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Case Study of Risk Management in the
USAF LANTIRN Program

Susan J. Bodilly

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A RAND NOTE

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Case Study of Risk Management in the USAF LANTIRN Program

Susan J. Bodilly

Prepared for the
United States Air Force

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PREFACE

This Note presents one of seven case studies of the development of major weapons systems carried out as part of the Project AIR FORCE study "Managing Risks in Weapon Systems Development Programs." The larger study addresses the manner in which government policies and practices shape the management of risk during the design and development of major weapons systems. The study is intended primarily for higher-level Air Force, Department of Defense (DoD), and congressional personnel who create the environment and policies governing the acquisition process. However, the overall study and the supporting case studies should also be useful to policy analysts concerned with the management of large-scale research and development programs, particularly in the DoD.

Several criteria were used to determine which cases might be usefully explored for insights into how to improve risk management during procurement. The program had to be started in the midseventies or later for the researchers to have access to documents and managers for interviews. The program had to be a major weapon system, with both the Office of the Secretary of Defense (OSD) and congressional officials involved, to represent the complexity of the decision environment. A representative cross section of types of development situations was chosen by varying the type of systems developed, the size of the program, and the degree of technical risk involved.

The seven programs chosen were AMRAAM, advanced fighter engine, the B-1B bomber, the F-16 MSIP, the Global Positioning System (GPS), JSTARS, and LANTIRN. Two case studies in the series, on GPS and JSTARS, are authored by Tim Webb, but as yet are unpublished. The five remaining cases in the series are documented in the following Notes:

- Susan J. Bodilly, *Case Study of Risk Management in the USAF B-1B Bomber Program*, N-3616-AF, 1993.
- Susan J. Bodilly, *Case Study of Risk Management in the USAF LANTIRN Program*, N-3617-AF, 1993.
- F. Camm, *The Development of the F100-PW-220 and F110-GE-100 Engines: A Case Study of Risk Assessment and Risk Management*, N-3618-AF, 1993.
- F. Camm, *The F-16 Multinational Staged Improvement Program: A Case Study of Risk Assessment and Risk Management*, N-3619-AF, 1993.

- K. R. Mayer, *The Development of the Advanced Medium-Range Air-to-Air Missile: A Case Study of Risk and Reward in Weapon System Acquisition*, N-3620-AF, 1993.

The Air Force sponsor for these studies is the Deputy Assistant Secretary of the Air Force (Contracting) (SAF/AQC). The work was conducted in the Resource Management Program of Project AIR FORCE.

SUMMARY

This case study was undertaken in conjunction with six others to develop a better understanding of the risks involved in weapon system development and whether government policies effectively aid in the management of those risks to reduce the probability or severity of negative outcomes. The purpose of the larger study of seven Air Force procurement programs is to provide information that might improve the decision environment in which weapon systems are procured and thus to increase the probability of positive outcomes.

This case focuses on the procurement of the Low-Altitude Navigation Targeting Infrared for Night (LANTIRN) system. This case represents the procurement of an avionics system for single-seat fighter jets. Its direct program costs equalled \$3.8 billion in current dollars, as of 1991. It represents a mixed array of technical advances, depending on the subsystem examined. The case study identifies decisions regarding risks made early in the program prior to or at a full-scale development decision. The assessments of risk and its subsequent management are then tracked to show how the early risk management decisions impacted the program.

The term risk, as used throughout this Note, is the probability that, given that an activity is undertaken, an event will occur that has negative outcomes for those involved. This case study (1) identifies acquisition practices that shape and manage risk and (2) suggests possible improvements.

LANTIRN OVERVIEW

LANTIRN was developed in the 1980s to provide terrain-following and target acquisition capability during night and bad weather conditions for single-seat fighter aircraft. The urgent demand for the system was based on a long-standing wartime need to operate tactical air flights around the clock, posing a constant threat to the enemy.

The LANTIRN program definition and initial management strategy were developed by the Air Staff, outside of the normal Planning, Programming, Budgeting System (PPBS) processes. Those advocating the program within the Pentagon described it as having low technical risk and low cost. Engineers involved with the program indicated it had high technical risk. Despite this technical risk, the program strategy called for high levels of concurrency because of the urgent requirement. The LANTIRN System Program Office (SPO) had start-up problems, compounded by poor program definition. As the program unfolded, it had severe problems meeting original expectations of cost, schedule, and

performance. The causes of these problems are many and interrelated. For example, excessive cost growth was a result of poor program definition, technical difficulties, and budget stretch-outs. The magnitude of cost growth associated with any one of these problems is impossible to determine.

IMPLICATIONS FOR THE MANAGEMENT OF RISK

Strategic decisions concerning the management of the program increased the probability of poor outcomes.

- The Air Staff translated the urgency of the wartime need for 24-hour-a-day operations into a requirement for program concurrency, increasing the risk of poor program performance.
- High-level conceptualization of the program allowed it to start up quickly and protected it from potentially onerous review but precluded the development of a detailed program definition useful to decisionmakers in determining whether the program was technically ready for full-scale development (FSD).
- In addition, the Air Staff quickly acted to gain support for the program from Congress. Members of the Air Staff gained this support based on a poor understanding of the technical advance and costs involved. This resulted in Congress and others having expectations of a low-cost and low-risk program.
- The technical requirements developed for the LANTIRN far exceeded the operational need and imposed technical risk on the program.
- The program remained understaffed in its crucial first two years when program definition and thorough technical assessments should have been undertaken.
- The SPO faced a contractor that had committed to winning the contract to dominate the market. Although the SPO knew the contract was underbid, lacking good program definition and development, it could not determine what was a realistic cost or schedule.
- Alternative management arrangements, such as a hedging strategy for the most ambitious technical advances, necessary given concurrency and technical risk, were removed from the program to reduce costs.

From this emerges a more general set of themes that might have applicability to other programs.

- The technical requirements can impose risks on programs. Better review procedures or discussions between the using command and the engineers might have prevented this.
- The technical risk in the program should be explored early on before key management strategies are set in place. Then later technical problems might be anticipated and controlled if not avoided.
- In programs with technical risk, the probability of poor outcomes increases when program management imposes concurrency or tight budgets. Although an SPO might attempt to manage technical risk with hedging strategies or further development prior to production, higher-level policies that impose other constraints such as budget reductions or contracted schedules reduce the SPO's management options.
- Early program definition and technical demonstration, prior to an FSD decision, are essential parts of a risk reduction strategy. Risk reduction should take place before the commitment to FSD as well as after.
- The program strategy is just as important as all the small tactics to reduce risk. A failure to put a good strategy in place at first significantly decreases the probability that risk will be managed well.

ACKNOWLEDGMENTS

This research would not have been possible without the assistance of the members of the Air Force Systems Command History Office and former and current members of the LANTIRN Program Office. My colleagues at RAND also offered valuable assistance and commentary: Frank Camm, George L. Donohue, Thomas K. Glennan, Michael Kennedy, Kenneth Mayer, Giles K. Smith, and Timothy Webb. Most important was the excellent assistance of Luetta Pope.

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1. INTRODUCTION

PROBLEM

Weapon system development involves the risk of failure to achieve planned outcomes. The risk of failure involves not meeting planning expectations: failure to produce the performance sought for a particular aggregation of technologies within a specific time anticipated or for the cost anticipated. This definition of risk is described in more detail in Appendix B.

These failures are felt not only by engineers and line operators who design and construct weapon systems but also by government policymakers, business executives, and elected officials. These actors are exposed to risk of loss of different magnitudes, affecting different numbers of people in different ways. But all these actors share a common need to avoid or reduce risks or to effectively manage them.

The United States Department of Defense (DoD) has investigated and tested many ways to manage risk in an ongoing effort to avoid failures. The impetus of many defense reform initiatives has been dissatisfaction with exposure to risk or actual risks incurred. This case study attempts to contribute to that effort to reduce the risks involved in the weapon system acquisition programs.

RESEARCH OBJECTIVES

The objectives of this study are to

- Identify acquisition practices and institutional incentives that shape the risk of failure for individuals and organizations; and
- Better understand the ways in which exposure to risks can be managed by Air Force System Program Offices (SPOs) and suggest improvements in current policies and practices that affect risk management.

RESEARCH APPROACH AND SCOPE

This study reviews the history of one weapon system development, the Low-Altitude Navigation Targeting Infrared for Night (LANTIRN) system. It focuses on events that reveal how risks were managed and on barriers to the management of risks. The case study materials were collected from a literature review and interviews with former officials connected to the LANTIRN procurement. The literature reviewed included newspaper,

journal, and magazine accounts; formal Air Force documents collected by the LANTIRN SPO; and other written accounts of the program, especially Air Force histories.

The technologies upon which LANTIRN is based and the technical requirements for LANTIRN date to a period prior to 1980 when the elements of the program were classified. This analysis is limited by that classification and thus provides little material before 1980. The LANTIRN procurement is ongoing—the full procurement has not taken place. However, the technology has now stabilized. Nevertheless, this study ends in 1990, prior to the full procurement.

THE LANTIRN PROGRAM OVERVIEW

Prior to LANTIRN, one-seat fighter jets could not effectively find and attack targets at night and had only marginal capability during poor weather. LANTIRN's purpose is to provide 24-hour operational capability with terrain-following (TF) and target acquisition elements during night and poor weather conditions. LANTIRN equipment includes two components: a head-up display (HUD), which provides information to the cockpit, and a fire control system (FCS), which both navigates the craft at night and in poor weather and provides target acquisition and weapons release. This report focuses on the FCS. The HUD was competed and awarded to Marconi, Ltd., in England and, with some minor mishaps, was produced.

The FCS component of LANTIRN was procured with some difficulty. The program had large cost overruns, doubled in schedule, and had performance reduced from original expectations. Nevertheless, the system is considered a success in that it substantially improves the operational capability of the force as shown in Desert Storm. The system, including navigation and targeting pods, was successfully demonstrated on F-15Es prior to the expected Initial Operational Capability (IOC) date.

In the 1960s and 1970s, the Air Force procured a large number of single-seat fighter aircraft. To maximize these fighters' operational capability, the Air Force needed an improved avionics system for all-weather flight. For example, F-4 aircraft, two-seaters, were equipped with laser target designators and rangers and precision-guided munitions such as laser- and electro-optical-guided bombs and Maverick missiles. During the Vietnam War, this allowed precision surface attacks on the enemy during daylight hours under reasonable weather conditions. But there was no night targeting capability, and sorties were limited in poor weather. Furthermore, pilots in single-seat craft had difficulty processing the navigation, targeting, and flight information, even in daytime. The Air Force desired a new

system for single-seat craft that allowed night and poor weather attacks and did not add to the pilot information-processing workload.

In the late 1970s, the Tactical Air Command (TAC) of the Air Force developed a statement of need for a system that would "provide Tactical Air Forces with an improved 24-hour capability to acquire, track and destroy ground targets with a single seat aircraft (F-16 and A-10)."¹ Implicit in this statement of need were improvements in low-level night and poor weather navigation, nighttime and poor weather target acquisition, and display technologies.² The plan was to put the system developed onto some of the F-16s and A-10s in the tactical forces. The Air Force envisioned a production run of over 700 units. It should be noted that the basic capability goals of the system were stated in terms of improvements in night and poor weather operations and did not specify any particular level of increased number of target kills per pass or the need for an automatic target acquisition and identification capability. Simply providing the F-16 and the A-10 with the ability to locate and attack targets at night and under some forms of weather obscuration was considered to be a major improvement over then-current capabilities.

ORGANIZATION OF THE NOTE

The following sections tell the story in more detail. Section 2 describes the early history of the program and the LANTIRN requirement and technology and compares the advances to pre-existing systems. This should give the reader an understanding of the technical advance that was involved. Section 3 outlines the original acquisition program, including cost, schedule, and performance estimates; contract arrangements; and competitive sources. The subsequent sections describe selected events in the program and the responses to those events. Most sections conclude with implications for the management of risk and rewards. Conclusions are then drawn. Appendix A shows important program dates to aid the reader. Appendix B provides a further discussion of risk.

¹Acquisition Plan Number 80-1A-63249F, LANTIRN, program manager: Kenneth Anderson, ASD/AERS, March 1980.

²The Statement of Need, TAF 302-79, was approved in January 1979.

2. ESTABLISHING THE REQUIREMENT AND CONGRESSIONAL SUPPORT

This section describes the translation of the desired capability improvements into a technical requirement for the LANTIRN and the technical advances demanded by that requirement.

THE OPERATIONAL CONCEPT AND GAINING APPROVAL FOR THE PROGRAM

The LANTIRN Research and Development (R&D) phase prior to 1979 was conducted as a special-access program. A LANTIRN program did not exist per se prior to 1979. Instead, a series of individual technologies was being developed in different government labs or by different contractors. Three things were needed to create a LANTIRN program: an operational concept that unified the different technologies, agreement on the program by TAC and the Aeronautical Systems Division (ASD) in the Air Force Systems Command (AFSC), and congressional support.

The unifying operational concept came from a colonel located in the Air Staff. He had access to information from different technical developments in dispersed labs that allowed him to assemble a meaningful operational concept. In 1978 and 1979, he conceptualized the different pieces in an operationally sound configuration that met the long-standing need for night and poor weather missions for single-seat aircraft. He began to promote the operational concept within the halls of the Pentagon.

The strategy for development conceived in 1978 before the TAC statement of need (1979) was simple.¹ Ford, the producer of PAVE Tack, the existing navigation and targeting system on the F-4, would be given a sole-source contract to develop an integrated navigation and targeting pod. The pod would be an improvement over PAVE Tack in that it would allow for terrain-following, automatic target recognition, and automatic weapons handoff. The PAVE Tack technology would be shrunk to meet LANTIRN specifications and automated for use in a single-pilot plane. The assumption was that these changes were technically understood although pressing the state of the art. The Air Staff estimated that the system could be developed for about \$90 million.

In August 1979, AFSC approved the creation of the LANTIRN program in ASD.² In 1979, the LANTIRN program was grouped with several other weapons systems under the

¹There are no documents that establish this conception. This information was provided by early SPO members.

²The program was formalized with Program Management Directive Number R-Q0023(1)/63249F, dated December 1979, SECRET; and AFSC Form 56, dated January 11, 1980. The acquisition

Systems Integration and Test Division, Reconnaissance and Strike Systems Program Office, at Wright Patterson Air Force Base (AFB). The division was reorganized soon thereafter, and a separate LANTIRN SPO was created on April 15, 1980, under the Deputy for Reconnaissance and Electronic Warfare (ASD/RWN). At that time, Colonel John Schafer was named to head the LANTIRN SPO. (All further discussion of program problems referring to the SPO means either the original or reorganized SPO, depending on the period involved.)

The full program would be a major weapon system acquisition and thus reviewed by Congress. Members of the Air Staff felt the best way to get the program under way quickly was to get early congressional support; therefore, they delivered a briefing to Tony Battista, a key staffer on the House Armed Services Committee. Battista agreed to support the program but with the understanding that the effort would be a technically simple matter, requiring no more than \$90 million in development in a sole-source contract to Ford. In August 1980, the Joint Conference Report of the Senate and House Appropriations Committees requested that the LANTIRN program be accelerated and provided \$60 million in funds for doing so.³ As will be seen, the program did not proceed as originally briefed to Congress by the Air Staff. This would later cause concern on the part of Congress, which had expectations matched to the original Air Staff concept.

TECHNICAL REQUIREMENT STATEMENTS

The general statement for improved operational capability was translated into a series of very specific performance requirements by the initial LANTIRN SPO prior to 1980. The original Statement of Need (TAF 302-79) with specific requirements, the Program Management Directive (PMD R-Q0023(I)63249F), and Program Direction (AFSC Form 56, No. 63249-80-53) date to this period in late 1979 and early 1980,⁴ when the program was still classified. Because of this classification, we are unable to determine the process by which the technical requirements for LANTIRN were set, but set they were by 1980.

The technical requirements called for an HUD which reported concise flight and targeting information to the pilot, and an FCS, which included the navigation and targeting units.⁵ The LANTIRN operational capability was translated into the following design goals:

plan reads, "Due to urgent tactical requirements a joint AF/RDQ, AFSC/CC, ASD/CC meeting held at HQ/AFSC on 13 August 1979 directed the establishment of the LANTIRN program." Acquisition Plan Number 80-1A-63249F, LANTIRN, program manager: Kenneth Anderson, March 26, 1980.

³Colonel John Schafer, briefing: "Program Review," LANTIRN SPO, April 15, 1981.

