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REPORT ON THE FY 1986 ACTIVITIES OF THE DEFENSE SCIENCE
STUDY GROUP VOLUME (U) INSTITUTE FOR DEFENSE ANALYSES
ALEXANDRIA VA R J BERGMANN MAY 87 IDA-M-389-VOL-1

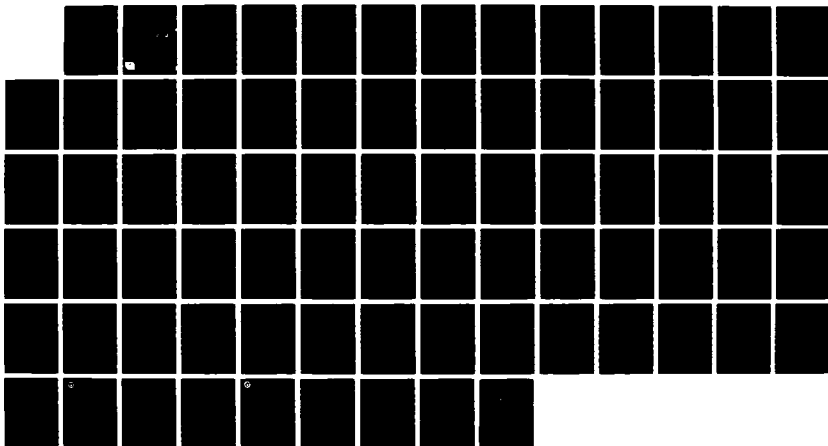
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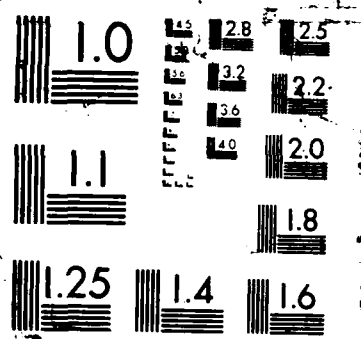
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IDA MEMORANDUM REPORT M-309

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DEFENSE SCIENCE STUDY GROUP

Volume I

Richard J. Bergemann

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May 1987

Prepared for
Defense Advanced Research Projects Agency

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IDA Log No. HQ 87-32091

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SECURITY CLASSIFICATION OF THIS PAGE

AD-A191132

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.		
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE					
4. PERFORMING ORGANIZATION REPORT NUMBER(S) IDA Memorandum Report M-309			5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION Institute for Defense Analyses		6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION		
6c. ADDRESS (City, State, and Zip Code) 1801 N. Beauregard Street Alexandria, VA 22311			7b. ADDRESS (CITY, STATE, AND ZIP CODE)		
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Defense Advanced Research Projects Agency		8b. OFFICE SYMBOL (If applicable) DARPA/ISTO	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER MDA 903 84 C 0031		
8c. ADDRESS (City, State, and Zip Code) 1400 Wilson Boulevard Arlington, VA 22209			10. SOURCE OF FUNDING NUMBERS		
			PROGRAM ELEMENT	PROJECT NO.	TASK NO. A-103
			WORK UNIT ACCESSION NO.		
11. TITLE (Include Security Classification) Report on the FY 1986 Activities of the Defense Science Study Group--Volume I					
12. PERSONAL AUTHOR(S) Richard J. Bergemann					
13. TYPE OF REPORT Final		13b. TIME COVERED FROM Dec.85 TO Nov. 86		14. DATE OF REPORT (Year, Month, Day) May 1987	
				15. PAGE COUNT 73	
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP	Defense Science Study Group, defense technology, defense-related academic research, young scientist program, defense science research		
19. ABSTRACT (Continue on reverse if necessary and identify by block number)					
The principal objective of the Defense Science Study Group (DSSG) is to reestablish and strengthen links between the Department of Defense and the scientific and engineering communities by fostering an interest among some of the country's most promising young scientists in some of the most important technical issues related to national security. Volume I of this report on the FY 1986 activities of the DSSG presents a description of the DSSG program and a summary of its first year of activity. Volume II contains copies of the unreviewed technical papers and proposals produced during the research phase of the program.					
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS				21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
22a. NAME OF RESPONSIBLE INDIVIDUAL Richard J. Bergemann				22b. TELEPHONE (Include Area Code) (703) 578-2881	22c. OFFICE SYMBOL

UNCLASSIFIED

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Volume I

Richard J. Bergemann



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DTIC TAB	☐
Unannounced	☐
Justification	
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Availability Codes	
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INSTITUTE FOR DEFENSE ANALYSES

Contract MDA 903 84 C 0031
DARPA Assignment A-103

ACKNOWLEDGMENTS

An undertaking as diverse in scope and people as the DSSG program requires the combined efforts of a few dedicated individuals to plan, organize, develop, and administer. I am most grateful to Ms. Nancy P. Licato, who has the overall administrative responsibility, plus the organizing of some technical sessions, the coordinating of all sessions and arranging the field trips; to Mr. Richard J. Bergemann, who I rely on for innovative ideas, planning and development, for organizing some technical sessions, and for writing Volume I of this report; to Dr. Maile E. Smith, who helped in originating the basic ideas and approach of this program and who assists in the planning and development; and to the other staff from the Science and Technology Division of IDA who we called upon to assist from time to time and who readily gave of their knowledge and time.

I am grateful to the mentors who, despite their busy schedules, made the time to join the Group in its educational briefings, field trips and for just being there when their advice was sought.

Finally, I want to thank the participants for their enthusiastic reception to each new learning experience and for their critical appreciation.

The success of the first year of the DSSG is due to the hard work, dedication, and persistence of my staff, the sustained interest of the participants, and the enthusiastic support and encouragement of the mentors.

Robert E. Roberts
Program Director

ABSTRACT

The principal objective of the Defense Science Study Group (DSSG) is to reestablish and strengthen links between the Department of Defense and the scientific and engineering communities by fostering an interest among some of the country's most promising young scientists in some of the most important technical issues related to national security. Volume I of this report on the FY 1986 activities of the DSSG presents a description of the DSSG program and a summary of its first year of activity. Volume II contains copies of the unreviewed technical papers and proposals produced during the research phase of the program.

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Radar Countermeasures

I. INTRODUCTION

Today's complex technical issues associated with national defense require the attention of the best scientists and engineers in the country. From World War II until the Viet Nam War, a close link existed between the elite of the scientific community and the defense establishment. This link not only helped ensure that the nation's defense needs were met, but also provided knowledgeable technical criticism of the highest quality. The Viet Nam War substantially weakened this link, depriving the defense establishment of access to many of the country's most talented researchers for both contributions and informed criticism.

A long-standing strength of the Institute for Defense Analyses (IDA) has been its ability to provide an atmosphere in which the scientific community could become aware of the specific technical content of national security issues and in which scientists could carry out academic research on defense-related technical problems. Recognizing this, the Defense Advanced Research Projects Agency (DARPA) established the Defense Science Study Group (DSSG) at IDA to identify a select group of young scientists and engineers in the country outside of the defense community and expose them to the major technical problems of national defense.

A. OBJECTIVE

The principal objective of the Defense Science Study Group (DSSG) is to reestablish and strengthen links between the Department of Defense and the scientific and engineering communities by fostering an interest among some of the country's brightest young scientists in the technical aspects of national defense issues. This is accomplished in a program that combines education on a broad range of defense topics with independent research on technical defense problems of interest. Program participants acquire an understanding of the difficulty and importance of national defense issues and an appreciation for the technical competence of the defense community. It is hoped that

participants will provide new insights on defense problems as a result of their research activities, guide some of the most promising students of today into defense careers and play an active role in the defense community in the future. The program seeks to foster a more complete understanding of the broader issues associated with the defense of this country among those individuals who are likely to be among the most influential and respected members of the scientific and engineering community of tomorrow.

B. APPROACH

The Defense Science Study Group is primarily academically based and is characterized by its multidisciplinary nature and the rigorous and careful processing that is followed to select participants. Candidates are identified by mentor nomination and suggestions made by organizations such as the National Science Foundation, the Office of Science and Technology Policy, and the Sloan Foundation. Nominations are also taken from outstanding individuals in any field of science or technology. The selection of candidates invited to join is made by IDA after consulting with a variety of senior individuals for references and after the candidate has been approached to establish interest in the program. The maximum length of time that participants can remain in the program is three years. A list of the 14 individuals who were invited to join the DSSG in FY 1986 can be found in Appendix A.

A group of senior mentors who have had distinguished careers in defense or academia serve as advisors. They help identify candidates, suggest defense problems of importance to study, advise IDA on the conduct of the program, independently review the technical work accomplished and assess the overall success of the program. A list of the mentors to the DSSG in FY 1986 can also be found in Appendix A.

The Institute for Defense Analyses directs and administers the DSSG program and gives it continuity. It selects all participants, organizes the program's agenda, arranges all program activities and provides the necessary administrative support. In addition, by virtue of its own active defense research and analysis program, it provides a convenient source of in-house expertise on a variety of defense topics. IDA is also responsible for identifying those within the defense community who are most likely to benefit from the work of the DSSG.

DARPA functions as the program sponsor. It provides guidance to the program, assists in developing the program's technical agenda and is the direct recipient of the results of the DSSG's activities.

DSSG activities are split between education and research. The educational portion of the program is structured around a number of major national security issues. The introduction to these topics includes presentations and seminars by defense experts and organized travel to major defense facilities.

Research activities are conducted by the participants who choose their own topics within very broad guidelines. Participants work alone or organize themselves into groups as they see fit. They are provided access to both classified and unclassified resources through IDA. Participants are encouraged to work on research projects when the DSSG is not formally in session and the IDA facilities and services are available to the participants upon request.

II. DEFENSE SCIENCE STUDY GROUP PROGRAM FOR FY 1986

The principal objectives during the first year of the DSSG were: (1) to select an initial set of participants and mentors; and (2) to develop and demonstrate the operating procedures of the DSSG. Selection of participants and mentors was complete prior to the DSSG's introductory meeting.

An education and research program was successfully conducted throughout FY 1986. The success of the overall program has been assessed and preliminary plans for FY 1987 have been developed. A description of the DSSG's activities, a program assessment and future plans follow.

A. ACTIVITIES

In its first year of operation, the DSSG convened five times as shown in Figure 1. Appendix B contains the agendas for each DSSG meeting held and Appendix C contains a set of minutes that were prepared for all but one of the meetings by the participants. The purpose, format, synopsis of activities and outcome of each meeting are described in more detail in the following sections.

FIGURE 1. Schedule for FY 1986

Introductory Session	December 8-9, 1985
Overview Session	April 19-21, 1986
First Working Session	July 14-24, 1986
Second Working Session	September 3-12, 1986
Review Session	November 7-8, 1986

1. Introductory Session

The purpose of the first meeting of the DSSG was twofold: (1) to have all the participants and mentors get acquainted; and, (2) to receive an introduction to defense technology problems. A reception was held on the first day. The second day consisted of talks and open discussions on the role of technology in national defense.

The meeting on Monday, December 9, was chaired by Stephen Berry, one of the program mentors from academia. It began with a welcome from General W.Y. Smith, President of IDA. General Smith explained why IDA came into existence and its mission. The program director, Robert E. Roberts, spoke next about the goals and objectives of the DSSG. He drew the group's attention to a list prepared by mentor Alexander Flax of outstanding scientific and technical problems that the DSSG might address. This list can be found in Figure 2.

