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Review of National Defense Science and Engineering Graduate Fellowship

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Executive Summary

Background

The National Defense Science and Engineering Graduate (NDSEG) Fellowship program has provided over 3,000 awards to U.S. citizens for the pursuit of graduate degrees in science, engineering, or other fields of study designated as priority interests to the Department of Defense (DoD). The fellowship is a highly competitive, merit-based award for graduate students who describe their intent to study in specific academic fields identified as important to DoD. The fellowships provide up to 3 years of full tuition and fees along with a monthly stipend to be used at the institution of the awardees' choice. The Institute for Defense Analyses (IDA) reviewed the NDSEG program and provided an assessment of how the awardees have contributed to DoD and the research interests of DoD.

Methods

To assess the outcomes of the NDSEG Fellowship Program, we collected and assessed the contributions and activities of a sample of 360 awardees who received the fellowship between 2000 and 2009. The DoD has records of those who received the scholarship, but does not have records on what the Fellows have done since receiving the scholarship (e.g., obtaining a degree, securing employment, conducting research in a given field). Therefore, IDA searched for and analyzed publicly available records to determine the subsequent outcomes for a sample of NDSEG Fellows. To assess the relative level of success between graduate fellowships, these outcomes were compared with those of groups that received a similar fellowship, where appropriate.

Findings

The intent of NDSEG is to "award of fellowships to citizens and nationals of the United States who agree to pursue graduate degrees in science, engineering, or other fields of study designated by the Secretary to be of priority interest to the Department of Defense" (U.S.C. 10, Sect. 2191). More than 3,000 awards have been made, and those have contributed to a very high rate of graduation of awardees and 95% of awardees have gone on to work in their designated fields that have been deemed of interest to DoD.

Graduation Rates

The results for the NDSEG Fellows in pursuit of their PhD indicated that they are very likely to graduate. Of the Fellows in our sample, at least 83% completed a PhD or PhD/MD within 10 years. This is comparable to the rate of National Science Foundation Graduate Research Fellowship Program (NSF GRFP) Fellows who graduated with a PhD within the same time period. The NDSEG Fellow graduation rates compare favorably with the national 10-year completion rates of 55 percent for mathematics and physical sciences and 64 percent for engineering.

Likewise, the time to graduate tends to be at least as good for NDSEG Fellows as for those who receive the NSF-GFRP fellowship; both are less than 6 years. These rates (NDSEG and NSF-GFRP) appear to be faster than averages of the NSF-Honorable Mention cohort, as well as the population for the Survey of Earned Doctorates and a sample of data from Department of Education, all of which are over 6 years.

Employment

When we could identify a work history of Fellows, we found that the overwhelming majority (95%) worked in their field. This indicates that the fellowship may have played a role in facilitating education that led to Fellows obtaining a job in a field that DoD identified as important. Because there is no other scholarship program with similar DoD-directed goals and processes, there isn't a clear comparison to determine how well the fellowship accomplished this goal. The closest comparison study was on the NSF GRFP, and the findings indicate that between 88.2% and 93.4% of the awardees were in jobs related to their field of graduate study.

We also assessed where the awardees worked (beyond working in their field) by categorizing the work history of the Fellows who were working in their field to determine their contribution to DoD and the U.S. Government. Approximately 25% of the Fellows directly worked on the DoD mission, either as part of the DoD civilian workforce or as contractors/grantees for DoD. Another 37% contributed to other components of the U.S. Government (not including DoD) as either civilian employees or as contractors/grantees. This indicates that the majority of Fellows contribute to the scientific mission of the U.S. Government (i.e., DoD and other government agencies).

Field of Study

Likelihood of graduation and place of employment appear to vary across the fields of study for Fellows; however, because of the small sample size per subgroup (360 Fellows across 15 designated degree fields), it is difficult to draw statistically significant conclusions. Differences across fields of study were also noted in the opportunities for employment in private industry and government or DoD. While the current sample may be too small to statistically distinguish outcomes across academic fields of study, analysis

suggests that a few fields of study had very high rates (80% or higher) of Fellows who worked for the U.S. Government or DoD or were contractors/grantees (e.g., civil engineering, oceanography, cognitive/neural/behavioral sciences, and aeronautical engineering). Conversely, there were a few academic fields of study where about 50 percent of the Fellows in that field worked for private industry that did not directly address U.S. Government or DoD needs (e.g., computer science and biosciences). These findings suggest that awards to Fellows in some degree fields may be more likely to benefit the government than awards to Fellows in other fields and could be considered in the selection/award process.

Contents

1. Introduction

The National Defense Science and Engineering Graduate (NDSEG) Fellowship program has provided over 3,000 awards to U.S. citizens for the pursuit of graduate degrees in science, engineering, or other fields of study designated as priority interests to the Department of Defense (DoD). The fellowship is a highly competitive, merit-based award for graduate students who describe their intent to study in the specific academic fields identified by DoD. The fellowships provide up to 3 years of full tuition and fees along with a monthly stipend to be used at the institution of the awardees' choice.

The NDSEG program is directed by the Basic Research Office of the Assistant Secretary of Defense for Research and Engineering, who asked the Institute for Defense Analyses (IDA) to review the NDSEG program and provide an assessment of how the awardees have contributed to DoD and the research interests of DoD.

A. Historical Background

The NDSEG was developed in 1989 based on Congressional authorization (PL 101-189) and the continuing authority is provided through US Code 10, Section 2191. The official intent is the "award of fellowships to citizens and nationals of the United States who agree to pursue graduate degrees in science, engineering, or other fields of study designated by the Secretary to be of priority interest to the Department of Defense" (U.S.C. 10, Sect. 2191). The NDSEG Fellowship is one of several mechanisms the DoD uses to support graduate studies, with others including graduate research assistants under grants and contracts for the performance of military department and defense agency science and technology programs, as well as the Science, Mathematics and Research for Transformation (SMART) Scholarship for Service Program. The intent of SMART is to develop the DoD science and technology (S&T) workforce and each SMART Fellow is guaranteed a DoD position as part of the federal workforce, while the goal of NDSEG is to help develop talent in fields of study with an understanding that much of DoD research is conducted on a contract/grant basis.

Since its inception, DoD has awarded over 3,000 NDSEG fellowships across fields of study identified as important to the DoD: engineering (aeronautical, chemical, civil, electrical, and mechanical); chemistry; cognitive, neural, and behavioral sciences; computer and computational sciences; biosciences; geosciences; materials science; mathematics; naval architecture; oceanography; and physics. Guided by DoD Instruction 3218.02, NDSEG fellowships are awarded through a nationwide competition where the

criteria for award are the applicant's academic ability and the priority of the applicant's proposed field of study to the DoD.[1] On average, only 10% of reviewed applicants are selected to receive awards each year. The selection of NDSEG Fellowship awardees is made by the Army Research Office, Office of Naval Research, Air Force Office of Scientific Research, and the High Performance Computing Modernization Program. The fellowships last for 3 years and pay for full tuition, mandatory fees, and a monthly stipend.

The Basic Research Office within the Office of the Under Secretary of Defense for Research and Engineering asked IDA to review the NDSEG Fellowship, to assess the program's outcomes. This was partly in response to Senator John McCain's critique of the NDSEG Fellowship program for spending "$352 million on graduate degree fellowships for 3,200 U.S. citizens and nationals…, but those fellows incurred no further obligation to DOD" (McCain 2016). This was part of a report that highlighted DoD programs that Senator McCain suggested were wasteful. The purpose of this evaluation was for IDA to assess the outcomes of NDSEG awardees with regard to the expected outcome of the NDSEG program (i.e., obtain graduate degrees and work in a field that is a priority for DoD) and produce a report that provides an assessment of how the awardees have contributed to DoD, the Federal Government, and the research interests of DoD or the Federal Government. The list of DoD's research interests is based on a list of 15 fields of study, with particular focus in any specific area being shaped on an annual basis by the individual Services and their calls for research.[2]

B. Evaluating Fellowships

Evaluating the outcomes of fellowships for graduate studies is not common in the academic literature (Ehrenberg and Mavros 1992). Challenges with evaluating the impact of fellowships include the context for the evaluation (i.e., specific research question), the longitudinal nature of impact of the fellowship, and the difficulty to identify a comparison group that differs only in the reception of the fellowship with few other confounding variables.

