Reflections of my Career with Lockheed Martin and its predecessor companies

My career with Sperry Univac started in August 1978. How I ended up with Sperry Univac is interesting. I was teaching Math and Science at Delano High School and had recently been elected the president of the DEA (Delano Educational Association) and had been the lead negotiator as part of very lengthy contract negotiations. I was not thinking about leaving teaching or exploring other opportunities, but on the way home from Church in May of 1978, I dumped the Sunday paper on the couch and it fell open to a big Sperry Univac Ad. The Ad wanted teachers with Navy background. I did a double take and said, "that is me", so I read the ad in more detail and decided to apply (what could it hurt). I hand wrote an application and 3 days later received a Mail gram asking me to come in for an interview. Doing an interview toward the end of the school year was not easily scheduled, but I set it up to start at noon on our last half day of school (last Friday of May) and arrived for my interview at noon. The first person I interviewed with was Eric Spring. Eric's interview lasted for about 2 hours and contained information on all the remarkable things Navy Undersea Systems was involved in and all its opportunities. I had 3 more interviews that day with the last one ending at 6:30 PM over at plant D. I then returned to Plant 8 to check with Human Resources regarding the next steps in the process. They were closed, so I drove back to Delano thinking this was a waste.

However, the following Tuesday there was a letter stating that Sperry Univac wanted to make an offer which was followed by several phone calls from Eric. I managed to push the decision date out a little and applied for a year's leave from teaching. This was approved at the next board meeting in June and so started a 33-year career with LM. I can now look back and probably count on one hand the number of days that I did not enjoy working at Lockheed Martin and its predecessor companies.

The first couple of weeks were pretty slow and I did think a time or two that I had made the wrong decision. We (there were about 10 of us that started that week) were given technical documents to read, there were forms to fill out, and clearances needing approval before we could look at anything meaningful, so in hindsight, it was pretty much busy work. Programming classes started in a couple of weeks and having done some programming it was not difficult, but the language was different from FORTRAN or basic. CMS-2 was the Navy standard language that we would be using in our work. Learning the language and programing was fun and getting paid for it was even more fun. Also, getting involved socially was something new and a little unexpected. There were flag football teams, volleyball teams, bowling teams, and several in our group of new employees were Twins fans and so we went to the Met more times than I had ever been to ballgames.

Finally, in early October, I was going to get to go up to METC (Military Engineering Test Center). I would now actually see the 688 Combat Control System (CCS-MK1) operating on a UYK-7 computer that we were working on and I would be testing and fixing problems. The technical documents that we had been reading were disjointed and did not give the systems view, but mainly provided details on specific components. In my reading, there had been no sense of an integrated system of multiple components and software modules. CCS-MK-1 was comprised of major components of Fire Control, Navigation,

Common Program (operating system and other common modules), On-Line Diagnostics and eventually, Casualty Recovery consisting of various degraded modes. Kris Jenson was assigned to show me the ropes at METC. Kris was a very busy engineer and instructed me to take detailed notes so that I could do this independently. The high-level task was to test the 688/700 Submarine Combat Control System. However, in order to do this, one had to configure the system (the famous METC patch panel) and then set up the computer to load the program. After seeing the patch panel and how it linked to each of the various hardware and software interfaces and all the ways it could be configured including simulation, I was pretty much lost. Kris patiently repeatedly went through the boot-up sequence for the computer (how to start the UYK-7), how to select the right program, how you would insert a patch, how to put in breakpoints, how to read your computer card, and many other details. The last thing Kris did was probably the best part and that was to introduce me to the Field Engineers and to state if you ever have questions ask them. Kris then went on a work trip and said to call if I needed help. The next few days at METC were frustrating, but with the help of my notes and the Field Engineers, I start to get the hang of it and understand what was going on. By November, I made my first trip to Newport, RI and NUWC (Naval Undersea Warfare Center) to run tests on the system in their lab, which was a more complete integrated system with different simulation software and more actual equipment that would be installed on the boats.

Fixing problems and continued testing on the system occurred for the better part of a year and included significant changes and new capabilities. The testing in NUWC was running 24/7 and so over half my time was spent at NUWC running repeated multiple tests. I could elaborate on many stories of the personnel involved, time spent in the summer at Newport beaches, and the details of the tests. I recall one in particular. I had been assigned the 7 PM to 3 AM shift during a 100-hour test. There were always two of us assigned with overlapping shifts. On this shift, there was one entry to be made and so it was an easy shift. I had been told earlier in the testing that I could "play" on the consoles and do various things to further stress the system in unpredictable ways a Navy operator might perform. I had been doing this during almost all idle times and had learned the system quite well. On this shift, I had come across an application that would create arcs (part of the torpedo launch software). I proceeded to build multiple arcs and suddenly, the system reloaded as part of the casualty recovery capability that was a very important and unique system requirement. I thought I had killed a 100-hour run in its 67th hour, but the system reloaded fine (reload was a critical piece because it had to pick up a navigation module within 5 seconds) and we were able to continue the test (I did not know that at the time). It was later discovered that the arcs had caused a buffer overflow (It could only build 31 arcs).

The reload sequence was a continuously changing area where two Engineers had differing opinions and it was not unusual for it to significantly change depending on which engineer had been on the previous shift. I recall this created quite an argument with the varying options, and the two main engineers finally agreed on an option that met requirements and it worked. During the development, integration and testing of this system, there were many disagreements. I arrived at one of my early morning shifts at METC, to a very verbal argument between a government representative and one of our lead engineers. They called each other about every name in the book and the argument lasted for at least a couple of hours. By lunch they were best buddies again and all was well (times sure changed over the years). This

was the second time I wondered if leaving teaching was the right career choice. Over my career, I learned that many of these engineers were very vocal in their opinions, but generally accepted the outcome with common respect and that great working relationships really existed.

As the combat system became more mature, I spent less time in Newport and was assigned a new task. We were gearing up for a combat system Program D, which was to be a major change with significant enhancements to the 688/700 combat system. I was now back to reviewing documents and was asked to review documents authored by much more senior engineers. Most went smoothly and if I did not understand something the engineer would explain it and, if needed, make the change. However, one review, did not go so well. Basically, it was a blue-sky document and after reading it and trying to figure out how it applied, I was at a total loss. I talked to the author, but he basically dismissed my questions. When we met for the review of this document, my plan was to not say a word. Unfortunately, after some editorial comments, we had to deal with the details. No one volunteered anything and then I was called on. I decided to say what I thought. I stated that based on my limited knowledge of the system and this application, I could not see the need for the application and, it was my opinion, that this implementation would be expensive and provided little benefit to the future combat control system. All but the author then jumped in with Quintin Heckert finally saying I'm glad someone said that before I did because I thought the whole document was BS. Program D eventually was cancelled which led to modification to the original program with revision levels B and C versions which Underseas Systems continued to develop at a reduced level.

