A CASE STUDY OF THE F-20 TIGERSHARK

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PREFACE

In December 1986 the Northrop Corporation terminated its F-20 Tigershark fighter aircraft program. The program had been in existence for over ten years and had cost over $1.2 billion. The F-20 program was unique because it was privately funded--i.e., Northrop and its subcontractors covered all of the costs. Northrop wrote off the program costs quarterly, so despite the huge loss, the company continued to prosper. Its other government contracts more than made up for the F-20 expenditures.

Northrop and many observers claimed that, from a technical point of view, the program was a resounding success. In point of fact, no one can know. No F-20s were ever sold. There is no doubt that the F-20 program was a marketing failure. There is, however, disagreement about why this was so.

This paper examines the F-20 program from both a research and development (R&D) and a marketing perspective. We state why the F-20 was built and we show how the F-20 program drew from a Northrop philosophy of what an export fighter should be. We examine why Northrop considers the F-20 R&D effort to have been successful. This examination leads us to discuss the problematic issue of finding and using appropriate measures of merit in evaluating a fighter aircraft system. We present some of our thoughts on why the F-20 was such a dismal failure in the market place, and what marketing lessons should be drawn from that failure. Finally, we conclude by examining the Northrop F-20 R&D and acquisition story in light of several prescriptions that RAND has uncovered in its research.

We would like to thank the Northrop Corporation, particularly those executives who allowed us to interview them and benefit from their knowledge of the Tigershark program. At RAND, Jean Gebman and Hy Shulman familiarized us with the complexities of measuring aircraft reliability and maintainability. And we owe special thanks to George Donohue and Michael Rich, who encouraged us to look at both sides of the story.

I. BACKGROUND

The Northrop decision to build the Tigershark was a reasonable one. Two lines of argument stood out in support of a new F-5-type fighter. The first was that a new plane was needed in order to service the still viable F-5 market. Secondly, it was argued that the emergence of new technologies underlined the need for a more advanced aircraft. The Tigershark was designed to meet these needs.

THE NORTHROP FOREIGN FIGHTER TRADITION

Through the late 1970s, Northrop had successfully marketed F-5s to friendly foreign nations. Northrop's success in the overseas fighter market had been aided by a longstanding U.S. government policy that aimed at enabling friendly third world nations to provide for their own air defense. The government had executed this policy by permitting the sale of a designated export fighter which would be suitable for use by developing nations.

The first F-5, the F-5A, was marketed in the 1960s under the auspices of the Military Assistance Program. At the beginning of the Nixon administration there was renewed concern that our friends in the third world needed to do more for their own defense. In air defense terms, the "Nixon Doctrine" led to the International Fighter Aircraft program. The Northrop F-5E "Freedom Fighter" won a paper competition and the right to be marketed under the banner of this program.

The early years of the Carter administration were marked by a shift in arms sale policy. The sale of arms to the Third World was seen as contributing to global instability. The sale of sophisticated weapon systems was especially discouraged. By 1980 the administration saw that a viable foreign policy would have to recognize selected arms sales as a policy alternative. A result of this new realization was the foreign export or FX program. The FX program was set up to facilitate the export of austere fighter aircraft to the Third World. These aircraft were to be "intermediate" in capability, between the F-5E and the General Dynamics F-16. General Dynamics configured an F-16 with the old J-79 engine as its contribution to the FX program. Northrop proceeded with a new design for an intermediate level FX aircraft. This aircraft was designated the F-5G Tigershark.

The start of the Reagan administration brought yet another shift in U.S. foreign fighter export policy. Now third world countries found it much easier to buy F-16s. This policy change had an effect on the Tigershark program. Northrop saw that the main

threat to their program was going to be the F-16. The Tigershark would have to be comparable to this aircraft to have any chance in the overseas market. Northrop conducted additional studies in order to incorporate avionics features into their aircraft that were more sophisticated than originally intended. The Tigershark would also get a newer more powerful version of the engine selected for it. As the Tigershark moved further away from its predecessors, the appropriateness of the F-5G designation came into question. Late in 1982 the Air Force redesignated the Tigershark as the F-20. It was now a new ballgame altogether.

AVAILABILITY OF NEW TECHNOLOGIES

By the middle 1970s, the emergence of new technologies began to influence Northrop F-5 program planning. Northrop saw that more sophisticated aircraft were going to be entering the third world fighter aircraft market. The "opposition" Soviet MiGs and French Mirage aircraft had made the F-5E obsolete. Competition, in the form of more advanced aircraft technologies, mandated a more advanced Northrop product. If the new technologies constituted a challenge to Northrop's market share, they also offered an implicit solution. This point will now be discussed in more detail.

The export fighter market, which had traditionally favored austerity, was beginning to change during the 1970s. Smaller developing nations began to desire more sophisticated aircraft of their own. Many of these nations would have gladly bought F-16s and even F-15s, were it not for the Carter administration restrictions on the export of these aircraft. Aircraft features such as more powerful radars, advanced fire control systems and armaments, airframe composites, and fly-by-wire were now being designed for aircraft (i.e., Mirage 2000s) that would be sold in the foreign market. Northrop realized that the next F-5 aircraft would have to have these kinds of features to be competitive.

Northrop started out designing a new F-5 product to fit within the constraints of the FX program. The Chief Executive Officer sent a one-page memo to his subordinates instructing them to design and develop an aircraft with 80 percent of the capability of the F-16 at half the cost. Later on, as mentioned above, Northrop was confronted with a new and unexpected competitor, the fully configured General Dynamics F-16.

The FX program's F-5G Tigershark had represented a significant leap forward from the old F-5E in terms of technical sophistication and performance. The F-20 Tigershark would be going even further forward. The problem was to make this leap while still fielding a relatively inexpensive aircraft, and one that maintained the old F-5 emphasis on

reliability and maintainability. Northrop management reasoned that the trend of electronic technical progress in the 1970s, in general, had been more performance at less cost with greater dependability. At least this was so in consumer electronics and computer technology. Northrop believed that they would be able to translate these advantages of high technology into the advanced avionics systems of the F-20. The new aircraft would have the extra capabilities associated with a "top of the line" plane, but at less cost.

It should be noted that actual experience with advanced avionics (i.e., the F-15 and F-16 programs) did not reflect this optimistic view. These programs suggested that great difficulties could be expected in the course of developing an advanced avionics suite with satisfactory performance and reliability. Northrop observed the problems in those programs and determined to build reliability and maintainability (R&M) into their aircraft from the start. Northrop had no corporate experience in advanced avionics integration. The F-5 had been pretty much a rocket with wings. Nevertheless, Northrop thought they could learn from the errors of their rivals and do it right the first time.

