THE ROLE OF MATERIALS AND STRUCTURES TECHNOLOGY IN DEFENSE–PART III

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The first two parts of this presentation dealing with aspects of national materials policy upon operations in the Department of Defense were given by Mr. J. Persh, primarily from the point of view of the DOD, and by Dr. M. A, Steinberg representing industry, This third part completes the triumvirate by expressing at least one academician's viewpoint. There seem to be essentially three relevant parameters of immediate concern: technical, economic, and institutional.

From the Government point of view, one might inquire as to how to get the DOD job accomplished within a zero-growth budget atmosphere. Mr. Persh has first described the technical dimensions of this problem by enumerating various pacing problem areas in which materials policy has an important impact: gun barrel erosion, penetrators, mine fields, composite materials, and all weather capability especially in tactical missiles. He has also observed that there are three areas in the overall design cycle, i.e., loads/environment, material characterization, and non-destructive examination, which the materials engineer must recognize as common threads to be understood and technologically supported by the materials community if its contributions to the overall design process are to be optimized,

Turning to economic-related issues, Mr. Persh has outlined the principal dilemma facing Office of the Director of Defense Research and Engineering as it attempts to provide advice. Because military systems are being pushed more and more toward the limits of technology, it appears more conservative to support relatively predictable improvements in the state-of-the-art rather than riskier investments in newer technologies and advanced materials. Generally speaking, there are inadequate funds to do both well, Furthermore, legislative pressures tend to demand short-term resuIts. Once the short-term payoff approach is adopted, however, there is the real danger of a rapidly accelerating erosion of the broad technology base which increasingly inhibits innovation, Ostensibly the Advanced Projects Research Agency was set up to help resolve this dilemma, but one point for discussion might be its degree of success in terms of return on investment, The other important economic matter is that of critical material shortages, a subject to be dealt with by one of the other panels, Institutional mechanisms referred to by Mr. Persh deal mainly with those improving technology transfer, and include intra-service, inter-service, inter-agency, and inter-governmental exchanges. In addition, he has mentioned the technology coordinating conferences in materials and structures at which public elements of DOD policy, plans, and concerns can be shared with industry and universities, In passing, it may be noted that the 1974 structures conference attracted only a half-dozen academicians: presumably a better representation can be obtained in 1976. And finally, one of his optimistic, key statements stressing the importance of creativity and innovations bears repeating: "Dollars can not produce good ideas. Progress [is] idea rather than funding limited,"

As to lndustry, it frequently seems to me that too many persons are inclined to forget that its major purpose is to operate with reasonable stability over the long term at a fair profit. Furthermore, since most of our upgraded life-style has emanated from that profit, it is not inherently bad.

Dr. Steinberg has made two primary technical points I should like to emphasize, First, materials scientists have been known to succeed beautifully in achieving announced "break throughs, " e.g., improved fracture toughness, but frequently succeed prematurely in the systems sense because too much "producibility" has simultaneously been lost, One inference could be that an effort should be made to ensure that the vistas of the materials scientist are broad enough to embrace an appreciation of the entire design cycle— from the atom to the end product and its uses. The second point, which impinges somewhat upon institutional barriers, is that there is plenty of information in the data bank, but there is a serious difficulty with technology transfer. There are really two facets to this subject, One is a "people-problem" in terms of the NIH [not-invented-here) syndrome. The other is legalistic in terms of anti-trust barriers which prevent industrial collaboration, even though as Henry C, Wallich, formerly a Yale professor of economics and now a member of the Federal Reserve Board, wrote in Newsweek, ". . . we might give some thought to whether a law enacted in 1890 to protect a nation against exploitation by robber barons still meets the needs of a nation now hard-pressed by its competitors around the world.'" As Dr. Steinberg says of the materials data base consolidation, "There is an avowed need for the Government and industry to get together . . . for the avowed purpose of saving manpower and resources. , . . The major policy question is then

1 As quoted in "Dialogue on Technology No. 6". CouId Inc.., 1976.

how best to accomplish this." Presumably, the current trade association mechanism is inadequate as is the utilization efficiency of our present set of data and information centers. Salient points of a more economic nature are the relatively low raw materials cost (in aircraft) of I-4 percent flyaway cost compared with the much higher cost of processing and fabrication.

