Technology Transfer at a Defense Contractor

Larry Yoshino, a lab manager at Parsons Controls Corporation, gazed out his office window and let out a short sigh. Dealing with manufacturing, he thought, had to be one of the biggest headaches of his job.

The 90 engineers of Yoshino's lab at the Sonar Division (SD) in Gaithersburg, Maryland had spent three years designing and building a prototype of the control unit for the S2 sonobuoy. (See **Exhibits 1** through **4** for description of corporate organization, sonobuoy, and Defense Department development process.) In order to complete the development contract, the blueprints and prototypes created in Gaithersburg had to be translated into easily replicable procedures for production in SD's Charleston, South Carolina manufacturing facility. However, the "transition" (as this process was called) was never easy; not only did the work represent a technical challenge, but also a seemingly endless series of minor skirmishes between the engineers in Gaithersburg and those in Charleston.

This morning, Yoshino's mind was on Peter Scalia and the soldering problem. Scalia was responsible for the control unit's motherboard. Three months earlier, Charleston engineers spotted a problem with the motherboard's solders, and Scalia's team had launched a series of experiments designed to identify an optimal soldering procedure. Progress on the experiments had been slow, and Scalia had complained a number of times that he was not getting the cooperation he needed from the Charleston engineers.

Yoshino wondered what, if anything, he should do to help ease the motherboard's transition. Even a minor technical hitch could become a major problem if it halted the development and testing of the entire project and became a "show-stopper." Although the soldering problem was not a show-stopper yet, time was running short.

Yoshino also wondered what should be done in the future to avoid these problems. The changing competitive environment had forced many managers at Parsons to reassess the way the company had typically conducted its business. Yoshino knew that cost-efficient production and greater integration of design and manufacturing would be important issues for the future. The transition had become a critical step in all projects.

Research Assistant Jaan Elias prepared this case as the basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation. Some names, products and places have been disguised to protect confidentiality.

Parsons's Organization and Culture

Technical Excellence

Robert Parsons founded Parsons Control in 1947 and guided its early growth as a designer of large technical systems primarily for the Department of Defense (DoD). A prolific inventor, Parsons stressed the importance of scientific innovation and encouraged his staff to strive toward technical excellence. Even as his company grew, Parsons remained in the laboratory, maintaining an active research program until his death in 1962.

After Parsons's death, his family retained control of the company, leaving management in the hands of a team of senior engineers. The family supported the new management's long-term investments in building technical capacity. Over the next two decades, Parsons's substantial technical staff attained a string of scientific breakthroughs and created a number of important systems for the military. Parsons was acknowledged as the technological leader in most fields it entered. Revenues had grown from $75 million in 1962 to over $3 billion in 1983.

Beyond gaining defense contracts, Parsons's reputation as "an engineer's company" was important in attracting and retaining key specialists. Engineers accounted for over one third of Parsons's 33,000-member work force, and all senior management positions were held by engineers with strong technical reputations. At all levels in Parsons, the ability to make sound engineering decisions was considered crucial. Word of an engineer's track record circulated widely and was the most important factor in determining an engineer's access to resources and future assignments.

Parsons gave its engineers wide latitude to pursue technical excellence according to their own vision. Autonomy was a cornerstone of Parsons' s corporate culture. The management structure was designed to concentrate decision making close to operations, distributing both technical and administrative responsibilities to all levels. Through a program of decentralization and diversification, Parsons had developed expertise in a wide range of fields (reflected in its growing number of divisions) allowing the company to maintain a large slate of projects. The large number of projects gave Parsons the opportunity to provide an unusual amount of job security for a defense contractor and also maintained a healthy level of internal competition.

One senior executive observed:

> Decentralization has always been a major strength for us. Internal entrepreneurship has been the rule; the company is not paternalistic. Things have been left relatively unstructured. At times, it seems as if you have thousands of anarchists running around defining their own jobs. . . . Overall, our structure depends on "hyper-interactive" systems, with the exceptional performer carrying the responsibility.

This loose structure and entrepreneurial culture were well-entrenched. Most management training at Parsons was informal. Yoshino described it as "learning through osmosis." One manager commented, "We just throw people into situations and find out what happens. . .A lot of what we do at Parsons comes naturally now. We don't talk about team building, for example, we just go and do."

Changes in the Competitive Environment

The large defense budgets of the 1980s had attracted additional competitors into the defense field and allowed the DoD to drive harder bargains. Fixed-price contracts for development had replaced cost-plus contracts, and the DoD had begun to second source the manufacture of military hardware. Previously, the company that won the development contract for a system could expect to be the manufacturer of the system. One senior Parsons executive observed: "The design of the product tends to be costlier to the company, while the profit is in sales from production. So competitors who couldn't out-design Parsons can underbid us on the manufacturing contracts and, using Parsons's drawings, take away the more profitable end of Parsons's business."

Parsons was responding to changes in the defense industry by launching a major initiative to upgrade its production capacity. Though the company had made its mark in design, in 1981 Parsons began a three-year, $450 million improvement program for manufacturing.

