Session XXXX

Representation of Women and Minorities in the Science and Engineering Disciplines

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Abstract

The United States (U.S.) Army Research Laboratory (ARL) has aggressively pursued workforce diversity by establishing a corporate Diversity Advisory Board and a Minority Outreach Program. In cooperation with the Equal Employment Opportunity and Human Resource Management offices, these elements have enabled ARL to make notable progress towards its diversity goals. Workforce diversity is a common goal for both the Government and private industry. Although the workforce diversity covers many issues, it is used here in reference to gender and race, national origin (RNO)∗.

ARL has focused recent efforts on the representation of women and minorities in science and engineering fields. In a parallel effort, ARL has augmented the education level of its workforce by establishing graduate study opportunities and recruiting scientists and engineers who hold Doctoral degrees (Ph.D.). In establishing its diversity goals, it became apparent that it was not only necessary to assess ARL’s current posture, but to 1) identify the composition of the civilian labor force (with respect to gender and RNO), 2) identify the representation among the nation’s science and engineering (S&E) Ph.D. recipients, and 3) identify the institutions from which the desired population can be recruited.

In the last year, ARL conducted a nationwide study of S&E Ph.D. programs and the distribution of these degrees. As part of this study, the trends for Ph.D. degrees conferred to the women and minority population over the last ten years were identified. This study also identified S&E Ph.D. programs and the number of Ph.D.s awarded by Historically Black Colleges and Universities (HBCU) and Minority Institutions (MI). This study has been expanded to include an examination of representation in the nation’s S&E occupations.

This study was performed using data from over a dozen federal and private agencies that track education and occupation statistics. A common thread among these resources was acknowledgement of the shortage of women and minorities in the S&E disciplines.

∗ Definitions of RNO are listed at the end of this report, before References.
I. Introduction

Because of the nature of the work performed by ARL, and the desire to maintain a position as experts in our field, it has become increasingly important to attract and retain Ph.D.-level scientists and engineers. To this end, ARL has instituted a performance metric that requires that 40% of the S&E workforce hold Doctoral degrees. In reaching this goal, ARL would like to maintain and perhaps enhance its workforce diversity by employing highly qualified women and minorities.

ARL took initial steps towards the 40% S&E Ph.D. goal by performing a nationwide study to determine the number of women and minorities that have received Ph.D. degrees over the last ten years. To complement this study, ARL identified all HBCU and MI in the U.S. and Puerto Rico, with emphasis on those that support Ph.D.-level S&E programs.

II. Study

The most populous S&E positions identified at ARL are aeronautical engineering, electrical engineering, materials/metallurgical engineering, mechanical engineering, chemistry, physics, mathematics, operations research, computer science, and psychology. The ARL nation-wide study therefore attempted to identify the supply and trend of women and minority Ph.D. graduates for these fields.

Statistical data derived from the Survey of Earned Doctorates (SED) was used for this study. The SED is administered by the National Opinion Research Center (NORC) under the sponsorship of the National Science Foundation (NSF), the National Institutes of Health, the National Endowment for the Humanities, the U.S. Department of Education (USDE), and the U.S. Department of Agriculture (USDA). The SED consists of information collected during the period July 1 of one year to June 30 of the next, from individuals who have fulfilled the requirements for a research doctorate.

For purposes of race identification, the SED enables self-identification using RNO groups defined by the U.S. Census Bureau. The five RNO groups are American Indian/Alaska Native (AI/AN), American Asian/Pacific Islander (AA/PI), Black, Hispanic and White. The NORC also compiles statistics for the group of recipients who do not designate an RNO. These recipients are classified as “unknown.”

Preliminary work performed by ARL covered the period 1994 through 1998. Over this period, the SED overall response rate exceeded 91%. U.S. citizens had a response rate of over 97% for the RNO variables. Because S&E fine field information was provided by NORC, it was possible to determine representation by women and minorities in the most populous ARL S&E disciplines with minimal calculations. Ultimately, the ARL study was expanded to cover the ten-year period 1990–1999.