THE R&D PHASE: THE NORTHROP VIEW

Northrop considers the F-20 program to have been a great R&D success. They are correct in the sense that the F-20 met or exceeded Northrop criteria for performance, reliability, maintainability, and operability. The Northrop marketing strategy for the F-20 keyed in on this fact. One can say that the F-20 system was "verified." The F-20 passed the tests that were specified for it throughout its brief test run. Northrop did not consider that it may have been using some inappropriate criteria all along for evaluating the F-20 system. The Northrop choice of F-20 system criteria or measures of merit is discussed in a subsequent section of this paper along with the wider issue of system "validation."

The R&D process for the F-20 can be characterized by some general tenets. These tenets are listed and discussed below.

The Northrop Philosophy

Northrop's export fighter program has been characterized by a consistent philosophy. In designing and developing an aircraft, performance must not outweigh cost, reliability, maintainability, and operability. This philosophy has been nurtured by Northrop's experience with the F-5 program. Their typical client country hasn't had the kind of support structure to operate and maintain a "Ferrari" level aircraft, but has done well with a "Ford Escort" aircraft.

Northrop has expressed frequently and with conviction, the importance of the relation between aircraft reliability and maintainability, and sortie rate. A reliable aircraft that is easier to maintain will fly more sorties. More sorties translate directly to a more effective air defense. For Northrop, sortie rate is a bottom line measure of merit.

Staying Within the Envelope

A corollary to the Northrop philosophy stated above is a willingness to give up a little extra performance in order to make significant gains in terms of affordability, reliability, maintainability, and operability. Northrop had never pushed the edge of the technical "envelope" with the F-5 program. They did not intend for the Tigershark to be an exception.

Northrop put these principles into practice by selecting F-20 subsystems which were either proven, or which had good paper "specs" with respect to reliability. The General Electric F404 engine was being used in the F/A-18 program in which Northrop was a subcontractor. This engine has less than one half the number of parts that the F-16's Pratt-Whitney F100 engine has. The mean flight hours between failure rate (MFHBF) for the GE engine was 190 as compared with the F100's MFHBF of 45.

Other F-20 subsystems were chosen with this rationale. General Electric had proposed a radar for the F-20 which was rated at 100 MFHBF. Northrop rejected the proposal and opted for a different configuration that was rated at 200 MFHBF.

Northrop had built their own facility for fabricating composite airframe components, for another program. The experience gained from this activity would facilitate the use of composites in the F-20 airframe.

An Emphasis on Production

The stability of the long F-5 program had enabled Northrop to invest in its own aircraft production facilities and equipment. Northrop did not rely on government owned, contractor operated (GOCO) facilities. Northrop had also been able to do longer range planning and innovation with respect to the aircraft production process. The Tigershark program would become Northrop's vehicle for demonstrating Northrop's advances in production technology.

The centerpiece of these advances was the Production Development Center (PDC). The PDC was constructed to serve as the design, development, and initial assembly facility for all future Northrop aircraft. The Tigershark was the first aircraft to be

developed in the PDC. Initial plans called for having six F-20s assembled in the PDC; the remainder would be put together at the regular assembly facility.

Northrop did not take a prototyping approach with the F-20. The F-20 design was verified through traditional paper engineering studies and tests on the shop floor with specific subsystems. The first F-20 was intended to be a production quality aircraft. The role of the PDC was to validate the aircraft design vis-à-vis the production set-up. The emphasis all along was on the production process: the proper design, configuration, and use of the production tooling. Accordingly, only production tooling was used in the PDC (so-called "hard tools"). The development of the aircraft would be accompanied by an ongoing development of the eventual production process for that aircraft. At the end of the PDC production run, tooling and most of the personnel would move over to the assembly plant.

The original motivation behind the PDC concept came, as so much else did, from Northrop's experience with the F-5 program. Northrop had run into difficulties in its transition from the initial production of F-5Es to full-scale production. The first 30 or so aircraft delivered to the Air Force had to be put into a Northrop modification program in order to make good aircraft performance deficits identified during flight testing. The modification program turned out to be expensive and aggravating. The PDC was designed in part to handle that type of situation.

Northrop built more than a facility with the PDC. The company also instituted new working practices. Designers, engineers, and manufacturing supervisors were all gathered under one roof in the PDC. Northrop management pushed for a "team" approach instead of letting each functional group sequester themselves from the others. Northrop also instituted practices which expedited the identification and correction of defects or suboptimal procedures. The results were heartening. Northrop reported that the number of quality "squawks" dropped markedly while group cohesion and morale soared.

THE TIGERSHARK PRODUCT

Ultimately the success or failure of any R&D process is judged by the product that emerges from it. Northrop was elated from the start with their new aircraft. The program had proceeded according to plan and looked like a winner.

The rollout of the first F-20 Tigershark occurred 32 months after the program go-ahead--it came out a month ahead of schedule. Unfortunately we cannot address whether or not the program came in at cost. Northrop did not provide us with cost data on the

program. Northrop officials did report that they were satisfied with the program with respect to costs.

Northrop rapidly tested the Tigershark through its flight envelope in order to enable foreign air force pilots to fly the aircraft as soon as possible for marketing reasons. The F-20 met or exceeded all of the Northrop performance goals set for it. Performance goals were measured in terms which included:

- scramble time
- time to mission capable status at 40,000 feet altitude
- instantaneous and sustained turn rates at different altitudes
- acceleration through different airspeed ranges at different altitudes
- deployment of its designated weapons systems
- successful use (firing and target acquisition) of armaments
- successful completion of its assigned mission profiles

The Tigershark was also evaluated with respect to reliability goals as expressed in terms of MFHBF for the aircraft as a whole. The F-20 exceeded the planned MFHBF rate as of its last flight. The F-20 accomplished approximately 1500 flights before the program was terminated. The F-20 also met its "operability" goal: foreign pilots were able to fly the single seat F-20 after just two days of simulator training.

Two of the Tigersharks produced crashed during the program. Studies verified by the U.S. Air Force concluded that in neither case was the crash caused by a system malfunction.

On the basis of its 1500 flights, the F-20 Tigershark seemed to score rather well. It had a much faster scramble time than the F-16. The bulk of the difference was attributed to the F-20 inertial navigation system. The F-20 was inferior to the F-16 in operating range (10-15 percent less range depending on altitude, speed, etc.) and in the amount of armaments that could be carried. The MFHBF for the F-20 was 4.2 at the time of program termination. The F-16 had accumulated a 3.2 MFHBF rate over many years of operational usage. The F-20 required maintenance manhours per flight hour (MMH/FH) of 15.1 during its test run. The F-16 had accumulated a MMH/FH of 33.9.

Northrop used these comparisons repeatedly in their marketing pitch overseas and later on for the Continental United States (CONUS) air defense competition which pitted the F-20 against its F-16 nemesis. In Northrop's view, the F-20 was comparable to the F-16 in performance, and far superior in reliability and maintainability. Northrop also

stressed the life-cycle cost savings that could be gained from purchasing F-20s instead of F-16s. To this day, Northrop does not recognize that there were serious problems with the manner in which they made those comparisons. It has been pointed out to us, however, that Air Force representatives had grave misgivings over the Northrop comparisons, and that Northrop lost a great deal of credibility by making them. This issue will be discussed in the next section.