Government specifications on defense projects also had increased enormously. The sharp rise in the number of standards was driven by the enormous complexity of defense hardware coupled with tighter parameters written to ensure standardization across contractors. "At one time the specifications for an assembly could be held in a couple of loose-leaf notebooks." One production engineer observed, "Now it takes an entire bank of file cabinets to hold the specifications for the same assembly."

Design engineers grumbled that contract interpretation and negotiation were replacing technical skill as the most important elements of their jobs. Many expressed concern about the way their technical freedom was ebbing away under the increased pressures from the government and competitors. "I have never been managed," one senior engineer noted with pride. "If this is the way Parsons is going, sometimes I think I'd rather go and design washing machines for a living."

Further adding to the worries of engineers was the 1983 sale of the company to Providence Machine Tool Corporation (PMT), a Rhode Island manufacturer of sophisticated machine tools. PMT management bought Parsons from the founder's family in an effort to expand and diversify PMT's technical base and markets. Although PMT kept Parsons's corporate structure intact, most engineers believed that the change in ownership would eventually lead to a greater short-term profit orientation.

A senior executive remarked:

> Perceptions are changing. Maybe there may be a time of cultural change, a reassessment of who we are. . . . This undoubtedly creates anxiety; this is not the same comfortable atmosphere there once was. We have to ask: Is Parsons becoming a different place? How can we build on our old strengths to take on some new realities?

The Sonar Division

Organization

The SD was formally organized as a group in 1968, with research and design facilities in Gaithersburg, Maryland, and a manufacturing plant in Charleston, South Carolina. The research and design center consisted of a number of low-slung buildings, an hour's drive from Parsons corporate headquarters in Alexandria, Virginia. (Both Gaithersburg and Alexandria were suburbs of Washington, D.C.) The grounds were well landscaped and the overall physical appearance of the center resembled a modern community college campus. Most designers worked in private offices or in a number of small prototype laboratories sprinkled throughout the grounds.

Parsons located its manufacturing facility for sonar in Charleston near a naval shipyard. The small South Carolina city (population 69,100) was just over an hour away from Washington, D.C. by air. Since opening in 1968, the Charleston plant had manufactured more than 75,000 mobile sonar sensors of various types. Charleston engineers from all levels spent a large portion of their time on the plant floor. Besides its production engineers, the plant's labor force consisted of unionized machine operators and material handlers. Military personnel were also present, inspecting and testing devices as they rolled off the line.

Dixie Blockade/Foggy Bottom

Sharp differences existed between engineers in Gaithersburg and those in Charleston. Manufacturing engineers and design engineers faced different tasks, employed different approaches to problems and valued different outcomes. Each function claimed that the other failed to recognize their problems; Gaithersburg engineers designated the divide the "dixie blockade"; in turn, Charleston engineers called Gaithersburg "foggy bottom." (Foggy Bottom is the name of a neighborhood in Washington, D.C.)

SD's management was looking for ways to bridge the gulf and better integrate design and manufacturing. Engineers were urged to give greater attention to "producibility" of their designs. According to a Parsons publication, producibility problems occurred when "(1) designs were released without enough attention to existing production capabilities; and (2) production processes and equip–ment are inadequate to meet new engineering requirements.[1]

Gaithersburg engineers felt that better integration could be achieved by creating more producible designs during the design phase. Charleston engineers, while acknowledging the importance of producible designs, felt that design engineers often held onto projects for too long. A production engineer commented, "The sooner I get a design, the farther down the learning curve I can get. If the design engineers spend too long with a design, making it 'clean,' there is little recovery time for us in Charleston if something should go wrong."

To ease the transition from the designer's table to the factory floor, management had sought to bring together production and design engineers earlier in development. However, when engineers from Gaithersburg went to live in Charleston for the duration of a transfer, the move often presented a considerable hardship to their families. Transitions could stretch out many months, sometimes years. Rather than choose reassignment, some lab managers rotated different Gaithersburg engineers through Charleston, but this hurt continuity of effort. Alternately, Charleston engineers were assigned to Gaithersburg during design. Most, however, who were willing to leave Charleston for that amount of time were younger and had fewer ties to the company. By the time the design had been completed, many of them had left the company or had transferred to other projects.

Some of the cooperative efforts were successful. One engineer reported that on his project, Charleston and Gaithersburg engineers had worked well together during the design phase and later had had an exceedingly smooth transition. The engineer described the camaraderie as "fortuitous": both design and production engineers had been approximately the same age and single. Had the engineers' backgrounds been less similar, he speculated, the ties which facilitated the transition would not have been as tight.

One engineer observed, "Each time we do a transition, we start from scratch and tend to make the same mistakes over again." Transitions of major systems did not occur often, and during any given transition the focus was on specific technical issues. Formally, the transition was the last step of the development process, and Gaithersburg engineers remained responsible for a design until both sides signed papers certifying the design as producible. Informally, manufacturing engineers were necessary to complete development, and design engineers felt responsible for their designs well after manufacturing had begun.

[1]"Design Policy," *Parsons Corporate Manual*, 1984.

