



DEPARTMENT OF THE ARMY
ARMY SCIENCE BOARD
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D.C. 20310-0103



6 DEC 1991

General William G. T. Tuttle, Jr.
Commanding General
U. S. Army Materiel Command
Alexandria, Virginia 22333-0001

Dear General Tuttle:

Attached is the final report of the Army Science Board (ASB) Independent Assessment of the U. S. Army Research Office (ARO). We are pleased to have accomplished this study and believe it will be of use to AMC and the futherance of ARO's technical work.

Should you elect to assign an action officer and/or action task force to follow up on the study, the ASB panel chair, Dr. Paul F. Parks, will be most pleased to be the point of contact for any continuing ASB interaction on this topic.

Sincerely,

Charles H. Church
Acting Executive Secretary
Army Science Board

Attachment

CF: Mr. Conver
Mr. Singley
Mr. Jacobs
Dr. Parks
Dr. Chait

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November 21, 1991

Mr. James Jacobs
Chairman, Army Science Board
Army Science Board
Office of Assistant Secretary
of the Army (RDA)
3E 359 Pentagon
Washington, DC 20310-0103

Dear Jim:

Enclosed is what I consider to be the final report on the Independent Assessment of the Army Research Office. Earlier I provided a draft copy to Duane. We have delayed submitting the final report until I could obtain additional information on the proposed ARO Washington Office. That information is included in the report. I am also sending a copy of this document to the other members of my committee so they can review the final changes in the report. I am trying to facilitate this process because apparently there is some urgency within ASA(RDA) and AMC to receive this report.

If the other members of the committee have questions or comments about this final document, I will transmit those to you as soon as possible.

Sincerely,



Paul F. Parks
Vice President for Research

PFP:mm

Enclosure

cc: Dr. Duane Adams
Dr. Jay Sculley
Dr. Peter Weinberger
Lt. Col. Albert Sciarretta

ARMY SCIENCE BOARD
INDEPENDENT ASSESSMENT OF THE
ARMY RESEARCH OFFICE

The Army Science Board (ASB) was asked by Mr. Stephen K. Conner, Assistant Secretary of the Army (RDA) to perform an independent assessment of the Army Research Office (ARO) in accordance with the Terms of Reference included in this report as Attachment A. The Committee was given additional guidance by its sponsor General William G. T. Tuttle, Commander, U. S. Materiel Command (AMC) and Mr. George T. Singley III, Deputy Assistant Secretary for Research and Technology, OASA(RDA).

General Tuttle requested that the Committee assess the effectiveness of ARO's current activities--including relationships with universities, relevance to Army needs, and organizational flexibility to change with changing Army technology needs. General Tuttle discussed the role of the Combat Materiel Research Laboratory (CMRL) as proposed in the LAB 21 recommendations.¹ He sees ARL as ARO's major customer and wishes to insure that the "customer/supplier" relationship is properly linked. The Committee was asked to determine if ARO is structured to effectively facilitate the exchange between ARL and the university research community. General Tuttle also asked that the Committee advise him on the organizational/reporting structure that would most effectively enhance ARO's performance.

Mr. Singley provided the Committee background information for the Study including: the Army's concern about the impact of

¹ CMRL has been re-designated the Army Research Laboratory (ARL). The new title will be used for the remainder of this report.

reorganization, downsizing, and budget constraints on its research and development programs; and the effect of the LAB 21 and the Defense Base Closure and Realignment Commission (BRAC) reports on the Army's technology base activities. Mr. Singley informed the ASB Committee that General Tuttle had asked for this study to assist him in the implementation of LAB 21 and BRAC recommendations. Of special interest here is the LAB 21 recommendation that ARO report directly to AMC Headquarters rather than the current reporting route through the Laboratory Command (LABCOM).

Dr. John Wachtman briefed the Committee on the basic science findings of the Board on Army Science and Technology Study on Strategic Technologies for the Army as background information.

The Committee, in performing its charge, interviewed representatives from AMC, ARO, Corporate Laboratories, Research, Development and Engineering Centers, and representatives from other DoD research management organizations. A list of persons interviewed is given in Attachment B.

