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Risk vs Payoff: An Acquisition Case Study of the Tactical Data System

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Teaching Notes for TDS Acquisition Case Study

Abstract

A new and inexperienced project officer reports for duty in a program office which is responsible for a complex series of command and control system upgrades in Navy ships. After being on board for less than a month, he is assigned to form and lead a study group to review the state of the project. He finds in his investigation that the program is in severe schedule trouble due to numerous technical problems in the support programs used to build the operational software. What should he do?

This case illustrates -- through a rather extreme example -- the uncertainty faced by a program manager when his technical community can't agree. One side claims difficulties which threaten the success of the program. The other side claims that the problems are only temporary setbacks and the technical foundation of the program is still sound. Neither side has conclusive evidence. Should he accept the technical problems as insurmountable and make sweeping changes in the structure and direction of the project, or should he look for a management solution which will allow the technical problems to be worked around or resolved?

Teaching Objective

The students should discuss the dilemma facing the study chairman and the program manager.

1. What are the alternatives?

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On February 12, 1986, RADM Chang fired the Commanding Officer of the Navy Programming Center in San Diego, relieving him of all responsibilities for the development of the tactical command and control computer program for the USS THEODORE ROOSEVELT (CVN 71). RADM Chang directed the program manager to go to San Diego and take over control of the day-to-day operations in the program's development. What prompted him to take this extraordinary action? In order to understand, we must first look into the background of the program.

History. The tactical data system (TDS) was installed in Navy ships in 1961 and represented one of the first military uses of digital computers. Designed to display and coordinate anti-air warfare information, the system automated the functions of the ship's Combat Information Center (CIC). Prior to the installation of the TDS, information from radar operators was passed verbally to plotters who recorded the information on large, vertical plexiglass boards. The ship's officers evaluated the information displayed on these plots and verbally assigned weapons to engage targets. The TDS eliminated the need for manual plots by allowing the data to be entered into a computer which then displayed the target's position, course and speed.

The system evolved through the decade of the 1960s. The air-search radar and weapons were hooked directly to the computer. The system then automatically collected target information, displayed the tactical situation for evaluation, and assigned targets to weapons systems at the push of a button. A radio data link was added which allowed computers on several ships to exchange information. Figure 1 shows the flow of information in the combat system.

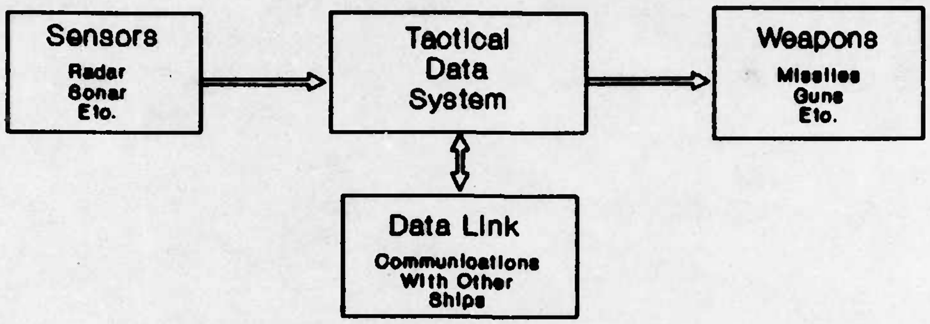

Figure 1. Combat System Information Flow

The system continued to become more capable in the 1970s as anti-submarine warfare and anti-surface warfare functions were added. The TDS, shown in Figure 2, had become the heart of the ship's combat system.

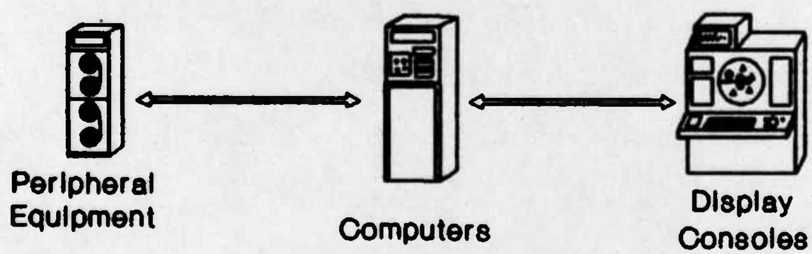

Figure 2. Tactical Data System Equipment

By the end of the 1970s, tactical data systems were installed in all aircraft carriers and cruisers. But they were still using the same first-generation computers as the original 1961 system. This computer had provided yeoman service for twenty years, but so many software features had been added that the computer's memory was filled to capacity. Its processing speed slowed to a crawl when even a moderate number of targets were present. New requirements were continuing to emerge, driven by the installation of new, advanced weapon systems designed to counter the technological advance of the Soviet Union. It was time to modernize.