⁴Colonel John Schafer, LANTIRN program manager, briefing: "LANTIRN REVIEW," July 1980.

⁵The contract for the HUD was separate from that for the FCS and was bid on by a completely different group of contractors. The funds for the HUD did not come from the LANTIRN program element but from the F-16 and A-10 program elements. It was provided as government-furnished

- Ability of system to launch six Maverick missiles in a single pass, meaning locate, identify, and attack six targets in a single pass.
 - Ability of an automatic target recognizer (ATR) to correctly identify 95 percent of military vehicles, 90 percent of tracked vehicles, and 70 percent of tanks, with a 5 percent false alarm rate.
 - Ability of the ATR to command the Maverick missile to lock onto the target chosen by the pilot.
- Ability to follow terrain closely to avoid detection using a terrain-following CO₂ laser or radar ranger.
- Ability to bank aircraft at a 60-degree angle and still maintain target visibility.
- Ability to add advanced weapon guidance and advanced radar technology with minimal retrofitting.

The technical concept was to develop a pod that could be attached to either the F-16 or the A-10 aircraft for the nighttime mission and that could be updated with new technology as it came along. Thus, a major constraint was that the pod be physically compatible with both types of aircraft, imposing both weight and size restrictions on the pod.

The navigation subsystem would contain a wide-field-of-view, forward-looking infrared (FLIR) and a terrain-following radar or laser. The FLIR would display on the new wide-field-of-view HUD, sending a picture of the terrain for low-level flight during night or poor weather conditions. The terrain-following radar would warn of possible obstacles during low-level flight. The targeting subsystem would include a wide- or narrow-field-of-view targeting FLIR, a laser designator ranger, an advanced target recognizer, a Maverick handoff unit, and an environmental control unit.⁶

The technical requirements were as follows:⁷

equipment to those programs. The technical risk involved in the HUD was how to develop the "diffractive optics" for the screen upon which navigational and target information would be flashed to the pilot. Two bidders, Hughes and Kaiser, chose a conventional but still risky approach. Marconi, the third bidder, proposed an unconventional approach that offered several improvements. Marconi was chosen. There were some initial delays due to the technical difficulties, but the system was procured in relatively smooth fashion.

⁶From *Jane's Weapons Systems 1984-1985*, Jane's Information Group, Alexandria, VA, cite 4305.393.

⁷Colonel John Schafer, LANTIRN program manager, briefing: "LANTIRN REVIEW," July 1980, which shows both requirements and design goals.

- Low-level navigation capability with FLIR on the HUD and manual TF (terrain-following) capability;
- Automatic fire control;
- 1.06 μ laser designation and ranging;
- Self-contained environmental control unit to reduce overheating;
- Weight of 500 pounds for a single pod system or 750 pounds for a dual pod system; and
- Commonality: common pod for both the A-10 and F-16, common module FLIR, modified PAVE Tack laser, use Mil Std-1589A higher-order language, and Mil Std-1750 computer instruction set.

The requirement was limited to single-seat fighters—the A-10 and the F-16. The existing F-4D/E, which had the PAVE Spike system for target acquisition, was being retired from the active force. Its mission was being taken over by the F-16. The existing A-10 had the PAVE Penny targeting system. Neither system had the desired level of terrain-following capability or the improved targeting capability envisioned for the LANTIRN.

It should be noted that these technical requirements far exceeded the simpler operational needs statements. The operational need for 24-hour-a-day capability could have been achieved without requiring the system to be able to locate, identify, and attack six targets in a single pass. To locate, identify, and attack a *single* target at night or under poor weather conditions would have met the operational need and would have been a vast improvement over the capability of the F-16 and A-10.

These technical requirements would be a subject of contention later in the program, as will be discussed in subsequent sections.

TECHNICAL ADVANCE

The LANTIRN concept, as translated in the technical requirements, implied a mixture of mature and immature technologies. Some technologies, such as target acquisition laser designators and terrain-following radar, had been developed on other systems. But other technologies, for example the ATR and the CO₂ laser, did not exist even at the breadboard stage.⁸ They were conceptually valid in terms of engineering principles, but the engineering had not taken place to prove their feasibility.

⁸A breadboard, a bench-scale model, is usually required prior to a decision for full-scale development.

The environmental control unit for the system would be a very important part of the development challenge. Many of the technologies had to be shrunk to fit into the dimensions of the LANTIRN system. The smaller units would still produce heat as a by-product of their work, and this heat would be confined in a smaller area. The advanced computerization that allowed the shrinkage would be susceptible to any overheating. Thus, shrinkage of the equipment might result in heat-related overloads that shut down the system or cause malfunctions. Better environmental control was needed to meet the size requirements of the system.

The ATR was the least technically mature of the systems. Target recognition has four levels of capability in ascending order of technical difficulty. First, the sensors must be able to *detect* a hot spot. Second, the processors must *classify* the spot as a vehicle, building, or animal. Third, the processors must *recognize* the target by differentiating between types of vehicles or buildings. For example, the ATR must recognize whether the vehicle spotted is a tank, a truck, or a car. Finally, the ATR must *identify* whether the vehicle is that of an enemy or a friend.⁹

The difficulty in performing all these ATR functions comes in the processing of information within the time frame allowed by the mission.¹⁰ Target recognition, at the fourth level of identification, is routinely done by ships traveling at slow speeds and facing the potential target head-on. The "picture" taken by the sensor can be compared to other head-on pictures in its "files" and identified.

The environment facing a fighter aircraft is, however, more demanding. First, the craft approaches the target at greater speeds, reducing the time available for scanning the target, resolving the image, processing the data gathered, and aiming the weapon. Second, the sensor is scanning several targets at once, gathering limited detail or only poorly resolving the picture of the target on any one pass. Third, the craft views the target from the angle of the pass. The processor has to artificially rotate the image until it is viewed at the same angle as its "file picture" to make a positive identification. Finally, the environment might be full of deliberate interferences by the enemy. The processor must screen out the false from the real images it is receiving. Thus, the task represents a major data processing challenge, intensified by a time constraint.

⁹Description of spectrum of target recognition activities provided by Lieutenant Colonel David Wright, deputy director for LANTIRN, December 10, 1990.

¹⁰This is based on a discussion with Victor Anselmo, analyst for the Defense Planning and Analysis Department, RAND, Santa Monica, CA.

In the late seventies and early eighties, developing an ATR was a major challenge. Technical advances made in the PAVE series and in space technology indicated that the technical approach had validity. However, at that time the hardware and software for the ATR had not been developed to prove the feasibility of the system. No breadboard of the system existed. The technical challenge was to improve other systems to the point that they could process the information needed in the time available while avoiding heat problems due to the small size of equipment required.

Finally, the integration of the many subcomponents was an added technical risk. None had been incorporated in the manner proposed. The interactions of the separate systems together were an unknown. For example, there was some concern as to whether the different sensing units required would interfere with each other and with other equipment on the aircraft. All the equipment working simultaneously would generate cooling and power requirements that would stress the environmental control unit and the power generation capacity. The integration effects would remain unknown until the system was tested on an actual aircraft under realistic conditions of operation.

Comparisons to Existing Systems

The proposed LANTIRN included night and poor weather navigation and targeting and the increased processing capability of the ATR to reduce the pilot's workload in identifying and attacking targets. This represents a capability improvement over existing systems, as summarized in Table 1. PAVE Spike, used on the F-4D/E, provided day/visual target acquisition. PAVE Tack provided day/night/poor weather target acquisition and laser designation on the two-seat F-4E, RF-4C, and F-111. It was produced by Ford Aerospace and Communications Corporation, with Texas Instruments and General Electric as subcontractors. It performed well on the two-seat aircraft, but the Air Force required some improvements for use on a single-seat aircraft where the pilot's attention would be limited. To be used on an F-16, PAVE Tack would require better interfaces between components and more automatic responses, with reduced pilot inputs. It would also have to be considerably downsized.

Table 1
Comparison Between LANTIRN Requirements and Existing Systems

	PAVE Spike	PAVE Tack	LANTIRN Goal
Weight	193 kg		750
Length	366 cm		
Diameter	25.4 cm		
HUD	No	No	Yes
Terrain-following	No	No	Yes
Day tracking	Yes	Yes	Yes
Night tracking	No	Yes	Yes
Under weather tracking	No	Yes	Yes
Laser designator	Yes	Yes	Yes
Maverick	No	Yes	Yes
Automatic handoff	No	No	Yes
Target acquisition	Yes	Yes	Yes
Aircraft	F-4	F-111, F-4, RC-4	F-16, A-10
Last produced	1977	1982	Current
Producer	Westinghouse	Ford	Martin Marietta

SOURCE: Colonel John Schafer, LANTIRN program manager, briefing: "LANTIRN REVIEW," given to General Slay on July 11, 1980.

IMPLICATIONS

The Air Force need for improved navigation and target capabilities at night or in poor weather conditions had been well established prior to the LANTIRN program. It had been developed by the user, TAC, and was an urgent need based on wartime experiences. The demand for an improved system was strong.

The LANTIRN program came into being based on an urgent need and an operational concept developed at the Air Staff. The program had no demonstration and validation (demo) and no pre-existing SPO when the decision to go to full-scale development (FSD) was made. These would come after the decision to create a program and begin a concurrent strategy between FSD and production.

This manner of conception protected the program from the difficult, bottom-up decisionmaking process of program and FSD approval, where decisions pass through layer after layer of hierarchy for final approval and many programs are cut or remolded in the process. Simply put, creation at the higher level means there are fewer veto points to pass through, raising the probability of program approval. The urgent need and the high-level support from within the Air Staff ensured that the program was protected in its initial stages from the funding and turf battles to which most programs are subjected. The program was rapidly approved and begun. Risks of early cancellation were minimized.

This manner of initiation was, however, detrimental to risk management in that the program did not go through the early program development activities that might have identified the key technical risks inherent in the technical requirements and brought them to the attention of important decisionmakers prior to FSD decisions. For example, SPOs usually form prior to dem-val and use this activity to uncover the technical risks of the proposal. This risk is then documented for higher-level decisionmakers to use in deliberations on whether the program is ready for FSD and to revise technical requirements statements. On the LANTIRN program the thorough dem-val activity took place after a concurrent program was approved by the highest levels in the Air Force. The program was hoped to be low risk, and this strategy would have been appropriate if these conditions had held. As will be seen, in fact, the program had high risks and associated cost growth.

When the SPO came out of classified world, the managers did recognize the technical risk involved in the LANTIRN technical requirements and did document it, but this was only after the Air Force had established the technical requirements and high levels had agreed to a concurrent approach. For programs that are created in a more bottom-up fashion, with continuity between an R&D effort and FSD, a more thorough investigation of technical risk inherent in the requirements would be the norm prior to FSD decisions about concurrency.

This manner of formation incurred another risk that most programs do not suffer. Without a thorough understanding of the technical risk and without even a demonstration of the technology, members of the Air Staff convinced other important actors in the Air Force and Congress to back the program based on a strategy appropriate for a low-risk, mature technology not reflected in the technical requirements. This campaign to gain support almost certainly resulted in high-level actors having misconceptions about the program risk. Assured that it was a low-risk program, they supported it and funded it on an accelerated basis, expecting quick and impressive results. But, when technical difficulties occurred in meeting the requirements, these actors, especially the congressional ones, interpreted events as poor program performance and management.

3. ORIGINAL ACQUISITION STRATEGY

This section describes the original program management strategy. It provides the baseline for understanding program changes and for comparing what was planned to what was actually accomplished. Furthermore, the manner in which the program was approved created expectations about the program risk. These expectations had repercussions on the program oversight. The following discussion of the SPO refers to both the original Reconnaissance Strike SPO created in 1979 and the reorganized SPO created in 1980 that managed only the LANTIRN system.

TRANSITION TO THE AERONAUTICAL SYSTEMS DIVISION SPO—1980 TO 1981

The process of transition from a lab-based technology to an FSD program managed by an SPO is idiosyncratic at best.¹ There is no standard for the number of billets in an SPO, and the rate at which personnel are actually assigned to billets depends on the funding picture. Thus, it is not uncommon for SPOs to be understaffed in their early phases. Furthermore, the transfer of knowledge from labs to SPOs can be tenuous: lab personnel familiar with the system can be assigned to the SPO or SPO acquisition personnel can be assigned temporarily to the labs.

The LANTIRN SPO had its share of staffing and knowledge transfer problems. First, according to early managers of the SPO, the SPO did not borrow personnel from the relevant R&D facilities where the different concepts for LANTIRN had been developed. Instead, the acquisition personnel were assigned from several other existing acquisition programs and installed in the LANTIRN SPO. In addition, managers said the new personnel were inexperienced in general and specifically inexperienced in the LANTIRN technologies. According to these participants, this led to a gap in understanding the concepts involved in LANTIRN. The technical, contractual, and managerial knowledge of those who developed the R&D concepts did not transition to the new SPO. In creating the LANTIRN SPO, ASD formed a fresh team that had had little say in the advocacy for the program and limited direct experience with the specific technology. It was the job of this group to define an acquisition approach, given the requirements statements.

Second, the billets for the SPO might be designated, but actual bodies to fill the billets trickled into the SPO at a slow rate. Although this is common, participants in this process

¹Interviews with General Glenn Kent, RAND, May 1, 1991, and Colonel Hutchinson, SAF/SQPW, May 6, 1991.

said that on this particular program the results were more detrimental than usual, simply because so much work had to be done in terms of program development. This is usually not the case when programs have been developed in an integrated manner within a single lab. Thus, during the very important stage of program definition, the SPO was understaffed.

Third, and an important aspect of the LANTIRN development, the newly assigned SPO members did not agree with the program outlined by those who had sought budgetary approval for LANTIRN. In fact, the new SPO immediately began its own program definition, which turned out to be different from the sole-source, simple development effort used to garner congressional support.

The first job assigned to the SPO was to create an acquisition strategy for LANTIRN. This was accomplished and approved by Headquarters AFSC in October 1979 and incorporated into Acquisition Plan Number 80-1A-63249F, March 20, 1980. At the same time, the SPO developed a draft request for proposal (RFP). This RFP, as described below, included a competition early in the program and recognized substantial technical and schedule risk.

THREAT AND SCHEDULE

Although the need for LANTIRN was identified during the Vietnam War, the political environment of the 1980s focused on the Soviet threat. Thus, the LANTIRN requirement specified a system that could fly air-to-air and air-to-ground missions in a European war environment. The concern of the late seventies and early eighties over a Soviet confrontation and Air Force reliance on single-seat fighter aircraft explain the time requirement placed on LANTIRN. The system had an "urgent tactical operational requirement."² The documents reviewed imply the system had a high priority, and the relevant players all agreed that the system should be acquired on a fast track.

Thus, the original plan for the program, developed by the SPO in early 1980, accepted the urgent need for the system and emphasized speed in completing the program.³ Interviewees said they never questioned the urgency of the requirement but focused instead on the means for meeting it. They emphasized that at that time, SPO personnel were not encouraged to argue with the user commands about urgency.⁴

²Background and Contracting History (Section 5.0), Acquisition Plan Number 80-1A-63249F, LANTIRN: program manager: Kenneth Anderson, March 1980.

³Acquisition Plan Number 80-1A-63249F, LANTIRN program manager: Kenneth Anderson, March 1980.

⁴SPO personnel claim that the culture in the SPOs has since changed so that the SPO personnel interact more positively with the user command to determine the right fit between feasible technology and the requirement. They credit total quality management practices with this result.

AIR FORCE ASSESSMENTS OF RISK

In formal documents, the new SPO recognized high technical risk in this program as defined by the technical requirements statements. The Acquisition Plan notes that "technical risk for full-scale engineering and development (FSED) is moderate to high because of the new technology that must be demonstrated from an airborne platform and the necessity to meet stringent weight and packaging requirements. The fire control pod program involves the integration of technologies never before put into a package for high performance aircraft, and, therefore, substantial technical risk is involved."⁵

The plan notes that technical risk was being reduced by the initial design competition and the airborne demonstration early in the program.⁶

SPO officials interviewed emphasized the advanced nature of the system, especially the ATR and the concept of a CO₂ laser terrain-following capability. Each interviewee thought the technologies were too immature to include in an FSD program. In support, they each cited the fact that neither technology was subsequently developed in this or any other program despite the fact that the government and contractors have spent significant amounts of funds on the ATR and CO₂ laser developments. However, they differed in opinion as to whether these technologies should have been tried. As one said, "If we don't put it in a program, it will never be developed."

