The revolutionary impact of the SDI on the growth of the world economy

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Twenty-four years ago, Soviet Marshal V. D. Sokolovskii wrote his shrewd insight into the flaws of the U.S. ballistic missile defense program then being developed. He foresaw, that high-speed interceptor rockets, and related kinds of so-called kinetic-energy weapons, could never provide an effective kind of strategic defense against ballistic and guided missiles. He foresaw, that only by using what he described as "advanced physics principles," such as laser-weapons, could defense obtain the superiorities in firepower and mobility needed to supersaturate a strategic thermonuclear offense.

Today, although the United States and others are studying the reasons why a system of kinetic-energy weapons is unworkable, we know that the usefulness of such a system is limited to an auxiliary role in ground-based point defense. Yet, stubborn defenders of kinetic weapons systems argue, that their systems could be successful, provided computer-software problems are solved. If one attempts to develop a computer, to cause rabbits to lay chickens' eggs, and the computer programmers' efforts fail, we should not describe this failure as a computer-software problem. No matter how good the computer systems of battle-management might be, a Soviet offense would have at least a three-to-one advantage in firepower and mobility over any kinetic-energy approach to SDI. It is a matter of physics principles, that a strategic defense based upon what are called "new physical principles" will have at least a 10-to-1 superiority in firepower, mobility, and cost, over a ballistic-missile offense.

Therefore, in speaking of a method of defense against thermonuclear offense, we must limit our attention to the workable forms of defense. I shall limit my remarks here, to indicating the way in which the technologies required for that sort of defense will cause a tenfold or greater increase of the productive powers of labor over the period of approximately the coming generation.

When I proposed a strategic defense mobilization, during 1982, I emphasized to both my government and friendly relevant institutions outside the United States, that strategic defense must be, not only defense against ballistic and guided missiles. It means also, effective methods of both passive and active measures of anti-submarine warfare. It means also, defense against biological and chemical forms of strategic offensive weapons. To solve the problems in each and all of these areas of defense, we must apply a certain spectrum of the most advanced technologies being developed on the frontiers of scientific work. This requires us to emphasize three classes of technology which I have termed "primary," and one which I have termed "auxiliary."

The frontiers of physics today, are dominated by the exploration and development of three primary areas of technology. The first, is the mastery of organized plasmas with very high energy-density cross-sections, including the development of fusion as a primary energy-source. The second, is the mastery of pulses of very coherent forms of electromagnetic radiation, merely typified by the development of lasers. The third is the emergence of what is called either optical biophysics or "non-linear spectroscopy"; this is a new direction in biological and related research, carrying us way beyond the inherent limitations of so-called biotechnology.

The attempt to master use of these three primary technologies requires rapid improvements in the development of computer technology. These improvements represent the most important of the auxiliary technologies required for effective strategic defense. For both military-defense and for production generally, we require dedicated computer-modules in the megaflop range; this requires a crash program in development of what is called "parallel processing." Digital computers are inherently defective devices, for treating the kinds of large-scale non-linear processes associated with use of the

