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ACQUISITION RESEARCH
CASE STUDY

Case Study: Readiness and Total Ownership Cost Analyses for New Fighter Aircraft, F-XX

29 November 2012

by

Dr. Keebom Kang, Associate Professor, and

Dr. Kenneth H. Doerr, Associate Professor

Graduate School of Business & Public Policy

Naval Postgraduate School

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Abstract

This case is intended to illustrate key trade-offs in planning the acquisition of a major weapon system. In particular, the impact of logistics and maintenance decisions on life-cycle costs and readiness are examined. The case provides sufficient data to allow a rich discussion of issues and trade-offs—without being overwhelming. The case raises strategic policy issues but provides an analytical framework and data so that the policy issues can be discussed in detail, and not merely with generalities.

Logistics and maintenance issues examined within the case include the critical protection (spare-part) levels and reliability of major components, depot and preventive maintenance turnaround times, as well as planning for exogenous factors such as variability in the price of petroleum, oil, and lubricants. By examining a set of related decisions simultaneously, the case allows students to explore the relative leverage of logistics and maintenance decisions on cost and readiness. By examining endogenous as well as exogenous factors, the case allows students to examine the impact of factors within the control of program managers as well the impact of factors beyond their control on budget and readiness risk. The intent of the case is to move beyond planning simple budget and readiness targets and to encourage students to discuss methods of robust *contingency* planning.

Specific learning objectives include

- an understanding of the life-cycle cost implications of logistics and maintenance decisions,
- an understanding of the readiness implications of logistics and maintenance decisions,
- an understanding of the trade-offs between life-cycle cost and readiness,
- an understanding of the implications of logistics and maintenance factors on readiness risk, and

- an understanding of the implications of logistics and maintenance factors on budget risk.

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Keywords: life-cycle cost analysis; major weapon system; risk analysis on readiness and budget, spare parts critical protection levels; inventory fill rates; reliability, availability and maintainability (RAM); logistics and maintenance factors

About the Authors

Professor Keebom Kang received his PhD in industrial engineering from Purdue University. He joined the faculty of the Naval Postgraduate School in 1988, where he teaches supply chain, logistics engineering, and computer simulation modeling courses. His research interests are in the areas of logistics and simulation modeling in various military applications.

Prior to joining the NPS, Dr. Kang was on the faculty of the Industrial Engineering Department at the University of Miami, Coral Gables, Florida (1983–1988). He held visiting professor positions at Syracuse University (Summer, 1985), Georgia Institute of Technology (Fall, 2003), Asia Institute of Technology in Thailand (Winter, 2004), and Pohang Institute of Science and Technology in Korea (Spring, 2004). Dr. Kang has taught IDARM courses in military logistics and supply chain management courses in many countries.

Dr. Kang has published many theoretical and applied papers in *Operations Research*, *Naval Logistics Quarterly*, *IEEE Transactions on Communications*, *IIE Transactions*, *Journal of Telecommunication Management*, and other technical journals and conference proceedings. He has made numerous presentations at professional conferences as well as Department of Defense agencies. He has been the principal investigator for many research projects sponsored by the Department of Defense, U.S. Navy, U.S. Army, and U.S. Coast Guard and has been involved in organizing and coordinating many international conferences.

Keebom Kang
Associate Professor
Graduate School of Business and Public Policy
Naval Postgraduate School
Monterey, CA 93943-5000
Tel: 831-656-3106
Fax: (831) 656-3407
E-mail: kkang@nps.edu

Dr. Ken Doerr received his BS from Indiana University in 1984 and his PhD from the University of Washington in 1994. Prior to joining the faculty at the Naval Postgraduate School, he taught at the University of Miami, the University of Washington, and Santa Clara University and also held research fellowships at the University of Waterloo and the University of Cincinnati. He has worked for Shell Oil, Monsanto Corporation, and PeopleSoft in manufacturing and supply chain systems.

His research has appeared in several leading journals, including *Management Science*, *The Academy of Management Review, IIE Transactions,* and *The Journal of Applied Psychology*.

His research interests are in process design, work design, and information technology to facilitate operations.

Kenneth H. Doerr
Associate Professor
Graduate School of Business and Public Policy
Naval Postgraduate School
Monterey, CA 93943-5000
Tel: 831-656-3625
Fax: (831) 656-3407
E-mail: khdoerr@nps.edu

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I. Introduction

Given the looming controversies over the Joint Strike Fighter (JSF), a small group of naval acquisition mavericks began meeting in secret to discuss the development of an alternative aircraft that would incorporate many of the state-of-the-art technologies of the JSF but would be dedicated to the narrower missions of the Navy and Marines. Unlike past design projects, the aircraft would have cost targets, and especially ownership cost targets, as a primary design criteria. The secret group called themselves *the F-Team*, reflecting either their focus on fighter aircraft or the grades they received in graduate school.