CONCURRENCY

The means to develop and produce the technically advanced LANTIRN under such urgency was straightforward: concurrency between development and production. The SPO developed a schedule for the program that would run for five years, with a 13-month overlap of full-scale development and production.

According to the original acquisition plan, FSED, lasting over 31 months with the completion of unit six, had two phases.⁷ The first phase was a competition between two contractors and included an airborne demonstration of the ATR and other critical technologies in month 14. The competition would end in a Critical Design Review (CDR) when one contractor would be chosen in month 18. Testing, however, would not be completed until 19 months after the award of Phase II and delivery of the prototypes. In FSED Phase II, the winning contractor would go on to produce the six FSED modules, the first of which

⁵Acquisition Plan Number 80-1A-63249F, LANTIRN, program manager: Kenneth Anderson, ASD/AERS, March 1980, p. 4.

⁶Ibid., p. 5.

⁷The terms used to convey program phases often vary by program. In the LANTIRN program, FSD is referred to as full-scale engineering and development, or FSED.

would be delivered eight months after the award of the Phase II contract (or 26 months after FSED began). The last would be delivered 13 months after the award of the Phase II FSED contract (or in month 31).

A production readiness contract would be awarded concurrently with FSED Phase II. The first production prototype would be delivered 19 months after the award (or in month 37 of the program), while the second and third would be delivered 23 months after the award (or month 41 of the program). This meant that production overlapped FSED by 13 months.

The full production contract would be in an option format attached to the FSED Phase II contract. Options were for a total of 195 pods, with 51 in the first lot and 144 in the second. Delivery of the production lots would commence 13 months after the exercise of the Lot I option. The delivery of the first production unit with both HUD and FCS was planned to be 51 months after the award of the FSED Phase I.

MANAGING CONCURRENCY

Concurrency can impose cost, schedule, and performance risks on a technical development in the following way. In concurrent programs, the testing of the article is often not completed before production decisions are made. Any technical flaws found during testing must be remedied in future production as well as past production articles. This retrofitting can be very costly in time and money, especially if tooling changes are required. When faced with these costs, decisionmakers often opt for reduced performance rather than a retrofit and production line change. This is appropriate as long as the reduced performance does not seriously degrade the mission capability. The key issue, then, is whether the program has probable technical risks that will become apparent in a test program. For mature programs, when the technology is well in hand, this is less likely, and concurrency does not impose a great risk. For more technically immature programs, the risk is greater.

On the other hand, completely sequential scheduling has its own costs. Producers' facilities can sit idle and urgent mission requirements might not be met.

Concurrency has been the subject of much debate in the defense acquisition world.⁸ Some early experiences with it produced excellent results, such as the early ballistic missile programs. Later efforts, such as the cruise missile, C-5A, and the DIVAD programs, showed less favorable outcomes.

⁸This discussion is based on information from Wayne Foote, Master's Thesis, *History of Concurrency: The Controversy of Military Acquisition Program Schedule Compression*, Air Force Institute of Technology, Air Force University, Wright Patterson Air Force Base, OH, 1986.

DoD and Air Force support for concurrency had waxed and waned over the years. After the C-5A experience under the Secretary of Defense, Robert McNamara, concurrency was discouraged. Review of several procurements showed it to be the cause of many problems. The Nixon administration instituted a "fly-before-buy" policy, requiring prototyping and substantial testing before a production decision. David Packard was the main proponent of this approach. However, in March 1978, a Defense Science Board study found that DoD had gone to excessive lengths to avoid concurrency, indicating concurrency should depend on the urgency and the technical risk of the program.⁹ The task force recommended several changes to the DoD Directive 5000.1 that would encourage more concurrency.

The Reagan administration encouraged concurrency to combat the perceived urgent Soviet threat. Concurrency can work under the following conditions, most of which were not met in the LANTIRN program. Some of these conditions apply to any program but more so for concurrent ones.

- The program has low technical risk. Many of the technologies incorporated in LANTIRN were immature and were recognized as such.
- The program is militarily urgent and thus has high-level support to push it through the bureaucratic mazes of the organization and reduce, by high-level exemption, the associated red tape that could slow down the concurrent schedule. The operational need for LANTIRN was strongly supported. The specific technical requirements, especially the ATR, were a subject of controversy. The LANTIRN program, after its inception, was exempted from Defense System Acquisition Review Committee (DSARC) review. Otherwise, it did not have unusual reporting procedures.¹⁰
- Highly skilled and qualified personnel lead the effort, reducing the probability of negative effects from poor management that might delay a schedule. Although the personnel on the LANTIRN program were highly skilled, they were not brought on fast enough to meet the start-up requirements of LANTIRN. The program remained understaffed for several years. In addition, the transfer of knowledge between the research and development communities was slow.

⁹*Report of the Acquisition Cycle Task Force*, March 15, 1978.

¹⁰Acquisition Plan Number 80-1A-63249F, LANTIRN, program manager: Kenneth Anderson, ASD/AERS, March 1980, p. 4.

- The program has extensive autonomy and managers have flexibility. The LANTIRN program had less autonomy and flexibility than normal because of the expectations developed early on concerning urgency and costs. Any deviation from these expectations resulted in demands for explanations. Actions were extensively reviewed.

To summarize, the LANTIRN program undertook concurrency by meeting some, but not all, of the conditions favorable to positive outcomes.

The acquisition plan recognized the risk involved in the tight scheduling. For the FSED phase, "The schedule risk is high for this program because the tight schedule planned will be jeopardized by any problem that arises from technical failures requiring significant redesign. An additional schedule risk is the delivery of material required for manufacture, including but not limited to electronics, connectors, germanium optics, casting, and gyros. At any time the delivery schedule for any of these parts can slip from three to six months due to vendor supply/production irregularities."¹¹

For the production phase, "The schedule risk is high because any technical or parts/components acquisition problems will jeopardize the schedule. The program has a high degree of concurrency and any technical problems in the latter phases of FSED will have a definite impact on the production program."¹²

CONTRACTOR CHOICE AND COMPETITIVE DESIGNS

The SPO strategy for LANTIRN was to use two contractors to develop competitive designs to demonstrate the technology. This type of competitive demonstration would normally be undertaken in the demonstration-validation stage prior to FSD but had not been done for LANTIRN. The SPO would choose between the two competing designs in the FSED Phase I, prior to the production of the six FSED units. The winner of the demonstration would produce the six FSED units.

SPO officials explained that this early competition in the design phase was a common approach at the time and was supported by written policy. SPO managers said that this competition was to encourage alternative design options, especially for the challenging ATR technology. It is basically a technical hedging strategy. Common wisdom held that early competition would encourage new and innovative technical approaches as well as provide a

¹¹Acquisition Plan Number 80-1A-63249F, LANTIRN, program manager: Kenneth Anderson, ASD/AERS, March 1980, pp. 4-5.

¹²Ibid., p. 5.

baseline of cost data to be used for program control later. Besides a baseline of cost data, SPO officials thought this approach would encourage lower-cost bids by the competitors as compared to those from a sole-source contract.

The winner of the competition would be selected based on the following criteria in descending order of importance: "technical areas, management and manufacturing, logistics supportability, and cost."¹³

CONTRACTUAL ARRANGEMENTS

In general, contractual arrangements do not impose further risk upon a program, nor do they remove risk. Instead, the contract allocates the existing risk between the parties to the contract. In the case of government contracting, the government is usually the least risk averse party—willing to accept more contractual risk to accomplish its goals. Contractors, because they are smaller and have a narrower range of projects than the government, cannot spread risk across projects as efficiently.

The above implies that contractual arrangements can be used as indicators of where risk lies in a program. First, the possibility of unplanned high-level government actions imposes risk on the program. Lower budgets than expected, program cancellation, or changes to requirements might make some part of the contractor's effort unproductive. If the contractors have invested large sums of nonreimbursable money into equipment to produce a particular design, then any changes to requirements can impose financial costs to the firm. Second, there can be technical risk in a program. This risk is increased the more the program incorporates technical advances or requires never before accomplished integrations. It is also potentially increased if a program requires commitment to production before ironing out all the technical difficulties or before the design becomes stable. In the event that the product does not perform as expected or the design changes, the contractor might be required to do extensive retrofits at its own expense. Third, there is risk of inflation and its effects on program costs. The contract cost can quickly increase beyond the estimates made.

In negotiations, the parties will assess and allocate the risks in the program. Contractual arrangements such as the contract type, the cost and price arrangements, and the special contractual terms are used to allocate these risks. Because governments are better able to tolerate large risks compared to contractors, the more these arrangements allocate risk to the government, the more likely the risk is large relative to the business base of the contractor. Significantly, these arrangements also show what risks the parties were most concerned about. Finally, the progression of contract type can indicate the degree of

¹³Ibid., p. 15.

risk involved as well. If contracts evolve from a cost-based toward a firm fixed-price contract without intervening steps, one can conclude that the parties assessed little risk left in the program at the time the fixed-priced contracts were signed. In highly risky environments, the contracts progress to fixed-price arrangements incrementally with provision for contract review to protect both parties from being tied into extremely unsatisfactory situations.

The following are rules of thumb that a contractor would use to protect its interest in a risky environment.

- Progress from a cost-based contract to a fixed-price incentive contract to a firm fixed-price contract only as technical and cost risks recede.
- Use a shareline on fixed-price incentive contracts that impose the least risk of cost overruns on the contractor, say 90/10 as opposed to 60/40, when technical or cost uncertainty exists.
- Use warranty clauses that limit contractor responsibility through time, dollar, or specification elements, when technical risk exists.
- Use engineering change proposal (ECP) clauses that allow for cost renegotiation when technical risk is high.
- Use extensive economic price adjustment (EPA) clauses when the economic outlook is uncertain or when the funding outlook appears to indicate program stretch-outs.
- Use generous indemnification, cancellation, and termination clauses when requirements and budgets appear unstable.

LANTIRN CONTRACTUAL CONCEPT

The government's proposed acquisition plan envisioned the use of fixed-cost, fixed-fee contracts in FSED Phase I. The acquisition specifications would be expressed as goals, not required standards. The plan said this "will limit the government's cost liability and will minimize the contractor's technical and financial risks."¹⁴

Phase II and the production options would have fixed-price incentive contracts with EPA clauses in the production contract. The acquisition specifications and performance requirements would be established as firm contractual requirements. The incentive contract would motivate the contractor to reduce costs.¹⁵

¹⁴Ibid., p. 15.

¹⁵Ibid., p. 16.

In total, this proposed contractual scheme of two phases and production options with no firm requirements in Phase I was thought to minimize overall risk for both parties.¹⁶ Without any specific performance conditions under the fixed-price FSED contract, the contractor would not be tied to any conditions that could lead to financial burden if technical difficulties occurred. At the same time, the fixed-price arrangement protected the government from excessive cost overruns. This proposed arrangement indicated the government was concerned over the technical risk and possible related cost growth.

COSTS

In the proposed plan, Phase I of FSED was estimated to cost \$72 million (\$36 million for each contractor). Phase II and the production options were estimated to cost \$467.9 million.¹⁷

The Acquisition Plan described the FSED and production cost risk as medium to high due to the potential technical and production problems. Some concern was voiced that if cooling and weight became problems, special parts would have to be used that might increase costs. To reduce the risk, contractor performance and cost-tracking information would be available for "in-depth program/contract management analysis."¹⁸

The Air Force, specifically the LANTIRN SPO, recognized a great potential for technical risk at the outset of the LANTIRN program, given the specific technical requirements statements. The existing ATR and the terrain-following capabilities were immature compared to those demanded by the requirements.

This technical risk associated with particular subsystems was compounded by the risk involved in the integration of the many different subsystems for the first time.

However, the possible benefit of undertaking the risk was great—a large increase in sortie and targeting capability.

The advisability of undertaking this high technical risk depended to a large extent on the flexibility and resources provided to the program manager to develop the technology. If the program management strategy was sound, the risk could be undertaken with some chance of success. On the other hand, management strategies can, and often do, impose further risk on the program.

The management plan for the LANTIRN proposed by the Air Staff and moderated by the SPO actually increased the risk in the program by proposing a concurrency strategy.

¹⁶Ibid., p. 17.

¹⁷Ibid., p. 15. Several interviewees stated that the total Phase I cost was to be \$90 million, with \$44 million to each contractor.

¹⁸Ibid., p. 5.

This concurrent approach was justified by the urgent need. But it had the potential for negative outcomes in a program with admitted high technical risks. This potential was somewhat ameliorated by management actions, including proposed prototyping.

The LANTIRN's unusual birth combined with concurrency laid the groundwork for other potential difficulties. The program, springing from many separate labs, lacked a continuity of leadership and consensus on approach. Program definition, usually undertaken prior to FSD, was accomplished in the first year of the program, when other tasks demanded attention if the condensed schedule was to be followed. Thus, the program immediately fell behind in its schedule, as will be seen.

Finally, the slow trickle of personnel into the SPO also increased the risk of problems occurring in the program due to management inattention.

4. INITIAL RESTRUCTURE, 1980

The RFP (request for proposal) was drafted and sent to contractors for formal comment but no bids in October 1979 and then sent again to elicit a formal response in February 1980.¹ Two contractors made a bid in April 1980: the Ford Corporation and Martin Marietta. The proposals submitted raised a red flag. The Air Force could not afford the program indicated by the contractors' responses.

INITIAL BIDS, BUDGET ACTIONS, AND TECHNICAL REVIEWS

The SPO had planned on a design competition between the two contractors and an award for further development based on the outcome of a critical design review. However, both contractors' initial reactions to the RFP indicated that the Phase I FSD program for a single contractor would cost between \$64 and \$66 million. A competition would not be possible within the \$90 million budget—the SPO would have to choose a single contractor from the outset.²

Ford proposed a single pod with both navigation and targeting included, which used infrared and laser-based technologies.³ Navigation would be accomplished by a terrain-following CO₂ laser and a fixed imaging navigation sensor (FINS) using a FLIR (forward looking infrared). Targeting would employ a FLIR target acquisition sensor and a laser. An automatic target recognizer, built by Honeywell, and weapons handoff were included along with an environmental control unit.

In contrast, Martin Marietta proposed two pods—one for navigation and one for targeting—which were infrared and radar based. The navigation pod used terrain-following radar and an infrared imager and FINS. The targeting pod simply used a target acquisition FLIR. It had an automatic target recognizer, built by Hughes, and a boresight correlator and tracker.

Given the price associated with the dual competition, the Air Force considered several options. The baseline option was to keep the program as described. This would cause a \$112 million funding shortfall in the out years.⁴ Option I was to reduce the program significantly

¹RFP No. F33657-79-R-0786.

²Acquisition Plan Number 80-1A-63249F, Amendment 01, September 11, 1980, p. 5.

³Description of the bids is taken from Colonel John Schafer, LANTIRN program manager, briefing: "LANTIRN REVIEW," July 1980, and conversations with SPO officials.

⁴Part of the \$112 million shortfall was from production and support cost estimates over the original budget.

by using a single contractor, deleting either the A-10 or the F-16 requirements, and buying only four R&D pods instead of six. This would bring the system in at the \$207 million approved in the FYDP. Option II was to use a single contractor but keep the rest of the program the same. This would result in a funding shortfall of \$49 million in the out years of the FYDP. Several other variations were proposed. All options assumed that the ATR could be developed within the cost bid.

"Following a series of sessions involving the contractors, the using command, and the source selection authority, a revised fire control pod acquisition strategy was developed."⁵ Option II was recommended. It kept both A-10 and F-16 capability, had a paper competition for an FSED award but required some additional funding support. This option was briefed to Headquarters/Air Force System Command (HQ/AFSC), the Office of the Secretary of the Air Force, and the Strategic Air Force during July 1980. The required parties agreed to the plan, and an order to begin an interim program "restructuring" was transmitted to Aeronautical System Division/Program Management (ASD/PM) on July 18, 1980.⁶

The SPO, now beginning to accumulate people, also turned its attention to the technical risk in the program. SPO officials recall that at this time a team was sent to review the technical risk with the two bidders, especially Ford. The team returned to the SPO to report that the technical risk of the program was quite high due primarily to Ford's laser terrain-following device and the TAC requirement for an ATR. Not only was the latter technology not available, even on a bench scale, but the compressed schedule made it unlikely to be developed within the proposed time frame. The program engineers recommended that the ATR requirement be reviewed and that the schedule be revised to provide more time. They also indicated that the program cost was unrealistically low.