In general, students who receive graduate scholarships/fellowships or research-related funding have higher completion rates and shorter time to degree than students who are self-supporting or receive teaching assistantships (Ehrenberg and Mavros 1992). Their analysis was done across a range of funding programs so it did not indicate how well any particular scholarship/fellowship program was achieving its goal, only that research-related funding in general is beneficial in producing graduates.

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1 http://www.dtic.mil/whs/directives/corres/pdf/321802p.pdf.

2 https://www.ndsegfellowships.org/ provides a broad overview of research interests of DoD along with direction for finding particular research interests within the Services.

Another framework for analyzing scholarship and fellowship programs is to compare the program to itself at a different point in time to determine if the program is eliciting improved outcomes over prior years. One example of such a study is Goldsmith, Presley, and Cooley (2002), who compared recipients of the National Science Foundation (NSF) Graduate Research Fellowship Program (GRFP) across 1979–1993 and found that completion rates increased and that women and minority awardee percentages increased over time. These results provide a picture of how the program is evolving over time, but the results may also be due to societal changes rather than actual changes to the fellowship.

Another method for evaluating the process of selecting scholars for a program is to compare awardees with those who did not receive the award but were finalists in the competition. The NSF GRFP categorizes applicants into groups. Quality Group 1 applicants are rated as those that are in the top 5% of applicants and should definitely receive a scholarship. Quality Group 2 applicants are those applicants that are in the next 10% of applicants. About half receive awards based on available funding, with the other half of Quality Group 2 applicants receiving designation as honorable mentions. An evaluation of the NSF GRFP was conducted by the National Opinion Research Center (NORC 2014) at the University of Chicago, and the center found that recipients of the GRFP were more likely to complete their PhD within 10 years than honorable mention applicants. Another analysis of NSF GRFP awardees from Quality Group 1 and 2 indicated that degree completion rates were higher for Quality Group 1 than for Quality Group 2 (Chapman and McCauley 1994). The predictive validity for long-term post-PhD measures like success in obtaining research grants was less clear but suggests the validity of the group-selection process.

The NDSEG and GRFP scholarships are similar in length and magnitude of award; therefore, the evaluation of the GRFP provides a potential comparison for NDSEG outcomes. There are differences between the NDSEG and GRFP in that the GRFP Fellows are expected to contribute to "develop the globally-engaged workforce necessary to ensure the Nation's leadership in advancing science and engineering research and innovation," with the expectation that awards will lead to a broad impact and benefit to society.[3] Comparatively, the NDSEG is focused on scientific domains that are specifically DoD relevant.

IDA aimed to assess the NDSEG program through two processes. The first is by evaluating the individual awardee outcomes in relation to the stated intentions of the fellowship. The outcomes of interest include Fellows likelihood of working in the field of study, working for the DoD or Federal Government, time-to-graduation, and contributions

[3] The program solicitation that describes the current requirements for the GRFP can be found at https://www.nsf.gov/pubs/2018/nsf18573/nsf18573.htm.

to the awardees field of study. The second was to compare the outcomes of NDSEG sample with similar group outcomes (e.g., NSF GRFP awardees and honorable mentions).

2. Method

To assess the outcomes of the NDSEG Fellowship Program, we collected and assessed the contributions and activities of a sample of awardees receiving the fellowship. The DoD has records of the names of the awardees who received the scholarship, but does not have records on what the Fellows have done since receiving the scholarship (e.g., obtaining a degree, securing employment, conducting research in a given field). A survey of awardees was not feasible because DoD does not have contact information on the awardees. Therefore, IDA searched for and analyzed publicly available records to determine the subsequent outcomes for a sample of NDSEG Fellows. To assess the relative level of success between graduate fellowships, these outcomes were compared with those of groups that received a similar fellowship, where appropriate.

A. Sampling Procedure

The initial step toward sampling NDSEG Fellows was the determination that the sample would be from awards given from 2000 to 2009. This 10-year span was chosen because most Fellows would have graduated and entered the workforce by the time of data collection (i.e., summer of 2018) and also because the Fellows from these years were likely to have a significant online presence. The nearly 2000 NDSEG Fellows from that time period attended 120 different schools, most of which were classified as the highest level of research institution in the 2015 Carnegie Classification, as depicted in Table 1. Appendix A provides a full listing of all the schools attended by all Fellows during this time period and those attended by Fellows in our sample.

Table 1. Classification of Institutions that Fellows Attended

Carnegie Classification	Count of Schools	Count of Fellows	Percentage of Fellows
R1	89	1874	96.15%
R2	20	37	1.90%
R3	3	3	0.15%
Other	8	35	1.80%
Total	**120**	**1949**	**100%**

The next step of the sampling procedure was an effort to obtain information on at least 300 Fellows (more than 15% of the total number of awards during that time). It was

anticipated that there might be some difficulty in finding data on all Fellows in the sample, so IDA researchers collected 3 rounds of data in batches of 120 Fellows per round. Fellows were randomly sampled from each year's awardee list, yielding 3 batches of 12 from each year, evenly distributed across years, for a total of 360 Fellows. During piloting of the public record search process, about 10% of those searched for were not found; therefore, we oversampled and searched for 360 Fellows to ensure we had records on at least 300 Fellows.

B. Identifying Contributions and Outcomes

For each awardee in the sample, two researchers searched independently on the internet using publicly available information. The process typically started with a systematic Google search of the awardee's name, "NDSEG," and the school that was listed on the awardee's application. This was followed with searches on commonly used networks and databases such as LinkedIn, Scopus, the Defense Technical Information Center (DTIC), ResearchGate, ProQuest, news organizations, and, as more information was obtained, university and company websites. In no case were individuals or institutions contacted directly. It is understood that publically available records on the Internet may not always be accurate, however this assessment had to rely on public records because no records are held by DoD on what the NDSEG awardees have done since their award.

1. Confirming Fellows' Identity

The first step was to confirm the identity and NDSEG status of the scholar. Because there are many people with similar names, we had to confirm that the person we found information about was the NDSEG awardee and exclude information about people with names similar to awardees who were not the actual awardees. IDA researchers only had a person's name, NDSEG award year, and the university name on their application (this was not always the university where they ended up attending), so it was important to verify that the information found was for the correct person. Often, individuals voluntarily listed the NDSEG award on a public biography, and sometimes the fellowship was mentioned in a news article or on a university website. However, it was sometimes impossible to verify an individual's NDSEG status directly, and in these cases the matching name and attendance at the expected institution would have to be relied upon as confirmation. An individual's name was never the sole source of information for corroborating identity. If identity confirmation was unverifiable, the Fellow was not scored.

2. Collecting Graduate School Metrics

After confirmation of the Fellow's identity, information was collected on the awardee's school (sometimes different than the institution they expected to attend at the time of the award), field of study, years of enrollment and graduation, and dissertation title.

In total, the identities of 343 of 360 NDSEG Fellows were confirmed by IDA researchers, with a subset providing a complete set of information across subsequent categories.

From the information collected about each Fellow, descriptive statistics were compiled on graduation rates, time to degree, and field of study. If any particular piece of information could not be found for any Fellow, the Fellow was excluded from the relevant analysis for that piece of information. For example, school start years were taken from students' biographies or CVs, but were not always available for all Fellows. Graduation years were preferentially determined from each Fellow's thesis or dissertation, with other sources such as LinkedIn or biography pages being used to corroborate dates if dissertations were inaccessible. Fields of study were categorized according to those listed on the NDSEG website (Solutions Through Innovative Technologies, Inc. 2018). Graduation years and degree types were determined for 337 Fellows, while school start years were confirmed for 236 Fellows. Fields of study were found for 343 of the 360 researched Fellows. Only six Fellows were found to have changed graduate schools from the one listed on their application.