II. THE R&D PHASE: A RETROSPECTIVE VIEW

The foregoing looked at the F-20 Tigershark R&D process primarily from a Northrop perspective. The F-20 was a successful program from a technical standpoint in Northrop's eyes, because they were able to verify that their product met their performance, reliability, and maintenance goals. This does not mean, however, that the F-20 was "validated" as a successful product. Such a verdict could not be arrived at until such time as large amounts of operational data were available. The comparisons between the F-20 and the F-16 were essentially meaningless because the F-20 flew only 1500 flights under very stringent, artificial conditions, whereas the F-16 numbers reflected occasions of system misuse and neglect inevitably associated with operational usage over many years. In point of fact, we don't know how good the F-20 really was and there is no way we can know based on its abbreviated lifetime.

However, we can say something about what Northrop did and did not do during the course of the F-20 R&D process. There were several positive R&D accomplishments during the course of the F-20 program. We will address these first. There were also deficiencies in what Northrop did. These were deficiencies not in the F-20 product itself, but rather in the measures Northrop used to evaluate the aircraft. Northrop's naive use of failure rate and maintenance manhour measures is not their problem alone. RAND research has identified this as a common shortcoming in the industry as a whole. Furthermore, the use of such inappropriate measures of merit has undesirable consequences that go beyond marketing disappointments. We will discuss these deficiencies as well.

NORTHROP ACCOMPLISHMENTS

From a positive point of view, the Northrop F-20 R&D process was marked by several accomplishments. Proponents of reform in R&D acquisition have repeatedly called for more private investment in weapon systems R&D. Northrop went out on a limb and funded their own program. Because of this, they had control over the design and development of the F-20. No one sent them a huge cargo plane full of technical specifications on how each nut and bolt in the aircraft should be aligned. The result was a relatively austere program that came in on time and met the technical goals that were set out for it in initial testing--no mean feat.

Northrop had a very clear idea of what they wanted their system to be, right from the start. Even when the Carter initiated FX program "went south," the Tigershark program adjusted fairly well. Program direction didn't deviate radically. Northrop management attempted to make the necessary modifications to be competitive in the changing foreign fighter aircraft market. They ended up backing a loser, but it wasn't for lack of planning or continuity in execution.

Northrop used an "incremental" approach to the design and development of the Tigershark. They sought out proven subsystems for their aircraft when possible, and when not, they were attentive to any evidence of superior dependability with respect to one proposed design versus another. They chose their subcontractors carefully and insisted that they share some burden of the investment cost. Though Northrop did not explicitly say so, they obviously benefitted from the technical lessons learned during the development of the F-15 and F-16. They did not push for the cutting edge of technology. There was no need for the most advanced technology for their given export market. Northrop's willingness to derate extra performance for extra reliability and maintainability reflected this realization.

Finally, Northrop paid attention to the production aspect of their weapon system. It is evident that from early on in the program, Northrop was concerned over the cost-effective producibility of the Tigershark. They took great steps towards ensuring that they would be able to produce a quality product that could be sold for a reasonable price.

NORTHROP DEFICIENCIES (AND EVERYONE ELSE'S)

As mentioned previously, Northrop had problems with the measures of merit that they used in evaluating and subsequently marketing the F-20 Tigershark. This problem is a common one in the industry, and cause for concern by parties other than Northrop stockholders.

Even good measures of merit would have been largely meaningless when applied to the F-20 during its initial test run. There is simply no way to compare the test outcomes of a carefully assembled, scrupulously protected production prototype, with those of its operational counterpart. The Tigersharks that were built were given an enormous amount of attention and care, from assembly through testing. Handpicked maintenance personnel worked on them. The test flight regimen was performed at Edwards AFB in the high desert. No flights were conducted under adverse weather conditions--let alone combat conditions.

The aircraft was not flown until Northrop was ready to let it fly. Obviously an operational aircraft would not have these advantages. It flies when it needs to as well as when it is scheduled to. Maintenance personnel on an air base are not handpicked with twenty years experience. They are often right out of tech school. The care bestowed on an operational aircraft is the care it gets as its share of the available maintenance manhours. In peacetime this is not as great a problem as in time of war. Finally and especially important considering the F-20's destination, operational aircraft in the air force of a third world country are going to face extremely "meager rations" when it comes to support resources. The maintenance record of the F-5 does not mean much in this context because the F-20 was not even a distant cousin to the F-5 in terms of its avionics.

More important for our purposes is a consideration of the appropriateness of the MFHBF and MMH/FH measures, given that they are obtained in an operational context. The new avionics subsystems usually do not fail, they degrade. Unless one has some kind of measure of system degradation, there is no way to sensibly assess the status of a subsystem at any given point in time.

Pilot reports and built in test (BIT) results offer at best, an incomplete basis for knowing exactly why a breakdown is occurring. The pilot can only report what function went out during what operational sequence. He has no knowledge concerning the events inside the black box that records equipment and flight performance data. BIT results often turn out to be either inconclusive or just plain wrong.

In addition, malfunctions can occur at seven gravities that will never show up in the backshop on a stationary test stand. The asymmetry between systems operating in a flight environment and the same systems operating on the ground is a source of real difficulties. Measures need to be taken of system degradation. Pilot reports and BIT results will inevitably be a part of this measure, but for the reasons given above, they are incomplete. New system degradation measures need to be developed in order to evaluate the performance of the complex avionics technologies that are being fielded in today's aircraft.

Maintenance manhours per flight hour are not a complete measure of maintainability if problems with the aircraft are not fixed. A more appropriate measure would be mean time to "fix" complaints. Again, degradation clouds the picture. It may not be evident what exactly is wrong with a certain subsystem and it may take several tries before a problem is fixed. These data need to be tracked in order to evaluate maintainability for a given subsystem or aircraft as a whole.

The point of the foregoing is not to flog the Northrop Corporation. It is evident that no one is doing too well at measuring reliability and maintainability for either aircraft or aircraft subsystems. The important point lies in the consequences of this common failure. Until adequate measures of merit are developed and applied to fighter aircraft, there is no real way to evaluate either the aircraft reliability and maintainability, or the maintenance procedures used to support the aircraft. To a large extent we are laboring in the dark when it comes to understanding the current state of aircraft reliability and maintainability. To the degree that we are ignorant about these matters, we are also ignorant about very crucial aspects of force readiness and force effectiveness, and this is the real bottom line.