Information about Committee members, Sponsor, Cognizant Deputy, Staff Assistant, and Technical Advisors is presented in Attachment C.

Army Research Office History and Role

Harold I. Sharlin in his publication, "Today's Science, Tomorrow's Advanced Technology," has traced the evolution of the Army's basic science policy and the development of ARO. The predecessor of ARO, the Office of Ordnance Research (OOR), was established in 1951 as a part of the Nation's post-war commitment to develop basic research

and "scientific capital"--especially in the universities. The military services had observed the contributions that basic science made to the war effort and moved to establish their own programs. According to Sharlin, OOR was to be independent--i.e., not closely aligned with an operating unit--and located on the Duke University campus to insure close association with University faculty and basic research facilities. Very early on, OOR began to develop its extramural funding procedures. In 1961 OOR became the Army Research Office-Durham and the Army Research Office-Washington and in 1973 the Army Research Office. These changes in name were recognition of the broader application of basic research to Army programs. ARO moved off the Duke University campus in 1975 and appointed a civilian director in 1982. ARO was placed administratively under AMC in 1974 and under LABCOM in 1985. This administrative arrangement is understandable when you consider that approximately three fourths of the Army's basic research (6.1) budget is administered through AMC. Questions have been raised, however, about ARO's ability to contribute to Armywide basic research needs under this administrative structure.

The current Director of ARO, Dr. G. J. Iafrate, defined the following functions of ARO:

- Oversee integrated AMC in-house and extramural basic research program
- Develop, implement, and manage AMC/Army extramural research program consistent with Army tech-base strategy and policy

- Serve as Army/AMC basic research advocate and spokesman
- Provide Army R&D management with technology assessments and forecasts
- Oversee and manage special Army programs and initiatives

RESPONSE TO THE TERMS OF REFERENCE (TOR)

- a. Evaluate ARO's conduct of the Army Materiel Command's extramural basic research program and recommend how it can be improved.

The general opinion of those that the Committee interviewed was that ARO has done an excellent job of managing the extramural basic research program. The Committee also concluded that ARO has very good working relationships with the university community. This is true to a great degree because the Director of ARO and Division Directors of ARO are competent scientists/program managers who have maintained their scientific competence through active participation in research and teaching at the research triangle universities. Because of this they have gained the confidence of university researchers. It should be noted that, because of time constraints, the Committee did not have an opportunity to interview members of the University Community. The observations presented above are based on discussions with representatives from AMC, ARO, and the Laboratories and Centers as well as experiences and insights of the Committee.

Selected examples (both historical and current) of contributions that ARO extramural programs have made to Army basic science needs are listed in Attachment D.

In response to the inquiry in the TOR about ways to improve the extramural basic research program, the Committee takes the position that "if it ain't broke don't fix it." The most constructive contribution that AMC can make to the continued improvement in ARO's management of extramural research is to insure stability in funding and personnel for these programs and provide the kind of enlightened administrative support that will allow this successful program to continue.

b. Obtain required input from the technical directors of the Research, Development and Engineering Centers (RDECs) and Corporate Laboratories concerning their current and recommended future working relationship with ARO.

Representatives of the Laboratories and the RDECs generally had high praise for the role played by ARO as peer reviewer of Laboratory and Center programs. See for example paraphrased comments from Directors and Technical Directors/representatives:

- Peer review is important function of ARO--assists in establishing priorities, making budget decisions, and assessing quality of programs
- ARO plays role of honest broker--must be allowed to maintain its objectivity
- Oversight of 6.1 programs has been very helpful--ARO has been an

ally in program development.

- Laboratory people look forward to ARO review--good relationship between ARO and Laboratory scientists.
- ARO should act as peer reviewer for in-house 6.1 programs, has done good job but could do better--be more critical.

One person in AMC questioned the value of this program assessment role for ARO. This person felt that these Laboratory reviews could be counter-productive or even divisive. However, as indicated above, the Committee found quite the opposite to be true. This program review is an important and constructive contribution that ARO makes to the Laboratories and Centers and should be continued. Every effort should be made in the future to protect ARO's objectivity in carrying out this function.

