

PHYSICS AND SOCIETY

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FORUM ELECTIONS IN THIS ISSUE. Ballot and candidate statements enclosed, on removable center fold. PLEASE VOTE!

LETTERS

THE GREENHOUSE AND THE NARROWNESS OF PHYSICS

I wholeheartedly endorse your editorial (Oct 1988). I've been writing about these matters in *Parade*. With its 65 million readers it provides an opportunity to speak directly to the many Americans who will be affected by such climatic change.

I'm enclosing copies of two related articles in *Parade*; one on the greenhouse effect (*Parade*, 3 Feb 1985), the other on U.S.-Soviet relations (*Parade*, 7 Feb 1988), with the environmental threats as one of the common enemies.

Carl Sagan
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THE ARMS RACE AND NUCLEAR WAR

I would like to thank Allan Walstad (October 1988) for pointing out some typographic errors and mis-statements in my text, *The Arms Race and Nuclear War*. Most of these are already scheduled for correction in the next printing. Others are misrepresentations on his part; e.g. on p.66 I clearly describe the difference between rem and rad, explaining that for gamma rays (and most treatments in the non-technical literature), the two are considered equal.

Our greater disagreement is over politics and pedagogy. I can only admire his certainty as to the cause of the nuclear arms race: "the Soviet Union, with its brutal disregard for human rights, its ideologically driven imperialism and its obsession with military power, threatens free peoples." Dr. Walstad may be surprised to learn that there is another view, expressed with equally zealous confidence — and, I might add, endorsed by scholars no less competent than he — that blames the United States for having

initiated the nuclear arms race, and for maintaining its momentum. I unblushingly attribute these views to the far right and far left, respectively. And indeed, I find it useful to identify other possible causes that are less extreme, including action-reaction sequences, technological "creep," service rivalries, career pressures, domestic politics, misperceptions, etc. (In issues of political causation, incidentally, there is no reason to expect that the "correct" answer is necessarily the arithmetic mean; as Einstein pointed out, politics is more complex than physics.)

I also plead guilty to devoting an entire chapter to "nuclear psychology," including topics such as perception theory, mirror imaging, crisis behavior, nuclear language, children's fears, and the psychology of deterrence. In addition, there are chapters on such "non-physics" issues as nuclear ethics (Just War doctrine, international law) and nuclear economics (different ways of calculating the "military budget," effects of military spending, etc.) Such concerns are less quantifiable than two-shot kill probabilities (which are also treated) but no less important. To discount these issues with a sneer about "missiles as phallic symbols and all that" is to give substance to the unfair caricature of physicists as techno-nerds with no social sensitivities...a calumny which, fortunately, *Physics and Society* so effectively belies.

David P. Barash
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Seattle, WA 98195

Response:

Much of my review is taken up with illustrating how Dr. Barash's ostensibly balanced textbook in fact promotes his own dovish-left viewpoint. But I hope he also read the part that says I use the book and have reason to believe that the contrast of views between him and me enhances both student interest and balance in my course.

Nevertheless, two weaknesses evident in Barash's text (despite his objections) are likely to afflict any single-author text on nuclear war. 1) The range of expertise of an individual is limited. 2) It's virtually impossible for one person to do justice to divergent opinions on a controversial subject. It seems to me that a viable alternative is to develop a text in which specific issues are addressed in essays solicited from authors with opposing viewpoints. Such an effort would be most likely to succeed if it were sponsored by the Forum. It might even make money!

Allan Walstad

THE FORUM

The Forum, to which I also belong, seems to gravitate very strongly toward issues related to nuclear defense. To be sure, it is important, but physics and society relate on so much broader a scale. I simply want to register my interest in whether Forum officers and programmers are actively trying to broaden the content of the newsletter and of Forum symposia.

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ARTICLE

A SIMPLIFIED ANTI-SUBMARINE WARFARE PROBLEM TREATED AS A STEADY STATE MARKOV PROCESS

Gerald E. Marsh and Robert Piacesi

Introduction

There is a growing interest in the physics community in questions related to strategic nuclear force survivability. Markov processes represent a powerful method for quantifying such questions. In this paper (1) we give an elementary introduction to Markov processes and chains (2,3) followed by a simple anti-submarine warfare example in which the scenario of a surveillance-surge attack is treated as a steady state Markov process.

Markov processes and chains

Consider a system that can exist in any of a number of states, numbered 1,2,3... j, and a stochastic process by which the system undergoes transitions from one state to another according to a set of transition probabilities. A Markov process is a stochastic process such that the probability of entering a certain state depends only on the last state occupied. That is, the n^{th} state transition probabilities $P_{ij}(n)$ depend only on the $(n-1)^{\text{st}}$ state.

If we allow a Markov process to go through a finite number of steps, we end up with a set of probabilities that the system will exist in each of the j states. This set of probabilities is grouped into a row vector:

$$\pi = \{p_1, p_2, p_3, \dots, p_j\}$$

which is referred to as a "probability vector." If we start with a system known to be in a particular state, the probability vector will consist of a single one, with a remainder of the entries being zero.

After n transitions, the new probability vector will be

$$\pi_n = \{p_1^{(n)}, p_2^{(n)}, \dots, p_j^{(n)}\}$$

The probability vector π_n can be derived from the previous probability vector by application of a transition matrix:

$$\pi_n = \pi_{n-1} P(n) \quad n \geq 1$$

where the effect of multiplying the j'th column of the transition matrix times the entries in row vector π_{n-1} yields the j'th element of π_n . The elements of the transition matrix are P_{ij} , the probability that in one step, the system will jump from state i to state j. A new probability vector is obtained after the transition matrix operates on the initial probability vector π_{n-1} .

By repeated application of the transition matrix,

$$\pi_n = \pi_0 P(1) P(2) \dots P(n)$$

where π_0 is the row vector corresponding to the distribution of initial probabilities.

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A *Markov chain* is a finite, or countably infinite, Markov process where the transition matrix $P(n)$ does not depend on n . Therefore, for a Markov chain

$$\pi_n = \pi_0 P^n$$

It is possible to classify the states of a Markov chain into equivalence classes that constitute a partial ordering with respect to the possible directions in which the process can proceed. The states corresponding to these equivalent classes are either ergodic, transient or absorbing:

- Ergodic states consist of the set of states that can be reached from any other state in the set; the set cannot be left once entered.
- Transient states consists of the set of states that can be reached from any other state in the set, and which can be left if entered.
- Absorbing states are those which, once entered cannot be left.

A transition matrix can be brought into canonical form where all ergodic and transient states are separately aggregated. If there are t transient states and $r-t$ ergodic states, the transition matrix takes the form:

$$P = \begin{pmatrix} r-t & t \\ E & O \\ R & T \end{pmatrix} \begin{matrix} r-t \\ t \end{matrix}$$

where the submatrix R relates the transient states T to the ergodic states E , and O represents a t by $r-t$ block of zero entries.

A transition matrix is said to be *ergodic* if the powers of P approach a limit matrix L :

$$\lim_{n \rightarrow \infty} P^n = L$$

and is said to be regular if for some n , P^n has no zero entries. If one starts with a probability vector π , and L operates on π , the result will be a new probability vector π_∞ :

$$\pi_\infty = \pi L = \lim_{n \rightarrow \infty} \pi P^n$$

Clearly, the elements of π_∞ represent the probabilities of finding the system in each state after operation with L . Let this set of probabilities be denoted $p_1^\infty, p_2^\infty, \dots$.

$$\pi_\infty = \{p_1^\infty, p_2^\infty, \dots, p_n^\infty\}$$

The p_i^∞ represent the fraction of time the process spends in state s_i .

Now L must have a structure such that when the j 'th column of L is multiplied times π , the result is p_j^∞ . Since the sum of the elements of π must add up to unity, it follows that if all the elements in column j of the matrix L are equal to p_j^∞ , the result of L operating on π will be π_∞ . Thus for a regular transition matrix P , the matrix

L has the form:

$$L = \begin{pmatrix} p_1^\infty & p_2^\infty & \dots & p_n^\infty \\ p_1^\infty & p_2^\infty & \dots & p_n^\infty \\ \dots & \dots & \dots & \dots \\ p_1^\infty & p_2^\infty & \dots & p_n^\infty \end{pmatrix}$$

Because of the definition of π_∞ ,

$$\pi_\infty P = \pi_\infty$$

which is an eigenvalue equation for π_∞ .