James Tegnalia, Deputy Director of DARPA, next gave a presentation on the history of DARPA. DARPA is staffed by managers with substantial backgrounds in science or technology, who initiate advanced technology projects, pushing the state-of-the-art. One of its current concerns is the relationship between DARPA and the universities.

John McTague, Deputy Director of the Office of Science and Technology Policy (OSTP) spoke on the subject of defense science and technology and the creation and utilization of science. He stated that he feels that the national security depends on advances in technology.

Mentors Lew Allen, Eugene Fubini, and William Press gave their differing perspectives on the subject of defense science and technology and why fresh views by the participants are needed. Lew Allen spoke about the need for technical superiority and a balance in electronics warfare and tactics. Eugene Fubini gave a view on the Army, Navy and Air Force. William Press discussed the question of why candidates should participate in a program such as this.

Two open discussion sessions were held, chaired by mentors S.S. Penner and Peter Carruthers, respectively. Mentor Martha Krebs, who has had past Congressional experience, attempted to characterize the different points-of-view held by the academic community and the Congress. While the academic community tends to think in terms of

FIGURE 2. Topics In Defense Science and Technology

Basic Research

Autoionization of High Density Metastable Helium
Nutrino Detection
Speech
Nanosecond Timing
Advanced Accelerators
X-ray Lasers
Free Electron Lasers
Computing Technologies
Very High Speed Integrated Circuits
Particle Beam Technology

Antisubmarine Warfare (ASW)

Torpedo Lethality
Attaching Contaminants to a Submarine
Underwater Vision
Physics of Sea Surface Scattering
Non-Acoustic ASW

Monitoring the Soviet Union

Soviet Ballistic Missile Defense
Indicators of a Soviet SDI
Drag Reduction: Soviet Research Program
Comprehensive Test Ban
Seismic Discrimination between Nuclear Tests and Earthquakes

(continued)

FIGURE 2 (continued)

Tactical Warfare

Radar Camouflage
Non-magnetic Remotely Piloted Vehicles (RPV's)
Synthetic Aperture Radar
Chemical Warfare
Anti-Tactical Missiles
Water Support of U.S. Forces in an Arid Environment
NATO TacAir Ground Survivability
Technology for Rapid Development Forces
Mapping, Charting, and Geodesy
Forward Area Laser Weapons
Fire Support for Amphibious Warfare
Urban Warfare
Counter Command, Control and Communications
Naval Counter Command, Control and Communications
Space Based Radar and Infrared Detection

United States and Strategic Warfare

EMP Hardening of Aircraft
Strategic Defense
Space-Based Laser Weapons
Ionospheric Effects of Nuclear Explosions
Nuclear Winter
Use of and Defense Against Cruise Missiles
Arms Control Implications of SDI Technologies
Midcourse Discrimination and Space Object Identification
Defense Nuclear Agency Cratering Program

(continued)

FIGURE 2 (continued)

United States and Strategic Warfare (continued)

- Review of the Defense Nuclear Agency
- MX Closely Spaced Basing
- Conventional Munitions and the Nuclear Threshold
- Long Endurance Aircraft
- Continuous Patrol Aircraft

Miscellaneous Studies

- Review of the Plutonium Special Isotope Separation Program of the DOE
- Fusion Fission Hybrid Reactors
- Improved Techniques for Wavefront Sensing and Correction in Adaptive Optics
- Hypervelocity Launchers
- Underground Facilities
- Automated Software Programming
- Reducing the Unit Cost of Equipment
- University Responsiveness
- Joint Service Acquisition Programs
- The U.S. and its Security Partners
- Training and Training Technology

facts and solutions, Congress most often deals with issues, options, and what is reasonable.

Alexander H. Flax next spoke about outstanding technological issues in defense. A synopsis of his views can be found in Section III.

As a result of the first meeting, 15 of the 16 candidates indicated their interest in taking part in the DSSG. In addition, they identified eight topical areas in which they had interest. The topics of principal interest were (1) technologies for surveillance and verification of arms control agreements; (2) sub-orbital planes; (3) sensing (including radar

and infrared) and image processing; and (4) technology of anti-terrorism. The topics of secondary interest were (5) anti-satellite weapons; (6) strategic and battlefield C³I; (7) cryptography; and (8) stealth technology.

2. Overview Session

The purpose of the second meeting was to present a top level technical and programmatic introduction to some of the defense topics that were identified by the DSSG at the December meeting. Criteria used in selecting topics for inclusion in the April meeting were DSSG interest, DARPA's interest, security considerations and IDA's assessment of whether it could put together a high quality program commensurate with the technical capabilities of the participants. The final selection of topics was made after consulting DSSG members.

Four half-day sessions were put together covering the areas of Command, Control, Communications and Intelligence (C³I); Technologies for Surveillance and Arms Control Verification; the Aerospace Plane; and Sensors and Image Processing. In addition, at the request of DARPA, a short session was scheduled on the DARPA Strategic Computing program. One half day was also set aside to discuss topics and activities that would be pursued during the two summer sessions.

The different sessions featured senior government officials, defense specialists, academics and industry experts. Among the speakers to the DSSG during the April meeting were Donald C. Latham, Assistant Secretary of Defense for Command, Control, Communications and Intelligence (C³I); Charles Fowler, Chairman, Defense Science Board; Jack P. Ruina, Director of the MIT Defense and Arms Control Studies Program and former Director of DARPA; William Brown, President of the Environmental Research Institute of Michigan; Azriel Rosenfeld, Director of the Center for Automation Research at the University of Maryland; and John Erdos, Vice President of General Applied Science Laboratory. These distinguished speakers and others discussed the technical details of selected defense problems, the overall context in which they arise and the elements that make them so important.

This second meeting led the DSSG to focus on three topics to explore in much greater detail during the summer. They were (1) the monitoring of Soviet missile tests;

(2) the survivability of integrated C³I; and (3) the evolution of space launch capabilities: implications for the aerospace plane. A description of these topical areas of interest as developed by the DSSG can be found in Appendix C.

3. First Working Session

The purpose of the first summer session of the DSSG was to learn more about the three topical areas of interest identified in April in preparation for independent research activities that would be undertaken later in the summer. The July summer session consisted of three intensive 2-day programs at IDA and a 4-day visit to defense facilities in Nebraska and Colorado. The session was designed to emphasize a defense perspective, a defense rationale, the technological aspects of the topics considered, tutorial presentations and a sense of the feasibility of engineering goals where stated. Moreover, the program was designed in light of the diverse background of the participants.

The two-day session on the Monitoring of Soviet Missile Tests included presentations on the Soviet threat, surveillance phenomenology and relevant technologies. The speakers to the DSSG on this topic included Peter Zimmerman, a William C. Foster Fellow at the U.S. Arms Control and Disarmament Agency; Garry Devinger of the Defense Intelligence Agency; Peter Daniher of the Central Intelligence Agency; and Isaac Weissman, Executive Director, Riverside Research Institute. In addition, the DSSG visited the U.S. Army Night Vision and Electro-Optics Center to hear about the development of tactical sensors and see them demonstrated.

The two-day session on the Survivability of Integrated Command, Control, Communications and Intelligence (C³I) focused on the strategic aspects of the problem. It started off with a one-half day visit to the Pentagon for an overview and a visit to the National Military Command Center and the hotline between Washington and Moscow. Other topics covered included warning system technologies and collateral effects of nuclear detonations. During this period, the DSSG also heard invited addresses by General Andrew Goodpaster, U.S. Army (Ret'd), former Supreme Allied Commander, Europe and John Grimes, Director of National Security Telecommunications and the Director of Defense Programs (C³) for the National Security Council.

The final two-day session at IDA on the Evolution of Space Launch Capabilities: Implications for the Space Plane reviewed lessons learned from aerospace program development and explored the technical challenges in future space access systems. Topics covered included propulsion, fluid dynamics, materials and ground processing. Special invited talks were given by Victor Reis, Vice President of Science Applications International (SAI) and Thomas Paine, Chairman of the National Commission on Space.

With the end of the sessions at IDA, the DSSG traveled to SAC Headquarters in Omaha, Nebraska. Following briefings and a tour of the facility, the DSSG proceeded to Colorado Springs where it visited the NORAD Operations Center at the Cheyenne Mountain Complex, Peterson Air Force Base and Falcon Air Force Station. Following this, a brief visit was made to the U.S. Air Force Academy and to Buckley Air National Guard Base. The visits ended at Martin-Marietta outside of Denver with a tour of their robotics research facilities and a briefing and tour of the autonomous land vehicle, an experimental moving test bed for the development of artificial intelligence systems and advanced computer architectures.

4. Second Working Session

The purpose of the 10-day working session of the DSSG in September was to provide time to identify and research outstanding technical problems suggested by the previous sessions. An initial set of potential research topics was developed at the end of the first working session by the DSSG and can be found in their minutes located in Appendix C. Most of the effort during this session went into the following topics: imaging concepts; missile volume as an arms control constraint; composite materials; mercury cadmium telluride; and radar countermeasures. Research on other topics was also pursued.

DSSG members both worked individually and in small groups. This led to a flexible organization and multidisciplinary approach to problems considered. DSSG members also tended to make contributions to several topics. While independent research was pursued, some activities focused on developing sound proposals for future research in subsequent years.

In addition to DSSG research activities, Dr. Herbert York addressed the members as a special invited speaker. He discussed his recent conclusions on U.S.-Soviet offensive and defensive initiatives over the past 40 years. Dr. York is currently the Director, Science, Technology and Public Affairs, University of California, San Diego, and his distinguished career has included the positions of first Chief Scientist to DARPA, first Director of Defense Research and Engineering (DRE) and first Director of Lawrence Livermore Laboratory.

5. Review Session

The final session of the DSSG in FY 1986 was directed at finishing up all technical activities for the year and presenting the results of these efforts to IDA, DARPA and the program's mentors. One day was allocated for additional research and one day for presentations and discussions. These discussions were with mentors and participants on program strengths and weaknesses and on the preliminary plans for FY 1987.

The technical papers that were produced by DSSG members and that were reported on at this session can be found in Volume II.

B. ASSESSMENT

The objectives for the first year of this program were to select an initial set of participants and set up a mode of operation that would address the overall objective of the program. These limited objectives were accomplished. A group of 14 of the best young scientists in the country today were successfully identified and did join the program. A balanced program of education and research was also successfully developed.

It is, however, too early to assess whether the program is meeting its overall objective. It had been planned from the beginning that each participant would spend up to three years in the program. It is clear that the members will need a significant amount of that time to learn about defense in general and issues of defense technology in particular. Research activities and papers also still need to be completed, or peer reviewed or shown to be relevant to defense problems of importance. The satisfaction of more general objectives

such as a strengthening of DoD's ties with universities will only become apparent with time.

Some observations nevertheless can be made which indicate progress toward the program's objective. The vast quantity of technical information on DoD programs and problems that was conveyed clearly left a positive impression on DSSG members and dispelled some misconceptions about defense. DSSG members acquired a real appreciation for the complexity of defense issues and technologies, the general competence of the military personnel and civilians working these problems and the involved nature of the decisionmaking process within DoD and the government. There are indications that some DSSG members are genuinely interested in pursuing defense research and many others have started to think seriously about defense problems for the first time. In fact, the positive feedback from the DSSG members over the course of the year coupled with their unanimous wish to continue into the second year are good signs that the members consider the program worthwhile.