3. Employment History

Next, information was gathered on each Fellow's employment history to categorize participation in the workforce. This search for information included all previous and current positions after graduation. Any government positions, especially in the DoD, were identified along with sources of funding for their post-graduation work, to determine if the work was in service to DoD or the U.S. Government. Publications were searched for the acknowledgement of grants, and company webpages were reviewed for information relating to the specific projects the individual worked on. For example, while it might be assumed that an NDSEG awardee who works for a company primarily known for defense work (e.g., Lockheed Martin) worked on a government contract, some cases (e.g., Boeing) required additional information to determine whether the individual performed work on behalf of the government or DoD specifically, or for the commercial sector of the business.

a. Categorization of Employment

Table 2 describes the categorization metric used to measure NDSEG outcomes related to employment. In summary, categorical scores were determined based on employment. Two categories indicated that the Fellow did not achieve a favorable outcome based on the goal of the NDSEG fellowship; these were "Not in Field" (NF) and "Technical but in Different Field" (DF). All other categories include successful outcomes that indicate an achievement of the goal of the fellowship (students obtaining advanced degrees and worked in their field of study). The category of "In Field" (IF) indicates that the Fellow had work experience in their field of study after graduation. The categories of "Government" (Gov) and "DoD" were given for work as part of the federal workforce for

the Federal Government or DoD specifically. If the recipient worked as a contractor or grantee in support of the government or DoD they were categorized as "Government Support" (GS) or "DoD Support" (DS), respectively.

b. Categorization Process

Using the guidelines outlined in Table 2, each researcher independently assigned each Fellow to a category if enough information to make a determination could be found. A third researcher then used the information compiled by both researchers to confirm the category when the initial raters agreed or to make a final determination when the two raters did not agree. Usually, discrepancies were caused by variations in the amount of information the researchers were able to find. For example, one researcher might find that after graduation, a Fellow worked on a government grant described in the Government Support (GS) category, but the other researcher may have not uncovered this information and only found information confirming that the Fellow had worked In their Field (IF). In total, enough information was found on 325of 360 Fellows (90%) for their post-fellowship employment to be categorized.

Table 2. Post-Graduation Employment Categorization

Category	Criteria
Not in Field (NF)	Employment history shows individual never worked in the (broadly scoped) field of their degree
Technical, but Different Field (DF)	Employment history shows that they did not/do not work in the (broadly scoped) field of their degree, but do require the technical skills from their degree to work in their field
In Field (IF)	Employment history shows that they worked in the (broadly scoped) field of their degree, but not for the government or a government contractor **OR** Publication history shows that they contributed to the (broadly scoped) field of their degree by publishing research post-graduation
Government Support (GS)	Employment history shows that they worked in the (broadly scoped) field of their degree for a non-DoD government contractor **OR** Employment history shows that they worked in the (broadly scoped) field of their degree at a college/university and received grants from (non-DoD) government agencies
Government (Gov)	Employment history shows that they worked in the (broadly scoped) field of their degree for the government (not including DoD)
DoD Support (DS)	Employment history shows that they worked in the (broadly scoped) field of their degree for a DoD contractor **OR**

Category	Criteria
	Employment history shows that they worked in the (broadly scoped) field of their degree at a college/university and received grants from any part of DoD
DoD	Employment history shows that they worked in the (broadly scoped) field of their degree in any part of DoD

4. Publications and Scientific Contributions

One of many ways to measure contributions to science is through publications. Information was collected on Fellows' publications as one indicator of their potential contribution to science. During data collection of Fellows in our sample, we identified academic publications that were published after they graduated as an indicator of scientific contribution. We considered five or more post-graduation publications as an indication that the person was a regular contributor to the academic literature, given that the sample was only from relatively new PhDs (i.e., likely to have started graduate school in the 2000–2009 timeframe).

C. Identifying Comparison Groups

Because there is no standard set of metrics to compare the NDSEG Fellowship against, we had to identify a few relevant data sets that we could use to provide context for our results. These include the data on NSF GRFP—both the awardees and the honorable mentions, as this covered those with a similar Fellowship (GRFP awardees) or those whose merits for fellowship awards were of similar quality (GRFP Honorable Mentions)—provided by NORC (2014). In addition, we used data sets on the general population of those who started a PhD program in science and technology domains as collected by the Department of Education (U.S. DOE 2005) and the results from the Survey of Earned Doctorates as provided by NSF, National Center for Science and Engineering Statistics (2017). These data sets share some similarities with the NDSEG data we found, but due to differences in populations, fellowship programs, and specific metrics, direct statistical comparisons were limited.

3. Results

In Table 3 we report the metrics for the NDSEG Fellows used in our analysis. The differences in *N* reflect the information confirmed about each Fellow.

Table 3. The Number of Individuals for Each Analyses

Data category	*N*
Total sample	360
Confirmed Identity (field and school)	343
Confirmed graduation year and degree	337
Calculated time to graduation	236
Categorized employment	325
Publications	302

The NDSEG Fellows were compared to three different groups from the NORC (2014) analysis of NSF GRFP, where appropriate. First are the NSF Graduate Research Fellowship Program awardees, who can be thought of as peers who have been awarded a similar type of scholarship. Second are the NSF GRFP runners-up, people who almost received the award and who are therefore similar to the winners in terms of their pre-graduate-school achievement levels, behaviors, and other characteristics. Additional groups for comparison is the general population of those who started a PhD program in science and technology domains as collected by the Department of Education (U.S. DOE 2005) and the Survey of Earned Doctorates (SED, a survey of all those who earned a research PhD in a given academic year used to assess the doctoral population and trends in doctoral education) (NSF 2017). Since data collection and scoring methods differ between our analyses of NDSEG, the NORC's analysis of NSF's GRFP, and the Department of Education data, only very large differences between the groups should be considered notable. These comparisons are presented to guide expectations in the absence of a true control group for NDSEG Fellows and to pose questions for future investigation rather than as a direct comparison of programs for statistical significance. The following analyses compare NDSEG Fellows to one or more of these comparison groups because relevant and comparable data were not available for all the groups.

A. Field of Study

Because the purpose of the NDSEG program is to increase the number of professional scientists in fields of interest to the DoD, we report which fields the Fellows in our sample studied (Figure 1). DoD has identified 15 fields of study that are of continuing interest, and we organize the data according to those 15 fields based on the degrees the Fellows pursued. In the subsequent sections of the report the metrics for the number of Fellows in each field are depicted for either their degree (Figure 3) or their employment categorization (Figure 6). There are 360 Fellows in our sample and breaking them down into their many component fields results in a small number of members in each category. It is therefore difficult to draw statistically significant conclusions.

