THE APL ASSOCIATE STAFF TRAINING PROGRAM

The Associate Staff Training Program has been an APL institution for many years. The following series of articles studies that program from several viewpoints. The first article is an overview of the program, its history and structure. Then two senior APL staff members discuss the influence of the program on the early years of their careers. Next, the technical advisor and a participant present their reactions to working in the program. Finally, trainees in a recent program summarize their work and experiences.

OVERVIEW

Vincent C. Messer

Intimidated and enthusiastic, naive and intelligent, bewildered and confident, hesitant and determined are a few of the adjectives describing the feelings of people starting their first professional employment. Most of us have experienced these emotional conflicts, but conflict, properly channeled, can benefit both new employees and their employer. An organization must tap its new professionals' determination and enthusiasm, channel their intelligence, and build their confidence in ways that will get them off to a quick, productive start.

The transition from academia to full-time work is a significant event. Students whose successes depended largely on independent effort suddenly discover that teamwork is fundamental to any accomplishment and to professional advancement. They find that they must assume minor roles on projects, have limited say in their work assignment, and may have little choice about where they work. New jobs typically require new employees to learn the special language of the organization, to understand its systems of doing business, and to cope with its internal procedures, all with limited guidance.

In some ways, the transition from academic studies to professional employment is as it should be. Some dues must be paid when entering a new milieu. The process of acculturation, however, requires employees and organizations to make time-consuming and potentially costly emotional and material investments in one another. Intelligent organizations continually seek new ways of minimizing the trauma of the transition while capitalizing on the special energies and dedication that talented graduates typically bring to their new jobs.

Over the past 28 years, APL has evolved a program that has helped to make the most of the transition. We call it the Associate Staff Training Program (ASTP); it is designed for selected new professionals to make a strong investment in learning to work effectively and efficiently within the Laboratory structure. APL also makes equivalent investments in the early career development of each individual trainee.

Since its inception, the ASTP has taken several forms. The original six-month program was trimmed several years ago to 10 weeks. Individual research projects—long-term efforts replicating graduate research work—were eliminated in 1967 and were replaced with group work on systems engineering problems. Technical course topics also have changed to reflect changes in technology. Their duration and intensity and the means used to evaluate each participant's performance have been moderated as well. However, the primary goal of the ASTP — that of facilitating each trainee's transition from the role of a student to the role of a fully productive technical professional — remains the same.

In its current form, the ASTP has four major components: course work, orientation, interviews, and activity related to a systems problem. Each is designed to help the trainees learn about different aspects of the Laboratory.

During the first two weeks of the program, trainees spend most of their time participating in short courses and attending orientation sessions. The ASTP currently offers 12 short courses ranging from five to ten instructional hours each. The volunteer instructors are senior engineers and experienced professionals with special expertise in the topics they are teaching. Some courses (e.g., statistics and technical writing) are intended to refresh the trainees' skills in subjects studied in college. Other courses (e.g., modeling and simulation, software engineering, and microchip technology) involve current technologies and some of APL's specific uses and applications. Still other courses address topics important to the mission of APL that rarely would have appeared on any trainee's college transcript (e.g., ocean environment engineering and analyses of threats to the Navy's fleet during warfare).

Trainees also participate in several one- or two-hour orientation briefings that describe the functions of some of the Laboratory's technical and support organizations. The general goal of the sessions is to make trainees aware of APL's mission, organizational structure, current major programs, and pertinent operating procedures. We divide the sessions into two categories: general orientation to APL and special talks on technical topics (e.g., APL/Navy relations, battle group organization, and ballistic missile systems). In addition, each technical department gives a two-hour presentation describing its organization, particular mission, special programs, and also current staffing needs. Trainees also hear from administrative and support groups.

Following orientation, the participants begin the third component of the program—the interviews. The groundwork for this process is laid some months earlier when each trainee-to-be completes a standard resume form. A resume package is distributed to the supervisors of technical groups. The supervisors, in turn, give information to the trainees about the work done in their groups through brief mission statements published in the *APL Group Descriptions Book,* which summarizes the kinds of work and projects undertaken by every technical and support group at the Laboratory. The trainees receive copies of the book and are encouraged to read it carefully as they prepare for their interviews with technical group supervisors.

By the end of the program's second week, the trainees attend short courses and orientations only in the morning. Their afternoon hours are occupied by interviews. The split schedule continues for four weeks. Many former trainees tell us that the interviews were valuable learning experiences; they met some of APL's key people and were able to learn firsthand about some of the work they do. The interviews often form the foundations of valuable contacts that the participants can use to their advantage after the training program. In return, the interviews also permit APL to get to know each trainee better.

Each trainee averages between 15 and 17 scheduled interviews during the program. The Education and Training Office, at the request of either a trainee or an interested supervisor, arranges the first interview for each trainee, but the trainees often arrange additional interviews with some groups. The follow-up interviews usually are more relaxed and less formal than the conventional employment interview because the training program participants have already been hired. The interviews give the trainees the opportunity to have an input into where they will work within APL.

At the end of the interviewing process, each trainee is asked to list, in priority order, at least five Laboratory technical groups they would like to work for. The supervisors of the technical groups who have interviewed trainees make similar prioritized requests for trainees whose talents they feel will match the jobs they need to fill. The Education and Training Office then tries to recommend the "best match" among the organization's needs, each department's requests, each group's requests, and each trainee's interests. The placement recommendations are reviewed by the technical departments involved and, finally, are reviewed and approved by the Laboratory's Director.

