

# My Seven Decades of Science “Advising” -- and Lessons Learned?

by

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[site:rlg.fas.org](https://rlg.fas.org) “Fast Fourier Transform”

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To summarize seven decades in 30 minutes is not easy, so I have documented what I say with references to where I have said it before, or other people have. First I summarize a dozen or so activities of “science advising” over the decades and then give more detail about three of them.

1. The Mike test of November 1, 1952, from my paper of July 25, 1951, leading me to arms control, etc., as well as the U.S. and the USSR to tens of thousands of two-stage thermonuclear weapons.
2. LAMP LIGHT Study -- extension of air defense of USA and Canada 1953-4, leading to my work in Washington.
3. Fast Fourier Transform, 1963, and 1968 Arden House conference and IEEE Section on Electroacoustics and publication of historical papers.
4. “Bombing by Navigation” GPS and precision guided munitions. From mid-1960s.
5. March 1968 *Scientific American* paper with Hans Bethe, *Anti-Ballistic-Missile Systems*, physics-based public summary of our work in PSAC panels in which we had been engaged.
6. Electro-Optic Imaging – EOI -- from satellites, replacing generations of film-return systems.
7. Convening the 1991 Washington conference on quenching the 690 decapitated oil wells in Kuwait.
8. Floating airports, September 1969, basis for tension-leg-moored oil platforms in deep water.
9. RLG’s May, 1967 *Public Health Report* Paper on reform of the U.S. Health Care system with digital technology.
10. Ban on ASAT Tests and Space Weapons with the late Kurt Gottfried and UCS (1982). Star Wars with Kurt, Hans Bethe, Henry Kendall, Carl Sagan.
11. March 1969 SST Report for President Nixon and later Congressional testimony and work.
12. Short-fat ships for enhancing U.K. and U.S. surface naval capability, 1981 to present. In support of David L. Giles.
13. Opposing the 1972 U.S. decision to cease mandatory vaccination against smallpox.

Item 1 -- It is important to understand how different from today things were in the 1950s and 60s, where much of this was done or begun. For instance, I went to Los Alamos as a summer consultant in 1950 just after having been appointed to a faculty position at the University of Chicago, and I was completely free to do anything I wanted. The first week I learned about nuclear weapons, and the second summer when I arrived there in May or June, I asked Edward Teller whether there was anything new. In short, he pointed me to the 03/09/1951 paper by Stan Ulam and Edward Teller, titled “*On Heterocatalytic Detonations I. Hydrodynamic Lenses and Radiation Mirrors (S)*.”<sup>1</sup> He said that what he really needed was the design of an experiment that would persuade even the most skeptical that this was the way to build a hydrogen bomb.

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<sup>1</sup> Stan Ulam and Edward Teller titled “On Heterocatalytic Detonation I. Hydrodynamic Lenses and Radiation Mirrors (S).” [Not publicly available.]

I responded by publishing a document in the Los Alamos Report Library 07/25/51, LAMD-7416, "*Some Preliminary Indications of the Shape and Construction of a Sausage, Based on Ideas Prevailing in July 1951 (S)*,"<sup>2</sup> and spoke about it at a meeting of the Family Committee or the Theoretical Megaton Group, but I had to leave in September.

In December 1952 I joined IBM at a small laboratory in New York City and believed that I had really found my calling -- that I was very good as a consultant to help solve other people's problems. That this was not universally shared is perhaps best illustrated by the recommendation that LASL Physics Division head, Jerry Kellogg, gave his IBM friends, when asked about my work at Los Alamos, "*You'll be sorry if you hire him, but you will be sorrier if you don't.*"

I thought that I could pursue ideas in physics and also in the technology of computers and communications at IBM and would not have the social structure of the high energy physics community that required me at Chicago to identify six weeks in advance and work with a group of six people if I wanted to use the 450 MeV cyclotron that had just been put into service at Chicago.

