# Tom Weaver's Memoirs

Spanning the period
from 1962 through 1994
Working at NADC

Written May 2003

## The Early Years: 1962-1966

Growing up in Hatboro, PA I was aware of the sprawling complex in Johnsville known as the Naval Air Development Center, but didn’t know much about the work being performed there. I had an above-average fascination with things both mechanical and electrical, so it was logical to aim for an Engineering degree after high school. One day I had a conversation with George Gimber who told me about the Student Engineering Development program at NADC. The program was designed to increase the pool of civilian scientists and engineers in the Navy R&D community. They offered work experience in technical departments, tuition assistance, and a guaranteed job upon graduation from college. So in my senior year at Hatboro, I took the Civil Service Exam, submitted my application, and landed a nice summer job two miles from my home.

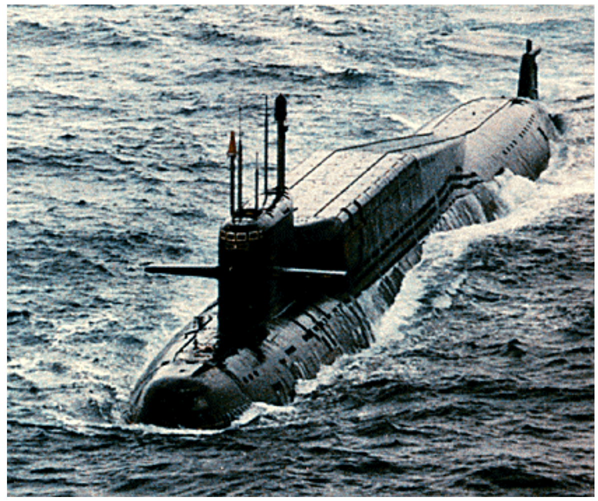
That first summer, I was assigned to the Air Warfare Research Department, and worked as an apprentice with several of the full time employees. There were 18 students selected that year for the SED program, and I was the only one assigned to the AWRD. Actually, it was during a meeting with the department head, Bill Raber, that I learned that this was the first time the department participated in the SED program, and that I was their first test case. In those years, the AWRD consisted entirely of senior scientists and engineers, all GS-13 and above. It was

NADC’s ‘think tank’. They were not involved directly with the design or test of specific aircraft equipment. Rather, their domain was entirely analytical. Through creative thinking and heavy use of mathematics, they were searching for the most effective use of Naval aircraft systems, and finding ways to maximize the chances of a successful outcome when those systems are used in a wartime situation. This department was also tasked to identify systems which did not yet exist, and to provide comprehensive technical support as to the cost and the effectiveness of the proposed systems to procurement planners in Washington DC. Frankly, as a high school graduate working his first job as an engineering intern, I was a little intimidated. Sometimes my task was to plot numerical data on K&E graph paper (this was before the arrival of the computer) or to proofread a typewritten draft. I can still remember the sound of the Marchant mechanical calculators crunching away on those numbers. All along I was getting a valuable lesson in Operational Analysis, and soon realized how important it is to understand the ‘big picture’ and the interactions between our systems and those of the enemy, who at that time was the Soviet Union. At the end of the summer, they invited me back, so off I went to Rutgers University to learn about Electrical Engineering.

Each summer I would return to NADC, and work for one of the high-grade scientists in AWRD, or for an engineer in one of the other departments. I developed an appreciation for the variety of work being conducted at NADC, and for the competence of the engineering personnel who worked there. True, the bucolic setting of Hatboro and Johnsville, and the tranquil times of the early 1960’s was a perfect backdrop for my childhood, but there loomed an immense threat halfway around the globe that could no longer be ignored. The Soviet Union embraced a political philosophy much different from ours, and showed every intension of spreading communism throughout the world. They invaded neighboring countries and overthrew their governments. As the rhetoric increased, so did their threats to our sovereignty. The Soviet military threat at that time had three components, each of which could deliver nuclear weapons to cities or military targets within the United States. They were: Intercontinental Ballistic Missiles, manned Soviet bombers, and Soviet submarines. The United States military in general, and the US Navy in particular, was developing new systems to counter these threats in order to protect the citizens and property of this great country. NADC personnel played an important role in defining, developing and testing some of these new systems and calculating their effectiveness. Much of the work at that time was highly classified, some had to do with the analysis of data gained from intelligence sources, and all of it was focused on winning the battle against communism. NADC’s efforts to counter the submarine threat established it as the lead laboratory in the nation for this technology, a position that it would enjoy for many years to come. I realized that NADC offered me an opportunity to work, not just for a paycheck, but for the defense of my country, and to be surrounded by very smart co-workers on a daily basis.