Other relationships between ARO and the Laboratories and Centers that have been successful in varying degrees include the following:

- ARO acts as extramural funding agent for much of the Army and provides Laboratory and Center scientists access to this research. This has included instances where Laboratory scientists have brought problems to ARO and ARO has assisted in the solution of these problems through the funding of extramural research--in some cases long-term research projects. Long-term basic research of this type would have been difficult if not impossible to do in-house. The Committee was also informed of an example where an idea (GaAs) introduced to a Laboratory by ARO became the major area of work in that Laboratory and led to a number of new ventures.

- ARO provides a contact to University faculty and students.

In the review of ways to improve future relationships between the Laboratories and Centers and ARO, the Committee noted considerable concern among those interviewed about the level of involvement of Laboratory and Center scientists in ARO's University Research Initiative (URI) Centers. Several Directors and Technical Directors commented on the lack of or limited involvement of their scientists and engineers in these URI Centers. In some cases this concern was stated more broadly to include interaction with University scientists in general. There is a pervasive interest among Army Laboratory scientists for more interaction with university scientists and these Laboratory scientists see ARO as the facilitator in this interaction. ARO should give careful consideration to how it can best perform this role and should make a strong commitment to provide this service to the Laboratories and Centers.

c. Compare ARO's Performance and Organization with the Navy's Office of Naval Research and the Air Force's Office of Scientific Research.

ARO is currently placed lower in the organizational structure than either the Office of Naval Research (ONR) or the Air Force Office of Scientific Research (AFOSR). ONR reports directly to the Chief of Naval Research who reports to the Assistant Secretary of the Navy (Research, Engineering, and Systems). The AFOSR reports to the Systems Command Deputy Chief of Staff for Technology who reports to the Commander, Air Force Systems Command. The Deputy Chief of Staff in his role as TEO also

reports to the Assistant Secretary of the Air Force for Acquisition.

Since March, 1991, ARO has been reporting to the Director of Corporate Laboratories (DCL) in LABCOM; previous to March, 1991, ARO reported to the Deputy Chief of Staff for Technology, Planning and Management (DCSTPM). The DCSTPM is a Major General who concurrently serves as Commanding General, LABCOM. The DCL reports to the Commanding General (CG), LABCOM. The CG, LABCOM, reports to AMC and AMC reports to the Chief of Staff of the Army. The Commanding General of AMC coordinates 6.1 programs with the Assistant Secretary of the Army (Research, Development, and Acquisition).

The responsibilities of ARO in the management of 6.1 basic research programs are more limited than those of ONR or AFOSR. ONR manages all Navy 6.1 money and allocates funds to Universities, Navy Corporate Laboratories, and ILIR programs. According to ONR representatives with whom we met, this allows ONR to coordinate the total basic research program including long-term planning and short term adjustments. ONR is also an active participant in the Navy acquisition decision process. The AFOSR manages all Air Force 6.1 money except the ILIR funds. The Director of AFOSR stated that he could not effectively do his job without this control. ARO manages approximately one third of the Army's 6.1 basic research funds. While ONR and AFOSR have responsibility for both internal and external basic research programs, ARO's responsibilities are limited primarily to the management of extramural programs. Roughly one third of the 6.1 funds are managed by the Army Laboratory system

and the remaining funds are administered by the Surgeon General, the Corps of Engineers, and the Army Research Institute. This places the responsibility for overall management and coordination of the Army 6.1 basic research program in ASARDA rather than in ARO.

Given the responsibilities assigned ARO by the Army, it has performed well, but it is clearly not performing the same functions being performed by ONR and AFOSR nor has ARO been assigned the same level of responsibilities assigned to the other two organizations.

d. Recommend how ARO may improve transition of its extramural research product to ARL, RDECs and the Army as a whole.

This is the area of ARO's performance that the Committee detected the greatest concern among those interviewed (we earlier noted the related concerns about involvement of Laboratory scientists in the URI programs). Otherwise strong supporters of ARO questioned how effectively ARO has transferred extramural research to the laboratories. Yet there were a number of examples where this transition has taken place very effectively. Also, more than one person pointed out to the Committee that this is a two-way street--there must be someone in the Laboratory willing to receive and apply the information to Army needs. One Laboratory representative observed that Laboratory Directors must insure that there is a receiver of the information in the Laboratory. Several people also observed that the transfer of basic research occurs most effectively between technical people "scientist to scientist." There is little question, however, that in the view of some senior managers the exchange has not been as effective as they would like.