The most current data available is the NSF 1999 early release tables. The 1994 through 1998 data previously used by ARL was reviewed and updated as necessary to agree with the early release tables. The NSF 1999 tables contain the statistics for the ten-year period of interest, but...
do not provide the fine detail that was available through NORC. As a result, ARL was not able to examine statistics for aeronautical engineering, materials/metallurgical engineering, and operations research. Operations research statistics are included in the field of mathematics, and the two engineering disciplines listed above are included in the “other engineering” category. Mathematics was included in the ARL study, but the “other engineering” category was not. A request has been made to the NSF to obtain fine field information, which would allow ARL to look at this omitted information in detail.

Population and Underrepresentation 1990-1999

All RNOs experienced population growth when 1990 data was compared to 1999 data. The minority RNO groups (AI/AN, AA/PI, Black and Hispanic) had the largest growth in population. In spite of this growth, in 1999 minorities still comprised less than 30% of the U.S. population. The White (non-minority) group experienced much slower growth (6.9%) in the population. Table 1 contains the percent change in the population for each RNO group.

Table 1. Change in population by RNO from 1990 to 1999

<table>
<thead>
<tr>
<th>RNO</th>
<th>Population Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI/AN</td>
<td>13.4%</td>
</tr>
<tr>
<td>AA/PI</td>
<td>30.1%</td>
</tr>
<tr>
<td>BLACK</td>
<td>12.1%</td>
</tr>
<tr>
<td>HISPANIC</td>
<td>28.0%</td>
</tr>
<tr>
<td>WHITE</td>
<td>6.9%</td>
</tr>
</tbody>
</table>

All minority RNO groups experienced at least a 35% increase in the number of Ph.D.s received for all fields and for the combined S&E fields. In spite of these large gains, in 1999 minority groups still received only 15.5% of the Ph.D.s for all fields and 15% of those for the S&E fields.

For analytical purposes, representation is determined by comparing the representation in the group of interest to representation in the U.S. population. Using this definition, the AI/AN, Black and Hispanic groups were under-represented in the group of all Ph.D. recipients and S&E Ph.D. recipients during each year between 1990 and 1999. Of the three groups listed, however, the AI/AN group appears to be closing the gap thereby approaching equality between the representation in the population and the representation among the Ph.D. recipients. Table 2 lists the percent change in Ph.D.s received from 1990 to 1999.

Table 2. Percent change in Ph.D.s awarded to each RNO from 1990 to 1999

<table>
<thead>
<tr>
<th>RNO</th>
<th>AI/AN</th>
<th>AA/PI</th>
<th>BLACK</th>
<th>HISPANIC</th>
<th>MINORITY</th>
<th>WHITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Fields</td>
<td>55.7%</td>
<td>51.6%</td>
<td>43.5%</td>
<td>35.0%</td>
<td>44.0%</td>
<td>3.3%</td>
</tr>
<tr>
<td>Science &amp; Engineering</td>
<td>63.2%</td>
<td>51.4%</td>
<td>54.3%</td>
<td>36.6%</td>
<td>48.9%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Sciences</td>
<td>62.9%</td>
<td>55.1%</td>
<td>52.4%</td>
<td>35.5%</td>
<td>49.3%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Engineering</td>
<td>66.7%</td>
<td>41.0%</td>
<td>67.0%</td>
<td>45.1%</td>
<td>47.3%</td>
<td>14.7%</td>
</tr>
</tbody>
</table>

Both men and women experienced population growth when 1990 data was compared to 1999 data. Over the period, however, women consistently comprised a slightly higher percent of the population than men. In 1999, women made up approximately 51% of the population, while...
men made up approximately 49% of the population. Table 3 contains the percent change in population for men and women.

Table 3. Change in population for men and women from 1990 to 1999

<table>
<thead>
<tr>
<th>Population Change</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.7%</td>
<td>8.3%</td>
</tr>
</tbody>
</table>

Both men and women experienced an increased number of Ph.D.s received for all fields and for S&E fields. Women demonstrated the largest growth reporting an 18.9% increase in all Ph.D. fields and a 23.5% increase in S&E Ph.D.s. The number of men receiving Ph.D.s in all fields and S&E fields stayed relatively the same from 1990 to 1999. A noteworthy comment is that men actually received fewer Ph.D.s in the Sciences in 1999 than they had in 1990. Women, on the other hand, increased the number of Ph.D.s received in the sciences by 22.2%, and in engineering by 41.8%. In 1999, women received 48% of all Ph.D.s and 40.5% of the S&E Ph.D.s. Although the gap is narrowing, women are still underrepresented among S&E Ph.D. recipients. The difference in this group is due primarily to the low percentage (17% in 1999) of engineering Ph.D.s conferred to women. Table 4 contains the percent change in the Ph.D.s awarded to men and women. Numbers in parenthesis indicate decreases.