The Initial Program. The Naval Sea Systems Command received approval for its TDS Improvement Plan in February 1981. It was to be improved using a two-step approach.

Step One was a low-risk development. The Navy's second-generation computers would be installed. These new, more capable computers had been operating in other systems for several years. Buying these proven products from the production line represented a low risk strategy for replacing the old TDS equipment.

New software programs were required to operate in the updated TDS hardware configuration. Again, a low risk strategy was selected. The programs would be developed with traditional programming techniques which had been in use for many years. The performance requirements for the software in Step One were kept simple -- provide the same functional capability as the current system. The program manager was located at the Naval Sea Systems Command in Washington, D.C. The cruiser software for Step One would be developed at the Navy's programming center in Virginia Beach, which had responsibility for all cruiser and destroyer TDS programs. The aircraft carrier software would be developed at its sister facility in San Diego; responsible for all aircraft carrier and airborne TDS programs. Hardware delivery was required in FY 1984 for a new aircraft carrier and in FY 1985 for a cruiser. Completed software programs were required in FY 1986 for both the carrier and cruiser. Figure 3 shows the schedule as it appeared in the 1981 Improvement Plan.

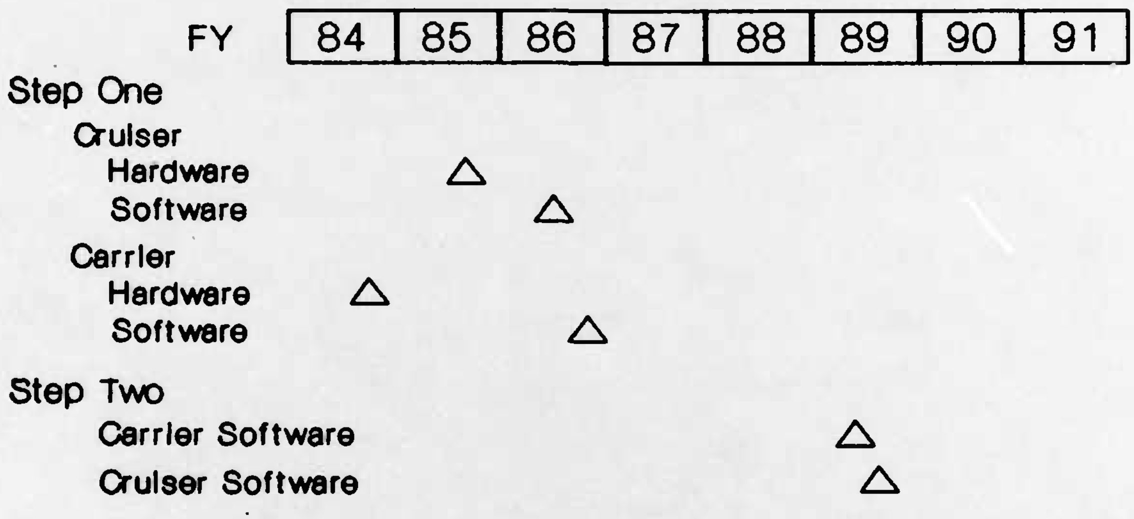

Figure 3. 1981 Delivery Schedule

<u>Step Two</u> was a medium to high-risk software development, incorporating significant functional improvements to the TDS program. This technologically advanced program was to be developed using a revolutionary new computer programming technique. This new technique allowed for faster development of high performance software programs at a reduced cost. The key to this was the development of computer-aided software production tools. The tools were designed by personnel from both of the Navy programming centers and had been under development since 1978. The programming center at San Diego was managing the

development.

Step Two software was to be completed for the aircraft carrier and the cruiser by FY 1989. These programs were to be developed under a cost-plus-award-fee contract starting in 1984.

Changes to the Plan. The ink had hardly dried on the original TDS Improvement Plan -- Step One and Step Two -- when the first changes were made.

In May, 1981, the Chief of Naval Material directed all new programs to use the Navy's third-generation computer scheduled to enter production in 1985. This change ensured the Program would be installing the latest state-of-the-art hardware. It also gave TDS the dubious distinction of being the first system to field an operational program in the new computer. This change increased the Step One hardware risk but was considered acceptable.

In June, 1982, the TDS program manager decided that the new software development techniques being used for Step Two were maturing at a fast enough rate to support development of Step One software programs. Consequently, he directed the Virginia Beach programming center to shift the Step One cruiser software development from the traditional method to the promising new software development technique. He did not shift the aircraft carrier program to this new development technique. The third-generation computer would not be available in time to meet the construction schedule for the new aircraft carrier. The THEODORE ROOSEVELT would receive a second-generation computer and a software program developed using traditional methods.