During the program's last four weeks, the trainees work full time on a systems engineering project, which deals with a topic of interest and importance to the Laboratory (see the boxed insert). On the last day of the program, the trainees as a group make a formal oral presentation of their findings. APL later publishes a report of the group's findings.

The systems problem activity is intense and important from an educational point of view. It is there that the trainees combine what they have learned during their formal education with the information and knowledge they have gained during the ASTP. Successful completion of the systems problem demands that the participants learn to work as a team. The process forces them to organize themselves efficiently to make trade-offs without sacrificing quality, and to work and communicate across organizational lines and educational disciplines to deliver a useful product within a schedule.

Before the program begins, APL supervisors are asked to suggest a systems problem topic, one of which (with the approval of the Director) is selected. During the program, leaders within appropriate line organizations donate their time as technical advisors and mentors for the trainees. Service organizations like the APL library and the Technical Publications Group also make special efforts to support the systems problem work. Many technical professionals make themselves and their skills available as resources to the trainees. The systems problem activity requires special effort; however, it enables the trainees to learn from many APL resources and to make meaningful contributions to the organization.

Feedback from program participants and from the supervisors of their first assignments repeatedly tells us that the ASTP gives trainees a noticeable head start over others who began their careers at APL without entering the program. Former trainees report that they frequently use the contacts they made during the program to help them later in their work. Shared experiences associated with the ASTP seem to create a bond among the trainees and a feeling of camaraderie among staff members who were in other training programs.

The importance and value of the ASTP are that it helps energetic, talented new professionals and APL to cooperate in an effective, constructive fashion that benefits both parties. In addition, it gives the trainees information, experiences, and contacts of long-term benefit throughout their careers at APL.

The sections below describe the views and recollections of past ASTP participants.

GETTING STARTED

Horace Malcom

When I came to APL in June 1974, I had just completed a masters program in physics and computer science. After eight years of college and graduate studies, I was very anxious to begin work on real-world technical problems. The work being done at APL seemed an ideal match with my background and interests, but when I learned that I would first have to complete the Associate Staff Training Program, I had a few reservations about its usefulness.

As the program progressed, however, my reservations were dispelled and I began to see some of its many advantages. One was the exposure to other participants

Previous ASTP systems problems

Year	Title	Principal Advisor(s)	Year	Title	Principal Advisor(s)
1967	*Evaluation of Three Contract Proposals for the SAM-D Missile System*	J. Long	1980	*Low-Cost All-Weather Ship Detection System*	T. R. Foard, H. W. Ko
1968	*Evaluation of Contractor's Proposal for an Advanced Surface-to-Air Missile System*	W. N. Sweet	1981	*Protection of the Space Shuttle*	T. Wyatt
				Satellite Self-Defense	D. V. Kalbaugh, C. C. Kilgus
1969	*Evaluation of Three Contractor Improved Urban Transportation Systems*	R. A. Makofski	1982	*Feasibility of a New Short Range Area Defense System for the U. S. Navy*	D. C. May, R. S. Farris
1970	*Air Traffic Control*	M. L. Moon	1983 (winter)	*Anomalous Propagation and Aircraft Landing Systems*	H. W. Ko
1972	*Integrated Communications/Navigation/Identification (CNI) System*	T. R. Foard, G. R. Knapp	1983 (summer)	*Alternative Fine Guidance Systems for the NASA Large Space Telescope*	M. D. Griffin
1973	*Integration of SYS-1 Concepts for Automatic Detection and Tracking*	J. F. Bradshaw	1983 (fall)	*Geodetic Survey of Air Launched Deep Ocean Transponders (ALDOT)*	C. L. Rowland, G. M. Starken
1974	*The Application of Mini- and Micro-Computers to Shipboard Data Systems*	M. J. Gralia	1984	*Designing a VHSIC-Based Signal Processor for Future ARH Missiles*	H. M. Kaye, Q. E. Dolecek
	Improving the Performance and Integration of the SSBN Sonar Suite	T. R. Foard	1985	*Conceptual Design of an Unmanned Air Vehicle Dedicated to Battle Damage Assessment (BDA)*	H. E. Heidepriem, K. T. Plesser
1975	*Global Satellite Data System*	T. Wyatt	1986 (winter)	*Medical Imaging in the Military: A Digital System*	W. G. Geckle, G. M. Starken
1977	*Satellite-Aided, Military Search and Rescue System*	C. C. Kilgus	1986 (fall)	*Feasibility Study for Flying an Expert System On Board a Spacecraft: The Spectrasat Intelligent Tracking Experiment (SITE)*	A. D. Goldfinger
1978	*Conceptual Development of an Information Management System for the Force AAW Coordinator*	C. C. Phillips, D. P. Serpico			
1979	*Small Scale Motion Analysis of APL Towed Ocean Profiling System (ALTOPS)*	W. A. Venezia			

who were at the same point in their careers that I was. The chance to compare notes and to weigh their views against mine gave me a much more realistic picture of what APL was all about.

Another benefit was the contact with department heads and other technical people who would talk to the program participants. These talks, together with the opportunity to interview individual groups within the various departments, gave us a much better perspective of the organization and the scope of the Laboratory's activities. They also made it much easier for each of us to decide exactly where we would best fit.

Part of the ASTP involved completing several short technical courses. Although abbreviated, they exposed us to technical areas outside our primary fields of training and conveyed a flavor of what it might be like to work in other areas. Talking to the course instructors and seeing demonstrations of various projects in which they were involved provided yet another view into the workings of APL.