Nevertheless, the national research emphasis on such unpopular subjects is, to say the least, low.

While it is not particularly emphasized as a critical economic matter to industry, Dr. Steinberg calls attention to the growing capital requirement in industry. The mature industries, including mining and natural resource conversion in particular, seem due for major injections of capital as our formerly ample supplies, internally and externally, dwindle. Such industries must somehow be assured that major capital investments can be protected, e.g., conversion of alumina ores to replace embargoed bauxite. Here one must carefully distinguish between subsidies, which usually imply Federal controls, and contingency insurance-retaining free enterprise and market checks and balances.

Finally, in addressing institutional barriers, Dr. Steinberg calls for a better way of doing business then specifying products to death, with little room for flexibility to change with product improvements at minimun cost. One may note optimistically the new DOD procurement policy that is being attempted. As reported in the WalJ Street Journal (July **28, 1976)** the emphasis is to be on meeting the end use requirement–any way you can! – without excessively detailed component specifications. Such apparent flying in the face of "normal specifications" could increase the present product liability suits, especially. if applied in the civil sector, yet this kind of management innovation would seem to fall within the "new idea" category advocated by Mr. Persh,

A View From Academia

While I have taken the liberty of editorializing rather extensively on my colleagues' previous remarks concerning the DOD and industrial involvement with the materials community, there are a few points that are peculiar to universities and the way their collaboration with the agencies of the Federal Establishment is effected. With few exceptions, the association is at the basic ("6.0") or applied ("6.1") research levels represented approximately by the science and engineering schools respectively, Especially since the Mansfield Amendment, a rough division might be that science schools tend to be supported by the National Science Foundation ("6.0") and engineering schools by more mission oriented agencies ("6.1") such as DOD, NASA, and ERDA. To the extent that academic research investigators are prepared to understand that relevance is required, the academic engineering community can make an important contribution to DOD and specifically to materials research—without compromising the individual professor's freedom of inquiry. The simplest resolution of any concern is a declination to bid.

Quality work comes from quality staff who work with quality students. This latter group is especially critical because the materials engineering constituency is not nearly as strong as are other more publicized and popular disciplines. In these days when high school students are frequently too influenced by TV and the news media, it is small wonder that there appears to be a relatively low registration of U. S. citizens in materials options. Considering materials graduates, e.g., metals, ceramics, polymers, and natural resource specialists as a national human resource, one would prefer that a substantial number of our trained engineers remain in this country to solve our future materials problems. Some new public relations initiatives in this area would seem fruitful.

The second major "technical" point I would like to make relates to the importance of choosing "good" teaching or research areas to study. After the fundamentals, schools must fight against the tendency to stagnate in classical areas, although the real problem of appearing to respond to industrial or Government "needs"—which may also have stagnated—while simultaneously being progressive is serious enough to deserve continuing attention. Two cases in point. The first relates to the aforementioned deficiency in most engineering schools in materials processing. It frequently appears that other than materials disciplines, e.g., computer science, are more concerned with manufacturing technology and CAD/CAM. The other example derives from the long-standing opinion in most U.S. chemistry departments that polymer science is not particularly academically suitable. As a result it is not surprising that polymer engineering and polymer processing suffers[2] in the United States compared with similar development in Japan, Germany, and the United Kingdom. In the latter country, incidentally, notwithstanding the economic downturn, something like £10 million has been authorized by the Scientific Research Council (SRC) for polymer engineering in the U.K. universities over the next 10 years.