## The Engineering Graduate

With the Vietnam war now in high gear, I graduated from Rutgers and returned to NADC to work full time. Though many of my friends were being drafted into the Army, I avoided the draft because my employment at NADC entitled me to an occupational deferment. The Selective Service Board decided it was more worthwhile for me to apply my scientific background to designing systems at NADC than to join the Army and carry a rifle. By now, NADC had its first mainframe computer, a Control Data 3200. The Operations Analysis work in AWRD was making heavy use of computer models, and I quickly became a part of that activity. Though I’ve long since forgotten what my earliest assignments were, I do remember this is when I learned computer programming and the Fortran language (which was not taught to Rutgers engineering students in those days). Tom Wiley, Dave Panetta, Glenn Carter and the other analysts kept me busy with new and challenging problems to solve. Solomon Getz introduced me as a GS-7 to the Navair scene. Navair was the headquarters for all Naval Air procurements, and was still housed in the WWII BuWeps buildings next to the Jefferson memorial in Washington. He would take me on his whirlwind visits to numerous Navair offices, where together we would collect technical and cost data for as many systems as we could find. Back at NADC, Sol was leading an effort to develop Cost Estimating Relationships, complex mathematical formulas for estimating the cost of new avionics, when little more is known about them than their size and weight. The results of these CER's were then used by Navair program managers and Pentagon planners as they prepared budget submissions to Congress to buy new weapon systems.



Later I worked with Bill Steuteville doing an analysis of the effectiveness of an airborne radar to detect a submarine periscope. True, most of the time a submarine will remain below the water's surface in order to avoid detection. But once it was realized that a submarine cannot complete its mission, which is to gain final targeting parameters and launch a nuclear-tipped missile, until it has come to periscope depth, we worked on finding ways to exploit this vulnerability. A high-powered pulse compression radar was developed to detect this very small object on the ocean's surface. We were working with Ed Koos and Otto Kessler on the development and evaluation of this system. A test facility was established near the coast of Hawaii, and vast amounts of data were gathered to determine the effectiveness of this new radar. Interesting work, bright people, good pay, and a trip to Hawaii, this job had it all.

As an outgrowth of this project, we initiated an investigation into the feasibility of automatically classifying the echoes from this ASW radar. The concern was that numerous other things could show up as a radar return, besides periscopes, and unless we could determine what they were and filter them out, we did not have a fully effective system. We wanted to go beyond just having an operator look at them on a display, because that resulted in too much operator workload. Working with Fred Prout, we recorded radar returns from various submarine masts, as well as other targets of interest, and converted them into a form where they could be studied on the NADC mainframe (now a Control Data 6600). A technique called 'pattern recognition' was employed to see if specific features of the radar returns could be recognized by computer software. There were several algorithms in the literature; each had its strengths and weaknesses. My job was to identify the algorithms, program the candidates in Fortran, and evaluate them using digitized radar returns. Of all my assignments at NADC, this one came closer to pure research than anything else I worked on. I had wide latitude in what I did and how I did it, and felt like a pioneer looking for a breakthrough for a new technology. Our result back in the 1970's was that radar returns from periscopes could be automatically classified, using pattern recognition techniques, and many other objects filtered out. But unfortunately, an acceptable level of false alarms could not be realized. Too often, other objects looked like a periscope to these algorithms. So a device with this capability was never built. Today, thirty years later, similar technology is starting to appear in products which employ voice recognition. It has taken that long for engineers to find those features of spoken sound that can finally allow machines to distinguish words in a rather short vocabulary list.

As an aside, the mechanical calculators on our desks (and Brownee, their repair expert) eventually gave way to an electronic system, made by Wang, which had 4 keyboards connected to a central processor unit. Each keyboard had a bright Nixie tube numeric display and provided math, trig and log functions. This system cost $1000 but was much faster (and quieter) than the mechanical calculators. We were pleased with the improvements. Now, if you fast forward to today, you can buy a hand held calculator with all of those functions and more for $25. Amazing!

## The Software Division

Over the years I gradually grew restless doing pure analytical work and felt the need to get involved with something more tangible. The Center was adjusting to the influences of new technologies and new projects. Whereas in the past, individuals would learn to do their own computer programming on an ad hoc basis, by the early-1970's the demand for programmers and the specialized knowledge needed was such that a new division was being formed on Center just for that purpose. In 1973, after an interview with Hank Stuebing and Dave Schimsky, I decided to transfer to the Systems Software Division in order to find hands-on work.

At that time, ASW developments were in full swing. Lockheed was producing quantities of the P-3 aircraft, which carried numerous systems developed or tested by NADC engineers. The primary means for detecting a submarine at that time was to deploy a field of sonobuoys and monitor the sounds being picked up by the hydrophones. The sounds were radioed back to the aircraft patrolling above the field, where operators could listen to them and observe their spectral characteristics on a paper chart. What was still missing was a way to classify those sounds so that the operators could know the source of the sounds. Through Naval intelligence, much was known about the sounds made by Soviet submarines. Several parallel efforts, at NADC and elsewhere, were underway to develop methods of automatically classifying those sounds. These algorithms were lumped under the name Machine Assisted Detection & Classification. The proponents of each method made vigorous claims that their method was superior, and the political bickering was intense. What was needed was a way of fairly and thoroughly evaluating each of the methods in order to determine which one was best.