The Over-the-Horizon (OTH) Targeting program for the Los Angeles (688) class submarine was the next major program for Underseas Systems. This system provided submarines with the capability to communicate via satellite while deployed. When operational, the submarine could receive communications via data links and provide for downloading and changing of missions (retargeting of cruise missiles destinations) while on station (Over-The-Horizon). The program was developed using the CMS-2 language on an embedded computer. The actual computer was not a UYK-20, but a Hughes emulation of a UYK-20 embedded in the Mk-81 Mod 3 console. Our development efforts included writing and documenting all the software, writing simulation and test software, integrating and debugging the system, developing test documentation and testing the system at METC and at NUWC. Underseas Systems grew significantly and quickly filled the 3rd floor of corporate square building C. My initial role was to lead the test software development group and the maintenance effort for the Common Program for the 688 and 700 classes of submarines. Part of the test software to be developed was to verify the performance of the MK-81. This was the only time I used more than my basic math background in the development of software. To test the graphic capability of the MK-81, the Combat System logo was developed and in this process, I was able to use formulas involving second degree equations. The testing was successful with the test display (Combat System Logo) getting many comments and a new name (those who worked on it will remember) along the way. Since the test software development group also tended to get the mid shifts at METC, our group became the main OTH program users of MTASS simulation which significantly reduced our METC time. MTASS allowed us to run the programs prior to going on the actual machine and proved very successful and productive in our applications.

The development of the software for the OTH program was behind schedule and was not going to support a planned Navy test in June of 1982 of the satellite communications capabilities, thus an alternative was needed. In March, I presented an idea to our management that would basically decode the message types and count the number of each messages type received and transmitted. This information would then be displayed on the MK-81 screen in a summary report. This approach also required writing software to support the interface to the SIU (Sensor Interface Unit) and decoding various communications protocols (i.e. STDL). I estimated this relatively simple development could be done for about 2 man-months of labor effort. After having my estimate increased by a factor of 10, I was sent to NOSC in San Diego to present the idea to the developers of the SIU. They liked the idea, requested some minor changes (like storing the sent and received data and then writing a program to printout the messages in an identifiable format) and stated they would like to start testing at NUWC in mid-June. In mid-April, a contract was agreed to and I was to lead 3 engineers. Two were recent hires and were assigned the task of writing the program to print out the data. I would do the data decode (used in both the display and printing applications), data storage, and display part of the software. The other engineer was assigned to write the STDL interface for the SIU, as he understood that interface because of his Navy background. By mid-May my software was in debug and working quite well on MTASS and the printing program was also making substantial progress. Unfortunately, I missed some red flags on the SIU interface software. The assigned engineer had asked some programming questions, and I explained how one would write the software using examples such as variables A, B and C, etc. and it seemed like it was being understood. To debug at METC on the MK-81, the two parts of the software needed to be integrated so after several requests, I insisted a first look at the interface software. What I discovered was a literal use of variables A, B, and C and little else of value. For the next week, I read and reread the SIU interface document and the STDL protocol and over the Memorial Day Holiday wrote the interface code and started testing at METC the following week. Mid-June we took the software out to NUSC and, after several SIU fixes, the software successfully supported the first combined message communications via satellite between the NOSC and NUWC. Later that summer, I was requested by NOSC to present to the CNO (Chief of Naval Operations) and his staff the scope of this successful communications (first successful submarine satellite communications). This opportunity and honor was certainly one of my career highlights. I developed the overview slides (no PowerPoint back then) and with the help of the NOSC team, put a demonstration together using the simulation system in NUWC. The presentation detailed the technology and showed how a cruise missile could be retargeted. My main mistake in the demonstration was that I re-targeted a missile to hit Tehran, Iran that was initially set up to hit Baghdad, Iraq (Iraq at that time was considered a friendly nation). I did not think that Iraq would ever become a target and that Tehran might.

Another small program that occurred during the OTH development was TCRS program (TRIDENT Carry-on-board Reduction System). This program would record data snap-shots at certain key events during a missile or torpedo event (launch) on the TRIDENT submarine. The OJ-172 (DEAC) was too slow to record the data and so the initial concept was to write a computer program to extract the breakpoint data from the UYK-7 computer and then spool it to a diskette (nothing could be slower than the OJ-172). The diskette approach also proved too slow and the system was implemented using a 10-inch Kennedy tape recorder. My effort was to test the system with the final sell-off being a 24-hour test in the NUWC

TRIDENT lab. Although each of the systems capabilities had been tested in partiality, our team was never given 24 hours of lab time to run the test from step one to the end. The 24-hour sell-off period was the first time for a complete run. It executed with no exceptions until 23 hours and 42 minutes, when we encountered a situation we had never reached before - the tape was full! The test procedures had a footnote indicating that if the tape becomes full, one would perform the change tape steps. The Program Manager argued with the government that this was beyond the test scope and that the test should be considered a complete success with the system sell-off complete. Being the Test Director and having been the only person involved for the full 24 hours, I disagreed with the Program Manager and argued we should change the tape. The head software developer was Tim Hall and a look at Tim convinced me that it would work. So, we proceeded and successfully completed the 24-hour test according to the procedures. However, the Program Manager was upset with the development and test teams and made life miserable for us the by demanding that the team be at a few meetings and performing tasks that were not necessary in the 8 hours following the test. About 10 years later our paths again crossed and the Program Manager apologized. He said he had been wrong and was happy we had such strong convictions in our product.

Sperry also had a major re-organization during the OTH development. It was decided that matrix organizations were more effective and efficient than program (business unit) based organization. By this time in 1983, my role was the Manager of the Underseas Simulation Group, the CCS MK1 Support group, the OTH Test Group, and several other small Underseas efforts. I was convinced by my management that the future was in the Program organization, so the approximately 65 engineers that reported to me (including 6 direct reports) in the Program organization would now matrix into the Underseas organization via their respective matrix disciplines with new managers. In one week, I went from having approximately 65 direct and indirect reports down to 0, however I still had to provide work and work direction for the same engineers, but now through a new layer of management. Was this really more efficient?

As OTH efforts completed, Underseas continued with a significantly reduced staff and shifted to new programs for submarines. PEO Sub was going with a new integrated combat program call Submarine Advanced Combat System or AN/BYS-1. It was determined that Sperry was not big enough, or the Ill Wind law suit issue would not allow us to win and so Sperry teamed up with IBM Federal Systems. The plan included an 18-month concept development program and included the proposal for the work. IBM provided $1M and the company invested another $1M to support our efforts on the IBM team. My role was to lead and manage (financially) a group of 18 engineers who would support our efforts originally defined as the operational program (software) and computing platform (hardware) which if we won would be a $100M program over the next several years. This team was handpicked by Underseas management from the Underseas engineers who worked on OTH and the Common Program. Over the next 18 months and numerous trips and interfaces with IBM, we managed to expand our efforts to include the Weapons System and our team now represented about 1/3 of the effort with a potential of over $700 M. The key engineers on this effort included perhaps the best systems engineer I encountered in my years with the company. Rod Ewert was a hardware engineer who had been a field engineer and both software and hardware developer. All these skills were key to our successes in