Knowing that the project would be doomed to failure without the design and manufacturing support that industry could provide, the F-Team used its contacts in the Aerospace Industry Association (AIA) to reach out to like-minded individuals from multiple defense companies. These defense company engineers were dedicated to rescuing the tarnished image of their profession by developing a design for an affordable, state-of-the-art aircraft in record time. They took as their role model the North American Aviation team that had designed and built the P-51 Mustang aircraft prototype (arguably the best American fighter aircraft in World War II) in 100 days.

The F-Team had assembled the skills it needed for its project, but it still needed development funding. It knew that seeking funds through official channels would kill the project. The AIA professionals needed resources. The F-Team needed $2 billion in a hurry. It was then that Bill Gates came to his nation’s rescue. Retiring from Microsoft, he secretly hired an actor to play the part of CEO so that he could pursue his dream of helping the nation’s defense. Under the guise of a humble business school dean at the Naval Postgraduate School, the “real” Bill Gates devoted his considerable business acumen to managing the secret project, funded with his own wealth.

The project has now reached a critical stage, and it is time to go public with a business plan that the nation's civilian and defense leaders can review. In this hour of need, Dean Gates has reached out to your project group (which, for some reason, he has dubbed *the D-Team*) to develop the business case analysis to be submitted for public scrutiny. Defenders of the status quo will be merciless in their review of your work. Your analysis must be thorough, precise, and exhaustive. The nation's future may depend on how you perform this task.

The data you need are all described as follows. You must use this data to predict yearly costs and life-cycle costs for the new aircraft. The public is weary of cost overruns on projects like these, so you must not only project a budgeted life-cycle cost but also assess the risk that the projected cost will be exceeded.

Although the technical design of the aircraft is complete, several design alternatives are still available for critical components. They involve, for example, the ability to invest in more expensive materials in order to reduce wear on a component, and hence, lengthen the mean time between failures (MTBF) for those components. Also, design of the logistics support process is not complete. Key decisions such as the proper spare-parts inventory level for critical components must still be made. Dean Gates looks to your project group, as logistics experts, to complete the design of the support processes for the aircraft.

Typically, a small number of components contribute to most of the major logistics costs and degradation of readiness. For this case study, you will consider only six components (as shown in the next section) for life-cycle cost and operational availability computation, assuming that these are major readiness degraders and high-cost items.

With the logistics process and key component reliability still in play, life-cycle costs of course cannot yet be determined. It will be possible to reduce up-front costs—and possibly life-cycle costs—by reducing reliability and availability of aircraft. So, your analysis must not only examine life-cycle costs but also reliability and, hence, the availability of the aircraft. But you must keep in mind that planning for military operations will assume a certain guaranteed level of availability for this aircraft. You must set that “planning threshold” for operational availability and also assess the risk that aircraft availability will fall below this threshold.

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II. The F-XX

The new aircraft that the F-Team has designed is code-named *the F-XX*. It is a single-pilot, single-engine weapon system. Its mission profile is classified. The F-XX program life cycle is estimated to be 35 years (beginning in the current year), with an operational life of 30 years (beginning four years from now). As aircraft are brought into service and lost (attrited), the effective operating life of a single aircraft will average 27 years.

The following six life-cycle cost categories should be covered in your analysis:

1. research, development, test, and evaluation (RDT&E);
2. procurement/production;
3. personnel;
4. training;
5. operations and maintenance (O&M), including preventative maintenance and mid-life component improvement plan (CIP); and
6. squadron stand up and phase out costs, including disposal cost and salvage value.

All dollar values that appear in this case study are in current-year constant dollars. The current year is designated FY00, the next year is designated FY01, and so forth.

A. Research, Development Test and Evaluation (RDT&E)

RDT&E Costs:	FY00	$150,000,000
	FY01	$175,000,000
	FY02	$200,000,000
	FY03	$200,000,000

Initial year RDT&E costs can be taken as a constant. Subject matter experts estimate that later-year costs may vary by as much as 10%.