III. THE TIGERSHARK'S MARKETING FAILURE

> To some extent, achieving higher readiness requires the investment of additional RDT&E money up-front. It takes extra effort from the outset to achieve reliability and maintainability objectives concomitant with improving operational performance.[1]

One of the most notable ironies in the history of defense production is Northrop's inability to sell a single Tigershark. In recent years the U.S. government has tried to encourage producer financing of R&D expenditures in military systems. Yet Northrop's loss of the $1.2 billion it invested in the F-20 program was due, in part, to its inability to persuade the U.S. Air Force (AF) to purchase Tigersharks. This was the single largest private investment ever made in the defense industry's history.

This part of the F-20 study examines the marketing failure in detail. This section provides a chronology of major events, while Section IV analyzes key factors that led to the Tigershark's marketing failure. Section V reviews the lessons to be learned from Northrop's experiences.

CHRONOLOGY OF THE TIGERSHARK'S MARKETING EVENTS

Northrop's F-5 program produced a highly lucrative international fighter and a relatively successful aircraft by most measures. Thirty-two countries have purchased more than 2600 F-5s with 28 different configurations of the F-5E alone. By the mid-1970s, it was natural that Northrop turn to an F-5E follow-on fighter, in the hopes of maintaining its international sales market. Retiring F-5s, F-4s and MiG-21s left an estimated void of about 4000 lightweight fighter aircraft in the world market, and Northrop hoped to secure up to 1500 of those sales.[2]

In 1975 Northrop initiated a series of engine studies to examine potential F-5G upgrades. A single General Electric F404 turbofan engine was selected by 1978, providing a 60 percent thrust increase over two J85-GE-21 turbojet engines (5,000 pounds each) in the F-5E.[3]

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[1]Thomas V. Jones, Chairman and Chief Executive Officer, Northrop Corporation. *Quality and the Military End Game*, statement before the National Defense University on 13 July 1984, Northrop Public Affairs publication, p. 2.

[2]Interview with Northrop officials.

[3]Robert Ropelewski, "F-5G Performance Emphasized," *Aviation Week and Space Technology*, hereafter *AWST* (28 July 1980): 12.

Two decades of a successful export program led Northrop to believe that new configurations of the F-5 could incorporate emerging technologies to enhance performance, yet keep the cost effectiveness important to third world countries. However, Northrop also wanted to retain as much commonality with the F-5 family as possible, so that investments in systems and support equipment by foreign purchasers would be minimal.

The Carter Administration's Original Export Policy

In May of 1977 President Jimmy Carter issued Presidential Directive 13, prohibiting development or modification of aircraft solely for the purposes of export. Carter's policy was motivated by two points. First was an assumption that the spread of conventional weaponry threatens world stability. Second, Carter argued that as the leading exporter of arms in the world, the United States held a special responsibility to "take the lead in restraining arms sales."[4] Arms transfers were to be viewed as an *exceptional* tool of foreign policy.

The Air Force approached Northrop in July 1978, expressing interest in the single-engine F-5G for Taiwan. Nationalist China wanted to purchase approximately 160 Mach-2 class aircraft as a deterrent against the threat they faced from the People's Republic of China (PRC).

Carter vetoed the sale in October 1978, however, with no official explanation. One likely reason was his unwillingness to export such advanced technology i.e., the F404 engine had been used in the Navy's F/A-18 aircraft.[5] Thus began a long series of near-miss sales for Northrop.

Carter's FX Program

Carter increasingly found the need to use arms sales as an exceptional foreign policy tool, eroding the credibility and effectiveness of his export policy restraint. By January 1980, PD-13 was revised to permit the development of export aircraft so long as those programs were not financed by the U.S. Government (USG). The so-called Foreign Export (FX) aircraft were to be between the F-5E and F-16 in capability--an "intermediate" level fighter. The AF was designated as Department of Defense's (DoD) executive agent for the FX program.

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[4]Michael Klare, *American Arms Supermarket* (Austin: University of Texas Press, 1984): 43.

[5]"Carter Vetoes F-5G Sale to Taiwan," *AWST* (23 October 1978): 24.

Northrop immediately entered the F-5G as an FX contender. A one-page memo written by Northrop's CEO Tom Jones had previously outlined a basic design philosophy for the Tigershark, but gave few engineering specifications. Instead Jones stressed total cost effectiveness in the Tigershark's design: procurement costs, reliability and maintainability (R&M), and operational readiness were all to be equally weighted. Northrop officials claimed that advanced technologies permitted the Tigershark to incorporate R&M features into the design without sacrificing much in the way of performance.

General Dynamics (GD) was Northrop's sole competitor in the FX category. GD marketed a degraded version of the F-16, using an older J79 engine with substantially fewer pounds of thrust (18,000) than the 25,000-pound Pratt&Whitney F-100 used in other F-16 configurations. The General Dynamics entry was half-hearted: topline F-16s were already being sold to Israel and NATO, and other foreign countries asked for the same. Perhaps GD foresaw that the FX program's days were limited.

Export Policies of the Reagan Administration

The entrance of the Reagan administration in 1981 brought with it a decidedly more permissive environment for arms exports. Although initially supportive of a program of intermediate export fighters, Carter's restraint policy was quickly overruled. Undersecretary of State for Security Assistance James L. Buckley was a main architect of Reagan's new policy. He argued that arms transfers "serve as an important adjunct to our own security by helping deter acts of aggression and enhancing the self-defense capabilities of nations with which we share close security ties."[6]

In July 1981 a Reagan directive permitted sales of first-line fighters abroad on a case by case basis. Pakistan, Venezuela and South Korea were permitted to purchase F-16s shortly thereafter, marking a substantial increase in the level of technology exported through foreign sales.

Reagan's change in export policies marked a critical juncture for Northrop's F-20 program. More advanced technology aircraft sold abroad meant that Northrop's market for intermediate level fighter aircraft was not protected. The Tigershark had been designed to compete primarily with foreign fighters like the Mirage 2000 or MiG-23. Now that F-16As had been sold to Venezuela and Pakistan, most developing countries

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[6]Klare, p. 97.

began requesting similar aircraft, regardless of their budgets or realistic assessments of their security threats.

Meanwhile, 42 countries received permission from the Department of State to receive briefings on the F-20 under the International Traffic in Arms Regulations (ITAR). Among those nations was Taiwan, who still hoped to purchase FX aircraft to replace aging F-5Es. In January 1982, the Reagan administration chose not to permit sales of advanced fighters to Taiwan, on the basis that there was no need for a more advanced fighter. Warmed relations between Washington and Beijing certainly played a strong part in the decision. Instead, Taiwan was offered an extension of an earlier coproduction agreement of F-5Es, an offer that did not please Taipei.[7]

Northrop's Reassessment

A total of three preproduction aircraft were built by Northrop, the first of which rolled out of the Hawthorne Production Development Center in August 1982. Yet no formal requests for the Tigershark were received by the State Department. Northrop officials alleged that the USG had not offered the F-5G in discussions with foreign buyers or had not given the Tigershark equal briefing time.[8]

In May 1982, Northrop's CEO Tom Jones issued an internal program directive which limited the project to two preproduction aircraft. Production personnel were shifted from the Tigershark program to other projects in an effort to cut F-5G costs until firm orders were received.[9]

In November 1982 the Tigershark was designated the F-20 in an effort to avoid the stigma associated with being an F-5 follow-on. Northrop executives said that some AF officials had urged them to continue the Tigershark program, despite the lack of FX sales.