expanding our efforts on the team. Another engineer, Les Dikis (ex-Navy master chief) operationally understood the total system better than anyone else including our IBM teammates. He was a colorful person with a sharp wit and contrasted with the stoic IBM team. He was however, highly regarded by the IBM engineers and generally by the Navy. Our team included a data base group, which was an evolving technology at the time but also successfully expanded our share of the effort. Quintin Heckert was an influential and verbal advocate on the team and with his connections within PEO Sub, provided the team with significant insights and the team was convinced we would win the effort. Our team's bid for the effort was $2B for the development effort and an operational system. A couple of days before Christmas in 1986, our team was informed by Virginia Senator Warner that we had lost the AN/BYS-1 contract to a team from General Electric in Syracuse NY. This was a very disappointing Christmas gift. In the debrief, we were told we did not really listen to the customer. At our reviews, they felt like our team was ignoring them and that "IBM knew best". Over the 18 months the two other main team members (Sperry and Raytheon) had also expressed this feeling in team meetings only to be told that this was the best and only approach. There was also one other factor in the award that always puzzled me. There was a stipulation that if a team was compliant and their bid was 10% less than another compliant team, they would be awarded the contract. The GE team was 10.02% below our bid which, as always, seemed strange. The GE AN/BSY-1 winning effort involved a distributed processing system (over 100 processors) as compared to our federated (UYK-43) computing approach. This also was listed as a discriminating factor. We had determined early in our system assessment that such a distributed system could not be developed within the target winning price. Later in the program, it was reported the AN/BSY-1 program development costs were well over $4B and scope and capabilities had been reduced before it was implement in 1992 (over two years behind plan). I am still convinced that our approach would have provided the capabilities listed in the proposal and probably only cost a little over $2B. Had we won, there were plans to build an entire Underseas complex.

PEO Sub also had other plans and had earlier requested bids for the CCS MK-1 program (as a backup plan for the AN/BSY-1). Sperry chose not to bid this effort because with all our OTH work, it was felt that we could not staff two simultaneous efforts.

By 1987, Sperry (now UNISYS) had gone from the primary developer in submarine combat systems to only minor support work to the Common Programs for the Program B and C versions. Unisys was asked to bid a back-up and support role for the CCS MK-1 program but did not do it, because others felt we were "systems developers". This work was then award to a Lockheed team in Austin Texas. The Lockheed team in Austin had virtually no experience or background in submarine combat systems. Therefore, PMS 425 (the submarine combat systems code), decided that PMS 425 would help the Lockheed team to come up to speed on the Common program, its modules, and how it worked. Unisys was contacted to put together a training program to bring the Lockheed team up to speed. Since our 43RSS team was the most knowledgeable on the operating system (the Common Program operating system was an off shoot of the 43RSS), they were asked to put the bid together. The resulting bid was over $500K for a two-week training session and this was considered way out of line by the customer. They asked us to take a second look at the effort. Since Underseas Systems now had little work, and most of the remaining staff looking for work, I was asked to look at the effort. After reviewing the

request for proposal and having been involved in the Common Program for several years, I indicated that if I could get the support of another software engineer, I could do the training for less than $100K. I would put the material together and the other engineer would support the review of material and help resolve questions that might come up during the training. After spending two months learning the OS, and developing materials for the OS and the other common modules, we headed to Austin Texas for two weeks of training. It was our expectation that they would at least have some basic knowledge of the system, but to our surprise, it was very limited. Our materials and training provided was overkill for their level of expertise, but the training went well with both of us being offered jobs in Austin. On this trip, I also discovered that there was another Dale Suckstorff, who was a professor at Michigan Tech. His son Matthew, could not understand why his dad named Dale was checked into the same hotel that he was staying at in Austin. Matthew contacted me and when he was on business travel (worked for American Airlines) in Minneapolis, he bought dinner for me on my birthday. To this day, I have not met the other Dale Suckstorff.

OTH completed with little follow on work and with no wins on the other submarine programs, it was time to look for other opportunities within Unisys. My opportunity turned out to be with Jon Simon and the 43RSS and MTASS software support teams as an assistant or deputy Program Manager. This was a notable change, because I was no longer a hands-on engineer or a technical expert in the area. The 43-support software tasking was part of a Time and Material contract on the AN/UYK-43 contract and involved many small tasks (over 100 at any given time) ranging in value from $10K to over $2M with a total value of over $5M in a year. Jon was the senior Program Manager, but also was the only marketer for this work. He would spend a significant amount of time with the customers getting new tasks, which I would then interface with the engineering team and developed a proposal which was generally approved. Monthly, a report on all these tasks was assembled and reviewed with a customer team to assess our progress and basically help them to understand that we were on track-effectively and efficiently producing the product. The best part of the reviews was that it rotated locations and at least once during the winter months would be held at the Oldsmar factory in Florida. This effort also allowed me to get involved in some aspects of the technology and to promote and lead some efforts independently removed from the 43-support software group.

The MCLAN (Marine Corps LAN on the LHDs) was one such program. This program was one of my favorite programs, because for it, my role included Program Manager, Project Engineer, Lead Installer, and provided me the opportunity to ride the LHD-6 (USS Bonhomme Richard) on sea trials. This program started as the USQ-69B (rugged PC being developed by LM) which was a replacement for basically a dumb display (V-70). This was a highly visible program within the company, because the USQ-69B was to become the standard ruggedized PC for the Navy. Ultimately, the USQ-69B became too expensive, did not mature fast enough to make the MCLAN program time line, and the speed of change within the commercial PC industry made it obsolete before it became mature. The LHD program office requested alternate approaches and LM provided a network approach with Compaq PCs and the Banyan VINES (Virtual Integrated Network Service) network. The MCLAN program was renamed as a non-mission critical program and therefore, could go forward with commercial equipment. The LHD program office quickly accepted our proposal and now, we needed to perform. Dwayne Kraska was the engineer

assigned to the program and we had several challenges that had to be completed in a short time. Among them was the secure mounting of the PCs in multiple spaces (11) within the LHDs. Dwayne had a relative who had a metal shop up in the north-western part of MN, and he called them describing the requirements and the size of the computers and monitors that had to be secured to tables and desks. Within 3 weeks we had a set and demonstrated it to PMO 377 which, with some minor changes, agreed that it would work. Dwayne learned the Banyan VINES network system and within 6 weeks we had procured 11 Compaq PCs, a server for the Banyan VINES, and ordered 2000 feet of fire retardant RG 6 cable to be installed (all shipped directly to the ship) on the USS Essex (LHD-2). Our test system in Eagan consisted of a server and 2 PCs and so our confidence level was not very high. Two months after the award, Dwayne, Larry Cude (field engineer) and I arrived at the USS Essex (second ship in the LHD Wasp class) to install the system. The installation was significantly more difficult than anticipated, because of how and where we had to install the cable. Also, the ship's force knew nothing about the systems and there was only one Marine officer on the ship. The system was technically owned by the Navy, but built to be used by the embarked Marines. After getting PMO 377's Brian Durham (the Program Director) to join us in Pascagoula and a local LM engineer to join us, progress was made. We had to run cable up 5 decks, back about 400 feet and down two decks and then forward with a total of about 3000 feet going up and down decks. We did not have enough cable, but with PMO 377 onsite, more cable was ordered and arrived within two days. Dwayne set up the server, the PCs, and installed the clamps to hold them in place and Larry and I ran cable. The cable run to the front was longer than the Banyan VINES system would support, so we needed to find a location for a repeater and would later need to integrate it into our system. A space was found and we ran the cables to it and proceeded to run the cables to the front of the LHD. Much to our surprise, most of the PCs connected to the network worked on the first attempt. To control the use of the PCs, they were configured to come up in the V-70 emulation mode. This configuration could only be changed via a passcode that we left with the Navy officer in charge of the system. Later the repeater was installed and the drops at the front of the ship were successfully tested. Besides the 11 PCs, multiple other drops were provided in various spaces (i.e. Captain's state room, XO, Marine commander, and most command locations where a computer could be connected). Over the next 3 years, the system was installed on 6 LHDs, with the LHD-6 being the last. The system was later replaced by a Hughes integrated program as part of the combat system upgrade.