Item 2 -- Imagine my surprise when I arrived at IBM and was soon asked by top corporate management to take a year or two off from my IBM work to serve full time as a member of the Project LAMP LIGHT study at Lincoln Laboratory in the Boston area, focused on the extension of the air defense of the United States and Canada from Soviet bombers carrying nuclear weapons. This was not why I joined IBM, and I declined, but realized that I would learn new things in this way and negotiated that I would work with the LAMP LIGHT group Tuesdays through Thursdays and do my IBM work at the Watson Laboratory on Mondays and Fridays and weekends. This was my introduction to the national security world beyond thermonuclear weapons -- including aircraft, ships, and the possibility of ballistic missiles.

\*\*Pointer-1\*\*

This was my first encounter with the study heads -- Jerome B. Wiesner and Jerrold Zacharias, both from MIT, and the first time I had met the great physicist from Harvard, Ed Purcell. Also some inventive electrical engineers especially David Sunstein, with whom I became friends and invented several non-defense items.

Item 3 -- Fast Fourier Transform, 1963 -- FFT -- was accomplished and published by John W. Tukey of Princeton/Bell Labs and James W. Cooley of IBM. The full story is given at the 1968 Arden House Conference<sup>3</sup>, in which I explain my role as the midwife to the introduction of the FFT, probably saving a couple of years before the world had this new capability.

The FFT is as important to the areas in which it can be used as was the introduction of arithmetic instead of counting. In both cases the number of operations required is reduced from  $N^2$  to  $N \log N$  -- actually, to  $N \log_2 N$ .

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<sup>2</sup> Los Alamos Report Library 07/25/51, LAMD-7416, "*Some Preliminary Indications of the Shape and Construction of a Sausage, Based on Ideas Prevailing in July 1951 (S)*," [Not publicly available.]

<sup>3</sup> "[The Fast Fourier Transform as an Example of Difficulty in Gaining Wide Use for a New Technique](https://rlg.fas.org/690600-fft.pdf)" (The 1968 Arden House Workshop on Fast Fourier Transform Processing), IEEE Transactions on Audio and Electroacoustics AU-17, No. 2, pp. 68-72, 06/00/69. <https://rlg.fas.org/690600-fft.pdf>

Item 4, “Bombing by Navigation” was espoused by the PSAC Military Aircraft Panel in the early 1960s, as we saw and experienced how things were done by USAF, Navy, and Marine Corps in our monthly two-day meeting and field trips. This built on my 1951 month in Japan and Korea during the Korean war, as an informal consultant to a group of academic scientists interested in creating one or more technical laboratories for the newly formed Tactical Air Command.

\*\*Pointer-2\*\*

Item 5, the March 1968 *Scientific American* paper with Hans Bethe, *Anti-Ballistic-Missile Systems*<sup>4</sup>, was a physics-based public summary of work in which Bethe and I had been involved since 1957 with the PSAC Strategic Military Panel that informed PSAC, the President’s Science Advisor and the President of the status of air defense and missile defense, and of our offensive and retaliatory forces. In fact, the work relating to bombers and air defense was largely done by my Military Aircraft Panel. Hans Bethe, Sidney D. Drell and W. K. H. Panofsky of Stanford University, and I were long-time members of the SMP, among others less involved in arms control.

Item 6, EOI Satellite Systems relates in some detail some aspects of this field, in which aerial photography in 1960 became supplemented by photographic imaging from space -- initially the CORONA film-return system<sup>5</sup>, of which 145 missions were flown, returning to Earth 165 reentry vehicles containing film to be developed by Eastman Kodak, printed in multiple copies, and distributed to authorized users in the intelligence and defense communities.

It was not a simple matter to consider replacing the film-return systems by high-quality Electro Optic Imaging -- EOI – and radio transmissions, and there were many options for doing so, including actual film developed in the satellite and scanned there by automatic means, as was done in the U.S. imaging of the Moon in early days. The earliest work by CIA, in response to recommendations by the “Land Panel” named for its chairman, Edwin H. Land, the inventor of Polaroid film and before that of inexpensive linear polarizing sheets for glare-reducing sunglasses and for research, teaching, and demonstration. The particular EOI system that has evolved to serve as the workhorse of the present day and was first operational on January 20, 1977 -- the first day of Jimmy Carter’s presidency -- as documented by recently declassified frank technical memos from the NRO -- National Reconnaissance Office.