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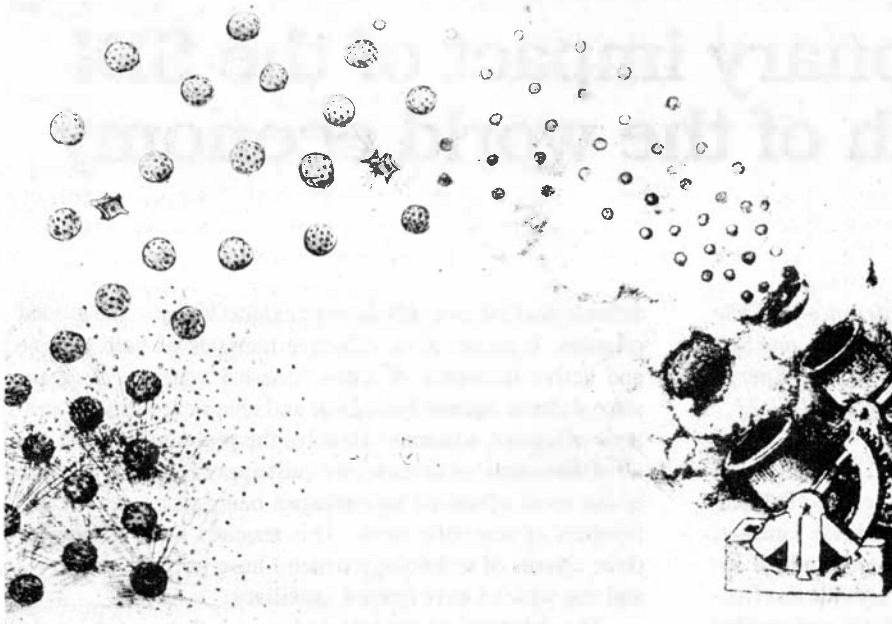

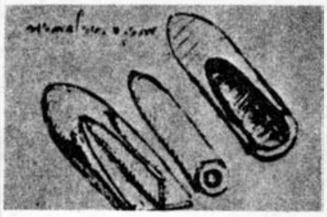

The first scientist to establish principles for the use of firearms was Leonardo da Vinci, who situated firearms in terms of applying projective geometry to define fields of fire of offense and defense. By examining the effects of improvements in firearms, in terms of the geometry of fields of fire, we see that certain important changes in warfare occured, but without changing the basic principles examined by Leonardo. Shown are some of Leonardo's drawings of bombardment and designs for exploding projectiles.

three primary technologies indicated. To overcome this difficulty, we require new species of analog-digital hybrids, incorporating analog modes of solving non-linear functions of differential geometry. At the same time, we must replace the now-traditional computer-systems architecture prescribed by John von Neumann, adopting new architectures, of a sort suited to applications of new types of analog-digital hybrids.

I shall refer briefly to the military applications of these technologies, and then concentrate upon the spill-over of these technologies into the world economy generally.

Without going into areas of discussion which might be official secrets, I shall identify the best thinking among U.S. professionals associated with SDI development.

Unless the Soviet command were to perceive that the United States lacked the will to honor its European and Pacific commitments to defense of its friends, the Soviet command would never engage its own national forces directly in a limited "conventional" or "nuclear" assault. Under all other circumstances, a Soviet direct assault on an ally of the United States would occur only as a subsidiary feature of a full-scale thermonuclear assault against the United States itself. This is Soviet military doctrine, and is also the direction of rapid current development of Soviet military and related capabilities. We may abhor the Soviet motives, but their military doctrine is a highly rational one, in the tradition of 19th-century German military science. Therefore, knowing Soviet doctrine and capabilities, we are able to foresee more or less exactly the kind of problem which strategic ballistic missile defense must master.

Any Soviet-launched nuclear war, will begin with a full-scale, first-strike attack against the United States, with simultaneous attacks upon the friends and allies of the U.S. This means that strategic defense must be capable of inflicting destruction upon a very high percentile of 3,000 to 5,000 Soviet missiles and their warhead complements. We must anticipate 3,000 to 5,000 targets for missile defense in the launch and boost phase, and must also be prepared to detect and destroy Soviet war-heads from among 30,000 to 50,000 objects detected in the mid-course range of war-head deployment.

Kinetic-energy weapons are incapable of dealing with the problems of the mid-course range. Therefore, theoretically, kinetic-energy weapons must be assigned to intercept missiles in their boost phase. For obvious reasons, this indicates launching of interceptor devices from low-orbiting platforms, such that the entire strategic defense would be easily destroyed by existing Soviet technologies, immediately prior to launch of thermonuclear missiles. For these and other reasons, a kinetic-energy mode of space-based defense is unworkable.