On one of our installations in San Diego, we were asked to go to one of the other LHDs because they were reporting problems with their MCLAN system not coming up correctly. After our installation, we investigated the situation on the other LHD. The problem was the PCs (we checked 3 of them) had been reconfigured to come up with games and the V-70 mode had disappeared from the configuration! Somehow the passcode had been compromised and sailors were finding ways to use them for their benefit and entertainment. They actually had networked the system so they could play games. We had identified this concern to PMO 377 much earlier in the program. We sent a report to PMO 377 and had no other reported issues identified with the MCLAN program.

There were some other interesting initiatives that I was also able to get involved in while working with Time and Material contracts. Two were hardware related and one was software. The software one was called the Ada cohabitation effort. CMS-2 had been the main software language for the UYK-43

computers and we developed and supported the 43RSS (operating system for the UYK-43) so it was in our best interests to prolong the use of the computer. The Navy had declared Ada to be its language of the future, but most of their existing programs were written in CMS-2. CMS-2 was deemed to be outdated, not strong, and many programs looked like a bunch of spaghetti code. Over time, the CMS-2 code had become complex with many changes added to it, but in general it still worked very well and efficiently. However, it was way too expensive to rewrite and test all this code, but every one of our competitors were offering programs to do just that. The best approach was probably some transition over time but the Navy had limited funding. Some plans included simulators and emulators that would work like the Standard Computers. The cohabitation idea was one of these transition approaches. It was going to allow both CMS-2 and Ada developed programs to run within the same UYK-43 or 44 computers. We got some traction with Kari Kruemple leading the effort and able to convince most of the decision makers that it would work. The approach was presented at several forums and to our customer and in most cases, well received. Unfortunately, the same money that was going to make Ada the standard would have to be used for the transition and the Navy did not have the funds to do both. Other languages were eventually allowed and therefore there would be no software cohabitation.

The hardware efforts were to extend and expand the life of the AN/UYK-43. Two of these projects were the HP (High Performance) CPU and the HBM (High Bandwidth Memory). Both were to be modules that would plug into the existing AN/UYK-43 and increase performance in both processing speed and memory size. Mike Bukovich was the marketer and I was the engineering spokesperson for the efforts. The competition was strong for new and different processing platforms, but most customers with standard computers in place were convinced that the technology would extend life and improve the performance of the AN/UYK-43. The Navy's standard computer program office was also for this approach, but most of their customers (ship building codes) wanted new and improved computers based on commercial technology. This push within the US Navy to move toward distributed processors and commercial computing and away from the standard computers basically made improving and expanding existing programs unaffordable. Mike was great to work with and had many contacts and the engineering team that designed the products was very talented. Progress was made and systems were updated, but eventually distributed computers including the Q-70 took over.

After being in the Program Management chain of command for several years I went back into engineering, but basically continued to do the same work for a year. Engineering wanted me to expand my horizons and take on some new challenges. In 1997, I left the Support Software organizations and went into marketing support for Communications Systems. Leaving the support software position was difficult, because I had a great boss. Jon allowed me to grow professionally, to work independently, and basically feel like I was my own boss which was nice within a large company.

The Communications Systems effort was started by a small group of engineers lead by Dan Raymond and supported by some outstanding communications engineers. They had successfully demonstrated to PEO Sub that an integrated automated radio room for the Virginia Class Submarine would save space, reduce manning, and improve performance using evolving commercial communications technology. This demonstration was a proof of concept on a small scale but large enough to convince the submarine

Navy that it would work. The next step was to convince PEO Sub that we could do the job. Our main competition was SPAWAR (the decreed code for all Navy communications) and they were supported by NUWC (Naval Underwater War Center) Newport, RI. PEO Sub requested that SPAWAR and NUWC provide a radio room to fit the available space. This meant that they would have to put their system together in 10 racks of equipment or less. Their response to PEO Sub was that it was impossible and the best they could do was 13 racks and maybe more if they wanted any new capabilities. Our team told PEO Sub that we could meet all the requirements in a 9-rack configuration. PEO Sub then took a risk and picked our team to develop a radio room for the Virginia Class submarines. The original plan was to contract directly with Eagan for the development. However, during this time our company went from Unisys to Loral to Lockheed Martin and as a result of this transition, LM Manassas was deemed to be the center of excellence for all submarine work. Therefore, our contract would have to go through Manassas. But it got worse. The Virginia Class development was a CFE (Contractor Furnished Equipment) development and EB (Electric Boat – Groton CN) was the prime and so all contracts for development had to go through EB. I will describe more details on this effort later.

Meanwhile, the submarine communications system (Radio Room) - was seen as a potential multi-billion-dollar business for Eagan. We could potentially leverage the submarine work into all US Navy ships, some foreign ships, as well as other platforms that needed automated communications integrated with combat systems. My transition into this effort was to put together a plan and concept to extend this to other Navy Platforms. This certainly was a challenging change, because I was not familiar with much of the equipment that would-be part of our proposed solutions. Our first effort outside of the submarine world was the LPD development. This also was a CFE development with Raytheon and Hughes being the prime contractors. John Cottrell was the marketer for the Submarine Communications Systems and had a contact at Hughes. Hughes was also interested in displacing the GFE (Government Furnished Equipment) radio room provided by SPAWAR. My effort was to put together a plan and concept for the LPD and then we would present this to Hughes. Our concept was much more than the traditional ship board communications, but offered an integrated networked back bone for the ship so that all communications could be securely routed to the end users. With future systems like Teledesic (a communications concept of 288 low orbit satellites providing global connectivity – this concept never happened!) and other satellite systems, the ships would have the ability to communicate like shore sites. Working with some talented communications engineers (John Uittenbougard, John Pernic, Steve Andersen, Duane Dawson, Don Moran and more), I managed to put together a presentation that they all supported.

So off to Hughes in Fullerton, California we go. We wanted to impress them with our of communication experts and so a total of 7 of us went but only John Cottrell and I had put anything together. He had the introduction slides (2) and then I had what was to be about an hour-long presentation on the approach, our vision, capabilities, and the details of the proposed system for the LPD. Upon arriving in California, the team wanted to go out and enjoy their evening (to them it was a boondoggle), but I declined. I spent the evening rehearsing and trying to make sure I understood everything - my confidence level was not very high. The next morning, we were at Hughes at 9 AM for our presentation. With questions and an interactive presentation, we completed it in time for a noon lunch break. During this time, I

presented the material and answered all but one question that was answered by one of our support team members. We broke for lunch and Hughes asked if we could come back for more discussions in the afternoon and to discuss a potential path forward. We jointly decided to move forward. I was made the Project Engineer (PE) for the effort and was to work with a similar engineer at Hughes to detail the plan and to divide the work based on the strengths of each team. We would then develop a combined proposal to present to the Navy. We spent about a month putting the details together and were back at Fullerton to formalize our final division of work and to start the formalization of our proposal. While in one of their conference rooms, the announcement was made that Raytheon had purchased Hughes and that they would now become Raytheon. The Hughes engineers indicated that nothing would change, however we knew that Raytheon was the prime on the LPD and had the capability themselves to develop a radio room for the LPD. About two weeks later we were called by the Hughes (now Raytheon) Program Manager informing us that Raytheon had put a stop to their efforts, and hence ours. The LPD eventually received the typical SPAWAR assembly of stove-piped communications gear.