Table 4. Percent change in the Ph.D.s awarded by gender from 1990 to 1999

<table>
<thead>
<tr>
<th></th>
<th>ALL</th>
<th>MEN</th>
<th>WOMEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Fields</td>
<td>9.8%</td>
<td>1.5%</td>
<td>18.9%</td>
</tr>
<tr>
<td>Science &amp; Engineering</td>
<td>10.2%</td>
<td>1.2%</td>
<td>23.5%</td>
</tr>
<tr>
<td>Sciences</td>
<td>8.3%</td>
<td>(3.1%)</td>
<td>22.2%</td>
</tr>
<tr>
<td>Engineering</td>
<td>20.9%</td>
<td>16.6%</td>
<td>41.8%</td>
</tr>
</tbody>
</table>

Ph.D. Trends 1990–1999

Trends were examined for Ph.D.s awarded in the S&E fields of interest for all U.S. citizens, minorities, men, and women. The highlights are provided below.

All U.S. citizens:

- The total number of S&E Ph.D.s received declined in 1999, rather than increased as in previous years.
- Ph.D.s awarded in science comprised over 83% of the Ph.D. degrees awarded in the S&E fields.
- The largest number of engineering Ph.D.s were awarded in electrical engineering, the largest number of science Ph.D.s were awarded in psychology.
Minorities:

- Minorities experienced largest growth (as a group) in the number of S&E Ph.D.s conferred. This growth is attributed to significant annual increases in the number of science Ph.D.s received.

- The percent of science Ph.D.s awarded to minorities increased annually, reaching 14.6% in 1999.

- Ph.D.s awarded in science comprised over 78% of the Ph.D. degrees awarded to minorities in the S&E fields.

- In spite of annual increases in the number of Ph.D.s received, minorities only received 15% of the S&E Ph.D.s awarded in 1999. This is up from 8.5% in 1990.

- The percent of engineering Ph.D.s awarded to minorities increased annually, with the exception of 1998, when it decreased slightly. In 1999, the number of engineering Ph.D.s received by minorities reached 17.5%.

- As was true for the group of all U.S. citizens, the largest number of engineering Ph.D.s was awarded in electrical engineering, and the largest number of science Ph.D.s was awarded in psychology.

Women:

- Women are steadily approaching gender equality for all Ph.D.s but still lag men by almost 10% for S&E Ph.D.s.

- At least 93% of the S&E Ph.D.s received by women were awarded in science, while less than 7% were awarded in engineering.

- Most science Ph.D.s were awarded in the social sciences (psychology).

Historically Black Colleges and Universities and Minority Institutions

With a better understanding of how the S&E Ph.D.s have been distributed over the last ten years, ARL endeavored to identify the contribution HBCU/MIs have made to the nation’s minority Ph.D. recipients.

In spring 2000, the ARL director met with the Florida A&M University (FAMU) president to discuss the funding challenges that face HBCUs. The FAMU president indicated that although HBCUs are very competitive in the race for scholarships and grants, a challenge exists to find funding to support research infrastructure. Because the Department of Defense (DoD) is the
largest supporter of research and development (R&D) at universities, the ARL director and the FAMU president pursued this resource to solicit financial support for developing the HBCU research infrastructure.

HBCUs are primarily teaching institutions with few resources devoted to research activities. They do not have laboratory space, state-of-the-art equipment, or the research faculty necessary to conduct research on the same level as traditional institutions (non-HBCU or MI). Not surprisingly, the number of minorities that graduate from HBCUs is low in the S&E fields, particularly at the graduate levels. Many HBCU bachelor-level graduates pursue graduate studies at traditional institutions rather than remaining at the HBCU. These graduates have discovered that the traditional institutions offer a wider variety of graduate programs and in some cases a higher status that is associated with attending a better-known institution. In addition, the traditional institutions often offer the HBCU students attractive scholarship packages.