The trainees also completed work on the solution of an assigned technical problem. For many of us, this was the first such project that required the collaboration of a group of people rather than the individual effort that many of us had grown accustomed to in school. It was a very good preview of the APL environment and of the kinds of interactions that would be necessary after completing the training program. Working together allowed each of us to become better acquainted with the skills and expertises of the other trainees. Relationships that developed during the ASTP in many cases have lasted over the years and have often resulted in gaining access to expert advice and information much sooner than might otherwise have been possible. Since completing the ASTP, there have been many occasions when the background I gained and the relationships I established have contributed to the timely completion of projects that require collaboration with different groups and people.

THE CHALLENGE OF THE ASTP

P. J. Herchenroeder

When I entered the Associate Staff Training Program in 1977, fresh from 18 years of schooling, I did not know what to expect of APL. I was overwhelmed by its size and by the diversity of activities. And, to be honest, I was not quite sure what I really wanted to do.

There were 25 trainees in the ASTP that year, with mixed educational backgrounds and degree levels from universities throughout the country. We all shared a common ambition—we were young, fresh out of college and eager to begin our careers. All we needed was to find a path of challenge and discovery to pursue.

The ASTP had three major components—applied course work and administrative briefings, interviews with the various technical groups, and a systems-oriented project in which we would all share responsibility.

Courses in radar, oceanography, probability and statistics, and modeling and simulation filled our morning schedules for the first month. Afternoons were spent reviewing our notes and doing the assigned problems we had received from each course. Naturally, we were not enchanted with the idea of course work—after all, we had spent almost two decades of our lives in the classroom. We had hoped that this part of our education was behind us.

However, the courses served a very useful purpose. They established our first link between academics and the solutions of real-world problems. We were finally investigating practical applications of the knowledge we had acquired. No longer were we solving problems "at the end of the chapter." We hoped to become more proficient in using our problem-solving skills as the years progressed, but the ASTP provided the first step.

The next several weeks were spent attending a series of administrative briefings and participating in interviews with technical personnel. Although the briefings could have been a bit more detailed, they did explain the mechanics of APL and gave us a greater understanding of the system within which we would be working.

The technical interviews were for me the most significant aspect of the ASTP. We all had been at APL for well over two months and were becoming comfortable with it and with ourselves. Now we had an opportunity in a relaxed atmosphere (for we had already been hired) to discuss our needs and interests along with the needs of the individual groups. The interviews gave us an excellent opportunity to assess the work of the groups. In exchange, the groups had a chance to meet us individually and determine who might match well with their needs. Although there were no guarantees of obtaining our first choice, we all had a number of top choices. And, in the end, most of us were quite satisfied with the groups in which we were placed. We had provided input on the matter and therefore felt some sense of control over our future. Having a voice, albeit a limited one, affected the attitude we took into our new groups.

The final aspect of ASTP was the systems-oriented project, an opportunity to do some original work. Our project dealt with the development of a satellite-based search and rescue system. It was our first lesson in how to apply our knowledge to the solution of a practical problem. Under the guidance of C. C. Kilgus, we were taught the basis for scientific investigation. We learned the importance of teamwork and how to work as part of a team, sharing our thoughts and ideas in an effort to solve a problem. We learned how to use the diverse resources that existed at APL for project needs. What was important in the exercise was not the solution itself, but the experience gained in reaching it.

The relationships I established during the ASTP have helped my career as much as the formal experience of the program because of the 24 people I came to know and could call on when I needed expertise from outside my group. They are still helpful though somewhat reduced in number.

* * * *

THE FALL 1986 SYSTEMS PROBLEM

Circling the globe at 27000 km per hour, 116 km above the ocean surface, the proposed Spectrasat satellite will receive spectral data from a synthetic aperture radar (SAR) that will measure ocean-surface-wave conditions more accurately than ever before. A piggyback package, the SITE experiment, is to be placed on board the spacecraft. Using the techniques of an expert system, it will process the data in real time and return the completely analyzed data to earth, thus eliminating the need for expensive downloading of raw data, time lapse in analysis, and the tedious workup of data by experts on earth.

A Phase A feasibility study of SITE project was assigned to the 32 newly hired college graduates who comprised the Fall 1986 ASTP.

A. D. Goldfinger of the Space Department's Computer Science and Technology Group was the technical advisor for the systems project. D. S. Garlick was one of the participants. They present their observations of the ASTP below from their different perspectives. J. T. Everett and A. R. Jablon, two other participants, summarize the technical solutions to the systems project assigned to the group.

VIEWS OF THE TECHNICAL ADVISOR

Andrew D. Goldfinger

When I was a new graduate student, I was invited to a closed seminar conducted by several junior faculty members and one very senior professor whose intellect and reputation were awesome. When he announced that he had cracked one of the major problems in theoretical physics, we gathered week after week to savor his theory as he unfolded it. The junior instructors eagerly nodded their heads, encouraging him to go further and further. I couldn't understand a bit of what was going on. Night after night I sat up trying to make sense of what he was saying, but I just couldn't follow. Finally I approached one of the junior members and confessed. He replied, "None of us can ever understand what he says!" Gathering my courage, I approached the professor. "Hmm,"—a few puffs on his pipe—"I guess you're right. It really doesn't make sense. Oh well, I guess I'll have to start over."

He took it easily in stride (he'd been there before), but I learned several important lessons: the real world is not like school but is filled with difficult, ill-defined, ambiguous problems that may not have solutions; consensus does not equal truth; and, sometimes, the emperor really has no clothes.