A production engineer from Charleston noted that building bridges between Gaithersburg and Charleston took time and required a great deal of personal initiative. "Initially when I went to Gaithersburg, it was hard to get a hearing from the design engineers. But over time, they get to know you and you get to know them. Now, they will go out of their way to ask me what I think of a design. I guess you just have to be persistent."

Problems With Workmanship

In 1982, following inspections by the military, concern had been raised over the workmanship in the Charleston plant. In response, Parsons shut down a number of manufacturing lines and instituted a schedule of periodic audits of all manufacturing procedures. Many production engineers likened the experience to an inquisition, and most agreed that it had adversely affected morale. They felt that they had been scapegoated to appease government critics. In their view, SD management had reacted to calls to "do something" by laying blame entirely at the feet of the production engineers.

Despite the funds expended on the production process and the increased attention to manufacturing procedures, some production engineers felt that real progress would come only if the basic perceptions of the company changed. Parsons's reputation as a "design shop" permeated the culture of the company. "When you look at all the literature the company puts out," noted one senior production engineer, "it's all about what a great place Parsons is to work on design. I think that says something about management's priorities."

The S2 Sonobuoy Project

Making of a Lab Manager

In his 24 years at Parsons Controls, Yoshino had built an enviable reputation for technical virtuosity and organizational ability. Peers praised his ability to complete difficult design problems and coordinate the work of other engineers. A senior executive noted of Yoshino, "The bottom line is he turns out products and delivers on promises."

In 1981, Yoshino was brought in to oversee the development of the control unit for the S2 sonobuoy. A sonobuoy is a device deployed by ships to search for enemy submarines. After being launched, the proposed S2 would descend to a designated depth, emit sonar waves, and transmit back data to a shipboard computer. In submarine-infested waters, sonobuoys could be placed around the perimeter of a convoy or towed in an array behind a single ship. The S2 represented the next generation of sonobuoys for the U.S. Navy. Since Parsons had attained a strong position in submarine detection equipment, the company fought hard to win the contract and remain preeminent in this area.

Most engineers felt that the development contract had been underbid but hoped that losses in development could be recouped in manufacturing. The U.S. Navy estimated that it would need upwards of 3,500 sonobuoys a year over the next seven years. Parsons also hoped to sell the technology to other allied navies.

Yoshino became involved with the project after the development contract had been won. His research laboratory was to develop the control unit -- the electronic equipment inside the buoy which controlled the sonar sensors and transmitted information. Meeting the performance standards for the sonobuoy was a leap into the unknown; many of the technologies outlined in the proposal were untried. The financial and time parameters were tight. And all military contracts were proving to be more politically controversial as the U.S. Congress increased its scrutiny of "big ticket" defense systems. "S2 was the biggest challenge of my career," Yoshino noted. "It's not the type of project that people line up to do."

Yoshino divided the work on the control unit into nine separate components (or chassis). The development of each chassis was assigned to a accountable engineer (AE) who selected a design team, supervised the work, and was responsible for the budget and schedule. Sonar was Parsons's forte; many of its scientists and engineers had worked on previous sonar devices. In making his selection of AEs, Yoshino took great care to match individuals with their assignments; he chose people he trusted and had worked with on previous projects.

Setting the schedule for completion of the control unit was one of Yoshino's first tasks. Initially, Yoshino met with each AE to get an assessment of the time to complete his chassis. Then he met with the program office that had made the initial bid. Over a number of months, Yoshino went back and forth between the program office and his AEs, attempting to finalize a schedule agreeable to both sides. Once the schedule was set, it remained fixed for the duration of the project.

Yoshino acted as mediator between the program office and his engineers on numerous other occasions. "Unlike some other managers, Larry wouldn't agree to anything without first consulting with his engineers," an engineer in the program office noted with some frustration. Yoshino believed program managers had to understand the concerns of his engineers before he would commit the resources of his lab. He noted that honesty and a track record of delivering on commitments were essential elements in building a good relationship between program and line managers. On this aspect of their relationship, the program office gave Yoshino high marks: "Once Larry gives his word, you know you can trust it."

Project Management

The schedule and budget set, the work of developing the control unit began in earnest. A large amount of Yoshino's time was spent with the client: standards and requirements needed frequent updating. Given the uncertainty surrounding interpretation of the contract and developing a new detection system, Yoshino had to constantly revise and update projections, developing contingency plans for each step of the project.

Managing the development of the control unit required long hours for planning and frequent meetings with other managers. Administratively, Yoshino had to document the work that had been done for the government and the program office. He also stayed in touch with other line managers to ensure that the control unit could be properly integrated with the rest of the buoy. From time to time, he met with managers of other programs to initiate planning of the work his lab would do as they completed the S2. To maintain good relations, Yoshino always followed the chain of command and responded quickly to those with whom he had a direct reporting relationship. Despite an often hectic schedule of meetings with clients and subordinates, Yoshino made sure to return phone calls the same day.

In monitoring the progress of his AEs, Yoshino said he did not believe in "micro-managing" a project. Although he met informally with engineers in their labs and offices and maintained an open door policy, he got his best sense of the "pulse" of the work from twice-monthly design review meetings and monthly budget and schedule reports.