\*\*Pointer-3\*\*

Item 7 refers to the 1991 conference that I personally organized in Washington of some two dozen scientists and engineers to see what could be done to extinguish the 640 oil well fires set by Saddam Hussein's military engineers in his invasion of Kuwait. Conventional wisdom held that it would take 5-10 years to do this, but I felt there must be a better way. Just in time, Henry W. Kendall, and the Union of Concerned Scientists, joined me in

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<sup>4</sup> "[Anti-Ballistic-Missile Systems](https://rlg.fas.org/03%2000%201968%20Bethe-Garwin%20ABM%20Systems.pdf)," by R.L. Garwin and H.A. Bethe in *Scientific American*, Vol. 218, No. 3, pp. 21-31, March 1968. <https://rlg.fas.org/03%2000%201968%20Bethe-Garwin%20ABM%20Systems.pdf>

<sup>5</sup> [https://en.wikipedia.org/wiki/CORONA\\_\(satellite\)#Overview](https://en.wikipedia.org/wiki/CORONA_(satellite)#Overview)

organizing and sponsoring this conference, which I believe was instrumental and capping all of the damaged wells by October, 1991<sup>6,7</sup>. In the sane issue of *Nature*, Peter Aldhous quotes “*Ralph Brown, who heads the Kuwait Petroleum Company's well-control task force ... The US scientific community was saved from a similar flurry of wasted effort, Brown says, by a symposium held in Washington in April (see Commentary, p. 11 ), which gave experts a chance to explain to interested US scientists the nature of the problems in Kuwait.*”

This intense involvement with the 690 gushing wells of Kuwait educated me for the 2010 British Petroleum oil spew in the Gulf of Mexico at a depth of a mile and with very high pressures. That exploratory well had hundreds of tons of wellhead plumbing at that depth. Secretary of Energy Steven Chu recruited me by phone one noon at my IBM office in New York for a meeting in Houston, TX, at 6 AM. the next day, to help solve this problem.

Item 8, the design of a floating airport, addressed the problem of a large structure at sea, unaffected by the waves, yet with enough vertical rigidity to support multiple million-pound aircraft anywhere on the structure. According to renowned oceanographer Walter Munk, this was the first use of tension-leg mooring that is widely used in deep-water exploration and production of oil and gas throughout the world.

Item 9 refers to my 1967 American Public Health Association<sup>8</sup> presentation and paper on reform of the U.S. healthcare system by the use of digital technology of that day. This was clearly a failure, and the reasons for that are multiple and deep.

Item 10, "Ban on ASAT Tests and Space Weapons"<sup>9,10,11</sup> was done with the late Kurt Gottfried and the Union of Concerned Scientists. Kurt and I testified to the Senate Committee on Foreign Relations and tried to persuade the United States to undertake such a ban but had little success. This helped prepare us and UCS for the battle over Star Wars, when President Reagan in a television speech on March 23, 1983 introduced the Strategic Defense Initiative. In that battle I joined Kurt Gottfried, Hans Bethe, Henry Kendall, and Carl Sagan.

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<sup>6</sup> "Quenching the wild wells of Kuwait," by R.L. Garwin and H.W. Kendall in *Nature* Vol. 354, No. 6348 (pp. 11-14), Nov. 7, 1991 (with brief comment by Peter Aldhous, p. 5).