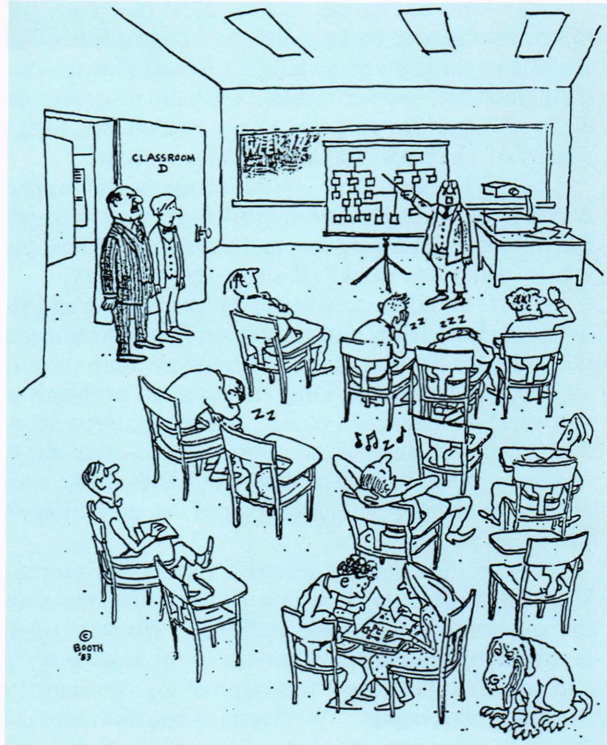
I recently experienced a similar situation from the other side. I was invited to supervise the team project of the Fall 1986 ASTP. Armed with an interesting and important project, I met with all the members of the program for the first time. For over two hours, I sketched out the dimensions of the problem and suggested solutions. There were a few rapt expressions and very little dialogue. On my return from the meeting, a colleague asked how it went. "As expected," I said. "They are still under the mistaken impression that I know more than they do." "That will quickly end," he replied. He was right.

The goal of the ASTP systems project is to enable the participants to go end-to-end through a real systems design effort. Following each program, trainees enter technical groups at the Laboratory and most probably begin their careers by developing smaller, more well-defined pieces of some large overall effort. It may be many years before they are given responsibility for a full system. The systems project component of the ASTP gives participants an opportunity to experience the frustrations and rewards of high-level design. There are several important lessons the trainees must learn:

1. Real-world problems are often poorly defined. Indeed, the definition of a problem is sometimes the hardest part of its solution.
2. So-called experts may, in fact, not be. At times you cannot find an expert to help you and must quickly become one yourself.
3. Systems design involves trade-offs and compromises. Decisions must be made with incomplete information and some degree of uncertainty.
4. Optimal design is seldom possible—there just isn't time.
5. Large efforts involve groups of people. Groups do not always run smoothly, but they can be very productive.

To achieve the above educational ends, the trainees are given a moderate-sized system to design. They are presented with a problem statement and some initial technical guidance and then are turned loose. The project advisor monitors their effort, helps with technical information, and facilitates the establishment of contacts throughout APL. However, all responsibility lies with the trainees, who are free to organize themselves as they wish and to divide the work load as they see fit.

For the Fall 1986 project, I chose a problem of great importance to APL's Space Department. We were proposing a satellite, Spectrasat, which would use a SAR to monitor ocean-wave spectra. Armed with the spectra, experts on the ground would be able to infer the existence of various ocean-surface phenomena (e.g., storm-driven waves and refraction by shoals and currents). Over the next two years, we will be involved in an Independent Research and Development effort to use artificial intelligence techniques to automate the process. Could the trainees design an on-board processor for



"It's a fast track here, Herndon.
Once you get through our training program."

Spectrasat that could implement the algorithms we will be developing during the research effort?

My initial presentation of the problem to the trainees went well. For almost three hours, I spoke to them and they listened. They appeared to be eager and perhaps a bit anxious about what would be expected of them. After outlining the problem, I asked them if I should stop or continue to present a capsule summary of the techniques of artificial intelligence that I felt would be useful. "Go on," they replied. I was enthusiastic and plunged forward. They continued to listen. Heads nodded in the age-old body language of students trying to please the instructor. But were they really understanding anything? Were they humoring me? Did they (as I thought most likely) not really understand but assume that they could get an explanation later from one of the other head nodders?

By the end of the session, we were all exhausted. I left and did not return for several days. During this time (let's call it the honeymoon), they began to gather information. Literature searches were done, books and journal articles were read, and contact was made with several of the other experts I suggested, including R. Beal and D. Irvine, who met with the group. As recounted to me, at one crucial meeting the trainees explained to the experts that they were designing a system that would capture the expertise embodied in global wind-wave models. What models should they use? "There aren't any yet," said the experts. "Then what does Goldfinger want us to do?" "We don't know," was their reply.

For about a week, a sense of frustration developed in the group. I could detect some of it during the meetings I held with a number of trainees. At one meeting in particular, I recall, one of them became almost antagonistic. He challenged my ideas repeatedly and succeeded in putting me on the defensive. I was quite uncomfortable during the session, but afterward I found myself looking forward to talking with him again. I even looked at his resume to see if he would be a good choice for our group when the program concluded. He was the first person to see that the emperor was unclad.

Things finally came to a head at a large, all-members-present meeting held a few days later. The session began cordially enough, but after the first hour people got a little hot under the collar. The workday ended and about half of the people left, but I remained with the rest. They were able to unwind. "How can we design an expert system if the expertise doesn't yet exist?" "You can't," I answered, "but you can make an educated guess as to the computing load that will eventually be needed and design a system that can handle it."

"How can we make such an educated guess when we can't find experts who can tell us which phenomena we will be dealing with?"

"Become experts," I replied.

"We really don't understand what you want. It doesn't make any sense. Maybe you're all wrong," they complained.

"Maybe I am," I admitted.

