Physics And Society

THE NEWSLETTER OF THE FORUM ON PHYSICS AND SOCIETY

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PHYSICS AND SOCIETY is a quarterly newsletter of the Forum on Physics and Society, a division of the American Physical Society. The newsletter is distributed free to members of the Forum and also to physics libraries upon request. It presents news of the Forum and of the American Physical Society (335 East 45th Street, New York, NY 10017) and provides a medium for Forum members to exchange ideas. PHYSICS AND SOCIETY also presents articles and letters on the scientific and economic health of the physics community; on the relations of physics and the physics community to government and to society, and the social responsibilities of scientists. Contributions should be sent to the Editor: Dave Hafemeister, Physics Department, California Polytechnic State University, San Luis Obispo, CA 93407, 805-546-2205.

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TWO FORUM SESSIONS ON SDI

A dozen speakers discussed the Strategic Defense Initiative at two Forum sponsored sessions in Washington, D.C., organized by Aviva Brecher, Mike Casper, and Peter Zimmerman. (See *Physics Today*, page 83-84, June, 1986.) Because of the great interest in this issue, *P & S* is publishing the summaries of the talks by the following speakers: Lt. Col. Simon P. Worden, Special Assistant to the Director of the SDIO; Anthony Fainberg and Gerald L. Epstein, who participated in the Office of Technology Assessment report, BALLISTIC MISSILE TECHNOLOGIES; and Vera Kistiakowsky, Physics Department, MIT.

THE STRATEGIC DEFENSE INITIATIVE by Simon P. Worden, Special Assistant to the Director, Strategic Defense Initiative Organization.

In order to understand the progress and content of the Strategic Defense Initiative (SDI) it is necessary to place the program in its strategic context. There are three basic deterrent strategies, Mutual Assured Destruction (MAD), retaliation-based military strategies, and defense-reliant deterrence. The role of strategic defenses differs greatly in each.

MAD relys on the threat of retaliation against an agressor's society. Analyses done in the early 1960's concluded that roughly 1000 warheads would be sufficient to insure catastrophic damage to an aggressor's society. In the MAD context, the addition of defenses is generally undesirable unless those defenses are nearly perfect against essentially all nuclear threats. The SDI is not predicated upon such a mission.

Retaliation-based military strategies, and not MAD, have long been the basis of the U.S. deterrent. The United States seeks to maintain sufficient survivable offensive forces which can, after suffering an initial offensive strike, retaliate against the aggressor's military forces and capabilities. The retaliation must be sufficiently credible to convince an aggressor that the final outcome of an attack and counterstrike would be a worse miltary situation than before hostilties began. Since the Soviet Union has several thousand military targets, this strategy demands many thousands of survivable nuclear warheads in the U.S. arsenal. Defenses can contribute in this strategy by protecting retaliatory forces. However, the addition of defenses by an aggressor as well may more than counteract the positive impact of defenses of retaliatory forces.

The SDI is based on defense-reliant deterrence. In this approach the defenses themselves are the primary deterrent, and not retaliatory forces. By constructing defenses, the United States would seek to progressively deny the Soviet Union, as well as the United States and other nuclear powers would find that their nuclear offensive forces have no military utility. It is not the defense of retaliatory forces which would deter, but the absence of credible military reasons for attacking.

To move the United States toward a defense-reliant strategy, the SDI seeks to prove that defense can be built which are survivable, capable of denying Soviet offensive strategy, and "cost-effective" in the sense that the Soviets would not conclude that they could add offensive forces or develop new offensive capabilities to preserve their offensive targeting strategy. The SDI is developing concepts for an initial layered defense shich might be deployable in the 1990's and effective against current and possible numerical increases in Soviet threats. To deter Soviet countermeasures and induce acceptance of a cooperative transition to defense-reliant deterrence for both sides, the SDI must also prove that cost-effective enhancements can be made to strategic defenses to counter "responsive" threats specifically designed to defeat defenses.

If the SDI is successful in demonstrating the strategic and economic futility of countermeasures to strategic defenses, the United States believes that the Soviet Union will join in a cooperative transition to defense-reliant strategies. Should this occur, the defenses actually deployed in the context of negotiated offensive reductions may be far more modest that worse-case scenarios.

Strategic missile defense system would have three principal elements: weapons, sensors, and battle management. The SDI is pursuing candidates and plans major experiments for each function for each phase of a ballistic missile's flight: boost and post-boost phase, midcourse phase, and terminal phase. The experiments are not system prototypes, rather they are in general sub-scale but sufficient to prove feasibility that full scale elements can be constructed. Since they do not have system capability, except for some of the ground-based elements, all of the experiments are compliant with the 1972 ABM Treaty.

Sensor options for initial systems fall into three categories. Infrared sensors carried on both high and low-altitude satellites could detect, track, and identify boosters, post-boost vehicles, warheads, decoys and debris in space. Experiments are scheduled for the early 1990's to validate this technology. Experiments beginning in the late 1980's with an airborne sensor platform - the Airborne Optical Adjunct - will show the potential of infrared sensors carried on high altitude unmanned aircraft to perform the ballistic missile sensor functions in late midcourse phase. Target tracking and identification for terminal phase might be shared between airborne optical sensors and ground-based imaging radar systems. The latter will be demonstrated in the early 1990's.

Homing non-nuclear kinetic energy interceptors provide weapons options for all defensive phases. Small interceptor rockets might be carried a few each on hundreds of modest satellites (100kg or less) to perform intercept during boost, post-boost and midcourse phases. Similar technology interceptors could be launched from the ground for late midcourse intercept. Homing terminal interceptors, capable of endo-atmospheric intercept would perform during terminal phase.

Much public controversy surrounds the battle management problem. Critics have correctly estimated the difficulty in producing a ten-million line computer program. However, these pessimistic estimates are predicated on a centrally-controlled battle management system where all weapons and sensors are under positive control of a central manager. A far less stressing and more survivable approach is a distributed system in which most functions are delegated to lower level autonomous battle managers. However, nearly autonomous operation lacks flexibility. The SDI has therefore concentrated on hierarchical battle management approaches which combine the survivability and less stressing software requirements of distributed systems with the flexibility of a centrally-managed sustem. Hierarchical battle management maintains a central control which assigns area responsibilities to lower level battle managers and sets general instructions in much the same way as a general directs subordinate field commanders. With this approach, it appears that the required battle management functions are within the state-of-the-art.

The SDI responsive threat work concentrates on three main countermeasures: decoys, new offensive missiles (fast-burn boosters), and direct attacks on the defenses themselves.

Against decoys, the SDI is developing interactive discrimination. Some form of directed energy, for example neutral particle beams, would be directed at potential targets. Signatures from this interaction, in the case of particle beams nuclear radiation, would reveal whether the target is a real warhead.

Against fast-burn boosters, the SDI is pursuing laser weapons which can reach deeply enough into the atmosphere to access the reduced-vulnerability booster. Both excimer and free-electron lasers show great potential as ground-based laser weapons which would be effective against even laser-hardened fast-burn boosters. The SDI program contains a multi-megawatt induction free-electron laser experiment within the next five years.

Perhaps the most stressing countermeasure is threats to defensive systems' survivability, particularly space-based elements. Despite common misconceptions, space-based elements of strategic defense system may enjoy a considerable survivability edge over other military systems such as ballistic missiles and warheads as well as terrestrial strategic systems. Through a combination of shielding, maneuver, deception, proliferation, and self-defense space-based elements might be rendered far more survivable than their missile and warhead targets. One key determining factor in making space systems survivable will be the combustion ramjets (SCRAMJETS) and composite lightweight materials show promise for one or two ordxers of magnitude cost reduction from current orbital costs.

In summary, the SDI is designed to provide means whereby all nuclear powers can safely shift to defense-reliant deterrence. The SDI technical program can make this possible by proving the feasibility of an effective, survivable, and cost-effective defense. And by proving that such defenses can be maintained against efforts to defeat them.

THE OTA REPORT ON BALLISTIC MISSILE DEFENSE I: TECHNOLOGIES by Anthony Fainberg, International Security and Commerce Program, Office of Technology Assessment.

Last September, the Congressional Office of Technology Assessment released a report on ballistic missile defense (BMD) technologies and applications. The report was the product of a study that lasted over a year. It had been requested by the House Armed Services Committee and the Senate Foreign Relations Committee. This paper discusses some of the technical contents of the report, including its principal findings.

The study focused on multi-layered BMD systems, such as those being researched under the Strategic Defense Initiative, although it also looked into the technologies required for more modest BMD efforts.

The principal technical goals to be attained, in order to develop an effective multi-layered BMD against an evolving adversary threat, include the following:

* Required levels of performance for both weapons and sensors.

* Adequate survivability of the system; that is, the ability of the system to function in the face of a direct attack upon it, either while being deployed or after deployment is completed.

* Adequate robustness of the system; that is, the ability of the system to function in the face of countermeasures such as decoys, deception, dazzling of sensors, short engagement times, hardening, etc.

* The design, development, and testing of a battle management system that will justify a high degree of confidence in its reliability.

Much research and development effort is needed before it is known whether these requirements can be definitively met. However, in order to develop more modest BMD systems, for example, systems designed to assure the survival of a fraction of hard U.S. targets after a first strike by an adversary, the technical requirements are greatly eased.

OTA arrived at a number of findings regarding BMD. Some which may be of particular interest to this meeting are:

1. The strategic value of a given BMD system depends upon complex interactions between the offensive and defensive forces. The outcome of the interactions will be difficult to evaluate even when both forces are well understood. At this point, it is virtually impossible to ascertain the strategic value of a BMD system.

2. A BMD which provides a high assurance of survival of a fraction of U.S. land-based missiles and of a fraction of C^3I centers against a first strike could be built with available or soon-to-be-available technology.

3. If the Soviets are determined to destroy many U.S. cities, BMD cannot assure the survival of all or nearly all of the U.S. population. That is, BMD cannot be near-perfect against an unconstrained Soviet threat. However, BMD, together with Soviet cooperation in large-scale offensive force reductions, could lead to a high level of assured survival.

4. In the absence of a well-defined system architecture, it is impossible to say at this time how effective an affordable system would be. Likewise, in the absence of a well-defined system architecture, the total costs and marginal cost-effectiveness cannot now be reliably estimated.

These conclusions were reached through a detailed study of the weapons, sensors, and support systems proposed for BMD systems, particularly for multi-layered BMD.

A multi-layered system is often divided into four layers, each one dealing with a well-defined stage or "phase" of a long-range ballistic missile's trajectory.