Subsequent preproduction aircraft incorporated design changes to enhance the F-20's capabilities and hence its competitiveness with the F-16. For example, digital avionics were incorporated into the second plane, including the General Electric AN/APG-67(V) radar developed for the F-20. Later changes increased the plane's internal fuel capacity to broaden its combat radius and improved radar detection up to 50 nautical miles. The F404's thrust was also increased from 16,000 to 18,000 pounds.

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[7]Paul Mann, "Reagan's F-5G Decision Pleases No One," *AWST* (18 January 1982): 17.

[8]Bruce Smith, "Northrop Cutting Costs on F-5G Line," *AWST* (5 July 1982): 24; and interviews with Northrop officials.

[9]Ibid., p. 24.

Two Preproduction Aircraft Crashed

Crashes of two out of three preproduction Tigersharks marred Northrop's marketing efforts and reduced the credibility of the F-20's operational claims. The first occurred in October 1984 at Suwon Air Base in South Korea. Chief test pilot Darrell Cornell was concluding a demonstration when the plane experienced an inverted stall after a climbing roll at 1200 to 1800 feet. Cornell was killed in the accident.

Northrop officials investigated the accident in conjunction with the Air Force. The investigation concluded that the aircraft systems had not failed and no design changes were made as a result of the accident. The investigation's conclusions were revealed in January 1985, although the official report was not released until July.

The second crash occurred in Goose Bay, Labrador in May 1985. Test pilot Dave Barnes was practicing his routine for the Paris Air Show when he probably experienced a g-induced loss of consciousness (GLOC). He too was killed in the crash. The accident was jointly investigated by the USAF, Northrop and the Canadian Aviation Safety Board. A March 1986 judicial inquiry indicated no aircraft system fault in the crash.

Despite no evidence that the two aircraft were to blame in the crashes, the incidents made the F-20 seem risky. It is impossible to conclude whether or not the events were due solely to bad luck.

U.S. Navy Aggressor Aircraft Competition

After the Reagan administration took office, Northrop increasingly became aware that sales to the USG were necessary for the Tigershark's success. Northrop argued that many foreign countries had been interested in the F-20, but were uncertain about the USG's commitment to the FX program.[10] In the case of some nations, Jordan for example, F-20 sales were conditional on production of the Tigershark for the USAF or some large scale buyer.[11]

Northrop's first attempt at getting the F-20 into the U.S. inventory was in a 1984 Navy competition for sales of fourteen aggressor aircraft. Ironically, Senator Pete Wilson (R-CA) was instrumental in getting money through Congress to purchase the Navy planes, undoubtedly in the hopes that Tigersharks would be bought. General Dynamics, however, offered a fixed price baseline F-16C with an F110 engine for a little over $11 million per aircraft flyaway (in 1984 dollars). Northrop's offer on the F-20 was at

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[10]Eugene Kozicharow, "USAF Will Increase Export Fighter Role," *AWST* (9 April 1984): 21.

[11]James Gordon, "Expected Congressional Opposition Delays F-20 Sale to Jordan," *AWST* (2 September 1985): 18.

approximately the same price, however, the F-16 was believed to be more capable of meeting the Navy's future threats.[12] General Dynamics won the contract.

GD's low bid attracted the attention of Congress--particularly since the AF was paying a substantially higher price for its F-16s. GD argued that it was able to take advantage of scale economies from a large-scale four-year AF contract in its Navy bid.[13] Yet many in Congress believed that Northrop had been "low-balled"--that GD had charged a price below the plane's manufacturing costs.[14]

Northrop's Unsolicited Bid

In April 1985, Northrop chose to face the F-16 head-on. It submitted an unsolicited proposal to the AF, offering to produce half the expected procurement of F-16s for the FY87-91 period (396 out of 792). The proposed fixed price for the F-20s was $15 million with support (1985 dollars), substantially less than GD's going price of $18 million for the F-16C. Northrop also claimed that the F-20 required half the manpower of the F-16 to support it, which GD hotly disputed.[15]

GD countered with an unsolicited proposal for a 720-plane package of stripped down F-16s at $13.5 million each with support.[16] Cheaper radar and fire control equipment were put in the new F-16 configuration, humorously referred to by some as the "F-16C-minus."[17]

Air Defense Fighter (ADF) Competition

Impromptu competition between GD and Northrop sparked the interest of both Congress and the Air Force. The AF weighed the possibility of including F-20s in its FY87 Program Objective Memorandum, despite the fact that Secretary of Defense Caspar Weinberger openly denounced the F-20 as no match for Soviet aircraft.[18]

Meanwhile, Congress ordered the Air Force to add a line item in its appropriations bill. 270 Air Defense Fighters were to be selected in 1986 from among the two aircraft. The competition was originally envisioned by Congress as a yearly event to hold fighter

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[12]David North, "Navy Selects F-16 for Aggressor Mission," *AWST* (14 January 1985): 25.

[13]Ibid., p. 26.

[14]Ralph Vartabedian, "Northrop Jet in Shoot-out with Dynamic's F-16," *Los Angeles Times* Section IV (11 May 1986): 1.

[15]Ibid., p. 6.

[16]Paul Duke, Jr. "Pentagon Gets Cut-Rate Offer for F-16 Jets," *Wall Street Journal* (21 June 1985): 4.

[17]"Dogfight Over Fighter Planes," *Fortune* (22 July 1985): 13.

[18]"Pentagon Confirms Play to Buy F-20," *Washington Post* (11 May 1985): A6.

prices in check. The Defense Resources Board, however, changed the flyoff's framework to a one-time-only competition for continental air defense. Essentially, the ADF paper flyoff became a winner-take-all competition.[19]

Both planes were good at point defense. Northrop's F-20 had a quicker scramble time and allegedly higher reliability, while the F-16 had better combat range, better turn performance and could carry heavier payloads. But a North Dakota Air National Guard analysis suggested that neither plane was well-suited for the mission; Adjutant General Alexander Macdonald argued that neither fighter had the radar and range capabilities adequate for long-range engagements or for tracking low radar cross-section cruise missiles.[20] Rather than spend $4 billion on purchases of new aircraft, Macdonald suggested modifying 180 older F-4s at a total cost of $750 million.