During the design review, each AE would present a 20-minute summary of the progress made during the previous two weeks. The meetings were attended by all of the AEs, people from the program office, Yoshino, and other members of Yoshino's staff. AEs were questioned, potential trouble spots identified and solutions proposed. Yoshino pushed his AEs to meet the schedule and budget commitments they had made. Engineers described the meetings as "intense." According to one engineer, there was always pressure to present "solutions, not problems. You never really wanted to be the bearer of bad news."

Avoiding delays meant avoiding "major surprises during the course of a project," Yoshino explained. "I tell the engineers to do it right the first time. It's important to invest time early to spot problems that could occur down the road. As the design gets closer to completion, it gets more difficult and expensive to change things."

Motivating engineers to put in extra work in order to complete an assignment quickly was one of Yoshino's biggest concerns. He felt it was important to make his engineers "feel special" by getting them the best possible resources—be it more computer time, lab space, or personnel. Despite Parsons's extensive facilities at Gaithersburg, the competition between programs and labs created substantial jousting for the prime resources. Yoshino's engineers gave him high marks in coming through on their requests.

Yoshino's approach to decision making was distinguished by the meticulousness characteristic of precise engineering. He noted that other managers made quicker decisions, but that he preferred to lay out all of the facts and decide issues on their technical merits. Colleagues observed that once Yoshino reached a decision, he was very persistent. "Larry will come back to you again and again. He's very polite—but firm; and in the end he'll generally get what he wants."

Transitioning the Motherboard

Design

Yoshino asked Peter Scalia to be the AE for the control unit's motherboard. Scalia had been with Parsons for 10 years. He had a strong design background, and he had been an AE for Yoshino on a previous sonar project. Scalia assembled a team of designers, negotiating to get engineers he knew and trusted. The motherboard development team consisted of a nucleus of five designers. A dozen other individuals (such as draftspeople, process engineers, and others) also contributed in other capacities.

The motherboard provided the connections between all of the other chassis as well as shielding and anchoring the entire control unit. Due to the large number of operations the sonobuoy had to perform, the total number of circuits in S2's control unit were an order of magnitude greater than any previous sonobuoy. However, because of physical constraints, S2's motherboard could not be larger than previous units.

Scalia's team began development of the motherboard in the summer of 1981. Early on, it became apparent that the design specified in the bid was infeasible. In order to meet performance standards, Scalia and his team had to create a motherboard that was quite different than any Parsons had manufactured before. It was, according to an engineer of another assembly, a rather "nifty" piece of engineering.

In the summer of 1982, the motherboard's basic design had been completed and Scalia's team began the construction and testing of a prototype. In order to build a working unit, the delicate interconnections between the motherboard and the other chassis had to be precisely fitted. The prototype was built by hand in a Gaithersburg workshop, allowing Scalia and his team to make quick alterations in the design and immediately incorporate them. The complex and time-consuming process took over a year.

Running the Dixie Blockade

Preparation for the transition had begun early in the project; Yoshino had asked that production engineers from Charleston be assigned to Gaithersburg to assist with design. Two production engineers had joined Scalia's team in the summer of 1981 and stayed with the group until the basic design was completed in the summer of 1982. During the subsequent year and a half period of building the prototype, the Charleston engineers who had been with Scalia's unit left the company or were assigned to other units. Scalia observed:

> They [the Charleston engineers] were good people, but they were young and inexperienced with manufacturing. They didn't understand how design decisions in Gaithersburg would prove important later on in Charleston. . .The Charleston people really did not have much impact on the actual design, but I had hoped that by observing what we did, the transition would be easier. There was a lot of lost training when the individuals who were here did not stay with the project in Charleston.

The task of seeing the motherboard through manufacturing in Charleston fell to James Pastore. Pastore joined Parsons-SD in 1979 and came to the S2 program in 1983 after a six-month international assignment. Acknowledged to be energetic and hardworking by engineers in both Gaithersburg and Charleston, Pastore put in long hours on the floor of the manufacturing facility. Pastore noted:

> In order to be successful in manufacturing, you have to be dynamic and take charge of the situation. The deadlines are tight, forcing you to get down on the floor and roll up your sleeves. The pressures we face in Charleston do not allow you to sit back and be a deep thinker.

Most engineers agreed that both Pastore and Scalia were confident of their own abilities and tended to be forceful personalities, although they did differ in temperament and style. One observer described it as the difference between "beer [Pastore] and wine [Scalia]." Pastore was thought to be aggressive and "quick on the draw." Some Gaithersburg engineers claimed "he had his finger in every pie" and was spread too thinly to be effective. Scalia, on the other hand, was thought to be a careful decision maker—much more "laid back" than Pastore. However, some Charleston engineers complained privately that he was aloof and inordinately interested in maintaining "good appearances" with superiors.

The Soldering Problem

In the beginning of 1984, the design of the motherboard and manufacturing specifications were sent to Charleston to begin production trials. In one step of the manufacturing procedure, five flex/cable connectors and six large connectors had to be soldered to a 16-layer printed wiring board. To solder the hundreds of joints at one time, the motherboard had to be placed through a wave-soldering machine (so-called because the motherboard travels over "waves" of molten solder on a conveyor). With a printed wiring board of 16 layers, significantly thicker than previous motherboards built by Parsons, Charleston engineers suspected that there might be problems wave soldering joints which were up to military specifications. Military specifications dictated precise standards for solder formation on-and-around the plated holes and connector pins of the motherboard.