I was tasked to create a target model which accurately simulated the known sounds of Soviet submarines and other underwater sources, which could feed those sounds into the candidate classifiers so that their performance could be scored. Of course, all the work I was doing was classified, and so are were the results. There wasn't much I could tell my family or my friends about my work at NADC, just that it was very interesting. This assignment, along with the specialized training courses I attended, gave me a wealth of understanding on exactly how acoustic energy propagates through water, how we pick it up with sonobuoys, and how it was analyzed on board the P-3. We were making huge advances in the field of underwater acoustics, but unfortunately the hardware on the P3 wasn't keeping pace.

Some of the pioneers in ASW had already decided to award contracts to buy new acoustic systems for the P-3 that would replace the AQA-7 paper chart processors with units that would be fully programmable. The plan was that as the threat changed and the sophistication of our processing methods improved, that new software could be loaded into the fully programmable modular processors without incurring costly hardware retrofits. The system design featured several programmable processors, each with a specialized purpose. For whatever reasons, separate contracts were awarded for each processor. And some of the contracts did not procure software for the associated processor. IBM was selected for these contracts, and built militarized computers whose architecture was similar to their IBM-360 mainframe machines. This became the Proteus project at NADC, and we were responsible for specifying, procuring, integrating and testing these advanced units. This was the first time that this much computing power had ever been placed on board an aircraft. With my background from the previous target modeling task, I was a natural to work on the Proteus project.

Engineers from throughout the Center were being assigned to this project. During our meetings we would evaluate what we had and what we still needed to make a complete, flyable system. Early on I realized that although the hardware interfaces between the units were specified, that the software interfaces were not. Along with Rich Goelz, we wrote the Proteus Interface Description in 1975. This document defined the software protocol and dialog between all of the units, including a new sonobuoy receiver, a programmable signal processor, several multi-purpose displays, a magnetic tape unit, and the P-3 tactical computer. Over the next few years, 300 copies of this document were produced and distributed. Little did I realize at the time, that the knowledge gained in writing this document would give me a unique broad perspective of all the capabilities within the system, which became known as Update III.

Meanwhile, brilliant minds from the System Design division, including Gerard Goulet, Jack Lamperez and Bob Minder, had been hard at work writing software specifications for the all important system control unit. These specs were turned over to us in the software division where we competitively awarded a contract to develop this software and integrate the various sub-systems into a flyable system for the P-3C. Computer Sciences Corporation, who already had offices in close proximity to NADC, won this multi-year contract in 1976, and I was put in charge of their activities. CSC assigned Marty Babst as their contract manager. At the outset, we knew the task was daunting. The software specification was very specific, and 1500 pages in length. The target hardware, called a system control unit, was still in development at IBM. There was no operating system. The programming language, SPL, and the software development tools were all brand new. A programming team of 30-40 people had to be assembled and trained on this new technology. Marty knew that in order to be an effective manager of this team that he had to be able to answer all of their technical questions. So he personally wrote the software for one of the most complex modules in the system, and by so doing, learned all of the tools and processes that his programming team would be using. As his primary interface at NADC, my job was to react to CSC's findings of deficiencies to keep the project running smoothly. In those early days, there were deficiencies in the specs, in the software development tools, in the target hardware, and the peripherals, all of which were furnished under the contract as GFE or GFI. We were pushing the state of the art, so we took these matters in stride. I had other software engineers assigned to me at NADC who reviewed deliverables from CSC and assisted me in troubleshooting technical problems. It was all very exciting.

## The P-3C Update III Project


In 1975 the P-3C Update III project office had been formed to manage and coordinate the many diverse tasks being performed throughout the Center, headed by LCDR Dave Seckinger and Project Engineer Franz Bohn. NADC had evolved into a matrix organization, where engineers were grouped together by technical specialty in departments and divisions. Projects would negotiate to obtain engineers with specific skills, who would work for the project as long as needed, or until a higher priority need came along. This project grew to become the biggest and most highly visible project on Center. There were many long days and nights spent putting the components of this system together and verifying that they were working properly. Engineers from numerous divisions worked on Update III, and they derived their identity from the project itself. The teamwork and cooperation was unique. As pieces of the project started coming together in the laboratory, it was rewarding to see the results of a large team effort. But the real test was across the street on a specially modified P-3C aircraft. An electro-mechanical rack was fabricated and installed to house and cool all of the new computers and avionics. Just one thing was still missing – a flyable tape unit from which the programs could be loaded. So we placed a 9 track tape unit from the lab in the back of a truck, ran cables through the aircraft doorway, loaded the software, unplugged the cables, and signaled the pilot to take off. The flight was a success, with Rich Goelz and I operating the equipment (using scenarios we had practiced numerous times in the lab). I still remember being greeted by the base commander as our maiden flight landed back in Warminster in the summer of 1977. Yes, the Soviet submarine threat was still out there, and getting quieter than ever, but we felt confident that we were working on a system that would allow the P-3C to maintain its supremacy for years to come.