The SPO briefed results of this review to General Slay, commander of ASD. The feedback was that all SPOs make these arguments: everyone always asks for more time and money. The program was to go ahead with the old schedule and plan, the ATR, and the existing performance requirements. However, some modest changes in the RFP indicate that the SPO incorporated a better understanding of the technical risks of the program while keeping with the concurrent schedule.

In July 1980, the SPO issued a revised RFP to reflect the new agreement.⁷ An amended acquisition plan described the new approach.⁸ The new plan stated there would be

⁵Acquisition Plan Number 80-1A-63249F, Amendment 01, September 11, 1980, p. 5.

⁶Ibid., p. 5. Restructuring is the term used for the development of a new management strategy.

⁷Modification Request-12, dated July 22, 1980.

⁸Acquisition Plan Number 80-1A-63249F, Amendment 01, September 11, 1980.

one contractor during FSED but required that two contractors be used for the development of the ATR. This action recognized the funding constraints but tried to keep a hedging strategy in the most technically advanced area. Airborne demonstration and a critical review in the 14th month after award of the FSED contract would determine the best ATR design. Six pods would be developed and delivered by the 26th month after award.⁹

The cost of FSED, including the six units, was estimated at \$119 million, and the production lots, totaling 300 pod sets, were estimated to cost \$757 million. The Air Force still thought in terms of eventually buying over 700 pod sets, a sizable production run for any contractor.

The plan proposed a new contract type. The FSED contract would now be a fixed-price incentive contract, exclusive of the ATR, with an 80/20 shareline and a target-to-ceiling ratio of 130 percent. The ATR portion of the development would be cost plus incentive fee, with an award fee for technical achievement. The shareline would be 90/10.¹⁰

The production readiness contract would be fixed-price incentive with an 80/20 shareline and a 130 percent ratio. The Lot I production contract would be fixed-price incentive with successive pricing¹¹ arrangements and a 90/10 shareline and 135 percent ceiling. The production readiness contract was as before, but the production lot options changed. Lot I had 34 pods, Lot II had 138 pods, and a new Lot III included 128 pods.

These new proposals indicate an increased awareness by the government of the real risks involved in the program and the likelihood of getting a contractor to agree to them. This new FSD arrangement realigned the technical and cost risks within the development. The special arrangements for the ATR show a clear recognition by the SPO of the risk involved in the ATR development and that the Air Force assumed that risk. At the same time, the arrangements for the remainder of the program indicate that the SPO thought that, without the ATR, the remainder of the LANTIRN system was substantially less risky and that the contractor had resources to bear much of that smaller risk.

Specific arrangements also indicate that the government perceived remaining program risk. Government policy allows up to a 135 percent ceiling and sharelines of 90/10 for the most risky contracts. The arrangements for the non-ATR portion come close to this allowance. The fixed-price incentive contract for the fire control pod FSD effort had an 80/20 share arrangement and a ceiling of 130 percent of target price. The cost plus incentive fee

⁹Ibid., p. 15.

¹⁰Acquisition Plan Number 80-1A-63249F, Amendment 01, September 11, 1980, p. 16.

¹¹Successive pricing means prices are fixed by agreement of both parties at certain dates or when certain cost estimates are completed. Thus, a fixed-price contract can be signed, but the price would not be finalized until later.

contract for the ATR used a 90/10 shareline, indicating a high remaining risk undertaken by the government.

In the production contract, despite the FSD program, the SPO concluded that substantial risk, due to schedule overlap and manufacturability issues, would remain in the program until well into production. The SPO determined that the risk should be borne by the government.

On the other hand, the warranty clause envisioned by the Air Force since the beginning of the program for the production pods potentially passed a great deal of risk onto the contractor. The idea was to get as close to a commercial warranty as possible. Although it would not be formalized in contract until much later, both Martin Marietta, in response to the RFP, and the Air Force were thinking in terms of a clause that would provide a range of acceptable performances. Dollar incentives would be provided for every hour of reliability obtained past the range. All pods would have to go through extensive acceptance testing. Most important, Martin Marietta would warrant the performance of all pods for two years or 400 hours of performance. Any failures in performance would be corrected by Martin Marietta, and all pods with the defect would be retrofitted. This can be considered a truly extensive warranty and one that placed considerable burden on Martin Marietta under fixed-price arrangements. However, it was not put into contractual language until the production contracts were signed much later.

THE CHOICE BETWEEN CONTRACTORS

In August, the two contractors resubmitted their proposals. The SPO comparison between the two bids focused on the following areas.

- The Ford proposal included a terrain-following laser that had not been proven, while the Martin Marietta design relied on more conventional radar and infrared.
- Ford proposed a minimum acceptable mean-time-to-failure (MTF) warranty for the production lots that was identical to that in the RFP: an upper bound of 100 hours and a lower bound of 50 hours. Martin Marietta offered a substantially improved upper bound of 140 hours and a lower bound of 70 hours.
- Ford offered the same schedule as that proposed in the RFP. Martin Marietta offered one reduced by three months but without a guarantee on the ATR.
- The best and final offer (BAFO) of Ford was \$234 million through Lot I production, while Martin Marietta's BAFO was \$242 million.

In September 1980, the Air Force awarded the contract to Martin Marietta. The planned buy was for 200 F-16s and 100 A-10s.¹² Martin Marietta would sponsor two ATR designs: one of its own and one by a subcontractor, Hughes. Interviews with SPO officials indicate that the judgment went to Martin Marietta based on the use of conventional radar, which the SPO thought would reduce technical risk, on the promise of less maintenance due to an increased MTF and on a vague feeling that Martin Marietta was committed to staying with the defense industry, providing the basis for a long-term relationship, while Ford was not.

RISKS REVIEWED

Much of the risk identified in the original acquisition plan remained in the revised plan. The ambitious requirements that necessitated the ATR were still incorporated into the program. Schedule concurrency remained, as did doubts about the costs of the program. However, some risk reduction did take place. The award of the contract to Martin Marietta reduced some technical risk by using radar as opposed to laser-based terrain-following equipment.

Officials interviewed at the SPO characterized both contractor proposals as "grossly underbid" and indicated that the SPO was aware of this at the time of the bids. However, discussions with SPO officials suggested that they felt that any contractor that agreed to a fixed-price incentive contract would be aware of the potential for cost growth. The contractor would be responsible for any cost growth above the ceiling. The Air Force would get a product whether the contractor made a profit or not. Thus, the SPO felt that the fixed-price incentive contract reduced its risk and placed the risk of underbidding on the contractor.

Martin Marietta viewed the program risks and rewards differently.¹³ It was not a new entrant into the electro-optical market, and it had just won the development of the Target Acquisition Designation System/Pilot Night Vision System (TADS/PNVS)¹⁴ for helicopters. In a strategic review, Martin Marietta management had targeted this market for development and expansion. If Martin Marietta could get the LANTIRN contract, it would dominate the market for both fixed-wing and helicopter applications and establish itself as the premier electro-optical night capability manufacturer in the country.

¹²Colonel John Schafer, program manager, briefing: "Initial Program Baseline," LANTIRN SPO, December 19, 1980.

¹³As outlined in a letter from the director of Business Operations, LANTIRN Program, Martin Marietta Electronics Systems, June 10, 1991.

¹⁴TADS/PNVS was designed for advanced attack helicopters. Martin Marietta was in sharp competition with Northrop Corporation in this market.

From Martin Marietta's point of view, the potential negative value of not meeting the price ceiling was compensated for by the potential expected value of rewards from gaining this market. Thus, its desire to capture the market overwhelmed any cost realism. Martin recognized the underbidding, but this was less a risk than not getting the contract.

The problem of underbidding was exacerbated by poor cost estimation by the Air Force. The bids, underbid as they were, included only part of the cost of the program. SPO officials stated that they had failed to include many items in the program cost estimates elicited from the contractor, seriously underestimating the scope of the program. In particular, the SPO had left many support equipment items out of the cost estimates. Thus, the bids covered only a portion of potential program costs and, for that portion, were underbid. The inadequacy of the program scope would continue to plague the SPO. A solution would have been time early on for development of more complete and realistic cost estimates. Time pressures and the concurrent approach program prevented this.

IMPLICATIONS

Once committed to a particular strategy and technical requirements, driven by military urgency and an initial underestimation of technical risk, the Air Force did not change the strategy or the requirements when new information on technical risk indicated a change might be wise. Two options were available: to reduce the concurrency or to reduce the technical advance attempted. The Air Force undertook a concurrent approach even though its own engineers said that the technology was very immature—an approach known to have some dangers. Given this strategic commitment, the SPO was either unwilling or unable to effectively advocate either change to reduce risk. Instead, it focused on changing specific contractual tactics to reallocate the risk but not significantly reduce it.

This is particularly evident in the handling of competition for the design of the system. The potential risks of concurrency were to be managed, at least in part, by a hedging strategy for the design technology. When the true costs of this approach began to be understood, the SPO deleted the dem-val competition, Phase I of FSED, from the program. The twin constraints of cost and schedule acted to reduce the technical hedging allowable in the program. The hedging was reduced to apply only to the ATR, and this strategy allowed only an internal competition between the prime and a subcontractor. This approach increased the potential for performance shortfalls associated with technical difficulties in a concurrent program instead of reducing them. No other adjustments were made to adequately manage the risk associated with concurrency.

In addition, the discussion shows that the SPO discounted the possible consequences of underbidding on the contract. Clearly aware of the underbid by both parties, the SPO allowed the contract. Although it is not possible to know exactly what the reasons for this decision were, there are at least four possibilities. First, as SPO officials have indicated, because the contractor agreed to a fixed-price contract, it would be responsible for covering cost growth. If it wanted to underbid to ensure getting the contract and was willing to take the risk of cost overrun, this was its problem and not the Air Force's. Second, the SPO might have believed that the contractor could indeed reduce its expected costs to meet the bid. Third, since there had been inadequate program definition, the SPO could not determine what a realistic cost would be (although it could recognize a clear underbid). Without this knowledge, it could not very usefully dispute the contractors' bids. Finally, the SPO might have been pursuing a "foot in the door" strategy in dealing with the administration and Congress. This strategy is commonly ascribed to government program managers, both military and nonmilitary. Whether it occurs in any given program is very difficult to verify. Observers of the procurement process have noted that the administration and Congress will be less likely to cancel or cut back a program if there are sunk costs associated with it. Thus, the sooner money is spent on a program, the better the chance of program survival. If a government agency is more concerned with program survival than eventual costs, it will undertake a procurement even if it suspects the costs will grow. Of course, for this strategy to make sense in a fixed-price contract environment, there must be some expectation that the contract will be renegotiated if the contractor faces difficulties carrying out the original contract. At any rate, any or all of the four considerations listed above might have led the SPO to accept a contract that it believed was underbid.

The contractor discounted the cost implications of underbidding as well. Its motive was strategic. It desired control over the market. The price of this control would be paid from other resources.

Thus, both sets of actors recognized the cost risk but chose to undertake it based on benefits that each felt would accrue.

5. SECOND RESTRUCTURE—1981

The initial restructuring and choice of contractors were followed by a series of individually modest problems in late 1980 through the summer of 1981 that quickly escalated into a second major restructuring in the summer of 1981. This was followed by several minor adjustments, so that by the end of 1982, the program was substantially changed to reduce and reallocate risk.

IMPACT OF FORD'S SUIT

After award of the contract to Martin Marietta, normal procedure would be to immediately have a postaward conference between the contractor and the SPO to iron out the details of the contract and set up the reporting procedures. This meeting is considered vital to ensuring a long-term exchange of information that allows a beneficial relationship to grow between the two parties. With LANTIRN, this meeting never occurred.

As a former assistant program manager recalled, the SPO team was getting on an airplane to Orlando, Florida, to meet with Martin Marietta for the postaward conference when the team received a message to cancel the trip. Ford had filed suit on October 1, 1980, in federal court against the Air Force, claiming the contract to Martin Marietta had been improperly awarded. The team was immediately called to Washington to aid in the defense against the Ford suit. The postaward conference was indefinitely delayed subject to the outcome of the suit.

In the suit, Ford claimed that the Air Force had improperly awarded the contract because it "(1) based its selection in large part on factors which were not solicitation requirements; (2) failed to point out weaknesses in Ford Aerospace's proposal in violation of the statutory mandate that meaningful negotiations be conducted; and (3) awarded the contract based on an alternative delivery schedule proposed by Martin Marietta which deviated from the delivery requirements set forth in the solicitation."¹

Due process in the federal courts led to a court decision in favor of the government and against the Ford suit on December 22, 1980. Ford was ordered to pay the full costs of the suit.²

¹"Decision of the Comptroller of United States," Matter of: Ford Aerospace and Commercial Corporation, File: B-200672, December 19, 1986.

²District Court, District of Columbia, Civil Action No. 80-2592, Plaintiff: Ford, Defendant: United States Air Force, Intervenor: Martin Marietta.

However, in the interim a great deal of SPO resources were devoted to responding to the suit as opposed to further developing the concept of LANTIRN and properly setting up the information systems that would provide the SPO with relevant information needed to monitor the contractor. Interviewees recalled numerous trips to Washington to testify on the suit, reducing their attention to daily business matters.

This activity did not threaten the program per se but had two detrimental effects in terms of increasing the risk of the program. First, the contractor and SPO delayed by approximately six months setting up the accounting systems needed to control the program. This resulted in a delay in recognizing problems. Second, the personnel resources of the SPO were absorbed in the legal activity instead of program definition and assessment of technical risks, again deferring any recognition of problems and actions until after damage had occurred.

EARLY COST GROWTH

In December 1980, the SPO produced the Program Baseline for LANTIRN in response to a tasking by Headquarters AFSC, dated November 24, 1980. Not surprisingly under the circumstances, it was apparent that the program was already beginning to slip in schedule and accelerate in cost growth.³

The schedule slipped from production completion in FY1985 (fiscal year) to completion in FY1986. This schedule slip was a result of AFSC and Headquarters review of the flight schedule. This group re-estimated the flight schedule to ensure that key technologies, including the ATR and automatic terrain-following, were demonstrated prior to production. The SPO estimated that schedule slip and poor program definition would cost an additional \$55.4 million in base-year dollars for a total program of \$721 million in base-year and \$1078.9 million in then-year dollars. The poor program definition referred to recognized growth in the costs of the advanced target recognizer and the advanced weapons guidance. These issues should have come up as part of program definition prior to award of a contract, but the fast-track schedule and shortages of personnel experienced by the SPO precluded this.

In the next few months, review of the cost estimates would also show that the early estimates had failed to include all the support equipment costs associated with the system. The addition of these costs would add to the perceived cost growth of the program. It would

³Colonel John Schafer, program manager, briefing: "Initial Program Baseline," LANTIRN SPO, December 19, 1980.

take several months to work out the magnitude of this cost increase; thus, cost estimates varied greatly in this period as the Air Force worked out more inclusive ones.

TEST CONCERNS

At the same time, an issue surfaced from outside the Air Force concerning the schedule concurrency for testing and production.⁴ The Test and Evaluation Master Plan (TEMP), submitted in December 1980, was disapproved by the under secretary of Defense for Research and Engineering (USDRE). The disapproval was based on inadequate test time in the plan to support a DSARC III decision to approve production. New initiatives to improve the acquisition process mandated a review by the Office of the Secretary of Defense (OSD) and encouraged a fly-before-buy approach, with adequate testing to prove the technology prior to production. The USDRE requested a briefing by June 1 on a more realistic schedule that would demonstrate the technologies prior to production approval.

The SPO was concerned that delays in the production decision to complete required tests would invalidate the "original acceptance of a high risk schedule" agreed to by the Air Force, the Office of the Secretary of Defense, and Congress. It began to consider other means for meeting the testing requirements, including a more ambitious test schedule or relaxing the requirements for the ATR and targeting pod while preserving the "night window" of LANTIRN incorporated in the navigation pod and HUD components.⁵

This issue of adequate testing would come up again several times over the course of the program. It is an example of two conflicting imperatives in the acquisition process coming face to face: an OSD-level imposition of adequate testing and an Air Force requirement for urgency that encouraged an opposite approach.

CONTRACTOR PROBLEMS

Lack of a postcontract award conference delayed the creation of the required cost and schedule accountability systems. During the spring of 1981, the SPO repeatedly warned Martin Marietta about the need for the cost and schedule data required by the contract. However, it was in March 1981, six months after the award of the contract, that the first cost, schedule, and performance reports from Martin Marietta came into the SPO. The news was not good. The reports indicated cost growth and schedule slips, but the documents were not detailed enough to indicate the reasons.