The decision to base the Step One cruiser software on the new development techniques increased the risk for this program. But, if the development techniques were successful, the software could be developed faster and at a much lower cost. The payoffs were big! Also, because the software developed in Step One could be used to fulfill some of the requirements for Step Two, the risk in the Step Two was reduced. The program manager decided the payoff was worth the risk.

Figure 4 summarizes the changes in the TDS improvement program occurring from 1981 to 1985 and gives the program office's assessment of the risk after each decision.

TDS Improvement Plan		Feb 1981		May 1981		Jun 1982		Jun 1985	
Strategy Changes and Risk Assessment		Cruiser	Carrier	Cruiser	Carrier	Cruiser	Carrier	Cruiser	Carrier
Step One Hardware	2nd Generation	X	X				X		
	3rd Generation			X	X	X		X	X
	Risk	Low	Low	Med	Med	Med	Low	Med	Med
Step One Software	Traditional	X	X	X	X		X		X
	New Technique					X		X	
	Risk	Low	Low	Low	Low	Med	Low	Med	Low
Step Two Software	Traditional								
	New Technique	X	X	X	X	X	X	X	X
	Risk	High	High	High	High	High	High	High	High

Figure 4. TDS Upgrade Program Changes

Program status in 1986. Three weeks prior to RADM Chang's action, a new project officer reported to the program office. CDR Charlie Bingay arrived literally in the middle of the flail. When he heard of the firing, he inquired what the problem was. It seems that the simple, low-risk software being developed for the THEODORE ROOSEVELT had not worked. This was discovered in June, 1985. The program office had devised a recovery plan which involved installing new, third-generation computers in the carrier. They'd recently been approved for production, and converting the carrier software to run in this new environment was considered a good move. The schedule allowed a relatively short period of time to accomplish the conversion.

Fortunately, the San Diego center had a small group of highly proficient programmers referred to by the other staff members as "The Magnificent Seven." In this case they were invaluable. Once they became interested in a problem, they tended to work sixteen hour days and skip meals until it had been solved. They were given the job of converting the carrier software.

In the software business an extremely proficient programmer is called a "guru" and is usually somewhat eccentric. When time is limited, they are invaluable. A guru can create a software program and make it work in half the time required by a normal programmer. Unfortunately, it is usually difficult to get them to document what they have done; they'd rather get on to the next problem.

In order to assist in the carrier software conversion, the program office hired four, $80 per hour software experts -- gurus -- and provided them to the San Diego programming center. Even with this high-priced talent, the facility commander had been unable to achieve satisfactory progress in the recovery effort. As one member of the program office staff put it, "he couldn't get his Magnificent Seven to cooperate with the gurus from out of town." Apparently the Admiral expected better team building skills from his senior officers; even if the players were all prima donnas. So he relieved the facility commander of the software conversion responsibility and told the program manager to leave his duties in Washington and take over the day-to-day management of the effort in San Diego. The program was required aboard THEODORE ROOSEVELT in four months -- this was definitely a crisis situation.

Before he left for San Diego, the program manager assigned CDR Bingay to head a study group. He was charged with assessing the state of the new software technique and the overall Step One and Step Two developments. The program manager wanted the report "by the Ides of March."

In his short time in the office, CDR Bingay had learned something of the status of the program. The lead ship for the cruiser program had been changed and the software was now required in April, 1987. Even with this ten month delay in the required delivery date, the step one cruiser program was four months behind schedule and seemed to be falling further behind. The step two program budget had been reduced which required the schedule to be extended two years. Figure 5 shows the TDS improvement program schedule as of February, 1986. Changes from the 1981 schedule are shown by dotted milestones and arrows.