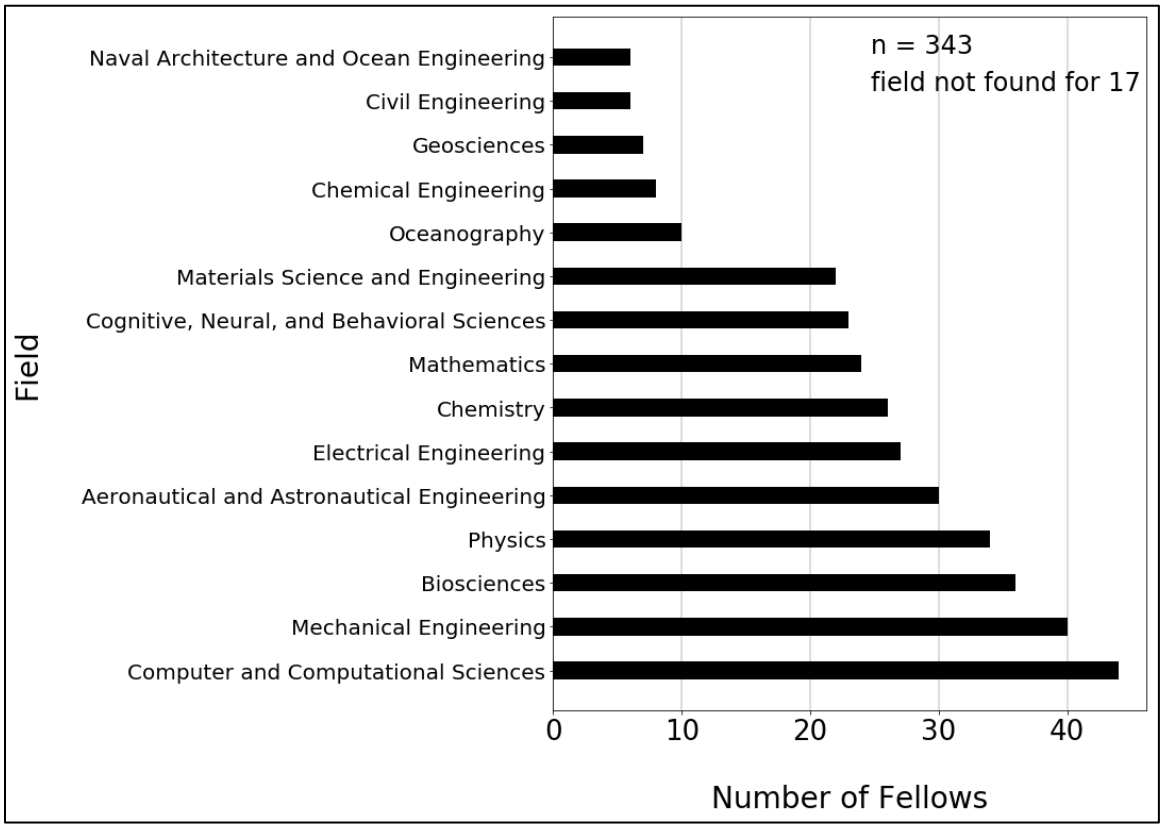

Figure 1. NDSEG Fellow Fields of Study

B. Graduation

Graduation is reported in two different ways: (1) the percentage of Fellows who were awarded degrees (i.e., graduation rate), and (2) the time it took for them to graduate (i.e., time to degree).

1. Graduation Rates

Figure 2 shows the degrees awarded. Of the 337 Fellows we could confirm schooling status (i.e., graduation with a degree or continued pursuit of degree), the majority of NDSEG Fellows (89.6%) were awarded a PhD (297 PhD alone; 5 with an additional MD); 31 (9.1%) were awarded an MS, and 4 (1.2%) of whom were still working on a PhD at the time of investigation. We could not confirm status of 23 Fellows, so they were not used in the calculation of graduation rate above. That is, they might not have graduated, or they might have little social media presence, so we were unable to confirm their schooling status.

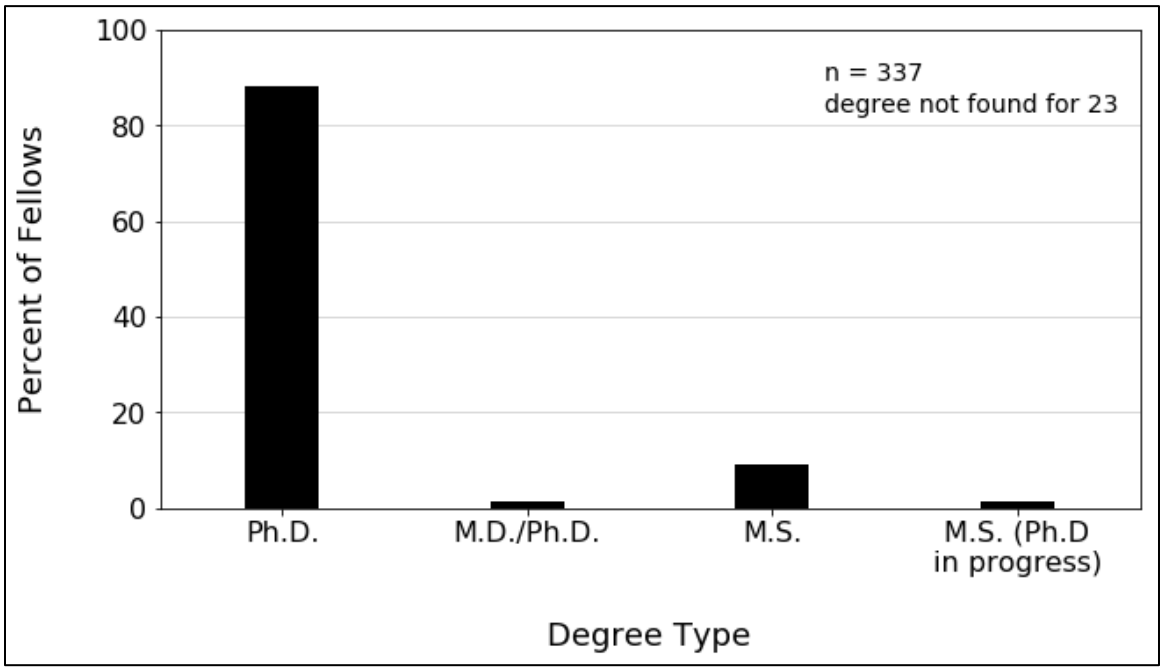

Figure 2. NDSEG Fellow Graduation Rates. The highest degrees awarded to each of the 337 Fellows are shown.

The most conservative measure of graduation rate for NDSEG, which is those that obtained a PhD (302) divided by the total number of Fellows in our sample (360), indicates a graduation rate of 83.8%. This compares well with the NDSEG PhD graduation data with outcomes of the NSF GRFP (NORC 2014, 75): 82.7% of GRFP Fellows graduated with a PhD within 10 years, compared with 77.9% of the GRFP honorable mention comparison group.

As a further comparison, we reviewed the National Center for Education Statistic's (NCES) *Baccalaureate and Beyond* longitudinal data set (U.S. DOE 2005). As part of this study, undergraduate seniors in 1992/1993 were asked for their academic intentions and then were resurveyed 10 years later, in 2003. For the sake of comparison to the NDSEG cohort that was only for STEM fields, students in the NCES data set were filtered for

graduate enrollment in STEM fields. Of the NCES respondents who stated an initial intention to obtain a PhD, approximately 47% had obtained one within 10 years. NCES respondents were further filtered by the receipt of grants, scholarships, or fellowships, and it was found that students who received these types of assistance had a 78% PhD graduation rate, while those who did not receive such assistance had a 29% PhD graduation rate.

Several factors limit direct statistical comparison of these numbers with the NDSEG. For example, the NDSEG cohort varies in fields of study (i.e., fields identified as important to DoD) from both the GRFP and NCES populations, and degree attainment and other outcomes vary strongly by field, as shown in the NSF report. In addition, the NCES study concerned students who on average entered graduate school over a decade before NDSEG scholars, but degree completion rates have changed over time (NORC 2014). Furthermore, both the GRFP and NCES studies rely upon large amounts of self-reported data, compared with this report's analysis of public information on NDSEG Fellows. However, it may still be suggested that NDSEG awardees graduate with a PhD at rates comparable to students receiving other sources of funding based on merit (i.e., GRFP or other resources covered in the NCES data) and at higher rates than NCES respondents that did not receive funding.

For the NDSEG Fellows, graduation rates were not consistent across fields of study, as shown in Figure 3. Of the 337 Fellows where we could confirm graduation with a PhD or master's degree, there were some fields of study where about a quarter did not receive a PhD (e.g., mechanical engineering and computer and computational sciences), which was at a much higher rate than the other fields of study. It is not clear what may influence this disparity of graduation rates, but it may be differences in the employment market for those with or without a PhD in particular fields.