But, our plan to expand the integrated radio room was not limited to LPD. Newport News Ship Yard (NNSY) was the prime contractor for a new effort called the CVX (New Concept Aircraft Carrier). So, our LPD team put together a plan for the CVX. Based on information that had been provided on the CVX plans, we knew it included a LAN (I-CAN). We decided that an automated integrated radio room could be built using the I-CAN as a back bone. This would however be by far our largest effort and we needed to show how we could leverage a 9-rack radio room into a radio room that could be 7 or more times larger.

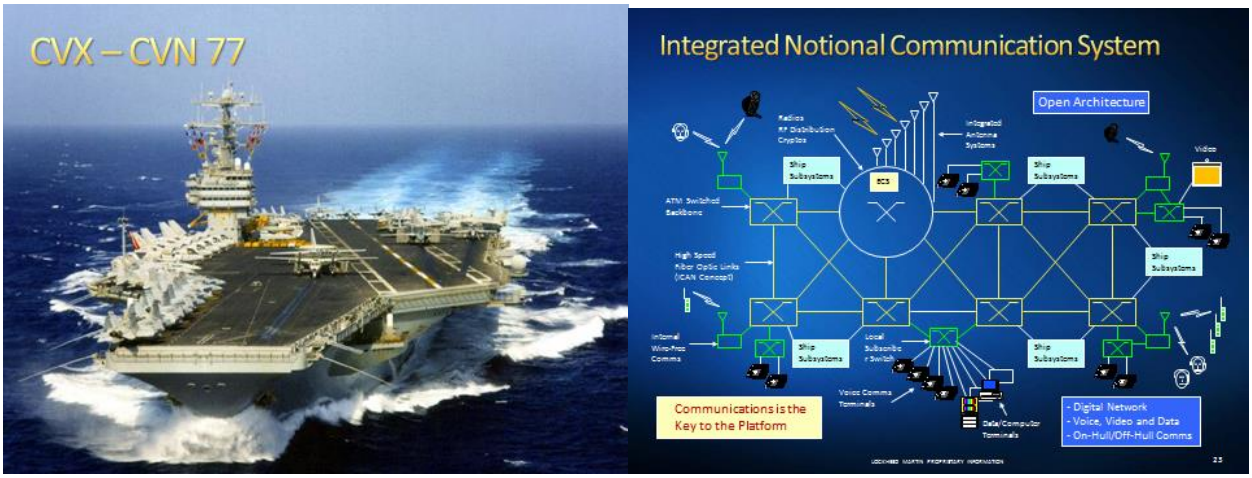

Figure 1 - CVN and CVN 77 Proposed Concepts for an Integrated Communications Systems

John Cottrell and Roy Valentini setup an invitation to NNSY to present our concept. John, Roy, Dick Kuhns and I, headed to NNSY about two weeks later. We expected to be presenting our technical concept to some of the NNSY engineering team, but instead we not only presented to the engineers, but also the Vice President of Program Management, Vice President of Engineering, and the CVX Program Manager. Roy did an introduction, and for the next two hours, I presented our concept (Figure 1 overview). Their comments were that they were very impressed, and their questions showed an

understanding of the concept and its possibilities. They also liked how we had incorporated their I-CAN (LAN) and thought it was a much better approach than the stovepipes offered by SPAWAR.

That evening a ball park estimate was requested by our marketing and so over dinner we came up with an estimate for the first CVX of $125M for development and installation of the first set of equipment. After several phone calls, we were permitted to provide this number to NNSY as a high-level ball park. After a couple more trips and additional engineering support, we were requested to join the CVX development team and were provided office space at NNSY. Since the CVN 76 was still in early development, NNSY asked about the potential for us to provide the system for it, thereby reducing the overall development costs for the CVX. This effort was worked on for a couple of years before SAPWAR successfully stopped the effort by refusing to provide support for products for which they were the only providers.

During this time, I had become more involved in the Submarine Radio Room effort (NSSN or the Virginia Class). It had progressed to the point where, PEO SUB, EB, LM Manassas, and LM Eagan agreed that if we could get the cost window for development and two shipsets for an Eagan price of $30M ($33M Manassas price), then we would be given the go ahead to start work. This verbal to start the effort was provided in mid-1998 and I do not know how or what commitments were made. The LM Eagan internal estimate was in the $43M ball park for the effort and so we needed to find ways to reduce the cost. We creatively brought the cost down: cables were reduced from an estimated 530 to 320 (LANs reduced the need for cables), removed some functionality, reduced the software capabilities, assumed technology would develop to meet our needs and many other challenges. We now were in the ball park! A Project Engineer was needed for the effort and I was requested to take on the challenge in October 1998.

Our team was not very large, but consisted of very senior Systems and Software engineering leads. Both were outspoken, highly skilled, and at a time in their careers where nothing phased them. In one of our early team meetings where I was discussing the challenges we had regarding our budgets; the Software Lead had had enough and basically told me that is was about time I got it in my pea brain that there was no (blank-blank-blank-blank) way that we could write even the reduced software effort for the budget. Both leads were extremely protective of their budgets and if it was not specifically called out (even if common sense and our internal procedures dictated we should do something), it would be very difficult to convince them to do something extra. However, my directions from LM upper management was to do whatever it took to keep the program sold (because the view was that this business could grow significantly). This created an interesting approach to management of the program – stay within budget and do whatever it takes to keep the program sold!

The Virginia submarine radio room development effort was a three-phased approach implemented over 6 years. The first phase was basically to put a concept together that would support the testing of other subsystems on the ship (interface requirements). The second phase was to put together a basic system that would meet ships safety and self-protect capabilities (be able to take the boat out to sea). The third phase was a completely redesigned communications system that would meet all the requirements for submarine communications and added features of: including the latest state of the art technology (COTs

and Military), having an open architecture, being automated (goal was unmanned), and utilizing common applications that would apply to other platforms and communication systems. The main purpose of this approach was to support the overall Virginia class development schedule and yet delay our final system so that the technology that was expected to evolve over the next 5 years could be integrated into the final system configuration. Conceptually this was a great approach (Figure 2), but implementing it when expected technology and products did not mature as fast as expected, proved to be a challenge.

Our initial engineering team was small but very talented. Our system architect was Steve Andersen who had led the team that convinced the Navy that we could automate the communications system and use COTS technology thereby removing the stovepipes that were part of the current 1970's vintage communication systems being deployed in the Navy.