Perhaps our biggest setback was in 1979 when we were directed by Navair to reconfigure the system so that production costs could be reduced. We stopped what we were doing and focused on various ways of driving two independent displays from a common processor, and reusing as much of the existing software as possible. Instead of having a dedicated processor, controller and display for each acoustic operator, we ended up with a shared processor and a single controller. This would involve years of additional engineering and software development work. But under Franz Bohn's steady leadership, we rewrote the program plan and set out on finishing the system. By now we had been through the development process several times, in accordance with the MIL-STDS that were in effect. And knowledge wise, the team was already up to speed. Our team became aware of a distinct phase in the development process, a period after all the software is written, but before everything works properly, now called integration. My job, and that of my co-workers, was to identify problems, prioritize them, and assign people to fix them. This is a difficult phase of a project to manage, because there is no way of knowing in advance how many problems there will be and their severity. But we persevered, and after thousands of hours of lab work and numerous test flights, we were ready to turn the aircraft and its new equipment over to the Naval Air Test Center, on schedule. We trained their aircrews, and their maintenance personnel. Since their testing is done independently of the developers, our engineers could not be there to pamper the system. There was a lot riding on the outcome. Lockheed needed to shift its aircraft production line over to incorporate Update III kits. And the companies making the Update III kits needed to start up their production lines. The funds for production were already programmed into outyear budgets, so a schedule slip at this point would have had dire consequences. Fortunately, both the technical and the operational tests were deemed a success, and in 1982 the system was approved to enter production. We felt a tremendous sense of satisfaction.

One of the supervisors, Dick Mitchell, kept asking me what we did that made Update III successful. I suppose he was looking for some lessons learned to apply to some less successful projects at NADC. I replied that I didn’t really know, it just happened, we were just doing our jobs. But he kept asking me the same question many times, and when I didn’t have a satisfactory answer, he told me to go talk to my project people, find out what they think, and write a report on what made Update III successful. So I interviewed each of the key players, took copious notes, and tried to find the answer to Dick’s question. Many months later, after perusing the notes spread across my dining room table, it occurred to me that it was the positive can-do *attitude* of the people. Update III was staffed with a number of technically sharp people, who trusted one another, and were totally focused on the goals of building this system in the allotted time. In 1983 I published a 35 page report detailing the cooperation and teamwork that existed on this project.

I spent fully 8 years working on Update III in the Software Division. It was during this period that working at NADC changed from being a job, to being a career. I had found something I truly enjoyed doing. One of the greatest rewards was being able to see a system grow and mature from an initial idea to a finished result. Seldom in one’s career does one get an opportunity to be a part of the entire R&D process from beginning to end. It was a tremendous learning experience, and the lessons learned would help me in later years. In 1979, about halfway through this phase of my career, John Heap, my Division Superintendent, had already noticed my work ethic and my tendency to extend my reach beyond my defined job of software team leader. Unbeknownst to me at the time, he initiated my promotion paperwork to a GS-13, based on accretion of duties. It was good work, and I was content to continue doing it for awhile. But then in early 1984 a vacancy was announced. Franz Bohn was leaving his position as Project Engineer. After some reflection, I prepared my application and submitted it, along with 20 other candidates. The highly competitive field was due to the fact that P-3C Update III was a high visibility project with a successful track record, and many people wanted to tie their careers to that. I was selected to the Project Office position and promoted to a GS-14, beating out several other highly qualified applicants.

In May of 1984 the first new production P-3C Update III rolled off the Lockheed assembly line in Burbank, CA. Just to make sure the aircraft with all of its GFE systems were working properly, Navair assembled a Navy team to fly and evaluate the production aircraft out of Burbank. I was assigned the role of test director. After arriving at the Lockheed facility, we ran our pre-flight tests, then buckled our seatbelts ready for takeoff. The pilot powered down the runway, and just when we expected the nose to come up and the wheels to leave the ground, the

pilot decided to perform an emergency stop instead. Several long minutes later, we got the message from the cockpit that the airspeed indicator did not move above 80 mph, thus the aborted takeoff. During this emergency, you don’t know what’s wrong, and it was a little scary. The engineers deplaned, and Lockheed personnel investigated the anomaly. After they replaced the cockpit gauge, we got back to our seats and prepared for takeoff. Another full power run, another emergency stop, same anomaly. Several hours later, we were called back to try again. This time, during the emergency braking, a tire blew out. It took them the rest of the night to change the tire, and to replace the air tube feeding the airspeed indicator. The next morning’s takeoff and subsequent tests were uneventful.