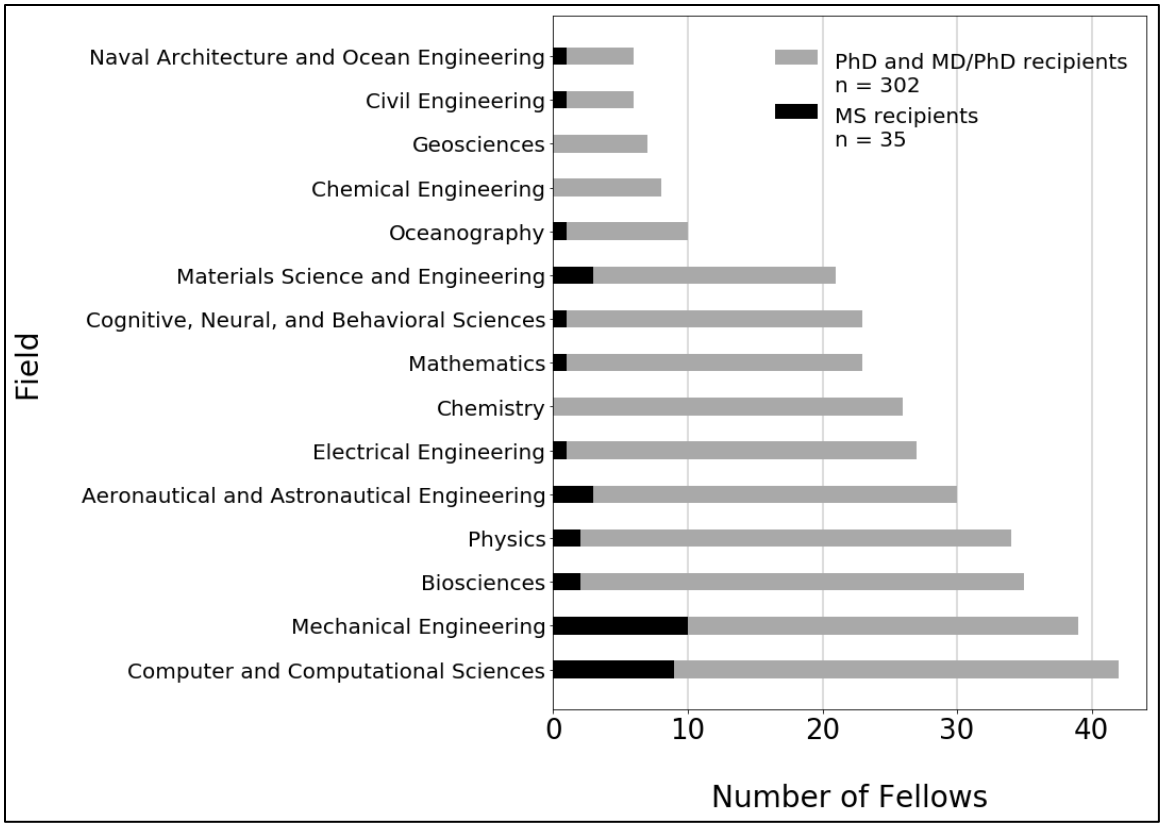

Figure 3. NDSEG Fellow Degree Field. The field associated with each Fellow's degree is shown. There were 337 Fellows whose field of study was known. The 302 Fellows who graduated with a PhD are shown in light gray; the remaining 35 Fellows are shown in black.

2. Time to Degree

The second graduation metric calculated was the time it took Fellows to graduate. Graduation time is defined as the difference between the year of entry to the graduate program (confirmed for 236 Fellows) and the year the final diploma was received (confirmed for 337). Fellows who earned a PhD graduated within 5.6 years of matriculation on average, with a mode of 5 years, as shown in Figure 4.

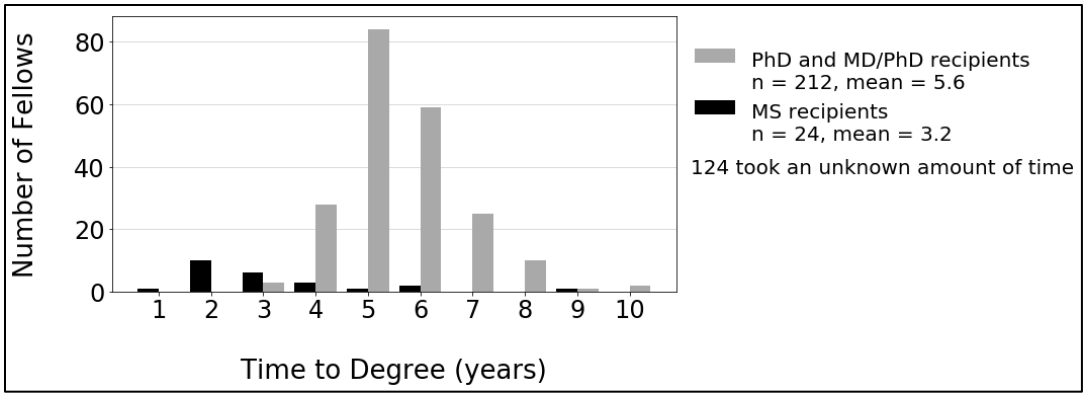

Figure 4. NDSEG Fellow Graduation Time. The difference between the year of entry to the graduate program and the year of the final diploma is shown for the 212 PhD or MD/PhD Fellows (gray) and 24 Masters Fellows (black) for whom we have data.

Some data for graduation times are available for comparison, as shown in Table 4. These data include the NDSEG data we found, the NSF GRFP and Honorable Mention groups as analyzed by NORC (2014), the Survey of Earned Doctorates (SED) (NSF 2017), and data from the Department of Education (DoEd) (U.S. DOE 2005). Note that differences in fields of study are not fully accounted for in these comparisons and may influence results, as found in (NORC 2014). In addition, some of these sources used units of months, while the NDSEG data was compiled in units of years (which could introduce some bias into the numbers). The results, shown in Table 4, suggest that NDSEG Fellows may complete their PhD faster than PhD graduates who receive the NSF GRFP and the NSF Honorable Mentions, and faster than the samples from the SED and DoEd.

Table 4. Average Time to PhD Completion (in years) across Student Groups

Source	*N* =	Mean
NDSEG	212	5.6
NSF-GRFP	7,459	5.95
NSF-Honorable Mentions	2712	6.17
SED	241,476	6.69
DoEd	7,982 (weighted)	6.14

C. Employment

Figure 5 plots the employment categorization for the NDSEG Fellows. Out of 360 Fellows investigated, 325 were categorized (see Table 2 for categorization codes and description); the remaining 35 did not have enough public information to categorize their employment. The vast majority (94.5%) of scored Fellows are categorized as having worked in their field of study after graduation (i.e., IF, GS, Gov, DS, or DoD), indicating

a successful outcome in that awardee worked in a field of study that DoD considers a priority. A quarter (25.2%) are in categories indicating that their work directly contributed to the DoD (i.e., DS or DoD), and over a third (36.6%) of the Fellows are in categories indicating that they have contributed to the U.S. Government beyond DoD (i.e., GS or Gov).