The research activities of the members already show promise. Work on composite materials for aircraft applications, detector materials and systems concepts for surveillance sensors, techniques for arms control verification and radar countermeasures all appear to represent contributions to the solution of outstanding defense problems. This is all the more remarkable given the fact that the members only worked on their projects for about two weeks. A unique and potentially powerful characteristic of the DSSG that has developed is their multidisciplinary approach to problems. This has generally resulted in the development of non-competitive working relationships and the selection of different technical approaches to problems.

General assessments by the mentors and DARPA are also positive. They are best summarized in the letters that can be found in Appendix D.

C. FUTURE PLANS

The principal objectives for the second year of the DSSG are: (1) to broaden the exposure of the DSSG participants to other aspects of defense; (2) to foster the initiation or continuation of defense related research projects; and, (3) to focus the attention of the DSSG on problems of direct interest to DARPA. Three new members will also be invited

to join and initial steps will be taken to transition the program into a staggered format so that about one-third of the membership is replaced annually.

Figure 3 shows the schedule of meetings planned for FY 1987. The principal thrust of the program will be an exploration of the key scientific and technical issues confronting the Navy.

FIGURE 3. Schedule for 1987

May 1987	A two-day meeting will be held to acquaint Program participants with defense research activities conducted at IDA and provide a Congressional perspective on defense R&D. New topics for research will be identified. Some research on ongoing projects will be continued.
July 1987	A seven-day session with a possible optimal extension will be conducted to explore selected defense research topics in more detail. The session will include visits to defense facilities.
September 1987	A nine-day session will focus on individual and group research of outstanding defense problems. Some briefings may be scheduled as requested. Draft reports on research activities will be prepared.
November 1987	A final two-day meeting will be held in order to complete technical reports, present research results and discuss the following year's program.

III. SOME OUTSTANDING TECHNOLOGICAL ISSUES IN DEFENSE

Alexander H. Flax (DSSG Mentor)

A. RECONNAISSANCE SENSORS AND WEAPON SEEKERS

Synthetic aperture radars (SARs) such as those used in aircraft are currently the only all-weather sensors suitable for wide-area imaging. Moving targets can be detected by radar within line-of-sight range as blobs, but identification is often difficult if not always so. Moving target identification (MTI) radars, to achieve wide search areas and utilize the doppler signal processing effectively, are nonimaging. Schemes have been devised to extract secondary doppler information such as that generated by the motion of the treads of tanks and other tracked vehicles, but, because these signals are weaker than the primary radar return, attempts to extract them with the present methods of processing in the presence of noise greatly reduce the effective sensor range. New, improved means of wide-area detection and identification of targets are needed, perhaps employing new processing algorithms, pattern recognition, and artificial intelligence techniques. Bistatic radar systems are not ruled out, although they are usually costly and complex to operate. They are often highly effective, particularly if coupled with antijam (AJ) and low-probability-of-intercept (LPI) capabilities. Modulation schemes such as spread spectrum are usually used to achieve the latter capabilities. More advanced coding schemes to obtain processing gains of greater than 20-30 dB are desirable.

The coupling of radar sensors for target acquisition from standoff platforms [e.g., currently the airborne Advanced Synthetic Aperture Radar System (ASARS) and the airborne MTI Pave Mover/Joint Surveillance and Target Attack Radar System (JSTARS)] with weapon delivery through missile seekers, direct command guidance, or other means is a major problem involving ambiguity in target hand-over and end-to-end time line for the process when targets are moving. When the attacking missile is equipped with a

completely autonomous target seeker, it usually has a rather short target acquisition range and must be delivered to within a small acquisition "basket".

Infrared (IR) imaging sensors (now most commonly in the 8-12 micron band but also in the 3-5 micron band) are a mainstay of U.S. tactical forces or soon will be. Such thermal IR equipment greatly enhances night capabilities and is used both on the ground and in airplanes and helicopters. Present systems generally involve scanning over relatively few detector elements, although "staring" sensors with large numbers of detector elements are in development. Cryogenic cooling to 70-80°K is required. Detector elements that did not require this much cooling would be desirable. Reduction of detector element size and increased packing density to improve resolution would also be advantageous. A serious problem of IR optical systems is vulnerability to laser energy, sometimes at surprisingly low fluxes and fluences at the sensor system aperture, because the systems amplify intensity. Electrooptical and nonlinear optical effects suggest themselves which could shutter an optical system automatically with very short time constants (down to nanoseconds)--something like a Kerr cell in effect. However, it may be that the solution to this problem lies in entirely new detector materials and phenomenology. Imaging infrared (IIR) sensors are used not only in ground-based and airborne surveillance systems but also in missile seekers such as the IIR Maverick, so a rather compact form of equipment is sought.

Millimeter-wave sensors (in the range of 30-95 GHz) have been explored in a number of R&D efforts in experimental systems. The availability of components for these sensors has improved in recent years. Target signatures at such very short wavelengths need to be better understood, but progress is being made, and it is likely that this part of the spectrum will be used more extensively in the future. Both active and passive millimeter-wave sensors are of interest.

Overlaid on the future prospects for all sensors and seekers is the problem of low observable ("stealth") vehicles, which are expected to become more common in the 1990s and beyond. Low observable vehicles have greatly reduced radar cross sections, and their other signatures, such as IR and optical, are suppressed. New phenomenology and system innovations are needed to deal with such targets. Many suggestions have been made for the use of multistatic radar, but no clearly effective system concept of broad general utility has emerged.

B. CHEMICAL AND BIOLOGICAL WARFARE DEFENSE

The major East-West adversaries have renounced first use of chemical weapons but not their production and deployment. Nevertheless, as long as inventories of such weapons exist, prudence dictates that defensive measures be available in the event that the weapons are used. In addition, it is evident that some "third world" nations have used chemical weapons, and they probably would have no compunction about doing so in the future.

After a period of neglect, the United States and a few of its allies have turned their attention to building up some "credible" levels of defense against chemical weapons. Protective clothing, group shelters, detection and monitoring equipment, and limited decontamination equipment have been acquired. However, even at their best, the burden of using these defensive measures and equipment severely limits operational effectiveness. Thus there is but limited deterrent value in maintaining a chemical defense posture only (without offensive capability), which some advocate, because a force constrained to use defensive measures will be at a substantial disadvantage with respect to a force not so constrained. However, some mix of offensive and defensive capabilities, in combination with some inherently unattractive features of chemical warfare, may suffice to deter all major powers from using such weapons, as in World War II.

From this standpoint, it would be desirable to make defensive measures more attractive and more credible by eliminating the severe discomfort and heat stress that most of the existing masks and protective clothing cause and by improving the vision and fields of view afforded. Decontaminants tend to be severely corrosive and particularly damaging to plastics, elastomers, and other organic materials, many of which are found in modern weapon systems. (A bioengineered "getter" with receptors specific to a chemical agent has been speculated on). Wet chemistry kits are still being used in the field to detect and identify chemical agents, but, with the speed of modern weapon delivery, these kits may be most useful for post-mortems. New electronic point detection equipment is being procured, but its usefulness is limited to identifying the specific agents for which it is designed and calibrated. There is no satisfactory equipment for the surveillance of wide areas for chemical agents, although a number of infrared scanning devices have reached prototype stages.

The picture with respect to biological agents is more obscure. The United States unilaterally announced that it would forego the production and deployment of biological weapons. Although protective clothing, masks, filters, and positive-pressure buildings designed for chemical defense may incidentally work against airborne biological agents, this may not always be the only mode of attack. In any event, since there is no biological agent detection and monitoring capability, no one would know when to use applicable chemical protective measures. In this age of wide diffusion of genetic engineering technology, it would seem that the entire matter of biological warfare and the development of means for protection from and control of biological agents is one that must receive continuing attention.

C. OCEAN WARFARE

Airborne operations above the sea surface and submarine operations are two of the most troublesome and yet most useful aspects of ocean warfare. It follows that naval aviation and attack submarines are two of the most important ocean warfare elements. In addition, strategic ballistic missile submarines depend for their long-term security on the virtual impenetrability of the ocean by almost all existing sensors. Yet U.S. naval forces depend on their ability to detect, identify, track, and destroy a potential opponent's submarines in order to protect major surface fleet units, especially aircraft carriers and their supporting battle groups.

The question of submarine detection and tracking is critical for both the "hiders" and "seekers" of submarines. The two principal sensors currently used for submarine detection are sonar and magnetic anomaly detection (MAD), the latter having relatively short range and therefore a low search volume per unit time. Sonar is the ubiquitous sensor in antisubmarine warfare. Sonar is used on surface ships and submarines, is deployed from airplanes, and is dipped from helicopters. It is operated singly, in multiples, in barriers, and in arrays. Great progress in sonar hardware design has been more than matched by advances in signal processing, especially for arrays, and by better understanding of oceanography and sound propagation in partially coherent media such as the turbulent ocean. There are large fixed arrays such as the Sound Surveillance System (SOSUS) for long-range surveillance of large areas, and there are towed arrays which,

while not as capable, are mobile and can be brought to bear in local areas where high levels of protection against submarines are needed.

Phenomena other than underwater acoustics for submarine detection have been pursued for decades. There has been particular interest in hydrodynamic effects such as internal waves, surface wakes, and the special character of cavitating flows. While much interesting phenomenology has been observed in experiments with these effects, no significant new operational system for submarine detection has emerged. Lately, the potential of the blue-green laser has been receiving attention. The quest for new sensors is pursued by the major military maritime nations, partly in the hope of achieving a real advance in antisubmarine warfare and partly out of fear and apprehension lest an adversary acquire some new and unknown capability in this field.

The problem of air defense of the surface fleet is also severe. The current paradigm for an attack on a surface fleet includes, in addition to the traditional bomb-dropping aircraft, a great proliferation of missiles, both low-altitude and high-altitude, high-supersonic (such as the Soviet AS-4). Such missile attacks may come from submarines, surface ships, aircraft, or land, depending on the location of the fleet.

To counter air attacks, a naval battle group usually has three layers of defense: (1) an outer zone with air surveillance radar aircraft (e.g., E-2C) and fighter-interceptors; (2) a middle zone with ship-borne radar (e.g., Aegis) and ship-to-air long-range missiles (e.g., the Standard Missile); and (3) an inner zone with short-range weapons including a radar-directed 20-mm Gatling gun (e.g., Vulcan-Phalanx).

Although improvements are being sought in all three zones as well as in countermeasures to radar-guided and optically-guided attacking missiles, particular concern is directed to the outer zone with the aim of intercepting, as far out as necessary, the attacking missile-bearing aircraft before they launch their missiles. This requires intercepts many hundreds of miles out, and at such distances from the aircraft carrier the limited range and endurance of both the surveillance and interceptor aircraft preclude 360-degree coverage (or even a fraction of that) for much of the time. Various options have been considered, ranging from extremely high-endurance, land-based aircraft to space-based radar constellations, but have not proved to be completely satisfactory in cost and effectiveness. The only new initiative, and a relatively low-cost one, being actively taken

in this area is the acquisition of transportable over-the-horizon backscatter radars (high-frequency) for air surveillance from island and coastal sites.