The phases are: boost, post-boost, midcourse, and terminal. Each presents its own opportunities and difficulties. To be successful, appropriate weapons and sensors must be developed for each layer. In addition, the whole must be integrated into an operational system. The integration will require a reliable battle management system which will be very rapid in reaction. This will rely on formidable computing power and make use of an enormus and highly sophisticated software architecture.

Many weapons options for use in a multi-layered BMD have been discussed. All are currently very far in performance from what would be required for an effective shield. These include chemical lasers, free-electron lasers, electromagnetic rail guns, neutral particle beams, x-ray lasers, and chemical rockets. The latter represent the most mature technology; however, to be effective in blocking a significant fraction of incoming warheads, a very large number would be required at a correspondingly high level of cost. Further, they might be vulnerable to relatively simple countermeasures unless compensated for by great improvements in sensor capabilities.

Sensors to be used would include various types of radar; other active sensing, such as laser radar (at various wavelengths); and passive electromagnetic sensors, in the visible, infrared, or ultraviolet.

As noted, each layer has its own particular needs, regarding weapons and sensors. For example, optical lasers which could penetrate the atmosphere would be ideal for a boost-phase defense. Very effective high-resolution sensing would be needed for the midcourse phase in order to respond to the adversary's attempts to fool the defense. Rapid acceleration ground-based interceptors are required for a terminal defense.

Perhaps even more challenging than reaching given specifications for weapons and sensor capabilities is the task of integrating each part into an effective whole, and providing the necessary logistics, maintenance, plus, above all, a battle management system.

Finally, the system must be able to defend itself against attacks, either from the ground or from another, similar BMD system which may have a similar reliance on space-based components.

OTA'S REPORT ON BALLISTIC MISSILE DEFENSE TECHNOLOGIES II: FUTURE RESEARCH OPTIONS by Gerald L. Epstein, International Security and Commerce Program, Office of Technology and Assessment.

Technologies to defend the United States against ballistic missiles have been studied for decades.[1] Although concensus is widespread that these investigations be continued, the intensity and scope of this research in the future is the subject of considerable debate.

The controversy centers on two major questions: How likely is ballistic missile defense (BMD) technology to be developed sufficiently to be worth deploying? Should our research program be carried out with the vigorous commitment that characterizes the Strategic Defense Initiative (SDI)? Answering these questions requires judging the strategic and political desirability of these systems as much as it requires assessing their technical capabilities.

Although the Soviets lead the United States in ther ability to deploy a limited-capability defense in the near term, the United States remains ahead of the Soviet Union in key technological areas required for advanced missile defense systems.

OTA identified five approaches to structuring BMD research. All include investigating, at a minimum, BMD technologies which will enable the United States to understand what the Soviets might be doing. However, the approaches differ in how much work would be done above this minimum, and how urgently. The SDI approach was based upon deciding in the 1990's whether to proceed to full-scale development and deployment. Two other options lead to development and deployment decisions sooner than that, whereas the remaining two do not include a commitment to make deployment decisions at all.

Option 1: The SDI Approach. This approach was intended to be a "technology-limited" program which would proceed towards deciding as rapidly as possible whether to develop and deploy a BMD system[2]. Each step in the research program was to be limited only by the completion of earlier technical steps, not by funding constraints.

* Urgency. The pre-SDI program did not call for a national decision to be made about whether to proceed to full-scale development and deployment of BMD.

* Visibility. The SDI has a much higher visibility, and a much higher level of Presidential attention, than did the previous program of BMD research.

* Direction. BMD research has shifted away from fairly mature BMD technologies--nuclear-armed, radar-guided interceptors which attack missiles in the last stages of their flight--towards more speculative technologies which attack incoming missiles throughout a great portion of their flight trajectories.

* Budget. Much more money will be spent on ballistic missile defense under the SDI than would have been requested without it.

* Arms Control Policy. The pre-SDI approach sought to reduce offensive forces, and the incentives to increase them, by maintaining the ABM Treaty ban on defenses against ballistic missiles. Current arms control policy instead is to seek agreement with the Soviets to combine reduced levels of nuclear arms with active defenses against offensive nuclear arms.

Option 2a: Early Deployment Approach. The early deployment approach places a high strategic value on the modest levels of effectiveness that could be provided with technology that is presently available. In this approach, technologies now within the state of the art would be engineered into operational status and deployed. More advanced technologies would also be investigated to increase capability and counter Soviet responses.

One possible early BMD deployment might use "traditional" nuclear-armed interceptors--the only BMD technology wth which either the U.S. or the USSR has had significant experience--to defend hardened targets.

Option 2b: Intermediate Deployment Approach. Unlike the early deployment approach, the intermediate deployment approach does not call for deployment of technology available today. Instead, it emphasizes making a decision soon to use BMD technology which can be developed and initially deployed by the early 1990's. In this approach, the deployment of these nearer-term technologies would not be forced to wait until the feasibility of more effective, but longer-range, BMD technologies had been established.

Option 3a: Funding-Limited Approach. This approach would share the SDI program's focus on advanced defensive technologies without also sharing the SDI program's premise that we can know in a very few years whether we should deploy these technologies. It would investigate the potential of advanced BMD technologies, at a funding level well below that of the SDI, but it would not prepare to decide in the near term whether to exploit that potential by initiating deployment. This approach would not include tests or demonstrations which raise questions of compliance with the ABM Treaty.

Option 3b: Combination Approach. This approach would balance serious study of advanced BMD technologies with the development of a high-confidence, near-term option to deploy BMD systems based on "traditional" technologies. This program, funded well below the SDI level, could deter the Soviets from abandoning the ABM Treaty by preparing a near-term option to respond in kind. It would also act as a hedge against future Soviet BMD developments, prevent technological surprise, and investigate the potential of advanced BMD technology.

References

1 For example, in the late 1950's the Army had designed and wanted to begin producing an anti-ballistic missile system called Nike-Zeus. Other technologies now associated with the Strategic Defense Initiative, such as lasers and space surveillance systems, have also been studied since at least the early 1960's.

2 The funding level appropriated by Congress, although providing significant annual growth, has not matched the "technology-limited" profile requested by the Administration.

SDI AND THE UNIVERSITIES by Vera Kistiakowsky, Physics Department, M.I.T.

The Strategic Defense Initiative (SDI) is a research, development, and demonstration program initiated in 1984 to discover whether there could be weapons technologies which would make possible the national defense system proposed in President Reagan's Star Wars speech. This concept and the program have evoked major criticism from the scientific community with respect to technical feasibility, strategic usefulness, and arms race implications, most recently in a report released by the Office of Technology Assessment to Congress. Thus the funding of university based research through the Office of Innovative Science and Technology (SDIO/IST) has provoked a heated controversy in the academic community, and hundreds of scientists and engineers on more than 60 campuses have signed a pledge not to accept SDI funding.

The SDIO/IST was established to:

"Mount a mission oriented, basic research program that drives the cutting edge of the nation's science and engineering effort in a direction that supports existing SDI technological development thrusts and points the way for future new initiatives."

This is an exerpt from the briefing paper distributed at the March 29th, 1985 meeting of SDI officials with university representatives to introduce the program. It describes the 17 narrow areas of research to be supported, and outlines a highly interconnected administrative structure for the direction and coordination of the research consortia and programs participating. A consequence of this structure is that individual research grants will only be made for brief introductory periods and then will be expected to fit into or develop into a consortium or program. Unlike true basic research, the funding decisions will not be made on the basis of scientific merit alone, the overriding criterion being usefulness to the program. The briefing paper included a request for "white papers", short descriptions of proposed research which would then be screened to select those for which formal proposals would be asked. In addition to this approach, other research has already been funded by SDI or taken over from other agencies.

The criticism of the university program which has drawn the most public notice, is the attempt by SDI officials to equate research participation with support for SDI. The presidents of

both MIT and Cal Tech made strong statements objecting to this and saying that the acceptance of SDI funds by research scientists and engineers at their universities should not be interpreted as an institutional endorsement. However, since the university administration must sign the grants and contracts and provide space and services for the programs, and does receive overhead for doing this, the university as a whole is certainly involved, not just the individual research workers. Furthermore, if many scientists and engineers at the universities do accept SDIO/IST grants, this will inevitably be presented as strong university support for the program when SDI goes to Congress for funding.

A second objection stems from the fact that SDI is a weapons RD&D program, and, consequently, is in general classified. Both a memo issued by SDI in August and a policy directive (NSDD 189) issued by the White House in September stated that the university research component would in general be treated as basic research and not classified. However, they also explicitly left open the possibility of classification of university research. An indication of the likelihood of restrictions is given in the briefing paper which suggests that the professors in charge and possibly even some graduate students get clearances to permit access to all relevant information. Since, the SDIO/IST research is all in areas which are considered militarily sensitive by the Department of Defense (DOD), the SDIO/IST officials have in the past conceded that it is likely to be subject to restrictions on participation and publication.

A third objection is that the large increase of funding in a relatively narrow area of basic rsearch in a period during which support of other basic research is decreasing (by approximately 8% between fiscal year 1985 (FY85) and FY86) will lead to a major distortion of national research priorities. Indeed the explicit purpose of the program, to "turn the cutting edge", is just that. Since the SDIO/IST does not support free basic research based on a criterion of scientific merit, this out of proportion support would have serious consequences for the freedom of scientific inquiry, a major source of our enormous national research strength. And the distortion would not be easily reversible, since a disproportionate amount of student support would be available in SDIO/IST programs, and many of the next generation of scientists and engineers would have their training in those fields.

Finally, there would be other consequences for the universitites besides the problems brought by classification and other restrictions. These research programs with their structured links with government and industrial weapons laboratories would bring quite a diferent ambiance to the campus. The freedom of choice of thesis field for graduate students would be sharply modified by the availability of support, and many of those students trained in SDIO/IST areas would be faced on graduation with a choice between work in a weapons program or in a field not using their training. Furthermore, it would be hard for the universities not to become explicit supporters of the SDIO/IST program, once that program was funding a substantial amount of research on their campuses.

SOVIET ACADEMY AND NRDC SIGN SEISMIC VERIFICATION AGREEMENT

On May 28, 1986 the Natural Resources Defense Council (NRDC), a national environmental organization, entered into an unprecedented agreement with the Soviet Academy of Sciences. The agreement calls for the establishment of three seismic monitoring stations near the principal nuclear test site in each country. The stations will be jointly manned by American and Soviet scientists and will operate for at least one year.