Effective defense against missiles means, chiefly, destroying flotillas of missiles and warheads by saturating the "windows" through which their trjectories must pass, with such means as x-ray-laser bursts, or by enhanced-radiation devices which neutralize warheads by such means as adequate densities of neutron fluxes. It requires lasers and so-called particle-beam weapons, to deal with those missiles and warheads which are not destroyed in the windows of coincident trajectories. The firepower and mobility of such defensive weapons is greater, by four to five orders of magnitude, than kinetic weapons. Taking into account combined factors, of firepower, mobility, and costs, we can fairly estimate that the defense has a 10-to-1, net superiority over the missile offense.

Many techniques for deploying beam-weapons have been discussed, including the techniques of strategic defense which my associates and I first proposed during 1982. During my discussions with French military officials in 1982, those officials asked me, if it were not true, that what I was really proposing, was not any single set of defensive systems, but rather that I was projecting very high rates of technological attrition in defensive systems over the decade ahead. I responded, that the French military's assessment of my proposal was the correct one. As rapidly as one set of defensive weapons-systems is deployed, work will begin, to develop effective countermeasures against such systems. To overcome those countermeasures, improved defensive systems must be deployed. The basic scientific principles of beam-weapon defense will remain the same for a long time to come; but, just as automobiles have changed again and again, without yet replacing the architecture of the internal-combustion-engine-powered vehicle, defense means the deployment of new, improved models of defensive systems during each two to five year interval over the decades ahead.

The case of modern firearms, is a comparable case of technological attrition. The first scientist to establish principles for the use of firearms was Leonardo da Vinci; the revolution in warfare based on use of breech-loaded firearms, was first proposed by Leibniz. The work of Leonardo and, later, Leibniz, situated firearms in terms of applying projective geometry to define fields of fire of offense and defense, as this doctrine was elaborated in France over the period from Vauban through Gaspard Monge's work. Up until the introduction of new physical principles to warfare, during the recent half-century, the technology of warfare was based upon the effects of improved types of firearms, with no change from the basic principles examined by Leonardo and Leibniz. By examining the effects of improvements in firearms, in terms of the geometry of fields of fire, we see that certain important changes in warfare occurred, but without yet changing the basic principles of firearms in general. Over the coming decades, changes in the designs of particular kinds of beam-weapons, will mean changes in the characteristics of fields of fire, for both the offense and the defense; but, the basic principle of design of defensive systems will remain generally the same.

The economic feasibility of the SDI

Since competent strategic defense requires high rates of technological attrition, the most critical feature of my 1982 proposal for a U.S. strategic defense initiative, was my assessment of the economic feasibility of sustaining the costs of such a defense policy. In general, a few, but not most of the military features of my proposal were not original to me. The Soviets have been committed to their own version of SDI since 1962, and have made rapid progress in developing such weapons-systems since approximately 1970-71. Maj.-Gen. George Keegan proposed that the United States develop a beam-weapon defense program, back during the middle of the 1970s. The unique feature of my proposal, was my demonstration that such a program could be maintained at virtually no net increase of costs of military expenditure. The critical point in my argument, has been that the increase of national income caused by introducing new technologies into the civilian economies, would add far greater wealth to the nation than the costs of strategic defense expenditures.

The starting-point of my economic analysis is not unfamiliar to Japan. My standpoint is broadly identical to that of such exponents of the American System of political-economy, as Alexander Hamilton, the Careys, and Friedrich List. My opponents among economists therefore label me either a "mercantilist" or a "neo-mercantilist." The basis for my own contributions to economic science, is the principles of physical economy first developed by Leibniz. My only original contribution to economic science, is my use of the work of Bernhard Riemann to solve the problem of correlating measurable advances in technology with resulting rates of increase in the productivity of labor. It was this contribution, which has been at the center of my proposals for a U.S. strategic defense initiative. It is this connection, between the new technologies of SDI, and increase of productivity in the economy generally, to which I turn your attention.