When tests on the wave soldering machine began in March 1984, visual inspection of the solder joints seemed to confirm the suspicions of the Charleston engineers. The solder joints were not "wicking" up through the holes as required by military specs. Before notifying Gaithersburg of the problem, Pastore wanted additional evidence. He had the boards x-rayed, cross-sectioned, and examined microscopically. Pastore felt the tests supported the Charleston engineers' identification of the problem and he fired off a letter to Gaithersburg, sending copies not only to Scalia, but also to Yoshino (see **Exhibit 5**). The letter laid out the technical problem and presented the test results (performed by quality control) in graphic detail, complete with photographs. Pastore also made recommendations about the manufacturing procedures and suggestions about modifying the design to make it more producible in the long term.

Yoshino was surprised by the letter and doubly surprised that a copy of the letter had also come to the attention of Yoshino's supervisor, Tom Nadal. While he did not feel it appropriate to respond directly to Pastore, Yoshino contacted Scalia and reviewed Pastore's findings. Scalia and Yoshino requested their own set of tests on the boards.

In examining the problem, Gaithersburg concluded that while the basic design of the motherboard was sound, a new soldering procedure was required to ensure quality. Scalia noted, "The real problem was recognized by our management. . . . We did a valid design; the wave soldering was the problem; But the first reaction out of Charleston is always 'redesign it for us." Scalia added that he did not understand why Pastore had sent the letter to Yoshino and others, "I thought I had good rapport with James. He just told me he didn't think he was getting my attention." Another Gaithersburg engineer attributed the letter to Pastore's style, "James has a flair for the dramatic."

Discussing the letter with the casewriter, Pastore explained:

> There is a strong, "not invented here," syndrome in Gaithersburg which keeps them from listening to Charleston. . . . We needed to get the x-rays and photos to get their [Gaithersburg's] attention; otherwise they wouldn't believe us. They would have come back and told us that we were crazy. We went to Larry when we felt that it might become an us versus them thing. Conflict happens when there is a lot of finger pointing and scapegoating.

Throughout the transition, Pastore worried that Yoshino might not have an accurate picture of the difficulties manufacturing the motherboard presented.

Once Gaithersburg engineers gave a detailed explanation of the rationale for their design of the motherboard, Charleston engineers withdrew their redesign proposals and concentrated their efforts on revising the procedure. "It would have been a lot easier if we had known this from the start," one noted.

Finding the Proper Procedure

Because there was no wave soldering machine in Gaithersburg, all of the tests to find a new procedure had to be run in Charleston. In correspondence with Charleston, Scalia's team outlined a systematic approach to the problem. They proposed varying the time and temperature of the machine and the ways of preparing the motherboard before soldering in a series of experiments on other layered boards. The complicated procedure for testing each run of layered boards took over a week to complete.

The Charleston engineers felt many of the experiments tested procedures unsuited to manufacturing. Working from their knowledge of wave soldering, the production engineers tried their own approaches. "If this had been some new process or product, then fine, Gaithersburg might have a better handle on it. But I had been working with wave soldering for years. Each week we had to spend time trying to convince them that we knew what we were doing," one Charleston engineer noted.

For Gaithersburg, the engineers in Charleston were too "cut-and dry." For example, one of the few available prototypes of the motherboard was burned in Charleston. "It was simply because they were not following directions," Yoshino noted with some chagrin. "That should have never happened, it was simply careless." (Charleston engineers told the casewriter that they felt they were performing an essential experiment.) With three years of work on the motherboard design behind them, Scalia believed Gaithersburg had the most applicable knowledge. "We understand the complexities of the design. Without knowing, Charleston's rework of the procedure could invalidate the rest of the design. We take care of any changes."

Resource Problems

To oversee the transition, a Gaithersburg engineer spent one or two days a week in Charleston on rotation. However, when Gaithersburg engineers went down to Charleston, they often found that they could not get on the soldering machine to run the tests, or that materials necessary for running the experiments were not set up. Progress on the tests seemed unnecessarily slow. Scalia described his team's frustration:

> We were having problems getting them [Charleston] to even set up desks for us. We didn't have direct access to the floor of the plant, so we couldn't work directly on the machines. In order to get the operator to run a test, we had to go to a supervisor to get authorization. . .It was like playing a game of telephone.

Even as the soldering problem dragged on, Scalia and his team had other pieces of the motherboard to worry about. For example, an important part of the motherboard was being manufactured for Parsons by a small Pennsylvania company that was having trouble delivering a quality product. Scalia's team had to work with this company in addition to overseeing the transition in Charleston.

All of the Charleston engineers assigned to the motherboard had between 10 to 20 other projects. Each project had its own deadline; there was no strict list of priorities. They felt they were devoting as much time as they could to wave soldering, and had made progress toward writing a new procedure. Many of them expressed frustration that Scalia's team was not utilizing the work they had been doing. One engineer noted: "Production engineers are oriented toward getting physical results. Results are measured in the number of finished products that roll off the line."