Finally, it should be noted that our own aircraft launching cruise missiles against naval targets have a similar problem of over-the-horizon targeting for reasons somewhat like those discussed for fleet air defense.

D. ARMS CONTROL

Although many aspects of arms control are essentially political, verification is an aspect that is largely technical. Arms control agreements in the future may be more stringent than heretofore, involving more intrusive measures such as limited on-site inspection in addition to the current measures which depend on national technical means, including all sources of intelligence.

Future arms control agreements may well contain provisions to control individual warheads on multiple-warhead missiles and individual weapons other than missiles. Up to now (in SALT II), in recognition of the difficulty of actually counting the warheads on missiles if not the impossibility of doing so, treaty provisions have stipulated "counting rules" to the effect that if a given missile launch vehicle is ever observed to deploy n warheads in any firing test, all missile launch vehicles of the same type are subsequently assumed to have n warheads. The numbers of weapons carried by bombers cannot reasonably be pinned down in this way and are not controlled. Thus far, cruise missiles are generally assumed to carry one warhead each. As will be discussed below, however, cruise missiles pose different problems because in essentially the same missile configurations they may carry either nuclear or conventional warheads.

Even greater difficulties will confront possible attempts to conclude future agreements to control not merely deployed systems on launchers but total inventories, including reloads. With deployment of mobile missiles such as the Soviet SS-25 and some versions of the Soviet SS-24, the reload problem will become still more compelling. More generally, even the problem of verifying the number of mobile missile launchers will be very difficult. A tamperproof method of establishing for each missile (or warhead) an identity code that could be queried by reconnaissance sensors or on-site inspectors might

help to deal with these problems. Inventory control by secure robotic methods, subject to random validation by on-site visits, might also be used.

The modern cruise missile is rather small and is launchable from ground, ship, submarine, and aircraft. The U.S. Tomahawk and its variants display this versatility. In addition, as already mentioned, essentially the same cruise missile vehicle can carry either a nuclear warhead or a conventional warhead. The range of the conventionally-armed missile is usually less because the conventional warhead is usually heavier. Tests of cruise missiles to full range are unnecessary to validate their performance; closed-course ("racetrack") and incremental tests are adequate for this purpose, further complicating treaty verification. Distinguishing nuclear-armed from conventionally-armed cruise missiles is not only a problem in arms control but also in control of escalation in the event of a conflict.

Although the United States and the Soviet Union are both signatories to treaties eschewing first use of chemical and biological weapons, for lack of any effective method of verification it has proved to be exceedingly difficult for them to take the next step--prohibition of production and deployment of those weapons. The weapons in question often do not differ chemically, except in concentration, from substances produced for legitimate civil purposes. For example, the organophosphates are used both in nerve agents and in pesticides. The United States has unilaterally foregone the production and use of biological agents but has no effective means of monitoring biological agent activity in other countries.

Finally, the verification of underground nuclear test limitations remains a vexing problem. The seismic methods now used appear to have uncertainty factors of 2-4 even for the 150-kiloton limit currently agreed to. Means of improving the accuracy of nuclear weapon yield estimates from seismic data would be desirable, as would the development of methods of monitoring based on other phenomenology to augment the seismically derived information. In anticipation of more restrictive nuclear test ban treaties, sensors have been developed for on-site emplacement, and automatic seismic stations have been developed for remote emplacement, but there is still room for innovative new approaches here.

E. ANTITERRORISM

Publicly acceptable, unintrusive means of detecting explosives are needed. The ability of dogs to scent explosives is now the most widely used means of detection. (The "tagging" of explosives by additives obviously cannot be effective as a detection aid if the manufacture of explosives cannot be controlled.) Active sensors, such as those based on neutron activation, have yet to be developed in generally acceptable form for explosives detection. Should their development be successful, such sensors might be unobtrusively emplaced, so as to minimize detection range, at points controlling access to protected areas.

Magnetic detectors at fixed control points, as at airports, are reasonably effective in detecting weapons concealed on persons, but determined persons carrying weapons can sometimes circumvent the fixed control points. Portable weapon detectors would permit control at varied points, even aboard aircraft and ships.

Large crowds, where control points are not feasible and wide areas must be covered, present another unsolved problem in weapon detection. To meet this problem, schemes based on non-linear electric or magnetic properties of materials and the returns of metal-to-metal contact surfaces in response to radar illumination have been proposed and investigated, but they have proved wanting in range and unambiguous indications.

A further concern is the protection of water supplies from chemical and biological disease-producing contaminants.

APPENDIX A
MEMBERS AND MENTORS

DEFENSE SCIENCE STUDY GROUP

MEMBERS

Russel E. Caflisch	Courant Institute of Mathematical Sciences, New York University
Steven K. Case	Electrical Engineering, University of Minnesota
Katherine T. Faber	Ceramic Engineering, Ohio State University
Bruce Hajek	Electrical & Computer Engineering, University of Illinois
Steven E. Koonin	Theoretical Physics, California Institute of Technology
Frederick K. Lamb	Physics, University of Illinois
Nathan S. Lewis	Chemistry, Stanford University
Philip S. Marcus	Astronomy and Applied Mathematics, University of California, Berkeley
Thomas F. Rosenbaum	Physics, James Franck Institute, University of Chicago
Steven J. Sibener	Chemistry, James Franck Institute, University of Chicago
Daniel L. Stein	Physics, Institute for Theoretical Physics, University of California, Santa Barbara
Warren S. Warren	Chemistry, Princeton University
R. Stanley Williams	Chemistry, University of California, Los Angeles
W. Hugh Woodin	Mathematics, California Institute of Technology

DEFENSE SCIENCE STUDY GROUP

MENTORS

Lew Allen, Jr.	Director, Jet Propulsion Laboratory, General, U.S. Air Force (Retired), former member of the Joint Chiefs of Staff, former commander of the Air Force Systems Command and former Director of National Security Agency
Daniel Alpert	Director, Center for Advanced Studies, University of Illinois
Richard B. Bernstein	Professor of Chemistry, University of California, Los Angeles
R. Stephen Berry	Professor of Chemistry, University of Chicago
Solomon J. Buchsbaum	Executive Vice President, Bell Laboratories, Chairman, White House Science Council, Member, Defense Science Board
Peter Carruthers	Group Leader, Los Alamos National Laboratory
Alexander H. Flax	Member, Defense Science Board, former President, Institute for Defense Analyses
Eugene G. Fubini	Vice Chairman, Defense Science Board, former Deputy Director of Defense Research and Engineering (DRE) and Assistant Secretary of Defense
Andrew A. Goodpaster	General, U.S. Army (Retired), Former Supreme Allied Commander, Europe and President, Institute for Defense Analyses
Martha Krebs	Associate Director for Planning and Development, Lawrence Livermore Laboratory, former Staff Director of the Subcommittee on Energy Development and Applications of the Committee on Science and Technology, 97th Congress

Peter Lax	Director, Courant Institute, New York University
Stanford S. Penner	Director, Energy Center, University of California, San Diego and former Director of the Research and Engineering Support Division, Institute for Defense Analyses
David Pines	Professor of Physics and Electrical Engineering, University of Illinois
William H. Press	Chairman, Department of Astronomy, Harvard University
Herbert York	Director, Science, Technology & Public Affairs, University of California, San Diego and former Director of Defense Advanced Research Projects Agency, DRE and Lawrence Livermore Laboratory

APPENDIX B
MEETING AGENDAS

**FIRST MEETING OF THE
YOUNG SCIENTIST PROGRAM
DECEMBER 8-9, 1985**

AGENDA

Sunday, December 8

7:00-10:00 p.m. Informal dinner reception
Radisson Mark Plaza
Beech Room (lower level)

Monday, December 9

S. Berry, Chairman

8:00- 8:30 a.m. Continental Style Breakfast
IDA Board Room

8:30- 9:30 a.m. Welcome
Program Introduction
DARPA Overview
Defense Science & Technology Issues

**W. Smith
R. Roberts
DARPA
OSTP**

9:30-10:30 a.m. Perspectives on Defense
Science & Technology

**L. Allen
E. Fubini
W. Press**

10:30-10:45 a.m. Coffee Break

10:45-12:00 noon Introduction to and Open Discussion of
Technical Issues--Session I

**S. Penner,
Discussion Leader**

12:00- 1:00 p.m. Lunch

1:00- 1:15 p.m. Administration & Security

N. Licato

1:15- 2:15 p.m. Introduction to and Open Discussion of
Technical Issues--Session II

**P. Carruthers,
Discussion Leader**

2:15- 3:30 p.m. Executive Sessions
Board Room and Room 203N

3:30- 4:00 p.m. Results of Executive Session--Wrap-Up

4:00- 6:00 p.m. Social Get-Together

DEFENSE SCIENCE STUDY GROUP MEETING

**IDA BOARD ROOM
APRIL 19-21, 1986**

AGENDA

Saturday, April 19

8:00 a.m. Continental Breakfast Board Room

8:45- 9:00 a.m. Opening Remarks R. Roberts, Director,
Science and Technology Div., IDA

James A. Tegnalia,
Deputy Director, DARPA

Strategic and Tactical C³I

9:00-10:00 a.m. C³I Technology: Some Examples Donald Latham,
Assistant Secretary for C³I, DoD

10:00-10:15 a.m. Coffee Break

10:15-11:15 a.m. Some Thoughts on Tactical C³I Charles Fowler,
Chairman, Defense Science Board

11:15-12:15 p.m. MILSTAR: A Case Study of a
Survivable C³ System Barney Reiffen,
Communications Div.,
MIT Lincoln Labs.

12:15-12:30 p.m. General Discussion

12:30- 1:30 p.m. Lunch IDA Cafeteria

Surveillance and Verification of Arms Control

1:30- 5:00 p.m.	Technological and Other Issues in Treaty Verification and Compliance	Jack Ruina, Center for International Studies, MIT
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	State of Technology in Seismic Detection and Identification of Underground Explosions	Paul Richards, Lamont-Doherty Geological Observatory, Columbia Univ.
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	Krsnoyarsk, the SS25, and More: What We See and What It Means	Sayre Stevens, National Security Research Group, Systems Planning Corp.
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	New Technology and Treaty Compliance	Antonia Chayes, Endispute, Inc.
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7:00 p.m.-	Dinner Reception at IDA	Board Room
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Sunday, April 20

10:00-11:00 a.m.	Brunch	IDA Cafeteria
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Strategic Computing

11:00-12:30 p.m.	Technology Base	Saul Amarel, Information Processing Techniques Office, DARPA
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	Applications	Clinton Kelly, III Engineering Applications Office, DARPA
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12:30- 1:00 p.m.	Coffee Break	
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Sensors and Image Processing

1:00- 2:00 p.m.	Overview: Sensors	William Brown, Environmental Research Institute of Michigan
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2:00- 3:00 p.m.	Overview: Image Processing Board Room and Room 203N	Azriel Rosenfeld, Center for Automation Research, Univ. of Maryland
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Sensors and Image Processing (cont'd)

3:00- 3:20 p.m.	Advanced Focal Planes	A. Fenner Milton, Electrooptics, GE Company
3:20- 3:40 p.m.	Performance Requirements for Smart Weapons	Richard Legault, Science and Technology Div., IDA
3:40- 4:30 p.m.	Discussion	