NRDC Senior Staff Scientist Thomas Cochran, a physicist who has worked on nuclear weapons issues for ten years, first proposed an exchange with Soviet scientists in January 1986. The proposal grew out of NRDC's research on unannounced U.S. nuclear weapons tests. After several unofficial meetings with Societ scientists in the United States, the agreement was negotiated in Moscow over the course of a weekend. E.P. Velikov, Vice President of the Soviet Academy of Sciences, and Adrian DeWind, Chairman of NRDC, signed the agreement.

The exchange is significant because the Soviet Union has never before allowed foreign nationals on its soil to monitor nuclear weapons activities. While NRDC's seismic stations will not ensure nationwide compliance to a Comprehensive Test Ban Treaty (CTB), they provide a prototype for a network of seismic station to verify a test ban or moratorium. Seismologists estimate that a network of forty seismic stations, including twenty-five stations in the Soviet Union could detect any militarily significant nuclear test.

A number of leading U.S. seismologists have joined the project. Dr. Charles Archambeau, a professor at the University of Colorado, is the project's Technical Coordinator and chairman of the Technical Advisory Board. Dr. Archambeau selected a team of seismologists from the Scripps Institute of Oceanography at the University of California, San Diego to install and man the Equipmant in the Soviet Union. The San Diego team is lead by Dr. James Brune and Professor Jonathan Berger. NRDC and the Soviet Academy of Sciences are sharing the costs of the program; NRDC's share will be met entirely by private funding.

American and Soviet scientists installed the first seismometers in Karkaralinsk, U.S.S.R. on July 9, 1986. Two more stations, at Bayanaul and near Semipalatinsk, should be operational by mid-August. All three stations will be within 200 kilometers of the principle Soviet nuclear test site. Preparations are now underway for reciprocal seismic stations near the Nevada nuclear test site.

The data from the stations will be made available to the American and Soviet governments and to the interested scientists of both countries. The first set of seismometers will be placed above ground. In Novermber additional seismometers will be placed in 100 meter deep bore-holes to reduce the background noise. This equipment should be able to detect explosions at the test site as small as one ton.

Since August 6, 1985, the Soviet Union has observed a unilateral moratorium on nuclear tests. Even without listening to nuclear tests, NRDC's seismologists have already collected important seismic data from the Soviet nuclear test site that was previously unavailable in the West. The first seismic reading, dated July 10, 1986, shows several small earthquakes, indicating that the region is seismically active. Future data should be valuable in further resolving whether the Soviet Union has violated the limits of the Threshold Test Ban Treaty (TTBT).

AGREEMENT

From the 22nd to the 23rd of May, 1986, Soviet and U.S. scientists met in Moscow to discuss informally, a broad range of scientific problems related to the verification of a test ban treaty.

The meeting was attended by observers - scientists from Sweden and India, who reported on the technical basis for the offer by the Five Continent Peace Initiative to monitor a testing moratorium.

The participants agree that the current state of geophysical knowledge gives reasonable confidence in the detectability, using practical seismic networks, of nuclear weapons tests down to yields at, or below, one kiloton.

In order to ensure an early start of efforts to perfect seismic techniques, the Academy of Sciences, USSR and the Natural Resources Defense Council, Inc. agreed to launch, as soon as possible, a joint study of seismic events using US - manfactured high-accuracy instruments, in particular around the area of the test-site near Semipalatinsk.

Soviet experts have expressed willingness to participate in similar projects in the USA around the Nevada test-site.

The findings of this project will be helpful in demonstrating verification procedures to be used during a test moratorium or under a nuclear test ban treaty.

Under this agreement, three seismic monitoring stations shall be established adjacent to each of the principal nuclear weapons testing sites in the two countries: near Semipalatinsk in the USSR and the Nevada test-site in the US. These six stations will be manned and operated jointly by the Natural Resources Defense Council of USA and the Academy of Sciences of the USSR, subject to issuance of the necessary visas for travel to the locations chosen for observation points.

The equipment for all the stations will be obtained and supplied by the Natural Resources Defense Council. The equipment for the Academy will be paid for by and belong to the Academy if permitted by US regulations, and if not shall be paid for by the Natural Resources Defense Council. The equipment for the United States shall be paid for by the Natural Resources Defense Council.

Travel of US personnel to Moscow will be paid by the Natural Resources Defense Council and of USSR personnel to New York or Washington D.C. by the Academy. Incountry travel and food, housing and other expenses of personnel in each country shall be paid by the Natural Resources Defense Council in the US and by the Academy in the USSR.

On termination of the project equipment paid for by the Academy shall be retained by the Academy, otherwise shall be retained by the Natural Resources Defense Council.

Commencement of the joint project shall be, if possible, before the end of June 1986, or as soon thereafter as is practicable.

This agreement is subject to the Natural Resources Defense Council obtaining the necessary funding of its obligations, which shall be confirmed within 21 days of the signing of this agreement.

Natural Resources Defense Council — *Academy of the Sciences of the USSR*

Adrian W. Dewind — E. P. Velikhov

"DAVIDS AND GOLIATH:" HOW PHYSICS APPLIED TO ENERGY EFFICIENCY HAS SAVED 100 POWER PLANTS AND 1 ALASKA PIPELINE

by Arthur H. Rosenfeld, Director, Center for Building Sciences, Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720

Improved energy-efficiency has reduced the multi-billion dollar drain on our economy, brought us time to diversify our long-term energy options, and has reduced several environmental problems. If today's economy still operated at the wasteful level of 1973, we would be importing about 20 million barrels per day (instead of 5 Mbod) of oil and spending an extra $150 billion per year for energy (See Figure 1). Because buildings consume 40% of our $450 billion energy bill and 75% of our $135 billion electricity bill, tremendous savings are possible in the buildings sector.

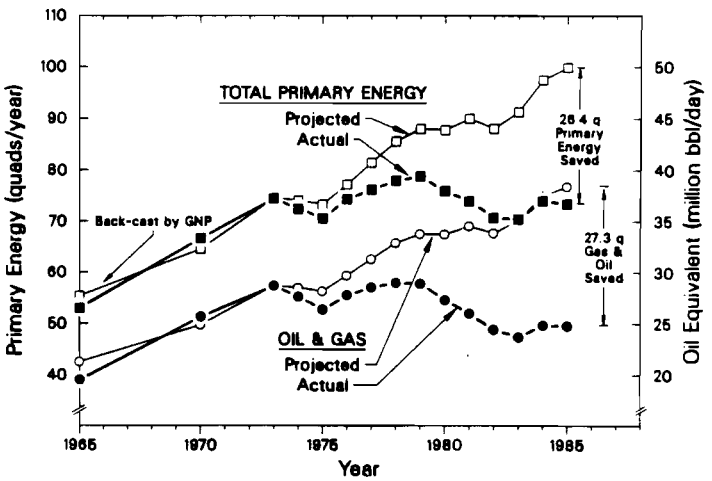


Figure 1. U.S. Energy Use, Actual and Projected by GNP. Projected energy calculated based on GNP, in constant $, with both forecast and back-cast values from 1973. Note how well GNP back-cast follows the actual consumption curve before OPEC. The 74 quads used in 1984 cost end-users $430 B. Source: Monthly Energy Review published December 1985 and EIA Annual Report to Congress. XCG 861-7060

As energy prices rose, newly energy-aware designers have used better methods and technologies to create energy-efficient buildings. The 1986 ASHRAE standards for large office buildings call for 100-125 kBtu/ft^2-year of primary energy, which is one-half that used by the present stock of office buildings and one-quarter that of the more glaring buildings from the 1972 era, which were characterized by acres of glass, lights and air conditionig equipment. Surprisingly, the first real-cost of these efficient buildings has not risen since 1972, primarily because of the reduced demands for cooling capacity. Because good designers have learned how to manage the internal heat of buildings, the need for heating fuels for buildings is rapidly vanishing, and electrical use has been cut to about half compared with the 1972-era building.

Superinsulated houses, costing a few thousand dollars more than a normal house, have reduced yearly energy bills in Saskatchewan to as low as $300. These amazing savings have come about by using thermally tight envelopes to take advantage of the internal heat of appliances, lighting and people. (Houses with air residence times of more than two hours should use air-to-air heat exchangers or forced ventilation to provide clear indoor air.) Since the oil embargo, the U.S. residential stock has improved by 30%, and superinsulated houses are capable of savings considerably more, about 75%.

U.S. refrigerators and freezers today consume the output of about 40 typical 1000-MW power plants, but the California energy standard for refrigerators has dropped to one-third since the oil embargo, from 1900 kWh/year in 1977 to 700 kWh/year in 1993 (with a one-year payback). U.S. manufacturers now conform to the California standard, so that eventually the U.S. will avoid the need for about 25-30 power plants from refrigerator-freezers alone: (1900 kWh/y - 700 kWh/y)(125 M R&F)(1 GWy/5 BkWh/y) ≈ 30 GW. In July, 1985, the U.S. Court of Appeals considered these facts when it upheld mandatory national appliance standards which will be enforced for eight major appliances in accordance with legislation passed in 1975. Fluorescent lighting can be improved by 25% by using high-frequency solid-state ballasts. Further, these new electronic ballasts are much easier to control than conventional ballasts made of steel and copper; hence, buildings can now exploit natural daylighting and raise average savings to 40%. Lighting now uses the output of 100 plants; improved lighting and the new compact fluorescent light bulbs could avoid the need for about 50 plants.

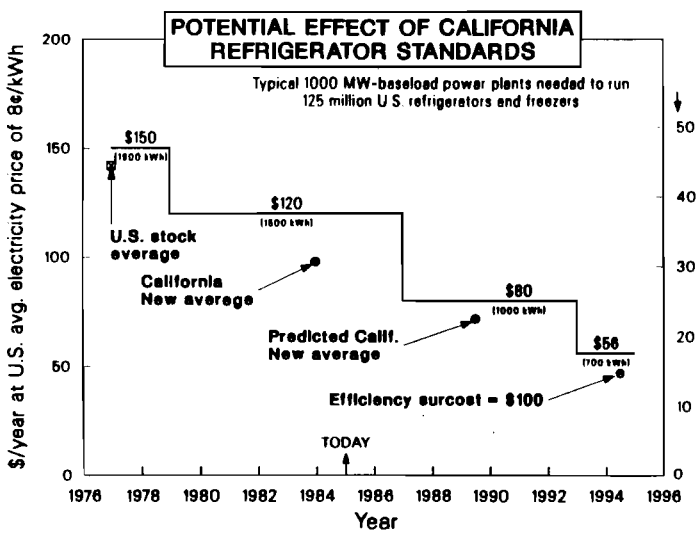


Figure 2. California Mandatory Refrigerator Standards.
the standards reduce the average energy intensity from 1900 kWh/year in 1977 to 700 kWh/year by 1993. The additional cost of $100 retail for the 1993 standard will be paid back in one year (left-hand scale). The number of 1000-MW base-loaded power plants needed to run the nation's refrigerators and freezers is displayed on the right-hand scale. XCG 858-9882

Over the last 5-10 years, conservation R&D has yielded societal returns on investment of about 1000:1. Just three of the new technologies which are now going into production--solid-state ballasts, transparent "Heat Mirror" films for windows, and improved appliances -- will save $20 billion/year. Federal support of this R&D has advanced the commercialization of these technologies by 2-5 years, thus saving about $50 B in utility bills. Yet the Federal R&D cost for these projects was about $15 M, yielding a payback of 3000:1.