In brief, the functional connection between technological progress and productivity, is demonstrated by comparing the potential population of so-called primitive society, of about 10 million individuals at most, with the present population, approaching 5 billion. This increase is due entirely to those kinds of modifications in human behavior, which the past 500 years history associates with scientific and technological progress.

We can sum up the results of economic science, by stating that the possibility of increasing the potential population-density of humanity, depends upon conducting technological progress in an energy-intensive, capital-intensive mode. This means, that the amount of usable energy per-capita and per-square-kilometer must be increased; it also means, that the portion of work allotted to capital improvements in land and work-places, must increase as a percentile of total work. For example: Without development of infrastructure, and without increasing rates of capital investment per operative, no nation is capable of sustaining technological progress in agriculture and industry.

By "economic science," we mean economic science as defined initially by Leibniz. Instead of simply "economic science," we might use the term used to describe the teaching of Leibniz's economic science in German universities during the 18th and early 19th century, "physical economy."

It may be recalled, that Leibniz's founding of economic science was begun with Leibniz's study of the principles of heat-powered machinery. Leibniz's principles of physical economy, introduced to the United States by Benjamin Franklin and others, form an essential and integral part of what became known as the American System of political-economy. The further elaboration of Leibniz's principles, from the vantage-point of the 19th-century work of Gauss and Riemann, is indispensable to advancing the level of the American System of political economy beyond the level of advancement accomplished by Friedrich List and Henry C. Carey. This further elaboration of Leibniz's principles of physical economy, permits us to define the strategic economic impact of SDI technologies with reasonable precision.

Perhaps the best way of demonstrating the impact of SDI technologies on the economy, is by considering the application of these technologies to the colonization of the Moon and Mars.

Two propositions were central to Leibniz's definitions of economic science. First, Leibniz examined the correlation between increasing the quantity of heat-power supplied to a machine, and the resulting increase in per-capita output of operatives. Second, Leibniz considered the special case, in which two heat-powered machines, each employed for the same quality of work-output, and each consuming heat-power at the same rate, nonetheless resulted in greater rates of output from the one machine, than from the other. The difference in the internal organization of the latter two machines, introduces the idea of "technology." In other words, the definition of "technology" emphasizes the effect of the internal organization, of a machine or of an analogous process. This assumes, that there is some way of defining the notion of internal organization of machinery's design, so that a directed increase of some form of organization, is, in itself, a cause for an increase in the rate of physical output of the operative.

To define the mathematical principle indispensable to measuring "internal organization" of machinery, or of analogous sorts of processes, Leibniz specified his geometrical Principle of Least Action.

Comparison of the historical changes in productivities of assorted national economies, provides us a clear experimental illustration of the functional interdependency of increases in energy-throughput and technology. Provided that we recognize, that building of basic economic infrastructure, and of improvements in land, have the same general significance as investments in the machinery, tools, and equipment of production, we can readily show that there are four principal factors correlating with increase of the productive powers of labor:

1) The amount of production of capital goods, must increase relative to production of households' goods.

2) The amount of usable energy supplied must increase, both per capita and per square kilometer.

3) The modal energy-density cross-section, and the relative coherence of energy supplies must be increased.

4) Technology, as Leibniz defined technology, must be advanced.

In the history of iron and steel production, for example, the increase of productivity of labor has proceeded by leaps. Each leap is associated with either an improved type of fuel, or an improved method of combustion of fuel. Today, we have two options before us. On the one side, we have new modes of steel-making, already developed, but yet to be introduced into production generally; these are associated with methods of combustion of a notably increased energy-density cross-section. On the other side, we are entering an age in which ceramics will displace steel. The production of ceramics means production at a substantially increased energy-density cross-section, and requires rapid development of the application of lasers as integral parts of machine tools for working of ceramic castings. We can foresee, that over the period ahead, we shall be emphasizing energy-density cross-sections sufficient to transform material into a plasma state, such that methods of controlling energy-dense plasmas now being developed in connection with thermonuclear fusion, will play a crucial role in primary modes of production.