Reports by the Congressional Research Service (CRS) and Congressional Budget Office (CBO) both supported the choice of the F-16 over the Tigershark. An October 1985 CRS issue brief pointed out that since the F-20 was not in production, it was unlikely that Northrop could produce the aircraft at the prices quoted. It also said that operational testing and evaluation expenses as well as the set-up of an F-20 logistical system would offset any advantages in lower operating costs.[21] A CBO staff paper cast doubt on Northrop's R&M claims. The study estimated that the F-20 would be cheaper to operate and maintain, but with a much smaller cost differential than that claimed by Northrop.[22]

Neither the Northrop nor the GD proposal was selected by the Air Force. On October 31, 1986, the decision was made to withdraw 270 F-16As from active AF squadrons and modify them for the air defense role. Planned purchases of F-16C/Ds would replace them. General Dynamics was awarded a $633 million contract to produce modification kits and spares for the F-16As. The planes were to be equipped with improved radar to track cruise missiles, external fuel tanks for better range, and accommodation for AMRAAM, AIM-7 and AIM-9 launchers.[23]

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[19]"ADF Competition Stirs F-20 Backers," *Aerospace Daily* (5 September 1985): 18.

[20]Mark Thompson, "How Politics Put Odd Spin on AF Jet Deal," *Miami Herald* (27 October 1986): 10.

[21]"CRS Weighs F-16, F-20," *Aerospace Daily* (22 October 1985): 277.

[22]Bill Keller, "Northrop's F-20 Hopes Dealt a Blow by Report," *New York Times* (5 October 1985): 31.

[23]Brendan M. Greeley, Jr., "USAF Selects Modified F-16A as ADF," *AWST* (10 November 1986): 25-6.

End of the Tigershark

Northrop closed out its F-20 project at the end of 1986, after investing about $1.2 billion in the program. Although final expenses pulled Northrop's profits down for the year, its involvement in the F-18, Advanced Tactical Fighter (ATF), Advanced Tactical Attack (ATA), and B-2 "Stealth" strategic bomber programs have kept the corporation relatively healthy. Experience and data collection from the Tigershark's development have also proved beneficial in ATF and ATA proposals.

IV. KEY FACTORS IN THE MARKETING FAILURE

Three broad groupings encompass the factors that led to the F-20's demise: the requirements of the world arms market; domestic bureaucratic and political constraints; and Northrop's managerial decisions. This section addresses each in turn.

THE WORLD ARMS MARKET

Northrop based its original F-5G design strategy on its assessment of conditions in the world arms market.

Strong Competition Among Fighter Producers

Northrop faced steep competition in the world's light fighter market. France, Great Britain, Israel, the USSR as well as other nations developed light fighters for foreign export, focusing on the same market as Northrop. Cost effectiveness in terms of acquisition price and life cycle costs were therefore especially important under these competitive conditions.

Limited Resources of Developing Countries

Particularly after the oil glut and world recession of the early 1980s, developing countries found themselves short of financial resources for arms purchases. Relative to petrodollar days of the 1970s, the debt problems of the 1980s restricted the arms purchases of many third world nations.

In this light, Northrop's strategy of developing an inexpensive follow-on to the F-5 family with the benefits of more advanced technology seemed to be sound. Northrop officials believed that by the mid-to-late 1970s, technology was available to incorporate R&M features from the design stage, thereby reducing life cycle costs. In its early design stage when performance enhancements were at a minimum (e.g., engine upgrade, aerodynamic redesign only), it was likely that the Tigershark's life cycle costs were held down. Without data, however, this is mere speculation.

An Eye to Performance and Prestige

As the Reagan administration's lenient export policies later demonstrated, developing countries highly value performance characteristics in fighter aircraft. In the absence of credible export restraints, countries such as Venezuela and Taiwan demanded

the highest level of technology they could acquire. This emphasis by third world nations frequently overrides affordability concerns or realistic assessments of threats.

A second and correlated emphasis in fighter purchases is often prestige. The F-16A, for example, was regarded as more prestigious than either the F-5G or the F-16/79 FX planes. This was due both to its relatively advanced technology and its instant credibility as an aircraft within the U.S. inventory.

Exports as a Symbol of Diplomacy

Developing countries frequently portrayed U.S. willingness to sell them advanced fighter aircraft as a symbol of U.S. intentions and friendship. Consequently, denying sales of advanced aircraft to nations was interpreted as a signal of encumbered relations and unwillingness to aid in the defense of our allies.

The bottom line for third world buyers of lightweight fighters is not affordability, instead, prestige and performance appear to have been stronger criteria in selecting fighter planes. When coupled with the symbolic interpretation of arms sales and the erosion of the U.S. export restraint policy, Northrop's emphasis on R&M over performance was a deadly strategy.

BUREAUCRATIC AND POLITICAL FACTORS

Several political and bureaucratic events complicated Northrop's marketing task and assisted in the Tigershark's downfall.

F-20's Label as an Intermediate Fighter

Carter's FX policy explicitly labelled the F-5G as an intermediate-level fighter with less than top-line capabilities and technologies. This label followed the Tigershark throughout its marketing efforts. It particularly worked to the detriment of foreign sales once top-line F-16s were permitted for export. The FX stigma suggested that the Tigershark's capabilities were substantially less than those of the F-16.

Administration Change/Policy Change

Northrop was extremely vulnerable to the outcome of the 1980 presidential elections. Its "protected" market of third world buyers who were not permitted to purchase the most advanced of U.S. technology quickly eroded once Reagan entered office. In contrast, Carter's restrictive policies held a sector of the world arms market relatively captive for the Tigershark. Had the FX restraint been adhered to longer, it is more likely that the F-20 could have secured some foreign sales.

Level-line Pricing was a "Foreign" Concept

Northrop's self-financing of the Tigershark led to some extra difficulties with the Pentagon in terms of aircraft pricing. Because most military systems are developed with USG R&D support, acquisition prices are generally set on some cost basis non-inclusive of R&D expenditures. Northrop, however, received no development support. In order to recoup its R&D expenses and earn a reasonable profit, it sought to establish a "level-line" pricing policy. Under this method, aircraft prices are set at a single average level of procurement costs rather than a series of prices determined by lot size and learning curves (see Fig. 1).