In truth, it did not really go so smoothly within me. I did feel defensive and inadequate, but I also knew that the honeymoon had to come to an end at some point and that it just had. The meeting marked a real turning point in the project. From then on, the trainees began in earnest to accept responsibility for the effort. No longer did they expect some expert to come along and tell them how to solve the problem. No longer did they believe that such an expert existed.

They began to organize themselves into working groups and to make progress. They did not formally select leaders, but de facto leaders developed as needed. I was quite impressed, as an outsider, at the closeness and fellowship they displayed. During one visit, I noticed a crudely drawn, somewhat uncomplimentary caricature of myself posted in a distant corner of the room. Perhaps I was not quite the bad guy, but I was certainly no longer the expert.

As the group progressed, I was able to make some small technical inputs without unduly influencing the participants' autonomy. On one occasion, I spent some time with a few people demonstrating how a small, toy, expert system could be written to handle typical ocean phenomena. I wrote a number of rules that could form the seed of a pilot system. They rapidly got the idea and proceeded to sketch out a pilot system of their own. My rules were abandoned. (At an earlier stage, they might have been kept.)

Eventually, time pressures forced the participants to make some hard decisions and to confront real-world limitations. Being very impressed with the APL programming language, I mentioned to them the existence of a dedicated APL processor at the Laboratory. They loved it! Could it be miniaturized and put on board? I doubted it, but they were not quite as jaded (practical?). They tried. In the end, with a bit of disappointment, they admitted that it could not be done within the time and budget available, but they did retain it as an option for future development.

Finally, the time came to put together the presentation and documentation. A few individuals decided to have some fun. They would make a video! I got a kick out of their having seen a way to use the freedom of the training program to do something creative. The trainees also decided to use a computer-based graphics system, Storyboard®, instead of viewgraphs for the main body of their presentation.

I was out of town the week before the presentation and felt frustrated at having to be away during that crucial week (especially since it meant that I lost my part in the video!). But in the end, it became apparent that I was not needed. By that time, the trainees were functioning well on their own. They wrapped up their work and were ready for dry runs of the presentation by the time I returned.

I was extremely impressed by the first dry run; it was so professionally done. I had a few technical comments and some criticisms, but they would have done fine without my inputs. They, however, didn't seem as confident. They scheduled about three more dry runs—an excessive number in my opinion. I cautioned them about becoming stale, but I recalled my first talk before a distinguished audience. It was rehearsed several times. It is sometimes hard to remember how difficult something was the first time.

The final presentation went smoothly. The combined video/computer graphics technique was very effective. The audience asked a number of excellent questions that were answered well. The quality of the presentation was not hype; rather, it was the product of the technical work underlying it. They had done their homework and it showed. After the presentation and at the luncheon following, compliments abounded. The group seemed relaxed and relieved. They were a bit stiff at the luncheon, with the director of APL and other important people around, but a great weight had been removed. I overheard several members of the group talking about the party they had planned as celebration. They had the good grace to extend a pro forma invitation, but I had the good sense not to go.

VIEWS OF A PARTICIPANT

Dean S. Garlick

On the morning of September 16, 1986, that old feeling of unfamiliarity once again settled in my stomach. As I gazed around the room the first day of the training program, I saw young and eager faces, some that I had seen in passing but none that I really knew. For the next three months I would see these same faces every day. Several thoughts ran through my mind that fall morning. Can I compete with these people? Am I as intelligent as they are? Am I as competent? I felt like a freshman on the first day of college all over again. We introduced ourselves, giving our name, rank, and what we did over our summer vacation. I began to realize that we were all in the same boat, and, for the duration of the training program, we would have some very interesting learning experiences.

New Experience for ASTPers

The training program and, especially, the systems project phase were new experiences for us. We had come from an academic environment with little or no professional background. There is a major difference between solving a second-order differential equation and conducting a study of an autonomous oceanographic spacecraft. While the academic world cultivates an attitude of personal confidence and independence, our systems project required a team effort and demanded that we rely on the work of others to accomplish our own.

We were a group representing many cultural and educational backgrounds and work experiences. People came from different parts of the country and the world, e.g., Korea, Vietnam, Hong Kong, India. The wide range of ideas and points of view proved beneficial to the systems project and created an interesting social environment.

Getting Organized

The topic of our project was introduced to us by the principal advisor, A. D. Goldfinger. He spent one afternoon explaining the concept of Spectrasat, showing us graphs, SAR spectra, algorithms, and satellite-based SAR images of ships and their unmatching wakes. References to various individuals at APL, who were experts in some particular area of our project, were also given to us. The experts, along with our advisor, were viable resources throughout the remainder of the program.

When we were left to organize ourselves and begin work, some loosely tied groups were developed based on primary interest and backgrounds. We all were able to find some aspect of the project in which we could contribute and participate. The initial organization consisted of four groups: software, hardware, geophysics, and space sciences. Each group was responsible for some aspect of the systems project. Our organization continually evolved throughout the program.

After the completion of our course work and some preliminary effort on the project, we organized ourselves again into new groups. The groups were nearly identical to the first set but seemed to become more refined. A similar trick is used by politicians when they reorganize an agency and give it a new name. Nothing really changes, but the psychology is effective.

Leadership

In all organizations there must be Indians and Chiefs. Leaders in our group emerged as the project progressed. We held no elections nor were there debates as to who was in charge. The leaders seemed to gravitate to positions of control as the work progressed.

Initially, a few people asserted themselves by getting everyone together to discuss the systems project. This act in itself allowed one person the opportunity to conduct the meeting, thereby giving an impression of being in control. At first one person seemed to stand out and take command of the group; however, by the time of our second organization, the strength of this position faded.