⁴Colonel John Schafer, LANTIRN program manager, briefing: "Program Review," LANTIRN SPO, April 15, 1981.

⁵Colonel John Schafer, LANTIRN program manager, briefing: "Program Review," LANTIRN SPO, April 15, 1981.

First, Martin Marietta had a manpower shortage. It was simultaneously working on an Army TADS/PNVS helicopter contract, and its engineers had been assigned there. It had counted on the completion of the Army engineering work prior to the start of the LANTIRN FSED so that the engineers could be transferred to start LANTIRN. Instead, the helicopter program was delayed. Martin Marietta was forced to recruit engineers nationwide, delaying the program and increasing manpower costs over the projected budget.

Second, the Martin Marietta subcontractor for the ATR, Hughes, was rapidly spending money for the development of that technology, far in excess of what was expected. As an SPO interviewee noted, "Hughes took the cost-based contract seriously." Hughes was spending money at a rate greater than anticipated and would soon run over budget.

Perhaps this event would not have been viewed as a problem if Hughes or Martin Marietta were showing progress on the development of the ATR. However, the views expressed in SPO documents show that development was not progressing as planned. Cost growth on the program was estimated to be \$33 million, with the ATR as the main contributor.⁶ Breadboards of the ATR, usually developed prior to FSD, did not yet exist, despite the expenditure of funds.

THE CONGRESSIONAL THREAT

Precipitating further problems for the SPO, OSD and Congress took several budget actions. In particular, OSD cut LANTIRN production readiness funds by \$54 million in February 1981.⁷ This led the SPO to delay the schedule for production until production readiness dollars could be restored. The delay was estimated to be about six months.

But that was only the beginning of the problems the SPO would face in justifying its program to higher levels, especially Congress. Starting about this time, both the House and Senate Armed Services and Appropriations committees began to review the LANTIRN program and voiced several concerns to the department. First, they were aware of the cost and schedule overruns of the program. It was becoming clear to staff, such as Tony Battista, that the program was not progressing as forecasted by the original sponsors. The congressional staffers implied that program mismanagement was the cause. Second, staff were concerned that the Department of Defense was inefficiently developing several different electro-optical systems for night attack. The Navy was developing the F-18 pod produced by Ford that some congressional staff thought might be a less expensive alternative to

⁶Colonel John Schafer, LANTIRN program manager, briefing: "Program Review," LANTIRN SPO, April 15, 1981.

⁷Colonel John Schafer, LANTIRN program manager, briefing: "Program Review," LANTIRN SPO, April 15, 1981.

LANTIRN.⁸ Third, and related to the first two, the congressional appropriations staff were under pressure to reduce the budget and were looking for ways to do so. Reducing the LANTIRN program and meeting the requirement with jointly developed technologies seemed a promising avenue for inquiry. Weekly activity reports of the SPO show that it was in correspondence with the different congressional staff on this issue. SPO arguments were that the F-18 pod did not have important additional technologies, such as the ATR, associated with it; thus, it could not meet the requirements.

Congressional inquiries escalated, with the SPO providing information to Dr. Kell of the Senate Armed Services Committee (SASC) staff and Tony Battista of the House Armed Services Committee (HASC) staff during May. Later in May, the HASC FY1982 budget markup reduced the LANTIRN R&D funding level from \$87 million to \$60 million. SASC continued to support the \$87 million.⁹ These interactions with Congress further drained away SPO personnel from their primary task.

LOW-RISK, HIGH-CONFIDENCE PLAN

Problems with the LANTIRN program were becoming evident to higher levels within ASD and AFSC.¹⁰ Alerted by congressional inquiries and the trickle of reports from the contractor, General Hall and Colonel Schafer visited Martin Marietta in early March to discuss schedule and funding options. They found that the targeting pod program was behind schedule by five months and that little progress was being made on the ATR. As a result of this visit, Martin Marietta was sent a "cure notice" to institute better reporting and accountability procedures.

But better information flow was not the solution to the problems that were beginning to surface. Thus the SPO, under the guidance of General Lawrence Skantze, began to work on a "low-risk, high-confidence strategy" for LANTIRN. Its details would be worked out over the course of the summer, but its general outline was apparently developed in an on-site visit by Generals Hall and Skantze to Martin Marietta in March 1981. The low-risk, high-confidence platform had four planks: (1) reduce the effort on the ATR but keep a place for it on the LANTIRN, (2) let the targeting pod schedule slip slightly, (3) get the navigation and HUD components produced as soon as possible, and (4) use an engineering change order to revise the contract schedule and raise the contract price.

⁸Weekly Activity Report, March 19, 1981.

⁹Weekly Activity Report, May 14, 1981.

¹⁰Weekly Activity Report of February 26, 1981, shows a handwritten note stamped by General Lawrence Skantze and reporting that they had begun an "in-depth review of the LANTIRN program in light of the information recently gained."

This second program restructuring gained momentum in the following months as evidence of cost growth and schedule slippage accumulated, congressional budget battles continued, and technical difficulties with the ATR were not resolved. By coincidence a required general officer review¹¹ of the program was scheduled for April. This review supported the restructure.

As briefings within the Air Force began to gel the support for the restructure, the SPO worked with Martin Marietta on interim measures. An outline of an agreement reached was formalized in a letter dated June 12, 1981, from the SPO to the contractor, requiring Martin Marietta to (1) cease all overtime effort on the target pod, (2) defer release of final drawings until breadboards were tested on high-risk hardware such as the ATR, (3) curtail full-scale development efforts on the ATR while continuing the technical demonstration (tech demo) effort, and (4) review the risks in the program and set up mechanisms to reduce them.¹²

After a comprehensive program review chaired by ASD on June 10-11, the SPO received orders to implement the restructure on June 19, 1981.

A major change in personnel accompanied the restructure. In July 1981, Colonel Schafer announced his retirement. He was replaced as SPO director by Colonel Russell Boice on August 18, 1981. Kenneth Anderson, the deputy director, was reassigned, and his position was taken by Mr. Billy Harlan on August 11, 1981.

SPO officials indicated that General Skantze, as part of the negotiations with Martin Marietta, put pressure on the contractor to replace its existing LANTIRN program managers. This was done concurrently with the SPO personnel move. Mr. Robert Jackson replaced Mr. Lenard Wroten as program manager in August 1981.

General Creech, commander of the Tactical Air Forces, was briefed on August 19, 1981, and supported the strategy. He apparently felt that too much emphasis had been placed on the rigorous technical requirements for the ATR to be able to identify tracked vehicles, and he indicated he would be satisfied with a lesser performance level. He emphasized his "strong desire to obtain a night capability-navigation pod and target pod without recognizer."¹³

Further briefings to the Air Force Council and Air Force Board were made in September, and the low-risk, high-confidence strategy was approved at these levels. Later in

¹¹As a matter of course, the general officers review the status of major programs in light of changing Air Force priorities or program problems and make recommendations for changes accordingly. These are known as general officer reviews and are scheduled periodically.

¹²Letter from U.S. Air Force, Aeronautical Systems Division, dated June 12, 1981, to Martin Marietta Corporation, Orlando division, Attention: Mr. Arthur Alhin.

¹³Weekly Activity Report, August 20, 1981.

September, Dr. Cohen of Strategic Air Force and Dr. Wade of OSD were briefed separately on the program and approved the restructure.¹⁴

This restructuring did not allay everyone's concerns about the program. Significantly, the test community was still dissatisfied. Although delays in the ATR and target pod schedule would allow testing prior to a production decision, part of the restructure called for saving budget dollars by reducing by one the number of test aircraft dedicated to the program. This saved \$3 million, but the test community was concerned that there would not be enough test assets for the program.

FURTHER CONGRESSIONAL ACTION

An amendment to the restructuring came as a result of congressional action. Dissatisfied with Air Force responses to their concerns, Congress issued a statement to the Air Force in the form of a conference report, House Report 96-546. The houses reached a compromise in November 1981 on the LANTIRN budget for FY1982. Both agreed to the \$87 million for development requested but under the following conditions:¹⁵

- The ATR was to be put in advanced development with full competition until the technology was proven.
- The Air Force would conduct a competitive hardware development program between the LANTIRN and either a product-improved variant of the Navy's F-18 pod or another existing electro-optical pod of similar capability that could meet the current LANTIRN schedule.
- The Air Force would investigate various alternatives to meet the navigation requirements for the F-16 aircraft, including modifications to the aircraft radar to provide terrain-following capability.

As a final control on the program, Congress designated the program as a Selected Acquisition Report program, with the first reporting due in December 1982.¹⁶

¹⁴Weekly Activity Report, September 10, 1981, and October 1, 1981.

¹⁵If these conditions were met, a competition between LANTIRN and the F-18 FLIR would be feasible. Dropping the ATR from LANTIRN and putting the terrain-following equipment on the aircraft instead of in the pod significantly reduced the differences between the LANTIRN and F-18 FLIR.

¹⁶Semi-Annual Historical Report—Report Control Symbol HAF-CH09AR-7101, covering July 1–December 31, 1982.

CONTRACT RENEGOTIATIONS

The projected budget and funding for LANTIRN remained very unsteady throughout 1981 and into 1982. For example, at one point in 1981, there was a \$10 million shortfall in the budget that triggered the termination clauses of the contract with Martin Marietta.

This was a fortuitous circumstance. The potential termination opened the possibility of a contract restructure without financial penalties by either party. The contractual arrangements could be changed to match the low-risk, high-confidence strategy. From Martin Marietta's point of view, this was an opportunity not to be missed.¹⁷ Martin Marietta could see that the old arrangements would cause it hardship. As the cost of the LANTIRN development exceeded the target price, Martin Marietta would bear 20 percent of the cost overruns. At the same time, the new Air Force strategy called for almost eliminating the effort on the ATR, which had become a source of considerable trouble to Martin Marietta. With the ATR removed from the contractual effort, Martin Marietta could allocate more engineering resources to fixing the relatively minor problems on the rest of LANTIRN. Furthermore, corporate officials thought the rest of the LANTIRN technology was under control.

Another issue concerned Martin Marietta. As part of the posturing over budgets in 1981 and 1982, congressional staffers had on several occasions threatened to completely cancel the program. Congress clearly intended a competition for a large part of it and a potential award to Ford. Martin Marietta's reputation was at stake as a reliable defense contractor, not only because of the performance on LANTIRN but also because of poor performance on several other programs. It needed to redeem itself in the eyes of the defense community. In addition, Martin Marietta took the congressional threats to cancel the program very seriously. As discussed above, the corporation had chosen to deliberately create a dominant position in this market. Congressional cancellation of the contract would prevent this.

Thus, Martin Marietta felt pressure to make sure the LANTIRN worked and to show both the administration and Congress that it was seriously committed to the LANTIRN program. At the same time it was under less pressure to meet unrealistic technical advances. In response to the congressional cancellation threats, Martin Marietta proposed that, as part of the restructure, a new, firm fixed-price FSED contract be developed for the LANTIRN minus the ATR. The reduced ATR would remain cost based. This meant that Martin Marietta would bear all the risks of further technical difficulties in the main body of

¹⁷Letter from Business Operations, LANTIRN Program, Martin Marietta Systems, June 10, 1991.

the LANTIRN program. However, Martin Marietta also requested a large increase in the FSED price.

As part of the on-site meetings in March 1981, a contract revision was agreed to on the basis of a handshake. On September 14, 1981, an engineering change order was issued that changed the target price of the total FSED effort to \$290.9 million, including the ATR.¹⁸ But due to unstable funding, a full contract change was delayed. Finally, on July 30, 1982, a new contract was signed.¹⁹

TECHNICAL PROBLEMS AND SCHEDULE SLIPPAGE

Further schedule slips caused by technical problems other than those on the ATR made the restructuring even more necessary. There were several problems.

First, Sunstrand, the maker of the environmental control unit (ECU), had fallen three months behind schedule due to design instability. In addition, the ECU was running over weight, a major concern from the perspective of the SPO. Its maintainability was also questionable.²⁰ Second, Texas Instruments, developer of the terrain-following radar, began to fall behind schedule because of difficulties in integrating its equipment with the rest of the navigation pod and trouble matching the traveling wave tube to the amplifier.²¹ Third, Martin Marietta was having difficulties getting the digital scan converter to produce clear pictures in the navigation pod.²² Finally, foreign military sales of the F-16 precluded delivery of test vehicles to the LANTIRN SPO, delaying the testing program.²³

It was clear that the schedule would have to be relaxed for technical reasons, but this news did not sit well with the Air Force Board.²⁴ The board was briefed in September 1981 on the restructure and told that the production pods would not be in the field until 1986. However, the F-4 laser designator capability in Europe would be phased out before that time. The board took action to review the F-4 phasedown to ensure some capability was in place until LANTIRN was ready. Clearly the urgency of the schedule was still felt by members of the board.

¹⁸Taken from *Selected Acquisition Report (SAR)*, December 31, 1982; and Colonel Boice, system program director, briefing: "Secretary of the Air Force LANTIRN Program Review," February 1982. The effort still included two separate contracts, one for the ATR and one for the rest of LANTIRN.

¹⁹Semi-Annual Historical Report—Report Control Symbol HAF-CH09AR-7101, covering July 1–December 31, 1982.

²⁰Weekly Activity Report, September 24, 1981, and December 10, 1981.

²¹Weekly Activity Report, October 22, 1981, and December 1981.

²²Weekly Activity Report, December 10, 1981.

²³Weekly Activity Report, December 10, 1981.

²⁴Weekly Activity Report, September 10, 1981.

RESTRUCTURE CONDITIONS

The following is the final configuration of the program after the restructure, congressional action, the new contractual arrangement, and briefings to Congress with its acceptance of the estimates.²⁵

The FSED was covered by a firm fixed-price contract for \$204 million. Cost performance reporting was required as part of the contract. The ATR was put under a cost plus fixed-fee contract of \$28.8 million, with a limit on government obligation. Finally, support equipment FSED was put under a separate firm fixed-price contract for \$64.9 million (not to exceed). Table 2 summarizes the cost growth on the FSD contract to this point, which included only six units.

Table 2
FSD Cost Growth as of 1982
(\$ millions)

Effort	Base Contract	Restructure	Difference
FCS FSD	\$78.4 M (FPIF)	\$204.0 M (FFP)	\$125.6 M (160 percent)
ATR FSD	\$15.7 M (CPIF)	\$ 28.8 M (CPFF)	\$ 13.1 M (83 percent)
Support equipment FSD	0.0	\$ 64.9 M (FFP)	\$ 64.9 M
TOTAL	\$94.1 M	\$297.7 M	\$203.6 M (217 percent)

FPIF: Fixed-price incentive, fixed.

FFP: Firm fixed price.

CPIF: Cost plus incentive, fixed.

CPFF: Cost plus fee, fixed.

Missing from this is the estimated production costs of the program. The options that were included in the original contract lapsed, and no production contract was signed as part of the restructure. However, Air Force estimates show that total program costs, including production of 300 sets, were close to \$2 billion, double the 1980 baseline estimate.²⁶

The schedule was relaxed from the highly concurrent one originally envisioned. The ATR was placed in advanced development. The first navigation pod delivery was delayed by

²⁵Taken from SAR, December 31, 1982; and Colonel Boice, system program director, briefing: "Secretary of the Air Force LANTIRN Program Review," February 1982.

²⁶Taken from SAR, December 31, 1982; and Colonel Boice, system program director, briefing: "Secretary of the Air Force LANTIRN Program Review," February 1982.

three months and scheduled for February 1983. The first target pod delivery was delayed by eight months to July 1983. The FCS F-16 flight tests were to be completed by December 1984. A production decision would be delayed until February 1985, allowing for adequate data to be evaluated as required by the fly-before-buy policy then in place. First production deliveries were scheduled for July 1986.

CONTINUING SPO MANPOWER SHORTFALLS

The activity level in the SPO during this period was daunting and gives an indication of the multiple and complex issues that SPO management must address. The SPO was engaged in developing a major restructure of the program, fending off congressional threats to the program, reviewing information from the contractor, and managing the complex technical development of the different parts of the LANTIRN system.

During this time the SPO staff, still understaffed, worked long hours. Boice reported that the management staff worked a combined average of 42 percent contributed overtime in August 1981. Some six individuals contributed 80 percent overtime in the month of August. Boice continued to urgently request more staff.²⁷

Given the array of tasks and the still lagging manpower, the accomplishments of the SPO are impressive. One wonders what additional manpower would have done to allay some of the crop of problems evident at this time.

