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The Director's Summer Program at the NSA

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The Director's Summer Program at the National Security Agency is a research experience aimed at the very best undergraduate mathematics majors in the country. Each summer, we invite a number of exceptional students to participate in a 12-week program in which they collaborate with each other and with Agency researchers to solve classified, mission-critical problems. The inaugural DSP in 1990 hosted eight students; it was successful even beyond the high hopes of the mathematicians who organized it, in ways that would not become apparent for years. The program has grown steadily with its success, and we now invite about two dozen students each year.

The DSP is not intended to be a recruiting program, though dozens of alumni have since joined the NSA as permanent employees. Nor is it intended to be an educational program, though the participants learn a great deal about mathematics and life at the NSA. Rather, the DSP was born of the recognition that the health of mathematics at NSA depends on both the health of the external mathematics community, and on a robust connection between NSA and that community. Obviously, as the nation's largest employer of mathematicians, NSA relies upon the mathematics community to provide a technically strong workforce. However, no matter how skilled our people are, we cannot hope to keep up with the research frontiers in all fields of mathematics. Often, advances which seem unrelated to our current work turn out to provide essential clues to the solutions of our most difficult problems. We rely upon the outside community to help us identify and apply these advances, and we can be successful only if the top mathematicians have a deep understanding of NSA's problem set and mathematical culture.

In the late 1980s, the NSA mathematics community explicitly recognized the importance of fostering a close relationship with the nation's academic mathematics community, and undertook a number of initiatives to reinvigorate this relationship. Richard Shaker, then head of mathematics research at NSA, described a few of these initiatives in an address at the 1992 Joint Mathematics Meetings [1]. In 1987, we invited a hundred mathematicians to come hear ten unclassified talks on research being done at the Agency. We set aside a few million dollars annually to support academic research proposals. (While this figure represents a small fraction of the U. S. government's support to pure mathematics research, it amounts to a large portion of our technology budget.) We established a sabbatical program to allow

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mathematicians to visit us while retaining their academic affiliation, and another program to enable NSA mathematicians to visit universities or industry. We have also initiated a number of programs which support mathematics education at both the undergraduate and K-12 levels.

The Director's Summer Program is a cornerstone of our strategy to engage the academic mathematics community. While some of the other NSA summer mathematics programs are targeted primarily at recruitment, the aims of the DSP are higher:

- to introduce the future leaders of the U. S. math community to the Agency's mission, and share with them the excitement of working on mathematics problems of national importance,
- to provide a deep understanding of the vital role that mathematics plays in enabling the Agency to tackle a diverse set of technical challenges,
- to encourage bright undergraduates to continue their study of mathematics and pursue careers in the mathematical sciences,
- to advance science at the Agency, thereby setting the stage for future successes, and of course
- to provide solutions to current operational problems.

Despite containing the term "summer" in its name, the Director's Summer Program is the result of a year-round commitment by some of the Agency's top mathematicians, and by a dedicated support staff. What follows is a rundown of a typical year of the DSP.

Autumn. Since participants work on classified problems of operational interest, the application process for the DSP is more complicated than that for an REU at a university. While many REUs have application deadlines as late as April, applications for the DSP must be received by October 15 of the previous year in order to accommodate the lengthy security clearance process. Application is open to any U. S. citizen, and the top U. S. citizen scorers on the Putnam examination receive invitations to apply. The most distinguishing characteristic of a potential DSP participant is not a concentration in any particular field of mathematics, but rather an interest and ability in collaborating to solve hard problems. A certain comfort level with computer programming is also helpful, as is experience with some of the common mathematical computing packages, but these are not absolute requirements.

Each year, the program is coordinated by two or three technical directors. The TDs rotate every few years, but they are always top NSA scientists who take time away from their own work to mentor the DSP students. In late October, the TDs review several hundred applications. The NSA personnel office mails a package, including security forms, to the top ten percent or so of the applicants. Once the package is returned, our Human Resources office arranges an interview, which includes a polygraph exam.

Winter. By the time the students come to Maryland for applicant processing, the leaves have long since fallen off the trees. As a respite from the HR interviews and the polygraph exam, the students spend some time talking about math with the technical directors. Unfortunately, the TDs can't say much about what specific problems the students will be working on; not only are the problems classified, but they won't be determined for months!