Monday, April 21

8:00 a.m.	Continental Breakfast	Board Room
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Aerospace Plane

8:30- 9:15 a.m.	The Technology of Space Launch	Robert Cooper, Pollard Road, Inc.
9:15- 9:45 a.m.	National Aerospace Plane Technology and Challenges	Robert Williams, Air Warfare, Tactical Technology Office, DARPA
9:45-10:00 a.m.	Coffee Break	
10:00-10:30 a.m.	Dissociation, Combustion, Diffusion, and Catalysis in Hypersonic Scramjet Engines	John Erdos, General Applied Science Laboratory
10:30-11:00 a.m.	Turbulence Modeling in Scramjet Engine Combusters	Harold Gilreath, Applied Physics Lab., Johns Hopkins Univ.
11:00-11:45 a.m.	Challenges in Mathematical Modeling of Advanced High Temperature Materials	Phillip Parrish, Materials Sciences, Defense Sciences Office, DARPA
11:45-12:00 noon	Discussion	
12:00- 1:00 p.m.	Lunch	Board Room

Planning Session

1:00- 1:30 p.m.	Overview of DSSG Summer Activities and Options	Robert Roberts
1:30- 3:30 p.m.	Identify Technical Areas of Interest to Pursue During the Summer	DSSG Participants
1:30- 3:30 p.m.	Mentors Advisory Meeting	Mentors, IDA and DARPA
3:30- 4:30 p.m.	Joint Discussion of Summer Activities	All
4:30 p.m.-	Wine and Cheese Social	Board Room

DEFENSE SCIENCE STUDY GROUP MEETING

INSTITUTE FOR DEFENSE ANALYSES

JULY 14-19, 1986

AGENDA

Monday, July 14 (Board Room)

8:45- 9:00 a.m. Opening Remarks IDA

Monitoring of Soviet Missile Tests

Overview and Problem Description

9:30-10:30 a.m. Overview Peter Zimmermann,
U.S. Arms Control and Disarmament Agency
(William C. Foster Fellow)

10:30-10:45 a.m. Break

10:45-11:30 a.m. The Technical Characteristics of LtCol Garry Devinger
Soviet Ballistic Missiles Defense Intelligence Agency

11:30-12:15 p.m. Soviet Approach to Arms Control Dan Gouré,
Verification SRS Technologies

12:15- 1:15 p.m. Lunch IDA Cafeteria

1:15- 5:00 p.m. Discussions

Phenomenology and the Monitoring of Qualitative Limits

7:00- 8:30 p.m. Missile Plume Phenomenology Hans Wolfhard,
Science and Technology Div., IDA

8:30- 8:45 p.m. Break

8:45- 9:30 p.m. Physics Phenomenology and the Peter Daniher,
Analysis Process Central Intelligence Agency

9:30-10:15 p.m. Monitoring Qualitative Limits on Anthony Czajkowski,
Missiles in Arms Control U.S. Arms Control and
Disarmament Agency (Visiting Scholar)

Tuesday, July 15 (Room 305N)

Relevant Technologies

8:30- 8:45 a.m.	Introduction	Richard Legault, Science and Technology Div., IDA
8:45- 9:30 a.m.	Technical Intelligence Collection	Elwyn Harris, RAND Corp.
9:30-10:30 a.m.	Radar Techniques for Monitoring Foreign Missile Tests	Isaac Weissman, Riverside Research Institute
10:30-10:45 a.m.	Break	
10:45-11:45 a.m.	Development of the Optical Airborne Measurements Program (OAMP)	Daniel Mooney, Lincoln Laboratory
11:45-12:45 p.m.	Lunch	
12:45- 2:30 p.m.	Informal Discussions	
2:30- 3:30 p.m.	Utility of Telemetry Data in the Determination of Parameters of Interest for Arms Treaty Monitoring	David Brandwein, System Planning Corp.
5:30 p.m.	Van leaves IDA for Ft. Belvoir, VA	
6:30-10:00 p.m.	Dinner and Visit to U.S. Army Night Vision and Electro-Optics Center	

Wednesday, July 16 (Pentagon, Room 3D1042B)

8:00 a.m. Special Van leaves IDA for Pentagon

Survivability of Integrated C³I

Strategic C³ Processes and Threat

8:30- 8:45 a.m.	Introduction	LtGen C.E. McKnight
8:45- 8:50 a.m.	Overview	Robert Fallon, OJCS (C ³ S)
8:50- 9:35 a.m.	C ³ Strategic Connectivity	LtCol Robert Kramer, CAPT John Piepenbrink

Strategic C³ Processes and Threat (continued)

9:35- 9:55 a.m.	Airborne LF/VLF	LtCol Peter Verga
9:55-10:10 a.m.	Tactical Warning and Attack Assessment System Overview	Maj Albert Lucas
10:10-10:25 a.m.	Break	
10:25-10:40 a.m.	Ground Wave Emergency Network (GWEN)	Maj Albert Lucas
10:40-10:55 a.m.	Extremely Low Frequency (ELF)	Stanley Jakubiak
10:55-11:25 a.m.	Satellite Communications	Maj Veloris Marshall
11:25-12:00 noon	NAVSTAR GPS/NDS	Maj. Robert Stepan
12:00- 1:00 p.m.	Lunch (Executive Dining Room)	
1:00- 3:00 p.m.	National Military Command Center Visit	
3:00 p.m.	Return to IDA	
3:30- 5:00 p.m.	Informal Discussions	
7:00- 8:00 p.m.	Collateral Effects of Nuclear Detonations (Board Room)	Brian Gabbard, EOS Technologies, Inc.

Thursday, July 17 (Board Room)

Warning System Technologies

8:30-10:30 a.m.	Producibility of Infrared Focal Plan Arrays	Cornelius Sullivan, Defense Logistics Agency
10:30-10:45 a.m.	Break	
10:45-12:15 noon.	Radar Warning System	Edwin Lyon, SRI International
12:15- 1:15 p.m.	Lunch	
1:15- 2:00 p.m.	Informal Discussions	
2:00- 3:00 p.m.	Invited Address	GEN Andrew Goodpaster, U.S. Army (Retired)

Warning System Technologies (continued)

3:00- 5:00 p.m.	Informal Discussions	
7:00- 8:00 p.m.	Invited Address: A National-Level View of Strategic C3	John G. Grimes, National Security Telecommunications

Friday, July 18 (Board Room)

Evolution of Space Launch Capabilities: Implications for the Aerospace Plane

Lessons in Aerospace Program Development

8:30- 9:15 a.m.	Early High-Speed Experimental Aircraft: The X-Series	Richard Hallion, Wright-Patterson AFB
9:15-10:00 a.m.	The Space Transportation System: Early System Trade-Offs	Scott Pace, The RAND Corp.
10:00-10:15 a.m.	Break	
10:15-11:15 a.m.	Launch Vehicle Technologies	Darrell Branscome, NASA Headquarters
11:15-12:00 noon	Panel Discussion	
12:00- 1:30 p.m.	Lunch	IDA Cafeteria

System Challenges in Space Access Systems

1:30- 2:15 p.m.	Aerospace Plane Concepts and Technologies	Larry Hunt, NASA Langley
2:15- 3:00 p.m.	Advanced Propulsion Overview	William Heiser, Aerojet Propulsion Research Institute
3:00- 3:15 p.m.	Break	
3:15- 4:00 p.m.	Computational Fluid Dynamics Technology	Joseph Shang, USAF Wright Aeronautics Laboratory
4:00- 4:45 p.m.	Thermal Structures	Don Rummmler, NASA Langley

Saturday, July 19 (Board Room)

9:00- 9:45 a.m.	Hypersonic Wind Tunnels/ Instrumentation	Bob Voisin Naval Surface Weapons Center
9:45-10:30 a.m.	Aerospace Plane Fleet Logistics	LtCol George Sawaya USAF Space Division
10:30-10:45 a.m.	Break	
10:45-11:45 a.m.	The National Aerospace Plane: Space Access & the Technological Imperative	Victor Reis Science Applications International Corp.
11:45-12:45 p.m.	Lunch	IDA Cafeteria
12:45- 2:00 p.m.	Informal Discussions	
2:00- 3:00 p.m.	Invited Address	Thomas Paine, National Space Commission
3:00- 5:00 p.m.	Informal Discussions	
7:00 p.m.	Dinner Reception at IDA	Board Room

DEFENSE SCIENCE STUDY GROUP SITE VISITS

JULY 21-24, 1986

Monday, July 21

7:00- 7:40 a.m.	Breakfast at leisure	Officers' Club
7:50 a.m.	Visitors arrive HQ SAC, Omaha, Nebraska	
8:00- 8:05 a.m.	Welcoming Remarks	Lt Gen Hatch
8:05- 8:45 a.m.	Soviet Strategic Force Modernization (S)	Maj F.M. Early
8:45- 9:15 a.m.	SAC Today (S)	Maj K.B. Young
9:15- 9:50 a.m.	Deterrent Forces: How Much is Enough? (S)	Maj T.E. Kolter
9:50-10:00 a.m.	Break/Travel to Balcony	
10:00-10:45 a.m.	SAC Command Control (S)	Capt K.G. Malmstrom
10:45-10:55	Travel to SAC Theater Entrance for departure to flightline	
11:05-11:45 a.m.	EC-135 Tour (S)	Flightline
11:45 a.m.	Visitors depart flightline for SAC Theater entrance	
11:50 a.m.	Visitors arrive SAC Theater entrance	
11:55-12:35 a.m.	Lunch	
12:40- 1:00 p.m.	Aircraft Base Escape Methodology (S)	Mr. R. Valek
1:00- 1:35 p.m.	C ² Architecture (S)	Mr. A.A. Buckles
1:35- 1:40 p.m.	Break	
1:40- 2:20 p.m.	C ² Architecture (continued)	
2:20- 2:50 p.m.	POC/ET (S)	Mr. A.A. Buckles
2:50- 3:00 p.m.	Break	

Monday, July 21 (continued)

3:00- 3:30 p.m.	WWABCP/SECC (S)	Lt Col R.B. Phillips
3:30- 4:00 p.m.	Small ICBM Ops Concept (S)	Lt Col J.C. Wills
4:00- 4:30 p.m.	Wrap-Up Discussions	
4:35 p.m.	Visitors depart HQ SAC for quarters	
	Evening at leisure	

Tuesday, July 22

Breakfast

6:50 a.m.	Visitors depart HQ SAC for NORAD, Colorado Springs	
10:30 a.m.	Arrive Cheyenne Mountain Complex (CMC) met by Vice Admiral William Ramsey, USN, Deputy Commander in Chief, USSPACECOM	
10:35 a.m.	Welcome Remarks	VADM Bill Ramsey
10:45 a.m.	Command Overview	Lt Col D. Szafranski
11:45 a.m.	Depart for interior of CMC	
12:00 noon	Lunch with VADM Ramsey and Brig Gen "Bart" Bartholomew, USAF, Vice Director, NORAD Combat Operations, NORAD	Granite Inn
1:00 p.m.	VADM Ramsey departs for Chidlaw	
1:05 p.m.	Tours and Briefings begin. Divide into two groups.	
	Group I Hosted by Brig Gen Bartholomew	
	1:15 p.m. Missile Warning	Maj Ron Morse
	1:35 p.m. Space Surveillance	CDR John Craig
	Group II	Hosted by Dr. Finkleman
	1:15 p.m. Space Surveillance	CDR John Craig
	1:35 p.m. Missile Warning	Maj Ron Morse
	Groups rejoin in Command Post	
1:55 p.m.	Command Post Orientation	Brig Gen Bartholomew