SALT COMPLIANCE AND THE FUTURE OF ARMS CONTROL by Leo Sartori, Physics Department, University of Nebraska.

President Reagan announced recently that the United States would no longer be bound by the commitment "not to undercut" SALT II. The principal reason given for this change in policy was that the Societ Union has consistently been violating the Treaty.

The following questions are germane to the debate over the President's decision:

-- How persuasive is the evidence that the Soviets have indeed violated SALT II?

-- How do the violations, if real, affect US security?

-- What is the overall pattern of Soviet compliance; in particular, how do the provisions they have observed compare in importance with those they have allegedly violated?

-- How is the President's decision likely to affect the strategic balance and the future of arms control?

I shall address these questions briefly here. A detailed analysis, under the auspices of the Stanford Center for International Security, will be published elsewhere.

I. The principal SALT II violations charged by the Administration involve the deployment of a second new type of ICBM (SS-25) and the encryption of flight test telemetry.[1]

According to the Soviets, the SS-25 is a modification of the SS-13, a single-RV missile first flight tested in the 1960s. The Administration charges the SS-25 is a new type because its throw weight exceeds that of the SS-13 by much more than the 5% allowed by the Treaty.

The dispute apparently hinges on what should be included in throw weight. The Treaty defines it as the weight of the re-entry vehicles, penetration aids, and any "self-contained dispensing mechanisms or other appropriate devices" for targeting re-entry vehicles. In modern missiles, including the SS-25, the dispensing mechanism is a post-boost vehicle or "bus" which separates from the last stage of the booster. The SS-13 has no PBV, but a recent statement by Soviet Marshal Akhromeyev suggests that there is a targeting device, perhaps attached to the last stage, whose weight the Soviets count as part of the missile's throw weight. By omitting that contribution the US would be underestimating the SS-13's throw weight, which the Soviets say is actually greater than that of the SS-25.

Inasmuch as the Treaty does not restrict the location of the "other appropriate device", the Soviet position appears to have some technical basis. On the other hand, if such a targeting device is indeed part of the last stage and never separates from it, there would be no way for the US to measure its weight by "national technical means". It seems implausible that the framers of the Treaty intended such an unverifiable component to be included in the throw weight.

It is important to recognize that the SS-25 is not required to be an actual derivative of the SS-13 in order to avoid being classified as a new type. It need not even come from the same design bureau. The only requirement is that the two missiles not differ in any of the specific ways listed in Article IV.9. If the 25 is a "new" misssile that technically falls within the box defined by the parameters of the 13, the Soviets might be said to be exploiting a Treaty loophole but they would not be guilty of a violation.

The encryption issue arises from imprecise treaty language. The Soviet position is that so long as the US can verify compliance it has no grounds for complaint; the treaty does not say, however, that encryption must prevent verification in order to be a violation. Any encryption that impedes verification is banned, but the term impede is not defined. The high level of encryption detected in several Soviet flight tests provides a prima facie case for the Administration's charge that verification has been impeded. The case is weakened, however, by US refusal to specify what data have been denied that would aid in verification. Providing such information could ostensibly compromise sensitive intelligence sources and methods.

II. The strategic significance of the alleged violations is not great. The throw weight of the SS-25 is less than that of several other Soviet missiles; it carries only one warhead. With a smaller throw weight it might have been marginally less effective, but it is hard to argue that the extra throw weight poses a serious threat to US security. Mobility is the novel feature of the SS-25; this enhances survivability but does not make the weapon more potent.

As for encryption, the Administration does not claim it has been prevented from verifying any specific Treaty provision. No doubt verification has been made more difficult; perhaps the uncertainty in US estimates of some Soviet missile parameters has been increased. But US security has not been directly affected.

III. There is no doubt that the Soviets have abided by the most significant provisions of SALT II, including the ceiling on MIRVed launchers and the limit on the number of warheads that may be carried by MIRVed missiles.

Table I presents data on the strategic systems the Soviet Union has dismantled in compliance with SALT requirements, or has replaced with newer systems. The numbers are substantial. It should be noted however that some of the dismantled weapons, e.g. the SS-7 and SS-8, were very old and would probably have been retired in any case. The SS-17 and SS-19 might likewise have been deployed in SS-11 silos (and the SS-18 in SS-9 silos) even without any treaty; building new silos for all those launchers would have been very costly as well as time-consuming. So one should not exaggerate the impact of SALT on the present Soviet force structure. Nonetheless one can make a fairly long list of strategically significant actions the Soviets would have been capable of taking over the past seven years, which the Treaty has precluded.[2] Without the no-undercut commitment some of those actions would no doubt have been carried out.

IV. What of the future? The only near-term benefit of abandoning SALT will be to relieve the Pentagon of the obligation to retire older MIRVed systems (presumably Poseidon SLBMs) as new Trident submarines enter the fleet, or after the 130th B-52 is equipped for air-launched cruise missiles this fall.

The Administration has indicated that two Poseidon boats will probably be retired in any case this year because refurbishing them would be too expensive. The net saving over the next couple of years will therefore be only two or three old submarines.

The Soviets have announced that once the US breaches any of the SALT ceilings, they will consider themselves freed of all restraints. They could in principle carry out a fairly massive breakout, since they have several missile production lines open. My guess is that they will proceed cautiously at first, exceeding the SALT ceilings by no more than the US does. Their most plausible immediate response is to not retire other ICBMs as mobile SS-24s and SS-25s are deployed. (SALT would require an SS-17 or SS-19 to be dismantled for each SS-24 deployed.) The MIRVed 17s and 19s are modern accurate systems and are strategically more significant than a comparable number of Poseidon SLBMs. (The US cannot similarly retain Minutemen as MX is deployed because the MX launchers are going into Minuteman silos.)

The impact of the President's decision on the future of arms control is hard to predict. The Soviets are unlikely to break off the negotiations, but will surely try to capitalize on the generally adverse world reaction to the President's announcement. The absence of "interim restraints" could complicate future negotiations. Most troublesome would be some irreversible step, for example Soviet flight testing of a missile with more than 10 RVs.

Another undesirable consequence of abandoning SALT will be the lifting of all restrictions on deliberate concealment and other measures that interfere with verification. The Soviets can readily implement a wide variety of concealment measures; US intelligence estimates of Soviet strategic programs will necessarily become less reliable.

In sum, the President's abandonment of SALT seems unjustified by the Soviet violations, even if they are real. US security will, on balance, not benefit and the prospects for progress in arms control could be harmed.

Notes

[1] The most significant compliance issue, that of the Krasnoyarsk radar, deals with the ABM Treaty.

[2] L. Sartori, "Will SALT II Survive?", International Security Vol.10, pp. 147-174 (Winter 1985/86).

TABLE 1. SOVIET POSITIVE SALT COMPLIANCE RECORD
(Source: Arms Control Association)

SALT-Accountable Delivery Vehicles Dismantled or Destroyed

ICBMs:	281	(190 SS-7, 19 SS-8 and 72 SS-11 launchers dismantled)
SLBMs:	245	(224 SS-N-6 and 21 SS-N-5 launchers dismantled)
Bombers:	15+	(Bisons partially dismantled)

SALT-Accountable Delivery Vehicles Withdrawn or Converted

ICBMs:	798	(288 SS-9 and 510 SS-11 withdrawn from silos; replaced by SS-17, SS-18, and SS-19)
Bombers:	30	(Soviets claim some Bisons converted to aerial tankers; US disputes this claim)

Total SNDVs Dismantled, Destroyed, Withdrawn or Converted to Comply with SALT

ICBMs:	1079	
SLBMs:	245	
Bombers:	45	(30 in dispute)
Total:	1369	

STORING THE WORLD'S SPENT NUCLEAR FUEL: A NONPROLIFERATION INITIATIVE by Jack N. Barkenbus, Alvin M. Weinberg, and Marcelo Alonso, Institute for Energy Analysis, Oak Ridge National Laboratory.

Our reassessment of nuclear power and its relationship to nuclear weapons proliferation has come to guardedly optimistic conclusions.[1] The several obstacles to proliferation, among them the Non-Proliferation Treaty and the safeguards system of the International Atomic Energy Agency, have proved extremely resilient. Yet in order to ensure nonproliferation, renewed dedication to its achievement is required, as well as some new initiatives. Foremost among these would be the establishment of a spent fuel take-back service, in which one or a few nation-states would retrieve spent nuclear fuel from nations generating it. The centralized retrieval of spent fuel would remove accessible plutonium from the control of national leaders in non-nuclear-weapons states, thereby eliminating the temptation to use this material for weapons.

The Soviets already implement a retrieval policy with the spent fuel generated by East European allies. In addition, the Chinese have offered to store foreign spent fuel for a price. We believe that it is time for the United States to reopen the issue of spent fuel retrieval, and thus to strengthen its nonproliferation policies and the nonproliferation regime in general.

The global inventory of spent fuel is accumulating as the commercial nuclear enterprise expands; latest projections illustrated in Figure 1 indicate that spent fuel inventories outside Communist countries will swell to 135,000 metric tons of heavy metal in spent fuel by the year 2000. Although this amount is much lower than earlier forecasts, based upon overly optimistic projections of installed nuclear capacity, it still constitutes nearly a fourfold increase in spent fuel holdings over those that currently exist. Until recently the disposition of this spent fuel was considered a rather straightforward, uncomplicated matter.