In practice, one desires the limiting probability distribution in a problem. There are two techniques for determining π_∞ , one being solution of the eigenvalue equation, and the other being computation of a high power of P , P^n , to sufficient accuracy.

An anti-submarine warfare example

The example we wish to describe involves searching for a ballistic missile submarine. The purpose of this very simplified exercise will be to relate SSBN survivability to anti-submarine warfare capability in a surveillance-surge attack scenario. For the sake of definiteness, assume that the SSBN has a speed-of-advance (SOA) of 5 nautical miles per hour: the actual speed of the submarine may be greater, but the SOA corresponds to that average speed associated with going from one point to another while performing evasive maneuvers. Assume further that there is the opportunity for a transient detection by surveillance assets every half day with probability p . By a transient detection we mean that there is no holding of contact by trailing the SSBN.

Each SSBN detection datum reduces the area-of-uncertainty (AOU) of its location to a very small value (assumed to be zero in this example). The AOU grows as a function of the SOA of the submarine and the time t that has elapsed since the last detection as,

$$AOU = \pi [(SOA)(\tau)]^2$$

We will assume that each SSBN operating area is 1 million square miles, and treat the problem as a steady state Markov process where the Markov states are defined by the time since the last detection and the corresponding areas of uncertainty.

Table 1 shows the 10 Markov states appropriate to this problem, and also lists the corresponding average area of uncertainty $\langle AOU \rangle$ which is computed from

$$\langle AOU \rangle = \frac{1}{T_f - T_i} \int_{T_i}^{T_f} A(\tau) d\tau$$

with

$$A(t) = \pi [r(t)]^2 = \pi [(SOA) \cdot t]^2$$

the <AOU> is

$$\langle \text{AOU} \rangle = \frac{\pi(\text{SOA})^2}{3} \frac{T_f^3 - T_i^3}{T_f - T_i}$$

The transition matrix must reflect the following constraints. The SBMN may

- move to state s_{i+1} if undetected in state s_i (probability $1-p$)
- move to state s_i if detected in state s_i (probability p)
- remain in state s_i if detected in state s_i (probability p)
- remain in state s_{10} if undetected in state s_{10} (probability $1-p$)

The 10 x 10 transition matrix therefore takes the form,

$$P = \begin{pmatrix} p & (1-p) & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ p & 0 & (1-p) & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ p & 0 & 0 & (1-p) & 0 & 0 & 0 & 0 & 0 & 0 \\ p & 0 & 0 & 0 & (1-p) & 0 & 0 & 0 & 0 & 0 \\ p & 0 & 0 & 0 & 0 & (1-p) & 0 & 0 & 0 & 0 \\ p & 0 & 0 & 0 & 0 & 0 & (1-p) & 0 & 0 & 0 \\ p & 0 & 0 & 0 & 0 & 0 & 0 & (1-p) & 0 & 0 \\ p & 0 & 0 & 0 & 0 & 0 & 0 & 0 & (1-p) & 0 \\ p & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & (1-p) \\ p & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & (1-p) \end{pmatrix}$$

The fraction of time that an SSBN would be expected to spend in each state (corresponding to different areas of uncertainty) in the steady state case is given by π_∞ as discussed in Sec.2. We will chose, parametrically, the probability of detection, p , to be 0.1, 0.2...0.5 and calculate the powers of P .

The results are given in Table 2 for $n = 10$; higher powers of P show no change in the limiting state distributions.

For a given value of the parameter p , each component of the probability vector π_∞ gives the probability that the SSBN would be in state s_i corresponding to the associated average area of uncertainty $\langle \text{AOU} \rangle_i$.

The cumulative probability distribution can be used to determine the probability that the SSBN has an $\langle \text{AOU} \rangle$ which is less than or equal to a specified value. For example, for $p = 0.1$ the limiting probability distribution is $\pi_\infty = (0.1, 0.09, \dots, 0.387)$; the probability that the $\langle \text{AOU} \rangle < 26,389 \text{ n mi}^2$ (where $26,389 \text{ n mi}^2$ corresponds to s_2 from Table 1) is $0.1 + 0.09 = 0.19$. The results for different values of p are shown in Fig. 1 (assuming each submarine operates in 10^6 n mi^2 of its own).

Force survivability can depend on two factors, namely the ability of surveillance assets to make detections and the capability of ASW attack forces to sweep out the AOU and prosecute the attack. The calculations here are for one submarine, and we assume all submarines can be treated identically; that is, they all operate in a similar manner in operating areas of the same size and encounter identical surveillance and attack assets.

At any time t after the beginning of the attack, the rate of change of survivability of a given SSBN is equal to the product of the survivability at that time and the ratio of the element of area dA_{sw} swept out by ASW forces to the average area of uncertainty,

$$dS(t) = -S(t) \frac{dA_{sw}(t)}{\langle \text{AOU} \rangle}$$

The srurvivability S (the probability that a single submarine will survive) is then,

$$S = S_0 e^{-\frac{A_{sw}}{\langle \text{AOU} \rangle}}$$

where S_0 is the survivability of the SSBN at the beginning of the surge attack (assumed to be unity). A_{sw} is the product of the ASW

sweep rate, the number of ASW units deployed against each SSBN, and the time over which the ASW sweep is conducted. It is assumed that the survivability of the submarine is equivalent to the probability of not being swept out.

The expected survivability of each SSBN, given that an attack occurs randomly in time (i.e., the decision to attack is not related to the state of surveillance of the SSBN forces, which is a reasonable assumption since a surveillance network would operate continuously against the SSBN force whereas an attack order could come at any time) is related to the limiting state probability distribution by

$$s = \sum_{i=1}^{10} p_i e^{-\frac{ASW}{\langle \text{AOU} \rangle_i}}$$

where p_i and $\langle \text{AOU} \rangle_i$ are given in Tables 2 and 1, respectively.

Normalized to the original number of SSBNs, the survivability of the force as a function of A_{sw} is shown in Fig.2 for different values of the parameter p .

Summary

The problem treated in this paper could easily be generalized and expanded to include additional kinds of surveillance and ASW attack forces. For example, surveillance assets might have a capability to "hold" contact on the submarine with some probability over a finite time and ASW attack forces might consist of a barrage of the submarine AOU by weapons delivered by ballistic missiles.

Such an attack would make sense in the case of a limited AOU where the number of weapons required to barrage the area is relatively small. The advantage of this method of attack is that it can be executed in a short time, perhaps on the order of a half hour. Other methods of attack might include ASW aircraft or attack submarines (SSNs) that search the AOU to detect and destroy the ballistic missile submarines. Each of these methods take increasing amounts of time thereby making the task more difficult by allowing the AOU to grow.

The use of Markov processes to help quantify force survivability questions is not limited to the ASW problem. The technique used in this paper is obviously applicable to many other areas of interest including mobile missiles and bomber survivability on warning of imminent attack.

It should be noted that the example discussed in this paper should not be construed as indicating any vulnerability of the U.S. SSBN force. The surveillance capability assumed for the problem (in order to make it interesting) far exceeds that which currently exists or could be reasonably projected into the future.

REFERENCES

1. A somewhat longer version of this article is scheduled to appear in *Applied Physics Communications*, Volume 8(4).
2. John G. Kemeny, and J. Laurie Snell, *Finite Markov Chains*, D. Van Nostrand Company, Inc., Princeton (1969).
3. U. Narayan Bhat, *Elements of Applied Stochastic Processes*, John Wiley & Sons, Inc., New York (1972).

TABLE 1 Definition of Markov states for ASW Example (T_i, T_f are in hours, AOU and $\langle AOU \rangle$ in square nautical miles; a SOA = 5n mi/hr is assumed)

	T_i	T_f	AOU	$\langle AOU \rangle$
s_1	0	12	0 - 11,310	3,770
s_2	12	24	11,310 - 45,239	26,389
s_3	24	36	45,239 - 101,788	71,628
s_4	36	48	101,788 - 180,956	139,487
s_5	48	60	180,956 - 282,743	229,965
s_6	60	72	282,743 - 407,150	343,062
s_7	72	84	407,150 - 554,177	478,779
s_8	84	96	554,177 - 723,823	637,115
s_9	96	108	723,823 - 916,088	818,071
s_{10}^*	108	120	916,088 - 1,130,973	1,021,646

* s_{10} is equivalent to the enemy only knowing that a submarine is in its patrol area of 10^6 nmi², but not knowing where it is within the patrol area.