[https://rlg.fas.org/Taming%20Wild%20Wells%20of%20Kuwait%20354011a0\(2\).pdf](https://rlg.fas.org/Taming%20Wild%20Wells%20of%20Kuwait%20354011a0(2).pdf)

<sup>7</sup> Aldhous, P. Oil fields under control. *Nature* **354**, 5 (1991). <https://doi.org/10.1038/354005b0>

<sup>8</sup> "Impact of Information-Handling Systems on Quality and Access to Health Care," by R.L. Garwin, presented to the American Public Health Association, published in *Public Health Reports*, 83, No. 5, pp. 346-351, May 1968. <https://rlg.fas.org/050068IHS.pdf>

<sup>9</sup> [Draft Treaty presented by the Union of Concerned Scientists to a Subcommittee of the Senate Foreign Relations Committee, "A Treaty Limiting Anti-Satellite Weapons,"](https://rlg.fas.org/051883TLAW_Draft_Treaty_Limiting_ASAT_Weapns.pdf) May 18, 1983.

[https://rlg.fas.org/051883TLAW\\_Draft\\_Treaty\\_Limiting\\_ASAT\\_Weapns.pdf](https://rlg.fas.org/051883TLAW_Draft_Treaty_Limiting_ASAT_Weapns.pdf)

<sup>10</sup> [A Treaty Limiting Antisatellite Weapons,](https://rlg.fas.org/A%20Treaty%20Limiting%20Antisatellite%20Weapons%20051883TEST.pdf) by R.L. Garwin. Oral testimony for a subcommittee of the Senate Foreign Relations Committee, May 18, 1983.

<https://rlg.fas.org/A%20Treaty%20Limiting%20Antisatellite%20Weapons%20051883TEST.pdf>

<sup>11</sup> "Space Weapons," joint articles -- 'History and current debate,' by R.L. Garwin and J.E. Pike, 'Effect on strategic stability,' by Y.P. Velikhov, and "A treaty limiting anti-satellite weapons," draft treaty (pp. 10S-11S), *Bulletin of the Atomic Scientists*, Vol. 40, No. 5, pp. 2S-15S, May 1984. <https://rlg.fas.org/space-weapons.pdf>

Item 11 is just to record the month-long committee effort I led for President Nixon's Science Advisor in April 1969, that provided a brief negative report on continuing U.S. development of a commercial Mach 3 Supersonic Transport -- SST. This may have contributed to President Nixon's terminating PSAC in February, 1973.

Item 12 is a considerable effort extending from 1981 to the present, to counter initial misunderstanding and later disinformation about the relative merits of short, fat ships, in particular semi-planing hulls – in competition with the traditional Royal Navy's long-thin destroyers, "Greyhounds of the Sea." Until 2016 or so this was *pro bono* on my part; only when it came to a patent infringement suit against the U.S. government's use of two 1969 U.S. patents by David L. Giles, did I receive compensation other than reimbursement of my travel expenses over the years. Giles's patents and R&D efforts led to the Lockheed Martin proposal for the semi-planing hull to be used for the U.S. Navy's Littoral Combat Ship – LCS – *Freedom* class. This was a lot of effort on my part over the decades, involving, early on, technically contradicting the judgments of the chief naval architect of the British Ministry of Defence, detailed ultimately in the suit against the U.S. government, decided (and again on appeal) by the U.S. courts and resulting in an overall judgment of \$44 million.

Item 13. Opposing the 1972 decision by the U.S.A. to cease mandatory vaccination against smallpox<sup>12</sup>. In 1972, just before President Nixon was asked to validate the decision to cease mandatory smallpox vaccination in the United States, the question was brought to the President's Science Advisory Committee. I was the sole opponent to that cessation, among the 18, maintaining that an unvaccinated population would give a terrorist group an enormous, existential target, that could readily and increasingly safely be avoided. I put this both concisely and, I think, cogently in a short section of my 2001 paper "*Enrico Fermi and Ethical Problems in Scientific Research*," presented in Pisa, at the centennial of Enrico Fermi's birth.