B. Procurement and Production

Production Time Line:	Begins in FY03 (F-XXs will be fielded in the year following their production).	
	Total Aircraft Produced:	96 aircraft
	Annual Production:	24 aircraft

Production Costs:

Unit Procurement Cost:	$50,000,000
Support Equipment	$20,000 per aircraft

Each copy of the F-XX has an average unit cost of $50 million. Support equipment costs $20,000 per aircraft. These one-time costs are incurred when the F-XXs are phased into the squadrons.

Your life-cycle cost model does not need to incorporate factors such as reductions in unit cost attributable to learning curve theory and economies of scale, nor does it need to consider potential cost overruns due to change orders later in the life cycle. The $50 million unit cost is the best-estimate average unit cost of all F-XX aircraft produced across the life cycle, accounting for those factors.

If the F-XX production line closed and were reopened later in the life cycle, it would likely incur significant setup cost. However, it is reasonable to assume that the production will be open for many years, since these aircraft will be sold to allied countries in the future. (See the Squadron Stand up and Phase Out Plan section.)

C. Squadron Manning and Personnel Costs

The F-XX aircraft system will be set up with eight squadrons. Two squadrons on each coast of the continental U.S. (CONUS), and one squadron each for the Pacific, Indian, Mediterranean, and Atlantic Oceans will be stood up to accommodate the new system. Each squadron will have a total of 12 aircraft.

Personnel requirements and costs are as follows:

Pilots and Ground Support Personnel (per squadron):

17	Pilots
4	Ground Support Officers
16	Chief Petty Officers (CPOs)
176	Enlisted

Headquarters Personnel (per squadron):

2	Commanding Officer (CO) and Executive officer (XO) (both are pilots)
1	Administration Officer (non-pilot)
2	CPOs
4	Enlisted

Average Personnel Cost per Year (cost to the DoD):

Pilot Officer	$180,000
Ground Officer	$160,000
CPO	$110,000
Enlisted (E1 to E6)	$60,000

See http://www.defenselink.mil/comptroller/rates/fy2013/2013_k.pdf for the DoD standard composite pay that includes standard benefits (housing, food, medical, etc., not including re-enlistment bonuses, combat pay, etc.).

D. Training Requirements and Costs

All F-XX personnel will require both basic and advanced levels of training. To meet the requirements to fill an assigned billet, each person must be fully qualified in accordance with the designated Navy Enlisted Classification Code (NEC) or Navy Officer Designator and pilots must complete all levels of flight training. The squadron CO and the XO are both pilots. It is assumed that these two senior officers (CO and XO) have previously completed basic flight training and that they only need to go through the advanced pilot training. They also will take headquarters (HQ) basic and advanced training.

The manpower annual turnover rate is 20%, and additional personnel must be trained due to attrition. The initial training will start one year prior to squadron activation, and the training program will be closed by the end of FY30. The man power turnover rate at the beginning of the life cycle would be lower than 20%, but we will assume a flat rate of 20% per year once the initial training cycle starts. Required training time and costs are as follows:

Pilots and Ground Personnel

	Basic	**Advanced**
Officer		
Pilot	36 weeks	12 weeks
Ground	12 weeks	2 weeks
CPO	12 weeks	2 weeks
Junior Enlisted	24 weeks	24 weeks

Headquarters Personnel

Basic Administration Training (Officers, CPOs, junior enlisted):	10 weeks
Advanced Administration Training (Officers and CPOs):	3 weeks

Training Costs (including travel and per diem)

Basic Training:	$2,000 / person / week
Advanced Training:	$3,000 / person / week
Pilot Basic:	$11,000 / person / week
Pilot Advanced:	$11,000 / person / week

E. Operations and Maintenance (O&M)

Operations

F-XX Flying Hours per Aircraft	40 hrs/month, or 480 hrs/year
Petroleum, Oil, and Lubricant	$2,000 per flying hour

Corrective Maintenance (CM)

The MTBF, cost, and required protection level (spare fill rate, or customer service level) for some of the major components are as follows:

Component Name	MTBF	Criticality	Protection Level	Unit Cost
APU	250	Non-Critical	0.85	$100,000
GEN	400	Critical	0.95	$ 250,000
PAS	1000	Critical	0.95	$ 400,000
AC	1000	Critical	0.95	$ 500,000
LG	500	Critical	0.95	$ 400,000
ENG	500	Critical	0.95	$ 2,000,000

APU: Auxiliary Power Unit
GEN: Generator
PAS: Phased Array System (Radar)
AC: Avionic Computer
LG: Landing Gear
ENG: Engine

Management of spare parts will be on a one-for-one exchange at the squadron level (organizational level, or O-level). It takes two days to swap the failed component with a spare part, if the part is available. For a critical component failure, the aircraft will be grounded until a ready-for-issue (RFI) spare part becomes available. An average waiting time for an RFI spare part is assumed to be 50% of the depot repair turnaround time. A failed component is sent to the Navy depot or contractor-managed depot for repair. The required O&M factors are as follows:

Each squadron's activity has start-up fixed costs, which are incurred at $10,000,000 per activity prior to squadron activation. Additionally, operating variable costs, which are estimated at $5,000,000/year per O-level activity, are incurred for each year that a squadron is operational.