TABLE 2 Probability Vectors Corresponding to Limiting State Distributions with the Probability of Detection p as Parameter

p	π_∞
0.1	(0.1, 0.09, 0.081, 0.073, 0.066, 0.059, 0.053, 0.048, 0.043, 0.387)
0.2	(0.2, 0.16, 0.128, 0.102, 0.082, 0.066, 0.052, 0.042, 0.034, 0.134)
0.3	(0.3, 0.21, 0.147, 0.103, 0.072, 0.050, 0.035, 0.025, 0.017, 0.040)
0.4	(0.4, 0.24, 0.144, 0.086, 0.052, 0.031, 0.019, 0.011, 0.007, 0.010)
0.5	(0.5, 0.25, 0.125, 0.062, 0.031, 0.016, 0.008, 0.004, 0.002, 0.002)

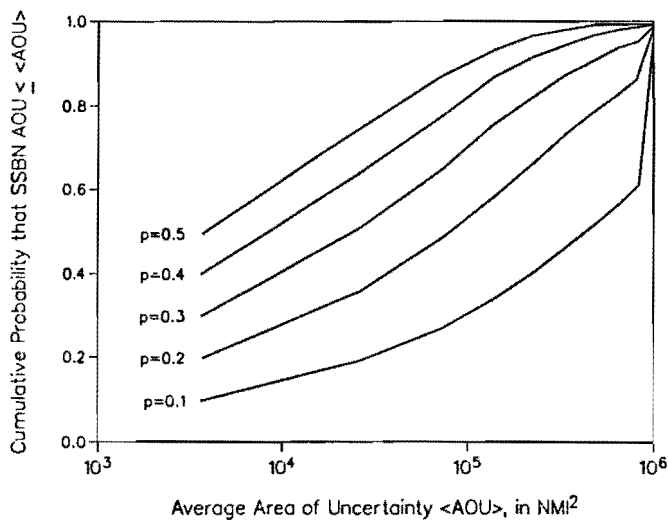


FIGURE 1 Average Area of Uncertainty $\langle AOU \rangle$ Cumulative Probability Distribution for Various Values of the Probability of Detection Parameter p

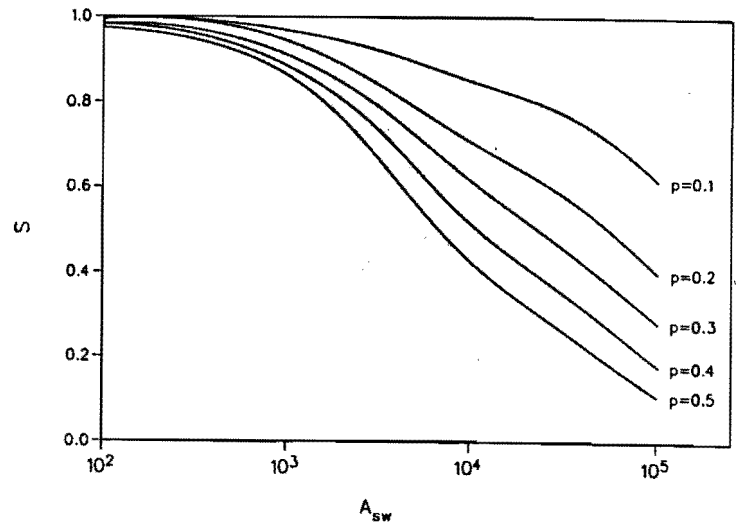


FIGURE 2 Normalized SSBN Force Survivability as a Function of the Detection Probability, p

FORUM ELECTIONS

It is time for Forum members to elect their officers. This year, elections are being held for the offices of vice-chair and three executive committee members. This removable center fold contains the candidates' statements and a ballot for the Forum elections. Indicate your choices on the ballot, then fold the ballot and mail it to the address shown on the reverse side. Please mail it by 6 February 1989. The nominations committee was chaired by Tony Fainberg.

CAMPAIGN STATEMENTS

Tom Moss (Vice-Chair)

BACKGROUND: Dean of Graduate Studies and Research and Professor of Physics, Case Western Reserve University. PhD, Cornell. Research: solid state physics and biological applications of Mossbauer and other spectroscopic and magnetic resonance techniques. APS Congressional Fellow, 1974-75, then Staff Director and Science Advisor to Congressman George Brown of California. Staff Director of the House Science, Research and Technology Subcommittee, 1979-82. Joined Case Western Reserve University in 1982. Member of POPA, 1972-75. Vice Chair and Chair of POPA, 1985-86. Forum Executive Committee, 1983-84. Member of APS study panel on nuclear waste and AAAS Committee on Science, Engineering and Public Policy. Editorial Boards of the journals *Science, Technology and Human Values* and *Environment*.

STATEMENT: The next few years provide a uniquely exciting opportunity to build on the strengths of the Forum as an important vehicle for expression of the ideas of the membership of the APS, and as an important voice in the science community in matters of broad public concern. With a new federal administration soon to take office, with many new state initiatives being launched in science and technology, and with a new international climate for scientific exchange, all factors point to an opportunity for intense and effective action by the Forum. My goal as Vice Chair and Chair of the Forum would be to work with APS membership, Divisions, the Panel on Public Affairs (POPA), and Council, to keep APS in the most effective possible position at the interface of scientific and social concerns.

My predecessors in the Forum and APS leadership have built a strong reputation of APS credibility on matters of physics and society. Now is a time to capitalize on that credibility, especially in reaching out to build coalitions with other groups active in science and society matters (National Academy, FAS., AAAS, etc.), and to use those coalitions to be sure that coming critical national and international science and technology decisions are made from the very strongest foundation of thoughtful science and public policy understanding.

Arms control, international cooperation in major science initiatives, global atmosphere and geosphere change, identification of social opportunities in physics research, public science literacy, and support of physics are examples of issues in which the Forum's activity can be particularly important in the next three years. I would look forward to being part of this activity as part of the Forum leadership, just as I have valued being part of it in previous service with POPA, the Council, and the Forum Executive Committee.

Mark Sakitt (Vice-Chair)

BACKGROUND: Senior Scientist, Physics Department, Brookhaven National Laboratory. PhD, high energy physics, University of Maryland. Adjunct Lecturer, State University of New York at Stony Brook, teaching "Technology and Policy in National Security." Carnegie Science Fellow, Center for International Security and Arms Control at Stanford University, 1986-87. Authored *Submarine Warfare in the Arctic: Option or Illusion*, a monograph critiquing current U.S. navy strategy, published by Stanford. Member of Forum's study group on the future of land-based missiles. Served on the Forum Executive Committee. Fellow of the American Physical Society.

STATEMENT: There are three areas where the Forum plays a unique role in the American Physical Society which should be enhanced. The first is providing a mechanism for physicists to keep aware of the social aspects of technology by presenting invited topical sessions at the regular APS meetings. These sessions should provide a balanced informative presentation to enable the general physics community to understand the essential points of the debate. Secondly the Forum provides the means by which a physicist can start to participate in this interdisciplinary field. The special "short courses" enable one to incorporate some of these topics into the normal teaching role and also to start some people on the road to undertaking small research problems. This road is further widened by the opportunity to join a Forum study group that undertakes a well defined task often leading to a published book. The last area of the Forum is to provide a vehicle for presenting short articles on these topics by publishing the journal *Physics and Society*.

I believe that these three separate but related roles should be expanded and broadened. While my own interest is in national security policy I would like to see the Forum broaden by increasing our efforts in physics educational and environmental areas. I would like to see our journal further expand and become a refereed journal with longer, deeper analytical articles, some of which could be commissioned. These articles could be both research results and review papers. We should be enlarging the group of people who direct and implement the plans of the Forum.

Sam Baldwin (Executive Committee)

BACKGROUND: Senior analyst at the Congressional Office of Technology Assessment, currently studying the role of technology in US trade competitiveness. PhD, solid-state physics, University of Maryland, College Park, 1980. APS Congressional Fellow, energy and science policy under Senator Paul Tsongas, 1981. Directed an eight-country energy program in the West African Sahel, developing technologies to ease the deforestation/firewood crisis, 1982-83. Worked on science policy for Sen. John Glenn's Presidential Campaign, 1984. Hewlett Fellowship, Center for Energy and Environmental Studies, Princeton University, and lecturer at the Woodrow Wilson School for Public Affairs, 1985-88. Currently participating in the Forum energy study.