IMPLICATIONS

This restructuring of the LANTIRN program brought it further away from its original conception and toward the approach advocated by the engineers earlier in the program. From 1979 to July 1982, the SPO struggled to meet the very ambitious technical requirements. It finally significantly reduced the program risk by removing the ATR from the program and reducing the concurrency. It also reallocated the risk in ways that more realistically reflected the ability of the relevant parties to bear that risk.

The restructure, however, had at least two potentially negative features, depending on one's point of view. First, it removed a significant potential performance capability from the program—the ATR. The program took the approach of allocating a space for inserting the ATR if it were ever developed. But without a dedicated program, the ATR was unlikely to be developed soon. On the one hand, deletion of the ATR was a reasonable reaction to a technology far too advanced for inclusion. On the other hand, eliminating it meant the

²⁷Weekly Activity Report, October 1, 1981.

technology might fall by the wayside, never to be developed.²⁸ Of course, both of the above potential negative features cannot be valid. The first essentially says that the program stepped away from a critical technology that should have been retained despite the risk, while the second says the program retained too much risk anyway. Hindsight indicates that the second criticism was correct. Second, with hindsight it is clear the new strategy did not go far enough. Even without the ATR, significant risk remained in the program in the form of concurrency and the remaining technical challenges. Although these challenges were far reduced from those encompassed in the ATR requirement, they were enough to force yet a third restructure of the program.

Several themes concerned with organizational processes and the ability of the SPO to manage risk emerge from this restructuring effort.

First, the undermanning of the SPO must have had some effect on the workload that could be accomplished and might be the root cause of some of the management difficulties reported by the SPO. This effect cannot be quantified, but SPO managers indicated it was clearly an important internal constraint that impacted the program risk in that it reduced the management capability of the SPO to effectively deal with risk-related issues.

Second, the importance of and time involved in maintaining OSD and congressional relations stand out. In this example, the SPO personnel were clearly pulled in two directions: managing the risks involved internal to the program between the SPO and contractor and managing the external risks evidenced by congressional budget threats, OSD oversight on test and evaluation, etc. Resources spent on one cannot be spent on the other. In the zero-sum game of using a fixed number of personnel, the SPOs can be caught in a no-win situation, where good internal relations are maintained at the price of poor external ones. A careful balance must be made.

Third, the seemingly simple process of restructuring was, in fact, very complex. The approvals needed, garnered through a yearlong series of briefings, are in themselves an indication of the magnitude of the problem of coordination in a system as large as the Department of Defense. Although the restructure could progress based on a simple handshake between the contractor and commander of ASD, the full process of approval

²⁸For the next two years, the SPO funded the ATR competition at \$2 million per year. In 1983, the Defense Science Board reviewed the concept for the ATR and flatly stated it could not be produced with the current technology. In 1985, the ATR was completely dropped from the program. Since then, the contractors have attempted to develop the ATR using Independent Research and Development (IR&D) funds and have periodically made presentations of progress to the Air Force. However, they have been unable to develop a model with performance that the Air Force approves.

required strenuous efforts by the SPO. It had to create briefings especially tailored for each audience on the way up and across the organizational ladder.

Input from OSD-level organizations and Congress were key in promoting a restructure. It was, at least in part, the concerns of the OSD-level test community that led to a more relaxed schedule, allowing testing prior to production decisions. And it was the congressional threat of cancellation that prompted the SPO to act quickly to save the program. This threat also acted as a strong incentive to the contractor to restructure the program. This is an example where oversight proved to be helpful, not a hindrance.

Fourth, the SPO and the contractor, beset by problems, looked for opportunities to reduce risk and made productive use of opportunities that presented themselves. The restructuring of the contractual arrangement due to funding shortfalls is an example. In these circumstances, both parties saw an opportunity to reduce technical risk without penalties.

Fifth, the technical difficulties encountered were not surprises. They materialized in the technologies identified early on as the most ambitious and risky. Their impact on the program, however, was exacerbated by the tight schedule and growing budget constraints.

Sixth, the SPO was being buffeted by conflicts in policies or approaches to management dictated by higher levels. For example, new policies on testing required a fly-before-buy approach. This was directly counter to the Air Force insistence on an urgent requirement necessitating concurrency. At the same time, the concurrency strategy was undermined by congressional control over the budget. Under increasing budget constraints, the technical hedging demanded of a reasonable concurrency strategy was not possible. In this period, the SPO was in a reactive state, trying to balance approaches mandated by others.

The discussion above shows the difficulties of managing risk in an environment with multiple actors, competing demands, and different perceptions of risk. Not only was the SPO confronted with pressure from above, it also had to deal with a contractor whose purposes and assessments of risks were driven by its own necessities.

6. THIRD RESTRUCTURE—1984

The program made significant technical progress in the next two years; however, it did not keep to the schedule in doing so. The slippage was due in part to technical problems, especially with the target pod, and continued budget constraints. This section describes those issues that led to a series of programmatic changes, culminating in a restructure in August 1984.

ADDRESSING THE CONGRESSIONAL REQUEST FOR COMPETITION

For the next two years the program was under continual scrutiny from Congress. The first order of business was to respond to the mandated competition between LANTIRN and the F-18 pod.

Documents dating from November 1981 show that the SPO did not seriously entertain the merit of the congressional mandate. The Weekly Activity Report that noted the congressional mandate also elaborated on reasons why the idea was infeasible. The arguments were simple: current levels of program funding would not allow a competition (the lesson learned in 1980) and a competition between Ford and Martin Marietta had already been conducted.¹

The SPO quickly prepared a study and briefed the Air Staff in December 1981. The conclusions of the study showed that any meaningful competition would require an additional \$130 million to \$390 million and would delay the schedule for six months to two years. The range of time and dollars was dependent upon who won the competition. The briefing was presented soon thereafter to Tony Battista, on the HASC staff.²

In a March 30, 1982, letter to the House Armed Services committee, the secretary of the Air Force, Verne Orr, outlined the Air Force position on the competition issue.³ The Air Force allowed that a procurement competition for the production contract could be feasible.⁴ However, the F-18 FLIR would have to be improved under a product improvement contract to meet the operational requirements. This contract would have to be funded out of the Navy's

¹Weekly Activity Report, November 5, 1981.

²Taken from SAR, December 31, 1982; and Colonel Boice, system program director, briefing: "Secretary of the Air Force LANTIRN Program Review," February 1982; Colonel Boice, briefing: "LANTIRN Program Targeting Pod Alternatives," February 1982.

³"Committees Want Competition Between LANTIRN, F-18 FLIR," *Aerospace Daily*, April 22, 1982.

⁴"AF Secretary's Letter On Competition Between LANTIRN, F/A-18 FLIR," *Aerospace Daily*, May 6, 1982, p. 30.

F-18 program, not LANTIRN. If Congress appropriated the money, the competition would continue. The Air Force scheduled a competition fly-off for the last quarter of 1984.

The idea of the competition died out shortly thereafter. First, Congress never appropriated the money for the product improvement for the F-18 FLIR, and the Navy refused to let a contract until the funds were appropriated. Second, Ford, when approached about a product improvement and competition, was not interested. It saw a low probability of a long-term production contract coming from such a venture and refused the idea.

However, the reaction of the Air Force left some congressional staff bitter. The perceived poor reaction to the congressional mandate would come up again as reason for cutting the program. For example, the FY1983 budget hearings in Joint Committee indicated that the HASC thought the competition was not carried out in a timely manner.⁵

TECHNICAL PROGRESS

During this period, the development proceeded, but not as scheduled. The first delivery milestone of both the navigation and targeting pods occurred on schedule, and the SPO took heart in this accomplishment. Meeting this milestone was a brief respite from a series of problems that plagued the program from 1982 to 1984.

First, a briefing to the secretary of the Air Force in early 1982 showed some significant user concerns about the program. A LANTIRN simulator had not been directed or funded. Furthermore, an Integrated Logistics Support System Plan had not been developed, hindering orderly and timely development of system support.⁶

Second, acceptance testing on the FSED pods uncovered technical problems. The SPO and Martin Marietta had worked out a stringent test program to ensure that the pods met the warranty requirements. In the previous restructures of the program and in subsequent ones, the SPO held the contractor to the proposed warranty that had helped Martin Marietta win the original competition with Ford.

Weekly Activity Reports show that acceptance and flight tests uncovered a series of problems with the pods.⁷ Within the navigation pod, the terrain-following radar continued to have some problems with the power supply, and the FLIR's performance tended to be erratic during different flight maneuvers. Target pod problems were more severe. Operation was

⁵"Committees Want Competition Between LANTIRN, F-18 FLIR," *Aerospace Daily*, April 22, 1982, p. 306.

⁶Taken from SAR, December 31, 1982; and Colonel Boice, system program director, briefing: "Secretary of the Air Force LANTIRN Program Review," February 1982.

⁷Weekly Activity Reports, July 14, 1983; July 28, 1983; September 1, 1983; September 8, 1983; September 15, 1983; and November 10, 1983.

erratic whenever it was hooked to the power supply, circuitry and wiring problems were frequent, excessive noise on the FLIR delayed acceptance testing and integrated flight tests, and fluid leaks showed up during flight tests. The missile boresight correlator did not work as planned. It was not until the fall of 1984 that this latter technology was demonstrated.⁸

Finally, Initial Operational Test and Evaluation (IOT&E) testing on both pods was slow due to difficulties in integrating the software used to compare performance of the aircraft without the pods to performance of the aircraft with the pods. This system was being developed by General Dynamics and the System Integration Laboratory, not the LANTIRN contractors.

The SPO and contractor solved the relatively simple problems with the navigation pod. For example, it was discovered that the navigation pod required structural changes. Fiberglass doors had to be replaced with aluminum ones, requiring an engineering change order in August 1983.⁹ The navigation pod stayed on schedule.

However, the FSED target pod deliveries began to slip schedule. They simply could not pass the acceptance test. Noise on the FLIR and fluid leaks prevented their even being tested.

By November 1983, the program difficulties had caused a significant schedule slip. The production decision was delayed until February 1985. First production deliveries were not expected until December 1987 and an IOC date was estimated for FY1989.¹⁰

THINKING ABOUT PRODUCTION

Despite this slippage, a draft production RFP was scheduled for September 1983.¹¹ The SPO wanted a sole-source contract with Martin Marietta, using a fixed-price, incentive contract with fixed costs and not to exceed provisions. The SPO wanted to get the RFP out prior to October 1, 1983, when Public Law 98-72, which affected sole-source contracts above \$1 million, went into effect.

In formal reviews of the RFP, the Air Force Headquarters and the Office of the Secretary of the Air Force proposed other approaches, including possible leader/follower arrangements, dual sourcing, and successive cost targets.

The sole-source RFP was approved in October 1983 with one major change. A proposal was expected in December 1983. Air Force Headquarters inserted language that said that

⁸*Semi-Annual Historical Report, July 1, 1984, to December 31, 1984, May 2, 1985.*

⁹Weekly Activity Report August 4, 1983.

¹⁰Briefing: "LANTIRN Program Status," presented to the Honorable Thomas E. Cooper, December 8, 1983.

¹¹Weekly Activity Report, September 8, 1983; September 28, 1983.

the production options could not be exercised without the specific approval of the Air Force Selected Acquisition Review Council.¹² The contractor responded in November and added cost data in December. This did not mean the issue of dual sourcing disappeared. On the contrary, the Air Force Headquarters still expected some response from the LANTIRN SPO on this issue prior to exercising any production options.

The SPO proceeded with developing production contracts with Martin Marietta. The SPO and contractor reached agreement in April 1984 on a six-year program to produce 720 pod sets. A fixed-price, incentive fee contract had a tentative target price, in then-year dollars, of \$2.9 billion and a ceiling price of \$3.1 billion with successive targets.¹³ Successive targets means the actual prices would be determined in detail at an agreed-upon future date based on more complete information but using an agreed-to cost-based formula. The bottom line is that the target and ceiling prices could grow but only within certain bounds defined by the actual costs of specific input variables at the time of the successive target date.

This contractual arrangement potentially increased the risk to Martin Marietta in that it was a fixed-price arrangement with a relatively smaller difference between the target and ceiling. Cost overruns would have to be paid for by the contractor. On the other hand, it called for successive targets. This reduced the risk in that better information would be available upon which to set a firm price.

BUDGET CONCERNS

The year 1982 opened with significant budget problems. The projected FY1984 and outyear funding did not match the directed program.¹⁴ R&D was short by \$61 million, and production had a shortfall of \$328 million in then-year dollars. The SPO estimated this would cause a further schedule delay of one year. Cost growth of the December 1980 baseline compared to January 1982 was \$467 million and inflation was \$391 million, with total program growth at \$858 million. The program cost had more than doubled.

The Air Force took its own internal action. General Gabriel, then chief of staff of the Air Force, imposed a cost cap on the program.¹⁵ The cost of the program was not to exceed

¹²Memorandum for the Record, October 20, 1983.

¹³Colonel Fain, briefing: "LANTIRN Production Program Restructure," August 28, 1984.

¹⁴Taken from SAR, December 31, 1982; and Colonel Boice, system program director, briefing: "Secretary of the Air Force LANTIRN Program Review," February 1982.

¹⁵The exact timing and date of the cap is vague; no documents provide them. A Weekly Activity Report for September 1983 notes its existence. General Gabriel came into that position after July 1982. Thus, it was some time between July 1982 and September 1983 that the cap was imposed. SPO officials disagree on the amount. It apparently changed to adjust for inflation.

\$3.98 billion in then-year dollars for a total buy of 716 pod sets and HUDs.¹⁶ This had no legally binding effect on the program but served notice to Congress and the SPO that cost growth would be controlled by Air Force Headquarters if it could not be controlled from below. At the same time, it notified Congress that the Air Force expected to buy 700, not just the 300 that it had developed options for in the original contract.

SPO officials noted that the cap did not have a large effect on the program. It did change the way briefings and progress reports were put together. These focused on the differences between the cap and actual spending or projected budgets. It allowed the SPO to articulate the differences against a set target.

In FY1984 budget deliberations, the House made a full-fledged attack on the program by denying any funding authority. In contrast, the Senate authorized the full amount requested. In conference, both sides expressed concern over the cost growth of the program and the lack of competition in production, despite the fact that Congress had not appropriated funds for it.

In August 1983, the Congressional Joint Authorization Committee Conference Report ordered the LANTIRN program slowed. The conferees believed that the program underwent excessive cost increases. Congress required a tangible demonstration of system performance and cost stability before production funding would be authorized. The committee did not dispute the LANTIRN requirement but questioned its affordability. It restricted the program to demonstration, test, and evaluation only, with no authorization for production readiness or production funding.¹⁷ Congress ordered the Air Force to submit by April 15, 1984, test and evaluation results and cost estimates. Future support would be contingent upon these results. The report also reduced the LANTIRN program in FY1984 by \$30 million, from \$89.892 to \$59.892 million, primarily in the area of support equipment.¹⁸ This resulted in a restructuring of the support equipment development program, slipping the schedule for six months.¹⁹

¹⁶Briefing: "LANTIRN Program Status," presented to the Honorable Thomas E. Cooper, December 8, 1983.

¹⁷The FY1983 production funds were frozen and \$4.5 million in FY1984 production funds were cut. Briefing: "LANTIRN Program Status," presented to the Honorable Thomas E. Cooper, December 8, 1983.

¹⁸*Semi-Annual Historical Report, January 1, 1984, to June 30, 1984*—Report Control Symbol HAF-CH09AR-7101, January 24, 1984.

¹⁹Briefing: "LANTIRN Program Status," presented to the Honorable Thomas E. Cooper, December 8, 1983.

QUESTIONING THE PROGRAM QUANTITIES

Within this same period, the Air Force was reviewing its need for fighter aircraft and the missions they would fly. From the beginning, the need for LANTIRN depended on the need for night and poor weather missions for the F-16 and A-10.

The Air Force had two concerns. First, in its day-to-day operations of aircraft, it now favored the F-15E over the A-10. Second, the Air Force was evaluating the number of missions that it could expect to fly in the European theater, especially under wartime conditions.

These deliberations had an immediate impact on the LANTIRN program. First, the A-10 LANTIRN system was no longer felt to be urgent. Instead, the Air Force ordered the SPO to consider whether LANTIRN would be feasible on the F-15E. Second, while at one time the Air Force had considered putting LANTIRN on the entire F-16-C/D fleet, it now considered it unnecessary. It reduced its proposed future F-16 requirement for LANTIRN to 250.