Third, I agree with the implied conclusions of my colleagues that a more integrated understanding by materials engineers of

[2] "Polymer Engineering and its Relevance to National Materials Development", F. R. Eirlch and M. L Williams, Washington. D. C., 1973, Library of Congress 73-8!9413,

the overall design process would be very beneficial. One would hope that it would lead to more selective work, at least among those with engineering rather than scientific inclinations. A better bridge between the microscopic and macroscopic views would be enlightening, For example, in rubber elasticity theory, one can show that the materials scientist's parameter of cross link density of the molecular chain is directly proportional to the mechanical engineer's (longtime) Young's modulus of elasticity. While most micro-macro associations are not as simple, such associations are of immense value in permitting improved interdisciplinary thought processes,'

From the economic standpoint, the most important financial matter to universities is reasonably long term research stability, e.g., 3 years **as a** minimum. Such consideration is by no means unknown in DOD because of the major investment in Interdisciplinary Materials Laboratories (IDL) over the years. They were effective in producing materials scientists, although I have heard some adverse criticism regarding the lack of engineering impact and balance among a wider interpretation of what the materials field embraces, Some changes in the IDL program are being effected under the current NSF responsibility for this program, In terms of Federal research funding (1974-75), the top 25 engineering colleges spent approximately $200 million. With their combined staffs of about 5000 faculty members, the average research support per faculty member was approximately $40,000, Before leaving this subject, it may be noted that R&D expenditures in 1975 by industry totaled $26 billion plus $9 billion in Government laboratories or about 2 percent of the GNP as reported by Business Week (June 28, 1976) (table 1). According to NSF, the distribution in percent was basic research (3.5), applied research (20.0), product development (76,5). The average R&D expense per employee varied between $500 and $2,000 per year which corresponds to 1-4 percent of sales,

As a final point of economics, equipment grants are very important, especially for equipment used in sophisticated materials research and related automatic data acquisition and processing systems. To the best of my knowledge, NSF is the only major agency with a special equipment grant program for universities,

It is tempting to close my remarks by expanding upon the subject of institutional barriers. Much has been said already of the importance of technology transfer and the mandatory need to make it work. International competition demands it, whether one

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3 "The Engineering of Polymers for Mechanical Behavior", F, N. Kelley and M, L. Williams, Rubber Chemistry and Technology, 42,4.1175-1185, September 1969.

TABVLE 1.– Industrial R&Dl Expenditures*

	R&D $/ employee	R&D $	% Sales	% Profit	Sales
Aerospace	$1.324	.$ 825.3	3.2	136.0	$26.023M
Rockwell	252	31.0	0.6	30.5	4.943
IJnlted Tech	2,344	323.7	8.3	275.5	3.878
Boeing	2,589	188.0	5.1	246.6	3,717
Lockheed	916	52.8	1.6	16.6	3.387
Chemical	$1.579	1,317.4	2.6	39.4	$51.056M
DuPont	2,538	335.7	4.6	123.5	7.222
IJnlon Carbide	1.123	120.2	2.1	31.5	5.665
Dow	3,153	167.4	3.4	27.2	4,888
Electrical	$1 .038	1.345.1	3.0	81.5	$44,692M
Instruments	1,990	695.6	5.4	68.6	1‘)~f5f3
General Machinery Mfg	673	288.1	1 7	405	16.531
Metals. Mining	698	204.2	1.2	33.3	13.241
Natural Resources. 011, Coal	1 .008	715.2	0.4	8.3	169,250
Steel	294	105.9	0.6	10.9	17.043
Telecommunications	630	735.3	1.9	19.9	36,877
AT&T	661	619.4	2.1	19.7	29,272

● Source: (Business Week, June 28, 1976)

speaks from a Government, industrial, or academic platform. Suffice it to close for now with an observation made by Etzioni in a recent Science editorial (July 30, 1976). He distinguished between collegial and positional meetings and the need to recognize the difference, In short, the former can be a rather unstructured meeting of the community for information exchange, accompanied by considerable sociability, The latter is one at which a policy or a position is to be developed, It must be carefully structured as to its participants so that the subject matter stays on course, even to establishing a ruthless chairman.

On behalf of the three of us, we are pleased to have been here. to have had an opportunity to present our views in this positional meeting, We hope your policy recommendations will eventually evolve by the end of this week, without the complete absence of the collegial sociability.