## Channel Expansion

Although the fleet was beginning to receive Update III systems, the development process back at NADC never slowed down. Years earlier, when the cost cutting measures caused us to reconfigure the system, it was decided to totally rewrite the acoustic processor software. The result was a lengthy development process at IBM to double the number of sonobuoy input channels, and an equally lengthy process at NADC to integrate that program. Other items were added to the project, including touch-sensitive operator panels (instead of pushbutton switches) and an antenna/receiver system for measuring the locations of sonobuoys in the water. The Channel Expansion Project, as it became known, was every bit as ambitious as the Update III baseline which preceded it. Most of the engineers from the baseline continued to work on CHEX without interruption, so LCDR Nick Brownsberger, the Project Officer, and I didn’t have to do very much recruiting. There was something about working on P-3 that made people stick around for long periods of time; there was very little turnover. Steady funding, interesting work, good people and the knowledge that you were helping the fleet – those were some of the reasons. But I did have to fill my vacancy back in the software division. I selected Barry Knouse to take over the software team leader duties. He was bright, energetic, and picked things up quickly, qualities I thought were essential for the job.

Working now as the chief engineer in the Project Office, I was in charge of budgets, schedules, plans, tasks, and results for a multi-million dollar project, one of the largest projects at NADC dollarwise. We had full responsibility for all phases of the work, from defining the requirements through flight testing. I had direct liaison with our Navair sponsors, and direct liaison with our fleet users (customers), the people in the VP squadrons at Moffet Field CA, Jacksonville FL and Brunswick ME. We had satisfied customers. We received numerous phone calls and messages from the squadron personnel who were using the Update III, attesting to how much better it was than the predecessor, and encouraging us to deliver the CHEX capability as soon as possible. It was a busy and exciting time, and there were periods I enjoyed the work so much, I would have done it for no pay. In Washington, CDR Dave Seckinger was now the deputy program manager, and LDR Panos was his right hand man, working from the avionics procurement office. I traveled to Navair on a regular basis to present our progress, our problems, and to hear the presentations of other agencies and corporations who had roles on CHEX. We periodically made trips to the VP squadrons, to hear firsthand how they were doing with the Update III's, and to explain our progress on CHEX. I had become the subject matter expert for this system, and was frequently called on to make presentations.

In 1985 we invited representatives from the VP squadrons, and from Patuxent River to attend a two day briefing at NADC where we described in detail the planned capabilities and the design of CHEX, and solicited their feedback. To the best of my knowledge, this had never been done before, to essentially show your customers what you were planning to develop for them, solicit their input, and promise them a milestone when it would be completed. But such was the nature of the teamwork that existed at this time.

In 1986, along with 3 Navair personnel, I was invited to travel to Japan to give a series of presentations about the Update III. The Japanese government had been making arrangements through our state department to obtain copies of our equipment design drawings, and NADC-developed software, so that they could manufacture equivalent Update III's for their own use. Our briefing party was the first to provide them with technical and performance data. It was a privilege and an honor to represent the Center, the US Navy and my country during these meetings. The Japanese people are tremendous hosts, this was a once in a lifetime experience. In subsequent years, Japanese officers, along with their families, would travel to NADC to receive hands-on training for the Update III. It was around this time that I met Marlene, who was a budget analyst for the P-3 project. (We were married in June of 1988).

In early 1987 we completed our lab and flight testing of the CHEX system, and sent it to Patuxent River for technical testing. Unfortunately, it bounced back, with a deficiency called a SASP freeze problem. During flight, and usually without warning, the computer system would stop working. The crew would then have to reload the software, and lose valuable minutes. In a real ASW situation, those valuable minutes could mean the difference between success and failure. We had seen some freezes during our development, and if they were repeatable, we were usually able to fix the cause. But now they were occurring like random events, and with no known way of repeating them. The programs had grown to millions of lines of code, the largest ever installed on any Navy aircraft, and now they didn't run reliably. The sponsor was upset, production lines all over the country were gearing up in anticipation of this system. By now, Update III was both a forward fit, meaning new aircraft, and a back fit, meaning that older P-3's were having their avionics removed to make room for these newer systems. The scheduling of these back fits was linked to when each squadron was away on deployment, when they were home, and when their crews were available for Update III training. In other words, the ripple effect was huge. We were embarrassed. The sponsor even considered canceling the program, but inputs from the fleet people said they need it, and they need it as soon as possible. The head of the Navair program office complained directly to the NADC base commander about this dire predicament, and wanted to know what the Center was going to do to correct matters. I was called up to Guy Dilworth's office, the Center's technical director, to explain what went wrong, and to provide a plan to fix it. This was the most difficult period of my career.

Mr. Dilworth had a reputation of being very demanding. He was on a mission build NADC's business base and make it technically superior. Some people feared him and didn't like his heavy handed decisions upsetting their comfortable little worlds. I knew that my career was on the line. I told him what I knew about the problem and what I thought the team needed to do to build reliability into the software. He was already aware of my technical expertise. His first decision was whether to fire me or keep me; he decided to keep me on the project. He explained that CHEX was the most important project at the Center, because of the dollars involved, because of its impact on the fleet, and because of its effect on the Center's image. He went on to say that I had to succeed. We would not get a third chance. He offered me *any* resources I needed, people, facilities, or whatever, to fix the freeze problem. All I had to do was tell him what I needed. It was like having a blank check.