Nationally, there are 3,706 colleges and universities. Further research revealed that there are 103 HBCUs, 25 of which confer Bachelors and Masters degrees in the most populous ARL S&E disciplines. Only ten of these offer Doctoral programs that support these disciplines.

There are at least 290 MIs classified as Hispanic Serving Institutions (HSI). Eighteen of these confer Bachelor and Master degrees that support ARL’s most populous S&E disciplines. Only nine of these offer Doctoral programs that support these disciplines.

The AA/PI and AI/AN RNO groups do not have educational institutions designated in the same manner as HBCUs and HSIs. The study found that these RNO groups attend the traditional institutions (i.e., non-HBCU/MIs). The study did identify the top 20 institutions that conferred Doctoral degrees to AA/PI students and the top 17 institutions that conferred Doctoral degrees to AI/AN students.

The research also found that HBCUs comprise only 3% of all U.S. colleges and universities. In spite of this, they graduate 16% of America’s Black college students. They are responsible for graduating 27% of all Bachelor degrees, 16% of all Master degrees and 9% of all Ph.D. degrees awarded to Black students. Despite their small numbers, HBCUs make a substantial contribution to the education of Black college students.

The Ph.D. program descriptions were collected from each HBCU/MI that conferred Doctoral degrees. The program descriptions were then cross-referenced to ARL’s ten most populous S&E fields. The HBCU/MI institutions that support one or more of the ten ARL S&E disciplines, along with the number of programs supported (in parenthesis), are listed below:

HBCU Institutions:

- Howard University (7)
- FAMU (2)
- Morgan State University (2)
- North Carolina A&T University (2)
- Alabama A&M (2)
• Clark-Atlanta (1)
• Jackson State University (1)
• Tuskegee University (1)
• Hampton University (1)

HSI Institutions:

• New Mexico State University (7)
• University of New Mexico (6)
• University of Texas at El Paso (3)
• University of Puerto Rico, Rio Piedras (2)
• Florida International University (1)
• St. Mary’s University in Texas (1)

ARL Recruitment Practices, Partnerships, and Educational Opportunities

ARL has developed a number of programs that extend to academia. These programs are used to leverage other institutions, provide the opportunity to contribute to U.S. Army research, and to enhance ARL’s visibility as a favorable place of employment for scientists and engineers. Some of these programs target minority groups and institutions in an effort to achieve workplace diversity. In addition, ARL has a Minority Outreach Program Manager (MOPM) who administers outreach programs and develops recruitment strategies targeted at HBCU/MIs. The MOPM works closely with the ARL director, keeping him informed of issues and concerns that affect relationships with HBCU/MIs.

ARL collaborates with many HBCU/MIs, some of which do not confer Doctoral degrees in the ARL S&E disciplines. ARL currently has educational partnerships with Alcorn State, Lincoln, City College of New York, Southern University, Southwestern Indian Polytechnic Institute, University of California at Los Angeles, and the University of the Virgin Islands. In addition, ARL has contractual relationships totaling over $10 million with Howard University, Clark-Atlanta University, Morgan State University, North Carolina A&T University, and the University of New Mexico.

Through educational partnership agreements, ARL scientist and engineers: 1) support student mentoring, work with university faculty and students under internship programs, 2) serve as science fair judges, 3) serve on business advisory and economic development groups, and 4) donate surplus laboratory equipment that enhances the technology and education community. In 1999, ARL established 43 educational partnerships and donated more than $2.1 million of scientific equipment to educational institutions.

In 1996, ARL developed the Science and Technology Academic Recognition System (STARS) program to reach HBCU/MI science (to include mathematics) and engineering juniors and seniors. Since that time, ARL has recruited 11 students and contributed more than $1 million to
the program. Although this program is administered at the undergraduate-level, ARL encourages, and provides the opportunity for, STARS students to pursue graduate studies. The ARL MOPM administers the STARS program.