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<sup>12</sup> "[Enrico Fermi and Ethical Problems in Scientific Research](https://rlg.fas.org/011019-fermi.htm)," by R.L. Garwin, presented at Public Lecture in the Centennial Celebration "Enrico Fermi and Modern Physics," Pisa, ITALY, October 19, 2001.  
<https://rlg.fas.org/011019-fermi.htm>

**Pointers and Notes.docx**  
**(For "7 Decades of Science Advising")**

Pointer-1

<https://www.ibm.com/blogs/research/2016/11/garwin-medal-of-freedom/> (Itself saved as PDF). .... Significant quote,

*"Garwin gives IBM much of the credit for enabling his public life. Thanks to a unique agreement he made with the company when he was hired in 1952, he was permitted to devote one-third of his time to his other vocation: placing science in the service of humanity as an advisor to the U.S. government."*

[IBM Vice President of Research Arvind Krishna on the occasion of the award by President Obama of the Presidential Medal of Freedom.]

Pointer-2

[From 7253ATCS.SCRIPTXS ]

*The TDOA system had historic roots. President Dwight D. Eisenhower proposed the "Open Skies" regime on July 21, 1955, with the purpose of preventing the outbreak of accidental war because of the Soviets' possible response to what they might regard as U.S. bombers penetrating their air space. In response, I proposed to implement a system in which U.S. bomber aircraft would carry free-running transmitters, each broadcasting about once every second, the signals from which would be picked up by special satellites and returned to ground stations on Earth, to provide TDOA locations of the bombers; the time differences in arrival of radio signals at the ground stations via the various satellites would be converted to path differences by the known speed of radio waves-- the speed of light in vacuum-- 300,000 km/s. This would be used, of course, in exercise mode, and would, presumably, be turned off in wartime. The purpose would be to reassure the Soviet Union that the bombers remained well outside Soviet territory.*

*When I was a member of the U.S. delegation to the 10-nation Conference for the Prevention of Surprise Attack in Geneva, I formalized this with the concept related in my 1958 paper sent ultimately to E.R. Piore, at that time IBM Director of Research.<sup>13</sup>*

*It is not easy for a new navigation system to gain acceptance. The airlines were fearful that they would be required to pay for the infrastructure as well as for all of the equipment that they would need to carry, in addition to, rather than as a replacement for, the existing navigation aids. My Military Aircraft Panel in the 1960s had the same problem in gaining acceptance for GPS, and I personally visited the Joint Chiefs of Staff in the "tank" in the Pentagon to brief our proposal in*

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<sup>13</sup> "Proposal for an International Air, Sea, and Space Traffic Control Using Radio Beacons on the Vehicles," by R.L. Garwin, July 20, 1958. Available at [www.fas.org/RLG/072058pias.pdf](http://www.fas.org/RLG/072058pias.pdf).



2. SC-2016-00001\_C05093200.pdf

(Containing July 24, 1971 Land Panel report by R.L. Garwin (acting for Dr. Land). [underscore added 09/05/2022]

First paragraph,

*“Dear Dr. David:*

*Acting for Dr. Land, I am transmitting to you a recent Panel report dealing with the near-real-time photo reconnaissance program. The report has now been signed by James G. Baker, Sidney D. Drell, Richard L. Garwin, Marvin L. Goldberger, Edwin H. Land, Donald P. Ling, Joseph F. Shea.”*

Final paragraph:

*“The Panel is unanimous in its judgment that the FROG program has the higher risk. We respectfully urge that FROG be dropped and EOI acquired on a schedule to result in first flight November 1974.”*

3. SC-2016-00001\_C05098512.pdf

EOI Chronology from 1951 to August 1977. (Declared operational January 20, 1977 (President Carter’s inauguration day).