Spent fuel stored at the reactor site was to be sent to a reprocessing facility, domestic or foreign, where uranium-235 and plutonium would be chemically separated from the other constituents. This recovered uranium and plutonium would then be fabricated into new fuel elements and either recycled into thermal reactors or used as fuel in breeder reactors, when commercially available.

The continuing surplus of uranium, both natural and enriched, however, has made reprocessing a questionable economic venture. Attention has turned instead to the possibility of indefinitely storing spent fuel, thereby deferring a decision on ultimate disposition. Were a few nations willing to step forward and provide a centralized, for-profit, storage service, they may find the following takers: (1) nation-states with rather small nuclear power programs might find it more economically advantageous to send their spent fuel abroad rather than to construct storage areas away from their reactors; (2) nation-states under public and legal pressure to dispose of their nuclear waste might welcome the opportunity; (3) nation-states lacking suitable waste disposal sites (geological formations) may want to dispose of their spent fuel and never see it again. A commercial spent fuel storage service could develop, therefore, having significant nonproliferation benefit.

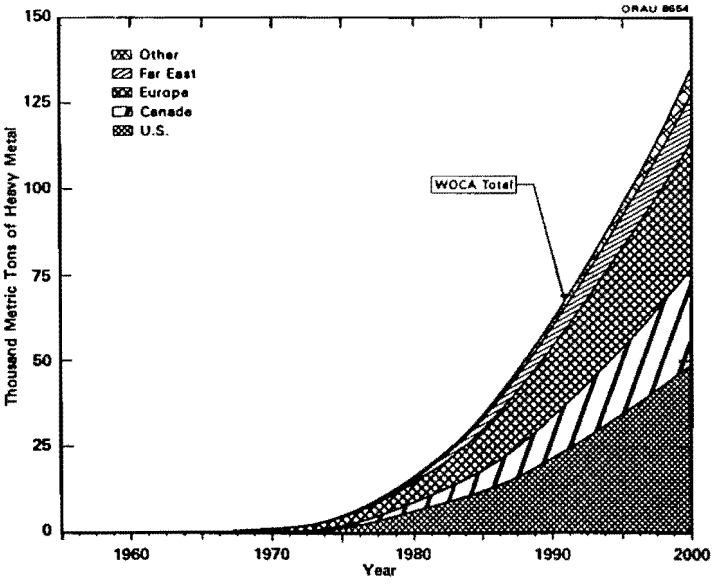


Figure 1. Cumulative Net Discharge of Spent Fuel (Mid-Case), for World Outside of Communist Areas (WOCA).

Note: The values shown represent net additions to spent fuel inventories (i.e., the quantities of spent fuel removed from inventories for reprocessing have been subtracted from the total amount of spent fuel discharges).

Source: Department of Energy/Energy Information Administration, World Nuclear Fuel Cycle Requirements 1984, DOE/EIA-0436(84), November 1984, p. 47.

The United States is a possible provider of a centralized spent fuel storage service, yet acceptance of foreign spent fuel is regarded by many as politically unacceptable--the United States already has enough trouble dealing with domestic spent fuel; why further complicate an already fragile nuclear waste process? But this assessment may be unduly pessimistic. Those who most vehemently oppose retrieval of foreign spent fuel on environmental grounds are ofrten the same activists who are most concerned about proliferation. Thus a plan that clearly reduces the threat of proliferation, while presumably adding to the environmental burden, presents such groups with a sharp choice: which is more important--nonproliferation or environmental purity?

We believe that a careful assessment of environmental risks would tilt strongly in favor of the take-back scheme. We would argue that the incremental burden associated with handling waste from foreign reactors is not large.

A limited U.S. take-back policy was proposed during the Carter Administration, but failed to gain the necessary congressional approval. There are valid reasons to reconsider such a proposal: first, foreign spent fuel could be incorporated into U.S. national plans as set forth in the Nuclear Waste Policy Act of 1982; second, it has become increasingly clear substantial financial gain could accompany this proliferation policy; third, as we have seen, there may be an increasing willingness on the part of utilities and states to get rid of their spent fuel.

Several key issues must be debated and resolved before a practical policy can be formulated: Would the United States take title to the spent fuel? Would storage alone be offered, or would waste disposal be an option? If eventually reprocessed, would the sender receive credit for the energy value in spent fuel, and if so, how would the value be calculated? These are important questions, but they should not obscure the most important goal--obtaining political support for the concept itself.

Obstacles to centralized fuel storage have been formidable. The Soviet model of retrieval has been tantalizing, but recognized as inapplicable in a world of multiple suppliers and fiercely independent and nonaligned countries. Nor has there been sufficient collective will to create supranational institutions with the power to regulate or retrieve spent fuel accumulations. An internationally directed retrieval regime for nonproliferation ends, therefore, has never been palatable to the international community, and it still holds little promise.

The commercial approach to retrieval contains a glimmer of hope because of changing perceptions and time-frames regarding the desirable disposition of spent fuel. The goal and expected payoff in emphasizing this opportunity must be made clear. It is unrealistic to expect all non-nuclear-weapons states to part willingly with their spent fuel. Cooperative efforts in storage, therefore, should not be judged solely on the basis of whether today's threshold countries agree to participate in such a scheme. What we really seek to establish is a new element in the nonproliferation regime--one that over time may create a new international norm governing behavior. The utility of various spent fuel storage plans, therefore, should not be assessed solely on the basis of short-term payoffs, but rather on their potential to manage fuel cycle activities when commercial nuclear power expands significantly beyond current levels. We believe that the Congress and the Administration would further both nonproliferation and commercial objectives by offering such a commercial service in the United States.

Reference

[1] Alvin M. Weinberg, Marcelo Alonso, Jack N. Barkenbus, eds., The Nuclear Connection: A Reassessment of Nuclear Power and Nonproliferation (New York: Paragon House, 1985). This is a condensed version of an article originally appearing in The Bulletin of the Atomic Scientists, November 1985.

NUCLEAR WAR EDUCATION CONFERENCE by Robert Ehrlich, Physics Department, George Mason University.

In recent years a number of short courses and conferences on nuclear war or arms race education have been offered for university faculty. The APS has, for example, held a short course for physicists, as have other professional organizations. Recently, George Mason University sponsored a Nuclear War Education Conference on April 10-12, 1986 that was unique in being a conference intended for nuclear war educators across the spectrum of academic disciplines. The Diversity of participants was striking, with 13 humanities faculty, 22 social scientists and 24 natural scientists in attendance.

The conference included two panel discussions, one on the nature of nuclear war education, and the other on SDI. Opinions on these issues were predictably diverse, with speakers often agreeably disagreeing. Of particular interest were 38 short contributed papers on topics as diverse as "Nuclear War in Science Fiction," "The Role of the Press in Nuclear Policy," and "Nuclear Winter." The ability of participants to hear and discuss papers far from their own academic areas allowed for a very interdisciplinary and stimulating kind of discussion. With one exception, the discussions were entirely free of rancor and were a genuine debate (as against two monologues). The one exception revolved around several papers relating to Accuracy in Academia, the creation of Reed Irvine, an organization to monitor liberal "inaccuracies" in the nation's universities. Three papers on this subject were given by Reed Irvine, Mark Reader, an anti-nuclear educator who was the subject of AIA's attacks, and myself.[1]

For those newsletter readers interested in more information about the conference free copies of a 200 page conference document is available from me. The length of the document also included order forms for audio and video cassettes of any portion of the conference. Additionally, a book: Nuclear War Education: A Variety of Perspectives, consisting of an edited version of the conference proceedings, is currently in preparation, and will be published by Greenwood Press in 1987.

The response of participants to the conference appears to have been overwhelmingly positive, so much so that a follow-up GMU-sponsored conference is being planned for the Fall of 1987 to be sponsored by a grant from the Sloan Foundation.

Reference

[1] A shorter version of my paper: "Accuracy in Academia: The Chief Thing to Fear is Our Own Hysterical Reaction" appeared in the May 16 issue of the Chronicle of Higher Education, p. 96.

JOB OPENING

(LOTS OF WORK, NO PAY)

THE FORUM IS SEEKING A NEWSLETTER EDITOR

The Executive Committee of the Forum has decided to make the Newsletter our top priority for this year. We want to expand it, include technical and interpretive articles, letters to the editor, jobs offered and sought, etc.

To make this happen we need a permanent EDITOR. Lots of psychic income.

If you're interested contact Paul Craig [Applied Science, UC Davis, 95616. Tel. 916-752-1782/0360] or Dave Hafemeister [Physics Department, Cal Poly, San Luis Obispo, CA 93407, Tel. 805-544-5096].

AAAS ARMS CONTROL COLLOQUIUM DECEMBER 4-5 IN D.C.

The first annual AAAS Colloquium on Science, Technology, Arms Control, and International Security will be held in Washington, D.C. December 4-5. The event will bring together more than 300 science, government, business, and citizen leaders to look at the future of international security as well as to examine in depth some of the key issues relating science, technology, and national security. By providing a range of viewpoints on a variety of questions, the colloquium will offer a balanced examination of complex arms control and national security issues.

The colloquium will include plenary sessions on the role of science and technology in shaping national security policy, advances in weapons technologies and their impact on security, an evaluation of the strategic and technical merits of SDI, the Five Continent Initiative, and the question of how science and technology can help us create a safer world. In addition to the plenaries, smaller group sessions will give participants an opportunity to interact with each other and with experts on a variety of timely issues.

Participants will also have the opportunity to participate in smaller group sessions on such topics as the impact on security of advances in weapons technologies, C^3I and nuclear stability, and nuclear testing and weapons proliferation. Confirmed speakers include Sidney Drell, Jane Sharp, William Perry, James Abrahamson, Dick Clark, David Hamburg, and Ashton Carter.

For registration information about the colloquium, contact April Moore at the AAAS Committee on Science, Arms Control, and National Security, 1333 H Street NW, Washington, D.C. 20005, (202) 326-6494.

BOOK REVIEWS: COURSES ON ARMS RACE

Books reviewed by Michael J. Harrison, Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan 48824.

Undergraduate courses in nuclear arms race issues can be organized with varying admixtures of technical matter, strategic considerations and the history of arms control negotiations. An early key decision facing the instructor concerns how much of the science and technology of nuclear weapons, their effects and delivery systems ought to be included in the course syllabus. Most physics department faculty will want to provide students with at least some understanding of the physics of nuclear weapons and their destructive potential in order to anchor solidly the class's study of broad strategic and policy issues.