Transportation Cost:	$200 per failure
Spare Inventory Carrying Rate: (Including Purchase and Depreciation)	20% of spare value per year
Sparing Levels (Protection Levels)	
Critical Units	95%
Non-Critical Units	85%
Repair Turnaround Time (TAT)	40 days
Depot-Level Repair Costs	$5,000 per repair
O-Level Activation	$10,000,000 for each O-Level activity
O-Level Operating Costs	$5,000,000/yr per squadron

Some uncertainty remains in certain O&M factors. Engineers from F-Team have proposed alternatives that involve additional up-front investments that can potentially lower turnaround times and increase MTBF for critical components to improve readiness and reduce the life-cycle cost.

Preventative Maintenance (PM)

Cost	10% of aircraft procurement cost
Interval	5 years
TAT	90 days

Mid-life Component Improvement Plan (CIP)

Mid-life CIP	Begins in FY18 2 squadrons per year
CIP Costs	25% of aircraft procurement cost + 4% of aircraft procurement cost for engineering RDT&E
Interval	Scheduled once during the life cycle per aircraft
TAT	90 days

F. Squadron Stand-up and Phase-Out Plan

The F-XX squadrons will be stood up and stood down two squadrons at a time with the following time line:

Stand up: FY04: 2 squadrons/12 aircraft each (24 total)
FY05: 2 squadrons/12 aircraft each (24 total)
FY06: 2 squadrons/12 aircraft each (24 total)
FY07: 2 squadrons/12 aircraft each (24 total)

Decommission: FY31: 2 squadrons/12 aircraft each (24 total)
FY32: 2 squadrons/12 aircraft each (24 total)
FY33: 2 squadrons/12 aircraft each (24 total)
FY34: 2 squadrons/12 aircraft each (24 total)

We assume that all aircraft will be in full operational mode at the beginning of the fiscal year when a squadron stands up; for example, 24 aircraft will be in operation in FY04 for the entire year. We also assume that the aircraft will be decommissioned at the end of the fiscal year.

As squadrons stand down, the assigned aircraft will be sold to foreign military sales (FMS)–eligible countries. The expected salvage value of each aircraft is $12.5 million, 25% of the average procurement unit cost. The savage value as well as disposal costs, if any, will be realized at the time of decommissioning. Classified weapon systems will be removed before the FMS sales. This disposal cost is estimated to be $250,000 per aircraft.

Ten additional aircraft will be purchased in FY07 as replacement aircraft that will be available as a one-to-one exchange when an aircraft is sent to depot for overhaul and CIP. An attrited aircraft will be replaced as needed at a future time. The average attrition rate is estimated to be approximately 1% per year. For modeling purposes, we assume that one aircraft will need to be delivered every year from FY08 until FY30 to replace the attrited aircraft.

The procurement and maintenance costs of the training aircraft will not be included in the case study.

III. Case Questions

1. Estimate the life-cycle cost (or total ownership cost) for the F-XX system using the real annual discount rates at 2% and 7% per year, respectively.

   (See http://www.whitehouse.gov/omb/circulars/a094/a094.html)

2. Estimate operational availability of the F-XX aircraft squadron. Add your own reasonable assumptions as needed.

3. Re-compute the life-cycle cost with the assumption that the O&M costs are expected to creep with aging in excess of inflation at a rate of 4% annually, starting from the 11th year of operation (FY14). The CIP cost will remain the same as estimated.

4. Develop five what-if scenarios that a decision-maker (e.g., program manager) would be interested in. For example, if the critical spare parts protection level is changed from 95% to 85% and, at the same time, the depot (repair) turnaround time is increased from 40 days to 50 days, what is the impact on the life-cycle cost and operational availability?

5. Estimate the probability that the life-cycle cost will exceed some threshold value—say, $17 billion (discounted cash flow).

6. Estimate the probability that the operational availability falls below some threshold value—say, 88%.

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