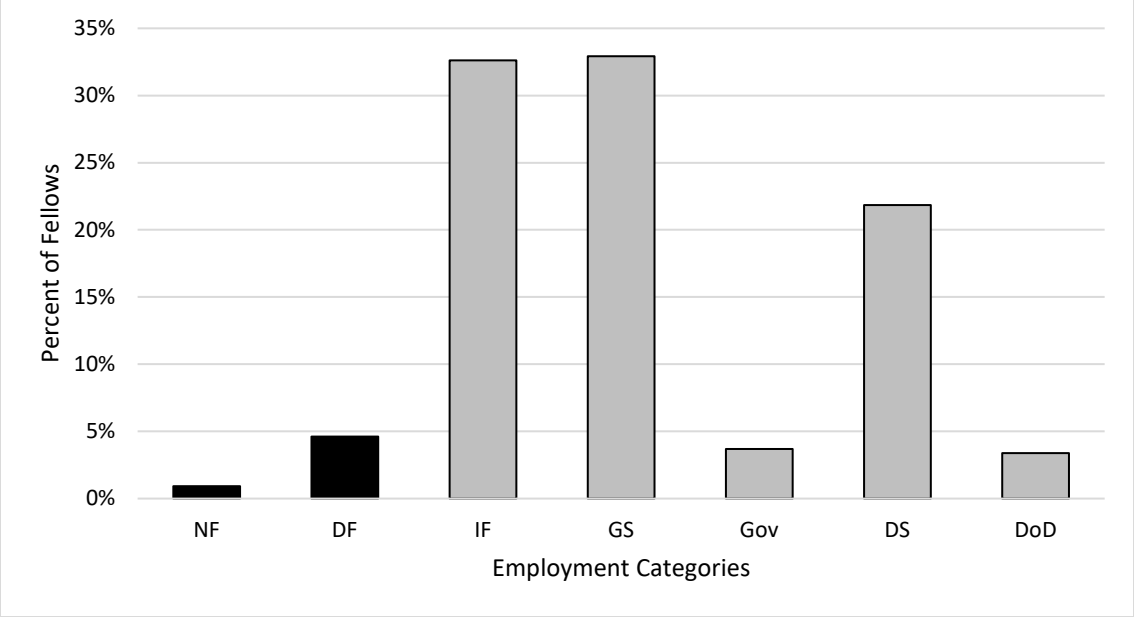

Figure 5. NDSEG Fellow Employment Category Distribution. The two black bars to the left indicate poor outcomes and the right-most five gray bars indicate categories that are positive in that the graduate worked in their field of study (i.e., the goal of NDSEG).

There is no clear comparison group from other data sets based on contribution to DoD, the U.S. Government, or a Fellow's field of study. The closest comparison is the NSF GRFP report. This report found that only 7.2% of PhD completers worked in government, but did not distinguish between U.S. and foreign governments (NORC 2014). The report also found that 31.4% worked in the private sector. Similarly, data from the Survey of Doctorate Recipients found that 11.2% of PhD recipients worked in U.S. or foreign governments and 38.9% in the private sector (NORC 2014). As another comparison, the Department of Education Survey results show that 13.6% ± 6% of STEM PhDs from not-for-profit institutions worked for the Federal Government (U.S. DOE 2005).

Across fields of study, there appears to be variation as to where people find employment. Figure 6 shows the fields associated with each Fellow's degree and employment categories. There were 325 Fellows whose employment and field of study were both known. The right and left graphs show the same data, with the left showing the data based on actual number of Fellows and the right showing data based on the

percentages in each field. The percentage-based data allow for an analysis of how likely an NDSEG Fellow in a particular field may work for private industry, the Government, or specifically the DoD. There are differences across fields. For example, in civil engineering, aeronautical and astronautical engineering, oceanography, or cognitive, neural, and behavioral sciences a Fellow is more likely to work for or support the government or DoD, whereas in computer science or bioscience a Fellow is more likely to work in private industry.

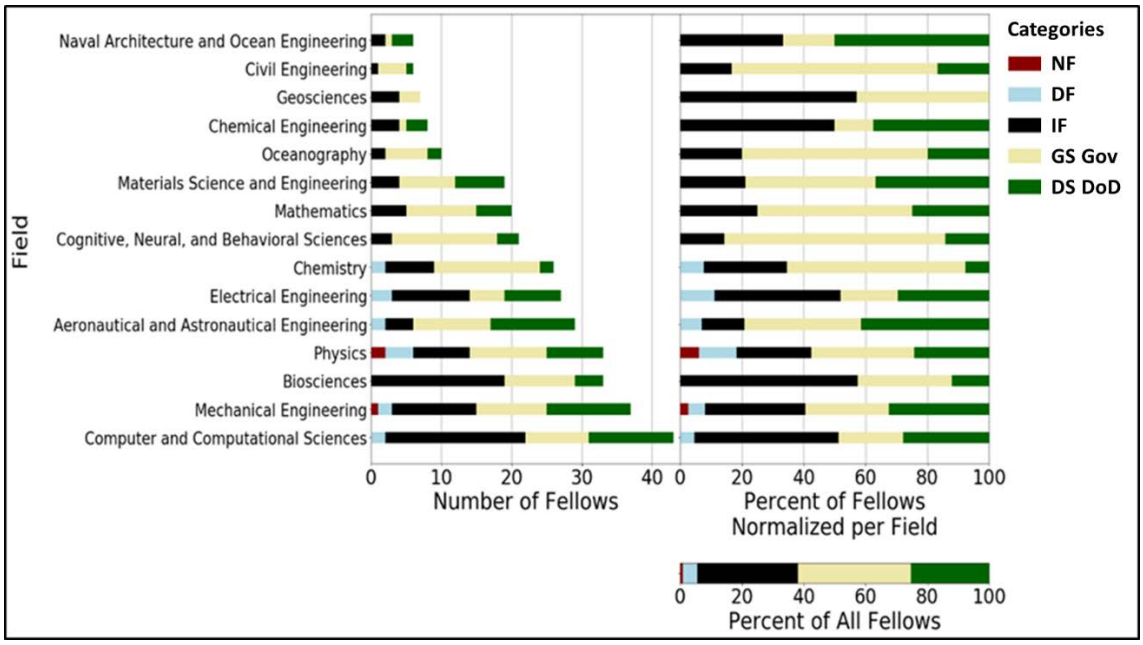

Figure 6. NDSEG Fellow Degree Field and Subsequent Employment Categories. The graph on the right contains the same information as the graph on the left, but is normalized to show the percentages in each column. The bar at the lower right shows the employment category percentages of all Fellows combined.

D. Publications

Counts of peer-reviewed publications after graduation were made for each Fellow. There is considerable variability in publication information available (e.g., academic research found through online resources like Google Scholar, Scopus, DTIC, ResearchGate, and ProQuest), along with uncertainty in attributing a publication specifically to work done after the NDSEG Fellowship was completed because publication dates regularly lag the period of when the research was completed by more than a year. Therefore, we categorized PhD and M.D/PhD recipients who produced five or more research publications post-graduation as active producers of scientific contributions. A majority (59%) of the 302 PhD recipients published five or more papers after graduation. There is no clear comparison group for this metric.

4. Summary and Conclusions

A. Summary of Findings

This assessment of NDSEG Fellows was to review the accomplishments of NDSEG awardees and analyze the results to provide an indication of how the scholarship program may have contributed to DoD, the Federal Government, and research interests that are important to DoD. The assessment was based on a random sample of 360 Fellows who entered the program over a 10-year period (2000–2009). This time frame was used because the cohort entering graduate programs during this period would be expected to have a web presence, allowing for public information to be gathered. The relatively recent time frame not only enabled us to consider how the program is functioning but also to depict some impacts of the degree attainment. The time frame was also broad enough (10 years) to minimize the effect of any short-term anomalies in economic opportunities.

The DoD has no on-going records of the fellows after they received the award, so the data-collection method used only publicly available information. In some instances the relevant information on NDSEG Fellows could not be found; in others, the information that was found could not be clearly distinguished between the NDSEG Fellow or a similarly named individual. The assessment was intended to provide a description of the impact of the program in general, not to describe the outcomes for any single individual. Therefore, no names were given, and only group data were provided. Only data that could be clearly linked to the NDSEG Fellow were included in our analysis, so for some impact measures, the number of cases used was less than the total number of the sample ($N = 360$).

1. Graduation Rates

The results for the NDSEG Fellows obtaining their PhD indicated that they are very likely to graduate. Of the Fellows in our sample at least 83% completed a PhD or PhD/MD within 10 years. This is comparable to the rate of NSF GRFP Fellows who graduated with a PhD within the same time period (NORC 2014, 75). Previous GRFP assessments of earlier cohorts had lower graduation rates (Chapman and McCauley 1993), but this may be due to cohort factors in education that have changed over decades. The NDSEG Fellow graduation rates compare favorably with the national 10-year completion rates of 55 percent for mathematics and physical sciences and 64 percent for engineering (Sowell et al. 2008). The current findings are also in agreement with Ehrenberg and Mavros (1992) who found that research funding of graduate students increases their likelihood of graduation.