The Charleston engineers were also disappointed in the effort Scalia's team was placing into the soldering problem. "You can't work on production problems from an office," one Charleston engineer explained. "You have got to get on the floor." Another felt that the rotation of different engineers was disrupting the continuity of effort. "You just can't get to know the problems in a couple of days a week. . . . You have to be at the plant for a couple of weeks straight so that you really get to know the manufacturing problems." Another said simply, "You can't engineer through IDC (interdepartmental correspondence)."

By April 1984, an engineer from Scalia's team was spending most of his days in Charleston. "If we weren't there, it [the experiments on the wave soldering machine] wasn't getting done," Scalia explained. "Charleston did not take responsibility for the problem. . .They seemed to feel that it just wasn't their job."

Privately, both Gaithersburg and Charleston were commenting that the other team seemed to be "in over their heads technically" and were unwilling to admit it.

Yoshino's Role in the Motherboard Transition

Yoshino had conferred frequently with Scalia (though not with Pastore, who was not under his direct authority) about the soldering problem. Yoshino trusted Scalia's technical judgments and felt that Scalia's approach to finding the right soldering procedure was sound. When Scalia had complained of Charleston's lack of cooperation, Yoshino had brought the issue up with his Charleston counterpart, Fred Brown, during their twice-monthly meetings. Yoshino enjoyed a good rapport with Brown and was respected by a number of manufacturing engineers in Charleston. Each time after he "rattled the cage" to get the resources, Yoshino had received reports that access for members of Scalia's team had improved for a time.

Even under the best of circumstances, writing a manufacturing procedure could be time consuming. Creating new technologies often involved a great deal of uncertainty and debate over proper approaches. Though Pastore had tried to involve him, Yoshino felt that it was best to "let the engineers slug it out for themselves in the trenches"; the role of the lab manager was to "set the tone of the transition and spread goodwill whenever he could."

Over the long-term, Yoshino felt that learning how to get along with production was part of the maturation of a design engineer. Scalia was known to be hard-headed, and like many technically proficient design engineers, he could be touchy about his work. Yoshino explained:

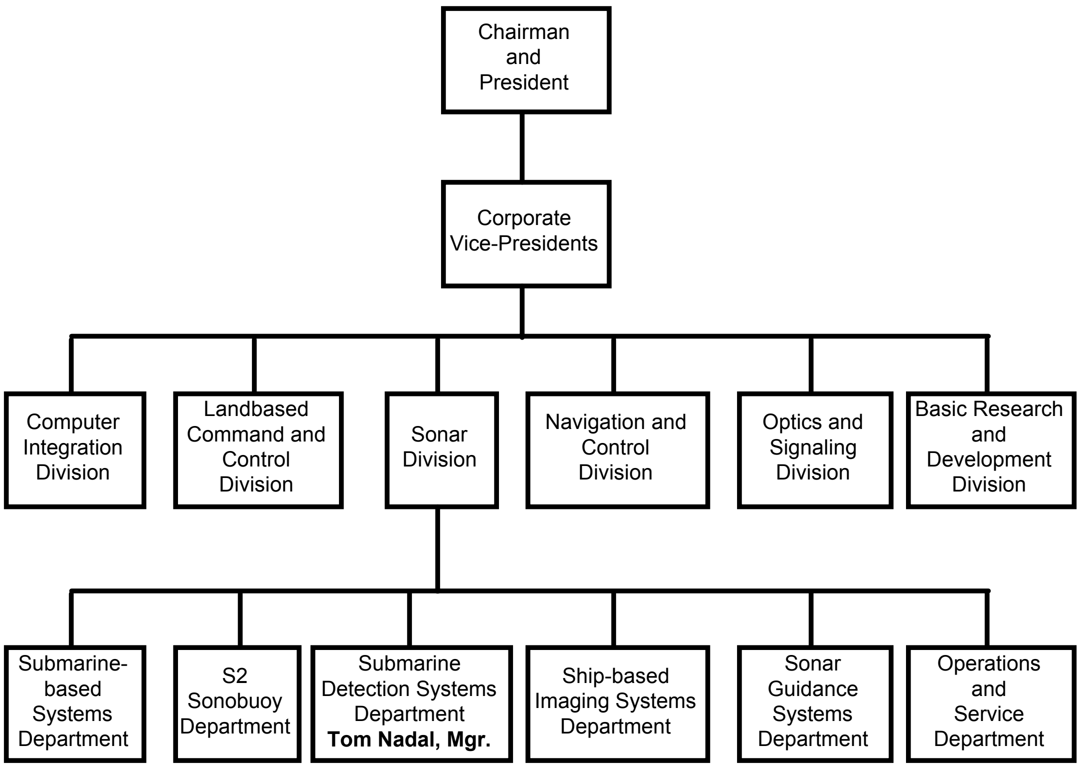
> Since they spend so long developing their designs, some designers see their own work so clearly that they have trouble explaining it to others, and trouble in accepting any changes. They get accused of trying to steamroller their ideas through. . . . I tell them, "You aren't just selling the design, you are selling yourself." You have to develop a level of trust to be effective.