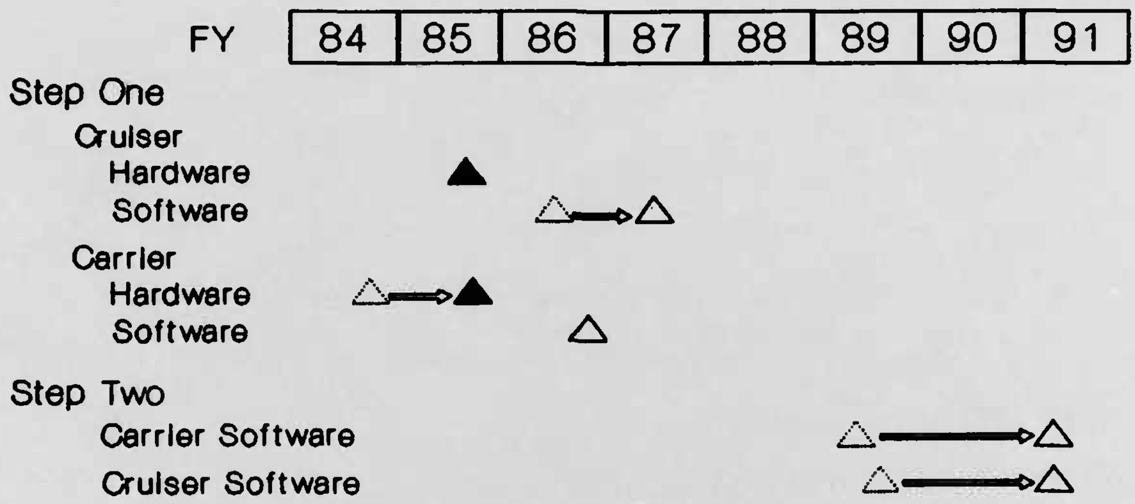

Figure 5. 1986 Revised Delivery Schedule

CDR Bingay continued to assemble his study group. He had been advised by the program manager to gather "a few unbiased experts" to help with the study. Very quickly he discovered that the new software development technique was highly controversial -- there were no unbiased experts! He settled for a group of six, experienced in software development, with at least their biases regarding the new technique a known commodity.

The study group first visited the San Diego programming center and found that the carrier program was finally making satisfactory progress. Personnel from the center attributed their recent success to the following factors:

a. The maturity of the traditional programming techniques.

b. The availability of programmers experienced with these techniques.

c. The program manager's ability to use the programming talent effectively.

There was a strong feeling in the San Diego center that this success proved the value of the traditional programming techniques.

Next the group met with the Step Two contractor personnel. During these discussions, the contractor's technical staff pointed out two problems which they felt would prevent the Step Two program from succeeding:

a. The new programming technique would not provide the expected enhanced productivity in software production.

b. The new programming technique was limited and would not allow Step Two to achieve its performance requirements.

The contractor strongly recommended that the Step Two development should switch to using another software production technique.

Finally, the study group met with the Virginia Beach programming center. The cruiser program was behind schedule but the senior people at the center were extremely positive that the cruiser program could be completed on time. Their confidence was based on the following:

a. Recent improvements in the new programming technique had resulted in increased productivity and more improvement was possible.

b. The remaining test phases could be overlapped in order to shorten the amount of time required to complete the program.

The Virginia Beach personnel also took issue with the idea that the new programming technique would not support the Step Two program development. They successfully refuted some of the contractor's arguments but could not present conclusive proof that the new technique would work.

After completing their investigation, the study group met to formulate their conclusions. They agreed that the following critical questions had been raised:

a. Could the new programming technique be improved enough to meet its promised high productivity for software development?

b. Would the new programming technique handle the revolutionary requirements of Step Two?

c. Should the Step Two development continue to use the new technique?

d. Should the Step One cruiser program continue to use the new technique?

The study group was divided over the answers to these questions. Some believed that the new technique was fatally flawed and would never work. Others believed that recent improvements showed that the process could be improved rapidly.

CDR Bingay took the comments of each member, thanked them for their participation, and proceeded to the task of writing his report to the program manager.

The basic issue was one of risk versus payoff. If the new programming technique met its goals, it would provide significant cost reduction over the life cycle of TDS software programs. The greatest payoff would be realized if both the Step One and Step Two programs were developed with the new technique.

For the Step One cruiser program, there was no, less risky alternative to continuing the program as it was currently structured. No other software development technique -- including the traditional one used for the carrier -- would allow starting the program over from scratch and completing it in less than three years. The cruiser schedule could still be met if the new technique could be made more productive. He recommended staying with the new technique for the Step One cruiser program, overlapping the test phases, and investing as many dollars as possible to make the new technique operate better.

CDR Bingay found it more difficult to formulate the proper recommendation for Step Two. It was early enough in the development to change the structure and technical basis of the program and still complete it on schedule. But, the life cycle costs could be much higher. He took the long term view and recommended that the new software development technique remain the basis for Step Two.

CDR Bingay submitted his report to the program manager on April fools day, having missed the Ides of March. The following day, the program manager returned the report and asked CDR Bingay to reconsider his recommendation for Step Two. The program manager didn't think the recommendation was wrong, but another review of the technical factors might yield a different answer. As he left, CDR Bingay thought; "How did we get into this mess?"