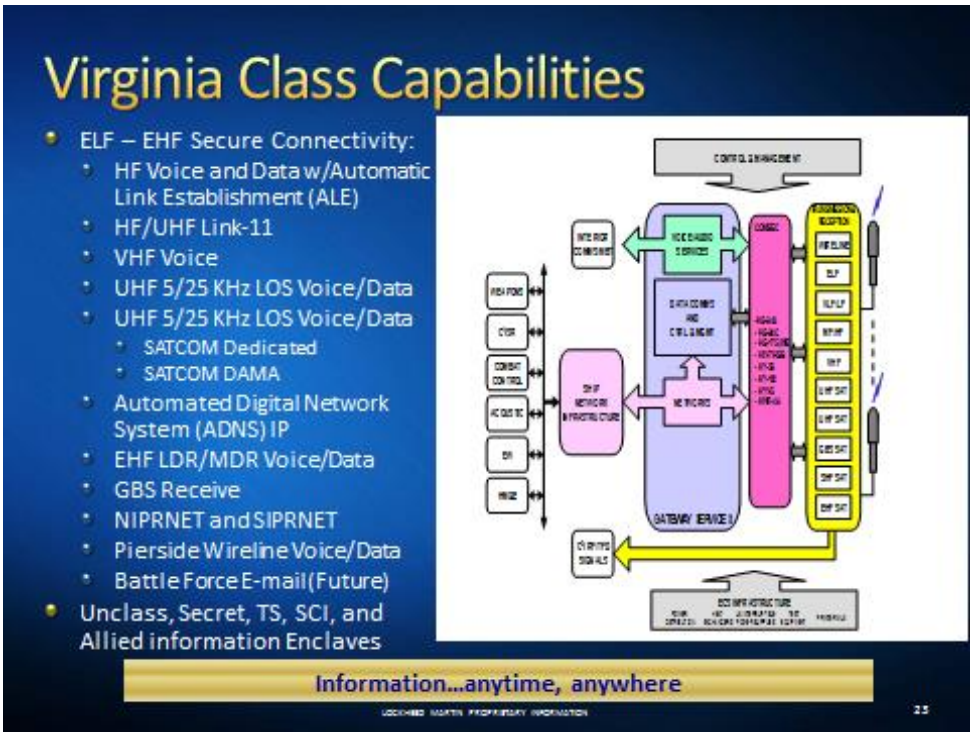

Figure 2 – Virginia Class Submarine Communications Systems

The Software Architect was Mark Dimick and it was the software control capability that was the core of the Automated Submarine Communications System (Figure 3).

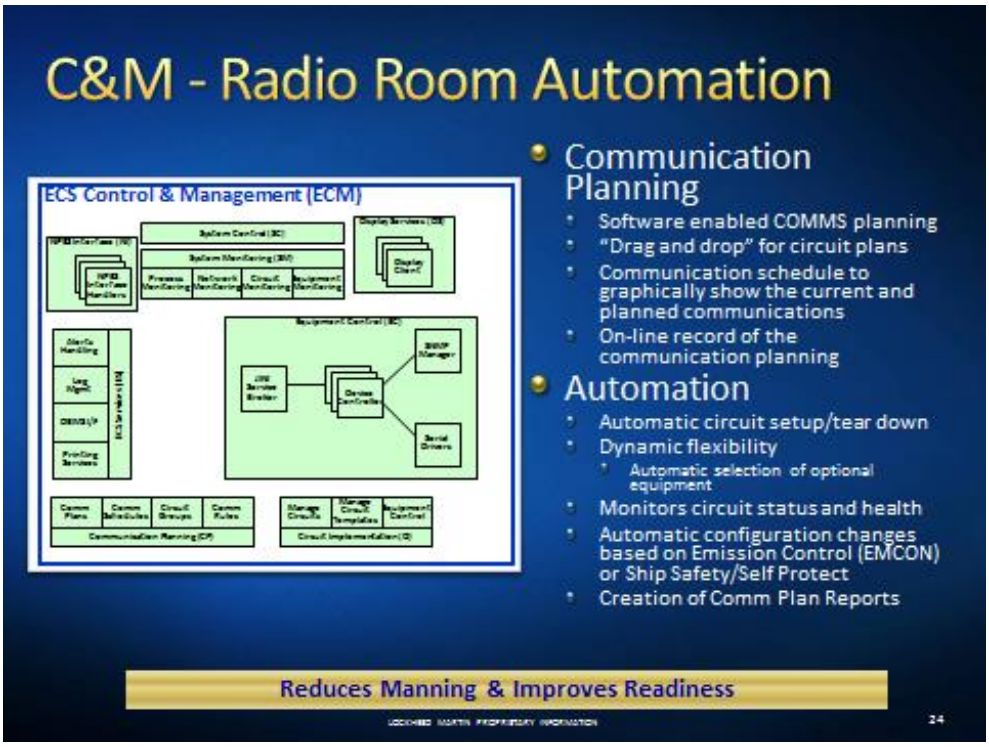

Figure 3 – Virginia Class Software for the Submarine Communications Systems

The mechanical lead was Scott Kraupa and he had the challenging task of meeting all the mechanical requirements involved in mounting the equipment into 9 racks. Besides the space issue, this involved meeting the shock, vibe, and cooling requirements and routing cables within and between racks. Developing mountings and cables for not yet developed or completed equipment was particularly challenging to our schedule (more on this later). Also, the final cable count was 523 and was significantly more than in our challenge in the bid, but was very close to our original estimate.

The rest of the initial team included 5 systems engineers and 4 software engineers with some part time support disciplines (CM, QA, and Processes support).

Our contract was finalized in April of 1999 and that summer this team of 15 engineers developing the system had our first government review. This was when we really became aware of the many challenges we would face over the next 5 years. We limited our number of attendees to 5, who would represent our team and would be presenting our status and approaches. For this review, 85 people showed up to review the work of our team. Most of the reviewers came from SPAWAR and NUWC who had apparently convinced PEO SUB that they had to be involved in any Navy communications system. Their objective was to insert whatever road blocks they could to kill the development of this system. We survived our first review, when they were unable to find holes in the approach (the one planned day review went 2 days). Our final contract was $30M for development and integration of two systems and a second contract that included the purchase and integration of the first 4 Virginia Class boats.

We made a minimal first phase delivery in late 2000 which was a very big deal because both Electric Boat (EB) and the government wanted us to show progress, or embarrass us for not delivering per plan. There was no pressing need for the system, but politics dictated a pressure filled last part of 2000. I am not sure this delivery was ever used, because other ship systems (i.e. combat) were not mature enough to test with our skeleton of a system.

At this same time, our Virginia Class program also had many significant changes. The Seawolf program (PMO 350) had been following the Virginia Development and they were not pleased with the communications systems (Stovepipes and not very functional) that was being provided by SPAWAR. In the fall of 2000 PMO 350 through PMO 450 (Virginia program office) requested a bid from us to provide radio rooms for the three Seawolf boats. The Seawolf had more requirements and a totally different layout and all new racks and requirements compared to the Virginia, but our proposal was able to leverage 70% of the Virginia development program. However, our development effort was significantly accelerated (final system moved up over a year) and the Seawolf would be our first delivery. This basically surpassed the ship safety and self-protect Virginia development and now we had two similar but different development efforts and another 50 government engineers looking over our development. The good news was that we now had over $100M in total contract value for work related to submarine communications and the term that was now coined was the Common Submarine Radio Room (CSRR) with plans to expand this to all submarines.