Likewise, the time to graduate tends to be at least as good for NDSEG Fellows as for those who receive the NSF-GFRP fellowship; both are less than 6 years. These rates (NDSEG and NSF-GFRP) appear to be faster than averages of the NSF-Honorable Mention cohort, as well as the population for the Survey of Earned Doctorates and a sample of data from Department of Education, all of which are over 6 years. Multiple variables influence the likelihood of receiving a scholarship, some of which are merit based, and these variables may influence how quickly students graduate (Graddy-Reed, Lanahan, and Ross 2017). It is therefore difficult to discern how much the NDSEG award enables a Fellow to graduate and how much the graduation rate is the result of the NDSEG selecting talented students who are already very likely to graduate.

2. Employment

A primary goal of NDSEG is to produce a technical workforce in fields of interest to the DoD. When we could identify a work history of Fellows, we found that the overwhelming majority (95%) achieved this positive outcome of working in a field of interest to the DoD. This indicates that the fellowship may have played a role in facilitating education that led to Fellows obtaining jobs in a field that DoD identified as important. Because there is no other scholarship program with similar DoD-directed goals and processes, there isn't a clear comparison to determine how well the fellowship accomplished this goal. The closest comparison study was on the NSF GRFP, and the findings indicate that between 88.2% and 93.4% of the awardees were in jobs related to their field of graduate study (NORC 2014, 51).

We also categorized the work history of the Fellows, beyond working in their field, to determine their contribution to DoD and the U.S. Government. We examined the work history of the Fellows who were working in their field to determine their contribution to DoD and the U.S. Government. Approximately 25% of the Fellows worked directly on the DoD mission, either as part of the DoD civilian workforce or as contractors/grantees for DoD. Another 37% contributed to other components of the U.S. Government (not including DoD) as either civilian employees or as contractors/grantees. This indicates that the majority of Fellows contribute to the scientific mission of the U.S. Government (i.e., DoD and other government agencies) directly or through contracts and grants.

The most relevant comparison group identified was from NORC (2014, 97), which identified those that worked in any form of government (U.S. or foreign). For the NSF GRFP PhD graduates, 7.2% worked for either the U.S. or foreign governments (the report did not distinguish which governments). The NDSEG Fellows were employed at a comparable rate (7%) directly for the U.S. Government, including the DoD; an additional 55% were working to support the U.S. Government through contract work or grants.

3. Field of Study

Likelihood of graduation and place of employment appear to vary across the fields of study for Fellows; however, because of the small sample size per subgroup (360 Fellows across 15 different degree fields), it is difficult to draw statistically significant conclusions. The results suggest that Fellows in some fields are more likely not to complete their PhD, stopping after receiving a master's degree (e.g., mechanical engineering and computer and computational sciences). This may be due to different opportunities of some fields, such as computer science and mechanical engineering, where a PhD may not be as advantageous for employment compared with fields like chemistry, behavioral science, and physics.

Differences across fields of study were also identified in the likelihood for employment in private industry and government or DoD. While the current sample may be too small to statistically distinguish outcomes across academic fields of study, visual analysis suggests that a few fields of study had very high rates (80% or higher) of Fellows who worked for the U.S. Government or DoD or were contractors/grantees (e.g., civil engineering, oceanography, cognitive/neural/behavioral sciences, and aeronautical engineering). Conversely, there were a few academic fields of study where about 50 percent of our sample worked for private industry (e.g., computer science and biosciences).

B. Conclusions

The intent of the NDSEG Fellowship program is to increase the number and quality of our nation's scientists and engineers that can contribute to research domains that are important to DoD, and the scholarship has helped many Fellows to graduate and work in fields of interest to DoD. The NDSEG Fellows perform well in graduate school, and an overwhelming majority of them contribute to the fields that have been identified as important to DoD. The success of NDSEG Fellows may be due to the competitive selection process in that only high performing students are awarded the Fellowship. This selection process may also be a strong influence on why they graduate at high rates.

The range of academic fields where people are encouraged to gain PhDs through the Fellowship is quite broad. It is not clear how the prioritization of those fields is determined. With the SMART scholarship program (Balakrishnan et. al. 2018), the determination is fundamentally made at the level of individual position needs of DoD labs and facilities because scholars are guaranteed a position at a particular lab if they successfully complete their education. However, the NDSEG program is not focused on filling specific positions at DoD labs (even though some of the Fellows go on to ultimately work as DoD researchers), but instead the goal is to encourage people to work in a field. The NDSEG and SMART programs have two different goals, with NDSEG working to promote people to study and work in particular fields of study and SMART to help develop the DoD civilian workforce. Each plays a distinct role in how DoD can promote science and technical education through DoD-funded scholarships. The DoD funds much of its basic research

through contracts and grants, and many of the Fellows gain the academic credential through NDSEG and then are qualified for research positions where they support DoD or U.S. Government research needs.

C. Potential Next Steps

This evaluation effort was a targeted assessment to review the accomplishments of NDSEG awardees to provide an understanding of how the awardees have contributed to DoD, the Federal Government, and the research interests of DoD or the Federal Government. This current analysis is an initial effort to understand the outcomes of the NDSEG program; however, additional analyses could be conducted to provide more detailed information on the program:

1. Analyze fields of study of awardees across years to assess how these may match DoD research requirements. This analysis could include a comparison of where the research is conducted, either in-house at DoD facilities or contracted out through research contracts and grants.
2. Collect qualitative data through interviews of a sample of Fellows. The questions asked could address the Fellows' perceptions of the application/selection process, the enabling effects of the funding on degree completion, and how the fellowship may have changed their understanding of DoD research.
3. Collect data from Fellows who were recently awarded the NDSEG, and track their progress longitudinally over the course of their fellowship. In particular, look at employment across sectors to see how their work may be contributing to the DoD mission.
4. Conduct a process evaluation, assessing the how the program selects awardees and facilitates their progression through the fellowship. This could be done through interviews with selection officials and applicants, along with the analysis of program documentation.

Appendix A.
Graduate Institutions Attended by NDSEG Fellows from 2000 to 2010

Table A-1 shows graduate institutions attended by NDSEG Fellows from 2000 to 2010, as well as those sampled in this study. Note that the school attended by a Fellow may not necessarily have been the one indicated on his or her application.

Table A-1. Institutions Attended by NSDEG Fellows from 2000 to 2010

Institution	Total Fellows from 2000-2010	Fellows in Sample	Percent of Total from 2000 to 2010	Percent in Sample	Carnegie Classification
Massachusetts Institute of Technology	307	67	15.75%	18.61%	R1
Stanford University	248	45	12.72%	12.50%	R1
University of California, Berkeley	158	29	8.11%	8.06%	R1
Harvard University	136	24	6.98%	6.67%	R1
California Institute of Technology	80	14	4.10%	3.89%	R1
Princeton University	73	15	3.75%	4.17%	R1
University of Michigan	71	20	3.64%	5.56%	R1
Carnegie Mellon University	52	5	2.67%	1.39%	R1
University of California, San Diego	47	3	2.41%	0.83%	R1
Cornell University	45	9	2.31%	2.50%	R1
Georgia Institute of Technology	44	10	2.26%	2.78%	R1
Northwestern University	42	6	2.15%	1.67%	R1
University of Illinois, Urbana-Champaign	41	8	2.10%	2.22%	R1
University of Washington	36	7	1.85%	1.94%	R1
University of California, Santa Barbara	31	7	1.59%	1.94%	R1
University of Texas at Austin	28	4	1.44%	1.11%	R1
University of Wisconsin, Madison	24	8	1.23%	2.22%	R1