STATEMENT: The Forum's newsletter, study groups, sessions at APS meetings, and awards have all been valuable in raising the awareness of physicists, as well as the public at large, to issues of physics and society. These efforts should be continued and strengthened. For example, greater awareness and participation by physicists might be achieved by (1) providing regular updates of Forum

activities in the newsbriefs of *Physics Today*; (2) providing commissioned papers, or perhaps even a regular editorial on "Physics and Society" in *Physics Today*; (3) organizing a study, and eventually producing a handbook, on how physicists can become involved in public affairs and how to do so effectively. This should include a spectrum of activities: from teaching science to disadvantaged kids; to writing and marketing editorials in local newspapers; to becoming involved in local, state, and national government. Other Forum activities might even include arranging sabbaticals in developing countries. In public policy efforts in particular, however, it is important for physicists to find leverage points where their unique knowledge and abilities can make a difference; to maintain a balanced perspective; to do in-depth, sophisticated technical and policy analysis (this will require physicists to learn about many "soft" political, economic, and sociological issues); and to interact effectively with the media. Developing a credible public voice is a slow, difficult process, but one that our increasingly technological society needs. At the same time, such efforts will help to legitimate the study of physics and society within the physics community itself.

Gerald L. Epstein (Executive Committee)

BACKGROUND: Senior Analyst, Congressional Office of Technology Assessment, specializing in energy and defense issues. Presently investigating defense technology base issues and acquisition policy in a study requested by the Senate Armed Services Committee. Directed OTA's assessment *Starpower: The U.S. and the International Quest for Fusion Energy* (1987). Wrote the proceedings of a workshop on Arms Control in Space (1984), and technical and policy chapters for OTA's *Ballistic Missile Defense Technologies* (1985), both as a Congressional Fellow at OTA. PhD, Berkeley, 1984. BS degrees in both physics and electrical engineering, MIT.

STATEMENT: Public policy issues that are relevant to, and that can be influenced by, the physics community continue to grow in importance in Washington. A significant and increasing fraction of the discretionary spending authority available to Congress and the President is being allocated to scientifically- and technically-intensive projects as political leaders look to technology to protect the environment, national security, economic competitiveness, international stature, and jobs in their districts. At the same time, fiscal pressures are making these funds increasingly vulnerable. There is no shortage of problems to which the Forum on Physics and Society can apply its interest and involvement.

The three avenues most directly available to the Forum—the journal *Physics and Society*, the Forum sessions held at APS meetings, and special study groups convened under Forum auspices—all provide means by which these problems can be explored. As a member of the Forum Executive Committee, I will work to use these means to foster communication and analysis among the physics community and between it and the wider public. The role of the Forum is not to make or recommend the value judgements that each of us as citizens must make on our own, but to provide the tools that will let all of us make these judgements more effectively.

Rush Holt (Executive Committee)

BACKGROUND: Currently at the US Department of State working on arms control, international space activities, nuclear proliferation, and technology diversion. Swarthmore College, teaching undergraduate physics, arms control, and decision making under uncertainty, 1980-87. New York City Bureau of Noise

Abatement and independent consultant in energy and environmental matters, 1970s. APS Congressional Scientist Fellow, and various APS committees including the Panel on Public Affairs, 1982-83. Member of the APS, AAAS, AAPT, Sigma Xi (former chapter president), and AAS Solar Physics Division. Former visiting observer at the National Solar Observatory, summer fellow at Woods Hole Oceanographic Institution, and visiting scientist at the High Altitude Observatory in Colorado.

STATEMENT: The most important function of the Forum is to demonstrate that concern for issues of physics and society is central, not peripheral, to the role of a responsible APS. Through the hard work of a number of people the Forum has developed a fine array of short courses and special programs, studies, and award ceremonies. *Physics and Society* has become an outstanding publication and an excellent instrument for fostering and focusing concern for public issues. The Forum representative to the APS Council is another important means to further our goals.

The APS is one of the most distinguished and respected societies in the nation, and many people—scientists and others—look to the Society for well-informed, well-reasoned statements on subjects about which physicists have special interest and special competence, such as arms control monitoring, radon contamination, and science education. The Forum has contributed significantly to the discussion of such issues. The Forum can devote some more attention to matters of science and international affairs. Of particular concern to me now is the need to counter the notion that our science and technology can be advanced by restrictions on international scientific communication and cooperation. I would be very pleased to work as a member of the Executive Committee of the Forum on Physics and Society.

Rustum Roy (Executive Committee)

BACKGROUND: Director of the Science, Technology and Society (STS) program, Evan Pugh Professor of the Solid State, and Professor of Geochemistry, Pennsylvania State University. Director, Materials Research Laboratory, 1962-85. Science Policy Fellow, Brookings Institution, 1982-85. Organizer of first national STS Conf. on Technological Literacy, 1986. Past President, National Assoc. for STS. Foreign Counselor, Societe Francaise de Mineralogie. Present or past editor of *Materials Research Bulletin*, *Journal of Materials Education*, and *Bulletin of STS*. Present or past editorial boards of *Journal of Materials Science*, *Journal of Crystal Growth*, *Chemical and Engineering News*, and *Annual Reviews of Materials Science*.

STATEMENT: I see the Forum as an outstanding effort by some members of the physics profession to create a community concerned with human values within a community defined by disciplinary training. Up to now the Forum has focused a great deal of effort—and rightly so—on nuclear war and secondarily on human rights and Big Science issues.

If elected I would attempt to broaden this range of concerns. I believe that this will attract a wider circle of colleagues and build a larger coalition by offering a longer menu of choices for engagement. Among the concerns on which I would seek to focus the community's interests on:

1. Involving physicists at every level in the problem of improving the technological literacy of the general public (*NOT* just training college-physics bound students even better). Academic physicists should be deeply involved in discovering ways to communicate affective and cognitive knowledge about technology and science to, say, the 25th percentile in science ability on the campus. Industrial physicists should be working through school boards and local supervisors to participate in pre-college education.

2. Involving physicists in understanding the interactions of science/technology and technology/industry so that they can participate more knowledgeably in the new era in which all science will be done in this country.

3. Involving the physics community as citizens equal with others like environmental activists, labor leaders, homemakers, electrical engineers, and English teachers in the common task of a grass roots effort to guide the future directions of science and technology in a democratic society.

Alan Sweedler (Executive Committee)

BACKGROUND: Professor of physics and Director of the Center for Energy Studies at San Diego State University, and research associate at the University of California's Institute on Global Conflict and Cooperation. PhD, University of California at San Diego, 1969. Faculty of the University of Chile in Santiago, sponsored by the Ford Foundation, establishing a superconductivity laboratory and assisting in the development of graduate research, 1970-72. Research physicist, neutron-induced disorder in superconducting compounds, Brookhaven National Laboratory, 1972-1977. California State University at Fullerton faculty, 1978-80, and San Diego State University faculty since 1980. Founder and Director of the University's Center for Energy Studies. Energy advisor to UNESCO for energy policy in Brazil, worked on energy and development issues in Mexico, and energy consultant to California and San Diego. Also active in international security and arms control, presently working on conventional arms control in Europe. APS Congressional Science Fellow, 1985-86. Carnegie Science Fellowship in International Security at the Stanford Center for International Security and Arms Control, 1987-88. Member of Sigma Xi, Phi Kappa Phi, AAAS, the Arms Control Association, and Association of Borderland Scholars.

STATEMENT: Having worked in foreign countries, a national laboratory, and academia, I have had an opportunity to directly experience a variety of professional settings. This has enabled me to see how physicists can provide input to decision-making pro-

cesses which have a direct bearing on public policy in general and science in particular. My own participation in this process, through serving as an APS Congressional Science

Fellow and involvement in energy and development and international security issues, has convinced me that physicists can make an important contribution to many social problems where technology is an important component. In addition, I believe that sound scientific and technical education and training for students in developing countries will be a critical factor in providing the human resources needed to develop the economic and political infrastructure of these countries. Here again physicists can play an important role as teachers, researchers, and advisors in developing research and training programs.