According to SPO sources, these deliberations on requirements had little to do with the performance or the cost of the LANTIRN system. They were based on TAC assessments of aircraft preference and mission requirements.

Thus, while the LANTIRN SPO was struggling to meet budget constraints, it was greatly helped by the reduced number of pods now advocated by the Air Force. Although unit costs might increase, the total program budget projections decreased. On the other hand, the pods' design had already been optimized to match that of the A-10. Switching to the F-15 required some redesign to optimize performance on the F-16 and F-15. For example, when the pods were attached to the F-15, the craft experienced low-frequency buffeting that caused excessive vibrations. The pods had to be retrofitted to accommodate the operational characteristics of the F-15. This added to the technical problems that the SPO and Martin Marietta were facing.

ACCEPTING THE NEED FOR A FURTHER RESTRUCTURE

In 1984, the schedule on the target pod slipped further as tests continued to show problems with the FLIR and fluid leaks. On the other hand, the navigation pod completed full IOT&E flight trials, demonstrating the full performance levels required.

Congress continued its overtures about cancelling the program. The SASC warned the Air Force that it might consider cutting back on the program or cancelling it altogether if

delayed procurement caused cost increases in the program above the self-imposed cap.²⁰ The favorable budgets of the late 1970s and early 1980s were coming to an end. The budget wars were heating up. Although reluctant to terminate programs completely, staff in both arms of government were looking for programs that could be stretched out, delaying decisions and funding.

On May 3, 1984, the Pentagon announced a budget cut in FY1985 of \$13.9 billion. LANTIRN was targeted in the cut.²¹ On July 20, 1984, a Program Decision Memorandum (PDM) formally reduced the LANTIRN program's budget.²² The SPO was forced to reevaluate the program schedule. Survival depended on cutting the number of pods or stretching out the program.

Some leeway was provided by the changed aircraft requirements. Pods for the A-10 could be delayed. The number of F-16 pods could be reduced. But the F-15 addition brought the total number of pods required back up to the 700 planned previously under a delayed IOC (initial operational capability). These manipulations, however, were not enough, and further changes had to be made to fit the budget constraints—slipping the target pod was an obvious choice. But some SPO personnel considered the proposed slip between the two pod schedules to be disastrous. The pods had always been thought of as an integrated package. Certainly all the program documents had treated them as such. For example, no separate pricing had been done, and the number of units had always been listed as pod sets. Thus, some felt that any discrepancies between schedules reflected badly on the program.

In particular, Colonel Dobrzelecki, the SPO manager, wanted to make sure the target pod schedule remained connected to the navigation pod schedule.²³ As it slipped, he pushed SPO personnel and Martin Marietta to work overtime to get the two back together.

The high level of activity to get the target pods accepted can be understood in another regard. During the summer of 1984, several VIP visits were scheduled to promote the program. For example, General Welch was scheduled to fly the F-16 in July with LANTIRN integrated into the system.²⁴ Generals Cunningham and Philips were scheduled for later in the summer. These attempts at displaying the accomplishments of the system were destined

²⁰"Air Force Presses LANTIRN Testing, Production Despite Cuts," *Aerospace Daily*, Friday, June 8, 1984, p. 217.

²¹"Air Force Presses LANTIRN Testing, Production Despite Cuts," *Aerospace Daily*, Friday, June 8, 1984, p. 217.

²²PDM 0023(10)27249F.

²³Colonel Dobrzelecki took over after Colonel Boice retired in November 12, 1982. SAR, December 31, 1982.

²⁴Weekly Activity Report, July 19, 1984.

for failure. The target pod remained unready. Although the navigation pod performed well and was praised, the missing target pod stood out.

From July 26 to 27, 1984, SPO personnel met with Martin Marietta managers.²⁵ Caleb Hurtt, president of Martin Marietta Aerospace Division, was present to reaffirm a commitment to providing a target pod that met all performance specifications by December 1, 1984.

General Lawrence Skantze, head of AFSC (Air Force Systems Command), demanded briefings from Colonel Dobrzelecki on how to restructure the program. Colonel Dobrzelecki was concerned about keeping the schedules of the two pods linked. In his mind the connection between the two was important. Any deviation would reflect badly on his leadership. He proposed other alternatives, such as production stretch-outs, and advocated pushing hard for increasing the funding.

General Skantze was less wedded to the pod linkage and was not in favor of asking for more money. The target pod simply was not ready for IOT&E testing, required before any further progress. In a series of briefings over the summer, General Skantze continued to push Colonel Dobrzelecki on this issue. Eyewitnesses to these meetings report that General Skantze gave clear indications that he preferred decoupling the pod schedules. Colonel Dobrzelecki rejected this.

On a weekend in August, General Skantze took his own action. Colonel Dobrzelecki was removed from the program on a Saturday, and a new SPO head, Colonel Fain, was installed by Monday. Colonel Fain immediately restructured the program.²⁶ Colonel Fain was a test pilot with the fighter community and had been on the LANTIRN program in its early stages and had helped set up the test program. He also had an engineering degree. Later, he had been moved to a different SPO, but he came back to LANTIRN as its head to replace Colonel Dobrzelecki.

THE NEW PROGRAM

The restructure had the following characteristics.²⁷

- The A-10 program was slipped to outyears to compensate for the FY1984 program reductions.

²⁵Weekly Activity Report, August 2, 1984.

²⁶Fain was assigned August 6, 1984.

²⁷*Semi-Annual Historical Report, July 1, 1984, to December 31, 1984*, May 2, 1985. SAR December 31, 1984. Colonel Fain, briefing: "LANTIRN Production Program Restructure," August 28, 1984.

- The target pod was delayed one year. A new schedule for testing had flight tests continuing through September 1985 and IOT&E tests from September 1985 to December 1985.
- Navigation pod production would begin in FY1985, with first delivery in February 1988 and final delivery in June 1992. Full ramp-up would be to 20 pods a month by March 1990.
- Target pod production would begin in 1987, with first delivery in February 1989 and final delivery in February 1994. Full ramp-up would be in the fall of 1991.
- The budget would be constrained to the base-year cap of \$2.31 billion.
- The number of pod sets would be reduced to within funding, approximately 650 sets. These would include only 250 F-16s. The F-15E would now be equipped with LANTIRN.

A new contract now needed to be negotiated. Colonel Fain decided to use change orders and options added onto the existing contract. This contract activity was scheduled for completion in April 1985.²⁸

Part of this restructure, as before, was to persuade Martin Marietta to replace its management of the LANTIRN program. Allan Norton replaced Paul Willis as director of the LANTIRN program at Martin Marietta in 1984.

In addition, Fain forced the contractor to agree to special contractual arrangements. The contractor had to agree to demonstrate signs of progress before any further production decisions would be made. These were scheduled about every three months. Slippage from progress did not re-open contract negotiation but simply slid a production decision.

IMPLICATIONS

Several themes from the previous restructures repeated themselves during this period.

First, the activities of external or internal higher levels had a tremendous impact on the program. Congressional relations, the changed budget milieu, and revisions of aircraft requirements all changed program risks. The changed requirements increased the technical risk while decreasing the cost of the program. The budget climate increased the risk of program cancellation.

Second, none of these changes was directly controllable by the SPO, indicating a limit to the ability of an SPO to manage risk effectively. For example, although the SPO could exert some influence to protect its own budget, in fact all the other SPOs would be doing

²⁸*Semi-Annual Historical Report, January 1, 1984, to June 30, 1984, August 2, 1984.*

likewise. The reduced budgets of this period would have their effect no matter what actions the SPO took.

Third, it became increasingly difficult in this complicated situation to trace cause or effect. Both technical difficulties and budget concerns worked together to cause slips from projections. To extricate the exact cause of a particular slippage or cost overrun was quite impossible as decisions had to reflect a balance of all these factors.

Fourth, external and internal scrutiny of the program, given previous expectations, began to drive management concerns. It is exactly at this point in FSED when technically advanced programs usually develop problems and search for solutions. If addressed prior to production decisions, the more cost-intensive rest of the program should have less slippage.

However, in this program, external scrutiny compared the actual performance to unrealistic promises made at the beginning of the program. Thus, normal technical difficulties became public relations problems of great magnitude and threatened the continuation of the program. Any further delays or problems in the testing program caused concern. Internally, the effect of this type of oversight created an incentive structure within the SPO that influenced the decisions made. This is most clearly seen in the reluctance of SPO leadership to decouple the pod schedules. Despite the apparent reasonableness of the action, the SPO feared that outsiders would consider it as one more sign of failure.

7. RELATIVE PROGRAM STABILITY—1985 TO PRESENT

Since the 1984 restructure, the program has remained relatively stable with steady, but slow, progress toward its goals. There have been no major restructures. However, the program has had some significant difficulties and changes.

PRODUCTION CONTRACTS

The program difficulties were finally taken into account with a production contract that allowed a great deal of flexibility on both sides while maintaining the firm fixed-price nature of the contract.

The production contracts are now firm fixed price. They now include an extensive series of options for units with associated prices connecting the total cost of the contract to decisions about which options are exercised. This allows flexibility in the face of the budget roller coaster.

Three clauses are particularly important. First, a clause, as indicated above, requires the contractor to show progress according to a milestone schedule. If the contractor slips from the schedule, all subsequent milestones slip the same number of days. The contract cost clauses cannot be re-opened for negotiation because of contractor slippage.

Second, given the problems with the budget, the government is allowed to exercise the options as long as it has at least 90 percent of the funding for each fiscal year. Price renegotiations cannot be opened unless the government funding falls below this point.¹

Third, the strict warranty clause covers all failures in equipment, including inability to meet the performance requirement, nonconformance with design specifications, and inability to perform function. The period of warranty is two years or 400 hours of operation. Martin Marietta must replace all failed items and retrofit any existing items with potentially similar problems. A 20-hour production reliability test must be performed on all items prior to acceptance.

INTERACTION BETWEEN CONTRACTUAL ARRANGEMENTS AND PRODUCTION

The production contract set the stage for some major redesigning of the pods. The contractor had built the six sets of FSD pods largely by hand, using relatively few highly skilled craftsmen. As a result, the pods passed the acceptance tests and were well on their way toward completion of all required flight tests. However, they had not met the reliability

¹Section H, Clause 5.

criteria promised by Martin Marietta in its original proposal or in the production contracts that the Air Force was developing, and they were far too expensive on a unit basis to meet the firm fixed-price arrangement.

The cost target level of the production contracts required more automated manufacturing. The high cost associated with the hand-built FSED pods could not be sustained under the cost targets. If the contractor was not able to transition to automated manufacturing to cut down unit costs, it would be forced to forgo its profits and might even forgo some operating funds.

Furthermore, the pods had to meet the reliability criteria of the warranty, or the contractor would have further cost-containment problems.

Thus, the challenge to Martin Marietta for the next few years was to reduce the per unit cost of producing the pods and make sure they could pass the warranty tests. The first few pods to come off the production line failed the reliability tests abysmally. Several subsystems within the pods had to be redesigned. Efforts at this began immediately.

For example, the printed wiring boards used throughout the system had been made by hand, but when machined they tended to fracture and could not pass the required acceptance tests. These had to be redesigned. The choice was to make a heat sink using copper or kevlar boards. Copper might add to the weight, while kevlar had few reliable manufacturers. They chose to go with the kevlar.

Similarly, the navigation control pod had over 21 wiring cards. Martin Marietta and the subcontractor, Delco, approached the Air Force with a plan to reduce the number of cards. The Air Force approved because the plan, if feasible, would make the pod easier to maintain. Delco had some difficulty accomplishing this task but eventually succeeded.

Officials at the SPO thought that the fixed-price contract created a win-win situation. It forced the contractor to re-evaluate its design for manufacturability. This eventually produced a more maintainable product for the Air Force. Martin Marietta had a strong incentive to accomplish this because of the fixed-price nature of the contract. If it was able to meet the contract, it achieved the profits it had projected. Both parties won.

AIR FORCE CONCESSIONS

The Air Force had to make concessions to keep to the schedule. For example, one manager reported that a computer subassembly the Air Force wanted could not be produced fast enough. It chose to go with a less sophisticated one that could be produced to meet the schedule and could be upgraded later.

In some cases, the Air Force also had to concede on the performance of the pods. For example, the first nine target pods could not pass the required tests. Martin Marietta worked the problems for a year and a half, from June 1987 to December 1989. Finally, it sent pod number 11, supposedly fixed, for acceptance testing. The pod did not pass. In this instance, the SPO approached TAC and asked for the requirement to be reduced. The LANTIRN system could hit one target with each pass, as opposed to the original requirement of six per pass. TAC agreed that the performance achieved was adequate; in fact, it was an improvement over what it could perform previously.

Finally, the program had been scheduled to have a rapid ramp-up to 20 pods per month. The contractor was not able to meet this ramp-up, especially as the target pod came on-line. The Air Force readjusted the schedule to match the realities of the situation.

REQUIREMENT AND COST CHANGES

Major initial milestones were largely met, while production schedules have slipped considerably.² The navigation pod continued on schedule with an Air Force System Acquisition Review Committee (AFSARC) III production decision in February 1985 and first delivery in March 1987. Target pod difficulties were resolved by the end of 1985 and IOT&E was begun. An AFSARC III low-rate production decision was made in May 1986, and high-rate production was approved in November. By the end of 1986, the target pod had successfully completed all IOT&E testing. In 1988, the first production target pod was delivered. Testing of the pods for weapons handoff continued through 1988, and other tests continue even now.

The aircraft requirements changed. The A-10 was dropped from the program completely. In addition, the number of F-15 pods fell because of budget constraints. This left a requirement for 700 pods, of which 392 would be on F-15s and 300 would be on F-16s.³ The rest were for testing. The Air Force did not get the FY1988 funding it requested for F-15s and thus reduced the number of LANTIRNs required for F-15s.

In 1989, the SPO and contractor agreed to a buy of 628 pods. The Bush administration subsequently reduced the budget, and the sets were reduced to 562 pods to be delivered by 1993.⁴

Further budget activity has left the program bouncing along, changing required aircraft pod numbers frequently but not drastically. The contractor has been unable to meet

²*Selected Acquisition Report*, December 31, 1988.

³"LANTIRN Approved for High-Rate Production," *Armed Forces Journal*, January 1987, p. 120.

⁴History Office, Air Force Systems Command, *History of Aeronautical Systems Division*, January-December 1989, Vol. I, p. 34. *Acquisition Program Baseline*, March 29, 1990.

the ramp-up requirements envisioned. Thus, production lags behind schedule. As of 1990, approximately 100 navigation pods and 32 target pods were produced.

Costs of the program remain uncertain, but it appears to be experiencing little cost growth.⁵ Base-year cost estimates (in 1980 dollars) are \$403.6 million for Research, Development, Testing, and Evaluation (RDT&E) and \$1,873.2 million for production, with total procurement at \$2,276 million. In then-year dollars, total procurement is \$3,801.3 million. Table 3 summarizes the 1980 baseline data as compared to those of the 1990 program.

⁵*Acquisition Program Baseline*, March 29, 1990.

Table 3
Comparison of Baseline to 1990

	1980	1990
Contract Type		
FSD	FPIF	FFP
Production	FPIS ^a	FFP
Quantity		
A-10	100	0
F-16	200	300
F-15	0	262
Total	300	562
Cost (\$ 1980 millions)		
RD&E	224.7	403.6
Production	483.9	1873.2
Total	708.6	2276.8
Schedule		
Program initiation	December 1979	December 1979
First delivery		
Nav pod	July 1982	February 1983
Tar pod	July 1982	July 1983
Production decision		
Nav pod	January 1982	March 1985
Tar pod	January 1982	May 1986
First production		
Nav pod	August 1984	March 1987
Tar pod	August 1984	July 1988
IOC		
Nav pod	March 1985	September 1990
Tar pod	March 1985	September 1991 ^b

SOURCE: Colonel John Schafer, briefing: "Initial Program Baseline," LANTIRN SPO, December 19, 1980. Jefferey Drezner and Giles Smith, *An Analysis of Weapon System Acquisition Schedules*, RAND, R-3937-ACQ, December 1990, pp. 142-151.

^aFPIS: Fixed-price incentive, successive.

^bAlthough the targeting pod was used in Desert Storm prior to September 1991, this did not represent initial operational capability.

8. CONCLUSIONS

This case is on the procurement of the Low-Altitude Navigation Targeting Infrared for Night system developed in the 1980s to provide terrain-following capability and target acquisition during night and bad weather conditions for single-seat fighter aircraft. Demand for the system was based on a long-standing need identified by the using command as urgent.