Spring. By the time the leaves return in April, the participant list is firming up, and the technical directors begin to settle on a set of problems. Like good thesis advisors, the TDs apply their wisdom and background to select an array of problems balancing risk (difficulty) against reward (payoff). The importance of problem selection is one reason why we ask our most experienced mathematicians to serve as TDs. The problem selection is usually done as late as possible; while this may seem like procrastination, the real purpose is to ensure that the problems are current and important. The opportunity to do mathematics for which the payoff is clear and of great value is one of the unique features of the DSP – it stimulates extremely hard work and dedication from both the students and the Agency staff.

The TDs canvass the entire Agency for problems, and recruit sponsors and subject matter experts for each one. In the early years of the DSP most of the problems focused on cryptography, but the range of problems has since expanded to include such topics as signals analysis, image processing, and algorithms for analyzing large data sets. Some problems are concrete and applied; others are more theoretical and connected to long-term research programs. The problem supporters work closely with the TDs to prepare background material for the students and put together introductory talks.

Summer. The program itself runs for about twelve weeks, starting right after Memorial Day and continuing through mid-August. The Agency facilitates housing, either at a nearby apartment complex or university, so that the students can be co-located to the maximum extent possible. In addition to increasing the social opportunities for the participants, this also helps to solve the problem that most of the students don't have cars.

During the first two weeks of the summer, the students receive a crash course which provides an introduction to NSA mathematics and presents the specific problems to be tackled. The course is tailored to the problem set, so it differs from year to year. The students are not assigned to problems; once the problems have been presented, the students are free to work on whichever they wish. They quickly form themselves into a number of overlapping groups, each participant finding his or her own unique way of contributing to the group effort.

For many of the students who are alumni of various REUs, the highly collaborative environment in the DSP is a new and invigorating experience. The math problems at the Agency are difficult enough that the great advances are typically achieved through cooperation, not only among mathematicians but across disciplines. Indeed, many of our problems defy categorization by discipline – but we need to solve them nonetheless.

During the summer, the students gradually become an integral part of the NSA mathematics community. An annual day-long classified math conference, called Mathfest, and an annual awards banquet, are timed so that the students can attend and learn more about the community, its history, and its luminaries. (In fact, two DSPers were recently invited to give Mathfest lectures on their work from previous summers – both gave great talks, despite having to wait to return to secure spaces to prepare them!) The students take interesting tours, both at NSA and at other agencies in the intelligence community. They participate in office outings and organize their own activities. As the students and Agency researchers become friends and colleagues, they share both the frustration of failed approaches and the elation of sweet successes. The importance and urgency of the problems

leads to an even greater emotional commitment among the participants, and an incredible bond often forms.

In the end, not all of the problems are completely solved, though most see partial solutions or progress. In each year, the DSP has contributed at least one or two remarkable solutions. The students spend the last few weeks documenting their work in classified technical papers. In recent years, the students have had the opportunity to present summaries of their work to the Director of NSA in person. In addition, the Director has usually taken the time for a leisurely question-and-answer session with the students. This provides a unique opportunity for participants to learn about the Agency, and truly understand why what they do is so vital to our nation's security.

Once the students have left, the TDs and problem supporters put finishing touches on the research papers from the summer, and compile a comprehensive report. The results of the summer go back to the sponsoring offices, and follow-on research often begins while the seats in the DSP room are still warm. No sooner do the TDs catch their breath in September, than the next "summer" is upon them.

As of this writing, the DSP has just completed its seventeenth incarnation. While some of the over three hundred alumni have joined the Agency, many have gone on to illustrious research careers, and continue their involvement with the intelligence community in other ways. Some work full time at research centers dedicated to solving NSA problems. Some are now academic mathematicians who regularly spend summers with us working on our problems. One former DSPer recently wrote us to recommend one of his students and stated that his own DSP experience was what convinced him to become a professional mathematician. In the past few years, our alumni have collected four Rhodes scholarships, three Marshalls, two Schafer Prizes (and several close finishers) and a Salem Prize. So our technical directors have had some success identifying the future leaders of the community.

Seven years ago, when I agreed to serve as a DSP technical director, I could not have known that the DSP would afford me some of the most rewarding experiences of my career. It is no exaggeration to say that lives have been saved by the successes of the Director's Summer Program. The job satisfaction that comes from working together to contribute directly to the nation's security is difficult to describe to someone who has not experienced it firsthand. But we believe our alumni try, for when we ask applicants where they heard about the DSP, very often the answer is that they heard about it from their friends.

Reference

[1.] R. J. Shaker, The Agency That Came In Out of the Cold, Notices Amer. Math. Soc., 1992, May/June, 39, 1992, 408-411.

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