The leadership role evolved into three categories: technical leader, presentation leader, and final report leader. Three people became technical leaders of the group. They attained the position by understanding more about the actual process of SAR spectra and the purpose of our project than anyone else. They made decisions and contributed heavily to the technical output of the project. The presentation leader assumed responsibility for circulating sign-up sheets for presentation participation, drafting a presentation outline, and organizing resources within the Laboratory. The final report leader was the person willing to take on the burden of getting the groups to complete their reports and then compiling and editing the data.

All three leadership positions were important to our success in the systems project. The need for leaders existed; without them, there was a power vacuum. These were not fabricated positions to boost egos but were essential parts of the process. The organization and leadership of the project were evolutionary and subtle, but without them we could never have operated effectively.

Working Together

One problem continually arose as we worked on the project: exactly what were we supposed to do and how were we supposed to do it? Everyone agreed on the overall problem, but when it came to details, mass confusion ensued. With 32 people, there were 32 different ideas. While we sought the guidance of our advisor, it became evident early that we thought we knew as much or more than he did about the problem.

Finally, we reached a turning point in the process. One afternoon, tired of the confusion, feeling the schedule pressure, and having done just enough research to be dangerously knowledgeable, we entered into the "big blowout." What started as a status/planning meeting quickly degenerated into a fierce debate over the direction of the group. Several small groups emerged, each with its own ideas and allies. People rallied support for their position as they simultaneously battled with opposing points of view. Arguments ensued about gathered information. Two different people would have consulted with an APL expert but reported conflicting stories about the expert's advice. Several people claimed that we were trying to create an expert system when there was no human expert to give the information. Others claimed, "Who cares if there is an expert. Let's design the system anyway." Others argued that we had amassed enough data to create an expert. Some of our ideas were brilliant, while others were completely "off the wall."

The brawl finally ended with no one really agreeing, but the general attitude was summed up by one trainee who said, "Why doesn't everyone compromise and do it my way!" After the confrontation, the whole attitude and flavor of the systems project changed. No one person's idea was implemented; rather, a combination of all the ideas created the final outcome of the project.

After the big blowout, the controversy subsided, and we began to work as an efficient group.

Making important decisions is never easy, but when they severely affect other people and their decisions, they become especially difficult. Since each group's decisions affected the other group's constraints, much debate and discussion ensued before any firm decisions were made. The process brought out differences and conflicts on a personal basis. Some suggestions were shot down—not because of technical merit but because of the person suggesting them. Others were accepted for just the opposite reason. Some people were offended when their suggestions were critiqued and felt that the other trainees were attacking them personally. Eventually we worked out the problems and made some sensible decisions.

Report and Presentation

Documentation has always been (and probably always will be) a thorn in every project's side. The creation of the final report was a difficult task of coordinating and editing of materials—all written separately by the different groups. Each group submitted its report to a central group that compiled the data and produced the final document. It soon became evident that getting the various groups to meet submission deadlines would be a monumental task.

From the beginning of the ASTP, the thought of presenting our findings to the APL professional staff was at best unnerving. Therefore, our presentation was prepared in a strategic manner. We viewed past ASTP presentations to get ideas and also brainstormed for something new. We finally decided on a conventional form (i.e., five speakers followed by a question and answer period). We also decided to do something different: we would make a short video and then use some new high tech equipment in place of viewgraphs to display our results.

The video would give an exciting and entertaining overview of the topic. It grew out of a "what if" type idea and evolved into a full production with the help of the APL Visual Communications Section and even APL's own narrator. The video turned out to be a lot more work than we had originally planned, but we felt sure that we had a great one-time opportunity to do something innovative. It also gave the people working on the video project a chance to make their cameo appearance on the big screen (even if it was only the white wall of the Kossiakoff Center).

The high tech style of our presentation was fueled by the need to present our materials in a fashion that would not only keep our audience interested, but also awake. We used a personal computer-driven presentation/graphics software package that would interface with a video projector, which created a more dynamic presentation. Lists actually grew and flowcharts really flowed. This took extra time in preparation but made a big difference in the final product.

Because of the time constraints, the final presentation was prepared simultaneously with the completion of the project. Drafting speeches, collecting visual aids, and even rehearsing began before we knew exactly what our speeches would entail. Thus, last-minute adjustments in oral presentations and in the final format were required.

When the time of the presentation arrived, there were some mixed emotions. We felt a combination of anxiety (mostly on the part of the speakers), relief that the work was finished, and excitement because we had completed a difficult task that became a memorable experience. When the presentation was over, we all felt good about the work we had done. We also were pleasantly surprised at the good reception we got from our audience. Perhaps we were a lot more organized and knew more about the issue than we realized.

In Retrospect

Even though the systems project was ultimately our responsibility, we frequently consulted our competent advisor and other experts at APL for help and counsel. On several occasions they gave their time to engage with us in long, serious, and in-depth discussions about the different options available in the systems project and the advantages of each. The phrase "Let's talk to Goldfinger about it" was sounded several times during the course of the program. Not only were our advisor, APL experts, and the Education and Training Office extremely helpful, but the entire APL staff seemed to bend over backwards to assist us in any way possible. We were extremely grateful for the assistance; without it our project would never have gotten off the ground.

The ASTP was an informative and beneficial experience. Personal growth and an opportunity to learn about oneself in an environment where past reputations and credibility were unknown were very rewarding results. Perhaps even more beneficial, however, were the friendships and camaraderie that developed among the trainees in the program.