Unfortunately, at this time our upper management wanted increased productivity from our current engineers (average time for the engineering org was under 41 hours/week and they wanted it to be over 41 hours). With the acceleration of our schedule we had a desperate need for experienced communication engineers. Our organization was now averaging 46 hours/week and we were approved for up to an additional 15 hours of overtime. This need for communications engineers did not matter. A hiring freeze was put in place with the expectation that this would eventually drive the average hours per week up. We quickly fell behind our accelerated schedule for both programs and in late 2001, it was finally decided that we could hire engineers, but the ratio of new grads to experienced had to be 5 to 1. This was not what we needed, but it was better than not getting any help. Over the next several months we hired 30 to 40 engineers and with that ratio of new employees, our schedule got worse. The newly added employees (mostly new grads) needed time from our existing staff and it seemed that our design for the system was going nowhere. However, we did successfully hire some outstanding engineers. But by now, we were over 6 months behind on our planned schedule and losing ground. Upper Management now offered to help by providing more engineers who were out of work on other projects, had not communications experience and so were of little help to our program.

Besides our staffing shortage there were also other problems with the accelerated schedule and the technology that was the foundation of our approach to the CSRR. Two of our main components, the DMR (Digital Modular Radio) and the RFDACS (Radio Frequency Distribution and Control System) were not available per the promised plan. We were directed to proceed with our design and development efforts (software, systems and mechanical) based on documentation that was far from complete. I/O (input output) was not defined, mounting specification and drawings were not complete, and software control definitions were not complete and, as we found out later, wrong. Our two largest software

efforts in terms of control were these two components. These components also had the most cabling connections making design difficult. Our design documents were completed as best they could be with the available staffing and information.

During this time, there were several attempts by SPAWAR and NUWC to kill the program. This would probably have been successful if not for Capt. Sharp, the Commanding Officer of SPAWAR. He was very impressed with our approach to automate the communications flow and understood very well the approach that our Software Lead engineer, Mark Dimick, was detailing in our reviews. Several side meetings were held and in these meetings Mark satisfied all the questions. After these exchanges, Captain Sharp would ask his team why they were against automating communications and bring communications into the 21st century.

In February of 2003 we had our CDR (Critical Design Review). EB directed that we had to limit our team to 11 attendees and, except for an overview by EB, they were the show. After two difficult days, our team of 11 satisfied the overflow crowd of reviewers (estimated to be over 120 - largest conference room was filled to capacity and some had to go to other rooms where they heard the presentations). A conditional approval was granted. Again, efforts were made to challenge our approaches, but each challenge was successfully meet. Our base team and our new hires had performed an outstanding job with incomplete and inaccurate base documentation. Our first delivery was now 16 months away with 3 more deliveries to be completed in 2004. To meet our schedule, implementation had to be started at risk in advance of our CDR. It was the only way our schedule could possibly be made.

The DMR was delivered 9 months late with disclaimers from the developer (Motorola at that time). After we had set the DMR up the Lab, the comment from one of our engineers was “we have the most expensive functional AM/FM radio ever developed in our lab”. These two functions were the only ones that we could get to work and the DMR was supposed to provide communications for the entire 2 MHz – 2 GHz band (HF/VHF/UHF/SATCOM system). The DMR was also to provide several of the related cryptos via emulated software. The DMR never did meet the expectations of our planned implementation (it might now). A brief summary of some of the shortcomings of the DMR included: no software cryptos, could not control via external software (our software could not do the crypto and frequency band switching), and work arounds had to be found for most frequencies. The inability to implement the DMR as planned and not able to utilize its potential capabilities were a couple of the most significant reasons why we experienced a significant cost increase and took a big technical hit on our functionality-as far as the customer (US Navy) was concerned.

The RFDACS was delivered 13 months late with no delay offered in our schedule. The delivered unit was not even at beta test level. One of our sharp new communications engineers, Graham Reissellman was assigned the full-time task of checking this unit out. We would have daily exchanges with the developer (NUWC) along with continuing promises for fixes. Our problem identification and documentation was significantly higher than the resolution of problems. The problem became so bad within the government that SPAWAR took over the management of the development from NUWC. This pretty much added another layer we needed to educate but at least the problems were being tracked and the government had some understanding of the problems we were encountering. At one-point Graham

suggested that we could build one from scratch and have it meet our schedule better than the functionality of the delivered RFDACS. A ball park figure for this development and delivery costs (significantly lower than the cost of RFDACS) was quickly dismissed by the Government. Debugging and getting the delivered unit operational, cost our development team several million dollars in changes and unplanned testing efforts. It was supposed to be to plug-and-play component. Also, the software interface documentation that was delivered to us had many errors and did not control the component as documented.

However, these items were not our biggest challenge which was cable development without final documentation. Because of the schedule changes, we now had to develop cables for 4 Virginia boats and 3 SEAWOLF boats. There were over 500 cables for each system (with many differences between the two platforms) and these cables were designed without complete and accurate documentation for the provided government components. The plan called for the cables to be built at our Clearwater, FL. Plant. However, to make matters even more difficult, we were directed (for political reasons) to have the cables developed at DRS in Pennsylvania. This location was different from Clearwater in that our mechanical engineering software system could automatically transfer the cable drawings to the Clearwater factory, but DRS did not have this capability and did not have a track change system established. We had over a 50% error rate and with 4 sets of the cables (Virginia) and 3 sets of cables (Seawolf) developed to the same specs. The resulting changes had a multiplying effect and was very costly.

Besides our development effort, the team also had to find time to produce several proposals. There were formal proposals for British submarines, the US Coast Guard (Deepwater), US attack Submarines, Australia (several platforms), Presidential Helicopter, AMF-JTRS (Airborne, Maritime, Fixed, Joint Tactical Radio System), Airforce one and informal proposals for several other ships with the newly designed DDX program (the Zumwalt-class) getting traction yearly. The most successful proposal was the LCS (Littoral Combat Ship) program, which we were awarded the Communications and Total Ships Computing Environment (TSCE). Another successful award was the AMF-JTRS program. We had also lost the CVN-76 development effort, so from a staffing standpoint, our bench strength had grown, but some of our top engineers on the CSRR efforts were now assigned to the key rolls on these other programs like the LCS.

The value of our communications contracts was now over $150M in value, so it was decided that we needed an overall lead of our Communications organization. This also affected my role as the PE of the Virginia and Seawolf development efforts. What I had been doing with a staff of one was replaced with a Communication manager and 6 other leaders. This was one of my bad days. I stayed with the Virginia program through the first delivery. Our relationship with the EB Program Manager was not good and getting worse. It was very evident (and had been for a long time) that EB intended to take back much of our work and to cut us out of future Virginia Class developments. After catching the EB PM telling a lie about one of our capabilities (involving security) at a government meeting, I asked that he formally apologize to our team and the government. Shortly thereafter, I was offered a job supporting Communications marketing and our vision to provide a Common Radio Room (CRR) for the US Navy.