The coming technological revolution

We are at the verge of the greatest technological revolution in mankind's history. This revolution will be based on greatly increasing the volumes of usable energy, both per capita and per square kilometer, with emphasis on leaps in the levels of energy-density cross-section, with increasing emphasis on the electrohydrodynamics of the plasma process, on the role of coherent forms of electromagnetic pulses in production, and on new qualities of robotics, by means of which operators will be enabled to control production processes of such energy-dense characteristics.

Perhaps the best way of demonstrating the impact of SDI technologies on the economy, is by considering the application of these technologies to the colonization of the Moon and Mars.

The establishment of artificial, habitable environments on Mars, and the need for continuously powered flight by flotillas, at one-gravity between Earth-orbit and Mars-orbit, requires the technologies of controlled thermonuclear fusion, of coherent electromagnetic pulses of very high energy-density self-focusing effects, and of optical biophysics. It also requires dedicated types of parallel-processing computers in the megaflop range. We shall be greatly advantaged to have analog-digital hybrids of the quality indicated. If our planet undertakes such a colonization program seriously, we could begin colonization of Mars during the third decade of the coming century; such a target has already been recommended by the U.S. National Commission on Space.

Obviously, if it is feasible to establish colonies on Mars, it is a much easier task to apply the same technologies to such tasks as developing rich agro-industrial complexes in the middle of the great deserts of Earth. It is even cheaper, to revolutionize the design of new qualities of cities in the more agreeable climates of Earth. With these technologies, the Earth's food-supplies can be produced far more cheaply, more abundantly, by energy-intensive industrial-process methods, aided by applications of optical biophysics.

The connection between the technologies of an SDI system and space-colonization technologies, is so immediate, that the research and development for the one is nearly identical with that for the other. If we could be certain that such technologies could be caused to spill over rapidly, from the military and space-engineering fields, into production generally, we can safely estimate that the productive output of an average operative could be increased by more than tenfold over a period of between one and two generations ahead. In general, we may say, that the firepower and mobility which certain technologies contribute to military capacities, correlate with the increase of productivities in the civilian domain.

Therefore, the central practical question to be confronted by governments and industries in connection with SDI, is the question of assuring ourselves that this desired kind of spillover of technologies into the civilian domain does occur.

Technology is transmitted into production chiefly through improvements in the technology of capital-goods produced. The greater the rate of advancement of technology in capital goods produced, and the greater the rate of investment in capital goods per-capita, the greater the rate of increase of productivity generally. Thus, the build-up of the capital-goods sector, for SDI and space development, is the most efficient mechanism by which such technologies are transmitted directly into the civilian domain. It is merely necessary to build up these new capacities on a scale significantly greater than that required for SDI and space requirements, and to cause the excess capacity to spill over rapidly into capital-goods for civilian production.

To ensure that this desired success occurs, we must adopt the policy of increasing greatly the percentiles of employment devoted to scientific and engineering occupations, while increasing significantly the percentile of national output devoted to capital goods production and infrastructure building.

A target of not less than 10% of the national labor-force employed in relevant science and engineering occupations, and a doubling of present percentiles of national incomes allotted to capital-goods and infrastructure, would be a good choice of targets for the coming 10 years. We must shift employment away from emphasis upon non-scientific services and redundant administrative and selling functions, moving these percentiles of the labor-force into either science and engineering, or capital-goods production. This requires obvious adjustments in educational policies, and also in policies governing priorities in preferential tax-rates and in flows of credit.

On condition that we inspire our populations, to associate personal achievement with contributions in these directions, and that we educate our populations to cope with the new technologies I have indicated, we shall accomplish the desired victory of strategic defense over thermonuclear offense, and shall also solve the principal non-military strategic problems of our planet. If we adopt the proper policies, the creative powers of many millions of scientists and individual operatives will do the rest.