Institution	Total Fellows from 2000-2010	Fellows in Sample	Percent of Total from 2000 to 2010	Percent in Sample	Carnegie Classification
Columbia University	23	5	1.18%	1.39%	R1
Pennsylvania State University	23	3	1.18%	0.83%	R1
Johns Hopkins University	20	2	1.03%	0.56%	R1
Purdue University	20	5	1.03%	1.39%	R1
Texas A&M University	20	3	1.03%	0.83%	R1
Yale University	19	5	0.97%	1.39%	R1
University of Colorado, Boulder	16	3	0.82%	0.83%	R1
New York University	14	3	0.72%	0.83%	R1
Brown University	13	4	0.67%	1.11%	R1
Ohio State University	13	1	0.67%	0.28%	R1
University of California, Los Angeles	13		0.67%	0.00%	R1
Virginia Polytechnic Institute and State University	13	1	0.67%	0.28%	R1
University of Chicago	12	2	0.62%	0.56%	R1
University of Maryland, College Park	11	1	0.56%	0.28%	R1
Duke University	10	1	0.51%	0.28%	R1
Rice University	10	1	0.51%	0.28%	R1
University of California, San Francisco	10	3	0.51%	0.83%	Other
University of Pennsylvania	9	1	0.46%	0.28%	R1
University of Washington, School of Oceanography	8		0.41%	0.00%	Other
University of Florida	7	1	0.36%	0.28%	R1
University of North Carolina, Chapel Hill	7	2	0.36%	0.56%	R1
Clemson University	6		0.31%	0.00%	R1
Rutgers University	6	1	0.31%	0.28%	R1
Scripps Research Institute	6	2	0.31%	0.56%	Other
University of Notre Dame	6	1	0.31%	0.28%	R1
University of Virginia	6	1	0.31%	0.28%	R1
Washington University in St. Louis	6	1	0.31%	0.28%	R1
Case Western Reserve University	5	1	0.26%	0.28%	R1
North Carolina State University	5		0.26%	0.00%	R1

Institution	Total Fellows from 2000-2010	Fellows in Sample	Percent of Total from 2000 to 2010	Percent in Sample	Carnegie Classification
University of Minnesota	5	2	0.26%	0.56%	R1
University of Rhode Island	5	1	0.26%	0.28%	R2
Drexel University	4		0.21%	0.00%	R2
Emory University	4		0.21%	0.00%	R1
University of Arizona	4	1	0.21%	0.28%	R1
University of California, Irvine	4		0.21%	0.00%	R1
University of Miami	4		0.21%	0.00%	R1
University of South Florida	4	1	0.21%	0.28%	R1
University of Southern California	4		0.21%	0.00%	R1
University of Wisconsin	4		0.21%	0.00%	R1
Auburn University	3	2	0.15%	0.56%	R2
Boston College	3		0.15%	0.00%	R1
Boston University	3		0.15%	0.00%	R1
Brigham Young University	3		0.15%	0.00%	R2
Lehigh University	3		0.15%	0.00%	R2
University of California, Davis	3		0.15%	0.00%	R1
University of Central Florida	3	2	0.15%	0.56%	R1
University of Connecticut	3	1	0.15%	0.28%	R1
University of Delaware	3		0.15%	0.00%	R1
University of Hawaii at Manoa	3	1	0.15%	0.28%	R1
University of Iowa	3	1	0.15%	0.28%	R1
University of Missouri, Rolla	3	1	0.15%	0.28%	R1
University of New Mexico	3	1	0.15%	0.28%	R1
University of Oklahoma	3		0.15%	0.00%	R1
University of Rochester	3		0.15%	0.00%	R1
Vanderbilt University	3		0.15%	0.00%	R1
Indiana University	2		0.10%	0.00%	R1
Iowa State University	2	1	0.10%	0.28%	R1
Michigan State University	2		0.10%	0.00%	R1
Michigan Technological University	2		0.10%	0.00%	R2
Oregon Health & Science University	2		0.10%	0.00%	Other
Rensselaer Polytechnic Institute	2		0.10%	0.00%	R2

Institution	Total Fellows from 2000-2010	Fellows in Sample	Percent of Total from 2000 to 2010	Percent in Sample	Carnegie Classification
The Rockefeller University	2		0.10%	0.00%	R2
University of California, Santa Cruz	2	1	0.10%	0.28%	R1
University of Illinois at Chicago	2		0.10%	0.00%	R1
University of Maine	2		0.10%	0.00%	R2
University of Massachusetts	2		0.10%	0.00%	R1
University of Pittsburgh	2		0.10%	0.00%	R1
University of Texas at Dallas	2		0.10%	0.00%	R1
West Virginia University	2	1	0.10%	0.28%	R1
Air Force Institute of Technology	1		0.05%	0.00%	R3
Alfred University	1		0.05%	0.00%	Other
Binghamton University	1		0.05%	0.00%	R2
Boise State University	1		0.05%	0.00%	R3
College of William & Mary	1		0.05%	0.00%	R2
Colorado State University	1	1	0.05%	0.28%	R1
Dartmouth College	1		0.05%	0.00%	R2
Florida Institute of Technology	1		0.05%	0.00%	R2
Florida International University	1		0.05%	0.00%	R1
George Mason University	1		0.05%	0.00%	R1
Kansas State University	1	1	0.05%	0.28%	R1
Louisiana Tech University	1		0.05%	0.00%	R3
Montana State University, Bozeman	1		0.05%	0.00%	R2
Mount Sinai School of Medicine	1		0.05%	0.00%	Other
Naval Postgraduate School	1		0.05%	0.00%	R2
Oregon Graduate Institute	1	1	0.05%	0.28%	Other
Oregon State University	1		0.05%	0.00%	R1
Stevens Institute of Technology	1	1	0.05%	0.28%	R2
Texas Tech University	1		0.05%	0.00%	R1
University at Buffalo	1		0.05%	0.00%	R1
University of Alabama	1		0.05%	0.00%	R1
University of California, Riverside	1		0.05%	0.00%	R1
University of Cincinnati	1		0.05%	0.00%	R1
University of Georgia	1		0.05%	0.00%	R1

Institution	Total Fellows from 2000-2010	Fellows in Sample	Percent of Total from 2000 to 2010	Percent in Sample	Carnegie Classification
University of Louisville	1	1	0.05%	0.28%	R1
University of New Hampshire	1		0.05%	0.00%	R2
University of North Texas	1	1	0.05%	0.28%	R1
University of South Carolina, Columbia	1	1	0.05%	0.28%	R1
University of Southern Mississippi	1		0.05%	0.00%	R2
University of Texas at El Paso	1		0.05%	0.00%	R2
University of Tulsa	1		0.05%	0.00%	R2
George Washington University	0	1	0.00%	0.28%	R1
Total	1949	360	100.00%	100.00%	119

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Abbreviations

DoD	Department of Defense
DTIC	Defense Technical Information Center
GRFP	Graduate Research Fellowship Program
NCES	Nation Center for Education Statistics
NDSEG	National Defense Science and Engineering Graduate
NSF	National Science Foundation
SED	Survey of Earned Doctorates
SMART	Science Mathematics and Research for Transformation
STEM	science, technology, engineering, and mathematics

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

This report reviews the National Defense Science and Engineering Graduate (NDSEG) Fellowship program, which has provided over 3,000 awards to U.S. citizens for the pursuit of graduate degrees in science, engineering, or other fields of study designated as priority interests to DoD. IDA reviewed the NDSEG program and provided an assessment of how the awardees have contributed to the research interests of DoD. The results for the NDSEG Fellows obtaining their PhD indicated that they are very likely to graduate, over 80 percent. The NDSEG Fellow graduation rates compare favorably with the national 10-year completion rates of 55 percent for mathematics and physical sciences and 64 percent for engineering. The time to graduate tends to be at least as good for NDSEG Fellows as for those who receive the NSF-GFRP fellowship. When we could identify a work history of Fellows, we found that the overwhelming majority (95%) worked in their field, and the majority of Fellows contribute to the scientific mission of the U.S. Government. Likelihood of graduation and place of employment appear to vary across the fields of study for Fellows, but because of the small sample size per subgroup, it is difficult to draw statistically significant conclusions.

15. SUBJECT TERMS

fields of study; National Center for Education Statistics (NCES); National Defense Science and Engineering Graduate Fellowship; National Science Foundation (NSF); NDSEG; Research Fellowship Program (GRFP); science, technology, engineering, and mathematics (STEM)

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