 20 years ago the system was entirely different, as you all know very well. Therefore, the social impact, you think that an earthquake will shake up or a fire breaks out and changes the entire scene all of a sudden overnight, but I do not call the social impact in this regard.

So I said word processor. I discussed it as an example. Our sensibility about the Chinese characters has completely been transformed because of the word processor. We learn Chinese characters in the primary school, 3,000 to 4,000 characters are acquired during the primary years, school age, and you cannot graduate unless you have mastered them, but all the characters are in the word processor now. You can just push the button and can get them written out. This is a revolution and, therefore, in this context, as you have just said, since ten years ago the social impact had been always discussed, and you pointed out there has been no particular outcome out of that. But as far as my judgment goes it has changed, but since we are flying along with the rate of the progress, and even if the jet airplane runs at the speed of sound, since you are within the airplane you do not perceive the rapid changes. That is my perception and analysis of the situation. Does that answer your question?

QUESTION: I recognize the impacts on the word processors themselves, but one might call social impacts what has happened to the people, what has happened to their interrelationships as people. Issues of this type I think are the questions that are real.

SIEKMANN: Then let's take a few social examples: Of course there is an enormous social impact. In most European countries that is very clearly visible. To start with the bad impact: we have currently 2.5 million unemployed! On the other hand, to give a positive example: I started myself as a skilled carpenter, later on I obtained my A-level in evening classes, and took my first degree as an adult. Looking around at my colleagues, many come from a low social background like myself and they are now working in well-paid scientific jobs. There is indeed a complete, radical social change going on!

Or to take another technological example to demonstrate the rapid changes, let's look at the work that is actually carried out everyday for example in a bank. Traditionally a bank used to be a building. You would think of a bank as a building with people moving in and out. Well, that is a completely wrong conception of it. A bank is a huge computer network with tokens (that may represent money) passing as fast as you can think. That's a completely different working environment. In other words, I don't think that nothing has happened during the last 20 years is our problem, as the speaker from the floor seems to imply. Our problem is that it happens so fast, that we can't cope with it socially.

WALKER: I think there are often very interesting bits of research being done at the moment linking IT architectures with the architecture of organizations. I think that is a very fruitful area for working out both the likely impacts that IT will have on organizations, and hence on the people who work in them, and for identifying and perhaps reaching a degree of agreement on.

I would like to use one example to show that these things are not always bad. There is a company I know with about 80 people, a small company, but it does have a terminal on everyone's desk and everyone in the company can use it to send messages. The managing director tells me that he has much more contact with the people on the shop floor and the cleaners because they are prepared to send him a message by electronic mail. They are not prepared to walk into his office and talk to him. So there are examples of how a slightly less personal arrangement actually improves communication. It doesn't always make it more difficult.

CHAIRMAN: Thank you very much. We have only five minutes left. Using the chairman's prerogative I would like to refer to some related examples. With regard to social impact there have been various opinions expressed—impact on individuals, impact on society as a whole. Different opinions have been expressed.

This morning I watched a TV satellite broadcasting about a European country where AIDS has spread. In order to prevent the spread of AIDS, people are encouraged to use condoms. That was decided by the government. But condoms manufactured in that country have a lot of perforations. One out of two condoms are not useful because of perforations. Only 50 percent are usable. That is a serious problem. Academics in that country said that if the prevalence of AIDS is reduced to half then AIDS will be reduced in that country. This academician used logistics as most of you do understand. If the parameter is reduced a little bit, the number of AIDS patients will be also reduced. So even if one out of two condoms cannot be used, is not usable, condoms should be used, so macroscopically speaking it is useful. But from the individual standpoint if failure occurs once every two times, that is a problem, isn't it? So that is the social impact on an individual scale and a social impact on governmental administration. They use different measures, different scales, as indicated by this example.

Well, we have asked you to stay with us for quite a long time, and we have enjoyed a very broad ranging discussion. I didn't expect to come to any conclusion after the panel discussion, but I am sure that we can correctly understand the important and critical points. In the morning as well as this afternoon we have discussed the purpose of the Fifth Generation Computer Systems project in Japan and the present status of this project.

In the First International Conference held in 1981 we announced that this machine will be launched, and a lot of people asked what kind of machine would be implemented. Mr. Okamatsu, who was in charge in MITI, gave a very smart answer. He said what we will try to aim at is a constellation which would look like a star when from a distance, but when you go closer to this cloud of stars you would find individual stars, not just a cloud of stars. Mr. Okamatsu is now Director-General of a Bureau, and he is so smart that I still remember his answer about the image of the fifth generation computer.

Parallel processing is now quite successfully operating at the stage of the Third Conference. I can still remember an active discussion about parallel processing that took place during the Second Conference. Some people said that parallel processing would not function successfully, but as you saw in the demonstration room parallel processing is functioning and operating quite effectively.

As Dr. Fuchi said in the morning, this is the jump stage after hop and step. After this jump is made, how will this fifth generation computer be integrated in society? How does it function? That is the kind of theme we have to study seriously in the future. As the Master of Ceremony introduced me at the very beginning of this conference, I was the Chairman of the Social Impact Study Committee of this project. It was about ten years ago when I got involved in this project, and I made a presentation after three years of research. As I observed the following subsequent process I did notice the rapid change of the society. What would be the opportunity for the technology to leap ahead, and what would be the impact of society after this leap is made? We have to consider this quite seriously.

We are very lucky to have experts from European countries and from the U.S.A. We would like to thank them for coming over and giving us very useful remarks. Thank you very much.