Tuesday, July 22 (continued)

2:45 p.m. Break

Briefings begin, hosted by Dr. Finkleman

3:00 p.m. SPACETRACK CDR John Craig

3:45 p.m. SPADOC CDR John Craig

4:30 p.m. Break

4:45 p.m. Missile warning Maj Gill Siegert

5:30 p.m. Depart CMC accompanied by Dr. Finkleman

6:00 p.m. Arrive DVQ

7:00 p.m. Cocktails

7:30 p.m. Dinner with VADM Ramsey
(Coat and tie) Officers' Club
Palmer Room

Wednesday, 23 July

6:45 a.m. Breakfast with VADM Ramsey and
Colonel John Weber, USAF,
Commander 2nd Sp Wg. Officers' Club

7:30 a.m. Depart Officers' Club accompanied by
VADM Ramsey and Col Weber

8:00 a.m. Arrive Falcon Air Force Station (FAFS)

Tours and Briefings begin

8:05 a.m. 2nd Sp Wg Overview Col John Weber

9:00 a.m. Tour facilities Col John Weber

9:30 a.m. SIO Briefing Col Al Rosa

10:30 a.m. 2nd Communications Squadron
Overview Maj Eldon Mickalson

11:30 a.m. Depart FAFS for Buckley AFS, farewell by Col. Weber

12:15 p.m. Lunch, AF Academy

Wednesday, July 23 (continued)

1:30- 3:00 p.m. Travel to Denver

3:00- 5:00 p.m. Briefings, Buckley Air National Guard Base, Aurora, CO

Thursday, July 24

7:30 a.m. Martin-Marietta bus leaves hotel

8:00- 9:00 a.m. Briefings, Martin Marietta, Denver

9:00- 1:00 a.m. Tour ALV, ITA, and robotics and lunch

1:00 p.m. Depart for Airport

**DEFENSE SCIENCE STUDY GROUP
2nd SUMMER TECHNICAL SESSION**

SEPTEMBER 3-12, 1986

AGENDA

Wednesday, September 3

2:00 p.m. Opening Meeting Room 120S

Saturday, September 6

3:00 p.m. Crab Feast at home of Bob Roberts

Monday, September 8

2:00 p.m. Interim Meeting Room 120S

Wednesday, September 10

2:00 p.m. Address by Dr. Herbert York Room 120S

Friday, September 12

10:00 a.m. Concluding Meeting Room 120S

Other meetings and events to be scheduled as needed.

**DEFENSE SCIENCE STUDY GROUP
BOARD ROOM, INSTITUTE FOR DEFENSE ANALYSES**

NOVEMBER 8, 1986

Moderator: Dr. Russel Caflisch

AGENDA

8:30 a.m.	<i>Breakfast</i>	
9:00 a.m.	<i>Introductory Remarks for IDA</i>	Dr. Robert E. Roberts
9:10 a.m.	<i>Introductory Remarks for the DSSG</i>	Dr. Steven J. Sibener
9:20 a.m.	<i>Composite Materials</i> General Introduction Design of Composites	Dr. Katherine T. Faber Dr. Philip Marcus Dr. Hugh Woodin
	Passivation of Carbon-Carbon Composites Coating Prospects Chemical and Physical Considerations	Dr. Katherine T. Faber Dr. Russel Caflisch Dr. Steven J. Sibener
10:00 a.m.	<i>Mercury-Cadmium-Telluride Sensors</i> Materials Perspective Physical Constraints Substrate Materials Growth Technology Device Processing	Dr. Nathan Lewis Dr. Thomas Rosenbaum Dr. Katherine T. Faber Dr. Steven J. Sibener Dr. Stanley Williams
10:40 a.m.	<i>Break</i>	
11:00 a.m.	<i>Spoofing of OTH Radars</i>	Dr. Warren S. Warren
11:15 a.m.	<i>Missile Volume as a Possible Arms Control Constraint</i>	Dr. Frederick Lamb Dr. Daniel Stein
11:35 a.m.	<i>Imaging</i>	Dr. Steven K. Case
11:50 a.m.	Concluding Remarks	Dr. Robert E. Roberts
12:00 noon	Lunch	
1:30 p.m.	Meeting of participants and mentors	

APPENDIX C
MEETING MINUTES BY MEMBERS

**INSTITUTE FOR DEFENSE ANALYSES
DEFENSE SCIENCE STUDY GROUP**

Minutes of Meeting 9 December 1985

Program Recommendations

1. The name of the program should be changed to Defense Science Study Group.
2. The program should not receive any publicity at present. The question of publicity can be considered again at a later time, when the program has been defined more clearly.
3. Every effort should be made to continue financial support of the program through DARPA rather than any other government agency. Participants should be notified immediately if any change in the source of funding is contemplated. (Participants are sensitive to the fact that support for research programs of some academic colleagues was recently switched from DARPA to SDIO without consultation or advance notification. IDA should be aware that should funding be switched to SDIO, many participants in the program would resign.)
4. Background investigations of all participants for top secret clearances should begin immediately. Otherwise, useful summer studies of topics that require top secret clearance will be precluded, given the additional time required to change clearances from secret to top secret.

Spring 1986 Briefing

1. Briefings should be arranged on four topics of principal interest and four topics of secondary interest. For each topic, one or two participants volunteered to act as points of contact between IDA and the DSSG in order to organize the briefings and to help make sure that they address the questions of interest to participants. The eight topics and the corresponding contacts in the DSSG are indicated on a separate page.
2. Adequate time should be allowed for executive sessions in which participants can discuss the topics covered in the briefings, in order to choose the topics to be pursued in greater detail in the summer study sessions.
3. In addition to the briefings, participants would like an opportunity to discuss current defense science issues with respected members of the community in an informal setting, perhaps in connection with dinner or at an early evening session. Richard Garwin and Gerald Yonas were suggested as examples of people with whom the DSSG would like to meet.

Summer 1986 Study Sessions

1. In order to partially equalize the travel burden of the summer study sessions, every effort should be made to hold one of them in the West, perhaps in California or Colorado.
2. Time away from their laboratories is costly for participants, particularly those who are experimentalists involved in laboratory programs. In order to keep the time away from laboratories to a minimum, the summer study sessions should run for nine days, from a Saturday morning to the following Sunday afternoon.

**DEFENSE SCIENCE STUDY GROUP
TOPICS FOR SPRING 1986 BRIEFING**

Topics of Principal Interest

- Technologies for surveillance and verification of arms control agreements
DSSG Members: Philip Marcus, Stanley Williams; Senior Advisors: Peter Carruthers, Martha Krebs
- Sub-orbital planes
DSSG Members: Katherine Faber, Steven Sibener; Senior Advisor: Alexander Flax
- Sensing (including radar and infrared) and image processing
DSSG Members: Russel Caflisch, Steven Case; Senior Advisor: Stanford Penner
- Technology of anti-terrorism
DSSG Members: Nathan Lewis, Thomas Rosenbaum; Senior Advisors: Richard Bernstein, Andrew Goodpaster

Topics of Secondary Interest

- Anti-satellite weapons
DSSG Members: Bruce Hajek and Frederick Lamb; Senior Advisor: Solomon Buchsbaum
- Strategic and battlefield C³I
DSSG Members: Daniel Fisher, Steven Koonin; Senior Advisor: Solomon Buchsbaum
- Cryptography
DSSG Members: Daniel Stein, Hugh Woodin; Senior Advisor: Lew Allen
- Stealth technology
DSSG Member: Warren Warren; Senior Advisor: Lew Allen

**INSTITUTE FOR DEFENSE ANALYSES
DEFENSE SCIENCE STUDY GROUP**

Draft of Recommendations Made at the April 19-21, 1986 Meeting

First 1986 Study Session

1. The session should run from a Saturday morning to a Sunday afternoon. The choice of exact dates (12-20 July or 19-27 July) should be made as soon as possible, but after consultation with participants. Participants desire to remain as a unified group for at least the first summer study session.
2. The format should be similar to that of a Gordon Conference, with plenty of time between briefings for discussion and study.
3. The following three topics were chosen for further exploration at the first summer study session:

Topic	Topic Coordinator	Consultants
Robustness of C3I	Dan Stein	Russel Caflisch Bruce Hajek Steve Koonin Tom Rosenbaum Warren Warren
Soviet Missile Tests	Fred Lamb	Steve Koonin Phil Marcus Tom Rosenbaum Hugh Woodin
Evolution of Space Launch Capabilities: Implications for the Aerospace Plane	Steve Sibener	Russel Caflisch Katherine Faber

Each topic coordinator will draft several paragraphs explaining in greater detail what the participants have in mind and suggesting several subtopics for briefings. Each topic coordinator will send drafts to the relevant consultants who will review the draft and make suggestions to the topic coordinator. The topic coordinator will then submit a revised draft to IDA and all participants.

4. Participants desire to have further input into the selection of site visits, briefing topics, briefers, and other aspects of the summer study session. The DSSG

communications net recommended below will provide a natural and convenient method of achieving close communication and iteration of suggestions.

5. The participants suggest convening the first summer study session in Colorado for site visits to one or more of the following: Buckley Air National Guard Base, Denver (early-warning satellite ground station), Cheyenne Mountain (NORAD, SPADOC), and Colorado Springs (ADCOM, CSOC, AFSOPC, Systems Development Corporation). The session could then continue in Colorado, if suitable facilities and briefings are available, or move to Washington.

6. Briefings by experts with differing points of view on aspects of the selected topics are desired, where possible. Ideally, these briefers would be present at the briefings discussing a given topic. Alternatively, briefers could remain at the site of the session for a day or so, to allow more time for follow-up.

7. The participants would welcome overviews of defense science issues by speakers such as Herb York or Harold Brown.

Support

1. The participants request that IDA set up an electronic mail network for the DSSG as soon as possible. The simplest and most attractive option is to use a commercial net, such as MCI Mail.

2. An effort should be made to provide adequate library and other support facilities at the site of the summer study. If possible, books, reports, and other materials relevant to the three tentative topics should be gathered in advance, on the basis of recommendations requested from participants, senior advisors, briefers, and IDA staff.

3. Participants would welcome receiving a list of available IDA and DARPA reports and examples of defense analyses.

Second 1986 Study Session

IDA should be aware that if the second summer study session cannot be held before October 1, most participants will not be able to attend.

DRAFT PROPOSAL FOR A STUDY OF SURVIVABILITY OF INTEGRATED C³I

Motivation: Current U.S. military doctrine and planning rely heavily on the integrated functioning of both strategic and tactical C³I during peace and war. Strategically, survivable command and control is crucial for any set of operations which involve control, selectivity, and precision. Tactically, systems such as JTIDS are expected to act as force multipliers, and present battle planning relies on the collection, integration, dissemination, and effective utilization of large amounts of information in short periods of time.