THE "SITE" FEASIBILITY STUDY: SYSTEMS PROBLEM RESOLUTION

James T. Everett and Allan R. Jablon

The Spectrasat spacecraft is expected to be launched early in the 1990s to gain an understanding of ocean-wave phenomena from data taken from SAR spectra. Spectrasat will transmit the SAR images to ground stations where experts will analyze them to determine ocean-wave characteristics, e.g., wavenumber, peaks, and direction. These parameters are of particular importance because they provide information about the possible location and severity of ocean storms.

Our goal during the Fall 1986 ASTP was to study the feasibility of placing an artificial intelligence expert system on board the spacecraft. This system would perform the data interpretation now done by scientists on the ground, thus establishing the viability of on-board artificial intelligence systems. This section presents a summary of the results of our feasibility study.

System Overview

The Spectrasat Intelligent Tracking Experiment (SITE) system combines the use of artificial intelligence routines with image processing and mathematical estimation techniques to track important ocean characteristics. A SAR passes digital spectral image data to the system, and image-processing techniques are then used to determine the location and frequency of peaks present in each image. Statistical measurements are performed to describe the shapes of the individual peaks. The artificial intelligence routine then classifies the peaks based on these statistical measurements (e.g., because of its shape, a peak may be attributed to a well-defined wave swell system). Based on the peak characterizations, the artificial intelligence routine selects an appropriate state space model to characterize the ocean-wave phenomena. Kalman filtering and smoothing techniques are then used to give optimal estimates of model parameters. These estimation techniques yield covariance matrices that give a measure of the correctness of the estimates, and these covariance matrices are fed back into the artificial intelligence routine. The magnitude of the estimation error may suggest that a different model is more appropriate given the observed wave phenomena. Smoothed estimates of wave characteristics will be transmitted to the ground at least once a day.

System Implementation Results

The functions described above show that the artificial intelligence expert system plays a fundamental role in the SITE system. To implement the expert system, we determined that a forward-chaining technique would be most appropriate. Forward chaining is the process of starting from known facts and applying rules to reach conclusions. This closely parallels our process of starting with a spectral peak and then classifying it to determine its possible source. The set of rules used to arrive at conclusions comprises a rule base, which we estimated would require approximately 800 rules to classify peaks and determine peak sources.

We incorporated two models into our system: (a) a naive model (a random-walk model making no assumptions about the physics underlying the observed wave phenomena), and (b) a smart model (a localized point-source model that assumes that the observed wave conditions are due to a localized storm).

To produce smoothed estimates of the parameters of these models (i.e., wavenumber and direction), we decided to perform Kalman filtering during flight as the SAR images are being processed and then to derive smoothed estimates from these filtered estimates as the satellite flies above the polar caps. This is an efficient technique because it allows the smoothing, a computationally intense procedure, to be done at a time when the SAR spectra are not being processed. (For a detailed description of these models, see Ref. 1.)

Two computer languages, LISP and C, were selected for use in the system. These languages reflected our need for a language for the artificial intelligence routines and also for mathematical computations. LISP was chosen as the language to code the artificial intelligence routines because it supports forward-chaining and rule-based knowledge representation. To handle the computations required by the Kalman filtering and smoothing, C was chosen because of its computational efficiency.

The design of the system hardware posed several constraints. The system would have to fit in 2.9×10^4 cm^3 volume and weigh less than 16 kg. The artificial intelligence code would have to run at a rate of 125,000 instructions per second. The Kalman estimation technique would require a processor speed of 25,000 floating point operations per second. In addition, 3 to 5 megabytes of memory would be needed to store SAR images and filter results for processing. Finally, the system would have to operate in space.

Several system configurations were developed, each with relative advantages and disadvantages. Our main recommendation consisted of a 68000-based system including three Motorola 68000 microprocessors in conjunction with two 68881 math coprocessors. The system would include 3 to 5 megabytes of random access memory. One 68000 microprocessor would be responsible for the artificial intelligence processing; the other 68000 microprocessor and its associated 68881 coprocessor would be used for processing the SAR spectra and performing the Kalman estimation routines. A third 68000 and 68881 microprocessor/coprocessor pair would be used as a backup or to perform additional processing if necessary. The system had several advantages. First, the 68000 was readily available and had been used extensively, and software development tools exist. In addition, the 68881 coprocessor can handle the demands placed on the system by our SAR processing and filtering routines. The 68000 also allows access to the large amount of data our system required. Finally, this was a general-purpose design that allowed flexibility should needs change in the future.

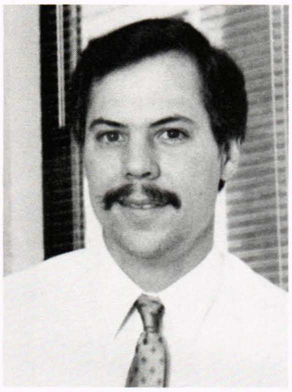
The proposed system did have a disadvantage: the 68000 and 68881 were not space qualified. However, considering the low, near-polar orbit of Spectrasat, it was felt that tantalum shielding would resolve this difficulty.

A more detailed presentation of the results of our SITE project can be found in Ref. 2. Our design goal was to determine the feasibility of flying an artificial intelligence expert system on board a spacecraft. It is our hope that the results of our project may serve as a pioneering effort in this exciting field.