- The Air Staff translated the urgency of the wartime need for 24-hour-a-day operations into a requirement for program concurrency, increasing the risk of poor program performance.
- High-level conceptualization of the program allowed it to start up quickly and protected it from potentially onerous review. Moreover, the decision to go ahead with the program as conceptualized was made prior to a technical demonstration and formal technical risk assessments. This beginning precluded the development of a detailed program definition useful to decisionmakers in determining whether the program was technically ready for full-scale development (FSD).
- In addition, the Air Staff quickly acted to gain support for the program from Congress. Members of the Air Staff gained this support based on a poor understanding of the technical advance and costs involved. This resulted in Congress and others having expectations of a low-cost and low-risk program.
- The technical requirements developed for the LANTIRN far exceeded the operational need and imposed technical risk on the program.
- The SPO remained understaffed in its crucial first two years when program definition and thorough technical assessments should have been undertaken. In addition, SPO personnel time was taken up with a lawsuit by a competing contractor. The result was that important decisions were made with little information or were delayed.
- While the program was conceptualized under favorable budget conditions, it had to be carried out under tighter budget constraints, which slowly eroded the funding available to the program. Budget fluctuations and squeezes affected the management of risk. Initially, budget constraints caused the SPO to increase program risk by eliminating a technical hedging strategy. Later, further budget constraints caused the SPO to completely eliminate the Automatic Target

Recognizer, greatly reducing technical risk on the program but also seriously reducing the performance potential. Throughout the program, budget instability caused the SPO a great deal of concern and consumed a great deal of SPO time as it reacted to save essential parts of the program.

- As part of a planned corporate strategy, Martin Marietta had committed to gaining a further share of the electro-optical market. To do so, it seriously underbid the LANTIRN contract. The SPO faced a contractor that had committed to winning the contract to dominate the market. Although the SPO knew the contract was underbid, lacking good program definition and development, it could not determine what a realistic cost or schedule was. Thus, it committed to the contract.
- Alternative management arrangements, such as a hedging strategy for the most ambitious technical advances, necessary given concurrency and technical risk, were removed from the program to reduce costs.

In conclusion, the program was initiated at high levels in a manner that led to increased program risks. These risks were knowable in advance of the decision to proceed to FSD. The management strategy for LANTIRN was developed at the Air Staff level without a thorough technical and risk assessment and with technical requirements that exceeded the operational need. A strong congressional commitment was forged without this needed information. Strategic decisions were made by these actors that introduced concurrency, cost constraints, budget fluctuations, changed quantity requirements, and high technical risk on the program. Lower-level SPO management attempted tactical changes to reallocate this risk and eventually reduce it but was hampered by a commitment to an unwieldy strategy. Risk management flexibility was reduced by policies made outside the SPO and imposed from above.

Appendix A
CHRONOLOGY FOR LANTIRN PROGRAM

1-79	Tactical Air Force Statement of Need.
8-79	Air Force Systems Command approves program and assigns program to "black world" multiprogram Systems Program Office.
10-79	Multiprogram SPO drafts an acquisition strategy and sends draft RFP to contractors for comment.
12-79	Program Management Directive formally creates program.
2-80	Formal RFP sent out.
3-80	Acquisition Plan issued.
4-80	Reorganization creates separate LANTIRN SPO
7-80	First program restructure begins. SPO issues revised RFP.
8-80	Contractors submit new proposals. Joint Conference Report by SASC and HASC requests program acceleration.
9-80	SPO revises Acquisition Plan to match restructure.
9-80	SPO awards contract to Martin Marietta.
10-80	Ford files suit against Air Force.
12-80	Ford loses suit.
12-80	Program baseline shows schedule slippage.
2-81	Test and Master Schedule Plan disapproved.
3-81	Late contract performance data show cost and schedule problems. Air Force and Martin Marietta informally agree to restructure program.
4-81	General Officer Review approves restructure.
6-81	SPO ordered to implement restructure.
11-81	Congress places new conditions on program, including competition.
12-81	Air Force responds to congressional conditions.
2-82	Concerns raised over lack of a Logistics Support Plan.
7-82	New contract signed with Martin Marietta.
82 to 84	Schedule begins to slip further. Testing falls behind. Congress orders program slowed.
2-83	First delivery of navigation pod.
7-83	First delivery of targeting pod.
8-84	Program restructured to reflect new schedule, budget cap, reduced quantity buy for A-10.
1985-86	Production decision go-ahead.

1987-88	First production lots received.
1990-91	Initial Operational Capability.

Appendix B

DEFINING RISKS

This section briefly examines how development managers view risk, risk assessment, and risk management and suggests simple ways to view these concepts that can help in understanding this Note.

Weapon system development is an inherently risky activity. Most people would agree with that statement, but few would agree about precisely what it means. Most would agree that it suggests that system development is not a predictable process. Many would go further to say that the activity involves many surprises with negative outcomes. That is, the word "risk" suggests not only unpredictability, but setbacks. This is especially true for risk management. The purpose of those who manage risk is to ameliorate the negative effects associated with the unpredictability of a weapon system development.

The very unpredictable nature of risk itself, however, tends to defy further formal definition. Any attempt to be precise about what risk is tends to give up some aspect of unpredictability. Where profound uncertainty exists, it is impossible—and perhaps even misleading—to be precise about it.

A REALISTIC VIEW OF RISK TO USE IN ANALYSIS

The dominant analytic definition of risk is probably that of economists and decision theorists, which emphasizes unpredictability. For economists, risk increases as the variance of outcomes associated with the process increases.¹

To illustrate, consider the two distributions in Figure B.1. The outcome of a process is represented on the horizontal axis in terms of a single metric of performance. *Subjective* probability density lies on the vertical axis. With this definition, distribution D1 is riskier than distribution D2 because D1 is more diffuse than D2. D1 is riskier even though the central tendency for D1 is well above that for D2 and would be riskier even if D1 strictly stochastically dominated D2.²

¹Many economists would go further to distinguish risk and uncertainty. Risk occurs when the unpredictability is associated with the outcomes of a well-understood stochastic process; uncertainty occurs when unpredictability results from outcomes of a poorly understood process. A related distinction will be useful below.

²That is, suppose that we imagine random draws from both distributions simultaneously. If we believe that outcomes for the two distributions are correlated so that the outcome for D1 always dominates that for D2, then D1 strictly stochastically dominates D2.

Now suppose that D1 and D2 represent the expected outcomes of two different approaches to developing a weapon system. The metric of performance might be the probability that a fighter aircraft prevails in a standardized air-to-air engagement with the enemy. Viewing these alternatives, weapon system developers would all agree that D2 represents the riskier approach.

They would justify this position by pointing out that poor outcomes are more likely with D2 than with D1. Going further, some might be willing to set a minimum standard of success for the aircraft and characterize risk as the subjective probability associated with outcomes lower than this standard. For example, if the standard were S in Figure B.2, which recreates the distributions in Figure B.1, the risk associated with each alternative would be proportional to the shaded areas, R1 and R2, representing the subjective probabilities that the aircraft designed by each process failed to meet the set standard.

The density functions in Figures B.1 and B.2 are essentially *risk assessments*. Risk managers cannot effectively make such assessments independently of the policies they intend to use to manage risk. That is, they effectively view *risk management* as a way to alter the shape of the distributions shown. Some of these policies are things the manager can put in place today, like an acquisition plan, system specifications, a contract, a test plan, and so on. Some of them cannot be made explicit in advance. The manager must expect surprises whose details he cannot know and plan for in advance. These surprises, which will occur repeatedly, will each presumably alter the manager's risk assessment and force him to change policy in some way to get risk under control again.

Viewed in this way, risk management begins to look very much like the general management of a development program. And, in fact, development managers draw little distinction between the two. In a sense, the central task of a development program is to eliminate basic uncertainties about a new design so that it can be transformed into a useful product. But managers do not generally think in terms of subjective probability densities like those presented above. They think more in terms of contingencies: What would happen if *this* happened? Routinely, how likely is it? What kind of trouble would it cause? What can I do now to mitigate that trouble? What kind of resources or staff would I want then to deal with it? This process of assessing risk, planning for it, and reacting to it is what this Note explores. The metaphors above reflect the understanding that managers generally focus on surprises that can hurt them as they seek ways to mitigate the effects of these surprises or events.

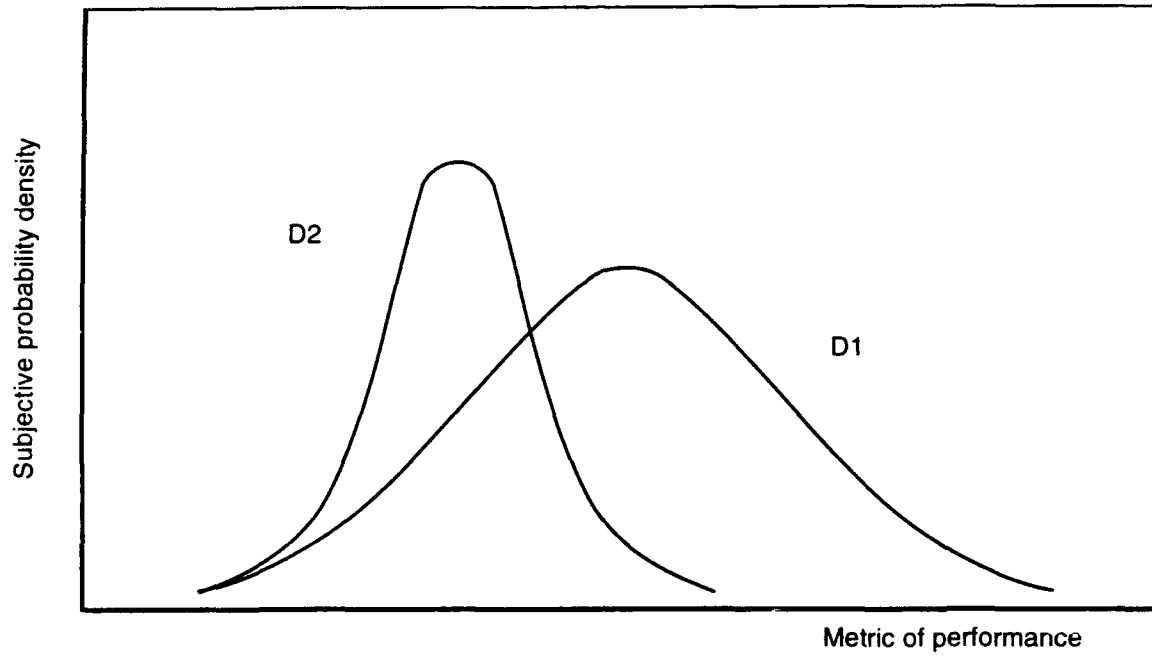


Figure B.1—Subjective Probability Density Distributions for Two Programs

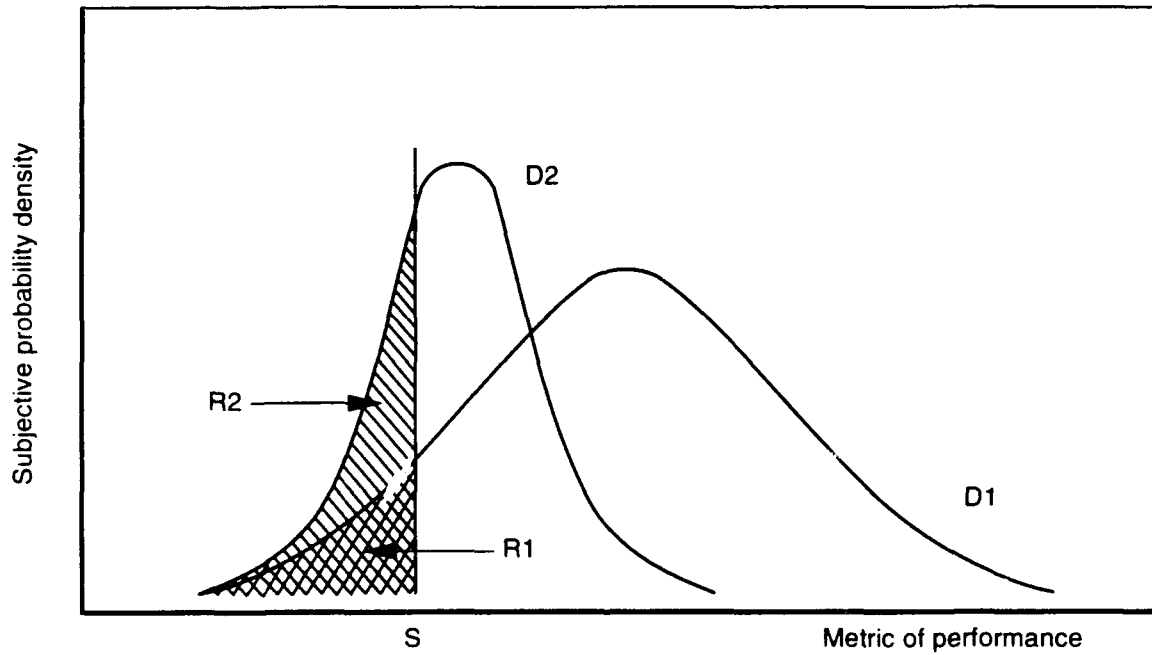


Figure B.2—Risk Associated with Two Weapon System Development Programs

PROGRAM ATTRIBUTES AFFECTED BY RISK

When surprises occur, they can affect the program in a number of ways. First and foremost, they can affect the probability that the program will survive to yield a useful product of some kind. With successful program completion, they can affect the resources and time required to complete the program. These are the "cost" and "schedule" criteria normally associated with development. They can also affect final system "performance" in a wide variety of ways. Traditional measures of system performance emphasize combat capability and can normally be measured in a variety of ways specific to each system. Producibility and production cost for the system round out the performance factors relevant to the manager.

SOURCES OF RISK

Managers look for surprises that increase risk in two places. First development takes time, and while it occurs, the world outside the program can change, precipitating surprises for a development. Most basically, changes in the threat can affect willingness to continue funding the program or the requirements set for the final product. Changes in technology can affect the availability of subsystem capabilities that the development relies on or the need for the system under development. Changes in the economy can change the cost of the development itself or of the final product or the availability of funds to maintain the development as expected. Changes in the Air Force testing and evaluation community can affect the availability of test assets. All of these factors are essentially beyond the manager's control. He can reduce their effects generally by keeping the length of a development down, so that fewer opportunities for surprises arise over the course of the development. More likely, the manager must anticipate specific kinds of surprises and tailor individual responses to each one.

Second, even if the world outside the development remains stable, surprises can be expected within the development. Development efforts can take more time or resources than expected to reach a particular performance improvement. Certain technical goals set in the program can turn out to be infeasible. The manager has greater control over such factors but can still not expect to eliminate surprises of this kind.

Risk does not always come from surprises; managers can introduce risk into a program by their own action. As a development program is normally defined, a manager will have a hard time meeting the multiple goals. To increase the probability of program survival early in its life, the manager must make the program look attractive relative to competing alternatives. Hence, the manager generally attempts to hold down goals for development cost and schedule and increase the performance goals of the system. To the extent that such

goals are adopted as standards like those in Figures B.1 and B.2—that is, a program fails if it fails to meet all of these goals—these actions actually increase the risk associated with a program. In most cases, however, the manager must accept such risk to reduce the risk of losing overall support for the program to a competing development program. Managers well understand this tension between the goals of program survival and other goals of the program; they view it essentially as a price of entry for conducting development activities. In the end, however, such behavior means that the manager cannot expect to meet all the goals and must expect to make trade-offs about how to allocate shortfalls among goals. However, the ability to make these trade-offs might be hampered by pre-existing policies or strategies that limit the manager's actions. In fact, these policies or strategies can impose risks on a program. This theme is explored in this Note.

When surprises occur, the manager must again make trade-offs among these factors. Some surprises will loosen constraints on the manager; an unexpectedly high performance outcome in one area might allow the manager to reduce risk associated with performance in another area or to hold the line on the costs or schedule of development. Negative surprises, on the other hand, will lead a manager to spread the negative effects across goals. A test failure, for example, may lead to a schedule slip and additional development work to achieve the initial performance goal at the expense of schedule and cost goals.

How a manager makes such trade-offs should depend on the relative priorities placed on different goals, based on either guidance from higher levels or personal goals. These priorities will differ from one development program to another and perhaps change over the course of a development. Patterns in such trade-offs are a primary concern in this Note.