In the following days and weeks, a GS-14 software engineer moved into my office. He was Mr. Dilworth's eyes and ears. He would monitor what our team was doing and report directly to the technical director. Another GS-14 systems engineer with a P-3 background showed up to run the integration tests in the lab and to expedite the finding and fixing of problems. A GS-15 engineer showed up to expedite getting contract packages through the contracting department on a fast track. Senior people who were tucked away in the matrix organization were being re-assigned to lend support. Our own people, some of whom were in the process of finding new work, stayed to fix the problems with CHEX. Capt. Joe Kiel came to NADC to hear my get-well plan. It was an uncomfortable meeting, given the circumstances, but he granted my request for 11 months and $3 million dollars. And he asked Mr. Dilworth to keep a close watch on this very important project. So every week, I marched upstairs to brief him on our progress. He probed deeply into our methods, and made sure that everything humanly possible was being done. Truthfully, it wasn't much fun working under a microscope like that. Meetings with Mr. Dilworth were sometimes very stressful. But through it all, I realized he wanted people to stand tall, to perform, and not just monitor the work of others. He had had more than a few arguments over the years with senior engineers who weren't pulling their weight. Through it all I developed a respect for Mr. Dilworth and his oversight of our project. He often said to me, if things get to the point where you feel you cannot succeed, you're free to quit the project. Otherwise, get back to work, and if you need any resources that you don't have, just come to me and ask for them.

Technically, what we did to correct the problem is outside the scope of this article. We built robustness into the software so that it could survive faults. We ran numerous 100 hour tests, which is about ten times the length of a P-3 mission, with the system heavily stressed, in order to measure the software reliability. We tested the system on a vibration platform to check for intermittents in the hardware. We tested the system in a thermal chamber to check for temperature effects. I doubt that a PC running Windows today could withstand the rigorous testing we did on CHEX. In 11 months, we had a program that we felt was ready. With my reputation solidly on the line, I transferred the CHEX aircraft to Patuxent River for resumption of independent testing. Typically, the combined technical and operational testing can take a year or more, during which time, no status is reported. Meanwhile, the fleet was clamoring for this capability. Because the Soviet submarines were getting so quiet, it required larger fields of sonobuoys to detect and track their movements. In the past, we did not release software to the fleet until after the testers at Patuxent River certified the programs. In those days, fleet resources were not to be used to test new systems. But the VP squadrons were asking to have their own look at the software, and after liking what they saw, they chose to use it on their ASW missions, in advance of formal release by the Pentagon. When the Patuxent River testing was finally done, there were still a few anomalies, but the positive response from the fleet was so overwhelming that the decision was made in 1989 to release it officially. I felt vindicated.

## New Sonobuoys

After years of struggle trying to find and fix software problems, we embarked on a crusade to *prevent* them from occurring in the first place. Every phase of the software development process was examined to see where problems were slipping through so that we could put measures in place to prevent that in the future. We installed reviews and cross-checks so that things could be built correctly on the first try. We preached problem prevention to every member of the project team. There was plenty of work to do, and several arenas to improve our process. A post-CHEX project was being defined, which provided new modes of operation to better match the acoustic signatures of the newest Soviet submarines. And a new sensor was being developed which was designed to cost less than the existing sensors. Navair had let a contract with a sonobuoy manufacturer to build a sensor to a very low unit cost. The goal was to deploy hundreds of these sensors into an ocean area where a transiting submarine was suspected to be. One or more of these sensors could alert a patrolling aircraft as to the presence of something of interest, but not relay acoustic sounds to the on-board aircraft processors. Traditional sensors could then be used to follow up, when required. Ed Reidinger was NADC's lead engineer for the sensor, and I was in charge of aircraft software and system integration. We were in our third and final year of development when the project was cancelled, because the sonobuoy could not be built to the fixed price and withstand the rigors of dropping from an aircraft and splashing into the ocean. Though we never flight tested that software, it was working satisfactorily in the lab.