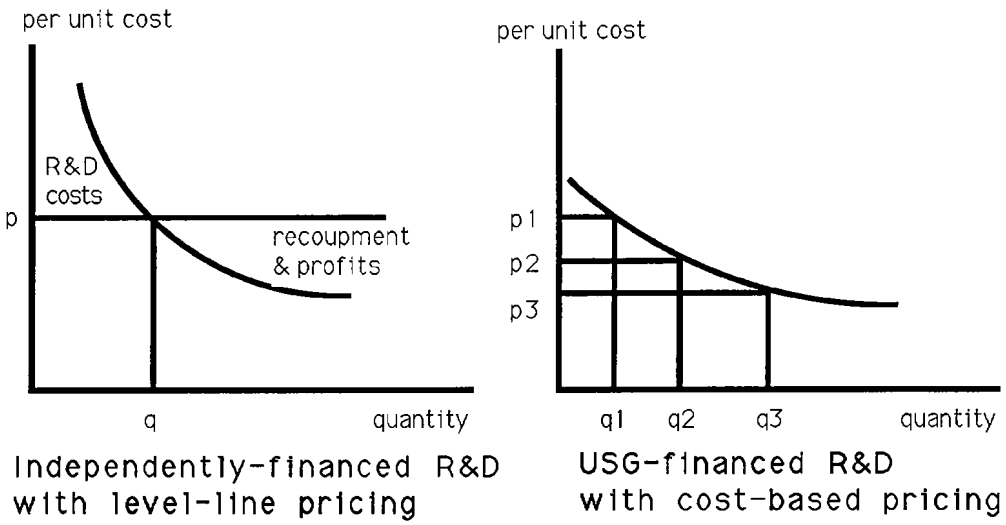

Fig. 1—Two pricing concepts, level-line vs. cost-based

As the left-hand graph shows, costs per aircraft at low levels of production are substantially higher in Northrop's case, due to self-financed R&D expenditures. In cost-based pricing, a decrease in unit price occurs as production levels increase. In order to recoup money lost at early low levels of output, Northrop proposed to charge a price that appears exorbitant at high levels of production. A series of negotiations between Northrop and the USAF was held concurrently with the Tigershark's development on this very issue.

To those in the AF familiar with cost-based pricing, Northrop's method appeared to be some sort of profiteering scheme. Northrop, however, required a guarantee that it would be able to recoup its R&D investments. After years of negotiation, a Memorandum of Agreement was signed between Northrop and the Air Force in May 1983. The difficulties that characterized this process, however, did not endear Northrop to the Air Force.

Inconsistent Signals Were Sent to Northrop by the AF

The Air Force sent signals of both support and disdain about the Tigershark program to Northrop. Initial lip service was paid to Carter's FX program. Northrop executives claim that they received encouragement to continue the Tigershark program following Reagan's decision to sell F-16s abroad on a case-by-case basis. Once Northrop provided a source of price competition in domestic acquisitions of lightweight fighters, the Tigershark received even more rhetorical support.

Yet a substantial commitment to the F-20 was lacking in many ways. Northrop alleges that the Tigershark received some highly symbolic snubs. For example, the "stars and bars" insignia was removed from the F-20 at the 1984 Paris Air Show since the plane was not a part of the U.S. inventory. Similarly, Northrop was not permitted to land the Tigershark at restricted air bases. Northrop management also alleges that the F-20 was not given equal briefings with the F-16 to foreign nations interested in purchasing U.S. fighter aircraft. They believed the "Not Invented Here" syndrome was highly applicable to the Tigershark's lack of marketing success.

The Air Force and State Department counter that inadequate amounts of data were available from F-20 testing. Furthermore, many in the Air Force saw the Tigershark's 1500 test flights on three "pampered" preproduction aircraft as humorous in comparison to the millions of flight hours logged by F-16s under real operating conditions. Northrop's measures of R&M were considered to be naive and bloated. For example, the Tigershark based much of its reliability claims on its high sortie generation rate. Yet no discernment was made between fully mission capable sorties and the figures quoted in Northrop brochures. Air Force officials saw Northrop as unsophisticated and their claims of Tigershark R&M as incredible.

An AF Vested Interest in F-16 Sales Abroad

However, the Air Force did have some strong incentives for promoting the sale of F-16s abroad. $745,000 in R&D expenses were recouped by the Air Force for every F-16

sold for export. Sales of F-16s around the world better assured the Air Force that spare parts and maintenance support would be available for emergency use. And a strong contingency of Air Force personnel had watched the development of the F-16 through its overwhelming acquisition success. It was considered a "favored son" by those in Air Force who oversaw its fielding.

Congressional Micromanagement

Congressional micromanagement in the F-16, F-20 competition probably prolonged Northrop's investment in the Tigershark program. The addition of an ADF line item onto the Air Force's appropriation was motivated by hopes that competition would lower the price of lightweight fighters being procured for the United States. This certainly occurred, with the Air Force and Navy both benefitting from less costly configurations of the F-16. However, Congressional involvement in the competition certainly prolonged Northrop's hopes of selling the Tigershark. Northrop might have cut its F-20 losses sooner if Congress had not gotten involved.

NORTHROP'S MANAGERIAL FACTORS

Naturally Northrop's own managerial factors played an enormous role in its decision on how to carry out and when to terminate the Tigershark program.

Export Restraint Policy Riskiness

Northrop management underestimated the riskiness of Carter's FX program. Carter's own attempts at arms export restraint under PD-13 eventually eroded because of the need for export "exceptions." It was somewhat risky to assume that more advanced technology fighters such as the F-16 would indefinitely be withheld from export. A "protected" market for less than top-line fighter aircraft was therefore not assured.

Northrop did, however, design the F-5G precisely for this "protected market." Although performance was enhanced over the F-5E, the F-5G was not designed to be a top-line competitor of the F-16. Once the FX protection from competition with advanced technology fighters was removed, Northrop was forced to emphasize the F-20's performance features.

Overemphasis on R&M

The F-20's claims of enhanced R&M and lower life cycle costs probably rang true for its austere early configurations. By the time it faced direct competition with top-line F-16s, however, the F-20's capabilities had been substantially enhanced. Better radar

capabilities, fire control and weapon delivery systems for AMRAAM and Sparrow missiles were some of the areas in which F-20 avionics were upgraded from the first preproduction aircraft. These enhanced the plane's capabilities, but at the expense of additional complexities in avionics integration, difficulties in fault isolation, and increased likelihood of degraded systems performance. Northrop's tests on its three Tigersharks were made under ideal operating conditions.

In these respects, Northrop's emphasis on the F-20's R&M features was naive. Once in competition with the F-16, many in the AF viewed Northrop's R&M claims and test data as incredible. Northrop's management failed to support their R&M claims with sufficient sophistication to suit the AF.

V. LESSONS LEARNED FROM THE F-20 EXPERIENCE

This section takes a broader look at the Tigershark case to draw development lessons. It is not intended to be judgmental--no one cause or organization can be entirely blamed for the program's failure. However, this section does seek to find signals of failure.

RAND PROCEDURES FOLLOWED

A number of procedures suggested by RAND's acquisition research were followed by Northrop in the F-20's early development.

Incrementalism

Much like the MiG and Mirage series, the F-20 was originally upgraded from a successfully fielded system, namely the F-5 family. Initiated as an engine-change-only configuration, the F-5G evolved directly from Northrop's foreign export experience.

Austere Early Development

As Fig. 2 shows, spending on the F-20 program was relatively austere until 1981-82. It was during this period that the F-16 became a direct foreign sales competitor of the F-20. Consequently the Tigershark's performance capabilities were enhanced and its development expenditures increased. It was also during this period that much of the work on Northrop's first two preproduction aircraft was completed.