But now (June 1984) time on the soldering problem was running short. The problem was not a show-stopper, but Yoshino realized that if a procedure could not be ironed out quickly, costly delays would result. However, he knew that the goal was not only to finish development on time, but also to create a high-performance sonar device that could be manufactured cost- efficiently and with high quality.

Yoshino wondered: What, if anything should he do now to help the motherboard transition? And what should be done in the future to assure effective transitioning of technology?

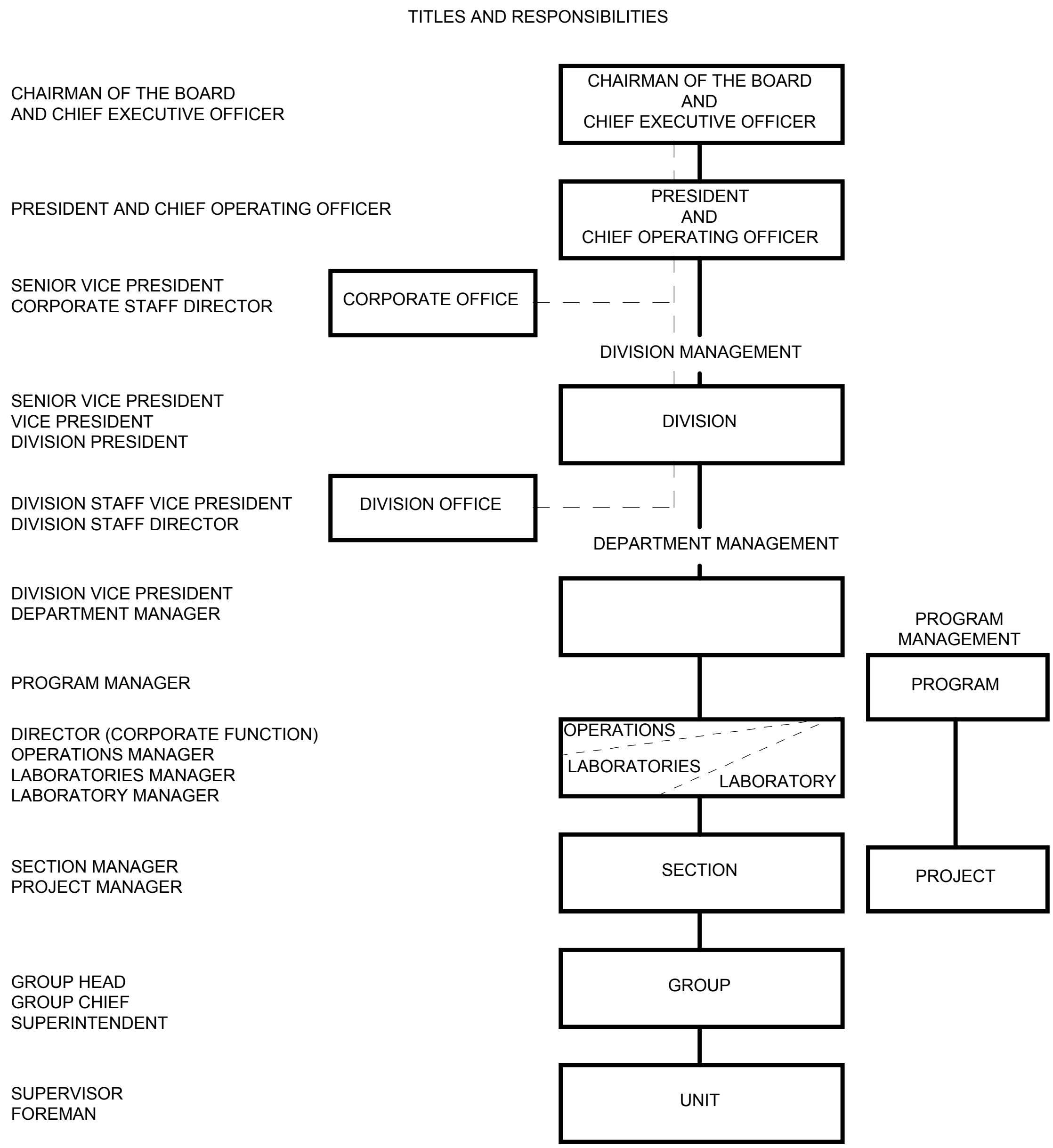
Exhibit 1

PARSONS CONTROL
CORPORATE ORGANIZATION



Source: Parsons Corporate Document

Exhibit 2



Titles indicate level of authority—those grouped together are approximately at same level.