Several texts have now appeared which combine technical nuclear material with strategy and policy. Two reviewed here are: Science Technology and the Nuclear Arms Race by Dietrich Schroeer, John Wiley & Sons (1984); and Nuclear Arms Race: Technology and Society by Paul P. Craig and John A. Jungerman, McGraw-Hill Book Company (1986).

Both texts combine the technical and non-technical aspects of nuclear arms race issues. And both are suitable for upper division undergraduate courses for non-science majors *provided* that the algebra underlying the physics of nuclear weaponry, silo vulnerability, etc. is soft-pedaled and accompanied by inspired hand-waving and anecdotal examples reflecting schoolyard games and conflicts familiar from childhood. For science and engineering majors the quantitative material in both books will be readily comprehensible and moreover will provide a useful reprise of some physics and engineering principles discussed earlier in conventional coursework.

The two texts differ in organization and emphasis. The book by Craig and Jungerman begins with an extensive discussion of the historical context in which nuclear arsenals and weapons policy have been developed by the United States and the Soviet Union. Only subsequently do these authors give an account of the technical and scientific concepts which undergird the construction and operation of nuclear weapons and their effects. This technical part represents roughly one-half of the book. The final one-quarter of the Craig-Jungerman volume is devoted to a discussion of nuclear strategic issues and various factors including proliferation, verification of agreements, the economics of the arms race and the psychological effects of nuclear weapons. The lists of study questions which appear after every chapter and the homework problems selected to accompany appropriate chapters should represent effective means to enhance students' understanding of important points discussed in the text.

The volume by Schroeer is also keyed to developing technical literacy in nuclear arms issues; he combines discussion of technical and scientific matters with accounts of related strategic and historical consequences more or less distributed uniformly throughout the whole book. It begins with a thorough discussion of nuclear arms including massive retaliation doctrine, and proceeds to an extensive discussion of the nuclear balance between the superpowers including strategic delivery systems and nuclear deterrence. After a systematic treatment of alternatives to nuclear deterrence the text concludes with an account of arms control and disarmament including the history of strategic arms limitations.

Both of these books are excellent main texts for an undergraduate course designed to develop capabilities to make informed judgments about scientific and political issues arising from the existence of nuclear arms. They can also be supplemented with appropriate additional readings: more substantial technical material for science majors and more extensive strategic and historical reading for everyone!

OPTIMIZED DOMESTIC SOLAR HOT WATER SYSTEM by John E. Poling, Physics Department, California Polytechnic State University, San Luis Obispo.

An optimized solar hot water system can provide a reasonable fraction of the domestic hot water needed year-round at a low cost. A small number of commercially installed systems were examined locally, and though all of these systems used expensive high quality components they were often combined and installed in such a manner that the system performance was not optimum. It was common to find the commercial systems producing more hot water than could be used in the summer, and very little hot water in the winter. The owners simply thought that solar hot water systems did not work in winter, but in the mild climate of San Luis Obispo, CA such systems should work fine in the winter.

We built and installed an inexpensive system which was assembled from prefabricated parts at a workshop. The total cost was between 1/3 and 1/2 the cost of commercially installed systems. The performance of this optimized self-installed system was considerably better than the performance of the commercial systems examined, even though it did not use expensive components. We were so pleased with the result that at a later date we conducted two such workshops locally resulting in the installation of a number of fairly well optimized inexpensive systems.

To understand the optimization, each component must be considered separately. The commercial systems usually used a larger pump than necessary, and thus some of the energy and dollar savings of the system were lost. An oversized pump was temporarily installed on our system along with a flow meter, a flow control valve, and accurate thermometers. Thermal collection efficiency was measured as a function of flow rate near noon with careful correction for changing sun angle and panel temperature. Our results are given in Fig. 1 as a plot of the energy increase of the water flowing through the panels (temperature increase times the flow rate in F° x gallons/minute) versus the flow rate in gallons/minute. The commercial systems examined used pumps with power ratings of from 75 to 130 watts and operated well past the "knee" of this curve. We permanently installed a small 29 watt pump which delivers about 2.6 gallons/minute because there is little thermal energy to be gained by operating past the knee of the curve, and the electric bill will be greater for a larger pump.

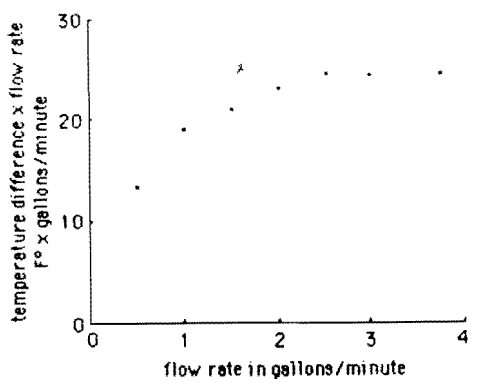


Figure 1.

The differential temperature controller is very important. Our controller turns the pump on when the water temperature in the panels is about 3 F° higher than the water temperature at the bottom of the storage tank, and turns it off when this temperature difference drops to about 1.5 F°. On a typical day near an equinox this optimized system runs for about 7 hours. One simply lets the controller turn an electric alarm clock on and off along with the pump to easily measure the total daily running time. When the alarm clock was used on commercially installed systems, daily total running times from 2 hours down to 45 minutes were found. The controllers were not turning the pumps in the commercial systems on until the temperature difference was 15 or 20 F°, and were turning it off when it dropped to 5 or 10 F°. The resulting intermittent operation reduces the efficiency of these systems.

The angle at which the panels are installed is important because the system should be designed to optimize the amount of usable hot water for the entire year. Most of the commercially installed systems examined had the panels tilted too far toward the zenith, resulting in more hot water than could be used in summer and very little hot water in winter. Many commercial systems simply put the panels flat on the roof. We chose an angle of 42° from the zenith. At 35.5° north latitude, this means that the panels are 6.5° higher than normal incidence to noon sunlight on March 21 and September 21, 30° high on June 21, and 17° low on December 21. The 42° angle favors winter over summer which is necessary for balanced operation because in winter the ambient air and tap water temperatures are colder, and there is less solar energy available. This system produces roughly equal amounts of hot water near the winter and summer solstices, and somewhat more hot water near the spring and fall equinoxes (Fig. 2).

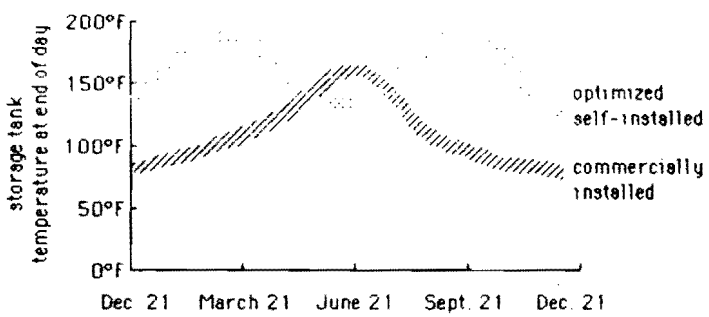


Figure 2.

One can obtain panels with a flat black surface or a more expensive black chrome surface. Black chrome surfaces have low emissivity in the infra-red of about 0.10 versus about 0.92 for flat black. As the difference between the panel temperature and the ambient temperature increases (because the water heats up during the day) larger amounts of energy are lost through infra-red emission from a flat black panel than from a black chrome panel. Thus the efficiency of a flat black panel decreases more rapidly than the efficiency of a black chrome panel as higher operating temperatures are reached (Fig. 3). However, given adequate roof space, simple calculations using the published efficiency of the panels as a function of temperature showed that it would be somewhat less expensive to use a larger area of flat black panels than to use a smaller area of more efficient but more expensive black chrome panels. This was also true when considering converting flat black panels to black chrome by applying self

adhesive black chrome foil. Another consideration is that if the water flow is cut off or severely restricted flat black panels stagnate at fairly harmless temperatures of about 200 F° whereas black chrome panels stagnate at somewhat higher temperatures which may damage the system. Overheating can even occur during a vacation when the system is operating normally but the hot water is not being used. Situations have occurred where insulation was melted from the pipes. Flat black was the best economic choice at the time our system was designed.

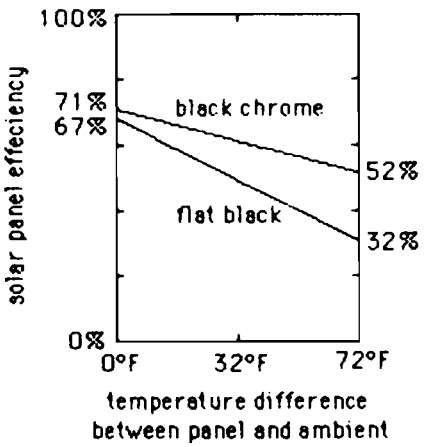


Figure 3.

Storage tank size was also considered. A larger storage tank can store more thermal energy while operating the panels at lower more efficient temperatures. However, we found that it was less expensive to add more panels and operate at higher temperatures to reach the desired thermal capacity than it was to install a storage tank larger than 80 gallons.

Clearly, the energy savings from solar hot water heating in San Luis Obispo have been less than they could have been because some commercially installed systems are not well optimized. The calculations leading to optimization of one's own solar hot water system can be a pleasant and useful exercise.

NEW EDUCATION/POPA POSITION AT APS-NY

The APS is searching for a full time physicist (or two part-timers) to begin in January 1987, to assist Bill Havens on educational and physics outreach matters. This position is presently held by Ken Ford, Chair of the Education Committee and Forum Councillor on an interim basis. If interested, please contact the Chair of the Search Committee, Professor Lillian McDermott, Physics Dept., University of Washington, Seattle, WA 98195.

NEW BOOK ON CIVIL DEFENSE

CIVIL DEFENSE: A CHOICE OF DISASTERS
John Dowling and Evans Harrell, editors
American Institute of Physics, 1986

Civil Defense is the first thing to come to mind when people think about nuclear war. Some aspects of it have been unchanged for forty years, as civil defense programs have gone in and out of favor. Yet others change as new weaponry and strategic doctrines are concocted, and as the effects of nuclear warfare become better known. This book has up-to-date and balanced discussions of both old and recent issues related to protecting the population from nuclear weapons. It is the first publication to come from one of the Forum's study groups on the arms race.

Civil Defense: A Choice of Disasters will serve well as a source book and text for a college course on nuclear war, in either a physics or a general science curriculum. It would also be useful for anyone wishing to be well informed about arms control and nuclear war.