The Forum provides an opportunity for physicists and other scientists to come together and exchange ideas in an open and stimulating setting. If elected to the committee, I will encourage discussion of the role that science and technology can play in providing assistance to developing nations, particularly in the areas of energy, environment, education, and training.

Valerie Thomas (Executive Committee)

BACKGROUND: Research Associate for arms control, Center for Energy and Environmental Studies, Princeton University. PhD, Cornell University, theoretical high energy physics, 1987. Research Fellow, Program on International Peace and Security, Carnegie Mellon University, 1987-1988. Participant in the Forum Study on Land-Based Missiles, in progress.

STATEMENT: I would like more physicists to participate in the Forum. The Forum (and society!) would benefit from increasing the range of topics under study, which can't be done without greater participation. To match the well-developed effort on nuclear weapons/arms race topics, I would like to see more attention given to issues such as the environment, energy (already in progress with the Forum Energy Study), and science education.

Encouragement of physicists with a broader range of interests and continued diversification of the newsletter should be Forum priorities.

FORUM ON PHYSICS AND SOCIETY 1989 ELECTION BALLOT

Put an X in the box for the candidates of your choice.

VICE-CHAIR (vote for one):

- Tom Moss
- Mark Sakitt

EXECUTIVE COMMITTEE (vote for three):

- Sam Baldwin
- Gerald Epstein
- Rush Holt
- Rustum Roy
- Alan Sweedler
- Valerie Thomas

Please fold and tape this ballot and return to H. H. Barschall by 6 February 1989. The reverse side is already addressed.

(FOLD HERE)

Place
1st Class
Postage
Here

**H.H. BARSCHALL, Sec-Treas.
Department of Physics
University of Wisconsin
1150 University Avenue
Madison, WI 53706**

(FOLD HERE)

PLEASE SEAL WITH TAPE (NO STAPLES). THANKS!

REVIEWS

NUCLEAR ARMS TECHNOLOGIES IN THE 1990s, Edited by Dietrich Schroeer and David Hafemeister

American Institute of Physics, New York, 1988, 484 pages, \$49.20 to APS Members, \$61.50 non-APS

Over the past six years the Forum has held three short courses on the arms race: 1982 in San Francisco, 1983 in Baltimore, and 1988 at the George Washington University in Washington, DC. The proceedings of the third short course have recently been published by the AIP as the book *Nuclear Arms Technologies in the 1990s*. This book is aimed at an audience of physicists since equations and graphs are used extensively. Traditional writings on nuclear issues in journals and books rarely apply science and mathematics to the study of the arms race; this book attempts to move against that well-established pattern. The authors listed in the table of contents below are well known in their fields, and have given us papers reflecting their high skills. A few comments on the contributions:

Nuclear winter, proliferation, conventional weapons. MacCracken quantifies various atmospheric effects which control the modeling of radioactive fallout and nuclear winter. Donnelly describes the technologies available to India and Pakistan, which slowly inches that subcontinental rivalry towards a nuclear confrontation. Deitchman discusses the high-tech conventional weaponry which may, or may not, improve the conventional posture in Europe.

Verification. In discussing the seismic monitoring of nuclear test ban treaties, Richards explains in great detail the observations of the seismic differences between the Soviet and U.S. test sites, the new observations of the L_g regional wave, the treatment of statistical data with systematic and random errors, and the limits one might expect on lower yield tests. Lamb focuses on hydrodynamic monitoring of test bans by describing the CORRTEX method, recently used to monitor the Soviet test at Semipalatinsk. CORRTEX monitors the reflection of pulses in a cable near the explosion, as the cable is crushed and shortened in the supershocked region. As one would expect, its accuracy depends on the suitability of fitting an algorithm, developed from tests at the US test site, for data obtained on the Soviet test site. Bescond pictures the growing capabilities of the public-sector reconnaissance satellites, such as SPOT. Brookner describes how large phased array radars work, and how they can be used to track many reentry vehicles at the same time. Hafemeister explores how infrared technologies can be used to monitor a ban on nuclear reactors in earth orbit.

SDI. Four chapters are devoted to this topic. Chrzanowski develops various equations which relate the specifics of offensive and defensive forces and how they interact with each other. Certain obvious truths emerge. For example, survivable basing modes lessen the need for SDI if the preservation of deterrence is its goal, there are both stable and unstable paths toward purely defensive weaponry, and so forth. Fainberg uses the basic equations of motions for kinetic kill vehicles (KKV) to show that the time window for intercepting missiles is very tight. Cunningham examines the effect on KKV's by the modernization of the SS-18s to the SS-24s and SS-25s, and quantifies the cost effectiveness at the margin for these forces. Goldstein examines some of the basic physics of the two main types of free-electron lasers, and indicates

several large technical barriers that must be surmounted before deployment of FELs can be contemplated.

Triad. Eubanks uses sophisticated mathematics to describe the basic physics of orbital mechanics for missiles in nonspherical gravitational fields, determining the final error budgets for the CEP of reentry vehicles. Zimmerman examines both the Midgetman and the MX rail-car basing modes as possible future land-based mobile ICBMs. Sakitt describes the basic equations of anti-submarine warfare, and the possible countermeasures and strategies that submarines can use to escape ASW detection. Scribner considers both the verification of and the military needs for nuclear sea-launched cruise missiles (SLCMs), arguing that this is a system which appears to have little specific purpose.

Policy. Two veterans of the arms control debates, Keeny and Luttwak, build on the technical beginnings of the book by asking several questions about what it all means. Keeny examines the over-promises of some of the technologies, and Luttwak laments a future world where the nuclear deterrent might no longer be viable.

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THE MASTER OF THE GAME, by Strobe Talbott

Knopf Publishers, New York, 1988, 416 pages, \$19.95

Strobe Talbott's trilogy, *End Game*, *Deadly Gambits*, and now *The Master of the Game*, is the best path to understanding our era's attempt to control the nuclear genie through the ABM, SALT II, INF, and START treaties. Talbott's latest gold mine of historical fact focuses on Paul Nitze, who has — more than anyone else — played a decisive role in both the limiting and the expansion of nuclear weapons. Nitze's resume and the corresponding list of results (for and against arms control) is simply miles longer (from Roosevelt to Reagan) than any other American. Thus it is no surprise that the Soviets preferentially refer to Nitze as Starik ("the old man"). *The Master of the Game* is the book to read because it combines the talents of a first class writer-historian with the most important American in the treaty process. It is precisely because both hawks and doves are somewhat angry at Nitze, that he is viewed as an objective and credible force.

On the one hand, the arms control community is tepid in their admiration of Nitze because, after all, Nitze: wrote large portions of the 1950 NSC 68 Report which galvanized the beginnings of the nuclear build-up, and the 1957 Gaither Report that inflamed the supposed missile gap and encouraged President Eisenhower to use his last State of the Union message to warn about the military-industrial complex, was against a ban on MIRVs in SALT I, did not support a ban on ASAT tests in the 1980s, supported Judge Sofaer in the "legally correct interpretation" of the ABM Treaty which ushered in the broad interpretation of the ABM Treaty, favored civil defense options in the early 1960s, promoted an air strike to remove Soviet missiles in Cuba, lobbied forcefully against SALT II as a member of the Committee on the Present Danger by raising the window of vulnerability for Minuteman beyond its logical case-ments (he later agreed with the Scowcroft Report that the window wasn't so wide after all), and so forth.

On the other hand, the hard-line group that is on general principles against arms control is ambivalent in their praise of Nitze because, after all, Nitze: developed some of the key passages of the ABM Treaty on his first walk in the woods with Shuhkin, tried to remove the impasse on INF with a second walk in the woods with Kvitsinsky and strongly guided the global double zero final result on INF, tried to save and strengthen the ABM Treaty with (1) criteria for SDI deployment and (2) "lists of parameters" to quantify what is an acceptable test in space, tried to save SALT II before the 131st ALCMed B-52 took off in November 1986, tried to trade some possible future advantages in US defenses for the Soviet actual advantages in heavy missiles, supported the Midgetman missile very early on in 1976, and so forth.