ARL offers many training opportunities for its employees. The Long-Term Training program for example, has been used by many ARL scientists and engineers to pursue graduate studies. The educational programs enable ARL to work towards its scientist and engineer education-level performance metric, as well as to compete with private industry when recruiting scientist and engineers.

National S&E Workforce Statistics

As part of its annual Affirmative Employment Program Plan (AEPP), ARL examines the S&E workforce to determine the representation of women and minorities. This effort includes a comparison of the ARL workforce statistics to the U.S. Census Bureau Civilian Labor Force (CLF) statistics. The AEPP identifies instances of manifest imbalance, conspicuous absence, and parity of women and minorities in the ARL workforce. A shortcoming of this analysis, however, is that the current ARL workforce is compared to 10 year-old CLF data (i.e., 1999 ARL data was compared to 1990 CLF data).

ARL discovered that a comparison to more recent national workforce statistics could be accomplished by using the NSF Scientists and Engineers Statistical Data System (SESTAT). SESTAT is a database of the employment, education, and demographic characteristics of the Nation’s scientists and engineers.

A preliminary comparison of 1997 SESTAT statistics to the 1999/2000 scientist and engineers ARL workforce has been completed. This comparison will assist ARL in developing programs and policies to obtain and retain highly qualified women and minority scientists and engineers, and in the developing education-level performance metrics for the ARL workforce. The NSF Science and Engineering Indicators 2000 report provides some useful insight regarding what is going on with the S&E workforce. Some labor force information that is particularly important to ARL is provided below:

- 51% of employed scientists and engineers worked in educational institutions (other than 4-year colleges or universities), non-profit organizations and state or local government (1997).
- Largest group of S&E degrees occurred in the 40–49 age group (1997).
- Largest group of S&E Ph.D. holders in the labor force occurred in the 45–54 age group (1997).
- Most S&E Ph.D. holders were employed as social scientists and life and related scientists (1997).
- 14% of individuals employed in S&E jobs reported the highest degree as Ph.D. In engineering, only about 5% of both men and women have Ph.D.s (1995).
• Engineers and physical scientists have the largest percentage of Ph.D. holders engaged in R&D as a major work activity. Almost 35% of all S&E R&D workers (by field of highest degree) are engineers.

• Employment opportunities for S&E are expected to increase by about 51% (or 1.9 million jobs) in the next decade (1998–2008). Engineering is projected to have the largest employment gains.

• The number of trained scientist and engineers in the labor force will continue to increase. The number of individuals who are now receiving S&E degrees greatly exceeds the number of S&E degreed workers who are near retirement age.

• Although women comprised almost 46% of the U.S. Labor Force (slightly less than their 51% representation in the U.S. population), they only comprised 23% of the S&E workforce in 1997.

• The number of working women with Ph.D. degrees is increasing. Women represented 20% of S&Es with Ph.Ds in 1993, 22% in 1995 and 23% in 1997.

• Women comprise over half of the social scientists, but only 22% of the physical scientists and 9% of the engineers. Women represented 12% of chemical engineers and industrial engineers, but only 6% of aerospace, electrical and mechanical engineers.

• With the exception of the AA/PI group, minorities are underrepresented in the pool of employed S&Es.

III. Conclusion

The results of the ARL study parallel the findings of the 1991 Army Science Board Ad Hoc Subgroup, “Initiatives to Improve the Participation of HBCU/MIs in Army Research, Development, and Acquisition to Strengthen Their Infrastructure,” which found that women and minorities continue to be underrepresented in the S&E disciplines.10

The trend, over the last ten years, for women and men Ph.D. recipients seems to indicate that gender equality is within reach. Among S&E Ph.D. recipients however, men still lead women by 10%. Although the number of women receiving S&E Ph.D.s is increasing, most of these degrees are awarded in the science field of psychology. The statistics revealed that less than 7% of the S&E Ph.D.s received by women are obtained in engineering.

Minorities experienced annual growth in the number of Ph.D.s received for all fields and the combined S&E fields. At least 78% of the S&E degrees were obtained in science. In spite of improved representation in both the engineering and science disciplines, minorities still received only 15% of the S&E Ph.D.s awarded in 1999.
The NSF predictions of increased demands for scientists and engineers imply that competition for highly qualified women and minority scientists and engineers will be fierce. The increased demand may also impact the availability of Ph.D.-holding S&Es since the benefit of a graduate degree may be questioned, given the projected job market. Ultimately, this could affect ARL’s ability to attain and retain a 40% Ph.D. S&E workforce.