CONTENTS

The book also contains appendices, technical data, teaching materials, film bibliography and reprints of talks making the cases for and against crisis relocation and bomb shelters (Barry M. Casper, Carsten M. Haaland, and Roger M. Sullivan). For information about ordering this book, write: Rita Lerner, Manager; Books Division; American Institute of Physics; 335 E. 45th Street; New York, NY 10017.

Minutes of the Executive Committee of the Forum on Physics and Society

Washington, D. C. 29 April, 1986

In attendance at the meeting were A. Brecher, P. Craig (V-Chair), I. Engle, K. Ford, D. Hafemeister (Chair), E. Harrell, R. Howes, B. Levi, M. Sakitt, L. Sartori and P. Zimmerman (Secy/Treas). Non-voting guests in attendance: A. Hobson, H. Nelson and D. Schroeer (V-Chair-elect).

The minutes of the previous meeting were passed out and approved as amended.

The Treasurer's report showed that the Forum lost a significant amount of money in the last 12 months, largely as a result of the cost of preparing seven awards certificates, a short-fall on the short-course on energy conservation and renewable resources, and the costs of funding the civil defense study. Nevertheless, our financial position is still sound, although we are consuming capital and will probably have to go back to Council.

Newsletter. Discussion ensued about the proper evolution of the Forum Newsletter. Mark Sakitt proposed, as a goal for the future, a major upgrade of the Newsletter in the direction of its becoming a prototype Journal of Science and Society. It was agreed that such an upgrade would provide a new journalistic outlet for articles on science and society within the APS. Paul Craig, Art Hobson, Barbara Levi and Dietrich Schroeer were appointed to serve as an Editorial Board to implement the decision to upgrade the newsletter. Dave Hafemeister was appointed Interim Editor and made an ex officio member of the Editorial Board. Forum Newsletter Editor John Dowling had offered to resign his position, partly in response to some discontent expressed over some editorial decisions. The Executive Committee voted to accept his resignation. In order to thank John Dowling for his many years of dedicated service as Newsletter Editor, the Executive Committee voted a special award to John. The award will take the form of a certificate/diploma similar to that now used by the Forum for the Szilard and Forum Awards. The Treasurer was authorized to order the diploma from the APS, paying for it out of Forum funds.

Forum Councillor. Ken Ford reported on the status of the POPA Directed Energy Weapons Study. A review panel of the APS is expected to meet in late May with official release later in the year.

POPA. Paul Craig reported: The image of the Forum within the larger APS population is good. The question of what is a Forum Study was a time-consuming one. The Forum's Civil Defense Study was formalized by saying that the Forum provided assistance to individual members who then published (as an AIP book) their own opinions without any official sanction. Future APS studies will be considered when the DEW study has been completed.

Awards. Two measures were adopted: (1) The publication "window" governing the Forum Award has been lengthened to five (instead of two) years prior to the award. (2) The Forum calls upon Council to recognize the Szilard and Forum Awards as being similar to all other APS Awards, with a call for nominations to be published in the Bulletin and award winners to be listed there as well. In the future the APS President must approve the membership of the Awards Committee. [This change was approved at the June APS Executive Committee meeting.]

Program Committee. Dietrich Schroeer suggests symposia on Physics & Society courses (with AAPT), University Research, the setbacks caused by the loss of the Shuttle Challenger, and Nuclear Fusion.

Fellowships. We are slowly making progress in understanding the formalities that the APS wants us to follow to nominate Fellows. H. Barschall and Aviva Brecher were nominated to the Fellowship Committee with Ruth Howes as Chair.

Studies. Paul Craig proposed a study on verification, particularly of a CTBT. Others suggested that verification SALT/START types of agreements would be at least as interesting. It was suggested that on CTBT verification the American Geophysical Union might be an interested collaborator.

Old Business. It was decided that the Forum should seek to have more contributed papers sessions but should try to arrange these to avoid an excessive number of crackpot papers in any one session. There was a sense of distress and embarrassment on the part of all over the conduct of the contributed papers session at the Washington meeting. Particularly unfortunate was the non appearance of the designated Chair.

New Business. At 2:10 p.m., Paul Craig assumed the mantle of leadership from Dave Hafemeister, wielded his gavel and called for new business. The call was answered by a motion from the new Vice-Chair, Dietrich Schroeer, that Hafemeister be allocated a special [one time only] appropriation of up to $2,000 for publishing the Newsletter. Passed unanimously.

The meeting was then adjourned. (P. Zimmerman, Secretary)

FORUM NEWS

From the Chairman

The **Forum on Physics and Society** is 15 years old! It hardly seems possible. In the early years the **Forum** was viewed as the stronghold within the APS of fringe, activist types. Today this has changed. Our members are as diverse as is the APS itself. We have become respectable. We have 4000 members, putting us in a tie for second place among APS Division. We sponsor sessions at most APS meetings, and have run several topical workshops. There have been two AIP books on energy conservation, and one on the arms race. The **Forum** initiated study on Civil Defense will soon be published by AIP. The two **Forum** awards, the **Szilard Award** and the **Forum Award** are highly regarded. [A review of Forum activities was published as a letter in Physics Today, March, 1986, pp 163-167].

The **Forum** was established to provide a vehicle for communication and action for members of the physics community concerned with issues involving physics and society. We attempt to be rigorously non-partisan. We provide avenues for communication in our area in just the same way as the APS Divisions do in theirs. The big difference is that our issues include values. This makes it much harder to maintain balance. The best evidence that we are succeeding is the virtually universal enthusiasm for and the high attendance at **Forum** sessions at APS meetings.

What Next for the Forum? The strength of the **Forum** is our members. We hope to expand the membership and to increase their involvement. Please tell us what we ought to be doing, and help do it. We want articles, letters, and announcements for the Newsletter. We want your nominations for the **Forum Award** and for the **Szilard Award**. We want volunteers to serve on committees, and to run for **Forum** offices.

Our highest immediate priority is to upgrade the **Forum Newsletter**. This is our primary vehicle for communication. The Newsletter serves several purposes. Substantive articles provide background and references on current issues. There will soon be a section listing current articles, reports and books in areas of interest to **Forum** members. These listings will be annotated, and (particularly important for the so-called "grey literature") will include sources.

Letters to the Newsletter are encouraged. The Newsletter will include job listings. We want the newsletter to contain material you can't easily find elsewhere. We want it to have archival value.

The **Forum**, like all APS Divisions, may nominate APS members for Fellowship. The **Forum** is the one place within the APS where recognition can be encouraged for activities which involve the impact of physics on society. Send your suggestions for nominees to the **Forum's** Fellowship Committee Chair, Professor Ruth Howes, Department of Physics and Astronomy, Ball State University, Muncie, Indiana 47306.

We are always looking for topics and speakers for **Forum** sponsored APS sessions. The organizer of these sessions is the Forum Vice Chairman, Dietrich Schroeer, Department of Physics and Astronomy, University of North Carolina, Chapel Hill, NC 27514.

Forum encouraged studies can provide an excellent means for individuals to participate in national issues. Under APS guidelines the **Forum** can provide resources to bring together Members to work on topical studies. The first such study, recently completed, explores nuclear civil defense. It was co-chaired by John Dowling (Mansfield University) and Evans Harrell (Georgia Tech) and will be published by the AIP this Fall. **Forum** studies will usually be educational in focus. Individual chapters will appear under authors names, and the studies will neither be approved nor endorsed by the APS.

A current study (chaired by Herb Nelson, Naval Research Laboratory) is focusing on the future of the land based leg of the strategic triad - the land based ICBM's. Papers are being written, and we hope to have a draft by the end of the year.

APS members may contribute abstracts to APS meetings. We want to encourage all APS members to submit abstracts. There is a "critical mass" phenomenon involved here. When there are only one or two abstracts it isn't possible to hold a special session, and these abstracts tend to get lost in the shuffle. With more abstracts we can move toward interesting contributed sessions. If you're going to be at a meeting to present a physics paper, why not use this opportunity to talk about your physics and society interests as well?

We are always looking for new **Forum** members, and for active members. An immediate need is for a Newsletter Editor. (See the announcement in the separate box). If you are interested in participating in the **Forum** in any way, or if there are things you's like to see us doing, let us know.

Paul P. Craig
University of California at Davis

CALL FOR NOMINATIONS FOR FORUM ELECTIONS

This winter the Forum will have elections for the positions of Vice-Chair (Chair-Elect), and three positions on the Executive Committee. The Vice-Chair will chair the committee that organizes the Forum sessions at APS meetings his first year, and the Executive Committee members will assist with the sessions, awards, and study groups. Please send your nominations and a letter of support to the committee chair, Dr. Mark Sakitt, Center for International Security and Arms Control, Stanford University, 320 Galvez Street, Stanford, CA 94305 (415) 723-9625.

CALL FOR FORUM SESSION IDEAS

The members of the Program Committee of the FORUM solicit your ideas for next year's sessions at APS meetings. This past year the FORUM held six sessions of invited papers, plus one of contributed papers (which needs to be improved), plus a visit to the Nevada Nuclear Test site, at various APS meetings. The FORUM will only conduct sessions that are balanced in content, and are technically interesting and/or deal with some public policy issue of pressing importance to the physics community. Please send your ideas for future sessions, including topics, talks, speakers, and organizers to the FORUM's Program Committee:

Dietrich Schroeer (Chair), Department of Physics and Astronomy, 039A, University of North Carolina, Chapel Hill, NC 27514 (919) 962-3019

Ruth Howes, Physics Department, Ball State University, Muncie, IN 47306 (317) 285-8868

Evans Harrell, School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332-0160 (404) 894-2715

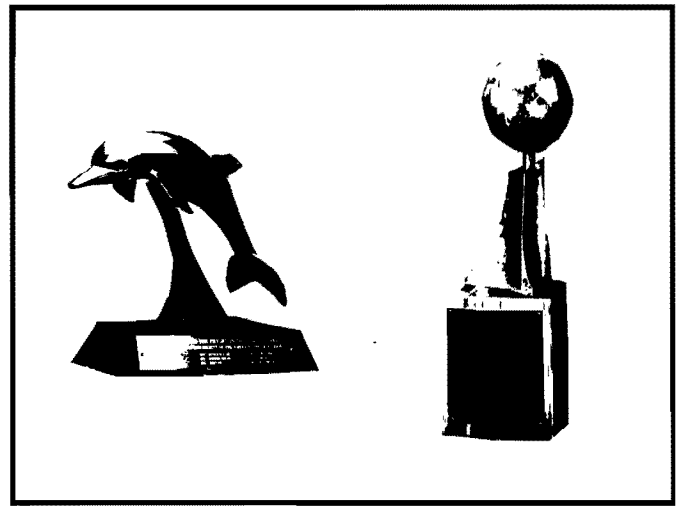
CALL FOR CONTRIBUTED PAPERS FOR D.C.