The narrow/broad interpretations

Because of space limitations, we will confine our discussion to Nitze's role on the diplomatic interaction between the defense (the ABM treaty and SDI) and the offense (Soviet heavy missiles, SLCMs, etc.) Of all the key SALT I advisors, only Paul Nitze has supported the broad interpretation of the ABM treaty which would allow the development and testing in space (not deployment) of those ABM systems which are based on "other physical principles (the OPP exotics)." Talbott tells us that Nitze realized two days too late that he was snookered by Sofaer, not realizing the constitutional aspects of flagrantly re-interpreting the treaty on the thin assumption that the Soviets had never unambiguously agreed to a provision banning development and testing of space-based OPPs. Nitze tried to repair his error with a memorandum, but before he could move it forward, NSC advisor MacFarlane went public on "Meet the Press," stating that "Only deployment [of SDI] is foreclosed....[The ABM Treaty] does indeed sanction research, testing, and deployment of these new systems." Shultz and Nitze soon softened this policy by stating that the broad interpretation was "fully justified ... [but that SDI R&D would] be conducted in accordance with a narrow interpretation." With SDI moving ahead via Sofaer and the thrust for early deployment, the ABM treaty became the second treaty (SALT II was terminated in November 1986) that appeared to be doomed. Nitze had always been uncomfortable with the ambiguities of the ABM treaty since it is clear that small lasers on space missions (such as the Soviet Phobos) are certainly legitimate.

The offense-defense trade?

In the last analysis, Nitze hoped to turn the sow's ear into a silk purse by: (1) developing criteria for the deployment of SDI, (2) removing the ambiguities in the ABM treaty on which space tests are permitted and which ones are prohibited, and (3) developing a trade in the treaty process between existing Soviet offensive forces and possible U.S. defensive forces.

(1) In 1985, Nitze reformulated the criteria for the deployment of the SDI system, namely that SDI must be effective, survivable, and cost-effective at the margin. Kissinger, now out of office and shifted to right, bitterly claimed that "Paul's position kills defense. The criteria are not meetable. And if you put the transition phase [of deploying defenses under the terms of Nitze's strategic concept] ten years into the future, Congress will kill it long before deployment. I'd like to move the transition phase to the present."

(2) During 1987, Nitze worked very hard to remove ambiguities on the rules for testing under the ABM treaty. As written the treaty allows considerable testing if is "not in the ABM mode," and not "ABM capable." The Soviets proposed a list of quantitative testing limits for each of the exotic systems, keeping a barrier for deployment by making the parameters sufficiently small. Nitze is well known for promoting this concept in the US government since it would "save the ABM treaty," but one can also interpret the testing limits as a nose under the tent for future larger tests. At any rate, the DoD and SDIO flatly didn't want any limits on the broad interpretation, and opposed the list concept.

(3) On many occasions Nitze and MacFarlane tried to use a "sting" operation, by trading the defensive system that was on the drawing boards for the systems that were in silos. The "Monday Package" of 1985 was developed to draw the first links between the offensive and defensive negotiations. Nitze met again with Kvitsinsky, giving personal thoughts on a combined INF/START/ABM bargain, but the Soviets preferred the formal front-channel of Geneva. These offense-defense forays continued up to Reykjavik, where suddenly everything was on the line. Nitze chaired the American delegation through the all-night sessions that resulted in

the mind-boggling zero ballistic missile offer (including UK, France, and PRC) by the US and the also mind-boggling counteroffer by Gorbachev for the elimination of all the offensive strategic arms (including bombers and cruise missiles). Finally, it dramatically hinged (and failed) on the word "laboratory" to which Gorbachev wished to confine SDI testing. As time progresses and technological realities appear, the coinage of SDI will undoubtedly be cheapened, as the fig leaf of the sting operation becomes more transparent. Who is to know where it all will lead, but Nitze was the key US chess player at the game. Somehow Nitze survived the

game while Weinberger, Perle, Adelman and Gaffney watch the action from the sidelines.

Talbott ends the book by stating that arms control would have continuity into the next administration because "Paul Nitze was more than the master of the game; he was also a victor."

David Hafemeister
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NEWS

MINUTES OF THE 1988 MEETING OF THE FORUM'S EXECUTIVE COMMITTEE, 19 APRIL 1988

The meeting was held at the Hyatt Hotel, Baltimore. Attendance: P. Craig, D. Schroeder, A. Fainberg, R. Howes, H. Barschall, D. Hafemeister, B. Levi, A. Hobson, L. Sartori, M. Einhorn, P. Zimmerman, K. Ford, R. Scribner, and I. Engle.

The meeting was called to order by Dietrich Schroeder, who made his report as chairman: All APS Fellowship candidates nominated by the Forum were subsequently approved by Council. The 1988 Forum and Szilard Awards were well received. The Forum newsletter is now available to nonmembers upon request; voluntary contributions of \$10 per year are welcome. Art Hobson has received many compliments on *Physics and Society*.

Peter Zimmerman gave the report of the secretary/treasurer. He indicated that it remained difficult to keep a timely and accurate record of Forum finances through the APS; ledger sheets are not provided at regular intervals. He discussed the Forum's several sources of income and the major expenditures each year. Ken Ford commented on raising money for Forum and Szilard awards. Major funding cannot be raised with small donations. It is also unlikely that industrial or foundation donors will be found. Any significant endowment might have to come from a rich single donor. Dietrich responded that we might join the APS queue for professional money-raising approaches. Heinz Barschall noted that the Society often receives rather vague bequests in members' wills and that committees then have to decide where to spend the money. Peter Zimmerman will talk to Tom Cochran at NRDC. Richard Scribner will talk to the MacArthur Foundation, and Tony Fainberg to the Carnegie Corporation. We could ask for a \$25,000 endowment or for a 10 year sinking fund.

David Hafemeister moved that we write Council to say that we will pay travel for award winners. Passed.

Harry Lustig, treasurer of the American Physical Society, reported on the financial status of the Society.

Art Hobson reported on the newsletter. He proposed that we adopt the following language (or something similar) in establishing a mailing program for non-members: "Non-members may receive the newsletter free upon request sent to the editor. A voluntary contribution of \$10/year would be welcome." Art will furnish the exact text he will use. One long term possibility is for *Physics and Society* to evolve into a journal. Should we be working in this direction? That trend is favored by those who feel the quality of articles would be enhanced. A lengthy discussion ensued covering questions of models/prototypes and which organization should sponsor such a journal (APS or AIP, for example). Ken Ford commented that AIP is receptive in a general way to creating a new journal. We should up-date the old 1977 study of this question to see

if it was financially viable. The Forum should write a letter to me, Ford said. AIP has 3 publishing models: publish a journal for a society (Physical Review), publish a fully independent journal, or find a hybrid. The committee agreed to have Art change the word "refereed" to "reviewed" in the fine print on the title page.

The Forum APS Councillor's Report was given by Ken Ford and David Hafemeister. The APS Council meeting was held Saturday and Sunday this past weekend and was reported on by Leo Sartori who filled in. At the Council meeting, the Condensed Matter Division representative suggested a 5 day summer study on "strategic planning of physics research." \$25,000 was allocated for this review of funding and priorities of fields in physics. Andy Sessler will probably run this group. The problem is that funding for condensed matter has gone down. There is congressional disenchantment with the peer-review system: people are worried. congressionally ear-marked pork will be with us for a long while. POPA will produce a report on funding priorities in physics. There was a proposal to drop the January meeting as a national meeting of the APS: AAPT is naturally unhappy. The decision was postponed at least a year. The January 1990 meeting in Atlanta will remain a national meeting. The Washington, DC meeting is not healthy, but is very important to the Forum. AAPT is interested in moving the January meeting to Washington. APS will stay in New York, mostly out of inertia.

Barbara Levi reported on the APS Panel on Public Affairs (POPA). POPA is disappointed at the current method of advising the President on science. POPA wrote a letter for the president of the APS to send to each presidential candidate. POPA proposed the summer study on strategy for funding. The APS should be setting priorities for physics funding. The question might also be phrased as: should the APS set priorities, or set criteria for setting priorities, or stay out of this area? Congress will only give NSF a small fraction of the increase it desires. But NSF has been given more responsibilities in engineering and education. Bob Park has been very active. He expresses special concern about the Superconductivity Competitiveness Act. POPA was pleased with the Forum's activities.

Ruth Howes and Paul Craig reported for the Fellowship Committee. The committee is happy to report that all 3 Forum nominees were approved. The new nominations must be in by May. Tony Nero is the new chairman. Irene Engle, Martin Einhorn, and Marc Ross are on the committee.