Source: Parsons Corporate Document

Exhibit 3

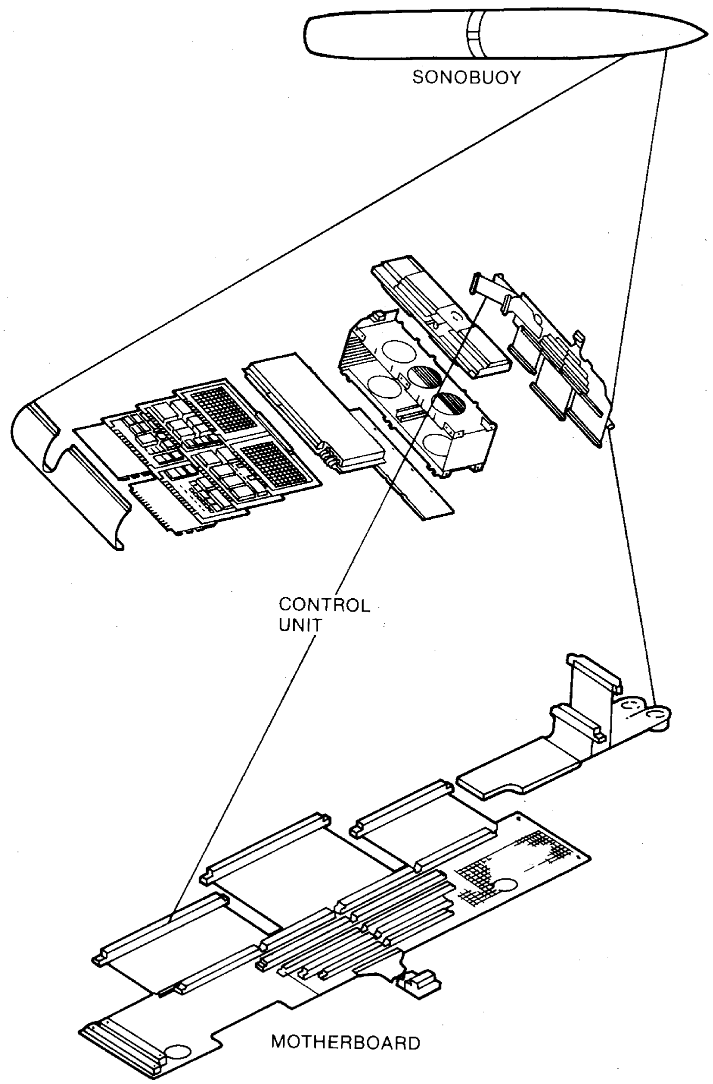


Exhibit 4

DOD PROCUREMENT PROCESS

VALIDATION

1. Department of Defense (DoD) solicits bids
2. Contractors submit proposals including budget, schedule and preliminary design
3. DoD awards development contract

DEVELOPMENT

7. Limited Production: Small production runs are conducted for product tests

6. Transition: Procedures are written for mass-production

5. Prototype: Engineers build working prototype and make tests

4. Design phase: Engineers prepare detailed drawings

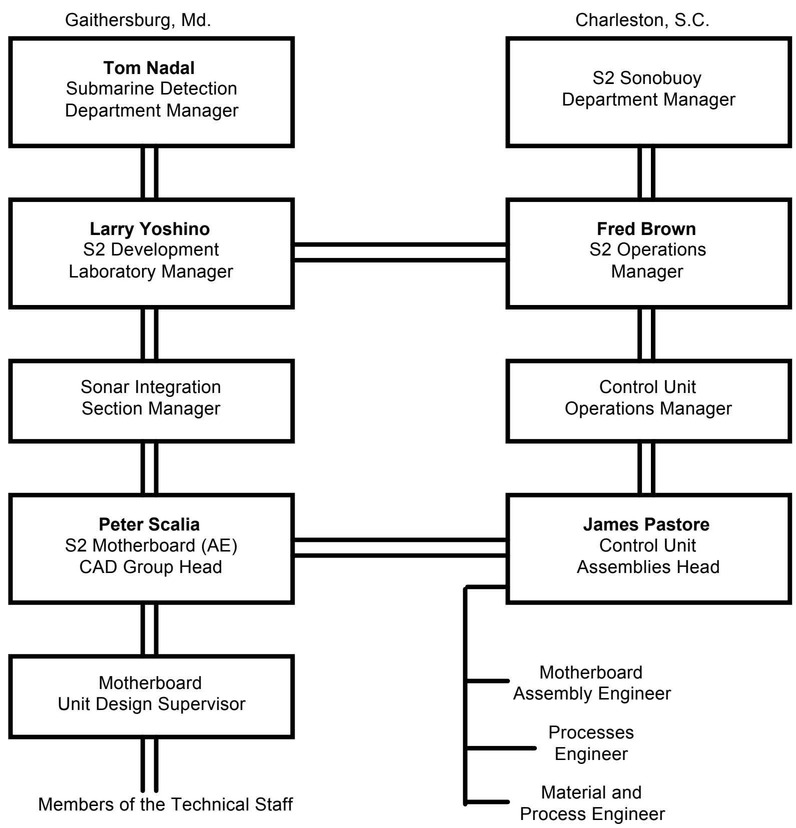
PRODUCTION

8. DoD solicits bids for manufacturing contract
9. DoD awards contracts
10. Delivery

Source: Casewriter's notes

Exhibit 5

CHAIN OF COMMAND FOR S2 SONOBUOY



Source: Larry Yoshino