This project brought me into contact with another program manager at Navair, Capt. Bob Colvert. He was responsible for procurement of existing sensors, development of new sensors, and for the signal processing software associated with those sensors. One of the obstacles he faced was that he needed to use aircraft systems and software in order to fully test his new sensors. But the P3 Navair sponsor was so busy with its own projects that they couldn't provide support to Capt Colvert. I decided to build a bridge between my development team at NADC and his programs. In 1988 I offered our resources and expertise to serve as lead platform and perform all of the system integration in support of the Tactical Surveillance sonobuoy. By now, processor chips had been miniaturized to the point where it was feasible to put them inside the sonobuoy. Conceptually, these buoys could be deployed in areas of interest, and perform surveillance without a patrol aircraft loitering nearby. The sonobuoys would have sufficient memory and battery life to do their job for many days, vice a few hours. When the patrolling aircraft returned to the sonobuoy field, it could interrogate each sonobuoy, which would replay the acoustics from memory at high speed, and the operators on the patrol aircraft could re-analyze the signals. The plan was that one platform would go through the R&D cycle and get the sonobuoy approved, then other platforms such as carrier-based airplanes or helicopters could reuse the designs and where possible, their software. I was now responsible for managing parallel developments for two sponsors in Navair, and sharing resources between projects without adversely affecting any of the projects. Working with Carl Hammond, the lead engineer for the sonobuoy, we broke the Tactical Surveillance project into two distinct phases. The first phase was designed to get production approval for the sonobuoy, which meant it had to be dropped from an aircraft and tested in an ocean environment. The second phase was to fully integrate the TSS sonobuoy into the Update III aircraft so that it worked concurrently with the existing capabilities. For the first phase, we created Update III software which just processed and displayed TSS sonobuoys, but nothing else. We completed this effort in under two years, and sent it to Patuxent River, where it was successfully flown. For the second phase, we needed to fully integrate the TSS with into the CHEX package for use by the VP squadrons in the fleet. I generated the high level software design, based on my knowledge of the Update III, my review of the sonobuoy specification, and input from the sponsor, then provided that to the design team for filling in the details. This helped get the team off in the right direction and avoided costly redesigns. Another of the things I did to accelerate the design phase was to encourage each of the members of the design team to use e-mail (heretofore unavailable) to send ideas and responses back and forth. Instead of waiting an entire week until the next design meeting was scheduled, ideas could be evaluated as soon as they appeared in one's e-mail. We were in our fourth and final year of this effort when in 1991 the project was shelved. By now, ASW budgets were shrinking, and since the buoy itself had previously been approved for production, the Pentagon felt it should spend its limited budget elsewhere. But we were hitting every intermediate milestone, and felt confident that our TSS product was well engineered.

Capt Colvert was known for chewing up and spitting out engineers when they failed to deliver on their promises. Like others, I had to give presentations of our plans and progress. At the end of one such presentation, he held both thumbs up, and said "Good job, Tom". Later one of his deputies came to me and said, "Tom, he's never done that before, you really impressed him". I had been working in the project office seven years, and was accustomed to giving crystal clear presentations to high level managers. I was frequently called on to demonstrate our facilities to VIP visitors at the center, including several admirals. My trip to Japan, my visits to Mr. Dilworth, countless briefings at Navair and fleet sites, all of these allowed me to feel comfortable speaking to a group. By now, we had anywhere between five and ten products being developed at the same time under my auspices, with numerous interdependencies between them. It was my role to understand those interdependencies and communicate them succinctly to my team, to my sponsors, and to my customers, the fleet. Finding that pictures often communicate better than just words, I created management plans that illustrated the product time lines and interdependencies. I became the master of the one-page summary. I kept a stack of viewgraphs in a file drawer, ready to go on a moments notice. This was before PC's with PowerPoint were available in conference rooms.

It was becoming apparent that the 20 year old tactical computer on the P-3C was obsolete and needed to be replaced. Navair awarded a contract to Unisys to build a form, fit and functional replacement, which became known as the ASQ-212. Using the advances that had been made in processing technology, a computer roughly ten times the power of the aging CP-901 was being developed. Unisys also had to completely rewrite the programs for the tactical computer, using the DOD standard high level language called Ada. Navair tasked us at NADC to perform technical oversight of the Ada development, and to independently test and validate the software.

I put Howard Shectman in charge of this project, because of his familiarity with the P-3C avionics and his rapport with the Navair sponsors.

From 1984 to 1991, the annual budgets for the Update III projects in my office roughly tripled, and peaked at about $15 million dollars. Almost all of this money paid for the salaries of scientists and engineers. In 1991 I was very pleased to receive the Center's award for Project Leadership. The criteria were: multiple project responsibility, sustained, multi-year performance, direct impact to the fleet, and a successful track record. The award ceremony took place in the aircraft hanger, in front of a large audience, which included members of my family. I felt very proud.

In 1991 Capt Colvert was managing a program involving a modified sonobuoy and a specialized processor, for which the lead platform decision had not been made. The climate in Navair at that time was shifting away from using field activities like NADC as system integrators, and sending the work instead to a prime contractor. I had stopped by Capt Colvert's office for some other business, when he said, "Come with me, we're going to see [his boss] about the lead platform decision". I listened quietly, and smiled inside, as he argued the virtues of our team, mainly a track record of successes, we can begin working immediately, lab and aircraft resources in place, and more flexible management of the development. His views prevailed, and we got the job.