Ruth Howes reported on Forum and Szilard awards. It is difficult to define people for these awards. In the past we have been able to find people on basis of a lifetime of service. We do need many more suggestions. Ruth asked if foreigners can receive awards. Most of the committee agrees that it is possible. Dietrich believes that the purpose of the awards is to encourage U.S. physicists. Dick Scribner, Bill Colglazier, Evans Harrell, and Heinz Barschall will serve with Peter Zimmerman as chairman of the awards committee

this year.

Ruth Howes reported on Forum studies. Ruth requested an appropriation for one meeting for an energy study. Topic: "What should we be doing to help prepare for the next energy crisis?" This is meant as a tutorial for educators and others. Studies have a role for people who are perhaps isolated. Studies help get them involved. Peter Zimmerman moved that money be made available to the land-based missile and energy studies for one meeting each in the next year. David Hafemeister seconded the motion which passed. No fixed dollar amounts were allocated for these two meetings; the organizers were expected to be prudent. Ruth Howes moved to allocate \$1000 to explore the feasibility of a Forum study of continuing issues in strategic defense. The motion passed. Peter Zimmerman is to run this study.

Barbara Levi and Richard Scribner reported for the program committee. Barbara reported a successful year. No problems were encountered with arranging either complementary registrations or travel. We do need to put more effort into organizing a contributed paper session for the "Washington" meeting. Dick Scribner reported that he is trying to get a session into the DNP meeting in the fall. In the past the DNP has been reluctant to allocate space and time to a Forum symposium. Symposia proposed for next year include accidental missile launches, nuclear detection of nuclear warheads, technical trends in strategic policy, beam stability and other SDI challenges, stockpile reliability, U.S. and Soviet scientists and arms control, monitoring and targeting relocatable targets, history of nuclear weapons and testing, management of national labs by universities, a two year retrospective on the DEW study, integrating social topics into physics education, energy and environment, greenhouse effect, non-thermal conversion of sunlight to useful energy, physicists and congress, women, non-traditional careers for physicists.

Dietrich Schroerer reported on short courses. 97 people came to the arms control short course in Washington, just prior to the 1988 Baltimore meeting (the resulting book is reviewed in this issue of *Physics and Society*). The course just about broke even financially.

The meeting adjourned with a resolution of thanks for the outgoing officers.

COMING FORUM SESSIONS: SAN FRANCISCO MEETING, 15-19 JANU- ARY 1989

The Forum will sponsor three APS invited sessions at the San Francisco meeting: (1) energy research and funding in the 1990s, (2) the University of California, the national weapons labs, and arms control, and (3) space nuclear power and arms control. See *Physics and Society*, October 1988, for speakers and titles of talks. The AAPT and the AAAS, who are sponsoring this meeting jointly with the APS, will also offer many sessions relevant to the social concerns of physicists. You will find a list of several interesting AAAS sessions in the October issue of *P&S*.

CONTRIBUTE A PAPER TO THE BALTI- MORE MEETING!

The Forum exists because issues at the interface of physics and society need to be addressed, in a professional way, by physicists. Social concerns need to be worked into the structure of the physics community. Although a few well known physicists have always been active in areas like arms control and energy resources, and even though most physicists have at least a peripheral interest in some of

these issues, the professionalization of physics and society has not extended far into the community of working physicists.

Few activities are more central to the health and growth of the scientific professions than the presentation and discussion of papers at meetings. Because it is especially important for physics and society issues to be included in this exchange of ideas, the Forum has always put a lot of energy into arranging invited sessions on significant issues. These invited sessions have been successful. But this success has not been matched by comparably successful contributed sessions. Despite the fact that there is only one contributed session per year, there are not many contributors and there are not many attenders. And yet it is in the contributed papers that most working physicists, especially those whose primary research might not be directly related to social concerns, can present their ideas.

The Spring meeting in the Washington area (1-4 May in Baltimore this year) is the main meeting of the year for the Forum. This year there will be several Forum invited sessions, the annual meeting of the Forum's executive committee, and presentation of the Forum's two annual awards. And there will be a session of contributed papers dedicated to science and society issues.

If you are a physicist who has done serious and original work that is related to any socially significant issue, please consider presenting your ideas at the Forum's contributed paper session. The APS deadline for receipt of contributed abstracts is 3 February 1989. Be sure to mark it "Forum contributed session" so that your paper isn't buried among the highly specialized contributions. It would be helpful if you would also send a copy of your abstract to the Forum chairman, Dr. Barbara Levi, 20 North Point Drive, Colts Neck, NJ 07722.

NASTS CONFERENCE ON TECHNOLOGI- CAL LITERACY

The National Association for Science, Technology and Society (NASTS) will hold its fourth annual technological literacy conference during 3-5 February 1989, at the Marriott Crystal Gateway Hotel in the Washington DC area. The topics for special lectures, sessions, and activities include: response to the math/science crisis, employment in America, solid waste disposal, AIDS, alternative paradigms for science/technology. Program inquiries should be made to: Franz A. Foltz, Conf. Manager, 117 Willard Building, University Park, PA 16802, (814)865-9951.

JOIN THE FORUM! GET THE NEWSLETTER!

If you are an APS member it is easy, and free to join the Forum and receive our newsletter. Just complete and mail (to the editor) the following form, or mail us a letter containing this information. (Nonmembers: see the masthead, on p.2).

I am an APS member who wishes to join the Forum and receive the newsletter.

NAME(print) _____

ADDRESS _____

COMMENT

FROM THE CHAIRMAN

Science — along with many other substantive issues — did not figure prominently in the recent Presidential campaign. Clearly, though, it *will* figure prominently in many critical decisions that now face our nation — military procurements, environmental cleanups, energy programs. As the next administration grapples with some of these complex issues, they will need a firmer technical grasp than ever if wise and effective policies are to be adopted. We hope that President-elect Bush will create an effective mechanisms for science advice. In our own small way, we hope through various Forum activities — study groups, invited paper sessions and newsletter articles — to promote a deeper understanding of critical issues.

Among the problems now facing the nation is the question of how to allocate increasingly scarce funds to the support of science projects. This year the Panel on Public Affairs has examined closely this crisis in public funding for physics. The basic problem is that there is not enough money to build the many worthwhile large facilities that have been proposed, each crucial to the progress of its subdiscipline, and still have funds left to support the spectrum of equally valuable small research projects. Physicists are left with two unpalatable choices: decide spending priorities among their own subdisciplines or let the government, typically influenced more by special interests than by technical considerations, do it for them.

A POPA-commissioned report has recommended that APS set its own priorities by commissioning a "Strategic Planning Committee" to function for three years (See the January issue of BAPS). The APS Executive Committee has approved this idea in principle but must consider the details of implementation at its January meeting. Any committee chosen to set priorities in physics funding would face an each of the areas of physics alive and well. Moreover, they must ask which projects are most likely to benefit our society, which is footing the bill. Distinctions may be subtle. We all like to feel that our research in physics helps society, but often it is in ways never anticipated or not immediately perceived. In a sense then the priorities panel would be dealing with the very heart of the relation between physics and society. We wish the committee luck.

Barbara G. Levi
Forum Chairman

EDITORIAL: THE BUSH ADMINISTRATION AND LAND-BASED MISSILES

The land-based strategic missile problem seems eternal. Americans have wrangled over missile vulnerability since 1968, when multiple-warhead (MIRV) testing began. Debate escalated as the MX missile entered advanced development in 1974.

The MX was a mistake in response to a mistake. The first mistake was US MIRV testing and deployment. MIRVs, once they were also deployed by the Soviets, made US missiles vulnerable. In a sort of

vulnerability escalation, the US responded by developing a new "missile experimental" (MX) that, while remaining vulnerable itself, would make Soviet missiles even more vulnerable than US missiles. The MIRV-MX drama is a perfect example of the kind of arms race a nation can have with itself. Some 40 basing modes (wide body jet, dirigible, tunnel, trench, small submarines, rail, superhard silos, multiple protective shelters, silo defense, etc. etc.) and several missiles later, the problem remains roughly on square one. US intercontinental ballistic missiles (ICBMs) remain in silos where they are vulnerable to a preemptive strike by accurate Soviet missiles, and where their own accuracy and vulnerability pose, in Soviet eyes, the threat of a US preemptive strike.