A large array of problems is apparent, with only a few listed below:

1. How robust are individual *components*, and what can be done to improve weaknesses? Factors to be considered include, among others, direct nuclear effects (blast, radiation), jamming, sabotage, natural random failure rates (equipment or human error), indirect nuclear effects (atmospheric ionization, EMP), and so on. In this respect, intensive study of individual systems such as MILSTAR, radar antennae, NEACP aircraft, etc. would be useful.
2. Tactical command and control, as already stated, requires the digestion of great amounts of information in short time periods by many people. Under different battle scenarios, what are the limits of feasibility of effective information utilization? What can be done to improve the quick allocation of only the most necessary information to where it is most needed?
3. How well can the present strategic C³I system be expected to work during an actual nuclear exchange? Again, different scenarios need to be studied. How vulnerable are we to "nuclear decapitation"? How will the airborne, submarine, ICBM, and satellite C³ systems function, both separately and together? What about communications between the U.S. and USSR? What are the possibilities of damage limitation, if any? How well does all of this compare to current planning?
4. All of these questions also apply to the Soviet C³I systems. How well might their systems work? How do the two systems stack up against one another?

These are only a few of the questions that might be asked. Undoubtedly, many more can be thought of, and all of those listed above have been studied by others. Nevertheless, we expect in the course of our study to encounter new questions, and expect that a fresh assessment of some of these issues will be useful.

DRAFT PROPOSAL FOR A STUDY OF MONITORING OF SOVIET MISSILE TESTS

Suggestions were made at the Spring Briefing that current and emerging technologies and new concepts might be used to better monitor Soviet compliance with arms control agreements restricting the types of ballistic missiles permitted and their characteristics. The DSSG wishes to explore whether this topic is suitable for a more detailed, interdisciplinary study. Briefings on this topic at the first summer study session will be used to decide whether to pursue it further.

Focus of Interest

The focus of interest of the DSSG is two-fold:

1. Can current or emerging advanced technologies coupled with new ideas provide more accurate determinations of the characteristics of Soviet ballistic missiles?
2. Could innovative concepts or alternative choices of observables be used in future arms control agreements which would address the militarily relevant characteristics of ballistic missiles but be easier to measure accurately with National Technical Means. For example, would it be more satisfactory to attempt to constrain missile volume rather than throw-weight?

Possible Topics to Explore

The following are subtopics that might be relevant to this study:

Missile Flight

1. Basic principles of staged missile flight, rocket fuels, thrusters, specific impulses and staging in the atmosphere and in space.
2. Properties of rocket exhausts in the atmosphere and in space: location, shapes, chemical constituents, temperatures, and electromagnetic spectra of rocket plumes.
3. Observable properties of post-boost vehicles and re-entry vehicles in midcourse: radar cross-sections, infrared signatures.
4. Observable properties of re-entry: RV and instrument package radar cross sections, bow shock temperature and density structures, RV temperatures, aerodynamic drag coefficients, electromagnetic signatures.

Principles of Ballistic Missile Flight Monitoring

1. Use of telemetry as well as radio, infrared, optical, and any other relevant data.
2. Use of modeling and simulations.

Possibly Relevant Technologies

1. Radio, infrared, optical, and other relevant sensors.
2. Image processing techniques.

Other topics

Any other relevant topics.

DRAFT PROPOSAL FOR A STUDY OF EVOLUTION OF SPACE LAUNCH CAPABILITIES: IMPLICATION FOR THE AEROSPACE PLANE

Defense Science Study Group

The space program of the U.S. is currently at a critical point in its history, with key technological and policy decisions being considered that will influence the space launch capabilities of our country well into the next century. One of the most revolutionary options being considered to meet our future needs is the construction of an "aerospace plane", which will be powered by a scramjet-based propulsion system. The DSSG would like to critically examine several aspects of this new endeavor, with the intent of (i) identifying crucial technological and/or production bottlenecks that may impede the fabrication of a test aircraft, and (ii) critically evaluate the feasibility of fully implementing such a revolutionary space launch system. The DSSG feels that it would be very valuable as part of this study to learn about past successes and failures relating to the development of advanced flight systems, and about the design of these systems. This background material will qualitatively strengthen our ability to make an informed and comprehensive review of the proposed aerospace plane program.

I. LESSONS FROM THE PAST

Even before the recent catastrophe in Florida, it was becoming quite apparent that the space shuttle program was falling far short of its original objectives--both technically and economically. We would like to hear about several aspects of the shuttle program from which we can draw lessons for the future:

- Evolution in Design:** Originally there were several proposed configurations for the STS. How were alternate designs eliminated from consideration, and were these decisions based on technical, economic, or time-constraint considerations? Why wasn't a fully reusable system developed? Early decisions about the lunar excursion module (Apollo program) might also be of interest here.
- Development Questions:** It is widely known that many systems and components on the shuttle were implemented without full testing and prototyping. Examples include the main engine (which blew up repeatedly during testing) and the thermal protection system (the tiles fell off). From a technical standpoint, these decisions were most serious, and cost huge sums of money and time to correct. *Why* were things done this way? A brief review of how the final form of the propulsion system was arrived at would be useful here.
- Basic Operational Goals:** Why low earth orbit instead of high altitude flight? Why not an unmanned vehicle?

- Performance and Reliability:** Why did things go wrong? Example--the main engines were scheduled to operate in excess of 50 missions before needing a major overhaul; experience indicates 5 flights is closer to reality. Was this a result of insufficient testing or materials failure? Turnaround time between flights might also be discussed here.
- Economics:** Possibly the most serious aspect of this program is that it missed by a considerable margin its goal of cost per payload pound of \$100 (close to \$6,000 in reality). As is now readily apparent, the rest of the world is poised to take advantage of this problem. It is therefore essential that our next generation space launch system not repeat this error if the U.S. is to remain competitive on a world-wide basis. Questions: *HOW* did the STS miss its goal? *WHEN* did people realize there were problems? Did costs slip steadily? If apparent early on, why wasn't something done? Lessons for the future?
- New Technologies:** Are there examples of bets on the development of new technologies that were needed, but which didn't exist at the time, which were essential for program viability? Thermal protection system, main propulsion system, materials for high temperature operation, ...(Metal fatigue in early jet planes?)
- Computer Modeling of Hypersonic Flight:** How accurate were predictions of airframe behavior and heating during re-entry at Mach 25? To what extent can information on shuttle re-entry at Mach 25 be used to aid aerospace plane design?

II. AEROSPACE PLANE PROGRAM

With the overview of past space programs covered as introductory material, the DSSG would then like to move on and ask analogous technical and policy questions about the aerospace plane program:

- Early Decisions:** Manned or unmanned operation? (Why not two versions?) Low earth orbit versus geosynchronous orbit? Why not construct a next generation supersonic transport to supersede the Concorde/SST if one goal is fast worldwide transportation? Will the civilian sector and/or the military control the program if it is fully implemented?
- Goals:** Can the proposed system actually achieve a cost per payload pound of \$100? What are the payload weight *and* volume goals? Cost per plane projections? Projections on the economic viability of the program if fully implemented?
- Technical Requirements:** Due to the revolutionary nature of this plane, a series of questions seem appropriate: How well can new technologies be assimilated which mature or come into existence once the program is under way (materials, electronics,...)? When is it better to take "new technology" risks rather than refining existing ones (again, new materials designs, propulsion...)? Adequate development funds and testing seem essential if long-term reliability is to be guaranteed--are appropriate steps being taken to avoid the errors made in the shuttle program?

---Propulsion System

1. The technical aspects of the propulsion system from takeoff through Mach 4 should be fully addressed, i.e., how to reach supersonic speeds were scramjets can operate. Will the required hardware (volume and/or mass) eliminate benefits versus rocket launch with regard to the payload that can be delivered into orbit? Should a more conventional engine be used during takeoff?
2. Will rocket assist be needed at high altitudes due to lack of oxygen? *SHOULD* rocket assist be included to achieve high altitude orbits?
3. Is it known how to sustain efficient combustion at supersonic flow velocities? Fuel and air mixing problems?
4. Materials questions: ability of the proposed propulsion system to operate at high temperatures for long durations? Long-term reliability of stressed materials? Please give examples of materials problems that were encountered during the development of advanced jet-engines. What materials are needed that are not currently available?

---Environmental Concerns: Noise at takeoff, shockwaves during flight. Is it realistic to expect existing airports to be adequate?

---Airframe: Discuss further details of airframe and propulsion system integration. To repeat an earlier question: how accurate were predictions of airframe behavior and heating during re-entry at hypersonic velocities of the space shuttle? Can (experimental) information gained from the shuttle aid (theoretical) design of the airframe? Is work under way for fabricating the needed hypersonic test facilities? What are the proposed airframes that are currently being considered? Do they get too hot at hypersonic velocities?

SUMMARY

A broad ranging study topic has been described which will allow the DSSG to become familiar with the technical and policy aspects of the aerospace plane program. Case histories from past programs were included so that the DSSG can develop a feel for how the final shape of huge endeavors such as this are reached. The ultimate goals of this study will be to identify critical technical and policy areas where further DSSG effort will be likely to contribute to the successful development of an operational aerospace plane, and to carry out an assessment of the economic viability of the program as a whole.

**INSTITUTE FOR DEFENSE ANALYSES
DEFENSE SCIENCE STUDY GROUP**

NOTES FROM JULY 14-24, 1986 MEETING

Structure of DSSG September Study Session

1. Speakers limited to Harold Brown, Herbert York, and George Heilmeyer, if available.
2. It is critical that this session be reserved for discussions among the participants, study, calculation, and writing.
3. Participants wish to pursue projects as members of interdisciplinary teams of 2-5 people rather than as individuals, wherever possible.

Suggested Topics for Exploration at September Study Session

1. Missile volume as a surrogate for launch weight/throw weight in arms control agreements.
2. Determining missile launch weights/throw weights using space-based multistatic radars.
3. Threats to early warning and C³I assets posed by space mines, space-based homing vehicles, and advertent or inadvertent space debris, and countermeasures.
4. Application of pattern-recognition software to the problem of missile early warning (recognition of missile launches, removal of background sources and clutter).
5. Effects of nuclear weapons on fiber optics and photonics.
6. Vulnerabilities of over-the-horizon radars, and countermeasures.
7. Communication with submarines using blue-green lasers.
8. Vulnerabilities of MILSTAR and countermeasures.
9. Penetrating camouflage using pattern recognition techniques.
10. Identification of the nature of objects and IFF using IR sensors.
11. Production of MCT IR sensors.
12. Micro- and macroscopic structure of composite materials (mathematical modeling of composites, high-temperature coatings).

13. Critical review of anti-matter propulsion concepts.
14. Properties of low-density gas flows over solid surfaces (particle-fluid transition, determination of boundary conditions).
15. Living on and mining Mars and its satellites.

Thoughts on New Participants

Should the program be continued for next year, we have the following recommendations:

1. The number of new participants should be restricted to 2-5.
2. There is a special need for participants in medicine, biology, and the life sciences.
3. Current participants will suggest possible candidates at the September meeting.
4. Participation should be restricted to non-smokers.

**INSTITUTE FOR DEFENSE ANALYSES
DEFENSE SCIENCE STUDY GROUP**

DRAFT MINUTES OF NOVEMBER 7-8, 1986 MEETING

Group Policy

Participants asked that mentors consult with individual groups about how best to follow up work to date. Some groups want to continue to pursue their topics, others feel they have accomplished what they set out to do and that their recommendations should now be followed up by somebody else.