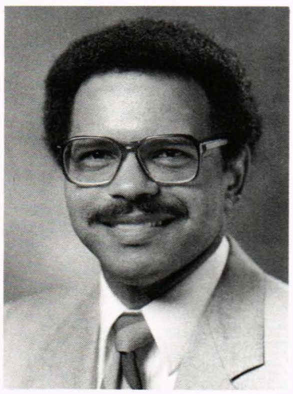
REFERENCES

1. A. D. Goldfinger, *Strategies for the Calibration and Operational Use of the ERS-1 SAR Wave Model*, Final Report, JHU/APL SDO-7565.
2. *The Spectrasat Intelligent Tracking Experiment: A Feasibility Study and Preliminary Design*, Fall 1986 Associate Staff Training Program, JHU/APL SR87-3 (Apr 1987).

THE AUTHORS

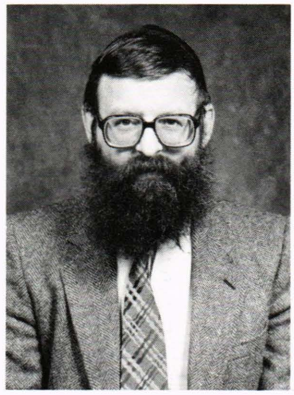


VINCENT C. MESSER is section supervisor for training and development in APL's Education and Training Group. Born in Baltimore, he received a B.A. degree in English from the University of Maryland. He has also earned master's degrees in English literature and in education, and he is currently completing a Ph.D. program in instructional development at the University of Maryland. Before joining APL in 1982, he taught in both secondary and higher education and worked on curriculum development projects for public education. His responsibilities include the development, coordination, and maintenance of APL training and development activities, including the Associate Staff Training Program, management training, personal computer training, and in-house training consultation for APL's technical and administrative units. He is a member of APL's senior staff.

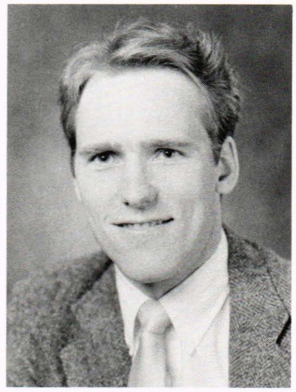


HORACE MALCOM was born in Atlanta, Ga., in 1946. He received an M.S. in physics from Emory University in 1972 and an M.S. in computer science from The Pennsylvania State University in 1974. He joined APL's Space Department in 1974 and is a member of the Computer Science and Technology Group, where he specializes in software engineering of real-time data acquisition and control systems. Mr. Malcom has worked on the Energetic Particles Detector instrument on Project Galileo and the Medium Energy Particle Analyzer instrument on the AMPTE/CCE spacecraft, for which he also designed the telemetry software system. Since 1981, he has been a lecturer in computer science in the continuing professional programs of The Johns Hopkins University G.W.C. Whiting School of Engineering. He has recently worked on the SATRACK II satellite-based tracking system.

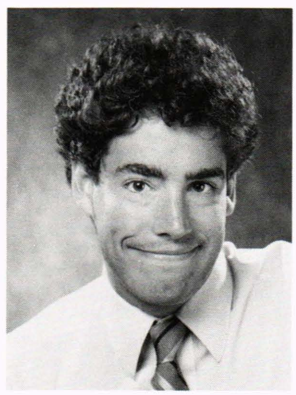
PATRICIA J. HERCHENROEDER is a project manager in APL's Naval Warfare Analysis Department. She received a B.S. degree in physics and astronomy (1975) and an MSEE degree in electrophysics (1977) from the University of Maryland. She joined APL in 1977 as a member of the Magnetics Group of the Submarine Technology Department, where she was involved in oceanographic research concerning underwater extremely low-frequency electromagnetic fields and magnetohydrodynamic effects. Since 1984, she has served as a project manager for the Technical Intelligence Program. She is a member of APL's Program Review Board.



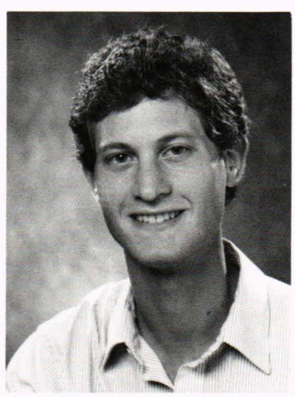
ANDREW D. GOLDFINGER is a section supervisor in the Computer Science and Technology Group of APL's Space Department. Born in New York City in 1945, he studied physics at Rensselaer Polytechnic Institute and Cambridge University and received a Ph.D. degree in physics in 1972 from Brandeis University. In 1983, he obtained an M.S. degree in applied behavioral counseling from The Johns Hopkins University. Dr. Goldfinger is currently working on applications of artificial intelligence to remote sensing, spacecraft operations, and VLSI design.



DEAN S. GARLICK is a member of the Space Department's Computer Science and Technology Group. He was born in Ogden, Utah, and worked for Morton Thiokol before coming to APL in 1986. He earned a B.S. degree from Weber State College in applied mathematics and is enrolled in The Johns Hopkins University G.W.C. Whiting School of Engineering pursuing an M.S. degree in computer science.



JAMES T. EVERETT graduated in 1986 from The Johns Hopkins University with a B.S. in mathematical sciences. During the summer of 1985, he worked in the System Accuracy Studies Group performing a numerical study of the error isolation methodology. Since completing the 1986 Associate Staff Training Program, he has been a member of the Systems Analysis Group, where he has been developing network control algorithms for the Cooperative Engagement System.



ALLAN R. JABLON is a member of the Communications, RF, and Optical Systems Group in APL's Space Department. He received a B.S.E.E. degree from Virginia Polytechnic Institute and State University in 1986. Before working at APL, he was employed at ARINC Research Corp., where he worked on electronic countermeasures systems. Since joining APL in 1986, he has been involved in antenna analysis and design and RF systems testing.