Limited Early Design Guidance

Northrop CEO Tom Jones initiated the Tigershark's design efforts with a one-page memo in which he outlined the program's strategy: emphasize R&M and minimize life cycle costs. Because the program was initiated by Northrop and self-financed, the F-20 was unencumbered by government performance specifications. Instead, Northrop was free to focus on what it believed the world arms market wanted: a plane with low acquisition and operating costs.

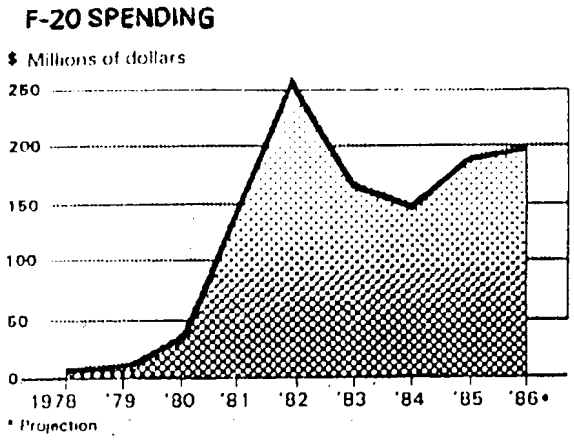

Fig. 2—Spending on the Tigershark

Source: "Northrop Jet in Shoot-out with F-16," *Los Angeles Times* Section IV (11 May 1986): 1.

Preproduction Aircraft

Northrop completed three preproduction aircraft in its Hawthorne PDC and had a fourth 25 percent completed at the program's close. These planes were intended to be sold when fitted with all the F-20's performance upgrades. Rather than follow the normal full scale development program to evaluate design changes prior to production, the first Tigershark was immediately built as a production configured aircraft. Collocation of manufacturing and engineering personnel at the PDC with short management channels of communication allowed design changes to be incorporated quickly into preproduction planes.

Development-Production Transition Management

Northrop's PDC allowed program managers to ease the transition from development to production. Designs of production tools were reviewed by collocated manufacturing and engineering design teams. All tools built for use in the Tigershark's development would have been transferred into production--that is, preproduction aircraft were built on

"hard" tooling. Precise tool discrepancy logs were kept, so that tools would be "validated" for the transition into full scale production.

IN SEARCH OF A MISSION

Largely as a result of arms export policy changes, Northrop found itself adjusting and readjusting the Tigershark's mission. These vicissitudes correspondingly affected the aircraft's design. For example, Carter's original PD-13 restraints held Northrop to an engine-change-only upgrade of the F-5. CEO Jones' guidelines later put design emphasis on operating cost effectiveness: slightly derating performance for enhanced R&M features. With the onset of Reagan's export policies, Northrop was forced to stress the Tigershark's performance features so as to compete with the top-line F-16. For the ADF competition, the Tigershark needed better range coverage and upgraded radar capabilities.

The flexibility required of the Tigershark to adjust among these missions was perhaps too much to ask of one aircraft. Northrop originally designed the F-5G as a very reliable high-performance fighter for the Third World. Reagan's change of export policies appears to have been the decisive factor in the Tigershark's fate. Although the Reagan administration stated that consideration of the full range of available fighters for sales abroad would take place, F-16s quickly replaced FX sales. This effectively forced Northrop to market the Tigershark as a top-line performance fighter--a role it was not designed to fill.

PROBLEMS INHERENT IN SELF-FINANCING R&D

Because Northrop self-financed its R&D expenditures, it was in a unique position. On one hand, it was free to design the Tigershark without stringent specifications and strict oversight. Some would argue that this factor allowed Northrop to develop the F-20 more cost effectively than planes developed for the U.S. inventory. However, Northrop's R&D financing also prevented the USG from believing it had a vested interest in the program's success. Self-financed development costs posed some difficult bureaucratic hurdles for Northrop.

Level-line Pricing

As previously mentioned, Northrop's level-line pricing concept was necessary to ensure that its R&D expenditures would be recouped. To AF officials more familiar with cost-based pricing, Northrop appeared to be on a profiteering scheme. Negotiations over this pricing policy were protracted and difficult.

The $1.2 Billion Risk

As Northrop painfully discovered, self-financing a program's R&D expenses is highly risky unless sales are guaranteed. The F-20 was something of an anomaly since it was not originally designed for the U.S. inventory. Therefore, without vested USG interests and strong support from the acquisition community, it is unlikely that other defense producers will follow the example of the Tigershark.

This conclusion has interesting implications in a time when producers are increasingly being asked to shoulder a substantial portion of development expenditures. In our interviews, Northrop officials suggested that they have had difficulty locating some subcontractors who are willing to finance independent research and development (IR&D) for their ATF program. Fewer subcontractors in the production game could lead to more sole-sourcing and less price competition.

LACKING BUREAUCRATIC BACKING

Northrop's troubles with the USG can be blamed both on some of its managerial decisions and on AF bureaucratic politics.

Not Invented Here

The AF and arms export community sent mixed signals to Northrop concerning their support for the Tigershark program. A lower technology intermediate fighter was an appealing idea for export authorities concerned about transfer of our most advanced technologies. But Northrop claims to have received unequal presentation to foreign nations. As a competitor to domestic acquisition of the F-16, the F-20 successfully forced GD to offer different aircraft configurations at lower per unit prices. But the Tigershark received Pentagon criticism because its performance characteristics were in some ways inferior to the F-16. The F-16 was visibly the AF's "favored son." Northrop's program was openly snubbed on several occasions. The Tigershark did not have credible support from the USG in the eyes of foreign buyers.

Naive R&M Claims

Also, Northrop's bloated R&M claims did not earn AF support. Incomplete or inappropriate measures such as failure and sortie rates did not provide sufficient evidence that the Tigershark had lower operating costs than the F-16. Since none were sold, we cannot know how F-20 costs would have compared with the F-16 under real operating conditions. Northrop's high R&M claims were sustained throughout the program, despite the fact that the F-20's capabilities had been upgraded to compete with the F-16.

Enhanced performance features typically mean more complicated avionics equipment and higher risk of degraded operating performance.

CONCLUSIONS

What have we learned from the case of the Tigershark? Perhaps most notably, we found that a program's development success is not sufficient to ensure its overall success. Northrop's early plans for a highly reliable and cost effective export fighter appear to have been a development success, yet the outcome was a massive financial loss.

The Tigershark's changing mission and the unstable export policy environment in the United States led to the F-20's demise. In the current unrestrictive export environment, no export aircraft program is likely to succeed without the vested interest of the USG. Given world arms preferences, aircraft performance characteristics are likely to be placed above cost-effectiveness.

The Tigershark's marketing failure was due partly to: bureaucratic politics, poor or risky managerial decisions, bad luck, but largely to changes in U.S. arms export policy. Luckily Northrop's massive losses have not destroyed the corporation's financial viability. The B-2 bomber, F/A-18, ATF, and ATA programs have ensured Northrop's continued financial health. However, the scale of losses in the F-20 program stands as a blatant example to the defense industry of the risks of IR&D.