See *Physics & Society*, April and July 1988, for several brief analyses of the problem and of some of the proposed solutions. The Forum will have a complete study out, soon.

The Bush administration will have to face this problem early on. The 1989 Defense Authorization Bill, and an accompanying appropriations bill, were signed into law by President Reagan before the start of the fiscal year on October 1. The bill divides an \$850 million authorization for ICBM modernization into three pots: \$250 million for rail-based MX, \$250 million for land-mobile Midgetman, and \$350 million to be held in escrow until this February when the new president is required to report on his plans.

The problem stems from two technological "advances": MIRVing and improved accuracy. The US initiated MIRV testing in 1968 partly in order to penetrate the missile defenses that we then expected the Soviets to build. Many voices called instead for banning both MIRV testing and missile defenses. The Soviets seemed interested. A MIRV ban was clearly in our own long-term security interest. Although it was discussed in the 1969-72 Strategic Arms Limitations Talks (SALT), a MIRV ban was opposed by the Nixon administration in general and by Henry Kissinger and Paul Nitze in particular. In the end, the US sought to maintain its short-term advantage and SALT I did nothing to discourage MIRVs. In fact, the agreement encouraged MIRVs by limiting missiles and not warheads. Later, Kissinger would remark that "I would say in retrospect that I wish I had thought through the implications of a MIRVed world more thoughtfully in 1969 and 1970 than I did."

And so the window of vulnerability and the great missile debate were assured by the ability of each missile to destroy very many warheads, provided the attacker could strike silos preemptively. The problem was further assured by increasingly accurate guidance systems, another elaboration of technique that might have been at least slowed by arms control agreement. It is especially ironic that a key MIRV promoter, Paul Nitze, was later a key window-of-vulnerability alarmist. In his classic "Assuring Strategic Stability in an Era of Detente" (*Foreign Affairs*, January 1976, pp. 207-232), Nitze argued that the Soviets were developing a first strike capability against US deterrent forces, and that the US needed a counterforce (i.e. first strike) weapon of its own to restore deterrence. This influential argument, fallacious in many respects, led to the MX missile and contributed to Ronald Reagan's election in 1980. Without MIRVs, there could have been no window of vulnerability, not even a fallacious one.

It is a tragic history, one that recurs like an ancient nightmare in superpower relations. We are all-too smart, but we are not wise. Our technical brilliance overwhelms our deeper qualms and creates "sweet" new devices. Once created, we use them, because they are there, because of immediate military advantage. More accurate guidance? —Certainly. Maneuvering reentry vehicles? —Why not? Systems that can search out and destroy mobile missiles? —Of course. Invisible bombers? —Irresistible. Only later, in this case two decades later, do we realize that another might-have-been has slipped away, and we "wish we had thought through the implications — more thoughtfully." Short-term advantage has become long-term dilemma. The way to resolve missile vulnerability was to have prevented it, in 1968. It is too late for that now, but it is not too late to recall the tale in hopes that, the next time, long-term wisdom may prevail.

American wrangling over missiles arises from two contradictory views of the arms race. It is a classic "hawks versus doves" argument. In one view, the problem is Russian aggressiveness, and the solution is US military dominance. This camp prefers some version of the MX missile, because its highly accurate ten warheads do more to threaten the Russians, per dollar, than any other solution. In the other view, the problem is the risk that nuclear war will occur through fear or inadvertence, and the solution is a more stable nuclear balance, one that poses minimal threat to both sides. Although this camp is not unanimous about its preferred solution, it knows what it opposes, namely the MX because even the rail-based version is at once vulnerable to Soviet attack and threatening to Soviet silos. Recently, many in this group have coalesced around a new, mobile, single-warhead, Midgetman missile, but many others would prefer no new land-based missiles at all, or the dismantling of present ICBMs in favor of a "diad" of bombers and submarines, or some other less expensive (mobile Midgetmen are expensive) new land-based system.

The land-based missile problem is, in my opinion, a real one. All analysts, hawks and doves and intermediate birds, agree that the most likely immediate trigger of a superpower nuclear war is instability in a crisis. Not surprise attack, nor computer or other error, nor a mad general or stoned lieutenants, but crisis instability. So if one takes the threat of nuclear war seriously in the first place, one is obliged to take crisis stability seriously.

America's present silo-based ICBM force is vulnerable to an attack by a small fraction of Soviet ICBMs, and this is destabilizing. It is true that the US has many other nuclear forces, namely the strategic submarines and bombers, that would partly survive a Soviet attack, but this does not necessarily imply that the Soviets would not try to attack the vulnerable ICBMs in a sufficiently extreme situation. Furthermore, vulnerability causes US missiles to be brought to very high levels of readiness at lower stages of an alert, or perhaps even to be put on "launch on warning" (launch before Soviet warheads have struck) status, and this is destabilizing. To take it one step further, US vulnerability increases Soviet fears that we will launch first in a crisis, and this too is destabilizing.

But what could possibly prompt the Soviets (or the Americans, for these arguments work both ways) to try such an insane venture, considering the retaliation that would surely lie in store for them? The answer is: fear and desperation. It would be done not out of any desire to hold the US hostage to Soviet desires following a hypothetical "clean" removal of US ICBMs, as envisaged in the paranoid window of vulnerability scenarios of Nitze and others. The risks are far too great, US deterrent forces are far too survivable and devastating, for any sane leader to attempt such a strategy.

The real risk has always been that the Soviets would attack out of fear of an *American* first strike, or in response to a perceived American first strike threat pressuring the Soviets into accepting US demands in, say, a Baltic or Mideast crisis. It would be done to reduce Soviet losses in an assumed nearly-inevitable coming catastrophe. It would be done in the hope that, against all odds, the attack might also pre-empt most US bombers by striking quickly against their bases, or most US submarines by striking their bases and hoping that command and control problems would prevent retaliation from many of the submerged submarines. It would be done because of Soviet knowledge that US MXs and Minuteman IIIs and, soon, Trident IIs, could themselves destroy a very large fraction of all Soviet warheads, because most Soviet warheads are in fixed silos. It would be done when it seemed that all else had failed. It is in this extremity that deterrence, and stability, take on their most vital meaning.

The model is not Pearl Harbor, not unprovoked surprise. It is the crisis situation, the assassination of an Archduke in 1914, the shipment of missiles to Cuba in 1962.

And so it makes sense to try to make US missiles invulnerable. But it does not make sense to do so in a way that further increases the vulnerability of Soviet missiles. In the arms race, as in ecology, "you can't do just one thing." The move that makes the Soviets vulnerable makes us all vulnerable.

Although these observations are not especially original—after all, the debate is two decades old—they remain important. And they seem to me to point the way to a solution, if both hawks and doves can bear to give a little in their sometimes doctrinaire positions. If doves can agree that there really is a problem here that needs a solution, and if hawks can agree that the real problem is stability so that de-stabilizing answers like MX will not do, then perhaps both sides can join in a serious search for a solution that will actually help instead of making both the strategic and the political situations worse.

The MX will not solve our problem. Even if rail-based, it will be vulnerable. And it will not solve the American political problem, precisely because the MX is so widely regarded as the hawkish solution.

Neither will ignoring the problem solve it. American silo-based missiles, especially the present 500 silo-based MX warheads, will remain destabilizing. And it will not solve the political problem, for MX advocates will continue arguing their case.

President Bush, when he was candidate Bush, has already opted for the missiles of both camps: MX as well as Midgetman. But this was clearly only a campaign tactic. He cannot expect that both systems will be approved, because of the enormous cost among many other reasons. Equally clearly, he will prefer MX to Midgetman. The MX is the traditional Republican solution (although it was the Reagan-appointed Scowcroft Commission that gave Midgetman its political start) and Midgetman costs twice as much.

Thus President Bush appears to be positioned to push through 50 rail-based MX missiles, if he chooses to do so. This political "victory" would ensure a continuing hostile missile debate, and would do little to solve the underlying stability problem.

But the new President does not necessarily need to choose between MX and Midgetman and doing nothing. There may be other options. A commitment to a serious search for an affordable basing mode that is actually survivable and stable could bring the country together on this 20-year issue at the same time that it contributed to a real reduction in the threat of nuclear war.

Art Hobson