The Virginia program completed with us delivering the first two systems (Figure 4) and EB retracting the work for the next two boats, thus cutting LM out of the development effort. The final development costs (even with all the cable problems and non-functional equipment) were $43M-which was our initial estimate! EB did not want to pay this amount because several changes were not documented through contracts, but after other documentation was produced (emails from their PM) they eventually paid the amount on the CPFF (Cost Plus Fixed Fee) contract. However, we as the engineering team, did not achieve many of our goals for a totally automated and integrated CSRR. We also delivered the first two Seawolf systems with EB again retracting the third delivery and installation. After the engineering efforts to bring the Submarine Communications into the 21 century, we lost the design engineering lead role and it returned to SPAWAR. The overall result was our only involvement in submarine communications was updating the software which is currently being performed by a small team in San Diego.

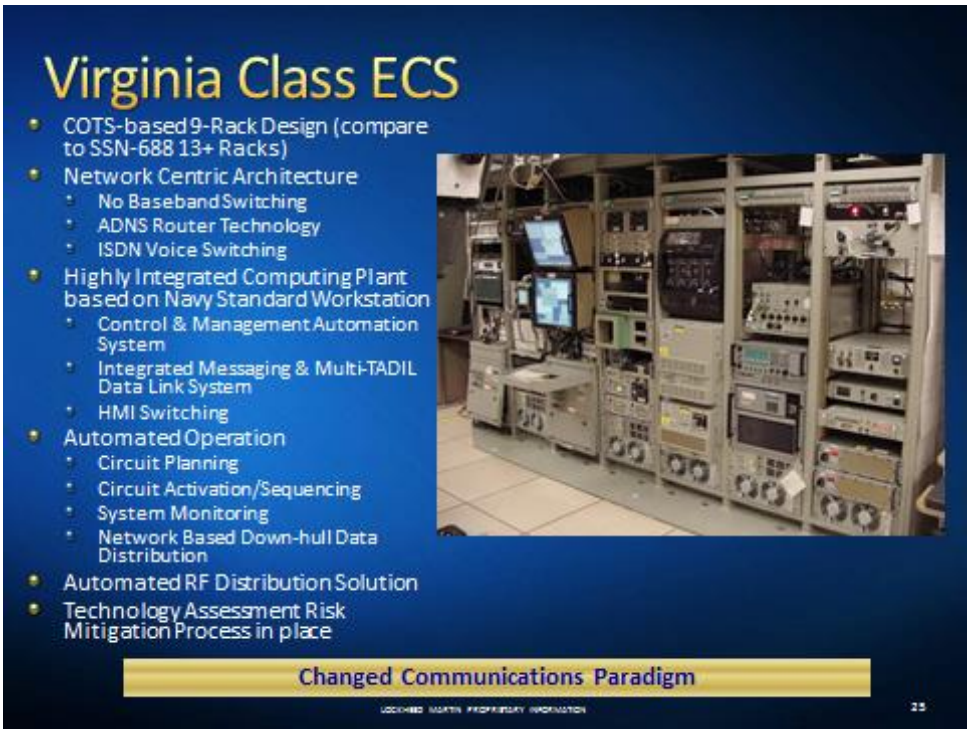

Figure 4 – Almost Completed Virginia Class Submarine Communications Systems

Over the next three plus years, I supported Daryle Hamlin in our marketing efforts to increase our role in Navy communications and to provide the Navy with a CRR (Common Radio Room). Our efforts in DC with the PMO were very successful. We presented to all ship classes, CGN, DDGs, CVN and the amphibious navy, with varying degrees of success. LM was also a developer of the AMF-JTRS program and, with LCS going well, we tied it together receiving some concept funding from the LHDs and DDGs. For the DDG we showed the PMO that by going to a CRR they could save $500M over 15 years and have the latest technology as it evolved (See Figure 5). We even went to our direct competitor, SPAWAR, and found a few key people who were supportive, but were not willing to be our champion. In May of 2007,

we started work on providing a concept for LHDs but soon after, received directions to stop all our efforts. The LHD PMO office said there had been a high-level meeting and that PMOs were directed to stop any efforts to develop their communications systems. They also said that SPAWAR had that responsibility and all funding for communications had to go through SPAWAR. In other words, we lost again. It is hard to win when you customer is also your competitor.

Figure 5 – Navy could have saved Millions and had State-of-the Art Communications

In the fall of 2007, I was asked to join a team (called gray beards) to travel to San Diego and review the Po Shang program that was, by all accounts, in trouble. After one week of reviewing the program, this team came to the same conclusion that the program was in serious trouble and that information was reported to LM upper management. The next step was to develop a plan for this program to get to CDR by May of 2008. This would be a real challenge. The main findings were that: the engineering management structure in San Diego was restricting, requiring all information to funnel through a single point; most of the systems engineers were ex-military operators and knew the systems, but were not engineers; little knowledge existed of the tools needed to create diagrams and documentation content required for systems design; and the engineers who had such knowledge were managers and overloaded. I became part of the team formed from other LM locations that came on-site to support the challenge of getting to CDR by May. My job was to take over the management of the systems engineers, so the in-place management team could concentrate on document development. An on-site assignment to San Diego during the winter months, sounded good, but with 60 plus hours of work each week, there was little time to enjoy San Diego. It was a heroic effort by mainly the managing engineers who were freed up to work the effort resulting in successfully completing the CDR.

During my time on-site, there were several proposals the San Diego team was asked to bid, but they had limited personnel for support, so I submitted bids for them. One bid was for establishing a development lab in Taiwan and training their military on developing software for the Po Shang program. For this bid, I stipulated the need to have a team from Eagan to bid the task.

Following the on-site assignment, I returned to Eagan and worked on multiple programs and proposals and managed a group of systems engineers. In the fall of 2009, I was called and told the Taiwan proposal was a go and that I should start developing materials, the initial Lab design, to order the equipment for the lab and identify a team. After several negotiations with Resource Managers, a team was assembled. I would lead the team and would teach the software development process, the lab environment, and create a two-week exercise to develop some software. Others would teach database management, DOORS usage, software development and development tools, and configuration management. The exercise task would integrate these concepts by documenting, developing, and testing some software.

In early December, LM announced there would be a voluntary layoff opportunity in February 2010. The offer included a severance based on years of service. After much thought, I decided I wanted the opportunity to teach in Taiwan, so I declined even though I was within two years of my planned retirement.

The opportunity to teach in Taiwan was worth it. I had three trips and a total of over 6 weeks in Taiwan. Our host was outstanding and joined us on weekends for various excursions. He also invited us to his home to join his family for dinner at local restaurants.

One of the requirements for the class included a reading and speaking ability in English for participants. That requirement, in many cases, was marginal. Our teaching material and lab were first class, but I am not sure of the knowledge transfer, because a year after we left, they still had not used the lab or even tried to develop software.

In the fall of 2010, it was announced that our plant would close by the end of March 2013 and there were several options for the employees. Employees were offered the opportunity to follow their program to its new location: Owego, Manassas, or San Diego. Exit dates were established based on when programs transitioned to their new location. If you did not transition with your program, you could apply for other opportunities within LM or you could accept the severance package. Since I was mainly involved in the transition of programs to San Diego, I developed an overview of the programs going to San Diego that included the program history and future opportunities. This was presented to San Diego personnel in December 2011 and again in January 2012. At the end of January 2012, I accepted my severance and ended a 33-year career with Lockheed Martin and its heritage companies. It was an outstanding experience and I thank the many outstanding personnel who helped make this a career that I would absolutely repeat.