The FORUM proposes to have a special session of contributed papers at the Crystal City meeting, which takes place April 20-23, 1987. We would like to generate a session of the highest quality, one which demonstrates that physicists have something to contribute to analyses of science-and-policy issues. Therefore we are soliciting abstracts for that meeting from the FORUM membership. The deadline for receipt of such abstracts at the APS Office in New York is 30 January, 1987. We encourage contributions that perform an analysis of some science-and-technology based issue, with the analysis to be informed by our specialized knowledge as physicists. For example, a back-of-the envelope estimate of the potential energy output from an A-bomb-powered microwave generator could make a big contribution to the debate about third-generation nuclear devices and strategic defense. We would like to discourage contributions that do not exploit our technical competence, and contributions that emphasize policy conclusions. It would be useful if you would send early copies of your abstracts to D. Schroeer at the above address.

CALL FOR NOMINATIONS FOR FORUM AWARDS

The Forum is now searching for nominations for its two annual awards, to be presented in the Spring of 1987. The Szilard Award recognizes outstanding accomplishment by a physicist in promoting the use of physics for the benefit of society. The APS Forum Award recognizes accomplishment in the endeavor to promote public understanding of issues involving the interface between physics and society. If you would like to suggest any names, please send them with supporting material to this year's Awards CommitteeChair, Dr. Aviva Brecher, 35 Madison Street, Belmont, MA 02178, (617) 489-1386.

This year, the Forum supplemented financial reward with symbolic recognition by presenting each recipient with a sculpture, to keep for one year until the next year's recipient is named. The sculpture commemorating the Szilard Award is a dolphin as shown below, to symbolize Leo Szilard's novelette, THE VOICE OF THE DOLPHINS. The sculpture commemorating the APS Forum Award is more abstract, as befits the more abstract task of "outreach." It is roughly spheroidal in shape and is made of hammered brass and bronze with pieces of bocote wood as shown below.



JOIN THE APS FORUM ON PHYSICS AND SOCIETY!

On the following page we have reprinted a letter that summarizes the work on the Forum (*Physics Today* March 1986). Please pass this essay on to some of your colleagues who might be interested in joining the Forum. Our membership has grown from 2600 to over 4000 in the past five years, by joining you will receive a copy of *Physics and Society* and you will give the Forum extra capacity to increase our activities. Over the past two years the Forum has held 15 sessions at APS meetings, and 5 sessions at short course held at OTA. Three AIP books have appeared from the Froum's work in the past three years on the Nuclear Arms Race (AIP 104), Civil Defense (AIP), and Energy Conservation Technologies (AIP 135). The Forum presently has a study group investigated the feasibility of the midgetman missile and other topics. Over the years, the Forum has been active in the development of the APS Congressional Fellows Program, the two conferences on Physics Education and Employment, and the annual awards (the Szilard and APS Forum Awards). If you or your friends are APS members and would like to join the Forum, please write to Dr. Peter D. Zimmerman, Carnegie Endowment for International Peace, 11 Dupont Circle, NW, Washington, DC 20036.

Forum on Physics and Society

PHYSICS TODAY / MARCH 1986 pp. 163-167

It has been several years since the Forum on Physics and Society of The American Physical Society has made a progress report on its activities to the physics community. As the past, present and future chairs on the Forum, we would like to inform you of our current activities and guidelines.

The Forum on Physics and Society was formed in 1971 in response to the growing interest among APS members in the broad issues of physics and society. Membership in the Forum is open to all APS members; today the Forum's membership of 4000 ties it for second place among APS divisions.

The Forum's primary role is educational. From the beginning its most visible activities have been the sessions at APS meetings. Several Forum-sponsored sessions are held at almost every national meeting. Forum sessions are often held in the evenings, and standing-room-only crowds are not unusual. In recent years weapons policy and arms control have been the single area of greatest Forum activity. Sessions have described and debated such topics as the MX missile, the Comprehensive Test Ban Treaty, the SALT Treaty and new weapons systems. Other areas of Forum interest include energy, environmental issues, human rights and government restriction of scientific exchanges. Several sessions have been cosponsored with the AAPT and APS committees on education, on opportunities in physics and on international freedom of scientists. The Forum also publishes a newsletter, *Physics and Society*, which is distributed to all Forum members and many physics libraries; the editor, John Dowling, will consider timely, brief articles for publication. One early Forum project was the highly successful Science Congressional Fellow Program, begun jointly by APS and AAAS and now expanded to 20 professional societies. The Forum also played an active part in organizing the well-known APS technical study on efficient uses of energy in 1974.

The Forum does not shrink from addressing topics that are controversial or that have a political component. In these instances it strives to ensure that the presentations span the spectrum of views on the issues. Last year the Forum sponsored nine sessions at APS Defense Initiative. Key individuals presented a broad spectrum of views of the program. Among the speakers were some of the leaders from the Fletcher report, which launched SDI: Edwward Gerry (Shafer Associates), chairman of the Systems Concepts Panel; Walter Sooey (Lawrence Livermore National Laboratory), member of the Countermeasures and Tactics Panel; and Gerold Yonas (SDI, DOD), chairman of the Directed Energy Weapons Panel and now chief science adviser to General James A. Abrahamson, the director of SDI. Those who spoke against "Star Wars" were Kurt Gottfried (Cornell), codirector of the Union of Concerned Scientists study on space-based missile defense; Kosta Tsipis, codirector of the Program for Science and Technology for International Security at MIT and an early author on space-based weapons; and Spurgeon Keeny, former deputy director of the Arms Control and Disarmament Agency and currently executive director of the Arms Control Association. Three other sessions last year centered around National Academy of Sciences reports on nuclear winter, acid rain and the electromagnetic pulse. These sessions were good examples of the Forum's policy of running balanced presentations on important issues with a strong science component. This year there will be three additional sessions on SDI at the San Diego and Washington meetings, as well as a session on energy risk analysis (Atlanta meeting), a visit to the Nevada test site (Las Vegas meeting) and a session on precision-guided conventional weapons (Washington meeting). At the Washington meeting, the Forum will also present its annual awards.

The Forum sponsors topical conferences and short courses on timely subjects. A two-day course on energy conservation was held after last year's Washington APS meeting. This course reviewed progress on energy-conservation technologies since the oil embargo of 1973-74. Two short courses on the arms race were held: in San Francisco in 1982 and in Baltimore in 1983. Two conferences on graduate physics education were held at Pennsylvania State University in the mid-1970's, back when the employment prospects for young PhDs were very bleak. The materials on energy conservation, on the arms race and on graduate education have been published in the AIP Conference Series. In addition, the proceedings of Forum sessions on nuclear proliferation, the arms race and acid rain have been publishd as AAPT booklets.

For the past decade, the Forum has presented two annual awards. The Szilard Award recognizes outstanding accomplishment by a physicist in promoting the use of physics for the benefit of society. Recent winners include two groups -- Paul Crutzen and John Birks, and Richard Turco, Brian Toon, Thomas Ackerman, Jim Pollack and Carl Sagan -- for work on nuclear winter (1985), Kosta Tsipis (1984), Andrei Sakharov (1983), Wolfgang Panofsky (1982), Hans Bethe and Henry Kendall (1981) and Sidney Drell (1980). The Forum Award recognizes accomplishment in promoting public understanding of issues involving physics and society. Recent winners include Mike Casper (1984), the *Bulletin of the Atomic Scientists* (1983), Philip Morrison (1982) and William Shurcliff (1980). Nominations for these awards can be made by any member of APS.

As Forum membership has expanded, the Forum has developed the capability to undertake special studies. These will provide an opportunity for APS members both to educate themselves and to contribute to public understanding of problems having significant physics content. The first Forum study, on civil defense, was chaired by John Dowling, and it is now approaching completion. A second study, which will analyze the viability of the Midgetman missile as a "stabilizing" technology, is in the planning stage.

During its first decade the Forum on Physics and Society has evolved and matured. Today it plays an important role within the American Physical Society. Robert R. Wilson, the current APS president, recognized this role explicitly in the letter he included with the APS billing notices. "Today," he wrote, "through POPA [the Panel on Public Affairs] and the Forum, many . . .[social] issues are faced by APS." As our society must make ever more decisions with strong physics components, new opportunities for the Forum to contribute are emerging. Growing membership and enthusiasm are making it possible for the Forum to rise to these challenges.

LEO SARTORI
University of Nebraska
Lincoln, Nebraska
DAVID HAFEMEISTER
California Polytechnic University
San Luis Obispo, California
PAUL CRAIG
University of California at Davis

CHERNOBYL AND RADIATION SESSION
Southeast APS at William and Mary
November 20

The Southeast Section of the APS is sponsoring a session on radiation problems and issues at its fall meeting that will be held at the College of William and Mary. The session will be held in the evening on Thursday, November 20, and it will be chaired by David Kocher of Oak Ridge National Laboratory.

Topic	Speaker
Radiation protection and radiation dosimetry	Keitl. F. Eckerman Oak Ridge National Laboratory
Reactor safety and the Chernobyl accident	Richard Wilson Harvard University
High-level waste disposal	Benjamin Ross Disposal Safety, Inc.
The radon problem	Bernard L. Cohen University of Pittsburgh

EFFECTS OF SHUTTLE DISASTER ON SPACE PHYSICS
Plasma Division, Baltimore
November 6

The Forum is sponsoring a session at the Plasma Division meeting in Baltimore on THE EFFECTS OF THE CHALLENGER DISASTER ON THE PURSUIT OF SPACE PHYSICS. The session will be held at 7:30 p.m. on Thursday, November 6 and it will be chaired by Carol Jo Crannell of NASA.

Title of Talk	Speaker
"The Impact of the Challenger Accident on the Space Science Program"	Jeffrey Rosendhal Assistant Associate Administrator for Space Science and Applications, NASA
"Space Science after the Challenger Accident"	Thomas Donahue Chair, Space Science Board, National Academy of Sciences and University of Michigan
"Science Policy - its formulation and implementation"	Richard Johnson Acting Science Advisor to the President Office of Science and Technology Policy
"A Congressional Perspective on Future Opportunities for Space Science post-Challenger"	Radford Byerly, Jr. Staff Director, Subcommittee on Space Science and Applications House of Representatives