But, there persists in the minds of the Committee the impression that the transfer of basic information between ARO scientists/program managers and Laboratory scientists is taking place reasonably effectively. This is happening in the following ways:

- Conferences and workshops presented by ARO involving Laboratory/Center scientists and University scientists--often at Laboratory sites.
- Involvement of Laboratory/Center scientists and engineers in the preparation of Broad Agency Announcements and review of proposals submitted to ARO for extramural research.
- Laboratory/Center scientists and engineers serving on URI/Centers of Excellence evaluation panels.
- ARO bringing Laboratory and University scientist together to solve a specific problem--often originating in a Laboratory or Center.

In summary, while we believe basic research results from ARO's extramural programs are being transferred to the Laboratories and Centers through several mechanisms, there is sufficient concern among Army research managers to suggest that ARO should redouble its efforts in this area. The following are some possible approaches:

- Form Board of Directors consisting primarily of Laboratory and Center Directors or Technical Directors to advise ARO on research priorities and transfer of research results. The AMC Tech Base Board of Directors may provide an appropriate forum for this interaction.

- Establish a Basic Science Institute within ARL (i.e., associate all basic scientists in ARL in some formal way) to act as the primary contact point and transfer vehicle between ARO and ARL. This Institute would be similar to the Naval Research Laboratory and would be the primary recipient of ARL's 6.1 money. Initially the Institute would be composed of senior scientists (S&T's) representing the Divisions of ARL and the Center. ARO would have close ties to the Institute; possibly through permanent or rotating assignment of some ARO staff to the Institute. You may also wish to consider reciprocal rotation of some Institute personnel at ARO's Research Triangle location.
- Place Director of ARO on the Board of Directors of ARL to act as spokesman for the Army's basic science needs.

e. Recommend how the Army can realize the most benefit from ARO reporting to AMC Headquarters as LAB 21 is implemented.

There are four roles performed by ARO that a large majority of those interviewed by the Committee judged to be very important. These are:

- Through its comprehensive interaction with Universities, ARO acts as the Army's primary contact to the basic research programs in the University community.
- ARO acts as objective peer reviewer for Army Laboratories and RDECs. This review role has been successful because Laboratory and Center Directors believe that ARO is an objective, "honest broker" in this process.

- ARO serves as the Army's principal basic research advocate.
- ARO has established successful working relationship with ONR, AFOSR, and other federal laboratories.

In the opinion of the Committee, all of these roles are greatly enhanced by ARO reporting directly to AMC Headquarters. While there is certainly some diversity of opinion, the great majority of those that the Committee interviewed from AMC, ARO, the corporate Laboratories and the RDECs support this organizational structure. The ideal reporting arrangement would be to the Commander of AMC or to the Deputy Commanding General for Research, Development, and Acquisition, AMC, to be most consistent with the above roles. This reporting structure would also allow the Commanding General of AMC the option to assign ARO an active role in the allocation and management of 6.1 resources in AMC Laboratories and Centers.

The placement of ARO in the organizational structure is, of course, related to the role that the Army leadership envisions for ARO in the Army's technology base programs. One way to increase the probability that basic research is closely related to Army needs is to include an organization whose principal business is basic research in the higher echelons of the Army's acquisition and planning structure. Also, the other services have found it advantageous to manage all or most of their 6.1 resources in a single research office (ONR, AFOSR). It is the Committee's understanding that this has effectively integrated the basic research programs into the Air Force and Navy technology base programs and allowed more effective stewardship of limited resources. Currently, the Army does not have any organization,

other than ARO, with the staff, organization, and broad technical competence to manage 6.1 programs on an Army-wide basis. It is not clear to the Committee how the Army's present management structure provides for the effective coordination of all basic research programs in response to Army needs or what mechanism exists for quality control of 6.1 programs throughout the Army. And, finally, what organization, other than ARO, can provide the Army a window to the Academic world? Should the Army decide to give ARO these broader responsibilities and also insure its independence and objectivity, then it seems reasonable to consider placing ARO administratively directly under ASA(RDA), reporting to the Deputy Assistant Secretary for Research and Technology.