## Process Improvement

Despite our record of successes, I was convinced our development process could be further improved. Problem prevention was working pretty well. But we were still spending almost two years writing software specifications. I decided the system design team should concentrate on producing a design **concept**, and document it in just 30 pages. Drawings, rather than wordy descriptions, were to be used to convey display formats, switch locations, etc. When complete, this document would be turned over to the software team. A senior member of the software team would participate in the system design meetings, and ensure that what was being planned was implementable. The software team would write the software specs, and proceed immediately into software design and coding without the delay usually associated with receiving a spec unfamiliar to them. This change was intended to free the system designers from the drudgery of word-smithing a detailed technical specification, and allow them to concentrate more on the design concepts directly. Also, it gave the software team a head start, because of greater familiarization with the specs. Even more noteworthy, I moved the design meetings from the conference room to a MacIntosh workstation, which I purchased specifically for this project. We implemented our design ideas in a hypertext language, so that we could see the display formats and switch locations on a screen. Changes to the design could be reflected in the hypertext language in one or two days. Individuals could "run" the system, and suggest changes and improvements, both during meetings and between meetings. Operators from Patuxent River were brought in to "run the system" on the MacIntosh, well before the software specs were written, and evaluate or suggest changes to our design, while there was still time to change it. We demonstrated our design to the Navair sponsor and his deputies at a very early stage in the development, to give them the confidence that we were on the right track. Before 1992, we didn't have tools like this. I'm convinced that this tool shortened the system design phase by 50% and saved hundreds of thousands of dollars.

By now, software was often the most expensive part of most new systems, and cost and schedule overruns were common. People had started to look at software development organizations in terms of their software maturity level. Level 1 was ad hoc, seat of the pants. The higher levels were attained when you had a process that was defined, repeatable, improving, and optimized. Capt Colvert and I had a side conversation one day about this subject. It was his opinion that our team was a level 3 or 4, based on what he had witnessed over the years where we served as his lead platform integrator. The truth is – we were still level 1. Although our process was showing signs of repeatability and in some areas was vastly improved, the process itself wasn't written down. It was mostly in our heads, those of us who had been doing it for years. And were we to leave the organization, our successors have no process documentation to learn what we already knew. We had no process group, we were all product oriented. We didn't have the resources to devote to document our process, to perhaps discover other ways of improving our process. Never the less, when other projects at NADC were seeing their work get handed over to contractors, we still had the full support and backing of Capt. Colvert. Regrettably, this AIS project was also shelved before it was completed, about the same time that the Soviet Union renounced communism.

In the early 1990's, with 150 Update III's in the fleet, we had amassed a sizeable set of change requests from the P-3C community. These changes and enhancements were built into an updated version of the software which was completed in the summer of 1993. The program was delivered to Patuxent River, and I loaded my family into the RV and headed off on a long cross country trip. Early one morning, while parked at the Grand Canyon campground, there's a knock on the RV door. Someone says "Come up to the office, there's a phone call waiting for you". Somewhat startled, I get on the office phone (no cell phones yet) and its one of my engineers who says, "The software's freezing up at Patuxent River, the sponsor is angry, and you gotta get home right away and prepare a briefing for the sponsor". That phone call, and my reaction to it, was one of the factors leading to my decision to retire from NADC. I was annoyed that they had to interrupt me with bad news when I'm on vacation with my family. I was annoyed that all the other high grade engineers back at NADC couldn't figure out how to deal with the sponsor on their own. Upon returning home, I briefed the sponsor that I would take over the day to day management of the effort to fix the freezes, and would install a complete set of measurement points to collect metrics on our progress. These metrics were revised and faxed to the sponsor every week (we still didn't have the capability of e-mail attachments). I was able to restore rapport with the sponsor and get the program working properly.

During this timeframe, NADC, now renamed NAWC, was on the list of bases to be closed as the DOD sought ways of downsizing their infrastructure, and people were very anxious about their futures. Budgets were shrinking every year. We won the cold war, the Soviets were no longer our enemy. Some of the more highly motivated people moved to Patuxent River early, to beat the rush and get first dibs on good jobs. Others left NADC to work for private companies. Many stayed on and grumbled. I began to realize that things had peaked, that the best days of P-3C were now behind us. I didn't want to be around when they started packing things into moving vans, and hear the complaining from people who disagreed with the decision to move to Patuxent River. It had been a fantastic ride, I was fortunate to have had one of the most exciting and highly visible jobs on Center, not for 3 or 5 years but for 10 years, but now it was time to move on. Several times, I had been offered supervisory jobs, with a GM-15 promotion, but turned them down, because working in the project office with the Navair sponsors provided more job satisfaction. But it was getting more difficult to do as budgets were cut, key people were leaving, and lab facilities were being moved to Patuxent River. My last action before I retired was to select Barry Knouse as my replacement, and bring him up to speed on the budgetary side of the project. April 1, 1994 was my last day, the end of my 32 year career at NADC.

PS: In 1996 the base at NADC in Warminster was closed, and the people, equipment, and facilities were relocated to Patuxent River, MD. The lives of 2500 people, most of whom were scientists and engineers, plus countless additional contractors who were supporting the Center, were affected by this downsizing. Though the mission of the P-3 has changed, the work to modernize its avionics and adopt its sensors to ever more complex roles continues to this day.