ARL views the HBCU/MI institutions as a potential resource for providing qualified minority scientist and engineers for employment in the DoD. It is for this reason that ARL identified institutions within this community that provide Doctoral programs in the ARL ten most populous S&E disciplines. Although, HBCU/MIs currently provide a limited number of minority graduates with Ph.D. degrees, ARL is committed to educational partnerships and outreach efforts in hopes of attracting and retaining qualified scientists and engineers. With substantial support, the HBCU/MIs may expand their academic focus to include research. The DoD has an opportunity to play a major role in this growth, by making a long-term investment to support the development of HBCU/MI research infrastructure. With this support, it is quite possible that Carnegie Research I or II status could also be obtained.

Armed with an understanding of the nation’s S&E Ph.D. recipients and their composition, the role of the HBCU/MI, and the S&E workforce projections, ARL is in a better position to develop strategies to ensure current and future workforces that reflect the diversity of the nation.

<table>
<thead>
<tr>
<th>Definitions</th>
<th></th>
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<tbody>
<tr>
<td>American Asian/Pacific Islander</td>
<td>All persons having origins in any of the original people of the Far East, Southeast Asia, the Indian Subcontinent, or the Pacific Islands. This area includes for example, China, Japan, Korea, and Philippine Islands and Samoa.</td>
</tr>
<tr>
<td>American Indian/Alaska Native</td>
<td>All persons having origin in any of the original people of North America, and who maintain cultural identification through tribal affiliation or community recognition.</td>
</tr>
<tr>
<td>Black</td>
<td>All persons having origins in any of the Black racial groups of Africa (not of Hispanic origin).</td>
</tr>
<tr>
<td>Civilian Labor Force</td>
<td>National population statistics compiled by the U.S. Census Bureau for comparison of occupational series grouped according to employment categories defined as professional, administrative, technical, clerical, other, and blue-collar (wage grade) (PATCOB). Used in workforce comparisons of white women and minority groups with the appropriate PATCOB.</td>
</tr>
<tr>
<td>Conspicuous absence</td>
<td>No minorities or women are represented in the workforce.</td>
</tr>
<tr>
<td>Hispanic</td>
<td>All persons of Mexican, Puerto Rican, Cuban, Central or South American, or other Spanish culture, or origin, regardless of race.</td>
</tr>
<tr>
<td>Historically Black Colleges and Universities</td>
<td>Designation based upon the history of the institution, generally established prior to 1964, whose principal mission was and is, the education of Black Americans.</td>
</tr>
<tr>
<td>Manifest Imbalance</td>
<td>50% or less representation of minorities or women in the workforce within the same categories, occupations, and grades of the nation’s civilian labor force.</td>
</tr>
<tr>
<td>Minority</td>
<td>Includes Black (not of Hispanic origin), Hispanics, Asians, American Pacific Islanders, and American Indian/Alaska Natives.</td>
</tr>
<tr>
<td>Minority Institutions</td>
<td>Institution of higher education whose enrollment of a single minority exceeds 50% of the total enrollment. A Hispanic serving institution must have an undergraduate equivalent of 25% full time Hispanic enrollment.</td>
</tr>
<tr>
<td>Parity</td>
<td>A group’s representation meets or exceeds its representation in the civilian labor force.</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>White</td>
<td>All persons having origins in any of the original people of Europe, North America, or the Middle East (not of Hispanic origin).</td>
</tr>
<tr>
<td>Underrepresented</td>
<td>Representation in the group of interest is less than the representation in the population.</td>
</tr>
</tbody>
</table>

References
5. URL: [http://www.sciencewise.com/molis](http://www.sciencewise.com/molis): Table 221, Enrollment and degrees conferred in Hispanic Serving Institutions (HSI) by institution, 1997.
9. National Science Board, Science and Engineering Indicators-2000, Volume 1; National Science Foundation 2000 (NSB-00-1), Arlington, VA.

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