The Committee noted that the BRAC report recommended the creation of an ARO Washington Office (five people) "to improve coordination and research transfer between in-house research of CMRL and the Extramural Research Program of the Army Research Office, Research Triangle Park, NC." It is the Committee's understanding that the LAB 21 report recommended that the ARO Washington Office provide support to ASA(RDA) in policy formulation for the development of Army Technology Base programs and laboratory management. Such an office can also assist ASA(RDA) in the coordination of 6.1 programs across the Army. The Committee believes that the ARO Washington Office, performing the duties just discussed, can significantly enhance the performance of ASA(RDA).



DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, DC 20310-0103

9 DEC 1991

TO: SARD-ZT

A copy of the Independent Assessment of
the U.S. Army Research Office is forwarded for
your information.

A handwritten signature in cursive script, reading "Charles H. Church".

Charles H. Church
Acting Executive Secretary
Army Science Board

Attachment



DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, DC 20310-0103

9 DEC 1991

TO: ASA(RDA)

A copy of the Independent Assessment of the
U.S. Army Research Office is forwarded for your
information.

A handwritten signature in cursive script, reading "Charles H. Church".

Charles H. Church
Acting Executive Secretary
Army Science Board

Attachment



DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, DC 20310-0103



8 JUL 1991

Dr. Duane A. Adams
Associate Dean
School of Computer Science
Carnegie Mellon University
Pittsburgh, Pennsylvania 15213-3809

Dear Dr. Adams:

A number of recent studies of federal laboratories have pointed out the importance of external effectiveness reviews as a means of assuring the continuing excellence of the institutions. Accordingly, I ask that you initiate an Army Science Board Independent Assessment of the Army Research Office (ARO). Based on independent observations, the Independent Assessment should:

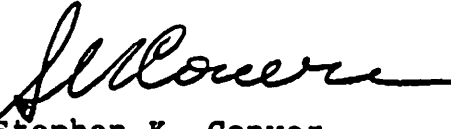
- a. Evaluate ARO's conduct of the Army Materiel Command's (AMC's) extramural basic research program and recommend how it can be improved;
- b. Obtain required input from the technical directors of the Research, Development and Engineering Centers (RDECs) and Corporate Laboratories concerning their current and recommended future working relationship with ARO;
- c. Compare ARO's performance and organization with the Navy's Office of Naval Research and the Air Force's Office of Scientific Research;
- d. Recommend how ARO may improve transition of its extramural research product to CMRL, RDECs and the Army as a whole; and
- e. Recommend how the Army can realize the most benefit from ARO reporting to AMC Headquarters as LAB 21 is implemented.

General Tuttle, Commander, AMC is the Sponsor. Mr. George T. Singley III, Deputy Assistant Secretary for Research and Technology, OASA(RDA) will serve as the Cognizant Deputy. LTC Albert Sciarretta will serve as the Staff Assistant.

It is not anticipated that your inquiry will go into any "particular matters" within the meaning of Section 208 of Title 18, United States Code.

The Independent Assessment should begin as soon as possible and complete its review by August 31, 1991.

Sincerely,

A handwritten signature in cursive script, appearing to read "S. Conver", written in black ink.

Stephen K. Conver
Assistant Secretary of the Army
(Research, Development and Acquisition)

List of People Interviewed

1. On 5 August 1991, the Committee met with:

GEN William G. T. Tuttle, Jr.
Commanding General
U. S. Army Materiel Command
Alexandria, VA

Dr. Richard Chait
Chief Scientist
U. S. Army Materiel Command

Mr. Darold L. Griffin
Principal Assistant Deputy for
Research, Development and Acquisition
U. S. Army Materiel Command

MG Jerry C. Harrison
Commanding General
U. S. Army Laboratory Command
Adelphi, Maryland

Mr. Richard Vitali
Director of Corporate Laboratories
U. S. Army Laboratory Command

2. On 13-14 August 1991, the Committee met with:

Dr. Gerald J. Iafrate
Director
U. S. Army Research Office
Research Triangle Park, NC