(Three entries on p. 5 of 7):

*“Late August 1971- Sid Drell and Dick Garwin gave a secret briefing to Henry Kissinger on desirability of building ZAMAN. pIV-6, DS&T History.*

*“Sep 1971- Kissinger letter giving go-ahead to ZAMAN and cancelling FROG. 5114*

*“30 September 1971 EXCOM- stated that Kissinger intended to limit spending on EOI to XX per year, with first launch in 1976. 92T-134.*

[Not from the NRO site, but from the 8-minute video of testimonials on the occasion:]

*The R.V. Jones Intelligence Award Ceremony*

*(transcript of 8-minute video), March 13, 1996 R.L. Garwin (Final paragraph:)*

*Narrator: The extraordinary contributions by Dr. Garwin can best be summarized by a quote from Lew Allen, Jr., Chairman of the Board, Draper Laboratory:*

*"I think Dick admirably exemplifies the Jones characteristics of science applied to problems of national security with irreverence, undaunted determination, and a history of being right. Wisdom based on a very sound understanding of science, given with vigor and a unique style which is impossible to ignore, that has been astoundingly influential over many years."*

A caution for amateur historians: In preparing my presentation, "7 Decades of Science Advising ..." for delivery in November, 2022, I realized that I had felt bad a few months before on reading the 1974 Lew Allen commentary with its seemingly negative view of the Land Panel and (elsewhere) of me, personally. But then I recalled hearing in 1996 General Allen's generous praise (22 years after he wrote his views of 1974) for the ceremony accompanying the 1996 Reginald V. Jones Award, in part for the same work, after 19 years of experience with the EOI System.

**Lessons learned** is not my field of expertise although it would have been helpful to guide my further efforts if from the beginning I had been more self-aware! Luis Alvarez was such a person, but I was not. On reflection,

1. My IBM contract in December 1952 was essential to my further constructive involvement with the U.S. government.

Doing many things at once was critical. If something hit a snag or a delay, I could move on to doing something else. For the most part I avoided other scheduled work, putting my U.S. government involvement first; according to my interpretation of my IBM contract, I informed IBM only in generalities what I was doing and after the fact. Not until I began to testify in Congress, did I let them know before, and provide them with my draft testimony the day of the session

2. Seeing people at many aspects in their careers was important.

2a. For instance, Lew Allen who figures a couple of times in my narrative already, first sought me out in the Theory Division at Los Alamos when he was, I believe, a Second Lieutenant in the U.S. Air Force, working at the USAF Lab in Albuquerque on the design of steel reinforcing rod structure for the Minuteman silos. His concern was not the mechanical strength but the ability of the welded rebar to shield the interior from the electromagnetic pulse from a close-in ground nuclear weapon explosion that would drive Compton currents into the ground at enormous scale. It turned out that the designers had ignored the almost perfect reflection of the magnetic field, and so assumed more required attenuation by Eddy current than was necessary. I then interacted with him on the NRO staff and finally in a friendly fashion about my previous White House responsibilities as head of the Military Aircraft Panel and the Naval Warfare Panel with him as Air Force Chief of Staff 1978-82.

2b. John Tukey, of the Cooley-Tukey algorithm, I first worked with intensively as part of the Killian Technological Capabilities Panel – TCP – on the panel under William O. Baker, Vice President for Research at Bell Telephone Laboratories, and a person who spent a lot of time consulting with the U.S. government. That was about 1955 and we worked on a special "Baker Committee" to review aspects of the National Security Agency – NSA – activity. I then worked with him at the Geneva Conference of Experts on Nuclear Weapons and the Ten-Nation UN Conference on Prevention of Surprise Attack at the same time in Geneva in 1958-9. We were members of the President's Science Advisory

Committee – PSAC, and I sat next to him, typically, and asked him about Fourier transforms at a break, after I saw him writing Fourier sums on a notepad during the PSAC session, which was on a totally different topic.

This long acquaintance with many people facilitated discussions, if not necessarily agreement. It was similar with **Edward E. David**, President Reagan’s second Science Advisor, with whom I had worked on “The Man-made World” program for a high-school course that would supplement and to some extent replace the Physical Sciences Study Committee – PSSC – enormous effort of the 1950s. So when Ed David took over as Presidential Science Advisor and Chair of PSAC, we were already well acquainted and had mutual respect. David differed substantially with me and the Land Panel over our recommendation for the electro-optical imaging system but played fair in this opposition.

I don’t know how helpful my limited understanding of lessons learned is, because that world no longer exists.

-- End --