There was a broad consensus that the group does want to learn about and pursue studies of (a) topics that were identified this past year but not pursued very far and (b) new topics to be identified now. It was suggested that the group make use of MCI Mail in developing suggestions for new topics. These suggestions need to be formulated soon if they are to be incorporated in next year's program.

At this meeting participants mentioned the following old topics that they would like to follow up:

1. anti-terrorism
2. communication with submarines
3. space debris/ASATs
4. test ban monitoring
5. Martian living (specifically whether there is water ice or only CO₂ ice on or near the surface--several participants indicated that this a controversial question and that the best idea would be to arrange briefings by two experts, one supporting the presence of water ice and one arguing against it; the two experts should be asked to sit through each other's talks and answer questions).

New topics that surfaced at this meeting included:

1. human/hardware interfaces (human factors?)
2. factors affecting innovation and industrial competitiveness in technology-based enterprises (here suggested speakers included John Young, President of Hewlett-Packard and Chairman of President Reagan's Commission on Industrial Competitiveness, and Armstrong (?), a vice-president at IBM who recently spoke at a national meeting on this topic (would the person who mentioned Armstrong please supply details?).

Time for discussion of topics for next year was limited. This list should therefore not be taken as definitive; topics may be added or dropped.

In general, participants whose other research was closely related to their DSSG research and who worked alone were less interested in spending DSSG time doing research and more interested in site visits and briefings; participants whose other research is further removed from their DSSG research and who worked in groups were more interested in allocating time for group projects.

All participants felt that site visits were a unique aspect of the program, difficult to impossible to arrange after the end of the formal three-year period of participation in the DSSG, and therefore important to arrange during this period.

Almost all participants emphasized that the interdisciplinary nature of the group was a main attraction of it. Many expressed a desire to think about ways of maintaining contact with the group after the end of the three-year period. This is a concern not adequately addressed by the possibility of consulting as individuals working on particular topics after the end of our time in the DSSG.

Schedule for 1987

As the result of extensive discussion, a consensus developed in favor of the following schedule:

April	2 days
July	7 days
September	9 days
November	2 days.

Spring Meeting

Allocate 50% of time (1 day) to research on ongoing projects, 50% of time (1 day) to learning about new topics. Participants were agreeable to dividing the latter time between two topics: "Technology Policy and the Political Arena" (to include discussions with a Senator or Congressman) and "Research Programs at IDA."

First Summer Study Session

Site visits should be the focus of this session. Visits to CINCPAC facilities are attractive. Participants viewed visits to San Diego and Washington State as acceptable, in view of the negative impact on image, costs, and scheduling of a trip to Honolulu. The hope would be that we could have two days of briefings with five days of site visits. This would be made easier if the briefings could be conducted at a facility on the West Coast, such as RAND. If there is a conflict between site visits and briefings during this session, participants agreed that it should be resolved in favor of the site visits. We hope this won't be necessary.

Second Summer Study Session

Group research should be the main focus of this session. Participants would also like to hear some briefings, perhaps up to one or two per day. Some briefings would be on new topics, others specific meetings with experts on topics already under investigation. Participants would like to finish draft reports by the end of this session to circulate to mentors in advance of the November meeting.

November Meeting

Purposes of this meeting would be similar to this year's November meeting, reviewing the year's program and planning the final year's program. However, participants would like to present their results earlier in the meeting and to have the possibility of discussing them with the mentors at greater length than was possible this year.

Library Facilities

Participants all felt that their research was seriously hampered by the lack of an adequate (unclassified) library at IDA. While classified materials are important in providing motivation for addressing particular questions or occasionally for providing a crucial piece of information, on most topics most of the work required access to unclassified materials. These generally were not available at IDA, greatly slowing and hampering the work. Use of other libraries in the Washington area is so cumbersome as to be (essentially) unworkable.

For sessions not in Washington, one possible mode of working would be to sit near an unclassified research library with the opportunity to occasionally consult classified documents. We do not know how to address this problem fully but wish to emphasize that it is a serious impediment to our work.

APPENDIX D
PROGRAM ASSESSMENT BY MENTORS AND DARPA



B. J. Buchheism
Executive Vice President
Customer Systems
AT&T Bell Laboratories

3L-650
Holmdel, NJ 07733
201 949-5564

November 11, 1986

Dr. Robert C. Duncan
Director
Defense Advanced Research Projects
Agency
1400 Wilson Blvd.
Arlington, VA 22209-2308

Dear Cliff:

I have been asked by the mentors of the Defense Science Study Group (DSSG) to write to you to express our views on the progress of the DSSG program and to make a modest recommendation. (The list of the mentors who attended the meeting of the DSSG on November 8, 1986 is attached.)

We were tremendously impressed with the progress the DSSG has made in so short a time. Clearly they are among the brightest, sharpest and most thoughtful young faculty our nation has. They have learned to work together and have become genuinely interested in some vexing technical problems and issues of importance to national defense, have become involved in those problems and have actually made a meaningful contribution in some of those. This is particularly true of the two materials problems they have tackled, namely composite materials and long wavelength detectors. The presentation on HgCdTe was as good a synopsis of the limitations of this materials system as I have heard, and the Group's approach to modeling composite material systems may well open up a new, very useful area of research.

We believe that DARPA should be both congratulated for launching this program and pleased with its progress. Clearly, the Group should be encouraged to proceed vigorously into the second year of their program. In this regard we urge you to enable the Group to expand by adding one or two additional members to it. The Group feels that they would benefit by having a life scientist and perhaps a computer scientist included in its rank. We wholeheartedly agree.

Sincerely,

Att.
As above

Copy to
R. E. Roberts
Mentors

D-2

**Mentors who Attended Meeting of DSSG on
November 8, 1986**

**Dr. Daniel Alpert
Director, Center for Advanced Study
University of Illinois**

**Professor Richard Bernstein
University of California
Dept. of Chemistry & Biochemistry**

**Dr. Solomon J. Buchsbaum
Executive Vice President
Customer Systems
AT&T Bell Laboratories**

**Dr. Peter Carruthers
Department of Physics
University of Arizona**

**Dr. Alexander H. Flax
President Emeritus
Institute for Defense Analyses**

**Dr. Eugene Fubini, President
Fubini Associates**

**General A. J. Goodpaster
President Emeritus
Institute for Defense Analyses**

**Dr. Martha Krebs
Associate Director
Planning & Development
Lawrence Berkeley Laboratory**

**Professor Peter Lax
New York University
Courant Institute of Mathematical
Science**

**Professor S. S. Penner
University of California, San Diego
Energy Center**

**Professor David Pines
University of Illinois
Department of Physics
Loomis Laboratory of Physics**



DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

**1400 WILSON BOULEVARD
ARLINGTON, VA 22209-2308**

5 - JAN 1987

**Dr. S. J. Buchsbaum
Executive Vice President
Customer Systems
AT&T Bell Laboratories
Holmdel, New Jersey 07733**

Dear Sol:

Thank you for the fine job that you and the other mentors have done with the Defense Science Study Group (DSSG). From my viewpoint, the November meeting at IDA was very successful and I was especially pleased to observe the group's teamwork and their spirited interest in defense-related science problems.

I plan to continue support of the DSSG because I believe it is important to encourage the nation's bright, young scientists to understand the challenging nature of the projects of interest to DARPA and other Defense organizations.

I concur that the disciplines represented by the group should be broadened and that DSSG be expanded to include a life scientist and a computer scientist. However, I would like to provide for both group broadening and membership turnover without expanding the number of participants. Perhaps a revolving membership with turnover of one-third per year is appropriate.

It would be most helpful if you and the other mentors could evaluate the composition of the group from the viewpoint of balance with respect to disciplines of interest to the DoD, and could develop a plan for rotating membership.

Lt Col Bob Kiggans has retired and his replacement as point of contact for the DSSG is Dr. William E. Isler, (202) 694-1664.

I look forward to working with the DSSG during the coming year.

Sincerely,

A handwritten signature in black ink, appearing to read 'R. C. Duncan', written in a cursive style.

Robert C. Duncan
Director

cc: R. E. Roberts

APPENDIX E
TASK STATEMENT



DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

1400 WILSON BOULEVARD
ARLINGTON VIRGINIA 22209

ASSIGNMENT FOR WORK TO BE PERFORMED BY INSTITUTE FOR DEFENSE ANALYSES

PROJECT ASSIGNMENT NO. A-103

DATE: SEP 6 1955

You are hereby requested to undertake the following task:

1. TITLE: Young Scientists Program
2. BACKGROUND: In order to solve the technical problems crucial to the defense of the United States, it is imperative that the country's best scientists and engineers become involved in defense issues. In recent years there has not been the high level of interaction between these scientists and the Department of Defense as was enjoyed in the past. There is currently a need for greater support from the scientific community, and in particular its younger members, on defense-related scientific and technical problems. The purpose of this task is to create an analysis program which brings together the brightest young scientists and engineers to work on current defense problems, and in the process to educate them to the nature and specifics of those problems.
3. TECHNICAL SCOPE: IDA shall seek out the best young scientists and engineers in the country and bring them together to discuss current problems in science and technology, which are of interest to the Department of Defense. This would be a select group of 10 to 40 scientists, who are recognized worldwide as being the new leaders in emerging areas of research. The scientists will be introduced to the technical problems of interest to DoD and will use their unique abilities to provide possible solutions to these problems.

In particular, IDA will:

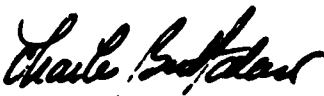
1. be responsible, in coordination with the sponsor, for definition of the problems;
2. conduct the selection process for the scientists;
3. act as the liaison between DARPA and the young scientists;
4. interact with and provide information for the young scientists; and
5. organize a final briefing for the sponsor in which the findings of the group are presented.

4. SCHEDULE: This task will be completed by November 15, 1986. A draft final report, which will include reports from the participants on their selected tasks, will be provided by January 15, 1987. A final report will be completed by March 15, 1987.

5. FUNDING: Expenditure of \$500,000 of FY 86 funds is initially authorized for this task, including all administrative support while working with IDA including salaries, travel arrangements, lodging, office space, and secretarial services for the young scientists.

6. TECHNICAL COGNIZANCE: Technical cognizance is assigned to the Director, DARPA.

7. REPORT DISTRIBUTION AND CONTROL: The Director, DARPA, will determine the number of copies of reports and their distribution. A need-to-know is hereby established in connection with this task and access to classified documents and publications, security clearances, and the like necessary to complete this task, will be obtained through the Director, DARPA.


CHARLES BUFFALANO
Acting Director

ACCEPTED: 

A.J. GOODPASTER
General, U.S. Army (Ret.)
President, Institute for Defense Analyses

DATE: _____

July 25, 1985

APPENDIX F
PROGRAM ADMINISTRATION

ADMINISTRATION

A stipend of \$10,000 per year will be provided, for which the participant will be expected to attend all meetings and summer sessions. In addition, travel and expenses will generally be fully reimbursed.

Participants will be required to obtain a Secret security clearance in order to participate in the program. IDA will assist in this process but cannot guarantee clearance. Independent research projects need not be classified, however.

IDA, in administering the Program, will make every effort to keep paperwork to a minimum and to respond to the needs of the participants in a direct and, wherever possible, informal fashion. IDA will be responsible for technical help ranging from providing computing time to arranging to bring participants together with experts in areas of interest.

END

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