Dr. George A. Neece
Office of the Director
Research and Technology Integration
U. S. Army Research Office
Research Triangle Park, NC

Dr. Robert G. Ghirardelli
Chemistry and Biological Sciences Division
U. S. Army Research Office

Dr. James W. Mink
Electronics Division
U. S. Army Research Office

Dr. Robert E. Singleton
Engineering Sciences Division
U. S. Army Research Office

Dr. Walter A. Flood
Geosciences Division
U. S. Army Research Office

Dr. Andrew Crowson
Materials Science Division
U. S. Army Research Office

Dr. Jagdish Chandra
Mathematical Sciences Division
U. S. Army Research Office

Dr. Bobby Guenther
Physics Division
U. S. Army Research Office

3. On 20 August 1991, the Committee met with:

Dr. Thomas Davidson
Technical Director
U. S. Army Armament Research, Development
and Engineering Center
Dover, NJ

Mr. Anthony V. Campi
Technical Director
U. S. Army Communications-Electronics
Command (CECOM)
Center for Research, Development and Engineering
Fort Monmouth, NJ

Dr. Rudolf Buser
Director
CECOM Center for Night Vision and Electro-Optics
Fort Belvoir, VA

Dr. Richard Rhodes (by phone)
Associate Director for Systems
U. S. Army Missile Command
Redstone Arsenal, AL

✘ Dr. John T. Frasier (by phone)
Director
U. S. Army Ballistic Research Laboratory
Aberdeen Proving Ground, MD

✘ Dr. Arthur Ballato
Principal Scientist
U. S. Army Electronics Technology
and Devices Laboratory
Fort Monmouth, NJ

✘ Mr. Jerry Reed
Director
U. S. Army Harry Diamond Laboratories
Adelphi, MD

Dr. Helmut Hellwig
Director
Air Force Office of Scientific Research
Bolling Air Force Base
Washington, DC

Dr. Gene Silva
Deputy Director
Office of Naval Research
Arlington, VA

Dr. John Cornette
Assistant Director for Planning and Integration
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Dr. Ted Berlincourt
Office of the Deputy Director
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24 June 1991

Participants List

**Army Science Board Independent Assessment
of the
U.S. Army Research Office**

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COGNIZANT DEPUTY

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for Research and Technology
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~~Dr. Gary A. Thiele
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5
TECHNICAL ADVISORY (CONTINUED)

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Air Force

Dr. Helmut Hellwig
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202-767-5017

ATTACHMENT D

CONTRIBUTIONS TO ARMY FROM EXTRAMURAL RESEARCH SUPPORTED BY ARO

- Development of new hydrogen compounds of boron leading to the development of high energy fuels for rocket motors and missile propellants. Nobel Prize, 1979.¹
- Studies on catastrophic failure in metals leading to extended life of helicopter blades.¹
- Superlattices studies in the field of semiconductors. Nobel Prize, 1973.¹
- High efficiency diode pumped lasers
- Table top vacuum ultraviolet laser
- Holographic sensor protection
- Ultra-fast, high resolution liquid crystal display
- Image processing at X100 speed
- Pioneered X-ray lithography for ultrahigh performance electronic devices
- First growth of HTC superconductors by MBE
- Record performance GaAs microprocessor
- Singars error-control technique
- Performance records for a wide class of MIMIC's
- Pioneered computer aided design (SPICE, SUPREME, PISCES)
- Real time video tracking

- Novel laser generated pulse technique for studying dynamic behavior of materials
- Evaluation of shear response in ceramics by oblique impact test
- Constitutive model for predicting localized deformation and shear banding at high strain rates
- Micromechanical modeling of dynamic void collapse and void growth in crystalline solids
- Catalysts for chem/bio decontamination
- Decomposition dynamics of RDX
- Semiconductor clusters of Si_n , Ge_n , Ga_nAs_m
- Economic polyphosphazene synthesis
- Optimal control of molecular motion
- Structural coupled composite blade dynamics
- Jet atomization fundamentals
- Numerical techniques for helicopter aero
- Combustion of programmed splitting stick propellents
- High temperature lubrication concept

¹Sharlin, Harold I., Today's Science, Tomorrow's Advanced Technology, ARO, 1991.